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## PRELIMINARY ANALYSIS OF THE FOSSIL VERTEBRATES OF THE CANYON FERRY RESERVOIR AREA

By THEODORE E. WHITE

The Canyon Ferry Reservoir will be located on the Missouri River below Townsend, the county seat of Broadwater County, Mont. The dam is being built about 1 mile downstream from the present Canyon Ferry Dam and Power Plant. The maximum pool will inundate an area approximately 25 miles long and 3 to 4 miles wide, and will include several known fossiliferous localities in Oligocene and Miocene sediments. The reservoir area includes one of the very few areas in the intermountain basins that have a complete succession of sediments from the Lower Oligocene well into the Middle Miocene. Fossil faunas are known from other intermountain basins in Montana but rarely do they embrace more than one of the time units represented here. These faunas are of special interest because they represent an environment totally different from that of the White River deposits of the plains and offer opportunities to study fossil faunas in the light of the principles of climatic zoning which have been worked out for recent faunas.

Most of our knowledge of the Tertiary deposits and their faunas of the intermountain basins of Montana is the result of the explorations and research of the late Dr. Earl Douglass around the turn of the century. His studies have been published principally in the *Annals of the Carnegie Museum*. His explorations have been greatly extended and enlarged by Dr. J. LeRoy Kay, of the same institution, whose assistance has greatly expedited the work of the River Basin Surveys. The studies by Douglass have been further augmented by those on the fossil rodents and lagomorphs by Dr. J. J. Burke, who

was the first to point out that certain genera were common to the Oligocene deposits of Eastern Asia and the intermountain basins. Also should be mentioned the work of the late Dr. W. D. Matthew on the fauna of Pipestone Springs, which is the only study on a single fauna which has been made on any of the intermountain basins.

As part of the salvage program being carried out by the River Basin Surveys of the Smithsonian Institution in the reservoir sites in the Missouri Valley, the fossiliferous localities in the Canyon Ferry Reservoir area have been prospected for fossils for three seasons. In 1947, the first season of work, largely reconnaissance, I was assisted by John C. Donohoe, now a student at the University of New Mexico; in 1948, by Mr. Donohoe and Ernest L. Lundelius, now a graduate student at the University of Chicago; and, in 1950, by William C. Harrup, Jr., a student at Columbia University, and Prentiss Shepherd, Jr., a student at Harvard University. With the aid of these sharp-eyed young men a collection of nearly 300 specimens was obtained from the several localities in the reservoir area, the basis of this study. These specimens are in the U. S. National Museum (USNM). In addition, Dr. Kay has given me free access to the material from the reservoir area in the Carnegie Museum (CM) which has materially supplemented the collection of the River Basin Surveys.

The graphic art of William D. Crockett has been invaluable in portraying the characters of the more interesting specimens.

In the discussion of the specimens, the localities from which they were obtained are indicated by code numbers according to the system used by the Missouri Valley Project of the Smithsonian River Basin Surveys. Following is a list of these localities.

#### Lower Oligocene (Chadronian) Localities

24LC16. NE $\frac{1}{4}$ SW $\frac{1}{4}$ , sec. 3, T. 10 N., R. 1 W., of the Montana prime meridian, about 1 mile north of Canyon Ferry, Lewis and Clark County, Mont. This is a small area of badlands at the foot of the bluff on which the buildings of the permanent offices of the project are built (fig. 40). About 130 feet of light buff ashy clays are exposed at this locality with Chadronian fossils in the upper half. Only the remains of the smaller mammals were sufficiently well preserved for identification.

24BW18. NW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 7, T. 9 N., R. 1 E., of the Montana prime meridian, about 1 $\frac{1}{4}$  miles southwest of the south end of Lake Sewell, Broadwater County, Mont. This locality (fig. 41) was originally discovered by Dr. Kay, who very generously directed the River Basin Surveys to it. Lithologically, the deposits in this area do not differ materially from those of the preceding locality, nor does the species

assemblage. About 300 yards east of this locality some Middle Oligocene fossils were collected but were so few that separate locality designation was not given.

#### Middle Oligocene (Orellan) Localities

24LC15. SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 10, T. 10 N., R. 1 W., of the Montana prime meridian, about  $\frac{1}{4}$  mile southeast of Canyon Ferry, Lewis and Clark County, Mont. This is a small butte, about 100 feet high, of light buff clayey ash showing indistinct bedding. The greatest concentration of fossils is on the south side. However, the fossiliferous area is so limited that it very strongly suggests that the fauna was brought together



FIGURE 40.—Locality No. 24LC16 from the south.

by an Oligocene owl. The photograph in the popular account by Douglass (1908) shows that this is the Canyon Ferry locality from which he obtained his Oligocene fossils.

24LC17. SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 3, T. 10 N., R. 1 W., of the Montana prime meridian, about  $1\frac{1}{4}$  miles north of Canyon Ferry, Lewis and Clark County, Mont. This locality offers a more complete Middle Oligocene section than the preceding one. About 140 feet of sediments are exposed at this locality. At the base they are light gray to buff clayey ash, grading to nearly pure ash, grayish green, at the top. The same faunal assemblage is found in the lower levels as at the preceding locality but no identifiable specimens were obtained from the upper levels.

### Lower Miocene (Arikareean) Localities

24LC18. S½SW¼ sec. 11, T. 10 N., R. 1 W., of the Montana prime meridian, about 1 mile east of Canyon Ferry, Lewis and Clark County, Mont. About 200 feet of fine-grained, dense, buff sandstone, which weathers into nearly vertical cliffs are exposed in this area (fig. 42). In texture and color these deposits very closely resemble the Harrison deposits of western Nebraska and eastern Wyoming. This locality is the one from which Douglass and others have obtained Miocene fossils at Canyon Ferry and it is still the most productive Miocene locality in the area; but, even so, fossils are not common.

24LC19. NE¼SW¼ sec. 2, T. 10 N., R. 1 W., of the Montana prime meridian, about 1½ miles northeast of Canyon Ferry, Lewis and Clark County, Mont. This locality is a small area of cliffs in the buff sandstone on the northeast side of the highway just southeast of the bridge over Cave Gulch. Very little material was obtained at this locality.

24LC20. SW¼NE¼ sec. 11, T. 10 N., R. 1 W., of the Montana prime meridian, about 1 mile east of Canyon Ferry, Lewis and Clark County, Mont. This locality lies across Magpie Gulch, about ¼ mile north of locality No. 24LC18, and represents the lower levels of that locality. Only a very small fauna was obtained here.

### Middle Miocene (Hemingfordian) Localities

24LC21. SE¼NW¼ sec. 13, T. 10 N., R. 1 W., of the Montana prime meridian, about 2 miles east and little south of Canyon Ferry, Lewis and Clark County, Mont. A few isolated and imperfect *Merychippus* teeth were obtained from a buff sandstone resting on a lens of fresh-water limestone. These few teeth were the only material collected in this locality.

Earl Douglass location. W½ sec. 25, T. 9 N., R. 1 E., of the Montana prime meridian, about 8 miles east of Winston, Broadwater County, Mont. Douglass (1908b, p. 274) secured the greater portion of a skull, a lower jaw, and some skeletal element of an advanced species of *Merychippus* from the bluffs on the east side of the Missouri River. And, as far as I know, no other specimens have been collected from this locality.

### Geology

The Canyon Ferry Reservoir area lies in the reentrant between the Big Belt Mountains on the east and the Spokane Hills on the west, at the north end of the deformational basin in which the Toston beds of Douglass (1901, pp. 242-243) were deposited. As near as could be determined in the limited time available, the beds are not lithologically

continuous with those of the Prickley Pear Valley or the Thompson Creek area until at least the Middle Miocene times. Also deposition was uninterrupted from Lower Oligocene (Pipestone Springs equivalent) into the Middle Miocene (possibly Marsland equivalent). In Late Miocene times orogenic movements tilted the earlier sediments to the northeast and coarse gravels, which were later cemented with calcium carbonate, were deposited on their truncated edges. As yet no identifiable fossils have been found in these gravels, but they are believed to be Pliocene in age. The Pleistocene is represented by local deposits of coarse, unconsolidated gravels which have not yet produced diagnostic fossils.

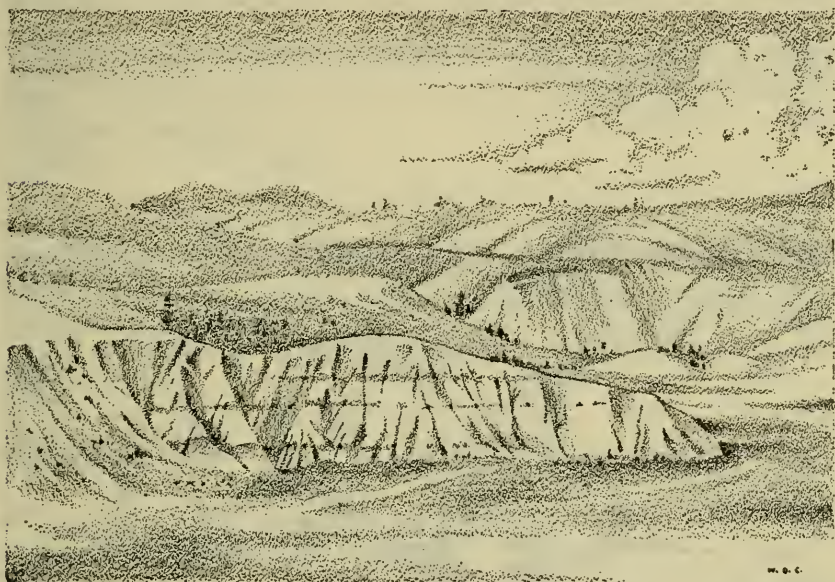


FIGURE 41.—Locality No. 24BW18 from the south.

The probable conditions under which these sediments were deposited are very well described by Douglass (1903, pp. 146–149). In summary, the sediments accumulated in a deformational basin which, in its lowest part, harbored a series of small, very shallow lakes or wet meadows or a combination of both. Evidence for the lakes lies in the several local areas of fresh-water limestones, some of which show very fine bedding planes. Evidence for the wet meadows lies in the areas of dark, gypsiferous clays, often with shale-like partings. However, in all probability the gypsum is of secondary development rather than primary.

As pointed out by Douglass (1903, p. 147) the fossils occur most abundantly near the margin of the depositional basin and are very

rare towards the central portion. One interpretation which could be placed on this fact is that only along the margins did sediments accumulate fast enough to bury the bone before weathering or other factors could destroy them. However, evidence of alluvial fans along the basin's margin have not been observed. The alternative, which seems the more probable, is that the accumulating soil of the central portion was more acid from decaying vegetation and the bones, reacting with the sulphides of vegetable decay, were a partial source of the gypsum in these deposits.

Throughout their observed exposures the Oligocene sediments are uniformly fine grained, ranging in color from light gray to light buff.



FIGURE 42.—Locality No. 24LC18 from the south.

No lithological distinction could be made between the Lower and Middle Oligocene sediments, but those which are believed to represent the Upper Oligocene contain considerably more ash, are less consolidated, and grayish green in color. The Oligocene sediments show rather even bedding planes which are indistinct except when the exposures are wet. Occasional stream gravels are found at nearly all levels but do not appear to have cut very deep into the Oligocene deposits. These gravels are made up almost entirely of angular fragments of the Proterozoic and Paleozoic sediments which form the Big Belt Mountains and the Spokane Hills.

The Miocene sediments, like the Oligocene, are uniformly fine grained but contain a higher percentage of sand and are better con-

solidated. In color and texture they very closely resemble the Harrison beds of western Nebraska and eastern Wyoming. Also like the Oligocene, the stream gravels occasionally encountered are composed largely of the angular fragments of the Proterozoic and Paleozoic sediments from the adjacent mountains. Also, basaltic, volcanic bombs from 8 inches to 1 foot in diameter are occasionally encountered, but they are not necessarily associated with the stream gravels. Although the Oligocene and Miocene sediments are quite different lithologically, at only one place, in a recent road cut, was the contact between the two observed. It was not possible to detect an angular unconformity either at this place or by measuring the angle of dip of the beds.

The following section was measured by Mr. Harrup at the north end of the reservoir area near the present construction camp; here, both the Oligocene and Miocene strata dip east  $50^{\circ}$  north at an angle of  $6^{\circ}$  from the horizontal:

Fine-grained, buff sandstone, often weathering into vertical cliffs; stream gravels common; occasional volcanic bombs. Arikarean fossils.—150 feet.

Light gray to buff clayey ash grading to nearly pure ash at top; lenses of stream gravels common. Orellan fossils at the bottom.—140 feet.

Dark gypsiferous clays, with iron nodules, alternating with lighter bands. No identifiable fossils.—110 feet.

Light buff clayey ash with Chadronian (Pipestone Springs) fossils at the top.—130 feet.

## Class REPTILIA

## Order SQUAMATA

## Suborder SAURIA

## Family ANGUIDAE

### *Glyptosaurus cf. montanus* Douglass

USNM 19081, portion of right frontal with scutes and portion of left dentary with six teeth, from the Lower Oligocene of locality No. 24BW18.

The limited material of this form does not permit any additions to Gilmore's (1928, p. 115) discussion of the species.

### *Peltosaurus* sp.

USNM 19085, a maxillary fragment; and USNM 19084, a dentary fragment; both from the Middle Oligocene at Canyon Ferry. These specimens appear to be referable to this genus but contribute nothing to our knowledge of the group.

## Suborder SERPENTES

## Family BOIDAE

*Calamagras* sp.

USNM 19082, a single thoracic vertebra from the Lower Oligocene of locality No. 24BW18, appears to be referable to this genus. As pointed out by Gilmore (1938, p. 36), this genus is difficult to distinguish from the following one, but in view of the very limited state of our knowledge it will be convenient to retain one genus for the small boids of the Oligocene and the other for the Miocene.

*Ogmophis arenarum* Douglass

USNM 19083, two thoracic vertebrae and the neural arch of a third in a connected series, from the Lower Miocene of Canyon Ferry, are referred to this species on the basis of the ovate central articulations, but the material is too limited to contribute anything to our knowledge of the genus.

It is interesting to note here that of the two other reptilian types commonly found in the Oligocene of the plains, one, the crocodilians, is unknown and the other, the turtles, is represented only by the terrestrial types. No fragments indicative of any of the aquatic types have yet been found. On the other hand, the aquatic types of turtles are rare in the White River deposits.

## Class MAMMALIA

## Order MARSUPIALIA

## Suborder POLYPROTODONTIA

## Family DIDELPHIDAE

*Peratherium fugax* Cope

USNM 18953, left mandible with  $P_2-M_4$ ; USNM 18954, left mandible with  $P_1-M_4$ . Both specimens are from locality No. 24LC15.

These specimens are nearly twice the size of *P. titanelix* Matthew from Pipestone Springs and only slightly larger than the measurements Scott (1941, p. 962) gives for this species. An examination of the material in the U. S. National Museum referable to this genus shows that the variation in the characters of the teeth and jaws is greater in this genus than in the higher mammals. It is probable, as Scott points out, that there are only two valid species, a large and a small, in the Middle Oligocene of North America. Measurements of teeth (in millimeters):

	USNM 18953	USNM 18954
$P_1-3$ -----	6.0	6.3
$M_1-4$ -----	7.5	7.1

## Order INSECTIVORA

## Family SOLENODONTIDAE

*Apternodus mediaevus* Matthew

USNM 18914, fragment of right maxilla with  $M^1$ , from locality No. 24LC16; CM Field No. 30/48, skull and jaws somewhat crushed, from locality No. 24BW18.

The discovery of the skull and jaws was unusually fortunate in that they show the character of the enlarged upper and lower first (?) incisors.

*Description.*—Upper incisor is simple, placed nearly vertical in the premaxilla, tapering very slightly in width toward the tip and slanted medially so that the tips meet, stronger anteroposterior taper which extends from base to tip on the posterior side, anterior face slightly convex dorsoventrally and with uniform curvature, enamel covered except at tip where worn. Lower incisor is simple, making a very obtuse angle with the axis of the jaw, medial face flattened, lateral surface convex, very slight taper in width, anteroposterior taper from base to tip, tooth enamel covered.

## Family LEPTICTIDAE

*Ictops acutidens* Douglass

USNM 18910, badly broken skull and jaws with skeletal fragments; USNM 18912, left maxillary fragment with  $P^4$ – $M^3$ . Both specimens are from locality No. 24LC16.

This material does not permit any additions to be made to Matthew's (1903, p. 207) discussion of the species.

## Family TALPIDAE

## Genus and species undetermined

USNM 18915, right humerus lacking the distal epiphysis, from locality No. 24LC16; USNM 19024, right humerus lacking the distal epiphysis, from Pipestone Springs; CM 9184, right humerus lacking the distal epiphysis, from locality No. 24BW18.

*Discussion.*—A comparison of this material with the humeri of recent moles in the U. S. National Museum does not reveal any close affinities with any of the genera represented. On the other hand, the derivation of the humerus of the Talpinae and Scalopinae from this type of humerus would require only an exaggeration of its present characters. Consequently, the reference of this material to the Talpidae is reasonably certain, but generic designation will be withheld pending the acquisition of better material.

The discovery of this material confirms the suggestion (Simpson, 1947, p. 637) that this group probably migrated to North America from Eurasia during the Early Oligocene. Also of interest is that the group reached North America before the humerus acquired the extreme modification which it has today.

### Family NYCTITHERIIDAE

#### *Kentrogomphios strophensis*, new genus, new species

*Genoholotype*.—USNM 18870 (fig. 43), facial portion of a skull anterior to the cribiform plate, lacking one canine, the crown of the other, and the incisors.

*Referred material*.—USNM 18871 (fig. 44), right mandibular fragment with  $M_{2-3}$ .

*Horizon and locality*.—Lower Oligocene, Chadronian; SW $\frac{1}{4}$  sec. 3, T. 10 N., R. 1 W., of the Montana prime meridian, about 1 mile north of Canyon Ferry, Lewis and Clark County, Mont.

*Diagnosis*.—Portion of skull preserved about the same size as the corresponding portion of *Scalopus aquaticus*; skull elements securely fused together, orbit small, infraorbital foramen large and opening into a deep elongate pit anterior to orbit, lacrymal duct large and situated within the orbit, no palatine vacuities, zygoma believed present but very slender, foramina of the alisphenoid region similar to those of the Soricidae; I?, C1, P3?, M3; root of canine elongate-triangular in cross section with the acute angle posterior, cusps of cheek teeth very high, posterior border of  $P^4$  to  $M^2$  deeply emarginate between hypocone and metastyle, no anterior or inner cingulum, strong cingulum on hypocone;  $P^2$  (if present) minute, single rooted and simple;  $P^3$  three rooted, a single outer cusp with a broad shearing blade extending posteriorly, deuterococone minute and placed nearer the anterior than the posterior edge;  $P^4$  submolariform, parametacone twice as high as protocone, strong metaconal crest, parastyle and metastyle strong, external cingulum weak, protocone twice as high as hypocone, strong posterior cingulum on hypocone;  $M^1$  with paracone and metacone close together and subequal in height, metastylar crest strong, parastyle and metastyle well developed, mesostyle obsolete, a small metastylule present, protocone strong and as high as paracone, a small protoconule present, hypocone half as high as protocone and with a strong posterior cingulum;  $M^2$  similar to  $M^1$ , paracone and metacone farther apart, a strong parastylar crest, parastyle and metastyle well developed, parastylule and metastylule present, a strong mesostyle present;  $M^3$  triangular in outline, hypocone and metastyle absent, parastyle and parastylule present, a minute metaconule present, mesostyle well developed.

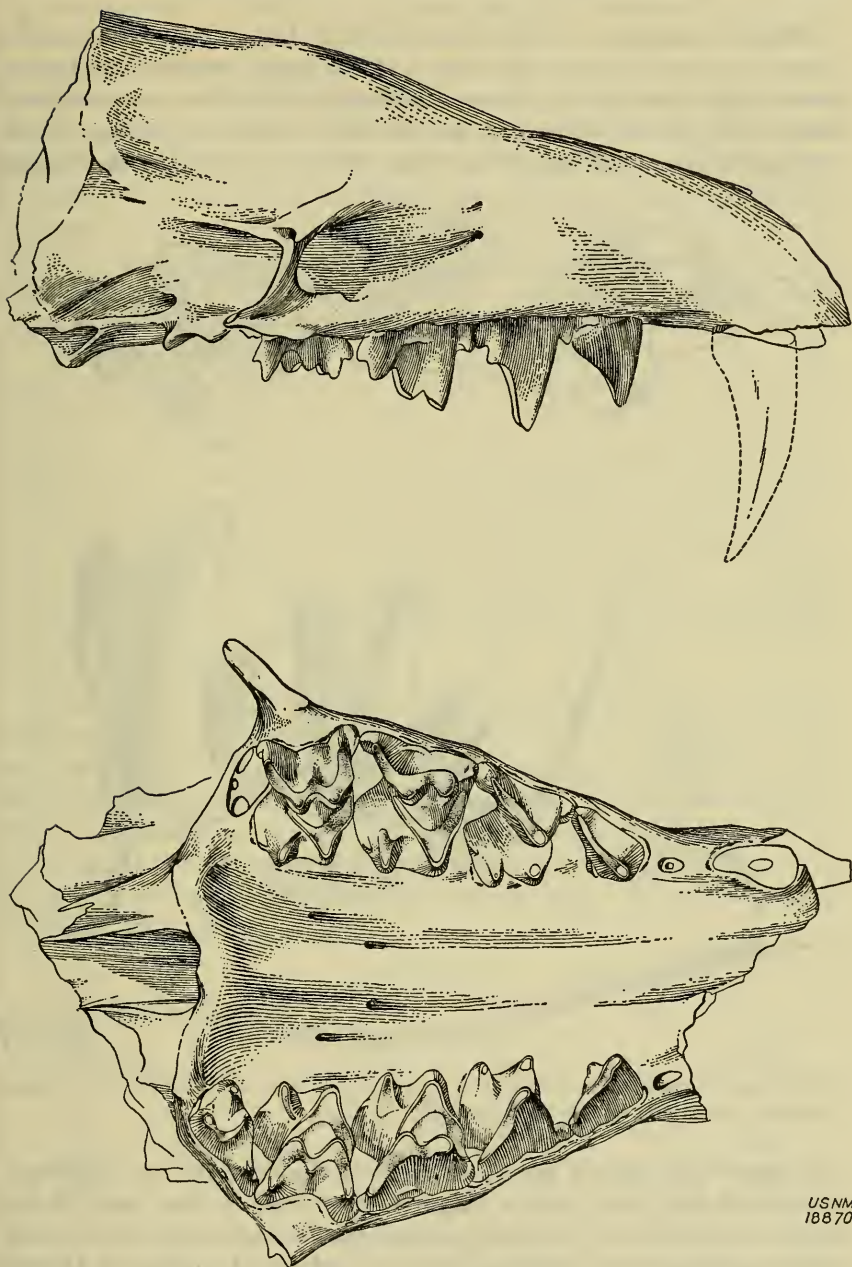
USNM  
18870

FIGURE 43.—Lateral and occlusal views of the type (USNM 18870) of *Kentrogomphios strophensis*, new genus and species.  $\times 7$ .

*Referred specimen.*—Trigonid on  $M_2$  high, height twice that of the talonid and nearly twice the length of the tooth, recurved and compressed anteroposteriorly, protoconid slightly higher than paraconid and metaconid, which are equal, an anterior cingulum present which terminates in a small but distinct cusp about the middle of the base of

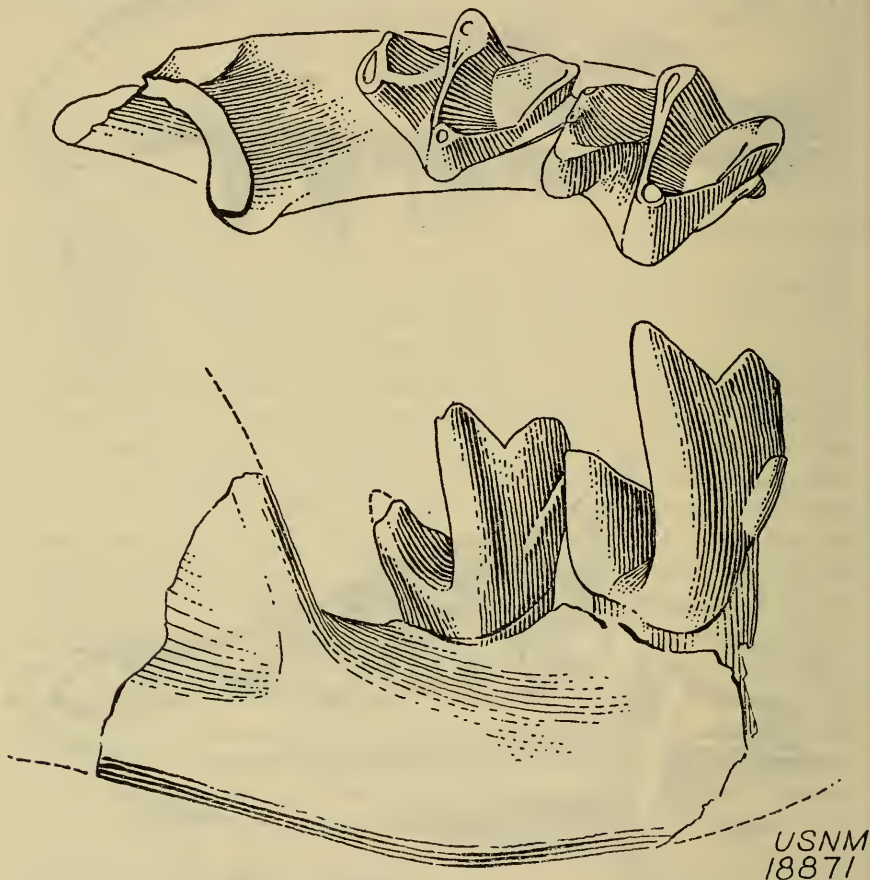


FIGURE 44.—Occlusal and lateral views of the referred specimen (USNM 18871) of *Kentrogomphios strophensis*, new genus and species.  $\times 7$ .

the paraconid; talonid nearly as long as the trigonid but narrower, hypoconid high and with a ridge sloping down to the base of the metaconid, height of hypoconid nearly equal to the length of the tooth, hypoconulid minute, entoconid nearly obsolete;  $M_3$  similar to  $M_2$  but smaller and with a narrower talonid.

The portion of the jaw preserved indicates a strong upward curvature back of the teeth. The masseteric fossa is deep and with a very prominent anterior rim.

This specimen is referred to this species on the basis of the occlusion with the type which is as good as occurs between different specimens of

the same species. The two specimens are from the same horizon and locality but the difference in amount of wear excludes them from belonging to the same individual.

*Discussion.*—Although this specimen adds many new data to our knowledge of this group of insectivores, the affinities of the family are still problematical. A number of the characters are shared by both the Soricidea and the Microchiroptera. Some characters are shared by some members of both groups but not by all members of either. Briefly, these characters are the fused skull elements and the character of the orbits. This is also true for the general characters of the cheek teeth. In some members of both groups the posterior border is deeply emarginate between the hypocone and metastyle. The parastylar and metastylar crests resemble both groups in their general features but in their details resemble the bats more than the shrews. The very high cusps of the cheek teeth, especially the hypocone, appear to be a unique feature of this specimen. The large canine excludes this specimen from the shrews but not from the moles (*Talpinae*) and bats. The elongate pit in front of the orbit is a characteristic of most shrews and many of the moles, but not of the bats. A slender zygoma is present in moles and most bats but is absent in the shrews. The rostrum is broken away and the anterior termination of the face cannot be determined.

In summary, the characters of this specimen exclude it from the Soricidae but do not definitely affiliate it with any other group. The molelike facial features certainly suggest that it could belong to the talpid humerus from the same locality. *Parascaptor* and *Scapatochirus* have a large canine and reduced premolars as does this specimen. However, the cheek teeth of this specimen are of a type unknown in any living moles and very suggestive of the bats. Measurements of teeth (in millimeters):

## USNM 18870

C-M <sup>3</sup> -----	11.6
P <sup>3</sup> -P <sup>4</sup> -----	3.6
M <sup>1</sup> -M <sup>3</sup> -----	5.5
	Length Width
P <sup>4</sup> -----	2.2 1.8
M <sup>1</sup> -----	2.3 2.5
M <sup>2</sup> -----	1.8 2.7
M <sup>3</sup> -----	1.1 2.2

## USNM 18871

	Length	Width		Height	
		Trigonid	Heel	Trigonid	Heel
M <sub>2</sub> -----	1.8	1.8	1.2	3.1	1.3
M <sub>3</sub> -----	1.8	1.5	0.8	2.1	1.0
Depth of jaw between M <sub>2</sub> and M <sub>3</sub> -----			2.3		
Depth of jaw below masseteric fossa-----			1.2		

## Order RODENTIA

## Family SCIURAVIDAE

*Prosciurus cf. relictus* (Cope)

USNM 18857, left mandible with  $P_4-M_3$ ; USNM 18858, left mandible with  $P_4-M_1$ . Both specimens are from locality No. 24LC15.

The enamel patterns of the teeth and the measurements agree with the figures and description by A. E. Wood (1937, p. 168) but this material does not permit any additions to his discussion. Measurements of teeth (in millimeters):

USNM 18857		
	Length	Width
$P_4-M_3$ -----	7. 2	----
$P_4$ -----	1. 5	1. 6
$M_1$ -----	1. 6	1. 7
$M_2$ -----	1. 7	1. 9
$M_3$ -----	2. 2	1. 6

## Family ISCHYROMYIDAE

*Ischyromys cf. pliacus* Troxell

USNM 18908, right mandible with  $P_4-M_3$ ; USNM 18909, left mandible with  $P_4-M_2$ ; USNM 18920, right mandible with  $M_1-M_3$ . Specimens are from locality No. 24LC16.

This material does not permit additions to our knowledge of the species.

*Titanotheriomys veterior* Matthew

USNM 18904, a palate with  $dP_3-M_3$ ; USNM 18905, a palate with  $dP_4-M_2$ ; USNM 18907, left mandible with  $P_4-M_3$ . Specimens are from locality No. 24LC16.

This material does not permit any additions to our knowledge of this species.

## Family CASTORIDAE

*Paleocastor cf. gradatus* (Cope)

USNM 18963, palate with left  $P^4-M^3$ , from locality No. 24LC18; USNM 18962, left mandibular fragment with  $P_4-M_2$ , from locality No. 24LC20.

This material is referred to this species on the basis of size. As pointed out by Stirton (1935, p. 409), this species is very close to *P. peninsulatus* (Cope). Definite allocation of the Canyon Ferry material must await the acquisition of better specimens.

## Family EOMYIDAE

*Paradjidaumo cf. minor* (Douglass)

USNM 18759, left mandible with  $P_4$ - $M_3$ , from locality No. 24LC16; USNM 18758, right mandible with  $P_4$ - $M_2$ , from locality No. 24LC17.

*Discussion.*—In size, this material agrees with both size groups which Wood (1937, p. 244) records from Pipestone Springs, but it differs in that  $M_1$  and  $M_2$  are broader than long in both specimens. One of the specimens measured by Wood (AMNH 9635) shows this condition, but with such a limited sample it is impossible to properly evaluate this character.

Although one of these specimens is from the Chadron equivalent and the other from the Lower Brule equivalent, I could find no morphological characters of the teeth which would separate them. Also, in the *Paradjidaumo* material from Pipestone Springs in the U. S. National Museum there is one specimen which agrees with *P. trilophus* in its dental morphology, including the flattened anterior face of the lower incisor. In view of the above facts and the variation in size and tooth proportions found in the material from Pipestone Springs and the Badlands, it is difficult to escape the inference that *P. minor* and *P. trilophus* represent species groups rather than single species. Measurements of teeth (in millimeters):

	USNM 18758		USNM 18759	
	Length	Width	Length	Width
$P_4$ - $M_3$ -----	6.2	---	---	---
$P_4$ -----	1.4	1.4	---	---
$M_1$ -----	1.5	1.6	1.3	1.4
$M_2$ -----	1.5	1.6	1.3	1.4
$M_3$ -----	1.6	1.4	---	---

*Paradjidaumo spokaneensis*, new species

*Holotype.*—USNM 18760, a badly crushed skull with right mandible.

*Horizon and locality.*—Middle Oligocene, Orellan; SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 10, T. 10 N., R. 1 W., of the Montana prime meridian, about  $\frac{1}{4}$  mile southeast of Canyon Ferry, Lewis and Clark County, Mont.

*Diagnosis.*—Upper teeth broader than long with mesoloph extending to labial margin, posterior cingulum uniting with hypocone and extending nearly to labial margin, mure extending nearly to middle of tooth, shortest on  $P^4$  and longest on  $M^2$ . Lower teeth with mesolophid long, extending to lingual margin, free on  $P_4$  and  $M_1$  but uniting with entoconid on  $M_2$  and  $M_3$  with wear.  $P_4$  longer than broad and  $M_3$  nearly as broad as long. Measurements of teeth (in millimeters):

P <sub>4</sub> -M <sub>3</sub> -----	Upper		Lower	
	6. 0		6. 7	
	Length	Width	Length	Width
P <sub>4</sub> -----	1. 6	1. 7	1. 7	1. 5
M <sub>1</sub> -----	1. 5	1. 9	1. 7	1. 6
M <sub>2</sub> -----	1. 5	1. 9	1. 6	1. 7
M <sub>3</sub> -----	1. 2	1. 7	1. 5	1. 4

The characters which distinguish this species are the larger size, the elongate P<sub>4</sub>, and the short, nearly quadrangular M<sub>3</sub>.

### Family CRICETIDAE

This family of rodents is represented in this area by a single genus, *Eumys*, and most of the specimens came from two localities, Nos. 24LC15 and 24LC17. The others, specimens in the Carnegie Museum, are from the upper levels of No. 24BW18, locally known as the Old Hadcock Ranch. This series of nearly 100 specimens, although showing considerable variation, is divisible into four groups, three of which exhibit characters of the teeth not readily referable to species described from the White River deposits of the plains. All of the specimens are 15 to 25 percent larger than those of the plains. Also, the teeth are higher crowned and the cusps are better developed.

By analogy with some of the wide-ranging species of the genus *Peromyscus*, one would normally expect only subspecific differences between the members of the genus *Eumys* from the Badlands of South Dakota and the Canyon Ferry Reservoir area since the former is on the plains and the latter is in the mountains. On the other hand, in the mountain areas two or three distinct species of *Peromyscus* usually occur in a single area in addition to the plains species. This appears to be correlated with the greater variety of ecological niches within a limited area, and the remains of a varied fauna from a variety of ecological niches could be concentrated in a very small area of deposition by the work of owls. In view of the geologic history of this region, the environment for small rodents during the Oligocene was probably as varied and as different from that of the plains as it is today. Although only one of the plains species has been positively identified in this material, A. E. Wood (1937, p. 250) reports *E. elegans* Leidy from Montana but gives no locality data.

The following artificial key gives the distinguishing characters of the species of this area:

#### Key to the species of *Eumys*

- a.<sup>1</sup> Anteroconid on M<sub>1</sub> large, anterior cingulum on M<sub>2</sub> extending the full width of tooth, a short but distinct mesolophid on M<sub>2</sub>-----*cricketodontoides*
- a.<sup>2</sup> Anteroconid on M<sub>1</sub> small, mesolophid on M<sub>2</sub> obsolete or absent.
  - b.<sup>1</sup> Cross lophs normal.

c.<sup>1</sup> Lingual portion of anterior cingulum on M<sub>2</sub> about half as long as labial..... *latidens*

c.<sup>2</sup> Lingual portion of anterior cingulum on M<sub>2</sub> obsolete or absent.

*spokanensis*

b.<sup>2</sup> Cross lophs weak, ectolophid strong..... *exiguus*

*Eumys cricetodontoides*, new species

*Holotype*.—USNM 18748 (fig. 45), right mandible with the incisor and M<sub>1-3</sub>.

*Horizon and locality*.—Middle Oligocene, Orellan; SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 10, T. 10 N., R. 1 W., of the Montana prime meridian, about  $\frac{1}{4}$  mile southeast of Canyon Ferry, Lewis and Clark County, Mont.

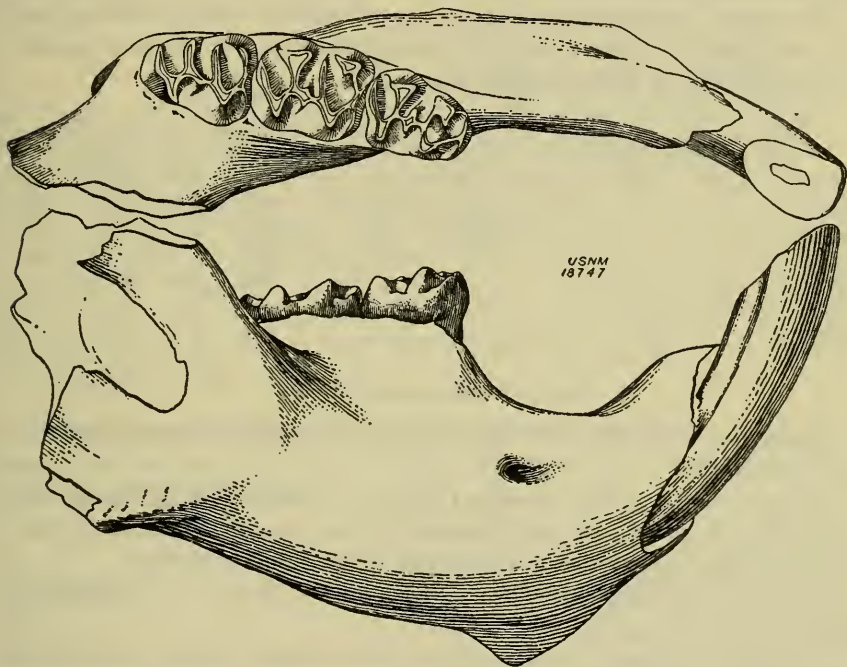


FIGURE 45.—Occlusal and lateral views of the type (USNM 18747) of *Eumys cricetodontoides* new species.  $\times 7$ .

*Referred material*.—USNM 18749–18754, six mandibles from the same locality.

*Description of type*.—M<sub>1</sub> elongate, anteroconid large, nearly as wide as tooth, anterior arm of protoconid united with anteroconid and posterior arm with the metaconid, mesolophid short but distinct, posterior cingulum not united with entoconid; M<sub>2</sub> quadrangular, longer than broad, anterior cingulum extending across anterior border of tooth, lingual and labial portions subequal, posterior arm of protoconid extending nearly to lingual margin of tooth, closely applied but not united with metaconid, mesolophid short but very

distinct, posterior cingulum not uniting with entoconid;  $M_3$  subtriangular in outline, sharply constricted behind protoconid, lingual portion of anterior cingulum short but distinct, posterior arm of protoconid extending to lingual border of tooth and united with metaconid at base, no mesolophid.

*Variation*.—In one specimen the anterior arm of the metaconid is united to the anteroconid while the protoconid is not. In one, both are united to the anteroconid. The mesolophid of  $M_1$  and  $M_2$  is variable in length but is always distinct. In two specimens the posterior arm of the protoconid  $M_2$  and  $M_3$  is shorter than in the type, but the teeth agree in other particulars.

The short mesolophid on  $M_2$  is very suggestive of *Cricetodon*, but the evidence does not warrant referring this material to that genus. Measurements of teeth (in millimeters):

USNM No.	$M_{1-3}$	$M_1$		$M_2$		$M_3$	
		Length	Width	Length	Width	Length	Width
18749.....	8.0	2.7	1.9	2.6	2.2	2.5	2.0
18751.....	8.2	2.9	2.2	2.6	2.4	2.5	2.2
18748 (Type).....	7.8	2.5	1.9	2.8	2.2	2.5	2.1
18753.....	---	2.8	1.8	2.5	2.2	---	2.0
18754.....	7.9	2.8	2.1	2.6	2.2	2.6	2.1
18750.....	7.7	2.6	1.8	2.3	2.0	2.6	2.0
18752.....	---	---	---	2.5	2.1	2.7	2.1

*Eumys latidens*, new species

*Holotype*.—USNM 18772 (fig. 46), right mandible of young individual with  $M_{1-3}$ .

*Horizon and locality*.—Middle Oligocene, Orellan; SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 10, T. 10 N., R. 1 W., of the Montana prime meridian, about  $\frac{1}{4}$  mile southeast of Canyon Ferry, Lewis and Clark County, Mont.

*Referred material*.—USNM 18764–71, 18773–80, 16 mandibles from the same locality.

*Description of type*.— $M_1$  elongate, anteroconid small, protoconid united to anteroconid and metaconid, mesolophid well developed and distinct, posterior cingulum not united with entoconid;  $M_2$  quadrangular, longer than wide, anterior cingulum extending across front of the tooth, lingual portion shorter than the labial, both protoconid and mesoconid united to anterior cingulum, posterior arm of protoconid not united to metaconid and not extending to lingual border of tooth, mesolophid obsolete, posterior cingulum not uniting with entoconid;  $M_3$  sharply constricted behind protoconid, lingual end of anterior cingulum obsolete, posterior arm of protoconid approaches but does not unite with metaconid, no mesolophid.

*Variation*.—The material assigned to this species is extremely variable in many of the dental characters but the designation of

another species does not seem warranted at this time. The anteroconid of  $M_1$  is always small but the anterior cingulum is variable in extent. In one specimen, both the protoconid and metaconid are united to the anteroconid. This variation occurs in all three species but is not consistently associated with other characters. The mesolophid is variable in extent but is always distinct. On  $M_2$  the lingual portion of the anterior cingulum is variable in extent but is always distinct. The posterior arm of the protoconid varies in length but never extends to the inner border of the tooth. The mesolophid is consistently obsolete or absent. On  $M_3$  the lingual portion of the anterior cingulum may extend nearly to the border of

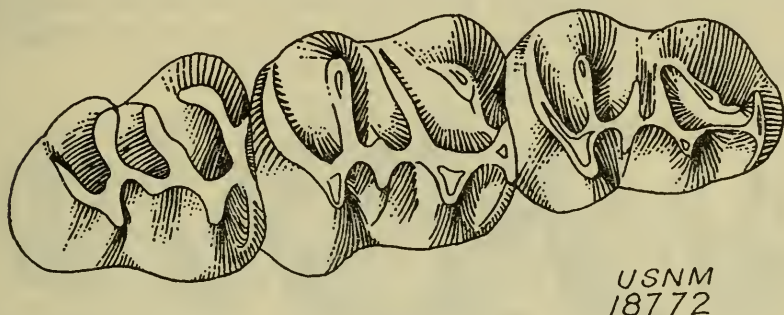


FIGURE 46.—Occlusal view of the type (USNM 18772) of *Eumys latidens*, new species, anterior end to the right.  $\times 7$ .

the tooth or may be nearly obsolete. The posterior arm of the protoconid may or may not unite with the metaconid. Measurements of teeth (in millimeters):

USNM No.	$M_{1-3}$	$M_1$		$M_2$		$M_3$	
		Length	Width	Length	Width	Length	Width
18772 (Type)-----	7. 7	2. 6	1. 9	2. 5	2. 2	2. 3	2. 2
18771-----	8. 0	2. 8	1. 9	2. 4	2. 3	2. 7	2. 2
18768-----	7. 9	2. 6	2. 1	2. 6	2. 4	2. 5	2. 3
18770-----	7. 4	2. 4	1. 9	2. 5	2. 2	2. 3	2. 1
18776-----	7. 6	2. 6	1. 9	2. 4	2. 2	2. 4	2. 1
18769-----	7. 5	2. 7	2. 0	2. 5	2. 2	2. 4	2. 1
18764-----	8. 2	2. 8	2. 1	2. 6	2. 4	2. 7	2. 3
18776-----	7. 5	2. 7	1. 9	2. 4	2. 3	2. 3	2. 1
18779-----	7. 6	2. 5	2. 0	2. 5	2. 3	2. 4	2. 2
18773-----	7. 5	2. 5	1. 9	2. 4	2. 1	2. 4	2. 1
18767-----	8. 1	2. 8	2. 0	2. 6	2. 3	2. 7	2. 0

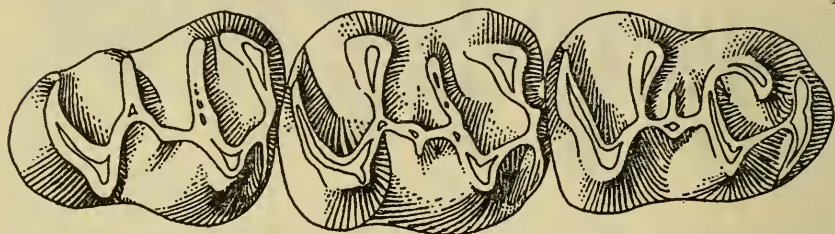
*Eumys spokaneensis*, new species

*Holotype*.—USNM 18833 (fig. 47), right mandible with  $M_{1-3}$ .

*Horizon and locality*.—Middle Oligocene, Orellan; SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 10, T. 10 N., R. 1 W., of the Montana prime meridian, about  $\frac{1}{4}$  mile southeast of Canyon Ferry, Lewis and Clark County, Mont.

*Referred material.*—Eleven mandibles from the same locality and C. M. 9136 from the upper levels of locality No. 24BW18, locally known as the Old Hadcock Ranch.

*Description.*— $M_1$  elongate, anteroconid small, anterior cingulum well developed, anterior arm of protoconid connected to anteroconid and posterior arm to metaconid, mesolophid well developed and extending nearly halfway to inner margin of tooth, inner end of posterior cingulum close to but not united with entoconid;  $M_2$  quadrangular, nearly as broad as long, lingual portion of anterior cingulum obsolete, posterior arm of protoconid closely applied to entoconid and extending nearly to inner margin of tooth, no mesolophid, posterior cingulum as in  $M_1$ ;  $M_3$  subtriangular in outline, sharply constricted posterior to protoconid, anterior cingulum as in  $M_2$ , posterior arm of protoconid united to metaconid at base, no mesolophid or mesoconid.



USNM  
18833

FIGURE 47.—Occlusal view of the type (USNM 18833) of *Eumys spokaneensis*, new species, anterior end to the right.  $\times 7$ .

*Variation.*—This species shows less variation than the other two. The teeth have the appearance of being shorter, for their breadth, and the cusps more crowded, but the measurements do not bear this out. On  $M_2$  and  $M_3$  the posterior arm of the protoconid often becomes united with the metaconid with wear. The lingual portion of the anterior cingulum of  $M_2$  and  $M_3$  is represented by a vertical fold near the midline of the tooth and soon becomes obliterated with wear. Measurements of teeth (in millimeters):

USNM No.	$M_{1-3}$	$M_1$		$M_2$		$M_3$	
		Length	Width	Length	Width	Length	Width
18833 (Type)-----	7.8	2.7	1.9	2.4	2.2	2.5	2.0
18831-----	7.4	2.5	1.8	2.5	2.1	2.3	2.0
18843-----	7.8	<sup>1</sup> 2.6	2.0	2.5	2.2	2.4	2.0
18840-----	7.6	2.6	1.9	2.4	2.1	2.5	2.0
18841-----	8.1	2.9	2.0	2.5	2.3	2.4	2.1
18847-----	7.7	2.7	2.0	2.3	2.2	2.3	2.1
18830-----	7.5	2.6	1.9	2.4	2.2	2.4	2.0
18846-----	7.8	2.6	1.9	2.3	2.2	2.6	2.3
18842-----	8.0	2.7	1.9	2.5	2.2	2.4	2.2
18845-----	7.6	2.7	1.8	2.2	2.0	2.5	2.0

<sup>1</sup> Estimated.

*Eumys cf. exiguus* Wood

USNM 18866 and 18867, 2 mandibular fragments with  $M_{1-3}$ ; USNM 18865, 1 maxillary fragment with  $M_{1-2}$ . All specimens are from locality No. 24LC17.

This material is provisionally referred to this species on the basis of the tooth cusp arrangement. While these specimens are larger than the type, the sample is too small to furnish grounds for separate designation. Measurements of teeth (in millimeters):

USNM No.	$M_{1-3}$	$M_1$		$M_2$		$M_3$	
		Length	Width	Length	Width	Length	Width
18867-----	7. 1	2. 7	1. 6	2. 2	1. 7	2. 3	1. 7
18866-----	6. 4	2. 3	1. 4	2. 1	1. 5	1. 8	1. 5
18865-----	----	2. 7	1. 9	2. 0	1. 6	----	----

## Order LAGOMORPHA

## Family LEPORIDAE

*Paleolagus temnodon* Douglass

USNM 18869, right maxilla with  $P^2-M^3$ ; USNM 18875, right maxilla with  $P^3-M^2$ ; USNM 18876, right maxilla with  $P^2-P^4$ ; USNM 18877, right mandible with  $P_3-M_3$ . Specimens are from locality Nos. 24LC16 and 24BW18.

This material does not permit any additions to Wood's (1940, p. 320) discussion of the species.

*Paleolagus intermedius* Matthew

USNM 18872, left mandible with  $P_3-M_3$ ; USNM 18873, left mandible with  $P_4-M_2$ ; USNM 18874, right maxilla with  $P^3-M^2$ . Specimens are from locality Nos. 24LC15 and 24LC17.

This species appears to be relatively rare in these deposits and the limited material does not permit a satisfactory comparison with the specimens from the plains.

*Paleolagus burkei* Wood

USNM 18879-18894, 4 upper and 12 lower dentitions. All of the specimens are from locality Nos. 24LC15 and 24LC17.

The upper dentitions are slightly larger than the measurements given for the type (Wood, 1940, p. 327), but they agree quite closely in the details of the tooth form and do not agree with *P. haydeni* Leidy. I have not seen any material from the Middle Oligocene of this area referable to the latter species. It is possible that this species could have been restricted to the mountains and *P. haydeni* Leidy restricted to the plains during the Middle Oligocene and that *P. burkei* Wood did not spread to the plains until the Upper Oligocene.

*Megalagus brachyodon* (Matthew)

USNM 18903, right mandible with  $P_4$ - $M_3$ ; USNM 18902, right mandible with  $P_3$ - $M_2$ . Both specimens are from locality No. 24LC16.

This limited material does not permit any additions to Burke's (1936, p. 150) discussion of this species.

*Archaeolagus* sp.

USNM 19096, right maxillary fragment with  $P^4$ - $M^2$ , from locality No. 24LC18.

This specimen is so incomplete that the generic reference is only provisional. The teeth are greatly flattened, the transverse diameter is twice the anteroposterior. The hypostria is deep, extending nearly to the middle of the tooth, a little closer to the posterior edge than the anterior, and extending to the base of the tooth. Groove on the lateral surface of the tooth shallow and broad. No crescentic valley (this may be a state of wear). No enamel on the lateral surface of the tooth. Cement present only in the hypostria (this may be an accident of preservation). The teeth appear to be rootless.

## Order CARNIVORA

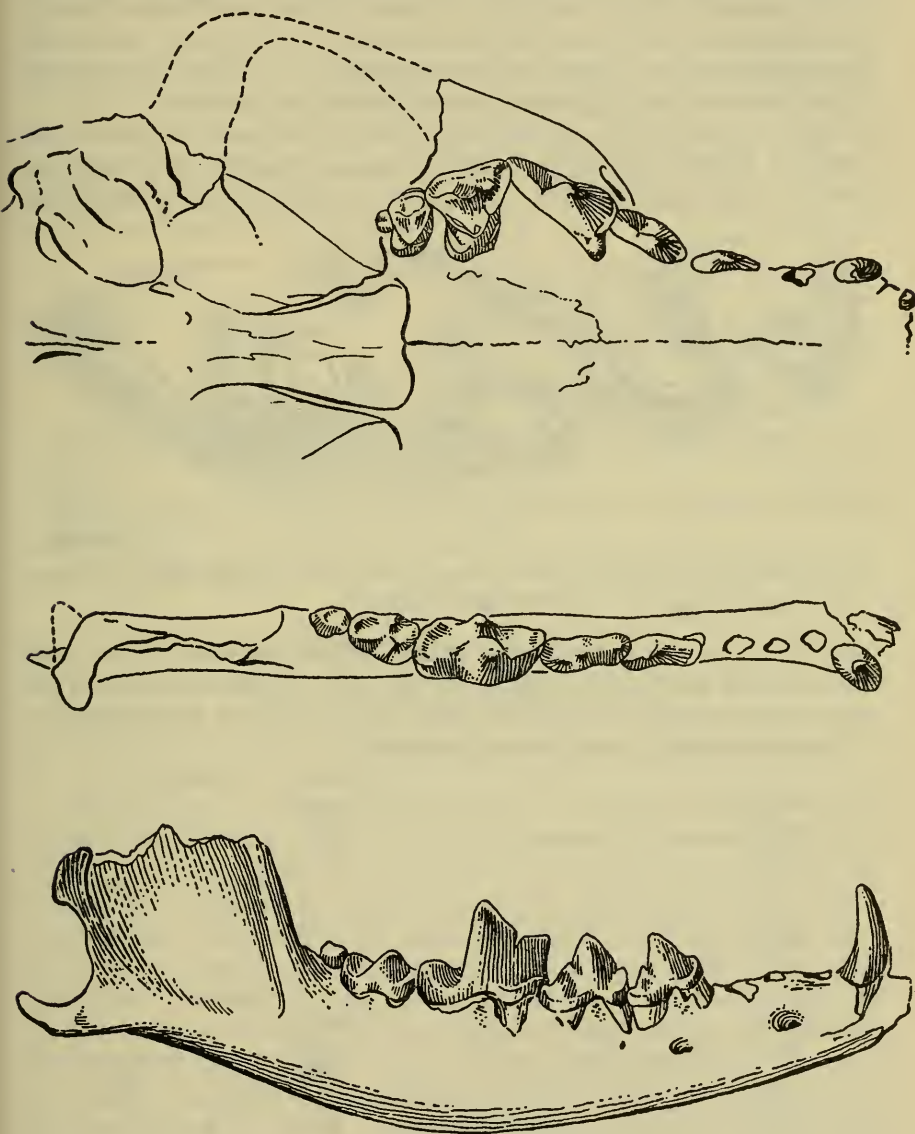
## Family CANIDAE

*Hesperocyon paterculus* (Matthew)

USNM 18911, skull and jaws (fig. 48) with the greater portion of the skeleton; USNM 18897, right mandibular fragment with  $M_{1-3}$ ; USNM 18896, left mandibular fragment with  $M_1$  & 2; USNM 18895, left mandibular fragment with  $P_2$  & 3,  $M_{1-3}$ . Specimens are from locality Nos. 24LC16 and 24BW18.

*Description*.—Dental formula:  $I_3^3$ ,  $C_1^1$ ,  $P_4^4$ ,  $M_3^3$ . Upper dentition:  $P^1$  single rooted and closer to C than to  $P^2$ ;  $P^2$  with anterior cingulum, incipient posterior cusp and minute cusp on heel;  $P^3$  with well developed anterior cingulum, posterior cusp and a cusp on heel;  $P^4$  with incipient anterior cusp;  $M^1$  without incipient metaconule, paracone higher than metacone, protocone well developed, protoconule small but distinct, hypocone well developed, anterior cingulum terminates at base of protocone;  $M^2$  similar to  $M^1$  but smaller;  $M^3$  minute and probably of no systematic significance. Lower dentition:  $P_1$  & 2 missing,  $P_1$  single rooted and closer to C than to  $P_2$ ;  $P_3$  & 4 differ only in size, each with well-developed anterior basal and posterior cusp, heel well developed and with a small cusp;  $M_1$  with well-developed hypoconid and incipient entoconid;  $M_2$  with protoconid and metaconid subequal and elevated above the paraconid, hypoconid well developed, entoconid incipient;  $M_3$  small, protoconid and metaconid subequal.

*Discussion.*—The general form of the skull of this species does not appear to be noticeably different from the other small dogs of the Oligocene of the plains, nor is it possible to detect differences in the skeletal material. The characters of the teeth of these specimens

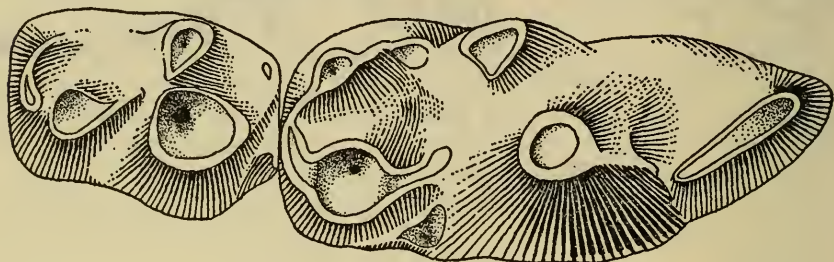


USNM  
18911

FIGURE 48.—Upper and lower dentition of *Hesperocyon paterculus* Matthew (USNM 18911).  $\times 1$ .

appear to be quite constant and agree very well with the material from Pipestone Springs in the U. S. National Museum. The variety of tooth-cusp arrangement and height of crown exhibited by the small carnivores of the Middle Oligocene which have been referred to *H. gregarius* (Cope), both in the literature and in collections, make any attempt at comparison with that species entirely futile. However, these specimens are easily distinguished from the single specimen of *Hesperocyon* from the Lower Brule equivalent of this area.

The specimens of small carnivores of the Oligocene of the plains which I have examined in several museums convince me that the species represented by this tooth-cusp arrangement had a very close



USNM  
18898

FIGURE 49.—Occlusal view of the first and second lower molars (USNM 18898) of *Hesperocyon gregarius* (Cope) showing dental caries.  $\times 4$ .

relative (if not the same species) in the Middle Oligocene. But until the material has been carefully studied and the indeterminate types have been relegated to *nomena nuda* we are helpless taxonomically.

Measurements of teeth (in millimeters):

	Length	Width	
P <sup>1</sup> -M <sup>3</sup> -----	33.0		
P <sup>1</sup> -4-----	24.5		
M <sup>1</sup> -3-----	16.0		
		Anterior	Posterior
M <sup>1</sup> -----	6.5	7.5	7.0
M <sup>2</sup> -----	3.5	5.0	4.5
M <sup>3</sup> -----	1.0	1.25	-----
		Trigonid	Heel
P <sub>1</sub> -M <sub>3</sub> -----	34.0	-----	-----
P <sub>1</sub> -4-----	20.0	-----	-----
M <sub>1</sub> -----	9.0	4.0	3.5
M <sub>2</sub> -----	5.0	3.5	3.0
M <sub>3</sub> -----	2.0	2.0	-----

*Hesperocyon gregarius* (Cope)

USNM 18898 (fig. 49), right mandibular fragment with M<sub>1-2</sub>, from locality No. 24LC15.

The specimen referred to this species differs from the preceding one in that on M<sub>1</sub> the entoconid is well developed and about half the size

of the hypoconid. A metaconulid and a protoconulid are present as in *Nothocyon* and *Tomarctos*. There is a small but distinct entoconid on  $M_2$ .

An unusual feature of this specimen is that both teeth show evidence of dental caries. On  $M_1$  there is a major lesion on the hypoconid (fig. 49) with a minor lesion on the entoconid, protoconid, metaconid and metaconulid. On  $M_2$  there is a major lesion on the protoconid with a minor lesion on the metaconid and hypoconid. Among the recent carnivores the only evidence of dental caries I have seen was in the teeth of the grizzly bears (*Ursus horribilis* Ord) in the Museum of Comparative Zoology and in the U. S. National Museum. Measurements of teeth (in millimeters):

	Length	Width	
		Trigonid	Heel
$M_1$ -----	11. 0	5. 0	4. 0
$M_2$ -----	5. 0	4. 0	3. 5

*Nothocyon cf. geismarianus* (Cope)

USNM 19097, right mandible with  $P_2$ – $M_2$ , from locality No. 24LC19.

This specimen is slightly smaller than the one described by Cope (1884, p. 920) but agrees in other details.

## Family URSIDAE

### Subfamily AMPHICYNODONTINAE

*Daphoenocyon cf. dodgei* (Scott)

USNM 19094, left mandibular fragment (fig. 50) with  $dP_{3-4}$  and  $M_{1-2}$ , from locality No. 24LC16.

This specimen is badly fractured but it is possible to make out the essential details of the teeth. The deciduous teeth are more caninlike in the cusp arrangement than are the permanent teeth, but are low crowned. In  $dP_3$  the anterior and posterior cusps are well developed, the posterior accessory cusp present and distinct, heel broad with pronounced internal and external cinguli. In  $dP_4$  the trigonid does not differ from that of the permanent tooth except in size, hypoconid and entoconid subequal with entoconid slightly larger, a distinct hypoconulid slightly smaller than the hypoconid present. The permanent teeth, being in an unworn condition, exhibit features on the heels of  $M_1$  and  $M_2$  which appear to be common to many members of this subfamily, namely, in the breaking up of the principal conids into smaller cusps. In this specimen, while the conids on the heel of  $M_1$  are quite distinct, the hypoconid has two apices and the entoconid has three. The heel of  $M_2$  is a further exaggeration of this phenome-

non. The hypoconid and entoconid are represented by two ridges which are beset with small tubercles and meet posteriorly.

Hough (1948, p. 594), noting the striking difference between the type of this species and the other species of *Daphoenus*, proposed a new genus, *Daphoenocyon*, to receive it. At the same time she erected a new family, the Daphoenidae, to receive a number of North American genera which had been included in the Caninae but which, quite obviously, had little in common with the true dogs. On the other hand, there are three groups, the Amphicyonodontinae, the Amphicyoninae, and the Simocyoninae—all of holarctic distribution from the Lower Oligocene to the Pleistocene and well established in the literature—into one of which any member of the new family could be fitted without changing the definition of the group. Also, to include the Simocyoninae, as represented by *Protamnocyon*, in the same family with the other two subfamilies is an unnatural and nongenetic grouping.

Since the characters of the auditory region (Hough, 1948, p. 577) and the post cranial skeleton, insofar as it is known, of the Amphicyonodontinae and the Amphicyoninae are closer to the bears than the true dogs, it is my opinion, in view of the evolutionary fate of the former, that these two groups should be placed in the Ursidae rather than being placed in a separate family or included in the Canidae. That the early members of these two subfamilies should possess a generalized canoid dentition is to be expected if they are to be included in that superfamily, but it is a fallacy to use the superfamily characters of the teeth to determine the family and subfamily affinities when these determinations contradict the affinities shown by the fundamental structure of the limbs and basicranium.

A comparison of the figures of *D. dodgei* (Scott) and *Parictis dakotensis* Clark (Scott and Jepsen, 1936, pl. 12, fig. 3; pl. 14, fig. 1) shows that these two genera are indeed closely related and belong to the same subfamily. This relationship was confirmed by the comparison of a series of jaws in the Carnegie Museum from Pipestone Springs which are referable to these two genera. In fact, except for very minor details, the only difference between the two is size. In both forms the teeth are low crowned, rather broad, and distinctly less bladelike than in the more typical canids. Although, in the material available, size is the only character which distinguishes the two genera, it is probable that when the material is better known valid distinctions will be found.

Although specimens of this subfamily of carnivores seem to be relatively rare in North America, I suspect that the scarcity is more apparent than real and that quite a number have been referred to either *Hesperocyon* or *Daphoenus* in the collections of our various

museums. I have prepared table 1 (below), partly from the literature and partly from my knowledge of the collections in a few museums, to show the distribution of this group in North America. An examination of this table shows that the smaller form, *Parictis*, persisted from the Lower Oligocene into the Lower Miocene, while *Daphoenocyon* continued only into the Middle Oligocene (Hough, 1948, p. 595) and we have no record of it after that. In the Lower Miocene two new forms appeared, *Pachycynodon* and the form from Florida which I described as *Parictis bathygenus* White (1947, p. 500). Even though the available data are limited, they appear to substantiate the opinion (Simpson, 1947, p. 630) that this group is Eurasian in origin and immigrated to North America. Also it appears that there

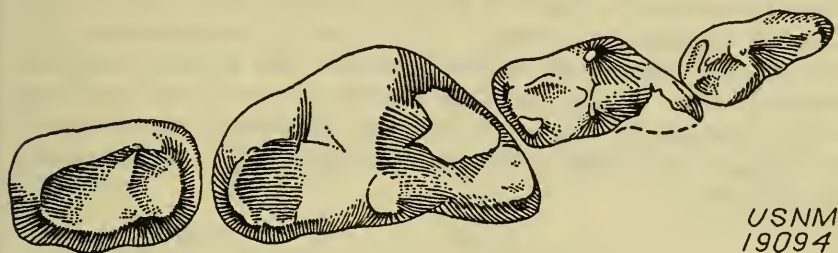


FIGURE 50.—Occlusal view of  $dP_{2-4}$  and  $M_{1-2}$  (USNM 19094) of *Daphoenocyon dodgei* (Scott).  $\times 1\frac{1}{2}$ .

was a migration in the Lower Oligocene and another in the Lower Miocene, since neither *Pachycynodon* nor *Parictis bathygenus* are at all closely related to the American Oligocene forms.

TABLE 1.—Distribution of the Amphicynodontinae in the Early Tertiary of North America

Locality	Chadronian	Orellan	Whitneyan	Arikareean
Pipestone Springs	<i>Parictis</i> <i>Daphoenocyon</i> <i>Daphoenocyon</i>			
Canyon Ferry				<i>Parictis</i>
John Day				<i>Pachycynodon</i>
Wyoming, Nebraska, and South Dakota	<i>Parictis</i> <i>Daphoenocyon</i>	<i>Parictis</i> <i>Daphoenocyon</i> (Hough, 1948)	<i>Parictis</i>	
Florida				<i>Parictis bathygenus</i>

## Order PERISSODACTYLA

### Family EQUIDAE

#### *Mesohippus hypostylus* Osborn

CM 9184, left maxilla with  $M^{1-2}$ ; CM 8998, palate with right and left  $P^2-M^2$ ; unnumbered, right maxilla with  $M^{1-2}$ ; USNM 18946, skull

with teeth badly worn; USNM 18949, right mandible with  $P_2$ - $M_3$ ; CM 9171, right mandible with  $P_3$ - $M_2$ ; CM 9365, right mandible with  $P_2$ - $M_2$ ; CM 9363, right mandible with  $dP_{2-4}$ ; CM 9364, right mandible with  $dP_{2-4}$ . Specimens are from locality Nos. 24LC16 and 24BW18.

*Discussion.*—In size and tooth characters the material agrees better with this species than any of the many which have been described from the Lower Oligocene. Also, the small crochet, which characterizes *M. portentus* Douglass, is lacking.

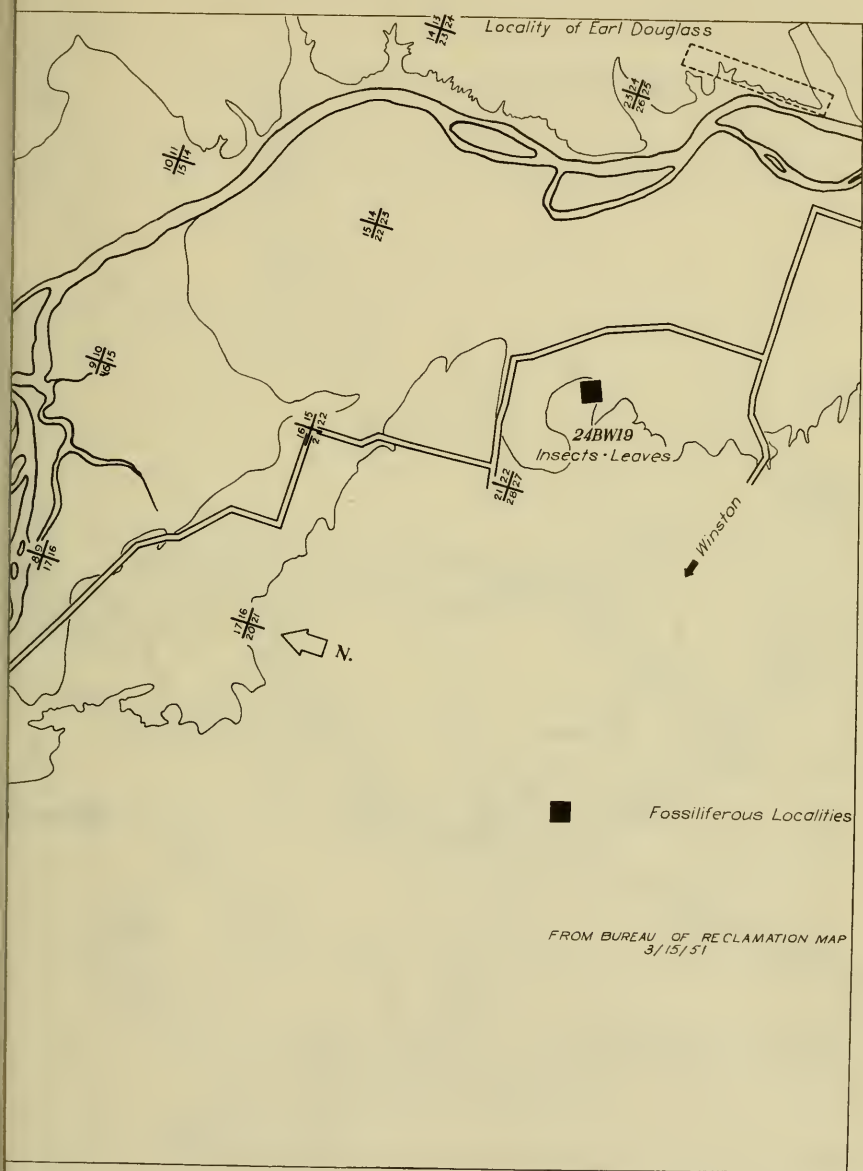
Since this material is more complete than any previously recorded from this area, it will be described briefly.

*Description.*—Upper dentition:  $P^2$  with protocone well developed, protoloph weak, protoconule indistinct, metaloph well developed with distinct metaconule, hypostyle distinct, mesostyle weak but distinct, parastyle distinct, no metastyle;  $P^3$ ,  $P^4$ , and  $M^1$  quadrangular, protoconule and metaconule distinct, parastyle and hypostyle distinct, metastyle weak, internal cingulum between protocone and hypocone, mesostyle strong;  $M^2$  similar to  $M^1$  except metaconule very indistinct;  $M^3$  similar to  $M^2$  except much narrower posteriorly. Measurements (in millimeters):

	CM 8993			CM 9184		
$P^2$ - $M^2$ -----	60.0			-----		
$P^2$ -4-----	35.0			-----		
$M^{1-3}$ -----	-----			40.2		
	Length	Width	Height at metacone	Length	Width	Height at metacone
$P^2$ -----	11.8	12.3	-----	-----	-----	-----
$P^3$ -----	12.0	14.0	-----	-----	-----	-----
$P^4$ -----	12.0	15.0	-----	-----	-----	-----
$M^1$ -----	13.5	15.0	(worn) 8.0	13.7	15.8	10.0
$M^2$ -----	12.8	16.0	8.5	14.4	16.2	8.6
$M^3$ -----	-----	-----	-----	13.0	15.5	-----

Lower dentition:  $P_2$  subtriangular in outline, protoconid reduced, metaconid not twinned, entostylid small but distinct, strong external cingulum;  $P_3$ ,  $P_4$ ,  $M_1$ , and  $M_2$  essentially similar, strong external, anterior, and posterior cinguli, small median external cusp, metaconid and entoconid distinctly twinned, parastylid indistinct;  $M_3$  with metaconid indistinctly twinned and entoconid not twinned. Measurements (in millimeters):

	CM 9171		CM 9365	
$P_2$ - $M_2$ -----	-----		64	
$P_3$ - $M_2$ -----	52		52	
	Length	Width	Length	Width
$P_2$ -----	-----	-----	12.4	8.6
$P_3$ -----	13.0	10.0	-----	-----
$P_4$ -----	13.0	10.6	13.0	11.2
$M_1$ -----	12.6	9.0	12.4	10.0
$M_2$ -----	12.7	8.3	12.6	10.3



localities.



Lower Oligocene Localities  
24LC16  
24BW18

Middle Oligocene Localities  
24LC15  
24LC17

Lower Miocene Localities  
24LC18  
24LC19  
24LC20

Middle Miocene Localities  
24LC21  
Loc of Earl Douglass

# NORTHERN PORTION OF THE CANYON FERRY RESERVOIR AREA

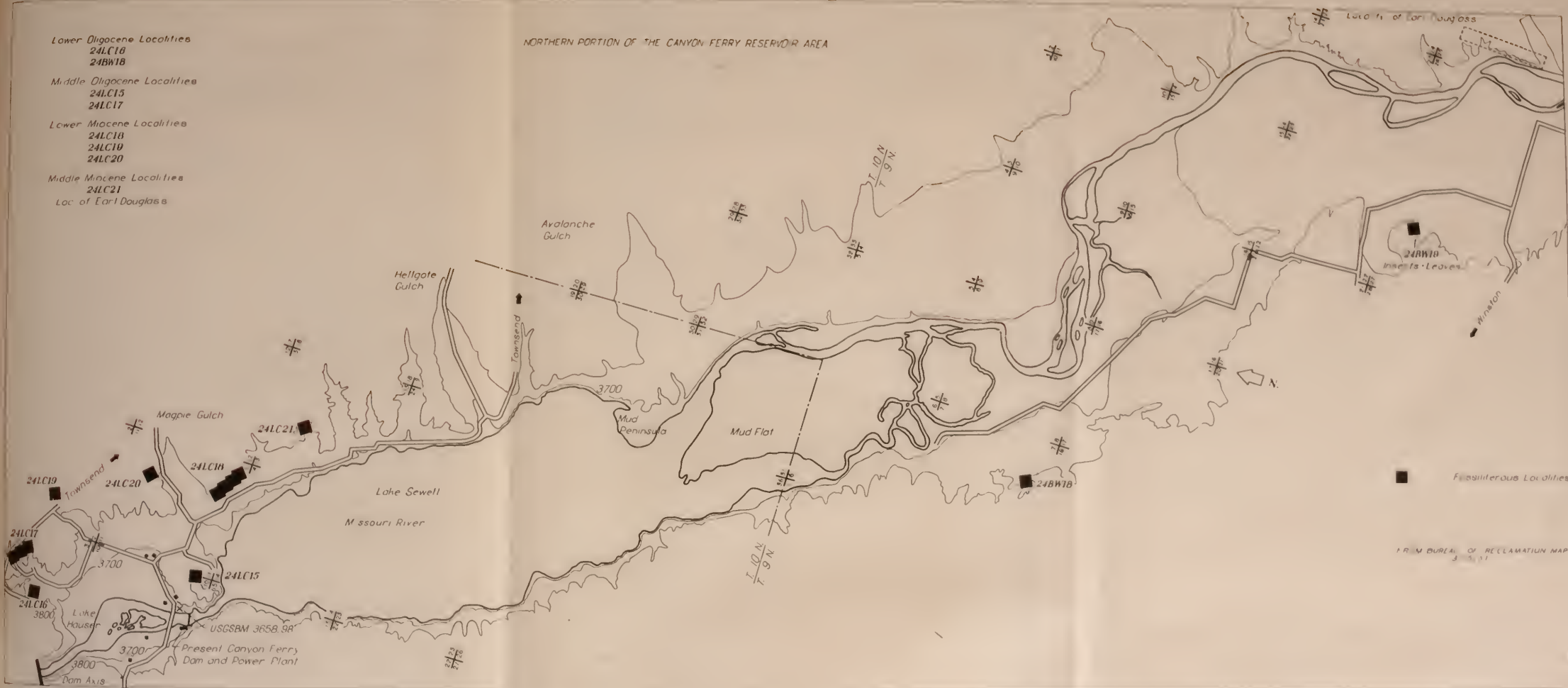


FIGURE 51.—Northern portion of Canyon Ferry Reservoir area showing location of the fossiliferous localities.



*Merychippus* sp.

USNM 19095, two fragmentary lower molars, from locality No. 24LC21. These teeth are too imperfect for specific identification but are sufficient to establish the presence of Middle Miocene deposits in this area.

## Superfamily BRONTOTHERIOIDEA

At locality No. 24LC16 a few fragments of teeth referable to the large members of this group have been found but they are inadequate for even generic reference.

## Family HYRACODONTIDAE

USNM 19025, right mandibular fragment with  $dP_3-M_1$ , from locality No. 24BW18.

*Discussion.*—This material is too fragmentary to permit allocation to any of the species described from the White River deposits. Sinclair (1922, pp. 65–79) recognized four species on the characters of the upper premolars and stated (p. 67) that no intermediate stages were recognized. Scott (1941, p. 841) expressed the opinion that there was only one valid species of this genus in the White River deposits on the grounds that four species of a single genus of large mammals could not occupy the same territory equivalent in size to that embraced by the White River deposits. On a previous page (p. 786) Scott quotes Matthew's (1930, pp. 271–272) views in connection with the species of *Trigonias*. In his introduction Matthew states that: "We do not, in fact, find two or more distinct species or subspecies of a genus occupying the same area and habitat at the same time." This statement appears to have been accepted by some workers as an axiom but, instead of inspiring caution and the use of recent faunas in interpreting fossil faunas, it has been used as a legitimate excuse for multiplying the number of genera. With the aid of Dr. Henry Setzer of the Division of Mammals, U. S. National Museum, I have prepared a short list of instances where two or more distinct species of the larger mammals occur in the same area and habitat:

CERVIDAE.—Within historic times the ranges of the Virginia deer (*Odocoileus virginianus*) and the mule deer (*O. hemionus*) overlapped by nearly a million square miles and they occupied the same habitat over the area. No natural crosses are known. These forms are morphologically distinct and the skulls and horns would be recognizable as fossils.

CANIDAE.—The above paragraph is true of the wolf (*Canis nubilus*) and the coyote (*C. latrans*).

EQUIDAE.—The horse (*Equus caballus*) and the ass (*E. asinus*) ran wild in western North America for about 300 years after escaping from the Spaniards

and no natural crosses are known. Also *E. prezevalskii* and *E. onager* occur together in Central Asia in the wild state and no undisputed cases of crossing are known.

BOVIDAE.—In the Malay region Lydekker (1898) records four species of *Bos* (*gaurus*, *indicus*, *depressicornis*, and *frontalis*) occurring in the same area.

ANTILOPIDAE.—Allen (1939) reports five species of *Gazella* (*dorcas*, *leptoceros*, *thomsonii*, *granti*, and *soemmerringii*) occurring together in the Anglo-Egyptian Sudan.

Even with this short list it is obvious that two or more species of a single genus of the larger mammals do occur together over large areas and in essentially the same habitat, and by analogy it is entirely possible that more than one species of a genus could be found in a "quarry fauna."

In his treatment of the fauna of a formation, Matthew (1930, p. 272) points out that there is a time factor involved and that shifts in ranges (possibly due to minor climatic fluctuations or seasonal movements of the herds) would make it possible for species with adjacent ranges to be found as fossils in a single time unit of a formation. This is illustrated by the ranges of the barren-ground caribou (*Rangifer arcticus*) and the woodland caribou (*R. caribou*), both of which range across Canada from east to west with a very narrow overlap in range. Even though the amount of overlap did not change, a minor climatic change would permit one to occupy a greater amount of the former territory of the other and the two might be found together as fossils, dependent, of course, on the accidents of preservation.

Another method by which species of adjacent areas may be introduced into an area of deposition is by floods. I think anyone who has ever seen the bloated carcasses of cattle floating in the streams of the west during a summer flood will admit that such a possibility cannot be overlooked in regard to the fluvial deposits of the plains. Even if this happened only once in each climatic microcycle (11 years) it would be sufficient to establish a species in a single time unit of a formation. It is obvious, of course, that the "visiting" species must have its range upstream from the area of deposition. A shift in the range of extraterritorial forms might be the explanation of the presence of *Caenopus* in only the Chadron and Upper Brule and its absence in the Lower Brule.

Another item which must be kept in mind in the consideration of fossil faunas is the territorial range of the individual. Some of the large predators, such as the mountain lion (*Felis concolor*) and the grizzly bear (*Ursus horribilis*), have a territorial range with a 200-mile radius, while with the large herbivores it seldom exceeds 50 or 60 miles. In the case of small mammals, such as *Microtus*, the radius of its territorial range seldom exceeds 20 or 25 feet. Even with this limited number of examples it is clear that with the same food habits

(carnivore or herbivore) the probability of dealing with a purely local fauna is in inverse ratio to the size.

This is not an attempt to justify the multitudinous species of *Mesohippus* or the subspecies of *Trionias osborni* but to point out, as did Matthew, that we must utilize the principles of distribution and ecology, which have been worked out by the neozoologists, in interpreting the fossil faunas.

### Family RHINOCERATIDAE

#### *Caenopus cf. mitis* (Cope)

USNM 19026, right mandibular fragment with  $P_4$ - $M_3$ , from locality No. 24BW18.

This specimen is referred to this genus and species on the measurements of the teeth which agree with those of the type. The teeth of this specimen are well worn and it may not be identifiable.

### Order ARTIODACTYLA

#### Family LEPTOCHOERIDAE

##### *Leptochoerus* sp.

USNM 18919, right mandibular fragment with  $P_4$ - $M_3$ , from Lower Oligocene of locality No. 24LC16.

The teeth on this specimen are so badly worn that only provisional reference is possible. However, it is sufficient to record the presence of this group in these deposits.

### Family MERYCIODODONTIDAE

#### *Meryciododon?* sp.

Only maxillary and mandibular fragments were obtained from the Oligocene deposits and these are inadequate for certain generic reference. The size of these specimens indicate an animal of about the size of *Meryciododon culbertsoni* (Leidy). Nothing in the size range of the small and poorly known genera has yet been found.

#### *Mesoreodon chelonys* Scott

USNM 19091, skull, jaws and greater part of the skeleton; USNM 19092, skull and jaws; both from the Lower Miocene of locality No. 24LC18.

These specimens are slightly larger than those recorded by Schultz and Falkenbach (1949, p. 154) from the same locality, but are still within the limits of individual variation.

*Promerycochoerus montanus* (Cope)

USNM 19089, skull and jaws with rostrum missing, from Lower Miocene of locality No. 24LC18.

This specimen is that of an old individual with the teeth well worn. However, the specimen is only slightly crushed and the size and configuration can be determined with reasonable certainty.

*Cyclopidius simus* Cope

USNM 19086, skull and jaws, from the Lower Miocene of locality No. 24LC18; USNM 19088, skull and jaws, from same locality; USNM 19087, right mandible with  $dP_3-M_2$ .

*Discussion.*—Thorpe (1937, p. 242) lists six species of *Cyclopidius* from the Miocene deposits of the Smith River area and concludes that only one species (*C. simus* Cope) is valid. Koerner (1940, pp. 856–858) describes two new species from this area, but he does not use the same set of characters to distinguish the two species from each other or from *C. simus*. Nor does he present a standard set of measurements for the three species. Consequently it is impossible to appraise the validity of his species from his treatise.

The best preserved specimen is somewhat larger than the measurements which Thorpe (1937, p. 291) gives for *C. simus* or its synonyms. It is nearly as large as *C. bullianus* Thorpe, but the details of the facial vacuities are very different from that species and agree with *C. simus*.

## Family CAMELIDAE

*Poebrotherium* cf. *eximium* Hay

USNM 18944, right mandibular fragment with  $P_3-M_1$ ; USNM 18945, left mandibular fragment with  $dP_{2-4}$ ; CM 9301, right mandibular fragment with  $P_4-M_1$ . All specimens are from locality No. 24BW18.

This material is too fragmentary for accurate specific determination but is adequate to establish the presence of this genus in these deposits.

## Family HYPERTRAGULIDAE

*Leptomeryx transmontanus* Douglass

*Leptomeryx?* *esulcatus* Matthew, 1903. Bull. Amer. Mus. Nat. Hist., vol. 19, p. 222, fig. 15.

USNM 18931, 18932, 18934–18939, eight mandibular fragments, and USNM 18933, one maxillary fragment, all from locality No. 24LC16; USNM 18940–18943 and CM 9293, five mandibular fragments, and CM 9291, 9304, two maxillary fragments, all from locality No. 24BW18.

Frick (1937, p. 625) synonymized *L.?* *esulcatus* Matthew (1903, p. 222, fig. 15) with *L. transmontanus* Douglass. On the following page he indicates that the specimens referred by Matthew (1903, p. 224) to *L. mammifer* Cope should be considered a large variant of this species, and on page 629 he refers the specimens figured by Matthew as *L.?* *esulcatus* Cope to *L. evansi* Leidy. The upper dentitions of *Leptomeryx* in the U. S. National Museum and in the Carnegie Museum from Pipestone Springs and Lower Oligocene of Canyon Ferry agree with the figure and published measurements given by Douglass (1903, p. 167, fig. 11) for the type of *L. transmontanus*. Also, a comparison of this material with the type (USNM 157) and referred material of *L. evansi* Leidy from the Middle Oligocene reveal a number of differences which are fairly constant and are presented in table 2. As far as it was possible to do so the characters of *L. evansi* were taken from the type.

TABLE 2.—*Contrasting characters of Leptomeryx evansi Leidy and L. transmontanus Douglass.*

Character	<i>L. transmontanus</i>	<i>L. evansi</i>
Median internal cusp on M <sub>1</sub>	weak or absent	strong
Median internal cusp on M <sub>2</sub>	weak or absent	strong
Median internal cusp on M <sub>3</sub>	small	strong
Postero-internal cingulum on P <sub>1</sub>	strong	weak
Posterior ridges on P <sub>3</sub>	inner always connects with heel, outer rarely	outer connects with heel
"Paleomeryx fold" on lower molars	absent	present and uniting with posterior crescent with wear
Mesostyle on M <sub>1</sub>	strong	absent
Mesostyle on M <sub>2</sub>	weak	absent
Mesostyle on M <sub>3</sub>	weak	absent
Anterior cingulum on lower molars	weak or absent	strong but soon obliterated by wear

Matthew (1903, p. 223) stressed the differences in the length of the posterior ridges on the protoconid of the third lower premolar as the distinguishing characteristic of this species and it is valid for the majority of the specimens I have examined. Normally, there are an inner and an outer cusp on the heel of P<sub>3</sub>, each with a short ridge extending antero-medially (axis of the tooth). These ridges usually meet and fuse near the middle of the heel. Normally, the inner ridge from the protoconid is united with this common meeting point. In the material at my disposal the outer ridge from the protoconid is variable in length, is usually bifid, and in one specimen it joins the heel at the common meeting point mentioned above. Occasionally the ridge from one of the cusps on the heel does not develop, or the ridge may extend directly anteriorly. In two specimens the ridges of both heel cusps have grown anteriorly and met the posterior ridges from the protoconid, giving P<sub>3</sub> the appearance of P<sub>4</sub>.

*Leptomeryx evansi* Leidy

USNM 18924-18926, three maxillary fragments; USNM 18923, 18927-18930, five mandibular fragments; and seven unnumbered

mandibular fragments in Carnegie Museum; all from locality No. 24LC15; and CM 8995, two mandibular fragments, from the upper levels of locality No. 24BW18.

A comparison of this material with the type of *L. evansi* Leidy (USNM 157) and the abundant material from the Middle Oligocene of Wyoming fails to reveal any constant differences in the details of the upper and lower cheek teeth. This material averages about 3 percent smaller than the type, but the sample is too limited for this to be of any significance.

### Climatic zoning of Lower Oligocene faunas

The possibility of climatic zoning of fossil faunas has received very little consideration in the literature. This is partially due to the lack of data (widely separated fossiliferous deposits of equivalent ages have become known only recently) and partially to the rather general belief that the Early Tertiary climates were uniformly mild. In regard to the latter, Berry (1922) pointed out that while the over-all climate of the Eocene may have been much milder than today the "arctic flora" of that time was not only distinct from that of temperate latitudes but was of circumpolar distribution. He also points out (1922, p. 13) that the southern limit of the Eocene "arctic flora" is about 15° north of the southern limit of the existing species of the same genera and that the present isotherm (p. 9) would have to swing 15° to 20° northward to permit the present existence of the same floras in the same areas from which we know the Eocene floras. Such a change would only eliminate the Arctic Zone of C. Hart Merriam as it is defined today and would by no means be sufficient change to produce a uniformly mild warm-temperate to subtropical climate. Simpson (1947, pp. 645-654) briefly cites evidence for climatic zoning in the Miocene in Asia and considers that climate was probably a relatively important selective factor in intercontinental migration. He also points out (p. 652) that while the evidence for climatic zoning is meager there is none against it.

The possibility of climatic zoning in the Tertiary was first brought to my attention by the relative abundance of the protoceratids in the Miocene of Texas and their extreme scarcity in equivalent deposits of Nebraska and Wyoming. These animals are large enough that they would not be easily overlooked. There are few areas in North America which have remained as consistently productive over a period of years as has the Miocene of Nebraska and Wyoming. Yet, from this area, *Syndyoceros* is known from only two specimens and *Prosynthetoceros* is entirely unknown. Even on such meager evidence it seemed highly probable that the factors which controlled the

present distribution of mammals in North America had been in operation throughout the Tertiary. The climatic zoning of mammalian distribution in North America by C. Hart Merriam (1892) is probably familiar to nearly everyone and will not be further discussed here. Many workers have greatly elaborated and refined the original statement (with some adverse criticism), but the basic concept is still valid.

It is the purpose of the present study to compare the Lower Oligocene faunas of the plains and the intermountain basins of Montana in the light of possible climatic zoning.

The statement often has been made that the nondiscovery of a particular form in a given deposit is not proof that the form did not live in that area while the sediments in question were being deposited. In general this is true, but to accept it as an axiom is to exclude from consideration all problems of distribution and intercontinental migration (see Simpson, 1947, p. 652). Probably the greatest value of the statement is that it is a very effective intellectual counterbalance against overenthusiastic speculation. For application to a specific problem it must be weighted against the answers to a number of questions:

1. Was the area accessible to the animal in question?
2. Is it known from older or younger deposits from this or closely adjacent areas?
3. Is it known from deposits of equivalent age from adjacent areas? Or, more remote areas?
4. If so, how frequently is it encountered?
5. Is it associated with other genera belonging to the same family?
6. How frequently are the related genera encountered?
7. Are the related genera found in the deposit in question?
8. Are the probable habits of the animal in question such that its remains would have a good chance of being buried and preserved?
9. How extensively and thoroughly have the deposits in question been explored?
10. Was the climate and environment of the area in question essentially the same as that of the adjacent area? Of the more remote area?
11. What was the size of the animal?
12. What was the probable territorial range of the individual estimated from the size and inferred habits?

If the faunas of Pipestone Springs and Canyon Ferry (see table 3) are compared in the light of these questions it will be seen that, since the two areas are so close both geographically and ecologically, any faunal differences must be attributed to the accidents of preservation and discovery.

On the other hand, Pipestone Springs and the Badlands of South Dakota are separated by a distance of 600 miles (air line), 3° of latitude, and 3,000 feet of altitude, and both have been collected extensively. Although the climate of Lower Oligocene times may have

been warmer as a whole, the environmental contrasts between the two areas must have been as great then as they are now, and it is permissible to expect these contrasts to find as much expression in faunal differences, particularly among the small, nonvolant mammals, as they do today. A comparison of the Lower Oligocene faunas of the two areas (table 3) shows that faunal differences did exist. By analogy with Recent faunas the differences appear to be correlated with environmental differences. It is expected that further explorations will modify the faunal differences somewhat; but, in view of the extensive explorations in both areas, radical changes are not anticipated.

TABLE 3.—*Distribution of Lower Oligocene fauna*

<i>Species</i>	<i>Plains</i>	<i>Pipe- stone Springs</i>	<i>Can- yon Ferry</i>	<i>Species</i>	<i>Plains</i>	<i>Pipe- stone Springs</i>	<i>Can- yon Ferry</i>
<i>Peratherium titanelix</i>	sp.	x	sp.	<i>Hoplophoneus robustus</i>	x		
<i>Apternodus midiaevus</i>		x	x	<i>Meshippus celer</i>	x		
<i>Apternodus altitalonidus</i>	x			<i>Meshippus portentus</i>	x	x	
<i>Micropternodus borealis</i>		x	sp.	<i>Meshippus latidens</i>	x		
<i>Talpa?</i> sp.		x	x	<i>Meshippus montanus</i>		x	
<i>Clinopternodus gracilis</i>	x			<i>Meshippus hypostylus</i>	x		x
<i>Metacodon magnus</i>	x			<i>Hyracodon cf. acridens</i>	x		sp.
<i>Kentrogomphios trophensis</i>			x	<i>Trigonias osborni</i>	x		
<i>Domnina thompsoni</i>		x		<i>Caenopus mitis</i>	x		sp.
<i>Ictops dakotensis</i>	x			<i>Colodon occidentalis</i>	x		
<i>Ictops acutidens</i>		x		<i>Colodon cingulatus</i>			x
<i>Ictops thompsoni, etc.</i>		x	x	<i>Titanotheres</i>	many spp.	sp.	sp.
<i>Prosciurus vetustus</i>	x	x		<i>Aepinacodon americanus</i>	x		
<i>Prosciurus jeffersoni</i>		x		<i>Archaeotherium cf. crassum</i>	x		
<i>Ischyromys pliacus</i>		x	x	<i>Archaeotherium marshi</i>	x		
<i>Titanotheriomys veterior</i>	x	x	x	<i>Archaeotherium seotti</i>	x		
<i>Cylindrodon fontis</i>	x	x		<i>Archaeotherium mortoni</i>	x		
<i>Pseudocylindrodon neglectus</i>		x		<i>Perchoerus cf. nanus</i>	x		
<i>Eutypomys cf. thompsoni</i>	x			<i>Perchoerus minor</i>	x		
<i>Adjidaumo minimus</i>	x	x		<i>Bothriodon americanus</i>	x		
<i>Paradjidaumo minor</i>	x	x	x	<i>Heptacodon sp.</i>	x		
<i>Paleolagus temnodon</i>	x	x	x	<i>Merycoidodonts</i>	x	x	x
<i>Megalagus brachyodon</i>		x	x	<i>Merycoidodon affinis</i>	x		
<i>Megalagus turgidus</i>	x			<i>Bathygenys alfa</i>		x	
<i>Desmatolagus dicei</i>		x		<i>Limnetes sp.</i>		x	
<i>Hyaenodon montanus</i>		x		<i>Hypertragulus chadronensis</i>	x		
<i>Hyaenodon cruentus</i>	x			<i>Hypertragulus crawfordensis</i>	x		
<i>Pseudopteronodon minutus</i>		x		<i>Leptomeryx transmontanus</i>	x	x	x
<i>Daphoenocyon dodgei</i>	x	x	x	<i>Leptomeryx annectens</i>	x		
<i>Parietis dakotensis</i>	x	x		<i>Hypisodus paululus</i>	x		
<i>Hesperocyon paterculus</i>		x	x	<i>Heteromeryx dispar</i>	x		
<i>Hesperocyon gregarius</i>	x			<i>Pseudoprotoceras longinaris</i>	x		
<i>Plesictis priscus</i>	x			<i>Eotylopus reedi</i>	x		
<i>Paleogale inflex</i>		x		<i>Poebrotherium eximium</i>	x	x	x
<i>Deinictis cf. fortis</i>	x			<i>Stibarus montanus</i>	sp.	x	
<i>Hoplophoneus o'harrai</i>	x			<i>Leptochoerus or Stibarus</i>	sp.		x
<i>Hoplophoneus mentalis</i>	x						

For purposes of discussion, the fauna of the Mountain Province as here used is the combined faunas of Pipestone Springs and the Lower Oligocene of Canyon Ferry. These two areas were chosen deliberately because they are separated from the plains by more than one range of mountains and cannot possibly be interpreted as having been in the

Transition Zone as can the deposits in Weld County, Colo., and the less-well-known faunas of Bates Hole and Beaver Divide, Wyo. Thompson's Creek, McCarty's Mountain, and the Drummond Beds have been omitted because they have been incompletely reported upon, both faunistically and stratigraphically.

The fauna of the Plains Province has been compiled from Scott, et al. (1936-41), Clark (1937), Cook and Cook (1933), and Cook (1934). This compilation of the Plains Province fauna may be introducing error into the comparisons because, with a north-south extent of nearly 600 miles for the Oligocene deposits of the plains, latitudinal zoning may have existed. But, with so few detailed studies of limited areas, definite evidence either for or against latitudinal zoning is wholly lacking.

The comparison of these two faunas is limited by necessity to the smaller mammals because the remains of the larger forms, particularly the titanotheres and rhinoceri, are often too fragmentary for more than family identification. However, such fragmentary evidence is sufficient to establish the group in the area in question. Those cases where the generic identification is reasonably certain but no specific identification can be made are indicated in table 3 by the abbreviation "sp." In the following paragraphs an attempt is made to evaluate the differences found in the two faunas.

INSECTIVORA.—Although representatives of this group are not numerous in collections, one finds it difficult to escape the inference that it is due to their small size. There are two genera, *Apternodus* and *Ictops*, common to both areas but the species are distinct. Two genera, *Clinopternodus* and *Metacodon*, appear to be confined to the Plains Province and, as yet, are unknown from younger deposits outside of the plains. Two genera, *Micropternodus* and *Domnina*, appear to be confined to the Mountain Province. *Micropternodus* does not appear to have survived anywhere beyond the Lower Oligocene, and *Domnina* is well represented in the Plains Province in the Middle Oligocene. Consequently, one would expect to find it in the Lower Oligocene of the plains. On the other hand, the alternative that it did not spread to the plains until Middle Oligocene times (as appears to be the case with some other genera) is entirely within the limits of possibility. Since *Kentrogomphios* and *Talpa?* are known from single specimens they are useless for this study.

RODENTIA.—*Prosciurus* is common to both areas in both the Lower and Middle Oligocene. *Ischyromys*, a large active form, appears to be restricted to the Mountain Province in the Lower Oligocene but is well represented in the Middle Oligocene of the plains, where it underwent considerable radiation. *Titanotheriomys* and *Cylindrodon* are common to both areas but did not survive into the Middle Oligocene. *Pseudo-*

*cylindrodon* appears to be restricted to the mountains in the Lower Oligocene but did not survive into the Middle Oligocene. *Eutypomys*, a large active form, is common to both Provinces in the Lower Oligocene. Both genera of the Eomyidae are common to both Provinces in both the Lower and Middle Oligocene.

LAGOMORPHA.—*Megalagus* and *Paleolagus* are common to both areas. The species are distinct in *Megalagus* and probably also in *Paleolagus*. *Desmatolagus*, as with *Domnina* and *Ischyromys*, appears to be restricted to the mountains in the Lower Oligocene but is represented in the Middle Oligocene of the plains.

CARNIVORA.—The creodonts are rare in the Lower Oligocene of both Provinces and consequently are useless for this type of study. *Daphoenocyon* and *Parictis* are common to both areas and no specific separation appears possible. *Hesperocyon* is common to both Provinces but the species are distinct. *Plesictis* appears to be restricted to the Plains Province and *Paleogale* appears to be restricted to the mountains in the Lower Oligocene but is well represented on the plains in the Middle Oligocene. To the best of my knowledge, not even fragmentary evidence of the felids has been found in any of the Lower Oligocene deposits of the intermountain basins. With such complete negative evidence for an area as extensively collected as Pipestone Springs, it seems reasonable to infer that the mountains were climatically unsuited to the Lower Oligocene felids.

PERISSODACTYLA.—*Mesohippus* is common to both Provinces but the Lower Oligocene species have not been reviewed since the time it was considered an act of the greatest discourtesy to place someone else's species in synonymy. Consequently the data furnished by the species of this genus are not suitable for this study. The remains of the Rhinocerotidae from the Mountain Province are fragmentary but *Hyracodon* and *Caenopus* were common to both Provinces. The remains of the Brontotheroidea are too fragmentary for generic identification. *Colodon* is common to both areas but its scarcity makes it unsuited for this study.

ARTIODACTYLA.—Although the Leptochoeridae are common to both areas, their remains are too rare to be suitable for this study. The Entelodontidae appear to be restricted to the plains, and, like the felids, seem to have found the mountains climatically inhospitable. The Tayassuidae are unknown in the Mountain Province but are also rare in the plains and consequently unsuited for this study. Likewise, the Bothriodontidae are unknown in the mountains and are rare on the plains. The remains of the Merycoidodontidae in the Mountain Province are very fragmentary and useless for this type of study. Of the Hypertragulidae, only one genus, *Leptomeryx*, is common to the two areas but no specific separation between the two regions can be

made. *Hypertragulus* and *Hypisodus* appear to be restricted to the plains and, like the felids, may have found the mountains climatically unsuitable. *Heteromeryx* is known from a single specimen and therefore unsuited for this study. The same is true for *Pseudoprotoceras*. Of the Camelidae, *Eotylpus* is known from only three or four specimens and consequently is unsuitable for this study. *Poebrotherium* appears to be common to both Provinces but the remains in the mountain area are very fragmentary and consequently the genus is unsuitable for this study.

TABLE 4.—Distribution of genera in the Lower and Middle Oligocene

Genus	Lower Oligocene		Middle Oligocene		Genus	Lower Oligocene		Middle Oligocene	
	Moun- tain Prov.	Plains Prov.	Moun- tain Prov.	Plains Prov.		Moun- tain Prov.	Plains Prov.	Moun- tain Prov.	Plains Prov.
<i>Domnina</i> *	x			x	<i>Brontotheriidae</i>	x	x		
<i>Ischyromys</i>	x			x	<i>Apternodus</i>	x	x	x	x
<i>Desmatolagus</i> *	x			x	<i>Ictops</i>	x	x	x	x
<i>Paleogale</i> *	x			x	<i>Proscelturus</i>	x	x	x	x
<i>Metacodon</i>		x		x	<i>Eutypomys</i>	x	x	x	x
<i>Plesictis</i> *		x		x	<i>Adjidaumo</i>	x	x	x	x
<i>Deinictis</i> *		x		x	<i>Paradjidaumo</i>	x	x	x	x
<i>Hoplophoneus</i>		x		x	<i>Megalagus</i>	x	x	x	x
<i>Archeotherium</i>		x		x	<i>Paleolagus</i>	x	x	x	x
<i>Perchoerus</i>		x		x	<i>Daphoenocyon</i> *	x	x	x	x
<i>Bothriodon</i> *		x		x	<i>Parictis</i> *	x	x	x	x
<i>Heptacodon</i> *		x		x	<i>Hesperocyon</i>	x	x	x	x
<i>Hypertragulus</i>		x		x	<i>Mesohippus</i>	x	x	x	x
<i>Hypisodus</i>		x		x	<i>Colodon</i>	x	x	x	x
<i>Micropternodus</i>	x				<i>Rhinocerotidae</i>	x	x	x	x
<i>Pseudocylindrodon</i>	x				<i>Leptochoeridae</i>	x	x	x	x
<i>Clinopternodus</i>		x			<i>Merycoidodontidae</i>	x	x	x	x
<i>Cylindrodon</i>	x	x			<i>Leptomeryx</i>	x	x	x	x
<i>Titanotheriomys</i>	x	x			<i>Poebrotherium</i>	x	x	x	x

\*Subfamilies to which these genera belong are believed to be immigrants to North America from Eurasia in Early Oligocene times (Simpson, 1947).

Table 4 reveals some very striking contrasts between the faunas of the two Provinces, particularly in the number of genera in the Plains Province which are not yet known from the intermountain basins. Most of these forms are medium to large in size and the subfamily, at least, would be recognizable on very fragmentary evidence. Consequently their nondiscovery at Pipestone Springs indicates, if not complete absence, that only occasional stragglers entered the area during cycles of maximum abundance. Four of these genera, embracing three subfamilies, are believed to be immigrants from Eurasia. One of the subfamilies, the Anthracotherinae, with its hippopotamus-like habits, quite obviously would have found the smaller, swifter mountain streams entirely unsuited to its way of life. In the case of *Plesictis* and *Deinictis* (if this is the true situation), it would appear that a temperature factor was involved. Of the nonmigrant genera, one family, the Hypertragulidae, is of special interest as only one genus, *Leptomeryx*, appears to have been able to invade the mountains and

is present in fair abundance. In view of the relative scarcity of *Hypertragulus*, *Hypisodus*, and *Heteromeryx* in the Middle Oligocene compared to *Leptomeryx* and in view of the Late Tertiary development of this suborder, one finds very attractive the suggestion that the center of development and dispersal was more southern and central and that the first three genera were very near the northern limit of their range.

That none of the genera of the Plains Province invaded the Mountain Province between the Lower and Middle Oligocene and the rather long list of genera common to the two Provinces during both ages indicate that the indigenous genera had become adjusted to their environment, or ecologically stabilized, by the beginning of the Oligocene and that there were no major climatic changes before the close of the Middle Oligocene.

The Eurasian immigrants embrace six subfamilies. One, the Amphycynodontinae, quickly became adjusted to both Provinces; two, the Nimravinae and Anthracotherinae, were restricted to the plains; one, the Mustelinae, was divided between the two areas; and two, the Soricinae and Ochotoninae, appeared to require a period of readjustment before invading the plains. The apparent absence of *Domnina* in the Lower Oligocene of the plains is certainly open to question since its very small size greatly reduces its chances of discovery. On the other hand, the zonal distribution of mammals is more clearly reflected by the small species, which is possibly a result of the much smaller territorial range of the individual. However, *Desmatolagus* would have had as good a chance of being preserved as *Megalagus* or *Paleolagus* if it had been present on the plains during the Chadronian.

*Ischyromys* is the same size as *Titanotheriomys*, and had it been on the plains during the Chadronian it would have had as good a chance of being preserved as the latter. The occurrence of *Ischyromys* in the Cypress Hills does not necessarily indicate that the fauna was mixed (Wood, 1937, p. 193), as Lambe (1908, p. 8) supposed, but could indicate temperature zoning on the plains during Lower Oligocene time. The large ground squirrels of the genus *Citellus* (sensu lato) are, with very few exceptions, restricted to the mountains and the Boreal Zone of the plains. The Cypress Hills are far enough north to be climatically equal to Pipestone Springs regardless of what was the Lower Oligocene climate as a whole.

The following genera have been omitted from table 4 because our knowledge of them in the Lower Oligocene is inadequate for this type of study: *Talpa*?, *Kentrogomphios*, *Sinclairiella*, *Manitsha*, *Ardynomys*, *Macrotarsius*, *Hyaenodon*, *Pseudopterodon*, *Aepinacodon*, *Bathygenys*, *Limnetes*, *Heteromeryx*, *Pseudoprotoceras*, *Eotylopus*.

In summary, the available data show that there was environmental (and, in a sense, climatic) zoning between the mountains and the plains in Lower Oligocene times. The faunal differences embrace larger systematic categories (Felidae and Entelodontidae) than the same areas do today (before civilization changed the picture). Both the immigrants and the indigenous faunas exhibit nearly the same degree of difference. The only change from Lower to Middle Oligocene was that the mountain forms were able to invade the plains and most of these were immigrants. None of the plains forms were successful in invading the mountains between Lower and Middle Oligocene times.

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