UNIVERSITY OF KANSAS
PALEONTOLOGICAL CONTRIBUTIONS

VERTEBRATA

ARTICLE 4
Pages 1-120, Plates 1-2, Figures 1-26

A CONTRIBUTION TO THE TERTIARY GEOLOGY AND PALEONTOLOGY OF NORTHEASTERN COLORADO

By EDWIN C. GALBREATH

UNIVERSITY OF KANSAS PUBLICATIONS

MARCH 15, 1953

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1953

24-3493

UNIVERSITY OF KANSAS
PALEONTOLOGICAL CONTRIBUTIONS

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UNIVERSITY OF KANSAS PALEONTOLOGICAL CONTRIBUTIONS
VERTEBRATA, ARTICLE 4, PAGES 1-120, PLATES 1-2, FIGURES 1-26

A CONTRIBUTION TO THE TERTIARY GEOLOGY AND PALEONTOLOGY OF NORTHEASTERN COLORADO [1]

By EDWIN C. GALBREATH

CONTENTS

1. A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Kansas.

ILLUSTRATIONS

ABSTRACT

Mesozoic and Cenozoic deposits are exposed in Weld and Logan Counties, northeastern Colorado.

The Tertiary sequence of stratigraphic units and faunas is as follows:

1. Ogallala formation; Pliocene.
   a. ?Kimball member. Fauna unknown.
   Disconformity.
2. Pawnee Creek formation; early middle Miocene to earliest Pliocene, inclusive.
   a. Stratal unit of earliest Clarendonian age; Sand Canyon local fauna.
   Disconformity.
   b. Stratal unit of late Barstovian age; Vim-Peetz local fauna.
   Disconformity.
   c. Stratal unit of late Barstovian age; Kennesaw local fauna.
   Disconformity.
   d. Stratal unit of early Barstovian age; Eubanks local fauna.
   Disconformity.
   e. Stratal unit of early Hemingfordian age; Martin Canyon local fauna.
   Disconformity.
3. White River formation; late lower Oligocene to early upper Oligocene, inclusive.
   a. Vista member of Whitneyan age; Vista fauna.
   b. Cedar Creek member of Orellan age; Cedar Creek fauna.
   c. Horsetail Creek member of Chadronian age; Horsetail Creek fauna.

The Tertiary beds are an accumulation of silts, sands, and gravels resulting from alluviation in channels and on flood plains, colluviation on valley slopes, and eolian deposition. Local to regional disconformities and weathered soil profiles mark interruptions in deposition.

The three faunas of the White River formation, although united by having numerous genera in common, are distinguished from each other by the restriction of some genera to only one or two of the faunas and by restriction to a single age of certain species which belong to relatively long-lived genera. The genera and species common to two or more of these faunas suggest, however, a close relationship in time for all three faunas and imply that the faunal differences are partly facial. The lithology of the beds further supports this latter supposition. The absence of such Oligocene genera as *Metamynodon* and *Protoceras* and the rarity of anthracotheriids and agriochoerids suggest environmental differences between the Oligocene faunas of northeastern Colorado and other areas—especially those of Nebraska and South Dakota.

The Miocene faunas are distinguished from each other principally by differences in the stage of evolution of the various species. Comparison of the Miocene faunas with other faunas in the High Plains and the Great Basin shows much faunal similarity and little evidence of environmental differences.

The existence of the Sand Canyon fauna in the early Pliocene is somewhat hypothetical, but its presence is postulated to account for certain equid remains that appear to be advanced over specimens representative of the older faunas.

These studies demonstrate, in general, that the changes in composition seen in the successive Oligocene and Miocene faunas of northeastern Colorado are largely the result of repeated invasions and replacements by species which have evolved outside the area studied. Only a few species seem to have undergone much evolution while continuously in residence. For this reason it is thought that the time interval represented by each of the successive faunas is short and that there was no isolation of them from adjacent faunas known from other parts of the High Plains.

The systematic account of the species found in northeastern Colorado adds new information about the morphology and evolutionary changes of some of the species, especially of the Oligocene rodents.

Genera heretofore unreported from northeastern Colorado are *Nanodelphys, Apternodus, Arctoryctes?, Titanotheriomys, Proheteromys, Diplolophus, Parictis, Proamphicyon, Daphoenocyon?, Miohippus, Perchoerus, Heptacodon, Agriochoerus,* and *Eotylopus* from the Oligocene; and *Brachyerix, Oreolagus, Sciurus* (*s. l.*), *Peridiomys, Monosaulax, Plesiosminthus?, Leptocyon, Hypohippus,* and *Calippus* from the Miocene.

New genera and species are *Apternodus iliffensis*, n. sp. (Solenodontidae); *Ankylodon progressus*, n. sp. (Erinaceidae); *Domnina compressa*, n. sp. (Soricidae); *Pelycomys rugosus* and *P. placidus*, n. gen. and spp. (Ischyromidae); and *Drassonax harpagops*, n. gen. and sp. (Mustelidae?) all from the Oligocene; and *Plesiosminthus? clivosus*, n. sp. (Zapodidae) from the Miocene.

INTRODUCTION

In recent years, field observations and collections made in the Tertiary beds of northeastern Colorado have shown that the faunal lists of the several stages are incomplete; that many stratigraphic assignments of species are either incorrect or too broad or narrow in range; that the stratigraphy is inadequately known for the purpose of compiling detailed and accurate faunal lists; and that the relationships of the species to geologically older and younger forms, as well as to those of the same time range in other areas, are often unknown or uncertain and in need of critical restudy in the light of more recent information. It is the purpose of the following account to correct some of these deficiencies and to add to the fund of knowledge concerning the area. The method of research followed to attain these aims was (1) a study of the stratigraphic history of the area; (2) an identification of the fossils in the light of present knowledge; (3) a grouping of species into faunas with greater detail than heretofore attempted; and (4) a correlation of these observations with observations on other Cenozoic faunas and deposits in North America. It is hoped that this study will contribute to a knowledge of the history of individual groups of animals, especially their phylogenetic and distributional relationships, and to the correlation of the geological formations so necessary for the solution of such problems as the Cenozoic history of the Rocky Mountains and the Great Plains.

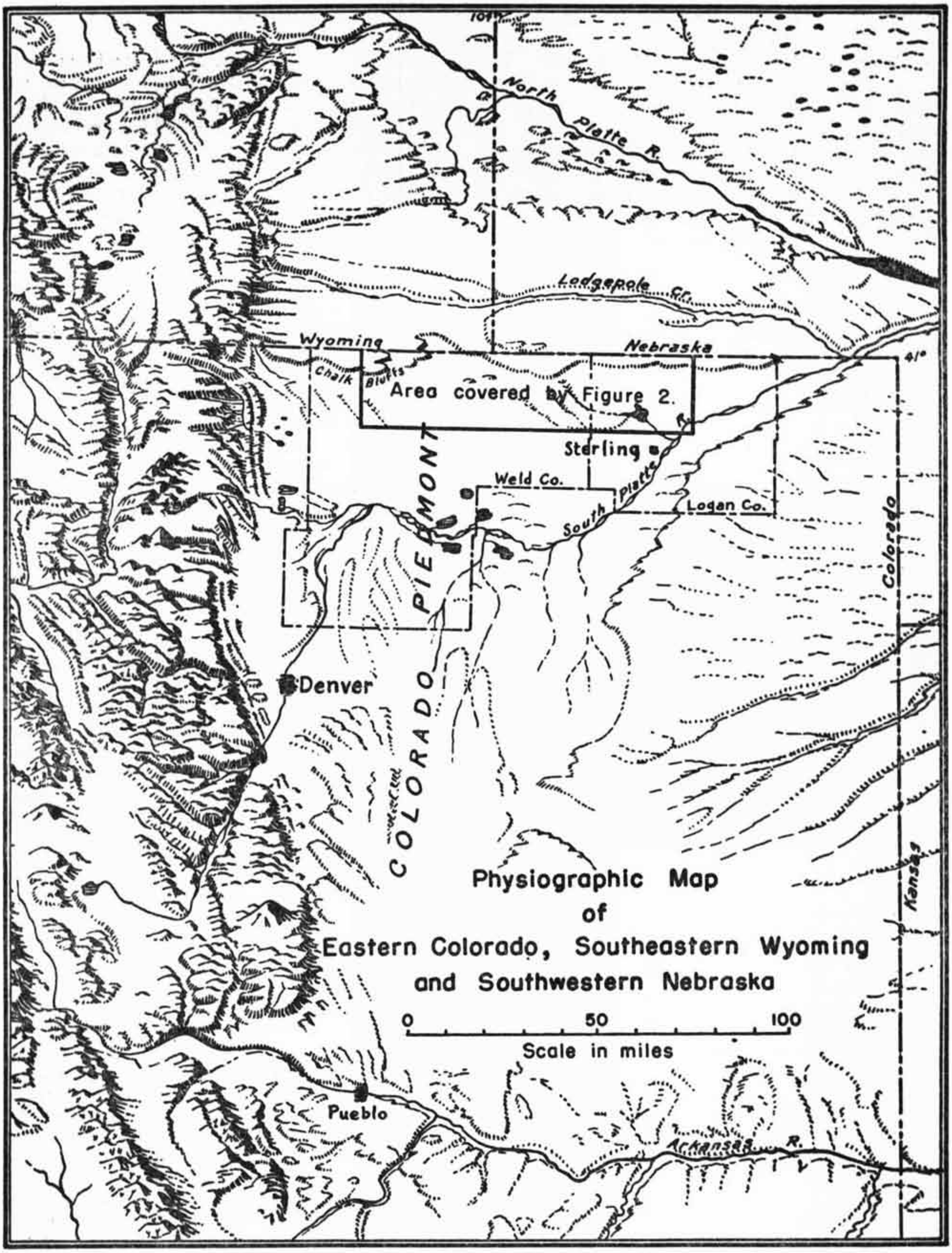
CLARK (1937) has presented a detailed analysis of the Chadron formation in the Dakota Badlands. H. E. WOOD (1949) has indicated the need for similar studies elsewhere. I regret that I cannot fully emulate CLARK and present a detailed sedimentational history of northeastern Colorado. For the most part, only specimens collected by me, or specimens from localities and levels known to me, were utilized in the present study.

Acknowledgment, with gratitude, is made first to Dr. ROBERT W. WILSON for his patient and kindly guidance throughout the course of this work. In addition, Dr. WILSON and Dr. G. EDWARD LEWIS permitted me to take over the study of the Cenozoic geology and paleontology of northeastern Colorado after they had devoted considerable attention to it. Drs. JOHN C. FRYE, EDWARD H. TAYLOR, A. BYRON LEONARD, and E. RAYMOND HALL, of the University of Kansas, advised and constructively criticized the work. The generous aid and cooperation of Mr. JACK CASEMENT and family and Mr. CLYDE WARD and family, of West Plains, Colorado, made the field work less rigorous and less difficult. Mr. A. B. ROPER granted permission to open Quarry A in Martin Canyon. The Plains Oil Company permitted me to make use of their well log for Haley-Smith Well No. 1 and to quote the part pertinent to this work. Mrs. RACHEL HUSBAND NICHOLS, of the American Museum of Natural History, furnished copies of American Museum records, checked specimens, and called my attention to many details which otherwise might have been overlooked. Mr. JOHN KOENIG prepared the maps, and Mrs. BERNITA MANSFIELD figured the specimens. There yet remain many citizens of northeastern Colorado, members of scientific staffs of many museums and universities, and others who, although unnamed, are remembered for their part in making this work a pleasure.

HISTORY OF GEOLOGICAL AND PALEONTOLOGICAL WORK IN NORTHEASTERN COLORADO

The first vertebrate paleontologist to investigate the Tertiary beds in northeastern Colorado was O. C. MARSH, who, in the summer of 1870, visited the beds in western Weld County (five miles south of the Wyoming state line on Little Crow Creek and "about thirty miles northeast . . . along the hills known as Chalk Bluffs") and noted the presence of "Titanotherium beds" and "above these . . . similar clay deposits . . . marked by abundant remains of *Oreodon Culbertsoni*, etc. . . . which characterize that horizon." His report (1870, p. 292) states that there were 150 feet of White River formation and 200 feet of post-Oligocene beds. BERTHOUD (1872, p. 48) reported the presence of fossils in the Crow Creek area during his search for ancient man in 1871. E. D. COPE visited the region in the summer and fall of 1873, and again in the fall of 1879, collecting fossils and studying the geology. He recognized the general similarity of the Tertiary beds to those of Nebraska and South Dakota (1874a). In 1882 an expedition from Princeton University collected in the region of the "Chalk Bluffs." Of these early expeditions only COPE's yielded anything that might have been considered a major publication upon the area and its fossils. In 1898, 1901, and 1902, field parties from the American Museum of Natural History led by MATTHEW, BROWN, and THOMSON explored Logan

FIGURE 1.—Physiographic map of eastern Colorado, southeastern Wyoming, and southwestern Nebraska showing the position of Weld and Logan Counties and the area covered by Figure 2. Based on the "Map of the Landforms of the United States" by ERWIN RAISZ; fourth revised edition; Ginn & Co., 1946; and reprinted by permission of Ginn & Co.


101°
North Platte R.
Lodgepole Cr.
Wyoming
Nebraska
41°
Chalk Bluffs
Area covered by Figure 2.
Sterling
Weld Co.
South Platte R.
Logan Co.
Colorado
COLORADO PIEDMONT
Denver
Kansas
Physiographic Map
of
Eastern Colorado, Southeastern Wyoming
and Southwestern Nebraska
0
50
100
Scale in miles
Pueblo
Arkansas R.

and Weld Counties (OSBORN, 1918, p. 19). The second and last major publication on the region (MATTHEW, 1901) resulted from these expeditions.

Since that time and until 1940 the collecting of fossils has been intermittent and, with the exception of work by the Denver Museum of Natural History, University of California, CHILDS FRICK, and University of Kansas, collecting has not been pursued on any large scale. In 1940 Dr. G. EDWARD LEWIS and Dr. ROBERT W. WILSON started in the area an intensive program of work which was interrupted by the war. In 1946 Dr. C. W. HIBBARD led a field party from the University of Kansas into the area at which time my interest in the area was stimulated. Subsequently, Drs. LEWIS and WILSON suggested that I continue and complete the investigation of the stratigraphy and mammalian paleontology.

GEOLOGY

GENERAL FEATURES

FENNEMAN (1931, p. 30) writes:

> Aside from the broad valleys of the Platte and Arkansas the Tertiary cover of the High Plains is almost unbroken along the eastern boundary of Colorado. On account of greater erosion farther west, this cover has mainly disappeared, its remnants being smaller, more scattered, and less flat. Where the mantle is entirely wasted away, the underlying rocks are themselves much eroded. The area which owes its topography to this dissection and denudation is the Colorado Piedmont. The outline of this section, as shown on the map, reveals at once its close relation to the two chief river systems which are the agents of the stripping. Along the axis of the Platte Valley, the denuded area extends far into northeastern Colorado and along the Arkansas it reaches to the Kansas boundary. On the divide between these two rivers the stripping is less perfect, and north of the South Platte the High Plains extend west to the mountains.
>
> The northern boundary of the Colorado Piedmont is almost coincident with that of the state. North of this line the streams of Wyoming and Nebraska flow east in consequent fashion down the original slope of the Tertiary mantle, having an elevation of a mile above sea level where they cross the Wyoming-Nebraska line. Along the same meridian, the South Platte, 50 miles to the south, is 1,000 ft. lower. Its small northern tributaries head against the south-facing break of the Tertiary upland.

This south-facing break in the Tertiary upland is the subject of the present study (see Figs. 1-3).

Tertiary deposits are best exposed in Ts. 11-12 N., Rs. 51-65 W. in Logan and Weld Counties, Colorado, and sporadically crop out to the north and south of this area, wherever left as outliers or not covered by soil or grass. Detailed mapping and study was confined to Ranges 53 and 54 in Logan County, an area which includes the type section of the "Martin Canyon Beds," and the type sections of the Horsetail Creek, Cedar Creek, and Vista members of the White River formation to be described in this paper.

Cretaceous beds underlie the Tertiary deposits in this region—the Laramie formation in western Weld County, and Fox Hills sandstone and Pierre shale in eastern Weld County and western Logan County. The White River formation is exposed to a limited extent in the South Platte valley floor (Chadronian and Orellan beds) and in the valley wall (Orellan and Whitneyan beds), where it lies disconformably upon Cretaceous beds (Fig. 4). Sections of the White River formation as much as 582 feet thick have been measured. Following deposition of the White River sediments, a long period of erosion and soil formation took place during all or most of early Miocene times. Middle and late Miocene deposits fill the valleys eroded into the Oligocene beds. A shorter interval of erosion preceded the deposition of the Ogallala formation. This formation caps the older Tertiary deposits and in a few places occupies channels cut in the older beds. A relatively resistant bed of Ogallala? limestone controls the topography of the High Plains in this region. The upland or plateau surface is commonly mantled with late Pleistocene loess in which the modern soil is formed, but at a few localities Pleistocene sands and gravels of Nebraskan age are present.

In the South Platte drainage system, which drains the area covered in this report, the valley floors are generally covered with Pleistocene and Recent deposits. Where the streams from the steep slopes of the valley wall emerge upon a valley floor, they abruptly change from degrading to aggrading, and large alluvial fans are built, many of which coalesce with their neighbors. Most of the small streams emerging from the steep slopes become braided and finally disappear on the aggraded plain of the valley floor. However, a few persist to unite with the South Platte tributaries. Because rainfall is scant, none of the streams of the region are permanent, except the South Platte River.

STRATIGRAPHY

COPE (1874, p. 9; 1874a, p. 429) presented a cursory description of the Tertiary deposits in northeastern Colorado and pointed out their similarity to the deposits in Wyoming, Dakota, and Nebraska. It remained for MATTHEW (1901, pp. 356-374) to describe the beds, discuss their probable origin, and make correlations with other sections.

Three Tertiary formations are recognized by me in northeastern Colorado (Fig. 5) — the White River, Pawnee Creek, and Ogallala formations. Evidence for an Arikareean formation is not conclusive.

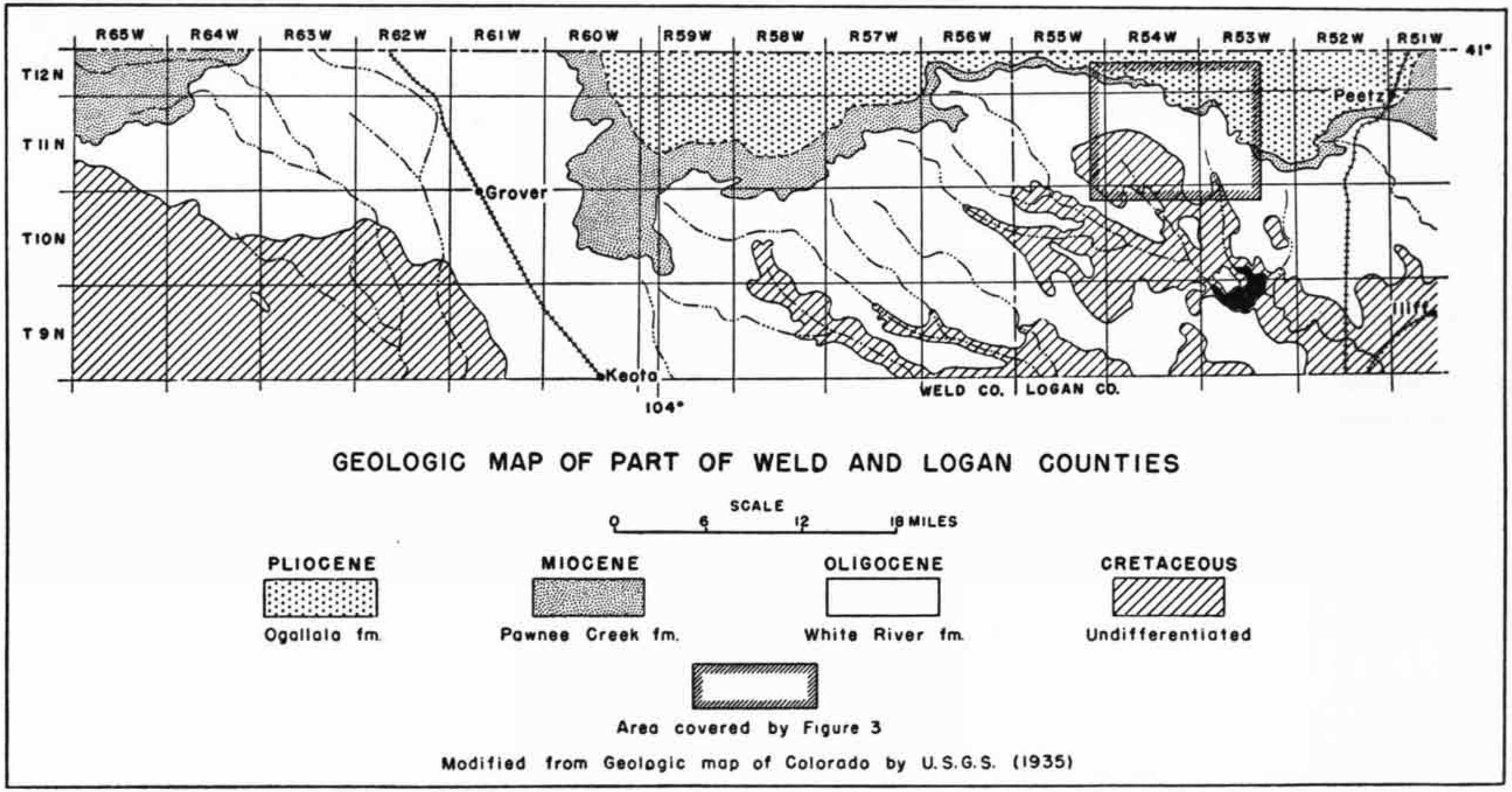


FIGURE 2.—Geologic map of part of Weld and Logan Counties showing areal distribution of the Ogallala, Pawnee Creek, White River, and Cretaceous beds, and area covered by Figure 3. Modified from geologic map of Colorado by United States Geological Survey (1935).

WHITE RIVER FORMATION

All of the Oligocene deposits are included in the White River formation and consist of three units—the Horsetail Creek, Cedar Creek, and Vista members. To group the Colorado Oligocene deposits in one formation in contrast to the practice in Nebraska and South Dakota appears justified on the following grounds. Disconformities between the Horsetail Creek and Cedar Creek members are not everywhere present. To recognize the Horsetail Creek beds as a formation means invoking a faunal definition to supplement the discontinuous lithologic break between the two members, but the faunal zones, especially the Chadronian, transcend the lithologic units. Therefore, to have a formation that was mappable would mean using a lithologic break when it was present and using faunal evidence elsewhere. But, since the fauna below the lithologic break at some points does not differ from the fauna above the break at other points, one would be at loss to map beds that grade vertically and laterally into each member. An arbitrary decision would be necessary to resolve these problems, which would mean a breakdown of the criteria that define each unit. The resulting confusion would not justify the practice.

Horsetail Creek member. — The oldest Tertiary deposits in the region are the Chadronian beds called the Horsetail Creek Beds by MATTHEW (1901, p. 356), Horsetail Creek by SIMPSON (1933, p. 99), and referred to as the Horsetail Creek facies of the Chadron formation by H. E. WOOD, *et al.* (1941, p. 22).

The Horsetail Creek member, of Chadronian and early? Orellan age, as herein described is based on exposures in Logan County, where gray, massive silts rest upon the Cretaceous surface (see measured section IX). The top of the member grades upward into tan to pink silt of the Cedar Creek member or is separated from that member by an erosional unconformity. Locally, there are beds of olive-colored silt and freshwater limestone with interfingering beds of whitish-gray silt at the top of the member.

Any concept of the pre-Chadronian surface in northeastern Colorado is to a great extent a product of speculation. The contacts are covered by grass, soil, or alluvium at almost all places. In western Weld County the Tertiary beds are known to rest on Laramie shales and sandstones. In eastern Weld County and as far east as R. 53 W., T. 11 N. in Logan County, I have seen outcrops of a soft, friable, mustard-yellow sandstone which is commonly considered to be Fox Hills sandstone. A deep well boring in sec. 26, T. 11 N., R. 54 W., Logan County, shows the Tertiary contact to be with Cretaceous beds reported as Pierre shale. Scanty as the evidence is, I think that the pre-Chadronian surface was developed on late Cretaceous rocks as a partially dissected topography with channels cut at least into the Pierre shale. Subsequent aggradation resulted in burial of the Cretaceous beds and continued, with minor interruptions, into late Oligocene time.

In the well boring mentioned above, a "gravel bed" was reported between the Pierre shale and the overlying silts. Its correlation with any exposed Chadronian beds is impossible at present. In South Dakota CLARK (1937, p. 277) found coarse sediments in the bottoms of lower Chadron channels resting on the Cretaceous floor. Comparison is made with the condition in South Dakota only to demonstrate that possibly the "gravel bed" in northeastern Colorado represents the first phase of Chadronian aggradation—one taking place in channels.

The lowest exposed Horsetail Creek beds are composed of grayish-white, massive silts and rest upon Fox Hills sandstone and Pierre shale. By the use of a Paulin altimeter 245 feet of Horsetail Creek beds were measured in T. 10 N., Rs. 53-54 W., Logan County. This measurement is based on a traverse of about eight miles across the valley floor and conceivably could be materially affected by dip, presence of channels, and error in measurement. Resting on the massive silts in Ts. 10-11 N., Rs. 51-54 W., Logan County, and interfingering with the massive silt at other localities, is a series of olive-green silts, gray-green freshwater limestones, and interbedded whitish-gray silts, which reaches a maximum thickness of 80 feet but may be thinner where part of the sequence is missing (Pl. 1, fig. *C*). The presence of freshwater limestones causes me to think that this sequence of beds was formed in a series of freshwater ponds.[2] At other localities the grayish-white, massive silt is in contact with pink, massive, fine-grained sandstone, and at still other localities the grayish-white silt grades upward into pink and buff silts. Faunal evidence is poor, but in all cases titanothere remains have been found near the top of the grayish-white, massive silts.

From the meager evidence present, it would appear that the Horsetail Creek member represented accumulating flood plain deposits terminating in an aggraded surface with sluggish streams and possibly marshes, ponds, or lakes upon it. At present the contact between the Horsetail Creek and Cedar Creek member beds is placed at the erosional break between the two members or, where deposition is continuous, at the base of the pink silts which coincides, apparently, with a change in fauna.

The location of the type section for the Horsetail Creek beds, as described by MATTHEW, is a matter for debate. CURTIS HESSE, who visited the region with H. T. MARTIN (a collector in the MATTHEW party in 1898), expressed the opinion, in a letter to Dr. R. W. WILSON, that the type section was not on the Horsetail Creek known today but did believe that the concepts of the beds were formed in the eastern Weld County-western Logan County area.

2. CLARK (1937, p. 283) reported similar series of deposits which he placed at the top of his Chadron section in South Dakota.

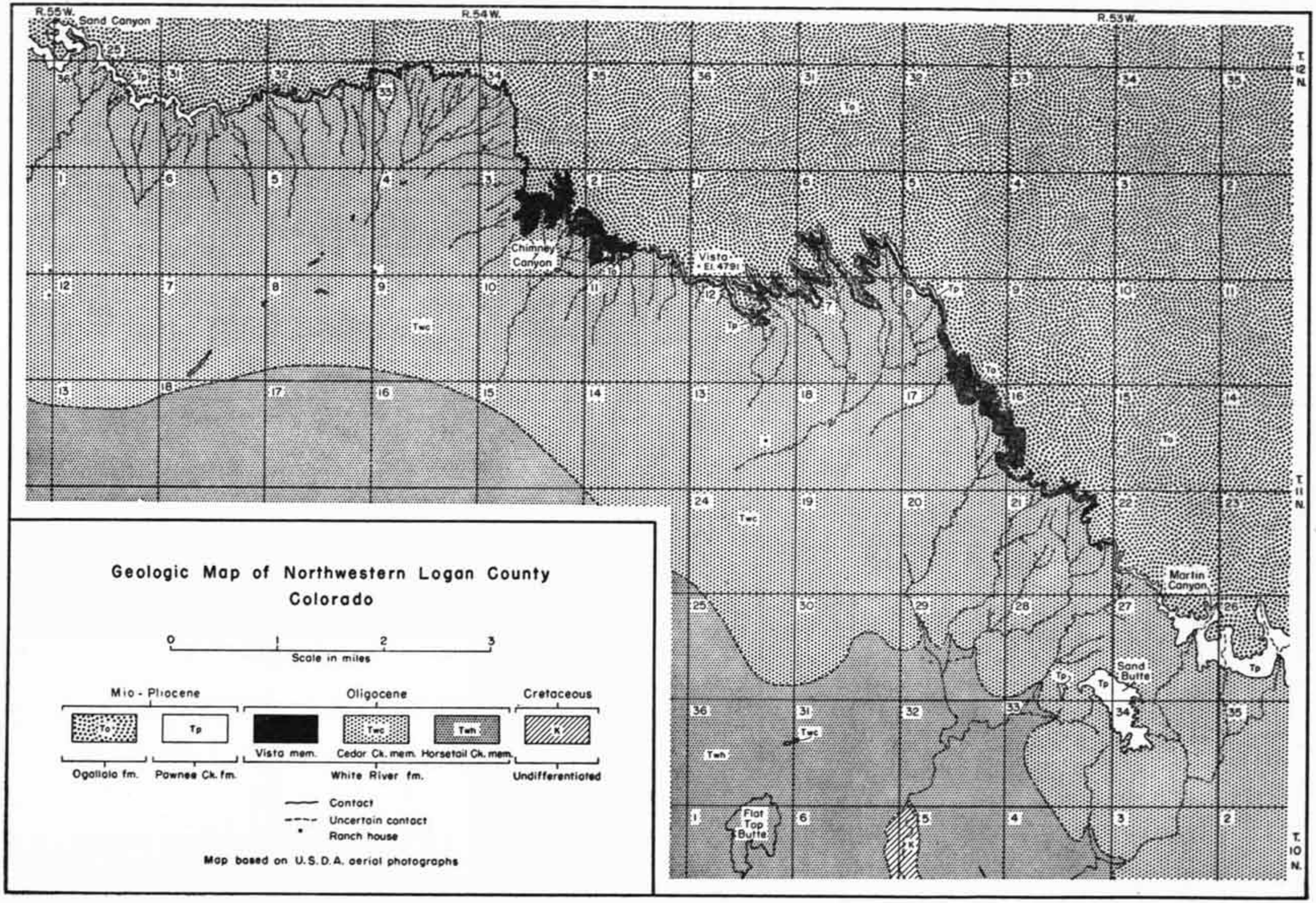


FIGURE 3.—Geologic map of northwestern Logan County showing areal distribution of formations and members of the Tertiary deposits described in this paper, prominent topographic features, and Vista triangulation station. Map based on United States Department of Agriculture aerial photographs, and modified to conform with corrected section lines.

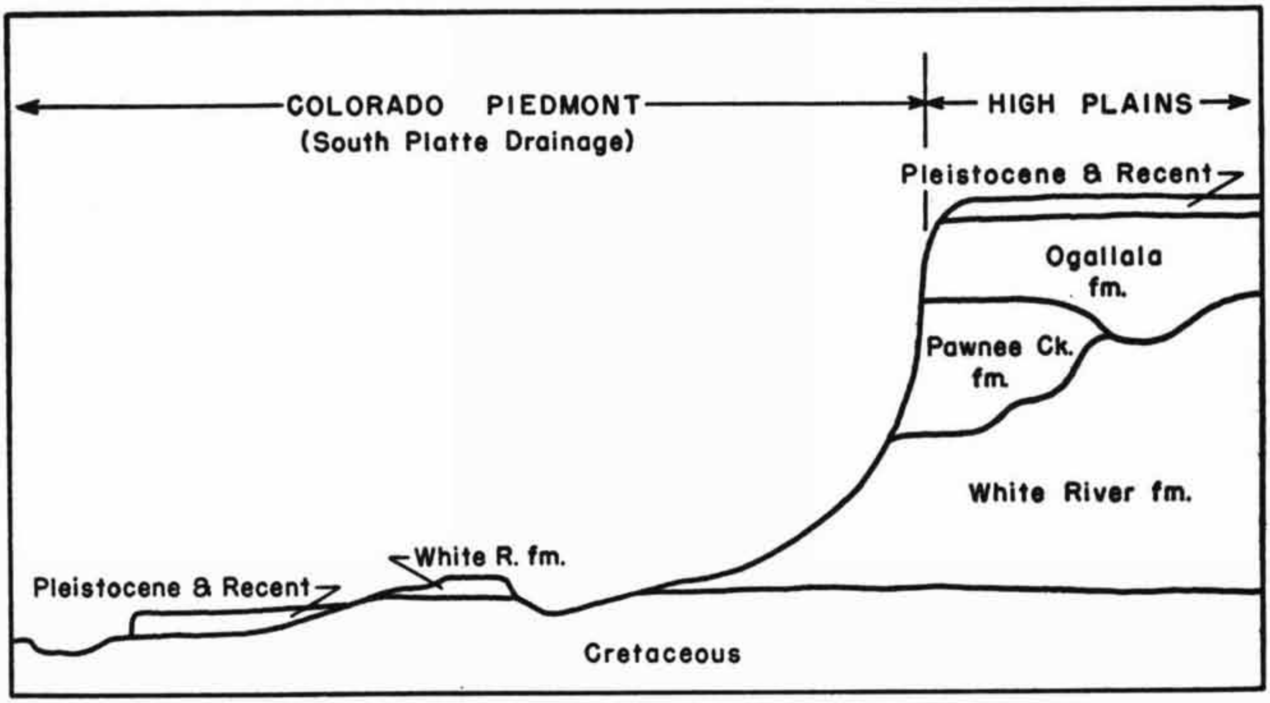


FIGURE 4.—Schematic cross section of beds in Logan County, Colorado, between the South Platte River and the northern boundary of the State.

OSBORN (1918, p. 19, fig. 10a) states that "The American Museum party of 1898 worked westward under Matthew to the head of Cedar (or Clear) Creek, . . ." This would limit MATTHEW's explorations, at the time when he was forming his concept of the Horsetail Creek beds, to places no farther west than Range 57, which would bring him to within a few miles of the present Horsetail Creek. In the southwest corner of T. 11 N., R. 56 W. there are good Chadronian exposures, and the Denver Museum of Natural History's Trigonias Quarry is less than a half-dozen miles southwest from this point on the Horsetail Creek drainage system. Chadronian beds are also exposed in T. 11 N., R. 57 W., Weld County, which MATTHEW possibly visited. Furthermore, the exposures of Horsetail Creek beds in T. 10 N., Rs. 51-54 W., Logan County are close to the Martin Canyon area. On the other hand, there is no evidence in MATTHEW's field notes that he visited any part of the northeastern Colorado area in 1898 other than Martin Canyon. For reasons that will be discussed later, it is possible that MATTHEW introduced the name Horsetail Creek beds after writing the manuscript of his 1901 paper because he saw beds at Horsetail Creek in 1901 that agreed with his original concept. In order to remove the existing uncertainty, I designate the Chadronian exposures in secs. 29, 31, 32, T. 11 N., R. 53 W., Logan County (see measured section XI) as the type locality of the Horsetail Creek member.

Cedar Creek member.—It is proposed here to use the term Cedar Creek member of the White River formation for the beds of Orellan age, composed of pink and tan sandstones and silts, that lie above the disconformity separating the Horsetail Creek member from this member or above the grayish-white silts where no disconformity is evident, and that lie below a "white marker" which is the lowest bed of the Vista member (Pl. 1, fig. *B*). These deposits are (seemingly) MATTHEW's (1901, p. 357) Cedar Creek beds, which the Wood Committee (WOOD, H. E., *et al.*, 1941, p. 16) called the Cedar Creek facies of the Brule formation. The Cedar Creek member is typically exposed in secs. 29 and 21, T. 11 N., R. 53 W., Logan County (see measured section XII). I think that the Cedar Creek member represents, in the upper part at least, the interval between the Orella and Whitney members which SCHULTZ & STOUT (1938) emphasized. If the complete history of the deposition of the White River formation were known, I think that the Cedar Creek and Orella members would maintain their identities.

With exceptions, the Cedar Creek may be divided naturally into three parts: a lower zone of pink to red, fine-grained sandstones or pink silts that interfinger with a massive, buff silt, containing channels filled with grayish, coarser sandstones or pinkish, arkosic sandstones in the upper part; an intermediate zone of thin-bedded silts and sandstones ranging from buff to red in color (but locally containing

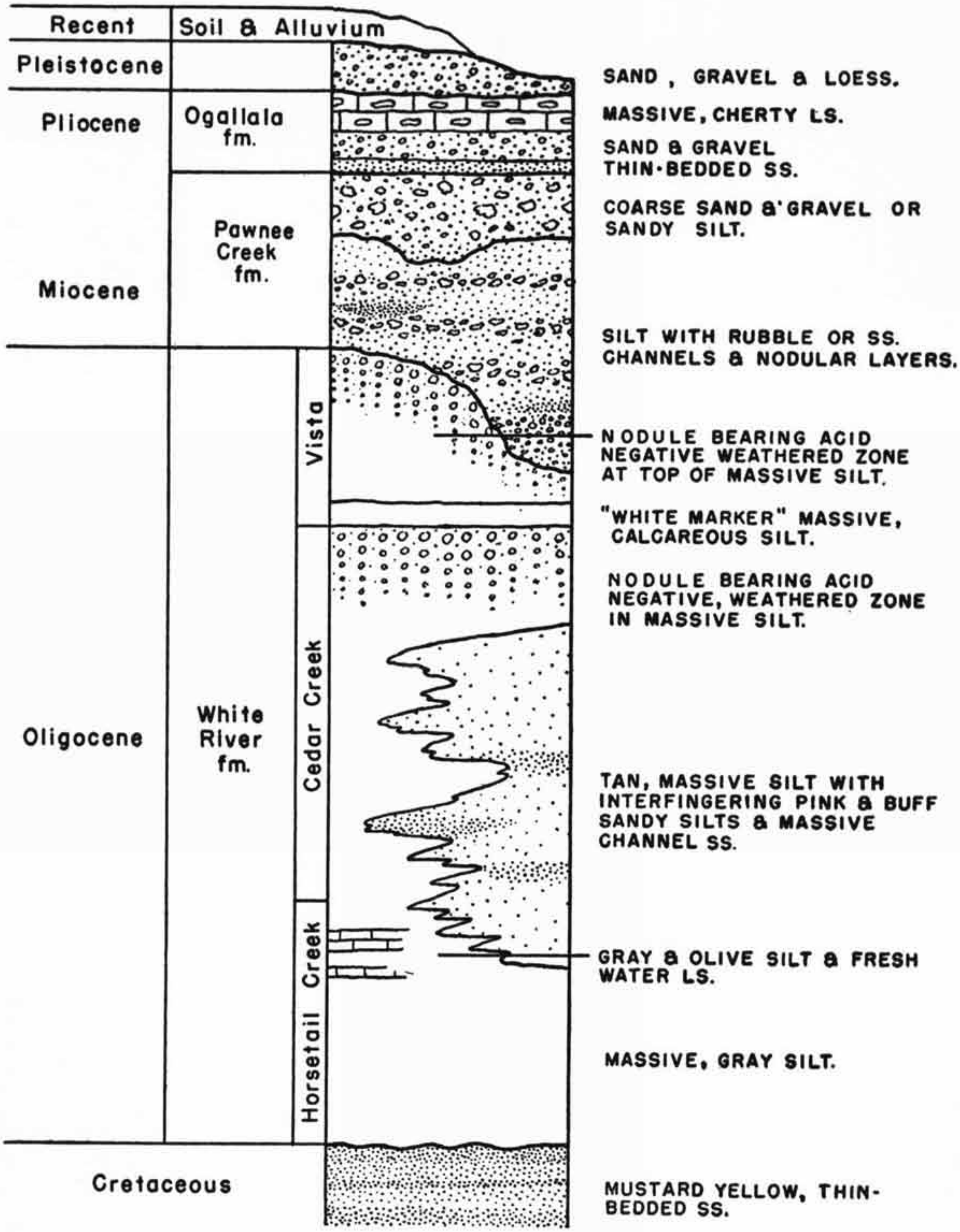


FIGURE 5.—Generalized columnar section in Logan County, Colorado.

beds of olive silts), which are a widespread continuation of the channel deposits seen in the lower zone; and an upper zone of massive, buff silt. Chunks of reworked volcanic ash are found in the lowest beds, and barite crystals are not uncommon in the upper half of the member. Thin clastic dikes of local extent are present, especially in the lower part of the Cedar Creek beds. No significant structural pattern has been traced for these dikes to date. The dikes are composed of sediments similar to those seen in the intermediate zone and cut into the lower massive silts. The "color-bands" mentioned by MATTHEW (1901, p. 357) are red or a shade of buff or tan. Most of the red zones are associated with the sandy silts or thin-bedded deposits. The possibility that these zones are old soil horizons or result from climatic conditions as suggested by MATTHEW should be seriously considered. The upper part of the massive Orellan silts are acid negative and bear nodules that are calcareous. These nodules reach a diameter of two to three inches near the top of the silt.

At present the top of the Cedar Creek member is considered to be immediately beneath the bottom of the white marker bed. Where MATTHEW placed the division between Whitneyan and Orellan beds is unknown since he stated that no stratigraphic demarcation could be made out, but it is possible that it was somewhere in the Orellan beds. The location of the Cedar Creek beds described by MATTHEW is not known definitely, but probably it was in Logan County. As in the case of the Horsetail Creek member, the typical section designated for the Cedar Creek member was selected because of its proximity to Martin Canyon, which would increase the probability of its being part of the exposures seen by MATTHEW when he described the beds, and because the most complete section is in this area.

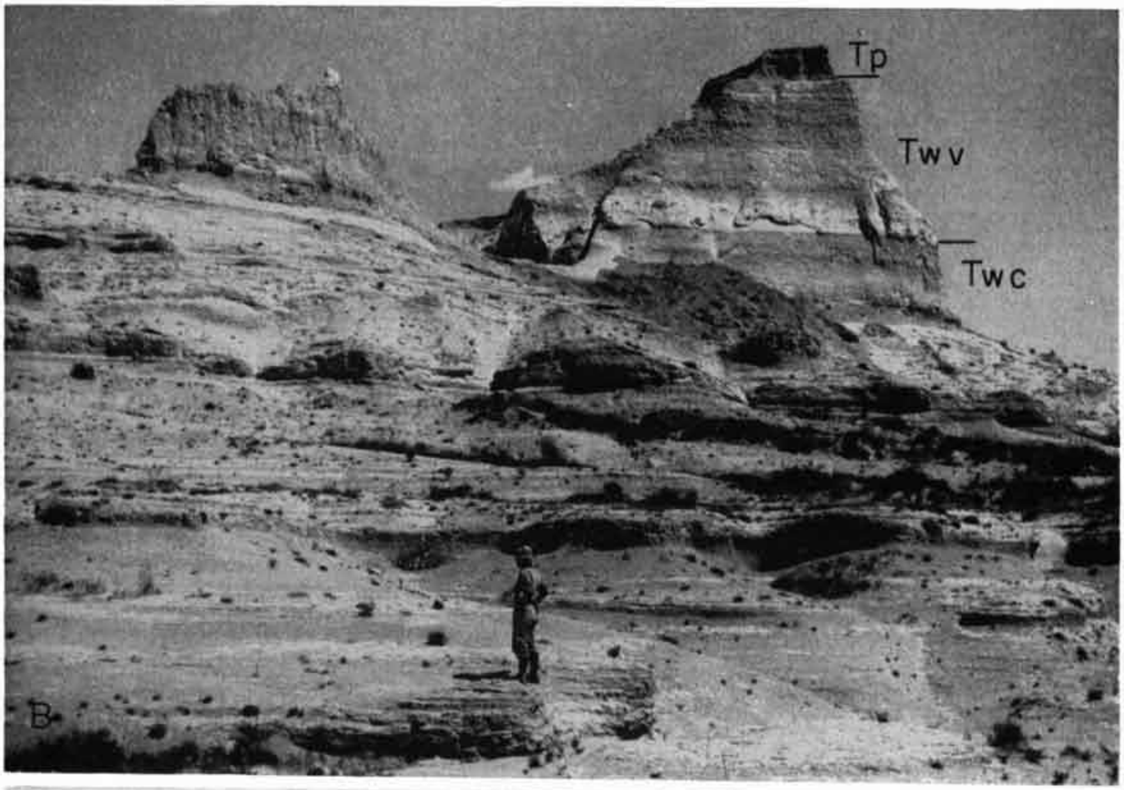
Vista member.—The name Vista member is proposed as new for deposits of Whitneyan age found in Logan County, Colorado, and is derived from the Vista triangulation station located in the SW¼ sec. 1, T. 11 N., R. 54 W., which is almost at the center of the Vista member exposures. The beds are composed of massive, tan silt with a highly calcareous zone (the "white marker") at the bottom and have an erosional disconformity at the top. (See measured section XI for the beds at the type locality in N½ sec. 17, T. 11 N., R. 53 W., Logan County.)

The "white marker" is highly calcareous, to which fact it owes its distinctive color. Except for the highly calcareous condition and the absence of nodules, it is difficult or impossible to distinguish this stratum at close quarters, especially at the upper limit where the white color grades into buff. When viewed from a distance, however, this white band appears sharp and clear cut (Pl. 1, fig. *A*). A thickness as great as 25 feet has been measured, although the bed tends to be thinner. Above the white marker the silts are massive, hard, and not as fossiliferous as the Cedar Creek deposits. The calcareous nature of the beds decreases higher in the section and generally at a level 10 to 15 feet from the top of the smooth massive silt calcium carbonate is almost absent. At this level small, brown, highly calcareous nodules appear in the silt. These nodules increase in size upward and at places grade into the fluted cliffs described as the weathered zone of the old surface on the Oligocene deposits. Locally there are beds of noncalcareous siltstone two feet thick between these lower brown nodules and the fluted cliffs. The presence of nodules at the top of the Vista member causes an unusual weathering feature whereby the vertical surface presents a distinctive type of face that appears to have long vertical streamers or a corrugated or fluted surface. A superficial examination would lead one to believe that these vertical streamers were solid vertical concretionary masses, but by digging into the streamers the nodular structure is revealed. These beds are resistant and the silt in the interstices of the nodules is harder and more compact than in the lower beds. As elsewhere in the White River formation of northeastern Colorado, the nodules are highly calcareous and the silt is noncalcareous or nearly so. No fossils have ever been found in these nodular silts to my knowledge, with the possible exception of a Daimonelix tube, which certainly supports the possibility that the surface was a weathering surface during Miocene times. However, this weathered zone appears so distinct from the typical Oligocene beds, especially the buff silts, that some observers have considered them as a separate entity not associated with the Oligocene beds. For the most part, the zone has been called Arikareean. Nevertheless, a careful examination will show that these nodular "beds" cut across deposits of Whitneyan and Orellan age and are continuous with whatever deposits they rest upon. Post-Oligocene erosion in this region at places has

EXPLANATION OF PLATE 1

FIGURE	PAGE
A—North side of Chimney Rock, Chimney Canyon, sec. 3, T. 11 N., R. 54 W., Logan County, showing "white marker" bed at bottom of Vista member of the White River formation. Photograph by C. W. HIBBARD	16
B—South side of Chimney Canyon, showing small remnant of Pawnee Creek formation (Tp), and Vista (Twv) and Cedar Creek (Twc) members of the White River formation. Photograph by C. W. HIBBARD	14
C—South end of Flat Top Butte, sec. 1, T. 11 N., R. 54 W., Logan County, showing massive silt and freshwater limestone of the Horsetail Creek member of the White River formation. Photograph by ALLEN BIGGERSTAFF of Sterling, Colorado	12


A


Tp
Twv
Twc
B


C

removed all the Vista member and part of the Cedar Creek member prior to the weathering process, and later Miocene channeling at a few localities has cut away the old weathered surface and all evidence of the nodules.

The Vista member represents a part of a cycle of sedimentation which includes the Cedar Creek member. It remains today as local remnants and its areal extent probably is not large (50 to 75 square miles). The only exposures known to me are those in Logan County. Today, as they did during Miocene times, these beds represent a topographic high.

The Vista can be distinguished faunally and lithologically, but it should be emphasized that the lithologic separation from the Cedar Creek is largely arbitrary. Were the fauna not known, the lithologic differences would have no stratigraphic significance. MATTHEW realized this and stated (1901, p. 357) "The upper part of the formation is separated on account of the difference in fauna, but no stratigraphic demarcation can be made out, the beds becoming gradually finer and softer as we ascend, but retaining all their characters to the top." When reading this sentence of MATTHEW's, one should keep in mind the fact that MATTHEW's original concept of the White River formation in northeastern Colorado included the Horsetail Creek, Cedar Creek, and Martin Canyon beds as units. Therefore, he meant that not only was a lithologic break absent between the Cedar Creek beds and the Martin Canyon beds, but that deposition was continuous in the Martin Canyon beds. MATTHEW did, however, separate the Martin Canyon beds into lower and upper parts, of which the lower part is Whitneyan, and the upper part, thought by MATTHEW to be early Miocene in age, is Hemingfordian (Fig. 8).

ARIKAREEAN? DEPOSITS

Material referred to *Nothocyon* and *Mesocyon* reported by THORPE (1922) from northeastern Colorado is subject to too many conditional assumptions to have any value in correlation or identity of beds. Granting that the specimens came from northeastern Colorado, it is possible that they came from a burrow, fissure, or very small deposit in the Arikareean soil surface. If they came from northwestern Weld County, it is possible that an extension of the "Harrison beds" of Wyoming into the area would explain their presence here.

PAWNEE CREEK FORMATION

MATTHEW did not designate a type section for the Pawnee Creek beds. His published description (MATTHEW, 1901, p. 358) of the beds would fit the section at Martin Canyon, Sand Canyon (SW¼ sec. 25, T. 12 N., R. 55 W., Logan County), and Pawnee Buttes. Of these localities, we know that MATTHEW, in 1898, saw the section at Martin Canyon and may have seen the section at Sand Canyon. MATTHEW's field notes for 1898 have a description of the Pawnee Creek beds at Martin Canyon. The manuscript for his 1901 publication, which was completed prior to his visit to the Pawnee Buttes area in 1901, has a postscript, written following the 1901 field season, stating that the exposures in this area confirmed the stratigraphic conclusions set forth in the memoir. The fauna that accompanied the description appears to be a composite of specimens collected in the Martin Canyon, Sand Canyon, and Pawnee Buttes area. Probably more important is the fact that MATTHEW used the name "Pawnee Creek" very few times, mostly using the terms "Loup Fork" and "Protolabis beds" both in the text and the figure captions. This fact gives me the impression that the term "Pawnee Creek" was introduced into the paper after it was originally prepared. Support for this view is seen in the terms "Horsetail Creek beds" and "Cedar Creek beds," both of which were used as headings and not in the text, which leads me to think that these names were also introduced later. Whatever the significance of these introduced names may be, I think that it indicates that MATTHEW had the Miocene deposits in the Pawnee Buttes area in mind when he named the beds.[3] Subsequent publications and faunal lists leave no doubt that MATTHEW considered the beds and faunas at Pawnee Buttes, Sand Canyon, and Martin Canyon to be the Pawnee Creek beds and the Pawnee Creek fauna (MATTHEW, 1924). CURTIS HESSE, in a letter (September 27, 1940) to Dr. ROBERT W. WILSON, quotes Mr. H. T. MARTIN as saying that MATTHEW's type locality for the Pawnee Creek beds was in the area around the "old Eubanks Ranch house" which was in or near the NE¼ sec. 1, T. 10 N., R. 59 W., Weld County.

It is evident that the Pawnee Buttes area became the basis for the "Pawnee Creek" concept, and, although I cannot present an adequate description of the faunas (or fauna) and their stratigraphic levels, the type locality of the Pawnee Creek formation is designated as NE¼ sec. 1, T. 10 N., R. 59 W., Weld County, Colorado (see measured section I).

Pawnee Creek formation is used in this paper as a mapping unit for the known Miocene beds in Logan and Weld Counties. As used here, the term includes MATTHEW's Pawnee Creek beds and the Pawnee Creek fauna, and the upper part of his Martin Canyon beds with its fauna. This is an expedient to avoid further confusion in the use of the term Martin Canyon and to avoid the introduction of a new term prior to solving the stratigraphic and correlation problems in the area. It is difficult to determine whether or not MATTHEW's Pawnee Creek beds included "upper Martin Canyon beds" in other localities, but possibly they did at all points except in the Martin Canyon area. Questions pertaining to the faunas and the complexities of depo-

3. This may seem contrary to the reasons for putting the Horsetail Creek and Cedar Creek type sections in Range 53, but it must be remembered that MATTHEW was selecting names in all three cases and, in addition, shifted his concept of the typical Miocene beds to the Pawnee Buttes area.

sition make it inadvisable to separate the Pawnee Creek formation into members at present.

The Pawnee Creek formation is represented in northeastern Colorado by a series of valley fills which eventually covered most of the uplands of the old Oligocene surface. The oldest deposits (MATTHEW's upper Martin Canyon beds at Martin Canyon and ?Pawnee Creek beds at other localities) are seen in the bottoms of canyons cut into the Oligocene surface and consist of massive silt or fine consolidated sand in thin layers. Superficially these deposits resemble White River deposits in many ways, but on the whole they are noncalcareous and less indurated. Capping the silts is a widespread, coarse rubble bed composed mainly of fragments of gray nodules, probably locally derived from the weathered Oligocene surface. Overlying the channel rubble are beds of massive, sandy silts containing layers of nodular concretions, gravel lenses, and thin channel sandstone. Locally the rubble may be absent, and it is possible that similar sequences of channel fills are not contemporaneous. This is a problem that needs much more attention, but at present the sequence of beds (see measured sections) is such that the same depositional cycle for all the channel rubble is accepted until positive evidence to the contrary is discovered.[4] In some places the rubble is overlain by an olive-gray silt followed by the massive silts, and in still other localities the rubble seems to be replaced by the olive-gray silt in the depositional sequence.

This description of the beds is equally applicable to most exposures in Logan County and eastern Weld County. The exposures in the Pawnee Buttes area have not been studied in sufficient detail to allow a comparable statement to be made concerning them. At least part of the sequence of beds that occur above the channel rubble in Logan County seems to be duplicated in the Pawnee Buttes area. Farther west, in Range 65, a sequence of beds is seen that appears generally similar to that in Logan County, but no fauna has been collected from it by me. It may be that the *Nothocyon* and *Mesocyon* material was collected from this general area if, indeed, the specimens came from northeastern Colorado. Were such the case, then some of these post-Oligocene beds might be part of the Arikaree formation.

Although the statement that the description of the beds is equally applicable to most of the exposures in Logan County is true, exceptions exist in that the Pawnee Creek formation exposed east of the type section of the Vista member (Fig. 3) shows a thicker section of beds containing a Martin Canyon fauna, and those lying to the west of this area have thicker sections containing a Pawnee Creek fauna.

The upper part of the Pawnee Creek formation, more than the lower part, shows intermittent periods of cut and fill. The lithologic similarity of each phase of channel cutting and filling often makes correlation of the beds from one exposure to the next difficult and very uncertain over large areas. Intermittent deposition of Pawnee Creek sediments continued throughout Barstovian time and perhaps into Clarendonian time. At least the youngest deposits were laid down probably during the transition from Miocene to Pliocene time, or in earliest Pliocene time.

The "Martin Canyon" problem.—At the site of the American Museum's Merycochoerus Quarry in the bottom of Martin Canyon (MATTHEW, 1901, p. 398, fig. 17) there are silts that superficially match the Cedar Creek silts in near-by exposures, but that yield Miocene fossils. MATTHEW (1901, p. 372) considered deposition to be continuous from Oligocene into early Miocene time and named the Oligocene layers and the "horizon C" Miocene deposits at Martin Canyon (Fig. 8) the Martin Canyon beds (which were subsequently often referred to as lower and upper Martin Canyon beds, respectively). Later OSBORN (1909, p. 75) and MATTHEW (1909, p. 112) included all of the lower Miocene in this section. The arrangement has not been challenged, although H. E. WOOD, *et al.* (1941, p. 25) wrote of it as "a poorly defined formation? or group? or referable to the standard formations to the northeast?"; and SCHULTZ & FALKENBACH, after visiting the area, wrote (1947, p. 203) "although some of the sediments in the Martin Canyon area have a typical White River appearance, a part of the section appears to be equivalent to the Marsland of Nebraska because of the similarity in mammalian forms and in certain lithologic characters." It is evident that extensive Miocene channeling has taken place in the area and that all of the Vista member and part of the Cedar Creek member have been removed by erosion before the sediments carrying the Miocene fauna were deposited. The nearest exposures of the Vista member are more than one mile distant from Martin Canyon. Continuous deposition of sediments is an impossibility. (See tables of measured sections and figures showing these sections graphically.) The quarry beds, which are composed of fine sands in thin, laminated beds or of fine, massive, noncalcareous silt with small, carbonaceous root marks, resemble Oligocene silts but on close inspection are found to be clearly separate from them lithologically.

Considerable confusion has existed concerning the section in Martin Canyon (physiographically it is a gully). Actually a few feet of Orellan silts are exposed in the bottom of the gully into which are channeled MATTHEW's Martin Canyon beds consisting of one exposure, 25 by 75 feet (MATTHEW, 1901, lower part of fig. 17) where the American Museum quarry was located, and possibly including two or three other smaller exposures within a

4. A note in the description of measured section No. X bears on this question, and it will also be considered again in the discussion of the faunas and the correlation of the beds.

few yards of the site (whether or not MATTHEW was aware of similar exposures to the west is unknown). The remaining 115 feet of section is what MATTHEW considered to be Pawnee Creek beds or later deposits. Martin Canyon is a term that should be abandoned as a name for a lithologic unit. The section did not exist as described: the lower part is assigned to the White River formation, and lithologically the upper part cannot be distinguished from similar beds that grade into the Pawnee Creek formation. The fauna is Hemingfordian and not Arikareean in age.

OGALLALA FORMATION

The Ogallala formation was named by DARTON (1899, p. 734) from a locality in southwestern Nebraska. In 1905 (p. 178) he commented on its presence in northeastern Colorado. MATTHEW (1901, p. 359) observed the beds at the top of the section in the valley wall at Martin Canyon and at Pawnee Buttes and commented on their resemblance to the Ogallala deposits, but he included them and their fauna in the Pawnee Creek beds. LUGN (1939, p. 1262) defined and described, as the uppermost units of the Ogallala group, the Kimball and Sidney formations from deposits in Kimball County, Nebraska and commented upon their extension into northeastern Colorado. However, none of the beds specifically identified by LUGN are included in the measured sections.

At the top of the Pawnee Creek formation, at the edge of the valley wall, there are deposits of undetermined age that may be a part of the Kimball member and are referred to in this paper as Ogallala formation. The lowest bed of the Ogallala formation, where it is exposed in the valley wall in northern Logan County, is a thin-bedded sandstone one to two feet thick, but locally exceeding this thickness—two examples being 5 and 12 feet. With few exceptions, the bed is always present unless removed by erosion. Above this lies a massive, coarse-grained, tan sandstone which is consolidated and hard when not weathered. It normally ranges in thickness from 5 to 15 feet but in some places is absent. Capping the massive sandstone is a cherty and silty limestone, ranging from 1 to 24 feet in thickness. These thicknesses, and those given in the measured sections, are deceptive inasmuch as only the rock exposed on the plateau surface at the valley edge was measured. Above the exposed part of the limestone, between the valley edge and the Nebraska state line, loess and soil mantle the Ogallala deposits, which include the Kimball exposures listed by LUGN (1939).

There is no mammalian faunal evidence to suggest that beds of late lower Pliocene or middle Pliocene age are represented here in the Ogallala formation. It may be inferred that SCHULTZ & FALKENBACH (1947, p. 202) think that much of the Pawnee Creek formation is referable to the Valentine member of the Ogallala formation and is of Pliocene age. The Pawnee Creek formation is a mapping unit as I have used it, and it is entirely possible that part of it is equivalent to the Valentine; but until some means is found to differentiate the parts, there can be no value in mapping some of the Pawnee Creek as Valentine. Until SCHULTZ and FALKENBACH amplify their statements on the Ogallala beds at Pawnee Creek, it is necessary to assume that they place *Merychippus paniensis* and its associated fauna in either the Marsland equivalent beds or in the Pliocene Valentine. Further reference to the age of the beds will be treated in the section on faunal correlations.

PLEISTOCENE DEPOSITS

Although this paper is not concerned with the Pleistocene deposits in northeastern Colorado, the following comments are added in order to complete the description of the Cenozoic beds. Sand and gravel terraces of Nebraskan age are found near and at the top of the South Platte valley wall in several places, notably W½ sec. 22, T. 11 N., R. 52 W., sec. 36, T. 11 N., R. 53 W., and SE¼ sec. 21, T. 11 N., R. 55 W., Logan County.

Grand Island gravels with a Pearlette ash lentil are exposed in W½ sec. 11, T. 10 N., R. 51 W., Logan County. This locality is six miles north of the South Platte, and midway between the Platte and the valley wall to the north.

Younger deposits are found between the Grand Island exposures and the river.

Late Pleistocene loess mantles the uplands or High Plains to the north of the valley.

GEOLOGIC SECTIONS

The following stratigraphic sections, from Weld and Logan Counties, are arranged from west to east. Measured sections II-XVI are given graphically in Figure 6. Figure 7 shows the locality of these sections. All thicknesses were measured by hand level, unless otherwise indicated, and were taken to the nearest foot except for certain significant smaller measurements. None of the sections were measured upward higher than the appearance of grass and soil at the top of the bluffs.

I. *Section at "Eubanks Ranch House," Pawnee Buttes, NE¼ sec. 1, T. 10 N., R. 59 W., Weld County.*

	Thickness in feet
?Pawnee Creek formation:	
8. Gravel, lime cemented; and channel sandstone	11
Pawnee Creek formation:	
7. Sandstone, brown, fine; grades into localized layers of gray- or olive-colored silt which becomes sandy and indurated in places	49
6. Silt, brown to tan; divided into equal upper and lower parts by a 2-3 foot layer of hard, sandy or silty, gray limestone. Silt grades into localized patches of sand, gravel, or indurated sandstone	32

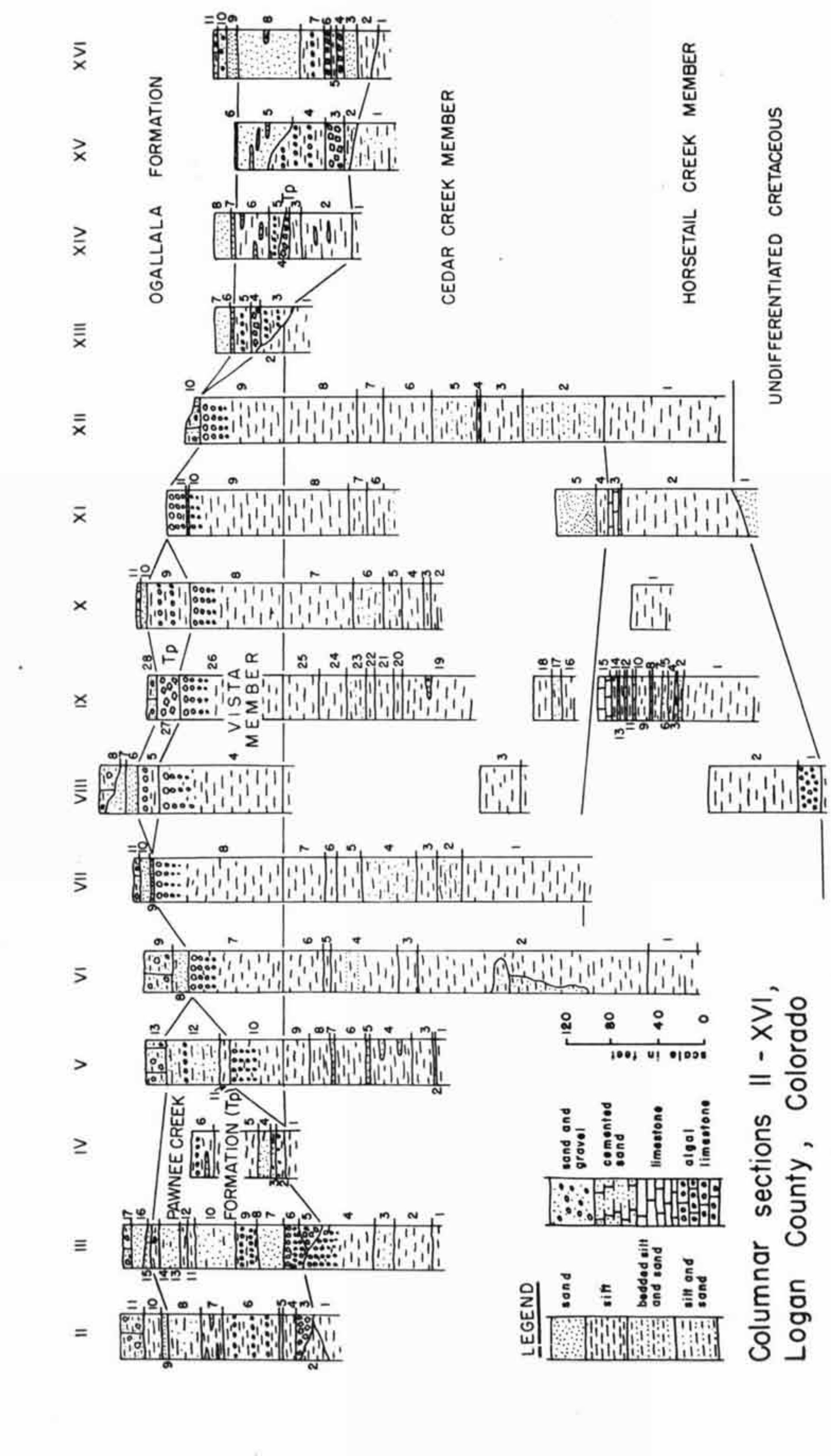


FIGURE 6.—Columnar sections Nos. II-XVI in Logan County, Colorado.

5. Silt, gray, limy, indurated; locally split into bands with soft, limy, gray silt between	16
4. Sand, brown to tan, locally soft or indurated; grades into silty limestone at top	28
3. "Pawnee Buttes" volcanic ash, weathered. Contains numerous fossil bones and teeth, especially of *Merychippus paniensis*	0–2
2. Sand, brown to tan, locally soft or indurated; grades into limy silt at top	17
White River formation:	
Cedar Creek member:	
1. Silt, tan, sandy, massive	Not measured

At least two volcanic ash falls are found in the Pawnee Buttes area. Miss ADA SWINEFORD, of the State Geological Survey of Kansas, supplied the data for the following descriptions of the two ash falls and suggested that distinctive names be attached to each—inasmuch as there is no definite evidence at present to demonstrate their similarity to any other ash fall.

Pawnee Buttes ash.—Sample collected from NE¼ sec. 1, T. 10 N., R. 59 W., Weld County. The refractive index is variable, but most of the shards are less than 1.504, whereas the Sheep Creek ash (from the type locality) has a refractive index of 1.505-1.507. The shards are not so elongate as the shards of the Sheep Creek ash, and the color is somewhat more orange. Miss SWINEFORD does not think that the impurities, mostly orange-stained quartz, can account for the difference in color. However, the Pawnee Buttes sample is slightly more weathered than the Sheep Creek sample, and that might change the color, reduce the index, and even make the shards more fragile so that the proportion of long ones is reduced.

Keota ash.—Sample collected from E½ sec. 34, T. 10 N., R. 59 W., Weld County. SWINEFORD reported the index of refraction of this ash as 1.499-1.500. It has curved and fibrous shards similar to those of the Pearlette ash, but its color is slightly pinker than typical Pearlette ash. It contains flakes of biotite. The stratigraphic position, age, and areal extent of this ash have not been determined.

II. *Section in Canyon in SW¼ sec. 26, T. 12 N., R. 55 W., Logan County.*

	Thickness in feet
Ogallala formation:	
11. Limestone, gray, thick, resistant; contains sand and silt	22
10. Silt, brown, sandy	16
9. Sandstone, tan, thin-bedded	5
Pawnee Creek formation:	
8. Silt, reddish-brown, soft, sandy; with restricted 2- to 6-inch thick channel sandstone occurring intermittently	27
7. Silt, tan-brown, indurated; grades into beds above and below where not separated by local channel sandstone	20
6. Sand and silt, tan, soft, fine; with calcareous nodules (often in layers), and gravel and sandstone lenses. Most productive fossil zone	49
5. Silt, grayish-olive	3
4. Silt, limy, often indurated	11
3. Cobble, grading into bed above	3–15
2. Silt, soft, fine	0–20
White River formation:	
Cedar Creek member:	
1. Silt, tan, massive	Not measured

III. *Section at "Sand Canyon," SW¼ sec. 25, and NW¼ sec. 33, T. 12 N., R. 55 W., Logan County.*

	Thickness in feet
Ogallala formation:	
17. Limestone, gray, massive to thin-bedded; contains some silt	5
16. Sand, tan, massive, coarse, with gravel lenses; both are consolidated and hard when not weathered	15
15. Sandstone, thin-bedded	2–5
Pawnee Creek formation:	
14. Silt, with hard, limy, irregularly shaped, gray nodules which thicken to a solid bed at the top	8
13. Sandstone or sandy silt, tan, massive, indurated; weathers with a honeycomb appearance	19
12. Silt, capped by a layer of limy nodules 6 inches thick	5.5
11. Silt, capped by a layer of limy nodules 6 inches thick	5.5
10. Sand or sandy silt, tan, massive, soft; with small, white, pipy concretions averaging ⅜-inch in diameter	38
9. Silt, with two layers of nodules 2 and 7 feet from base	16
8. Sand, gray, indurated; grades laterally into patches of consolidated gravels or limy silt. Surface weathers to a "knobby" or "warty" appearance. Bench forming	0.2–0.5
7. Sand, tan, massive, indurated; weathers to form a smooth cliff face	24
6. Silt, capped by solid layer of nodules; contains two layers of nodules 5 to 6 feet apart that form benches	18
5. Channel fill of cobble derived from weathered Oligocene nodules	0–15
White River formation:	
Cedar Creek member:	
4. Silt, tan, massive. Part of the upper surface shows weathering and formation of nodules, and at other points this old surface is eroded away. Wherever the nodular silts (No. 6) rest on the Oligocene beds not having nodules, there is a hard, resistant, 2-inch thick, limy layer	50–65
3. Silt, tan, stratified, hard, sandy	19
2. Silt, tan to pinkish, stratified, bench-forming	34
1. Silt, tan	Not measured

IV. *Section at east side of sec. 36, T. 12 N., R. 55 W., Logan County.*

	Thickness in feet
Pawnee Creek formation:	
6. Silt, brown, sandy; with large nodules and gravelly sandstone lenses	16
5. Silt, light brown, limy, indurated; weathers with a honeycomb appearance	38
4. Sand, brown, silty	11
3. Silt, indurated, sandy	4
2. Silt, gray-olive; with nodules grading into above bed	9
White River formation:	
Cedar Creek member:	
1. Silt, massive	Not measured

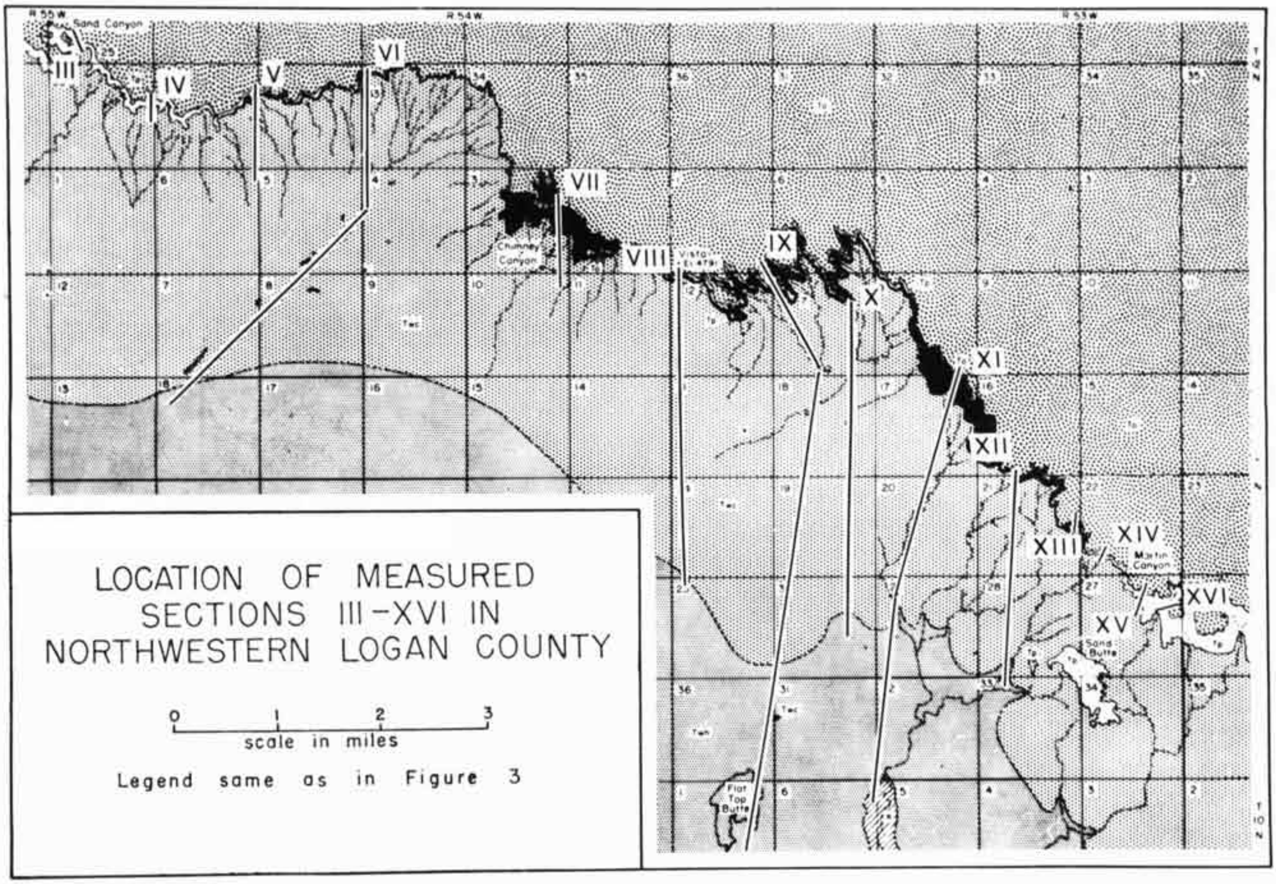


FIGURE 7.—Map showing location of measured sections Nos. III-XVI in Logan County, Colorado.

V. *Section in E½ sec. 31, T. 12 N., R. 54 W., and NE¼ sec. 6, T. 11 N., R. 54 W., Logan County.*

	Thickness in feet
Ogallala formation:	
13. Limestone, gray, thick, resistant; contains sand and silt	19
Pawnee Creek formation:	
12. Sand, brown, silty, with nodules	46
11. Silt, indurated, limy; with zones of gravel and sand that grade laterally into the gray silt, channel sandstone, and cobble capped by thin 2- to 6-inch channel sandstone	8
White River formation:	
Vista member:	
10. Silt, tan, massive; weathered at top and with highly calcareous zone at the bottom	46
Cedar Creek member:	
9. Silt, tan, massive	26
8. Silt, pinkish, laminated	20
7. Sandstone, dark red, resistant	1
6. Silt, pinkish, laminated	29
5. Sandstone, dark red, resistant	1
4. Silt, pink, laminated; with channel sandstone at top and channel of gray silt at bottom	39
3. Silt, pinkish-buff	21
2. Caliche-like zone	0.5–0.8
1. Silt, pink	Not measured

VI. *Section in W½ sec. 33, T. 12 N.; W½ sec. 4, N½ sec. 8, E½ sec. 7, and sec. 18, T. 11 N., R. 54 W., Logan County.*

	Thickness in feet
Ogallala formation:	
9. Limestone, gray, thick, resistant; contains sand and silt	24
8. Sand, limy, indurated; grading upward into soft silty sand	16
White River formation:	
Vista member:	
7. Silt, tan, massive; with weathered top zone and a highly calcareous zone at the bottom that appears white at a distance	79
Cedar Creek member:	
6. Silt, tan	38
5. Silt, pink	6
4. Silt, tan, massive; with 6-inch red zones 13 and 25 feet from top of the bed	58
3. Silt, red	19
Cedar Creek and Horsetail Creek members:	
2. Silt, whitish gray; grading upward into tan silt at about 60 feet from the top of the bed	200
1. Silt, whitish-gray; noncalcareous in upper part and containing a zone of nodules extending to within a few feet of the top	35
Not measured below this point.	

The bottom 35 feet of unit No. 2 and all of unit No. 1 were measured with an altimeter and cannot be considered as more than reasonable estimates of the true thicknesses of the beds.

Lateral to the point from which unit No. 2 was measured, there is a large prominent channel fill of red sandstone and silt whose top is 60 feet below the top of the silt—thus, in general, coinciding with the level at which the silt changes color from white to tan. The channel fill reaches thicknesses of 90 feet and more. Above the channel the beds continue as unit No. 3. The whitish-gray silt below the channel is probably part of the Horsetail Creek member, but the evidence to support this view needs more detailed study. To the west in Weld County this same channel cuts into definite Chadronian beds. Whitish silt lies below the channel.

VII. *Section at "Chimney Canyon" in E½ sec. 3, T. 11 N., R. 54 W., Logan County.*

	Thickness in feet
Ogallala formation:	
11. Limestone, gray, resistant; contains sand and silt	4
10. Sand, tan, massive	10
9. Sandstone, thin-bedded	2
White River formation:	
Vista member:	
8. Silt, buff, massive; with concretions in upper 30 feet and a highly calcareous zone at the bottom (referred to in this paper as the "white marker bed")	113
Cedar Creek member:	
7. Silt, buff, massive	37
6. Silt, reddish, sandy	11
5. Silt, tan	22
4. Silt, reddish, sandy	48
3. Silt, tan, massive	16
2. Silt, pinkish, sandy	22
1. Silt, gray, massive; grading into tan silt at the top and into pink, sandy silts and channel sandstones laterally	107
Not measured below this point.	

VIII. *Section in W½ secs. 12, 13, 24, and 26, T. 11 N., R. 54 W., Logan County.*

	Thickness in feet
Ogallala formation:	
8. Limestone, gray, resistant; contains sand and silt. (Top of this bed at this point has triangulation station Vista with elevation at 4,791 feet.)	6–14
7. Sand, tan, massive	14
6. Sandstone, thin-bedded	12
Pawnee Creek formation:	
5. Silt with layers of concretionary nodules	18
White River formation:	
Vista member:	
4. Silt, buff, massive; with concretionary nodules in upper part that weather to give the appearance of vertical fluting or stringers	110
Cedar Creek member:	
Grass covered valley wall and floor interval of approximately	170
3. Silt, tan; interbedded with areas of reddish, sandy silts	35
Section continued from well log of Haley-Smith Well No. 1 in NW¼ NE¼ sec. 26, T. 11 N., R. 54 W., Logan County. Elevation 4,254 feet. Valley floor interval approximately	170
Horsetail Creek member:	
2. "White clay"	75
1. "Gravel"; resting on Pierre shale	20

IX. *Section in NE¼ sec. 12, T. 11 N., R. 54 W.; W½ sec. 7, T. 11 N., R. 53 W.; E½ sec. 36, T. 11 N., R. 54 W., and N½ sec. 1, T. 10 N., R. 54 W., Logan County.*

	Thickness in feet
Ogallala formation:	
28. Limestone and thin-bedded sandstone	6
Pawnee Creek formation:	
27. Cobble channel fill; derived from weathered Oligocene surface	20
White River formation:	
Vista member:	
26. Silt, buff, massive; with concretionary nodules in upper 25 feet and highly calcareous zone at the bottom that appears white at a distance	90
Cedar Creek member:	
25. Silt, brown	32
24. Silt, tan; with barite crystals	24
23. Silt, reddish, resistant, sandy	17
22. Silt, dark tan, massive	11
21. Silt, pinkish-tan	16
20. Silt, pink	5
19. Silt, tan, massive; grading into laminated, sandy silt at top and containing tan and gray channel sandstone 27 feet from top	62
Section continued 3⅕ miles south at top of peak in sec. 36, T. 11 N., R. 54 W. Valley floor interval	57
18. Silt, brown, massive	15
17. Silt, reddish, resistant, sandy	9
16. Silt, tan, massive	11+
Section continued on "Flat Top," a butte in sec. 1, T. 10 N., R. 54 W. Valley floor interval	21
Horsetail Creek member:	
15. Limestone, hard, resistant	5
14. Silt, gray	7
13. Limestone, white, chalky, soft; weathers into large slabs	2
12. Silt, gray	7
11. Same as No. 13	2.5
10. Silt, gray	7
9. Same as No. 13	2.5
8. Silt, pink; grading upward and laterally into gray silt	14
7. Limestone, olive-gray, fine textured	1
6. Silt, pink; grading upward into gray silt,	8
5. Silt, pink; interbedded with sandy silts,	8
4. Silt, reddish-brown	3–4
3. Silt, olive-colored, resistant	3–4
2. Silt, pinkish-tan, sometimes sandy	3–4
1. Silt, gray-white, massive	60+
Section not measured below this point.	

X. *Section in E½ sec. 7, T. 11 N., R. 53 W., Logan County.*

	Thickness in feet
Ogallala formation:	
11. Limestone, gray, resistant; contains sand and silt	1.5
10. Sand, tan, massive	5
Pawnee Creek formation:	
9. Silt; with layers of concretionary nodules resting on cobble channel 5-15 feet thick or next lower bed	38
White River formation:	
Vista member:	
8. Silt, tan, massive; capped by a 2-foot layer of mudstone and containing brown concretionary nodules in upper 10 feet.	

Lower part highly calcareous giving a white appearance to the beds at a distance	81
Cedar Creek member:	
7. Silt, tan, massive; with narrow, red zone at bottom	62
6. Silt, pinkish and tan, sandy; with sandstone stringers	27
5. Silt, tan, sandy	16
4. Silt, tan	21
3. Silt, tan; with reddish zone at bottom	5
2. Silt, pinkish	5
Exposure continued, but beds not measured below this point. Section continued in E½ sec. 30, T. 11 N., R. 53 W. Position as shown in Figure 6 is approximate.	
Horsetail Creek member:	
1. Silt, gray	30
Not measured below this point.	

On either side of unit No. 9 of this measured section there are local areas in which there are no Pawnee Creek deposits. Also, there are local areas where the cobble channels are repeated and are in association with the massive limestone (unit No. 11). At one point the limestone overlies a local silt deposit containing seeds of *Biorbia fossilia*. However, I have not been able to get a traceable sequence of silt, cobble, and limestone, or cobble, silt, and limestone, as the case may be, that contains either plant or animal fossils. Until this is done, part of the rubble beds mapped as Pawnee Creek formation from the E½ sec. 2, T. 11 N., R. 54 W., to the W½ sec. 8, T. 11 N., R. 53 W., should be considered possibly as part of the Ogallala formation.

XI. *Section in N½ sec. 17, T. 11 N., R. 53 W., Logan County.*

	Thickness in feet
Ogallala formation:	Not measured
White River formation:	
Vista member:	
11. Silt; with gray nodular concretions that weather to form vertical columns to give a fluted appearance	14
10. Mudstone	3
9. Silt, tan, massive; with brown, concretionary nodules in upper 8 feet and a highly calcareous zone in the bottom 11 feet that appears white from a distance	80
Cedar Creek member:	
8. Silt, tan	59
7. Silt, reddish-tan; with barite crystals	15
6. Silt, tan, sandy	16
Exposure continued but bed not measured below this point. Section continued in W½ sec. 29, W½ sec. 32, T. 11 N., and E½ sec. 6, T. 10 N., R. 53 W. Correlated horizontally with measured sections on either side.	
5. Sandstone, red, massive, resistant; with prominent cross-bedding and internal channeling	35
4. Silt, red	10
Horsetail Creek member:	
3. Limestone; four one-foot thick, gray-green, fine-textured beds separated by three olive-gray silt beds	10
2. Silt, whitish-gray, massive	100
Cretaceous deposits:	
1. Sandstone, khaki-colored, soft, thin-bedded	Not measured

XII. *Section in W½ sec. 21, W½ sec. 28, and W½ sec. 33, T. 11 N., R. 53 W., Logan County.*

	Thickness in feet
Ogallala formation:	
10. Limestone, gray, resistant; contains sand and silt	5–10
White River formation:	
Vista member:	
9. Silt, tan, massive; with upper 20 feet weathered and nodular; white marker at base	70
Cedar Creek member:	
8. Silt, tan	65
7. Silt, pink	24
6. Silt, tan	43
5. Sand and silt, pink and tan	41
4. Silt, olive-gray	2
3. Silt, tan	38
2. Sandstone and silt, red and pink	71
Horsetail Creek member:	
1. Silt, white to gray, massive	100
Exposures continued but beds not measured below this point.	

XIII. *Section in NE¼ of SE¼ sec. 21, T. 11 N., R. 53 W., Logan County.*

	Thickness in feet
Ogallala formation:	
7. Sand, coarse	15
6. Sandstone, thin-bedded	2
Pawnee Creek formation:	
5. Silt, gray; with layers of concretionary nodules	15
4. Nodular rubble; in channel cut into next lower bed and Oligocene beds	8
3. Silt, tan; with layers of tan concretionary nodules; channeled into Oligocene beds	0–30
White River formation:	
Vista member:	
2. Remnants of "white marker" zone	0–20
Cedar Creek member:	
1. Silt, buff	Not measured

It should be noted that here none of the Oligocene beds have a weathered upper zone, a fact shown by the absence of nodular concretions.

XIV. *Section in SW¼ of sec. 22, T. 11 N., R. 53 W., Logan County.*

	Thickness in feet
Ogallala formation:	
8. Sand, coarse	15
7. Sandstone, thin-bedded	2
Pawnee Creek formation:	
6. Silt, limy, indurated; or sand with channel gravel; at places is caliche-like or bears nodules	30
5. Silt; with layers of nodules	9–15
4. Cobble derived from weathered Oligocene nodules	1–6
3. Silt, limy; alternately indurated or soft layers	13
2. Silt, tan, massive, soft; with lenses of sand and gravel	44
White River formation:	
Cedar Creek member:	
1. Silt	Not measured

XV. *Section in west side of Martin Canyon, NW¼ of NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.*

	Thickness in feet
Ogallala formation:	
6. Sandstone, thin-bedded	1
Pawnee Creek formation:	
5. Sand, soft or indurated, limy; with channel fills of gravel or sandstone. Contact with underlying beds marked by thin, warty sandstone, gravelly sandstone, or channel fills of hard, thin-bedded, limy silts	28–55
4. Silt, noncalcareous; at this point more or less equally divided into four parts by three layers of nodular concretions	49
3. Cobble, derived from weathered Oligocene nodules	15
2. Silt and sand	6–11
White River formation:	
Cedar Creek member:	
1. Silt, tan, fine or sandy	35
Base of exposures covered by post-Tertiary deposits.	

Quarry A of the University of Kansas is located in unit No. 4 between the first and second layers of nodular concretions and is the source of the greater part of the Martin Canyon local fauna.

XVI. *Section in east side of Martin Canyon, NE¼ of NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.*

	Thickness in feet
Ogallala formation:	
11. Limestone, gray, massive, cherty	2
10. Sand and gravel, coarse	8
9. Sandstone, thin-bedded	5
Pawnee Creek formation:	
8. Sandstone, fine, brown; with consolidated channel gravels	55
7. Silt, with concretionary nodule layers	21
6. Rubble, nodular	5
5. Mudstone	4
4. Rubble, nodular	5
3. Sand, tan, fine, consolidated; in thin layers	14
2. Silt, hard, massive	10–20
White River formation:	
Cedar Creek member:	
1. Silt, pink	5
Base of beds covered by wash of valley floor.	

This section is measured practically through the middle of the deposits shown in the photograph by MATTHEW (1901, p. 398, fig. 17). The American Museum Merycochoerus Quarry is in unit No. 2. In unit No. 10 a type of opalized rock occurs that is characteristically present below the algal limestone in Wallace and Norton Counties, Kansas, in beds judged to be of "Kimball" age.

XVII. *Section in W½ sec 16, T. 10 N., R. 51 W., Logan County.*

	Thickness in feet
White River formation:	
Horsetail Creek member:	
3. Silt, tan; grades into unit No. 2 below, but possibly channel sandstones separate units 2 and 3 locally	16
2. Silt, white	49
1. Silt, gray, with sandstone lenses and zones of pinkish-gray silt	50
Exposures continue downward but are obscured by valley fill at this point.	

Beds No. 1 and No. 2 carry titanothere bones, but nothing diagnostic was found in bed No. 3. Possibly No. 3 is the equivalent of the earliest Cedar Creek beds farther west.

ORIGIN OF THE BEDS

MATTHEW's demonstration (1901, p. 359) that the White River deposits were not lacrustrine in origin is now classic. In contrast to the theory prevailing at that time, he placed emphasis upon aeolian mechanics in accounting for the deposition of the unlaminated silts. This interpretation was based upon comparison of the White River deposits with "loess" of the High Plains and other regions. Neither he nor anyone else at that time knew that part of the High Plains deposits—called loess because of lithologic appearance—was actually redeposited loess and other accumulations of fine materials. That the White River deposits are partly the result of aeolian action is not questioned, and that some of the wind-borne deposits remained undisturbed is not questioned, but I think that a greater part of the originally wind-borne deposits was reworked by sheet flood, colluvial action on slopes, and fluvial action of aggrading streams in the valleys, and that this same action also applies to fine material derived from local sources that was never wind-borne at any time. That the Whitneyan deposits may be aeolian in a strict sense is a possibility that deserves inspection. It should also be kept in mind that these statements are applicable only to northeastern Colorado.

The post-Oligocene Tertiary beds are, for the most part, channel fills and flood plain deposits.

THE FAUNAS

The following Tertiary faunas are discussed in this paper. For their position in the Tertiary rock column see Figure 8.

- Faunas of the White River formation
  - Horsetail Creek fauna
  - Cedar Creek fauna
  - Vista fauna
- Faunas of the Pawnee Creek formation
  - Martin Canyon local fauna
  - Eubanks local fauna
  - Kennesaw local fauna
  - Vim-Peetz local fauna
  - Sand Canyon local fauna

Information is too scanty, or too unreliable, to permit one to discuss, as a faunal unit, the specimens reported by THORPE (1922) that possibly came from Arikareean beds.

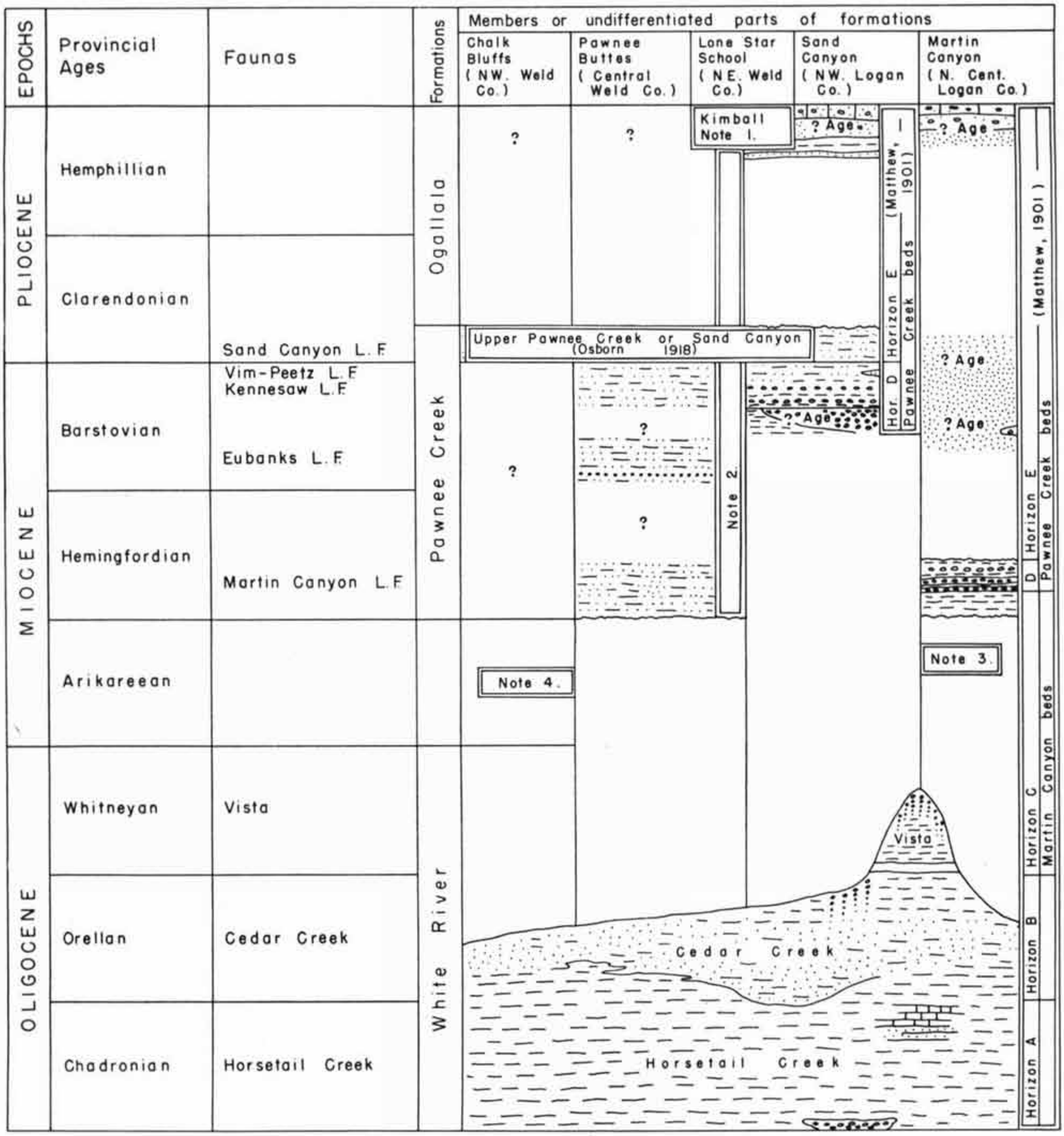


FIGURE 8.—Chart showing the Tertiary faunas and deposits and their relationship to the Tertiary time scale. The boxes (except note 4) contain the opinions and terminology used by other workers.

Note 1. LUGN (1939) listed only one specific occurrence of the Kimball member in northeastern Colorado, but stated that the deposits were widespread.

Note 2. MATTHEW referred all the beds in this area to the Pawnee Creek, without differentiating them as horizon D or E. OSBORN (1918) referred all the beds below upper Pawnee Creek to lower Pawnee Creek, or Pawnee Creek A, of middle upper Miocene age. SCHULTZ & FALKENBACH (1947) referred all the beds to the Ogallala, except the lower part of the section, which was considered a remnant of Marsland or "Martin Canyon" beds.

Note 3. MATTHEW thought there was continuous deposition from Oligocene through lower Miocene time at this point.

Note 4. Evidence for an Arikareean formation is not conclusive.

FAUNAS OF THE WHITE RIVER FORMATION

Never since the early explorations by MARSH has there been any doubt that faunal zones, roughly comparable to those in the Oligocene beds of Nebraska and South Dakota, existed in northeastern Colorado. The divisions were simple: Titanothere beds or zone, Oreodon beds or zone, and Leptauchenia beds or zone [the last being introduced, as the lower part of horizon C or upper White River, for this area by MATTHEW (1899, p. 51)].

The change in the mammalian population from one level to the next in the White River formation is effected by change in facies, by gradual or rapid extinction, by introduction of migratory species, and by evolution of resident species. The sediments, representing a more or less continuous period of deposition, show two important facies. One facies, massive silt, interfingers with the second facies, which may be thin-bedded silt, channel fill of sand and gravel, or lenses of freshwater limestone and olive-gray silt (marsh and pond deposits). The changes in facies are local and reflect the proximity of different environments, which has led to a mixing of the faunas found in each facies. The faunal units, although united by having numerous genera in common, are distinguished from each other by the restriction of some genera to only one or two of the faunas, and by restriction to a single age of certain species which belong to relatively long-lived genera. The genera and species common to two or more of these faunas suggest, however, a short time interval for each successive faunal stage and a close relationship of all the faunas. This situation is even more strikingly exhibited by the upper Miocene faunas in the region.

The comparison of the Oligocene faunas in northeastern Colorado with adjacent faunas in other parts of the High Plains shows that there was no isolation of the northeastern Colorado faunas. The absence of such genera as *Metamynodon* and *Protoceras*, and the rarity of anthracotheriids and agriochoerids suggest important environmental differences between the Oligocene faunas of northeastern Colorado and other regions — especially those of South Dakota and Nebraska.

HORSETAIL CREEK FAUNA

The mammalian fauna of the Horsetail Creek member is composed of the following species:

Peratherium fugax
Apternodus iliffensis, n. sp.
Palaeolagus intermedius
Pelycomys rugosus, n. gen. and sp.
Ischyromys troxelli
Titanotheriomys cf. *T. veterior*
Titanotheriomys? sp.
Adjidaumo sp. (Small form)
Paradjidaumo trilophus
Pseudocynodictis nr. *P. paterculus*
Parictis nr. *P. dakotensis*
Dinictis sp.
Mesohippus proteulophus
Mesohippus sp.
Megacerops acer
Hyracodon sp.
Trigonias osborni
Caenopus premitis
Caenopus mitis [5]
Stibarus obtusilobus
Stibarus lemurinus
Archaeotherium ramosus [5]
Archaeotherium potens [5]
Archaeotherium mortoni
Archaeotherium crassum
Perchoerus nr. *P. minor*
Anthracotheriid sp.
Merycoidodon culbertsonii
Merycoidodon gracilis
Eotylopus sp.
Poëbrotherium sp.
Leptomeryx esulcatus
Leptomeryx evansi
Hypisodus sp. (Form A)

GREGORY & COOK (1928, p. 3) considered the beds at the Denver Museum's Trigonias Quarry to be in the "Lower Chadron formation." HORACE E. WOOD (1931, p. 415) considered the titanothere zone to be an equivalent of the early Chadron beds in South Dakota. Since these opinions were stated, CLARK (1937) has listed the faunas of the lower, middle, and upper Chadron beds of South Dakota. There is not too much in common between the faunas of South Dakota and northeastern Colorado, but if the rarity of Chadronian fossils, the poor preservation, and the probable facies and locality differences are considered, this does not cause surprise. The presence of *Trigonias osborni* and *Archaeotherium crassum*, which CLARK thought might be restricted to the middle Chadron member, is evidence of an equivalent middle Chadronian age for the Horsetail Creek member. On the other hand, the similarity of the species to the upper Chadron fauna should not be overlooked. Neither should the fact be overlooked that the Horsetail Creek fauna represents an advance over the Pipestone Creek fauna, especially in the presence of Orellan species. In fact, at some localities, the only non-Orellan aspect of the fauna is the absence of *Eumys* and *Hypertragulus* and the rare occurrence of titanotheres. In my opinion, the Horsetail Creek fauna is not older than middle Chadronian and more probably represents a late Chadronian phase.

CEDAR CREEK FAUNA

Tentatively, the Cedar Creek fauna has been divided into lower, middle, and upper parts. Perhaps the division should not be made, inasmuch as only a few of the species are restricted to any one level. The divisions will be used, however, for their possible future value. Some of the species, for which there are no data as to level at present, may serve to accentuate the difference between the three units when better collections are made. It should be pointed out that these divisions are limited to the

5. Occurrence probably here rather than in the Cedar Creek member, but not yet demonstrated.

area in northwestern Logan County that was studied in detail (Fig. 9). The mammalian fauna is distributed in the three parts as follows:

	Lower	Middle	Upper[6]
Nanodelphys minutus	1[7]		
Metacodon magnus	1		
Ankylodon annectens	X		
Palaeolagus haydeni	X		
Titanotheriomys? sp.[8]	X		
Adjidaumo minutus	X		
Heliscomys vetus	X		
Proheteromys? sp.	1		
Agnotocastor coloradensis	X		
Eumys obliquidens	X		
Hyaenodon crucians	X		
Hyaenodon mustelinus	1		
Perchoerus nr. *P. nanus*[9]	1		
Poëbrotherium labiatum	X		
Peratherium huntii	X	X	
Peratherium fugax[8]	X	X	
Ictops sp.	X	X	
Metacodon mellingeri	X	X	
Ankylodon progressus, n. sp.	1	1	
Domnina gradata	X	X	
Domnina compressa, n. sp.	1	1	
Prosciurus relictus	X	X	
Ischyromys typus	X	X	
Paradjidaumo trilophus[8]	X	X	
Eumys nr. *E. exiguus*	X	X	
Pseudocynodictis gregarius	X	X	
Mesohippus eulophus	X	X	
Hyracodon sp.[8, 9]	X	X	
Subhyracodon occidentalis	X	X	
Stibarus lemurinus[8]	X	X	
Leptochoerus spectabilis[9]	X	X	
Archaeotherium mortoni[8]	X	X	
Merycoidodon spp.[8]	X	X	
Poëbrotherium wilsoni	X	X	
Hypertragulus calcaratus	X	X	
Hypisodus minimus	X	X	
Leptomeryx esulcatus[8]	X	X	
Leptomeryx evansi[9]	X	X	?
Palaeolagus intermedius[8, 9]	X	X	X
Megalagus turgidus	X	X	X
Eumys elegans (*s. l.*)	X	X	X
Cedromus wardi and *Cedromus* sp.	X	1	1
Proscalops sp. (Small form)		1	
Arctoryctes?		X	
Pelycomys placidus, n. gen. and sp.		X	
Heliscomys tenuiceps		1	
Diplolophus sp.		2	
Daphoenus cf. *D. vetus*		1	
Palaeogale lagophaga		2	
Drassonax harpagops, n. gen. and sp.		1	
Dinictis sp.		1	
Heptacodon sp.		1	
Leptomeryx sp. (Small form)		X	
Palaeolagus burkei[9]		X	X
Hyaenodon horridus		1	1
Pseudocynodictis lippincottianus		X	1
Protomeryx campester[9]			(?)1
Hypisodus sp. (Form B)			X

This list shows that the lower and middle zones carry closely comparable faunas. The interfingering of stratified silts and sands with unlaminated silts in the lower zone, and their gradual encroachment upon unlaminated silts which results in the widespread sandy silts and channels of the middle zone present a definite facies problem. However, most of the known species are common to the two types of deposits in both the lower and middle zones, which would suggest that the differences between the vertical zones are of greater importance than the possible facies differences. In the lower zone the distribution of the species (with the exception of *Subhyracodon*, *Perchoerus*, and *Agnotocastor*, which were found in a "pond" type of deposit) between the unlaminated clays and the interfingering sandy silts shows that the environmental differences were not great enough to reflect a distinct stream border fauna. The species, especially *Palaeolagus haydeni*, restricted to the lower zone probably are reliable indicators of that zone. Carnivores and perissodactyls are rare. The abundant remains of rodents, artiodactyls, and lizards indicate the presence of ecological niches similar to those on the High Plains today. Of course, some of this abundance reflects the fact that there are more unlaminated silts than laminated sandy silts in the lower zone.

With the encroachment of sandy silts and channel deposits over the whole area there seems to have been a definite change in the environment. The presence of *Subhyracodon occidentalis* and *Heptacodon* suggests that the streams involved in this change must have been larger and less transitory than before. Carnivores show a greater diversity of kinds and were more abundant than the figures in the faunal list would indicate (the list being, with few exceptions, a record of my personal collecting). Many of the species listed from the middle zone alone may actually be restricted to it. That this may be so is suggested by the fact that the few well-developed channel and silty phases in the lower level would provide an equally favorable environment. On the other hand, the extreme rarity of individuals of some of the species found only in the middle zone suggests that they may be present but undiscovered in the lower zone.

The occurrence of *Palaeolagus haydeni* and *Palaeolagus burkei* deserves special mention. Regardless of lithology of beds, *Palaeolagus haydeni* has a widespread distribution in the lower beds of the Cedar Creek member and then rather abruptly disappears at the top of the lower zone. Almost as abruptly *Palaeolagus burkei* appears and continues to be present throughout the remainder of the Oligocene section—regardless of lithology of beds or environment. So far I have found these two species to be excellent index fossils, but my observations were made only on exposures in Logan County (Ranges 53 and 54 West) where each exposure was divided into five-foot vertical intervals and the specimens were collected as a unit from each interval. While it is obvious that *Palaeolagus burkei* replaced *Palaeolagus haydeni* in the fauna at these exposures, so many factors affect observations of

6. The vertical range of these three zones is shown in Figure 9.
7. Numeral indicates number of specimens of species rare in northeastern Colorado.
8. Present in Horsetail Creek member.
9. Present in Vista member.

this kind that much more detailed work over a larger area, and a better understanding of the relationship of the unlaminated silts to the interfingering sandy silts and channel fills, would be required to make any generalization about the abruptness of this change in the *Palaeolagus* population in particular, and about its correlation with changes in the Cedar Creek fauna in general.

The beds of the upper part of the Cedar Creek member consist of fine massive silt, frequently cliff-forming, so that specimens are rare as float. Consequently, not enough of the fauna from the upper zone is known to show whether or not a faunal change took place that would be in keeping with the lithologic change. At present the only criterion of the upper zone is the fact that it is composed of massive silt.

This attempt to divide the Cedar Creek member and its fauna into three parts will have value for purposes of regional correlation if the fauna in each of these parts is the result of something more than local environmental or facies change. The lithologic and faunal separation of the lower and middle parts of the Cedar Creek is based on the change from a predominantly massive silt facies to a predominantly thin-bedded, sandy silt facies and on the change in the *Palaeolagus* population, that coincides, generally, with the level at which the sandy silt facies becomes widespread.[10] The separation of the middle and upper parts of the Cedar Creek member is based on the change from the sandy silt facies to the massive silt facies. I have already pointed out that specimens from the massive silt facies are rare and that it cannot be determined whether or not a distinctive faunal change took place. It is of interest to recall that SCHULTZ & STOUT (1938) pointed out that there was a hiatus in deposition between the Orella and Whitney members in northwestern Nebraska; and that BARBOUR & STOUT (1939, pp. 30-31) stated: ". . . the recent collections of the University of Nebraska State Museum disclose that . . . [*Ischyromys pliacus* and *Diplolophus*] . . . are both probably good index fossils for the uppermost faunal level of the middle Oligocene in northwestern Nebraska." In this area of Logan County under discussion there is continuous deposition of beds from Orellan time into Whitneyan time; and the occurrence of *Ischyromys* specimens similar to *Ischyromys pliacus*, as

10. Whether or not change in the *Palaeolagus* population, similar to that in the Cedar Creek in northeastern Colorado, takes place in other middle Oligocene beds is not known.

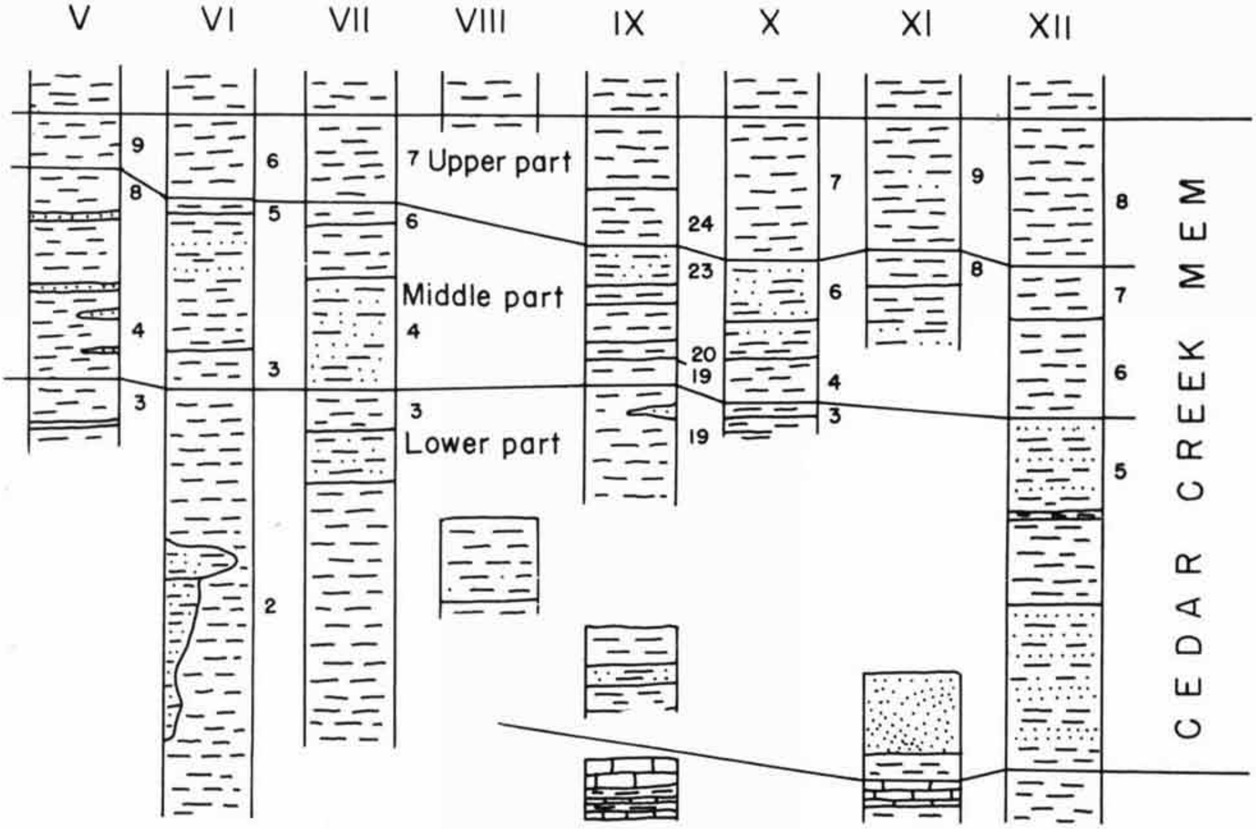


FIGURE 9.—Modified diagram of the columnar sections of Figure 6 showing the approximate vertical ranges of the lower, middle, and upper divisions of the Cedar Creek member.

well as the rare occurrence of *Diplolophus,* is at the top of the sandy silt phase. It may be that the period of deposition of the massive silt of the upper part of the Cedar Creek member corresponds to the erosional interval between the Orella and Whitney members in Nebraska.

VISTA FAUNA

The Vista fauna is scanty, and the fossils are individually rare. The fauna is significant, however, in that *Perchoerus* is the only genus present that is supposed to have been restricted to the vicinity of stream or river valleys. The absence of anthracotheres, entelodonts, *Subhyracodon,* and *Protoceras* further emphasizes the similarity of the Vista fauna to the "clay fauna" of MATTHEW (1901, p. 370), which he thought to be analogous with the fauna of the modern plains. This view is supported by the lithology of the Vista member.

Peratherium nr. *P. fugax*
Proscalops miocaenus
Palaeolagus intermedius
Palaeolagus burkei
Eumys brachyodus
Pseudocynodictis temnodon
Miohippus sp.
Hyracodon sp.
Leptochoerus spectabilis
Perchoerus nr. *P. nanus*
Eporeodon major
Leptauchenia decora
Protomeryx campester
Leptomeryx evansi
Hypisodus sp. (Form B)

FAUNAS OF THE PAWNEE CREEK FORMATION

The Pawnee Creek formation, a complex of flood plain accumulations and channel fills, covers a range of time from middle Miocene to late Miocene or possibly earliest Pliocene. The very nature of these deposits and their span of time make determination of the faunal zones and their correlation with other faunas a problem whose solution depends on a knowledge of many definitely identified and (stratigraphically) correctly placed fossils. Unfortunately, the Pawnee Creek formation is rich in species and poor in specimens with adequate morphologic and stratigraphic data. With exception of the Martin Canyon fauna, too few fossils have been found in the formation by me, and the published information and museum records are too inadequate or contradictory to satisfactorily establish the vertical and areal distribution of all the species. The complete answer can come only when, if ever, we have additional information concerning the earlier finds, when we have a surer means of identifying referred material, and when we have a better knowledge of the range of variation in the species — a knowledge gained by utilizing specimens from known localities and levels correlated with geological history. These additional data will then permit a re-evaluation of the species and a closer correlation of the faunas of northeastern Colorado with other faunas. The studies of mammalian groups, and their correlations, that have been made for other High Plains Miocene deposits do not appear adequate as yet to solve the problems found in northeastern Colorado. The University of Kansas Museum of Natural History is engaged currently in carrying out this phase of Tertiary research in northeastern Colorado.

COLBERT (in OSBORN, 1942, p. 1491) summarized the early work and opinions concerning the Pawnee Creek fauna made by MATTHEW and OSBORN thus:

> Dr. Matthew, in his first description of the Pawnee Creek beds of northeastern Colorado, recognized two fossiliferous layers or zones within the formation, but at that time he pointed out the fact that the separation between these zones, either stratigraphically or faunistically, was very inconstant, so he was inclined to regard the zoning of the Pawnee Creek beds as of little importance. Later, in 1909, in 1918, and in 1924, he regarded the Pawnee Creek formation as a unit containing a single fauna.
>
> Professor Osborn, however, held to the view that the Pawnee Creek formation consists of two levels, which he designated as "A" and "B," for the lower and upper divisions respectively. This view was expressed in 1918, in the monograph on the Tertiary Equidae of North America, . . .

In what was the first detailed study of the Miocene fossils of northeastern Colorado as a faunal unit, MATTHEW (1901) tried to divide the Pawnee Creek beds into what he called "horizon D" and "horizon E." An evaluation of MATTHEW's field notes, of museum records of specimens, and of my own observations on the Pawnee Creek formation shows that beds Nos. 4-6 of measured section II in this paper, 6-12 in section III, 2-6 in section IV, 11-12 in section V, 4 in section XV, and 7 in section XVI probably correspond to MATTHEW's description of "horizon D" (1901, p. 358, last paragraph). All the beds above this level, including the Ogallala formation, seem to correspond to "horizon E" (1901, p. 359, first paragraph). "Protolabis beds," a term used by MATTHEW, seems to refer to all or part of "horizon D." That MATTHEW considered the stratigraphic sequence west of Sand Canyon to be equivalent to the sequence at Martin Canyon seems substantiated by the faunal lists for "horizon D" and "horizon E" which show that the collections from these two localities were listed together. I am rather confident that MATTHEW got the idea of two faunal zones from fossils collected at Sand Canyon and Martin Canyon, and the idea that the zones could be separated stratigraphically from observation of the deposits at Martin Canyon. To realize fully why MATTHEW abandoned the concept of faunal zones, one must understand that "horizon D" at Martin Canyon is Hemingfordian in age and that "horizon E" is younger—including beds of latest Barstovian and ?late Hemphillian age (Fig. 8). On the other hand, although there may be Hemingfordian exposures in the Sand Canyon area, the beds, which I think MATTHEW correlated with "horizon D" of Martin Canyon, are middle to late Barstovian in age. "Horizon E" at Sand Canyon was even younger—the part in the Pawnee Creek formation being latest Barstovian, with possibly a Miocene-Pliocene transitional stage or earliest Pliocene. This confusion was compounded by the fact that the Pawnee Creek beds at Pawnee Buttes, which MATTHEW thought had a homogeneous fauna, contain species found in each of the local faunas described in this paper. The initial error in correlating the Hemingfordian fauna at Martin Canyon with the late Barstovian fauna at Sand Canyon and the close relationship between the faunal zones in the Barstovian deposits inevitably led to a union of the fossils as one fauna.

Oddly enough, the beds that prompted MATTHEW to give up zoning the Pawnee Creek formation contained the faunas that suggested two zones to OSBORN. To OSBORN, the "typical" Pawnee Creek fauna was represented by the *Merychippus paniensis* zone (Eubanks local fauna of this paper and at least some of the species in the Kennesaw local fauna). The "Upper Pawnee Creek" or Sand Canyon fauna was represented by fossils considered to be Pliocene in age and included at least part of the fauna of MATTHEW's "horizon E" at Sand Canyon. MATTHEW continued, as stated by COLBERT, to regard the all inclusive Pawnee Creek fauna as homogeneous. In his comparison of the Pawnee Creek fauna with the lower Snake Creek fauna [11] (1924, p. 72), he specifically referred to the fossils that are now regarded as older or younger than the fauna of the *Merychippus paniensis* zone at Snake Creek but concluded that "The differences between the two faunas are probably only facies, due to some environmental difference, geographic range, or selective action of different conditions of sedimentation." Although it has not always appeared so in print, most workers, other than MATTHEW, thought that all of the Hemingfordian fossils, especially *Merycochoerus proprius magnus*, from northeastern Colorado came from the "upper Martin Canyon beds," and not the Pawnee Creek beds. COLBERT (1943, p. 303) was of the opinion that the specimens of *Merychyus elegans* from Martin Canyon had been assigned the wrong age and concluded that they were obtained from the Martin Canyon beds of lower Miocene age, thus removing them from the Pawnee Creek fauna. Less specific doubt concerning the homogeneity of the Pawnee Creek fauna is expressed by COOK (1926, p. 29), FRICK (1937, p. 7), and H. E. WOOD, *et al.* (1941).

Considering that the Pawnee Creek formation is made up of a series of flood plain deposits and channel fills, covering a span of time from middle through late Miocene or early Pliocene, it is not difficult to postulate a series of faunas, or faunules, in the successive flood plain and channel accumulations. COOK (1926, p. 29) and FRICK (1937, p. 7) have expressed more or less the same view of the post-Oligocene deposits and faunas in this area. How these faunas are to be grouped is a problem dependent upon the geological history of the area, the range in time of the species, and the results of facies differences. The following tentative faunal zonation of the Pawnee Creek formation is presented as a working hypothesis.

Sand Canyon local fauna		Pawnee Creek fauna of MATTHEW
Vim-Peetz local fauna [12]	Pawnee Creek fauna of authors	
Kennesaw local fauna [13]		
Eubanks local fauna [14]		
Martin Canyon local fauna		

Based on the known fossils this represents five faunal divisions that may exist in the Pawnee Creek formation. It is theoretically possible that a typical Sheep Creek faunal stage is present. Neither the Kimball member of the Ogallala of ?late Hemphillian age nor the ?Arikareean deposits in northern Weld County have yielded a fauna that can be assigned to a definite age.

Evolutionary changes preclude these faunas from being different facies of the same age. On the other hand, the overlap of the vertical ranges of the species, or the close relationship of species at different levels, does not allow much time difference between the faunas.

MARTIN CANYON LOCAL FAUNA

The beds at Martin Canyon were divided by MATTHEW into three parts—"horizons C, D, and E." The Miocene part of "horizon C" (the upper part of MATTHEW's Martin Canyon beds) contains the well-known American Museum Merycochoerus Quarry. The faunule of this quarry, including a camelid found at this level by me and the fossils from "horizon D" are considered to be the Martin Canyon local fauna. The following species are known to occur in this local fauna, which was collected in the University of Kansas Quarry A and from beds containing the quarry.

Brachyerix sp.
Soricid sp.
Talpid sp.
Oreolagus nr. *O. nebrascensis*
Mesogaulus paniensis
Sciurus sp.
Sciurid sp.
Proheteromys sp.
Monosaulax nr. *M. curtus*
Plesiosminthus? clivosus n. sp.
Tomarctus sp.
Phlaocyon leucosteus
Parahippus pawniensis
?*Merychippus* sp.
?*Macrotherium matthewi* [15]

11. Throughout this paper the term "lower Snake Creek" refers to the fauna that MATTHEW associated with *Merychippus paniensis*. See MATTHEW (1924) and ELIAS (1942).

12. Named for Vim Postoffice and the village of Peetz, Logan County.
I am indebted to Mr. J. N. MINICK and Dr. P. O. MCGREW of the University of Wyoming for information on the lithologic pecularities of the post-Oligocene beds in northeastern Colorado which made it possible for me readily to distinguish the beds containing the Vim-Peetz local fauna.

13. Named for Kennesaw Valley, an area in northwestern Logan County bordering prominent exposures that carry the fauna.

14. Named for Eubanks Ranch at Pawnee Buttes.

15. For reasons discussed in the systematic account of each species, this species must be assigned tentatively to this fauna until better and more reliable discoveries are made.

Aphelops profectus
Tayassuid sp.
Merycochoerus proprius magnus
Merychyus elegans
Camelid sp.
Blastomeryx cf. *B. elegans*
Blastomeryx cf. *B. medius*

MATTHEW, as has been previously stated, considered the upper part of "horizon C" (upper part of the "Martin Canyon" beds) to be of lower Miocene age and "horizon D" as part of the Pawnee Creek beds, with its fauna showing only a facies difference from that of the lower Snake Creek fauna. Subsequently, specimens from "horizon D" that appeared too old to be included in the Pawnee Creek fauna have been ignored or considered to be from the "Martin Canyon" beds. SCHULTZ & FALKENBACH (1947, pp. 202-203) have presented the most recent opinion on the age of the "upper Martin Canyon beds" stating:

> The type section of the "Martin Canyon" of Matthew . . . was also visited by Falkenbach and later by Schultz. The exact location from which the skeletons . . . of *Merycochoerus proprius magnus* (Loomis) were collected was also determined. Although some of the sediments in the Martin Canyon area have a typical White River appearance, a part of the section appears to be equivalent to the Marsland of Nebraska because of the similarity in mammalian forms and certain lithologic characteristics.

It has been mentioned before that the beds in Martin Canyon containing the skeletons of *M. p. magnus* are the beds that have an appearance typical of the White River, and above these beds are nodular silts or "horizon D" (which MATTHEW called Pawnee Creek) that also contain remains of *M. p. magnus*. Although SCHULTZ and FALKENBACH do not specifically refer the beds above the American Museum quarry to the Marsland, as long as these authors restrict *Merycochoerus* to the Marsland formation, presumably they consider any fauna containing this genus to be older than the Sheep Creek fauna. Exclusive of *Merycochoerus* and *Merychyus*, the age of the Martin Canyon local fauna can only be arrived at by a consideration of a small part of the known fauna. *Phlaocyon leucosteus*, which MCGREW (1941, p. 34) considered more primitive than *Phlaocyon marslandensis* of the Marsland of Nebraska, would support a Marsland (or earlier) age determination. Suggestive evidence, but certainly not conclusive, is seen in the similarity of the *Plesiosminthus* specimen to the lower Miocene species in Europe. The general similarity of the teeth of *Proheteromys* to those of *Proheteromys floridanus* of the Hawthorn of Florida indicates an early middle Miocene age. That *Aphelops profectus* may be more primitive than *A. megalodus* is possible, and if *A. megalodus* is present in the Sheep Creek fauna, then this possibility might be indicative of an earlier age for the Martin Canyon beds. *Oreolagus* nr. *O. nebrascensis* cannot be safely used to indicate a correlation with the Marsland beds, since the species, or something as near *O. nebrascensis* as the Martin Canyon specimens, has been found in lower Snake Creek equivalent beds in southeast Fremont County, Wyoming. The talpid tooth from Martin Canyon is also similar to a talpid tooth obtained by me from the same beds in Fremont County. *Mesogaulus paniensis* has been reported from the lower Snake Creek fauna, but COOK & COOK (1933, p. 49) question its occurrence in the *Merychippus paniensis* zone of that fauna. The near identity of the *Monosaulax* teeth from Martin Canyon to those from the Eubanks local fauna is suggestive of an age closer to the lower Snake Creek fauna than is indicated by the species of "Marsland age," although the exact relationship of these specimens to *Monosaulax curtus* must be determined by more material. When enough specimens of *Parahippus pawniensis* and *Parahippus coloradensis* with accurate stratigraphic records are known, it may be possible to determine the relationship of these two species, if they are distinct, and the bearing of this relationship on the correlation of the beds in the Pawnee Creek formation. Until a revision of *Blastomeryx* is made, complete with localities, measured sections, and associated faunas, the genus offers nothing that is useful for correlation. The present identification of our cervid material suggests lower Snake Creek and Sheep Creek affinities for the Martin Canyon local fauna. The remaining specimens of the fauna cannot be utilized in any satisfactory manner. The fauna, as a whole, suggests the close relationship of the Marsland, Sheep Creek, and lower Snake Creek faunas—perhaps a closer relationship than is recognized at present.

The Martin Canyon local fauna and the beds that contain the fauna cannot be easily recognized at localities too distant from Martin Canyon. This is primarily owing to the lack of specimens. Enough material was found at Lewis Canyon, which is not far distant from Martin Canyon, to establish the age of the immediately overlying post-Oligocene beds. Also, the beds show a distinct lithologic similarity to the beds at Martin Canyon. In the Sand Canyon area, which is west of Martin Canyon, not a single fossil of Hemingfordian age has been found; and while some similarity is found between the two areas in the sequence of silts and cobble at the base of the Pawnee Creek formation, the evidence is not conclusive for pronouncing Hemingfordian beds to be either present or absent. At Pawnee Buttes the lithologic dissimilarity is greater, but fossils are present that suggest an age near that of the Martin Canyon local fauna for some of the beds in the area. On this subject SCHULTZ & FALKENBACH (1947, pp. 202-203) state:

> The writers noted the presence of 5 to 10 feet of massive brown sand at the base of the Ogallala (Pliocene) deposits in some instances. These basal deposits may be Miocene in age and may represent a remnant of Marsland (or "Martin Canyon," in part). No identifiable fossils were collected

from this basal horizon but the lithology was very suggestive of the Marsland formation in Nebraska, even to the type of sand crystals which were present.

The presence of *Mesogaulus paniensis* and *Merychyus elegans* in this area suggests a Martin Canyon equivalent. American Museum records suggest the possibility that *Merychyus elegans* came from the lower level mentioned by SCHULTZ & FALKENBACH, and these authors imply that such was the case.

PAWNEE CREEK FAUNA OF AUTHORS

The establishment of the Martin Canyon and Sand Canyon local faunas has revised, to some extent, MATTHEW'S concept of the Pawnee Creek fauna. By 1941 (H. E. WOOD, *et al.*) the general concept of the Pawnee Creek fauna included, for the most part, only fossils of Barstovian age. While WOOD, *et al.* placed the Pawnee Creek beds in the early Barstovian stage, their comments on the relationship of the Pawnee Creek beds and the Ogallala formation (p. 28) suggest that they were aware of certain elements in the fauna that did not fit into this time category. Nevertheless, there is no evidence that at anytime these authors, or SIMPSON (1933), or STIRTON (1936), ever included the whole late Barstovian fauna in the Sand Canyon fauna. Therefore, it is my opinion that the Eubanks, Kennesaw, and Vim-Peetz local faunas make up, essentially, the Pawnee Creek fauna of these authors. This fauna is composed of the following reported forms:

Brachyerix sp.
Cf. *Condylura*
Hypolagus sp.
Ceratogaulus rhinocerus
Mylagaulus laevis
Proheteromys sp.
Peridiomys sp.
Monosaulax curtus
Amblycastor? sp.
Tomarctus brevirostris
Leptocyon vafer
Euoplocyon sp.
Amphicyon sinapius
Amphicyon reinheimeri
Cynarctus saxatilis
(?)*Ursavus pawniensis*
Plionictis ogygia
Plionictis parviloba
Leptarctus primus
Pseudaelurus intrepidus
Pseudaelurus marshi
Serridentinus proavus
Serridentinus productus
Rhynchotherium rectidens
Mammut merriami
Parahippus coloradensis [16]
Hypohippus osborni
Merychippus paniensis
Merychippus sejunctus
Merychippus sphenodus
Merychippus republicanus
Merychippus labrosus
Merychippus proparvulus
Merychippus eoplacidus
Merychippus eohipparion
Merychippus proplacidus
Merychippus campestris
Merychippus sp. (Advanced protohippine)
Calippus sp.
?*Macrotherium matthewi* [17]
Tapiravus? sp.
Aphelops megalodus
Teleoceras medicornutus
Ustatochoerus medius
Ustatochoerus? *schrammi*
Protolabis fissidens
Protolabis heterodontus
Protolabis angustidens
Protolabis longiceps
Alticamelus leptocolon
Alticamelus giraffinus
Blastomeryx gemmifer
Barbouromeryx pawniensis
Dromomeryx pawniensis
Cranioceras pawniensis
Merycodus furcatus
Meryceros warreni
Meryceros minor
Ramoceros osborni

If the Pawnee Creek fauna is a homogeneous unit, there cannot be much question about its age or its correlation with the *Merychippus paniensis* fauna at Snake Creek, or roughly, with the Sucker Creek, Skull Spring, Beatty Buttes, Virgin Valley, and Mascall faunas from more western areas. Seventeen of the species show a specific correlation with the lower Snake Creek fauna, and 11 have a close relationship with all the faunas listed above. This is a remarkably close agreement, considering that no doubt some of the species listed above are not correctly identified and others possibly do not even belong in the fauna.

Seemingly against any division is the fact that the Columbia Plateau and Great Basin faunas cited above contain about equal numbers of species closely related to each of the divisions suggested for the Pawnee Creek fauna. A similar comparison could be made with the fauna of the *Merychippus paniensis* zone at Snake Creek, but it is probable that this collection is too unreliable for such purposes. The possibility that the Columbia Plateau and Great Basin faunas may represent intermediate stages, with small differences in the species, is avoiding the fact that subdivision is not practical if it takes a specialist working with a mass of data to detect these small differences. Nevertheless, evolution, migration, and interruptions in the deposition of the sediments are real phenomena, and eventually enough associated fossils may be found to give a picture of the changing faunal populations during the late Miocene.

EUBANKS, KENNESAW, AND VIM-PEETZ LOCAL FAUNAS

The division of the Pawnee Creek fauna into three local faunas — the Eubanks, Kennesaw, and Vim-Peetz local faunas—is suggested by differences in the composition of the three faunas.

16. Type probably from Martin Canyon local fauna. *Parahippus* from Eubanks local fauna not yet demonstrated to be *Parahippus coloradensis.*

17. See Martin Canyon local fauna.

The Eubanks local fauna is characterized by the presence of *Parahippus* and *Merychippus paniensis.* At present the fauna must be based on specimens collected from the Pawnee Buttes ash layer and the beds immediately above and below it at the type locality of the Pawnee Creek formation. Several species have been added to the faunal list as probable associates of *M. paniensis* and *Parahippus,* but only future collecting, with careful attention to stratigraphic relationships, will reveal further characteristics of the composition and vertical range of the fauna. The known and supposed members of the Eubanks local fauna are:

Occurrence certain [18]
- *Monosaulax curtus*
- *Parahippus* sp. (Possibly *P. coloradensis*)
- *Merychippus paniensis*
- *Merychippus sejunctus*
- *Aphelops* sp.
- *Ustatochoerus* sp.
- *Protolabis* sp. (Probably *P. heterodontus* and/or *P. angustidens*)

Occurrence probable
- *Amblycastor?* sp.
- *Tomarctus brevirostris*
- *Amphicyon sinapius*
- Proboscidea
- *Aphelops megalodus*
- *Ustatochoerus? schrammi*
- *Cranioceras pawniensis*

The Kennesaw local fauna is characterized by the presence of a more advanced species of *Merychippus, Merychippus sphenodus,* and the observed absence of *Parahippus,* which distinguishes this fauna from the Eubanks local fauna. Differences between the Kennesaw local fauna and the Vim-Peetz local fauna will be emphasized in the discussion of the latter fauna. Probably several species, other than horses, would characterize the Kennesaw fauna equally well. The fauna is based on collections made near Sand Canyon from beds Nos. 4-6 of measured section II or their equivalents to the east and west. The known and supposed members of the Kennesaw local fauna are:

Occurrence certain

Brachyerix sp.	*Leptarctus primus*
Cf. *Condylura*	Proboscidea
Mylagaulus laevis	*Merychippus sphenodus*
Proheteromys sp.	*Calippus* sp.
Peridiomys sp.	Rhinocerotids
Leptocyon vafer	*Ustatochoerus medius*
Plionictis ogygia	*Protolabis longiceps*

Occurrence probable

Ceratogaulus rhinocerus	*Alticamelus leptocolon*
Euoplocyon sp.	*Dromomeryx pawniensis*
Amphicyon reinheimeri	*Meryceros warreni*
Cynarctus saxatilis	*Meryceros minor*
Hypohippus osborni	

18. In this list, and those given for the Kennesaw and Vim-Peetz local faunas, the occurrences listed as certain mean that I am personally satisfied that the species occur at that level. Those species listed as probably occurring at one or the other levels are based upon less reliable information.

The Vim-Peetz local fauna is characterized by the presence of advanced protohippine and merychippine horses whose stage of evolution has reached the point where the occlusal patterns of the cheek teeth are closely similar to those of Clarendonian horses, but still retain the short, curved crowns of typical *Merychippus.* Another difference between this fauna and the Kennesaw fauna is the presence of cement on the deciduous teeth of the horses of the Vim-Peetz local fauna. The fauna is based on collections made in the area west of Sand Canyon from deposits (lower part of MATTHEW's "horizon E") which immediately overlie the beds containing the Kennesaw local fauna, and from the part of MATTHEW's "horizon E" at Martin Canyon that underlies the Ogallala formation. This fauna probably has more species in common with the Kennesaw local fauna than is recognized at present, but its relationship may be equally close to the Sand Canyon local fauna. The fauna which MATTHEW (1901, p. 359) listed for "horizon E" is a combination of species from the Martin Canyon, Kennesaw, and Vim-Peetz local faunas. Several species suggest that this is the level that OSBORN had in mind when he made the Sand Canyon fauna (OSBORN, 1918, p. 19). The name Sand Canyon, however, has become so firmly associated with *Neohipparion coloradense* and a typical Clarendonian fauna that it seems best not to use the name Sand Canyon for this level. The known and supposed members of the Vim-Peetz local fauna are:

Occurrence certain
- Cf. *Condylura*
- *Hypolagus* sp.
- *Mylagaulus* sp.
- *Tomarctus* sp.
- *Plionictis ogygia*
- Proboscidea
- *Merychippus republicanus*
- *Merychippus* sp. (Advanced protohippine)
- *Aphelops* sp.
- *Teleoceras* sp.
- *Ustatochoerus medius*
- *Alticamelus giraffinus*
- *Ramoceros osborni*

Occurrence probable
- *Pseudaelurus intrepidus*
- *Merychippus proplacidus*
- *Merychippus campestris*
- *Teleoceras medicornutus*

Unaccounted for in these three faunas are several species that have been assigned to the Pawnee Creek fauna. These present individual problems, the solution of which depends on the discovery of more material with accurate stratigraphic data.

SAND CANYON LOCAL FAUNA

Subsequent to MATTHEW's work, OSBORN (1918, p. 19) thought that the faunal evidence indicated, in addition to the "typical Pawnee Creek beds," an "Upper Pawnee Creek" horizon ("Pawnee Creek B" or "Protohippus-Hipparion zone") at Sand Canyon, Logan County, and at a place 10 miles west[19] of Grover, Weld County. He generally considered this hypothetical faunal stage to be of Pliocene age, although he vacillated on this point, sometimes referring to the age as late Miocene or Mio-Pliocene transition. H. E. WOOD, *et al.* (1941) used the name "Sand Canyon local fauna" for this stage and indicated that the age was questionable. The fauna consists of:

Neohipparion coloradense
Merychippus proplacidus
Pliohippus sp.
Serridentinus spp.
Rhinocerotid spp.

Of the species listed above, only *Neohipparion coloradense*, reported as coming from Sand Canyon, needs serious consideration. The rhinocerotid and serridentine specimens have been referred to known species, but much better material is needed to determine whether their real relationship lies with Barstovian or Clarendonian species. *Pliohippus* sp. may be referable to *Merychippus campestris* or *Merychippus perditus*. *Merychippus proplacidus*, reported in association with *Neohipparion coloradense*, has been referred questionably to the Pawnee Creek fauna (as defined in this paper) by STIRTON (1940, p. 182).

The stratigraphic position of *Neohipparion coloradense* is critical for the Sand Canyon problem. This species has been regarded as Clarendonian in age and comparable (or nearly so) with *Neohipparion* populations in unquestioned Clarendonian faunas (HESSE, 1936, p. 62; MCGREW, 1938, p. 317). However, no collecting party from the University of Kansas has ever found fossils referable to *N. coloradense*, or for that matter a fauna comparable with the fauna at the Burge locality or the one at the Laverne locality. CURTIS HESSE (personal communication to R. W. WILSON) not only failed to find a Clarendonian fauna at Sand Canyon, but finally came to doubt the correctness of the locality given for the type of *N. coloradense*.

It remains to be demonstrated whether or not a large series of specimens of *Neohipparion coloradense* from northeastern Colorado would be strictly equivalent to a large series from one or the other of the Clarendonian deposits cited by HESSE and MCGREW. Even if the population of *N. coloradense* in northeastern Colorado is more primitive than either the Burge or Laverne populations, there still would seem to be too great a difference ever to allow the association of the topotype population of *N. coloradense* with the closest related horse found in the area—that referred to *Merychippus republicanus*.

The Sand Canyon local fauna probably did not exist as OSBORN pictured it, and it is clear that there is no definite Sand Canyon fauna (*i. e.*, *Neohipparion coloradense* with an associated Clarendonian fauna) known which may be associated with any particular beds of the Pawnee Creek formation.

SUMMARY OF CORRELATION OF THE POST-OLIGOCENE BEDS AND FAUNAS

Figure 10 shows, diagrammatically, the history of attempted correlations of the Tertiary beds and faunas known in northeastern Colorado.

So far as I know, MATTHEW never commented upon the Sand Canyon fauna postulated by OSBORN and, presumably, more or less held to the views expressed in 1901. Nor did MATTHEW ever consider the Pawnee Creek beds and fauna to extend upward to correlate with the Niobrara River local fauna where I have placed the Vim-Peetz local fauna.

After MATTHEW and OSBORN there was no definite change of opinion concerning the beds, but WOOD, *et al.* (1941) did express the view of vertebrate paleontologists that certain problems of stratigraphy and correlation needed reinvestigation.

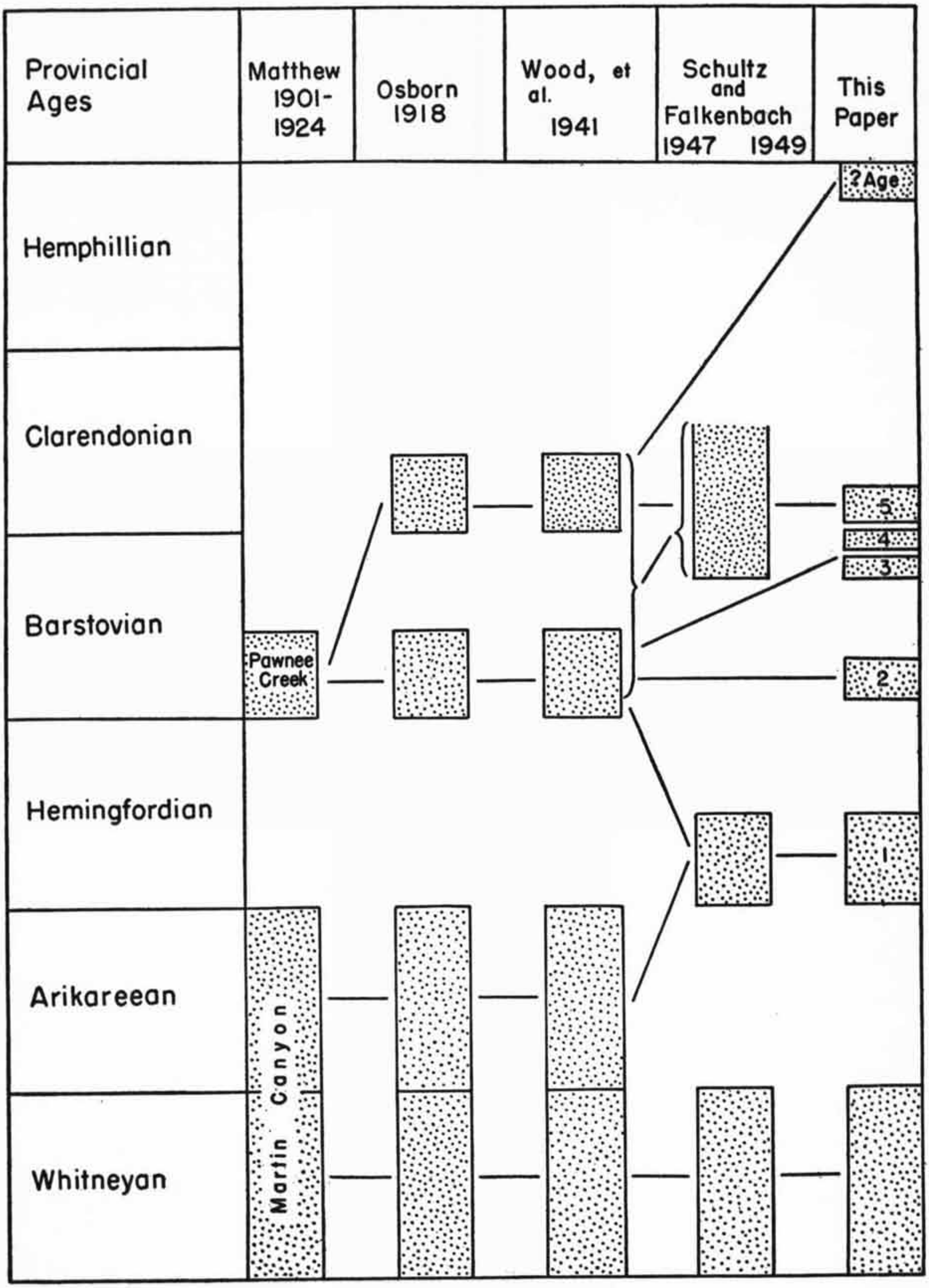
A radical departure from earlier opinion was expressed by SCHULTZ & FALKENBACH (1947). It should be kept in mind that while SCHULTZ & FALKENBACH called the post-Hemingfordian beds (including, seemingly, those bearing *Merychippus paniensis*) Pliocene in age, these authors consider the Pliocene (and Ogallala formation) to extend downward to include upper Barstovian beds.

My opinion of the stratigraphic and faunal sequence does not differ greatly from earlier views. The correlation of the Martin Canyon local fauna with the Marsland and Hawthorn (or younger than the Hawthorn and older than the Sheep Creek) seems valid. The Eubanks local fauna occupies the same place in the time scale, early Barstovian, as was held by the Pawnee Creek fauna of authors. The Kennesaw local fauna is considered to be older than, but near to, the Niobrara River local fauna in age. The Vim-Peetz local fauna is probably equivalent to the Niobrara River local fauna in age, and the hypothetical Sand Canyon local fauna must be considered as early Clarendonian on the basis of *Neohipparion coloradense*.

In Figures 8 and 10 I have shown beds of questionable late Hemphillian age. In both figures the beds referred to are those at the top of the valley wall, and not the Kimball exposure cited by LUGN (see part on Ogallala formation in this paper).

19. Catalogue records of the American Museum of Natural History suggest that OSBORN meant northeast of Grover. This possibility is supported by the fact that there are no post-Oligocene beds 10 miles west of Grover. On the other hand, OSBORN's map (1918, p. 19, fig. 10a) suggests that he could have had in mind exposures 20 to 30 miles northwest and west of Grover.

FIGURE 10.—Comparative views of correlation of the post-Oligocene beds in northeastern Colorado with the provincial ages. Level of occurrence of: (*1*) Martin Canyon local fauna; (*2*) Eubanks local fauna; (*3*) Kennesaw local fauna; (*4*) Vim-Peetz local fauna; and (*5*) Sand Canyon local fauna.


Provincial Ages
Matthew 1901-1924
Osborn 1918
Wood, et al. 1941
Schultz and Falkenbach 1947 1949
This Paper
Hemphillian
Clarendonian
Barstovian
Hemingfordian
Arikareean
Whitneyan
?Age
5
4
3
2
1
Pawnee Creek
Martin Canyon

SYSTEMATIC PALEONTOLOGY

The account of the species and specimens is presented in three parts — the Oligocene faunas, the Miocene faunas, and the Pliocene fauna.

For each species the type is cited if from northeastern Colorado, and the geological ages and localities of the type specimens are those of the describer unless otherwise stated.

For the referred specimens collected by me, the geological ages given are as determined and indicated in the section on geology and stratigraphy in this paper. Other referred specimens carry the locality and level cited by the author reporting the specimen unless there is positive evidence for modifying the data. All localities are in Colorado unless otherwise indicated.

Catalogue numbers without institution names apply to the Vertebrate Paleontological Collection of the Museum of Natural History, University of Kansas, Lawrence, unless otherwise stated. American Museum of Natural History specimens are referred to by the initials AMNH or F:AM.

Although I have studied primarily the mammals, the known occurrences of other groups are included. The taxonomic arrangement above the rank of species is that of CAMP, WELLES, & GREEN (1949) for the Amphibia and Reptilia; WETMORE (1940) for the Aves; and SIMPSON (1945) for the Mammalia. In most cases the authorities for the use of taxonomic names above the rank of genus are HAY (1930) and SIMPSON (1945).

THE OLIGOCENE FAUNA

CLASS AMPHIBIA

Fragmentary bones of frogs, and possibly also those of salamanders, have been found with the remains of small lizards and mammals in the concentrated microfaunas of the Cedar Creek member in western Logan County.

CLASS REPTILIA

ORDER TESTUDINES BATSCH, 1788

FAMILY TESTUDINIDAE GRAY, 1825

Testudo ligonia COPE

Testudo ligonius COPE, 1873a, p. 6.

Type.—AMNH No. 1148.

Testudo amphithorax COPE

Testudo amphithorax COPE, 1873a, p. 6.

Type.—AMNH No. 1145.

Testudo quadrata COPE

Testudo quadratus COPE, 1884a, p. 764.

Type.—AMNH No. 1149.

Testudo cultrata COPE

Testudo cultratus COPE, 1873a, p. 6.

Type.—Cannot be found.

Gopherus laticunea (COPE)

Testudo laticuneus COPE, 1873a, p. 6.
Gopherus laticunea, WILLIAMS, 1950, p. 25.

Type.—AMNH No. 1160.

HAY at first (1908) stated that these types were obtained from the Oreodon beds at the head of Horsetail Creek, northeastern Colorado, but later (HAY, 1930) he gave the stratigraphic position as Chadron Oligocene. As has already been pointed out, the position of this stream is in doubt, but if the present Horsetail Creek was the one referred to by COPE, it is probable that the age of the beds is Chadronian. There are several sizes of turtles referable to *Testudo* (*s. l.*) present in the Chadronian beds, where they are fairly common, and a few may be found in the Orellan beds.

WILLIAMS (1950, p. 29) considers the types of *Testudo quadrata* and *T. cultrata* too indeterminate to be "defined, synonymized, or allocated."

FAMILY EMYDIDAE GRAY, 1825

Stylemys nebrascensis LEIDY

Stylemys nebrascensis LEIDY, 1851, p. 173.

Referred specimen. — Cedar Creek member (middle): No. 8239; carapace and plastron; S½ sec. 21, T. 11 N., R. 53 W., Logan County.

This species of turtle is the common form found in the Orellan beds. Poorly preserved specimens indicate that perhaps this genus existed into Whitneyan time.

ORDER SAURIA MACARTNEY, 1802

In the following list I have cited GILMORE (1928) as the authority for the horizon and level for all the species described by COPE. However, there is no evidence that COPE collected from any localities in Logan County during his 1873 field season. All of COPE'S specimens probably came from Weld County.

FAMILY IGUANIDAE GRAY, 1827

Exostinus serratus COPE

Exostinus serratus COPE, 1873c, p. 16.

Type.—AMNH No. 1608; Oreodon beds, White River formation, Cedar Creek, Logan County, Colorado (*fide* GILMORE, 1928).

Aciprion formosum COPE

Aciprion formosum COPE, 1873c, p. 17.

Type.—AMNH No. 1609; Oreodon beds, White River formation, Cedar Creek, Logan County, Colorado (*fide* GILMORE, 1928).

Aciprion majus GILMORE

Aciprion majus GILMORE, 1928, p. 20.

Type.—Princeton Univ. Mus. No. 10015; Oreodon beds?, White River formation, Chalk Bluffs, Logan County, Colorado.

FAMILY AMPHISBAENIDAE GRAY, 1825

Rhineura coloradoensis (COPE)

Platyrhachis coloradoensis COPE, 1873c, p. 19.
Rhineura coloradoensis, GILMORE, 1928, p. 42.

Type.—AMNH No. 1607; Horsetail Creek beds, White River formation, Horsetail Creek, Logan County, Colorado (*fide* GILMORE, 1928).

Rhineura hibbardi TAYLOR

Rhineura hibbardi TAYLOR, 1951, p. 539.

Type.—Univ. Michigan Mus. Paleont. No. 25431; Cedar Creek member, White River formation, center W½ sec. 7, T. 11 N., R. 53 W., Logan County, Colorado.

Rhineura amblyceps TAYLOR

Rhineura amblyceps TAYLOR, 1951, p. 543.

Type.—Vert. Paleont. Coll., Univ. Kansas Mus. Nat. Hist. No. 7649; Cedar Creek member, White River formation, W½ sec. 7, T. 11 N., R. 53 W., Logan County, Colorado.

Rhineura wilsoni TAYLOR

Rhineura wilsoni TAYLOR, 1951, p. 548.

Type.—Vert. Paleont. Coll., Univ. Kansas Mus. Nat. Hist. No. 7651; Cedar Creek member, White River formation, W½ sec. 7, T. 11 N., R. 53 W., Logan County, Colorado.

Rhineura hatcherii BAUR

Rhineura hatcherii BAUR, 1893, p. 998.

TAYLOR (1951, p. 551) has referred specimens from the Cedar Creek member in Logan County to this species.

FAMILY HYPORHINIDAE BAUR, 1893

Hyporhina galbreathi TAYLOR

Hyporhina galbreathi TAYLOR, 1951, p. 532.

Type.—Vert. Paleont. Coll., Univ. Kansas Mus. Nat. Hist. No. 8221; Cedar Creek member, White River formation, SW¼ sec. 12, T. 11 N., R. 54 W., Logan County, Colorado.

FAMILY HELODERMIDAE GRAY, 1837

Heloderma matthewi GILMORE

Heloderma matthewi GILMORE, 1928, p. 89.

Type.—AMNH No. 990A; Oreodon zone, White River formation, Lewis Creek, Logan County, Colorado.

FAMILY ANGUIDAE BONAPARTE, 1831

Peltosaurus granulosus COPE

Peltosaurus granulosus COPE, 1873a, p. 5.

Type.—AMNH No. 1610; Cedar Creek beds, Oreodon zone, Cedar Creek, Logan County, Colorado (*fide* GILMORE, 1928).

Xestops pawneensis GILMORE

Xestops pawneensis GILMORE, 1928, p. 150.

Type.—Vert. Paleont. Coll., Univ. Kansas Mus. Nat. Hist. No. 1281; White River formation, sec. 28, T. 11 N., R. 53 W., Logan County, Colorado.

Glyptosaurus sp.

GILMORE (1928, p. 120) reported fragments referable to this genus from northeastern Colorado.

SAURIA, *incertae sedis*

Cremastosaurus carinicollis COPE

Cremastosaurus carinicollis COPE, 1873c, p. 18.

Type.—AMNH No. 1604; Oreodon zone, Logan County, Colorado (*fide* GILMORE, 1928).

Cremastosaurus rhambastes (COPE)

Platyrhachis rhambastes COPE, 1884a, p. 779.
Cremastosaurus rhambastes, GILMORE, 1928, p. 152.

Type.—AMNH No. 1606; Horsetail Creek beds (Titanotherium zone), White River formation, Oligocene, Horsetail Creek, Logan County, Colorado (*fide* GILMORE, 1928).

Cremastosaurus unipedalis (COPE)

Diacium unipedalis COPE, 1873c, p. 18.
Cremastosaurus unipedalis, COPE, 1874a, p. 516.

Type.—AMNH No. 1605; Horsetail Creek beds, Horsetail Creek, Logan County, Colorado (*fide* GILMORE, 1928).

Diacium quinquepedale COPE

Diacium quinquepedalis COPE, 1873c, p. 17.

Type.—AMNH No. 1602; White River formation, Logan County, Colorado (*fide* GILMORE, 1928).

ORDER SERPENTES LINNAEUS, 1758

FAMILY BOIDAE BONAPARTE, 1831

Calamagras murivorus COPE

Calamagras murivorus COPE, 1873c, p. 15.

Type.—AMNH No. 1603; Oreodon beds, Cedar Creek, northeastern Colorado (*fide* GILMORE, 1938).

Calamagras angulatus COPE

Calamagras angulatus COPE, 1873c, p. 16.

Type.—AMNH No. 1654; Oreodon beds, ?Cedar Creek, Colorado (*fide* GILMORE, 1938).

Calamagras talpivorus (COPE)

Aphelophis talpivorus COPE, 1873c, p. 16.
Calamagras talpivorus, GILMORE, 1938, p. 12.

Type.—AMNH No. 1598; Cedar Creek, northeastern Colorado (*fide* GILMORE, 1938).

FAMILY CROTALIDAE GRAY, 1825

Neurodromicus dorsalis COPE

Neurodromicus dorsalis COPE, 1873c, p. 15.

Type.—AMNH No. 1599; Oreodon beds, Cedar Creek, Pawnee Buttes, northeast Colorado (*fide* GILMORE, 1938).

Dr. E. H. TAYLOR, who is studying the amphibian and reptilian material collected by me, states that he has recognized a few snake vertebrae among the specimens collected from the Cedar Creek member in Logan County.

CLASS AVES

ORDER PELECANIFORMES SHARPE, 1891

FAMILY PHALACROCORACIDAE BONAPARTE, 1838

Phalacrocorax mediterraneus SHUFELDT

Phalacrocorax mediterraneus SHUFELDT, 1915, p. 58.

Type.—Yale Univ., Peabody Mus. Nat. Hist. No. 943; middle Oligocene (White River): Gerry's Ranch, northern Colorado.

From examination of old maps and from discussions held with "old timers" in Weld County, I think that Gerry's Ranch may have been in T. 11 N., R. 64 W., Weld County. In this area and in Ts. 11 and 12 N., Rs. 64, 65, and 66 W. are Oligocene exposures locally known, today and in the past, as Chalk Bluffs. Some of the exposures are Chadronian in age, whereas the remainder of the Oligocene beds are Orellan in age. No Whitneyan beds are recognized.

ORDER FALCONIFORMES SEEBOHM, 1890

FAMILY ACCIPITRIDAE SWAINSON, 1837

Buteo fluviaticus MILLER & SIBLEY

Buteo fluviaticus MILLER & SIBLEY, 1942, p. 39.

Type.—Univ. California Mus. Paleont. No. 36266; Univ. California Mus. Paleont. locality V-3743, Chalk Bluffs, Oreodon beds, Roy Elum Ranch on Owl Creek, T. 11 N., R. 66 W., six miles east of Carr, Weld County, Colorado.

FAMILY CATHARTIDAE HUXLEY, 1867

Phasmagyps patritus WETMORE

Phasmagyps patritus WETMORE, 1927, p. 3.

Type.—Denver Mus. Nat. Hist. No. 804 (fossil catalogue).

Palaeogyps prodromus WETMORE

Palaeogyps prodromus WETMORE, 1927, p. 5.

Type.—Denver Mus. Nat. Hist. No. 803 (fossil catalogue).

ORDER GRUIFORMES COUES, 1884

FAMILY RALLIDAE VIGORS, 1825

Palaeocrex fax WETMORE

Palaeocrex fax WETMORE, 1927, p. 9.

Type.—Denver Mus. Nat. Hist. No. 1078 (fossil catalogue).

FAMILY BATHORNITHIDAE WETMORE, 1933

Bathornis veredus WETMORE

Bathornis veredus WETMORE, 1927, p. 11.

Type.—Denver Mus. Nat. Hist. No. 805 (fossil catalogue).

The types of the last four species were collected from the Trigonias Quarries in the lower part of the Horsetail Creek member in sec. 26 and sec. 27, T. 10 N., R. 57 W., Weld County.

ORDER GALLIFORMES GARROD, 1874

FAMILY PHASIANIDAE VIGORS, 1825

Phasianid sp.

Referred specimen.—Cedar Creek member (lower): No. 9393; distal end of left tarsometatarsus; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County.

TORDOFF (1951) thinks that this fragment represents an unknown species which (in the distal end of the tarsometatarsus, at least) fairly closely resembles *Colinus* and *Lophortyx*. It is the earliest record of the American Quail, subfamily Odontophorinae.

CLASS MAMMALIA

ORDER MARSUPIALIA ILLIGER, 1811

FAMILY DIDELPHIDAE GRAY, 1821

Peratherium fugax (COPE)

Herpetotherium fugax COPE, 1873b, p. 1.
Peratherium fugax, COPE, 1884a, p. 794.

Type.—AMNH No. 5254; Brule, Cedar Creek, Colorado (*fide* SCOTT, 1941).

Referred specimens.—Horsetail Creek member: No. 9792; fragment of jaw with right M_4; E½ sec. 30, T. 11 N., R. 53 W., Logan County.

Cedar Creek member: No. 8290; right ramus with M_1-M_3; SE¼ sec. 17, T. 11 N., R. 65 W., Weld County. Nos. 8162, 8291, 8307, 8309-8311, and 8313-8314; rami with one or more teeth; secs. 2, 3, 12, T. 11. N., R. 54 W., and secs. 7, 28, T. 11 N., R. 53 W., Logan County. Nos. 8308 and 8312; maxillaries with right M^1-M^4, and M^2-M^3, respectively; E½ sec. 7, T. 11 N., R. 53 W., Logan County.

As a whole these specimens agree with the description and measurements of the type. There are variations in the dimensions. For example, 12 jaws with M_3-M_4 have a range in length in these two teeth of 3.45 mm. to 3.9 mm. and a mean of 3.72 mm. The same specimens have a mandibular depth at M_3 ranging from 2.7 mm. to 3.6 mm. with a mean of 3.14 mm. In seven specimens there are positive correlations between size of teeth and size of rami, but in the remaining five specimens there is a negative correlation. As yet there is insufficient information to correlate variation with position in the stratigraphic section. The vertical position of one-third of the specimens is known to within five feet, and the remainder, with one exception, are at least known to be in the Cedar Creek member.

Peratherium nr. P. fugax (COPE)

Referred specimen.—Vista member: Univ. Colorado Mus. No. 19877; right jaw with M_3-M_4; sec. 8, T. 11 N., R. 53 W., Logan County.

This specimen differs in some respects from the Orellan specimens of *Peratherium fugax*. The paraconid of M_3 is high on the trigonid, and the hypoconulid is reduced. Both the paraconid and metaconid appear larger than in *P. fugax*, but this condition may be in part illusionary because of the subequal height of the protoconid and metaconid. Wear may account for the sizes of the cusps. The M_4, although damaged, shows the same differences in the trigonid, but has a lower paraconid and metaconid. The cingula are weak as in *P. fugax*. In size the specimen resembles *P. fugax*, having an M_3-M_4 length of more than 3.4 mm. (the heel of M_4 is damaged) and a mandibular depth of 3.5 mm. at M_3.

The specimen is smaller than the type of *P. merriami* STOCK & FURLONG from the John Day formation of eastern Oregon, and does not have the cingula so well developed. No comparison with *P. youngi* MCGREW, of the Miocene of Nebraska is possible, and it remains to be learned whether or not No. 19877 has reached the phylogenetic stage represented by that species.

Peratherium huntii (COPE)

Herpetotherium huntii COPE, 1873c, p. 5.
Peratherium huntii, COPE, 1884a, p. 796.

Cotypes. — AMNH Nos. 5257 and 5275; Brule, Cedar Creek, Colorado (*fide* SCOTT, 1941).

Referred specimens.—Cedar Creek member (lower and middle): No. 8159; fragment of left jaw with M_3-M_4. No. 8163; fragment of left jaw with M_2-M_4. No. 8164; fragment of left jaw with P_4-M_1. No. 8315; fragment of right jaw with M_2-M_4. No. 8978; right jaw with M_1-M_4. All from sec. 7, T. 11 N., R. 53 W., Logan County. No. 8316; fragment of left jaw with M_2-M_4; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County.

With the exception of No. 8978, these specimens agree closely with the description of the type. *Peratherium huntii* may be readily recognized and differentiated from *P. fugax* by much smaller size. In addition it differs from *P. fugax* in having the premolar series uninterrupted and the entoconids of the molars sharper and higher.

No. 8978 differs from other specimens of *Peratherium huntii* in being smaller and having the hypoconulid weaker and more centrally placed on the first three molars. The hypoconulid is not present on M_4. In this specimen enough of the jaw is preserved to show that the angle of the jaw is inflected as in the Recent opposums.

Peratherium is not at all rare in northeastern Colorado, and MCGREW (1939, p. 397) considered it to be abundant in the White River beds of Nebraska. However, I cannot find any record of anyone ever reporting the upper teeth of *Peratherium huntii*, although the upper teeth of *P. fugax* have often been reported. In the light of this fact, it seems even more unusual that only upper teeth of *Nanodelphys minutus* have been found. These facts, together with agreement in size of teeth of *P. huntii* and *Nanodelphys minutus*, suggest that *P. huntii* belongs in the genus *Nanodelphys*.

Nanodelphys minutus MCGREW

Nanodelphys minutus MCGREW, 1937, p. 452.

Referred specimen.—Cedar Creek member (lower): No. 8997; fragment of maxillary with left M^3-M^4; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County.

With the exception of a smaller stylar cusp A on M^3 and a larger stylar cusp E on M^4, this specimen agrees in detail with the type and a referred specimen, Chicago Natural History Museum No. P25719. A small cuspule on the posterior border of M^4 between the protocone and metacone, which is not present on the type and the referred specimen, is probably an individual variation. The stylar cusp A on M^4 seems to be damaged by weathering, but it too probably is smaller than in the type. This damage to M^4 may account, in part, for the short transverse diameter of the tooth.

With the permission of Dr. MCGREW a second set of measurements (Table 1) is given for the specimens described by him (1939).

TABLE 1.—Measurements (in mm.) of *Nanodelphys minutus*[a]

	No. 8997	No. P25708	No. P25709	No. P25719	No. P25720
M^1, antero-posterior length	....	....	....	....	1.41
M^1, transverse width	....	....	....	....	1.23
M^2, antero-posterior length	....	1.38	1.47	1.50	1.50
M^2, transverse width	....	1.53	1.95	1.62	1.50
M^3, antero-posterior length	1.32	1.17	....	1.35	....
M^3, transverse width	1.74	1.59	....	1.80	....
M^4, antero-posterior length	0.84	....	....	0.75	....
M^4, transverse width	1.70[b]	....	....	1.83	....

a. These measurements were made with a binocular grid and checked with calipers. A transverse line through the tip of the protocone and tip of stylar cusp B was used as a base, and all measurements are parallel to or perpendicular to this line.

b. ?Damaged.

The possibility that *Peratherium huntii* belongs to this genus has already been considered. The eventual discovery of associated upper and lower teeth will undoubtedly settle the matter, and there is nothing to be gained by a premature reassignment of the species.

ORDER INSECTIVORA BOWDICH, 1821

Recent studies of the Oligocene insectivores of northeastern Colorado have materially increased our knowledge of them from this area. COPE (1873b, 1884a) reported three genera, *Ictops* (as *Mesodectes*), *Domnina*, and *Geolabis*. MATTHEW (1901) gave no indication that anything other than *Proscalops miocaenus* was found by the early American Museum expeditions. PATTERSON & MCGREW (1937) added one new genus, *Ankylodon*, a new species of *Metacodon*, and confirmed the validity of the genus *Domnina*. In the present paper I attempt to establish the stratigraphic levels and the associated faunas for most of the genera in a detail not previously known, and, although a matter of lesser importance, new species are named.

FAMILY SOLENODONTIDAE DOBSON, 1882

Apternodus iliffensis, new species

Figures 11-12

Holotype.—Part of left maxillary with P^3-M^3 in occlusion with left lower jaw with P_4-M_3, No. 9112, Vert. Paleont. Coll., Univ. Kansas Mus. Nat. Hist.

Geological age and locality.—Silt of Chadronian age in the Horsetail Creek member of the White River formation, W½ sec. 9, T. 10 N., R. 51 W. (six miles north of Iliff), Logan County, Colorado.

Diagnosis.—Differs from other species of *Apternodus* in relatively wider P^3-M^1, and narrower M^3; cingula not developed into protocones and hypocones; lower teeth relatively longer with large talonids, especially the talonid of M_3.

Description.—The small part preserved of the maxillary bone shows that this element resembles the maxillary of *Apternodus brevirostris* SCHLAIKJER much more than the corresponding bone in *A. gregoryi* SCHLAIKJER. The depression on the maxillary, antero-dorsally to the orbit, does not extend forward beyond M^1. The posterior opening of the infraorbital canal is above the posterior root of M^3.

The length of P^3-M^3 is less than in *Apternodus brevirostris* or *A. gregoryi*, and only in the length of P^3 and width of M^1 does this specimen exceed any corresponding dimension of these two species. All the teeth preserved are three-rooted.

The crown of P^3 consists of a central conical cusp, the amphicone, completely encircled by a cingulum that may be best described as weakly developed except on the external surface where it forms a metastyle and a small parastyle. The metastyle is not nearly so high as the amphicone and is united to it by a well-developed crest. This tooth differs from the P^3 of both *Apternodus brevirostris* and *A. gregoryi* in the development of a parastyle and the lack of development of cusps on the anterior and internal parts of the cingulum.

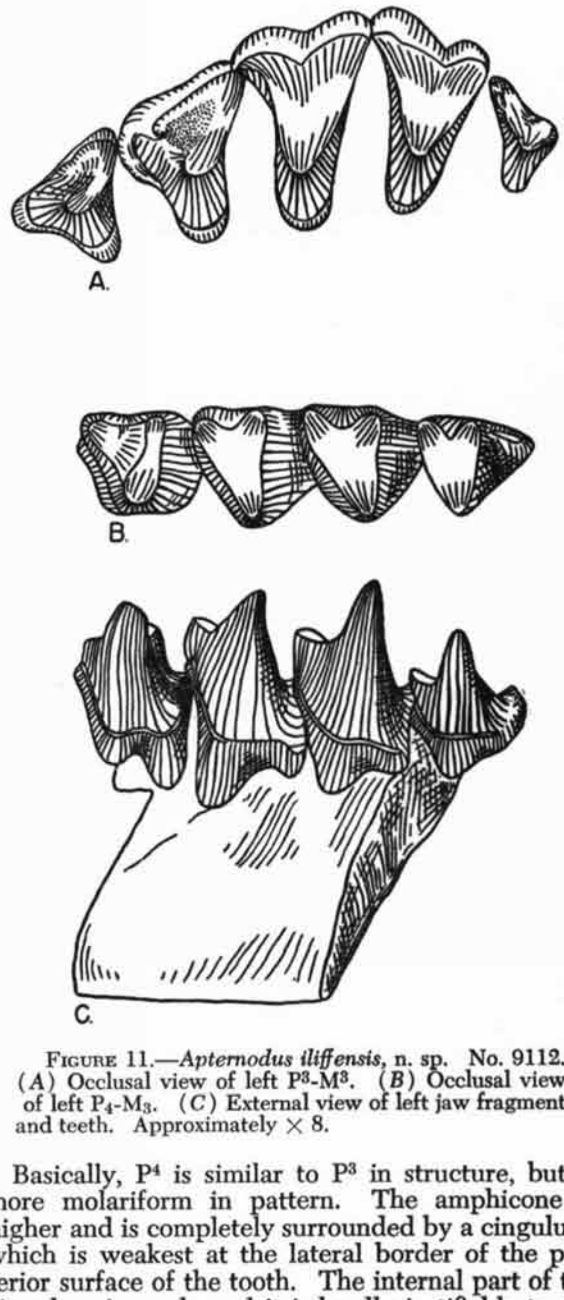


FIGURE 11.—*Apternodus iliffensis*, n. sp. No. 9112. (*A*) Occlusal view of left P^3-M^3. (*B*) Occlusal view of left P_4-M_3. (*C*) External view of left jaw fragment and teeth. Approximately × 8.

Basically, P^4 is similar to P^3 in structure, but is more molariform in pattern. The amphicone is higher and is completely surrounded by a cingulum, which is weakest at the lateral border of the posterior surface of the tooth. The internal part of the cingulum is weak, and it is hardly justifiable to say that a cusp is present—certainly not in the sense that cusps are developed in the other species. The antero-external part of the cingulum is developed across the lateral part of the anterior surface of the tooth as a broad, troughlike shelf or upturned wing. The metastyle is well developed and is as high as the amphicone. The large parastyle is located on the external cingulum lateral to the amphicone, from which, despite wear, it is separated by a valley. The amphicone is similar to those of the molars, and it is only the somewhat triangular shape of the premolar that distinguishes the medial half of P^4 from the corresponding part of M^1.

M^1 has the cingulum complete from the parastyle around the inner border of the tooth to the metastyle. At the internal border, the cingulum is even less expanded than on P^4, and on the medial part of the anterior face of the tooth the cingulum is reduced to a faint ridge. Antero-externally the cingulum is developed into a winglike, flaring trough similar to that on P^4 but longer, and is confluent with the parastyle externally. The metastyle is well developed and is extended laterally.

M^2 has a cingulum like that of M^1 but with the winglike trough on the anterior surface weaker, and with the internal part of the cingulum weaker still than on M^1. The metastyle is relatively much smaller than in the other known species.

M^3 is unusual in this species in its reduction in width relative to the other teeth, virtual absence of a distinct metastyle, and vestigial condition of the cingulum.

Only the part of the lower jaw containing P_4-M_3 is preserved, and this fragment indicates that *Apternodus iliffensis* had a jaw near the size of that of *A. mediaevus* MATTHEW and smaller than in either *A. brevirostris* or *A. gregoryi*. The preserved teeth show essentially the same pattern as the lower teeth of other species of this genus. A weak cingulum encircles all but the internal surface of each tooth. A well-developed heel, which becomes progressively larger in each succeeding tooth, is present on P_4-M_3

TABLE 2.—Measurements (in mm.) of *Apternodus iliffensis*

	No. 9112
Crown length of P^3-M^3	9.45
Crown length of M^1-M^3	5.35
P^3, greatest length	3.01
P^3, width at center of crown at alveolus	2.10
P^4, greatest length	2.6
P^4, width at center of crown at alveolus	2.9
M^1, greatest length	2.4
M^1, width at center of crown at alveolus	3.9
M^2, greatest length	1.81
M^2, width at center of crown at alveolus	3.35
M^3, greatest length	0.99
M^3, width at center of crown at alveolus	2.04
Crown length of P_4-M_3 at alveolus	7.4[a]
Greatest crown length of P_4-M_3	7.8
Crown length of M_1-M_3 at alveolus	5.3[a]
Greatest crown length of M_1-M_3	6.0
Crown length of M_2-M_3 at alveolus	3.6[a]
Greatest crown length of M_2-M_3	4.2
Depth of jaw on internal side	4.15
P_4, greatest length	2.05
P_4, greatest width	1.61
M_1, greatest length	2.19
M_1, greatest width	1.95
M_2, greatest length	2.14
M_2, greatest width	1.89
M_3, greatest length	2.21
M_3, greatest width	1.40

a. Estimated.

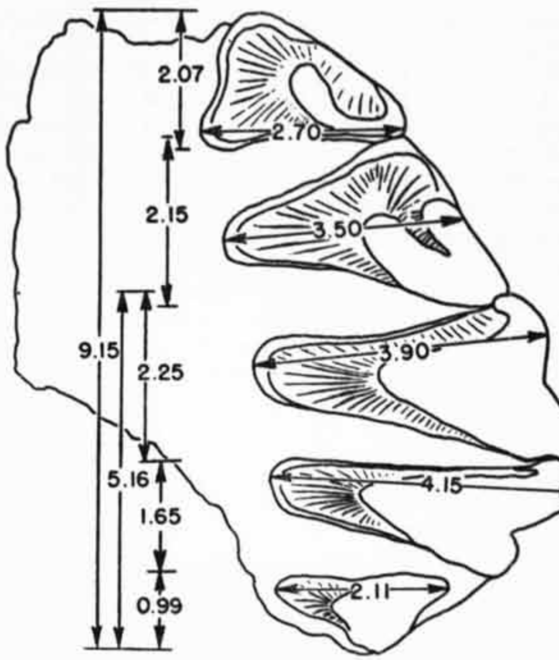


FIGURE 12.—*Apternodus iliffensis*, n. sp. No. 9112. Dimensions of left P^3-M^3 in millimeters. All antero-posterior measurements are parallel to antero-posterior axis of the skull. All transverse measurements are made with occlusal surfaces oriented to agree with their natural position in the skull.

and results in M_3 having a heel larger than in any of the other known species. The paraconids are not so well developed, and the teeth are more slender and higher crowned than in the other species. P_4 has progressed toward a molariform pattern to the extent that only the more closely set cusps, more narrow width, and slightly shorter crown distinguish it from M_1. The trigonid of P_4 forms an equilateral triangle, but in all the molars, the trigonids are a little wider transversely.

Two sets of measurements are given for this species. One set (Table 2) was made following the methods of SCHLAIKJER (1933, 1934), which were not entirely satisfactory for this particular specimen. The second set of measurements was made in accordance with the diagram in Figure 12.

Discussion.—Compared to *Apternodus brevirostris* the teeth of this species have a greater stylar development and molarization of the premolars, progressive simplification and reduction of size in the last two molars, and less development of internal cingular cusps on all the teeth. The lower teeth retain the relatively narrow trigonids, but have relatively enlarged talonids, and show molarization of the premolars. With *A. mediaevus*, which is represented by two lower molars, as a means of comparison, the reduction of the cingula on the lower teeth is seen as a character common to the other species.

The dominant teeth in the upper and lower dental arcades are the first molars as in *A. brevirostris* and *A. gregoryi;* yet, with the exception of the lower premolars of *A. gregoryi,* molarization appears to have advanced more in *A. iliffensis.*

The dentition of *A. iliffensis* is smaller than that of *A. brevirostris* and *A. gregoryi,* but may have been larger than that of *A. mediaevus.* Relatively, however, P^4 is shorter, M^1 wider, and M^3 much narrower. These relationships bear out the observation that the upper teeth of this species had greater molarization of the premolars and reduction of the last two molars.

It is noteworthy that the reduction of the M^3 is in width and that, although it is a weak and reduced tooth, relatively and actually, it still retains the length necessary to occlude with the elongate and well-developed heel of the lower third molar.

The heel of M_3 is actually large, but, like that of *A. gregoryi,* and in contrast to that of *A. mediaevus,* there has been a reduction of the trigonid (more so than in *A. brevirostris*) that emphasizes the size of the structure.

Development of the cingula is characteristic of these three specimens: there are incomplete cingula on the upper teeth of *A. brevirostris,* which are, nevertheless, well developed internally; there are complete and well-developed cingula on the teeth of *A. gregoryi;* and there are complete cingula on the teeth of *A. iliffensis,* which are not well developed internally, although the premolar parastyles seem to be more advanced than in other species.

With only four recorded specimens from four different localities (and described as four different species), it is difficult to distinguish individual variations from trends in evolution. Despite the absence of the upper teeth of *A. mediaevus,* this new species is considered to be structurally advanced beyond *A. mediaevus* and to be deviating from *A. brevirostris.*

FAMILY LEPTICTIDAE GILL, 1872

Ictops nr. I. bullatus MATTHEW

Referred specimen.—Cedar Creek member (middle): No. 8151; skull and lower jaws with fragments of the skeleton; SE¼ sec. 7, T. 11 N., R. 53 W., Logan County.

This specimen is tentatively placed near the species *I. bullatus* MATTHEW, and the salient characters —that is, those characters emphasized by previous workers such as COPE, LEIDY, and MATTHEW, and summarized by SCOTT (SCOTT & JEPSEN, 1936)—are as follows:

(1) Temporal ridges sinuous; thus like *Ictops* and unlike *Leptictus.*
(2) Skull broad for length, being proportionately wider than that of *Leptictus haydeni* LEIDY (which is wider than any species of *Ictops*). Otherwise the proportions are similar to those of *Leptictus.*
(3) Size large; thus like both *Ictops bullatus* and *Leptictus haydeni.*
(4) Muzzle narrow, and has some medial offset, as in *Leptictus.*
(5) P^3 with internal and postero-external cusps; thus like *Ictops* and unlike *Leptictus.* In addition this tooth (and P^4-M^1) has a well-developed antero-external cingular cusp.
(6) P^1-P^2 with some medial offset, and P^3 rotated with anterior end directed antero-medially, conforming with the medial offset of the muzzle.
(7) M_3 reduced, more so than in any species of *Ictops.*
(8) P^1-P^2 have posterior accessory cusps, which other species do not have.
(9) P^4-M^1 have relatively narrow transverse diameters.
(10) P_1 double rooted. SCOTT (SCOTT & JEPSEN, 1936, p. 14) states that P_1 of *Ictops* is single rooted.

Among the characters that serve to distinguish *Leptictus* are absence of an internal cusp on P^3, offset of the muzzle at P^3, and alignment of the outer side of the premolar tooth row with the inner side of the molar tooth row. In *Ictops* the internal cusp is present, and there is no offset to the muzzle or break in the dental arcade at the end of P^3. However, COPE described a genus and species (*Isacus caniculus,* 1873b, p. 3; *Mesodectes caniculus,* 1875, p. 30; now considered to be in the genus *Ictops*) based on one specimen from northeastern Colorado, that differed from *Ictops* only in having the postero-external cusp absent on P^3. The postero-external cusp is absent in *Leptictus* but seems to be normally present in *Ictops.*

No. 8151 approaches *Leptictus* in some ways but has more characters in common with *Ictops.* Characters similar to those of skull No. 8151 are present in a leptictid skull, No. 2568, from Custer County, South Dakota, which possibly was the one referred to by MATTHEW (1937, p. 217) as an "undescribed species of *Leptictus.*" Although having sinuous temporal crests, internal cusps present on P^3, postero-external cusps reduced or absent on P^3, and P^1-P^2 in line with the internal margins of the molars, the skull from South Dakota has the added distinction of large size, being 73 mm. long as measured without part of the muzzle, the addition of which would make it at least 75 mm. long. This is about 10 mm. longer than any other leptictid skull known to me. Also, the teeth are unusually wide.

These specimens that have been commented upon show, in addition to other characters, variation in the structure of P^3 ranging from a single cusp to a multiplicity of cusps. It would appear that the structure of P^3 is linked with the sharpness of the break or offset of the muzzle and the premolar alignment, and hence to the ratio of the length and breadth of the muzzle compared with the rest of the skull. No. 8151, however, differs from the usual condition in having the slightly offset muzzle and premolars combined with a strong tendency to form accessory cusps on the premolar. Individual variation and differences between the species are such that it is possible to conceive of a series of independent genetic factors that control each of the areas and parts of the skull in varying degrees of intensity, thus giving rise to variations which do not correlate with each other. If there is no great degree of variability in leptictid skulls, then specimens No. 2568 and No. 8151 probably represent new species. But, with the number of species of Oligocene leptictids known at present, it would be premature to name the specimens before the Oligocene genera have been revised.

Ictops sp.

Specimens of leptictids consisting of fragments of upper and lower jaws have been collected by me from exposures of the Cedar Creek member in secs. 7 and 28 of T. 11 N., R. 53 W., and sec. 12, T. 11 N., R. 54 W. in Logan County. All have been referred to the genus *Ictops*, and most of the material is probably of the same species as No. 8151, discussed above. Although variation in size is considerable among these fragments, especially in depth of lower jaw and width of teeth, one lower jaw fragment, No. 8149, may represent a second, slightly smaller species that coexisted with the larger form—a species with narrower cheek teeth and shallower jaws, perhaps *Ictops dakotensis*.

FAMILY ERINACEIDAE BONAPARTE, 1838

Metacodon magnus CLARK

Metacodon magnus CLARK (in SCOTT & JEPSON, 1936, p. 22).

Referred specimen.—Cedar Creek member (lower): No. 8155; right ramus with M_1-M_3; SW¼ sec. 21, T. 11 N., R. 53 W., Logan County.

If the material referred to this species is correctly assigned, it extends the range of the species from the Chadronian into the Orellan.

Metacodon mellingeri PATTERSON & MCGREW

Metacodon mellingeri PATTERSON & MCGREW, 1937, p. 258.

Type.—Chicago Nat. Hist. Mus. No. P15321; Cedar Creek member, sec. 17,[20] T. 11 N., R. 65 W., Weld County, Colorado.

Referred specimens.—Cedar Creek member (lower and middle): Nos. 8156-8157; right lower jaw fragments, each with one molar; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County. No. 8158; right M_3; E½ sec. 7, T. 11 N., R. 53 W., Logan County. No. 8161; right jaw with P_3-M_3; SE¼ sec. 7, T. 11 N., R. 53 W., Logan County.

PATTERSON & MCGREW described this species in detail. My study of the material from Logan County reveals nothing significant to add to their discussion.

CLARK (in SCOTT & JEPSEN, 1936, p. 22; CLARK, 1937, p. 310) placed the genus *Metacodon* in the family Leptictidae, and PATTERSON & MCGREW (1937, p. 257) placed the genus in the Erinaceidae. Later CLARK (1939, p. 139) commented upon the observations of PATTERSON & MCGREW but did not believe that the evidence warranted a definite assignment one way or another. BUTLER (1948, p. 491) created a new family, the Metacodontidae, to receive this and other genera stating: "This new family is created to include the genera *Metacodon*, *Meterix*, and *Plesiosorex* which, although they may eventually prove to be related to the Erinaceidae, are too imperfectly known to be placed with certainty in that family." I have no intention of passing upon the merits of the arguments offered by CLARK or PATTERSON & MCGREW for placing the genus *Metacodon* in either of the two families. Regardless of BUTLER's evidence of the homogeneity of this group of genera that make up his family Metacodontidae, his argument that the genera are too imperfectly known to be included in the Erinaceidae would seem to apply equally well to the thesis that they are not well enough known to warrant creating a new family. I leave the genus in the Erinaceidae because the family is a convenient taxonomic unit in which to place this Oligocene genus of uncertain systematic position.

Ankylodon annectens PATTERSON & MCGREW

Ankylodon annectens PATTERSON & MCGREW, 1937, p. 269.

Type.—Chicago Nat. Hist. Mus. No. P15326; Cedar Creek member, sec. 17, T. 11 N., R. 65 W., Weld County, Colorado.

The species is only known from the type locality.

Ankylodon progressus, new species

Figure 13

Holotype.—Posterior part of a right ramus with M_1-M_3, No. 8153, Vert. Paleont. Coll., Univ. Kansas Mus. Nat. Hist.

Geological age and locality.—Silts of Orellan age in the Cedar Creek member (lower) of the White River formation, Clyde Ward Ranch, SW¼ sec. 12, T. 11 N., R. 54 W., Logan County, Colorado. A referred specimen, No. 8152, a left jaw with M_1-M_3 was found in the Cedar Creek member (middle) in SW¼ sec. 21, T. 11 N., R. 53 W., Logan County.

Diagnosis.—In comparison with the type species (*Ankylodon annectens* PATTERSON & MCGREW, 1937) the first two molars of this species have the hypoconulids reduced; the principal cusps in transverse alignment instead of oblique, and with the protoconids equal in height to the metaconids instead of higher; and the anterior cingula less developed. Compared with referred specimens of *A. annectens*, the heel of the M_3 is narrower in this new species.

Description.—This species does not differ from *Ankylodon annectens* in the known parts except in larger size (Table 3) and the details given in the diagnosis. Concerning the specific differences, it is to be noted that on M_1 and M_2 the hypoconulid is represented only by a slight, posteriorly directed bulge on the rear of the tooth. These two molars have the principal cusps in transverse alignment, a condition resembling that seen in the species of *Metacodon* CLARK, but decidedly different from that in *A. annectens* which has the metaconids and entoconids in advance of their neighboring cusps.

20. The locality reference of the type specimen by PATTERSON & MCGREW to sec. 12 was an error.

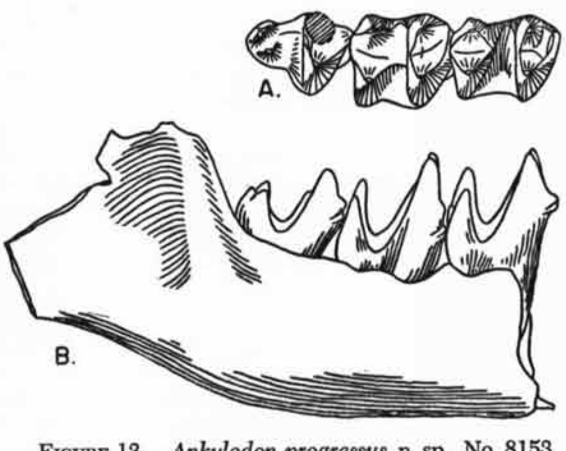


FIGURE 13.—*Ankylodon progressus*, n. sp. No. 8153. (*A*) Occlusal view of right M_1-M_3. (*B*) External view of right jaw with teeth. Approximately × 7.

In *A. progressus* the metaconids have larger bases than the protoconids but are equal to the protoconids in height. The entoconids are much higher than the hypoconids and have larger bases as in *A. annectens*, but relatively the entoconids of *A. progressus* are much higher than those on the molars of *A. annectens*. A cingulum is present on the antero-external surface of M_1 and M_2 below the paraconid ridge. This cingulum is a short ridge (0.5 mm. and 1.0 mm. long on M_1 and M_2, respectively) directed diagonally downwardly and outwardly. These remnants of the cingula represent the last stage before complete loss. *Ankylodon annectens* had much better developed cingula, yet PATTERSON & MCGREW rightly described them as weak. *A. progressus* has the paraconids reduced to mere ridges as in *A. annectens*. In the type specimen of *A. progressus* there is more reduction of the paraconid in M_2 than in M_1. This may be an individual variation since a damaged referred specimen has the paraconid on M_1 more reduced than that on M_2.

In the new species the paraconid of M_3 is reduced to a ridge equal in size to that on M_1. The metaconid has been broken off, but the base of the cusp is larger than that of the protoconid. The anterior cingulum is less reduced than on M_1 or M_2. The entoconid is much higher than the hypoconid, and the hypoconulid is well developed, distinct, and almost as large as the entoconid. The hypoconulid lies postero-internally from the entoconid on the median part of the rim of the heel but is more closely associated with the entoconid than the hypoconid, from which it is separated by a large notch.

TABLE 3.—Measurements (in mm.) of *Ankylodon progressus*

	No. 8153
Crown length of M_1-M_3	5.91
M_1, antero-posterior length	1.95
M_1, transverse width of anterior lophid	1.56
M_1, transverse width of posterior lophid	1.41
M_2, antero-posterior length	1.95
M_2, transverse width of anterior lophid	1.76
M_2, transverse width of posterior lophid	1.54
M_3, antero-posterior length	2.16
M_3, transverse width of anterior lophid	1.35
M_3, transverse width of posterior lophid	0.90

FAMILY SORICIDAE GRAY, 1821

Domnina gradata COPE

Domnina gradata COPE, 1873b, p. 1.

Type.—AMNH No. 5353; Brule (probably lower), Cedar Creek, Colorado (*fide* PATTERSON & MCGREW, 1937).

Referred specimens.—Cedar Creek member (lower): No. 8353; left jaw with M_1-M_3; SE¼ sec. 3, T. 11 N., R. 54 W., Logan County. No. 8160; left jaw with M_2-M_3; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County. Chicago Nat. Hist. Mus. No. P15320; left jaw with I_3, P_4-M_3; sec. 17, T. 11 N., R. 65 W., Weld County.

Cedar Creek member (middle): No. 8977; left jaw with M_1-M_3; W½ sec. 7, T. 11 N., R. 53 W., Logan County.

PATTERSON & MCGREW (1937) discussed this species, including the material from Weld County, and COPE's type. The specimens from Logan County are similar in structure to, and are within the size range of, the type of *D. gradata* and referred specimens from Nebraska and Weld County (Table 4).

Domnina compressa, new species

Figure 14

Holotype. — Posterior part of right ramus with M_1-M_3, No. 8154, Vert. Paleont. Coll., Univ. Kansas Mus. Nat. Hist.

Geological age and locality.—Silts of Orellan age in the Cedar Creek member (middle part) of the White River

TABLE 4.—Measurements (in mm.) of *Domnina gradata*[a]

	No. 8160	No. 8353	No. 8977	Patterson & McGrew
Crown length of M_1-M_3	....	....	5.25	5.4–5.8
M_1, antero-posterior length	....	....	2.07	2.2–2.5
M_1, transverse width	....	....	1.41	1.4–1.5
M_2, antero-posterior length	2.10	1.98	1.74	1.8–2.1
M_2, transverse width	1.35	1.41	1.29	1.2–1.4
M_3, antero-posterior length	1.59	1.50	1.44	1.5–1.8
M_3, transverse width	1.05	1.05	0.96	1.1–1.2
Depth of ramus at M_1	....	....	2.41	2.2–2.5
Depth of ramus at M_2	2.41	2.44	2.40	2.5–...
Depth of ramus at M_3	2.30	2.25	2.32	...–...

a. The following measurements include, besides those for the specimens found by me, the maximum and minimum measurements given by PATTERSON & MCGREW (1937, p. 256) for the specimens examined by them.

formation, SW¼ sec. 21, T. 11 N., R. 53 W., Logan County, Colorado.

Diagnosis.—Differs from *Domnina gradata* COPE and *Domnina thompsoni* SIMPSON in having: tooth row shorter, with the trigonids and talonids compressed antero-posteriorly relative to the width; entoconids separated from the metaconids by a notch; antero-external cingulum weak; and basin of heel of M_3 enlarged, with hypoconid and hypoconid crest better developed and more labial in position.

Description.—The jaw is slightly lighter anteriorly than in *Domnina gradata* and possibly was shorter, since the angle of the root of the third incisor in the jaw is more acute and the molar tooth row is short. The coronoid ridge is prominent and passes downward onto the side of the ramus as in *D. gradata;* but the side of the mandible is swollen, and the ridge seems to grade into this expanded part. On the internal surface of the ramus, under the paraconid of M_2 and close to the inferior border, there is a foramen—possibly a nutrient canal. The mental foramen is below the talonid of M_1. A feature of the ramus of this specimen is the presence of an elongate depression or pit below P_4 and the trigonid of M_1, anterior to the mental foramen and above the root of the incisor. Specimens of *D. gradata* from Logan and Weld Counties have only the faintest trace of this depression. The inferior border of the ramus is more convex than in *D. gradata.* Most of the ascending ramus is missing, but the lower part of the intertemporal fossa is preserved.

Following the suggestion of PATTERSON & MCGREW (1937), the teeth of this specimen were examined under ultraviolet light. Like COPE's holotype there is no evidence of pigmentation in ordinary light, but the teeth fluoresced orange over an area of the teeth corresponding to the pigmented areas on the specimens of *Domnina gradata* examined by PATTERSON & MCGREW.

The molar teeth are smaller (Table 5) than those of *Domnina gradata,* being practically the size of

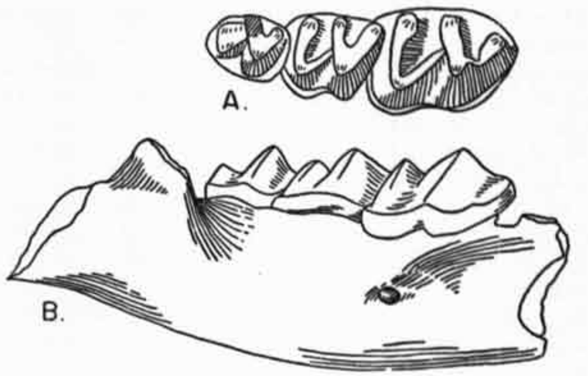


FIGURE 14.—*Domnina compressa,* n. sp. No. 8154. (*A*) Occlusal view of right M_1-M_3. (*B*) External view of right jaw with teeth. Approximately × 9.

the molars of *D. thompsoni,* and are crowded together antero-posteriorly more than in either of these two species. Both M_2 and M_3 have the whole of their paraconids lapping over onto the preceding teeth. At a point under P_4, the incisor is slightly compressed laterally in cross section. The posterior part of the alveolus of P_4 is preserved.

M_1 is the largest of the molars and, like the other molars, is swollen laterally. Compared to that of *Domnina gradata,* the trigonid of *D. compressa* is short antero-posteriorly but exceeds the size of the talonid. The protoconid rises above the other cusps, which are about equal in height, and it is anterior to the metaconid. The talonid is wider than the trigonid and has the anterior slope of the hypoconid forming a crest or facet of wear, which is directed inward and forward to join the posterior face of the trigonid at the mid-line of the tooth below the protoconid-metaconid crest. A similar transverse facet of wear extends from the hypoconid to the posterior end of the entoconid. There is no evidence of a hypoconulid in the present stage of wear. The entoconid is well developed, not transversely compressed as in *D. gradata,* and is separated from

TABLE 5.—Measurements (in mm.) of *Domnina compressa, Domnina thompsoni,* and *Domnina crassigenis*[a]

	Domnina compressa, No. 8154	*Domnina thompsoni,* AMNH No. 32647	*Domnina crassigenis* Cope, 1874a	Cope, 1884a
Crown length of M_1-M_3	4.44	4.8	....	....
Crown length of M_2-M_3	....	....	2.2	3.2
M_1, antero-posterior length	1.98	1.8	....	....
M_1, transverse width	1.38	1.2	....	....
M_2, antero-posterior length	1.56	1.5	....	....
M_2, transverse width	1.20	1.1	....	1.4
M_3, antero-posterior length	1.26	1.3	1.8	1.2
M_3, transverse width	0.90	0.8	....	....
Depth of ramus at M_1	2.28	2.0(*Ca.*)	....	....
Depth of ramus at M_2	2.40	....	....	3.0
Depth of ramus at M_3	2.22	....	3.0	....

a. These measurements include, besides those for the type of *Domnina compressa,* the measurements given by SIMPSON (1941, p. 2) for the type of *D. thompsoni* and two sets of measurements given by COPE (1874a, p. 470; 1884a, p. 811) for the type of *D. crassigenis* which is to be discussed in the following pages. Measurements of *D. compressa* were made by grid and checked by calipers.

the metaconid by a valley. The antero-external cingulum is noticeably weaker than in *D. gradata*, but extends from the anterior tip of the paraconid to the postero-external corner of the protoconid where it joins the hypoconid cingulum. The hypoconid cingulum extends around the rear of the tooth and passes under the cingulum of M_2.

M_2 is smaller than M_1 and has a proportionately longer talonid, which, however, does not exceed the trigonid in width. Both the metaconid and entoconid are proportionately better developed than on M_1, and the protoconid seems to be reduced. Otherwise the relationships of the cusps, crests, and cingula are as on M_1.

M_3 is the smallest of the molars. Although the metaconid has been broken, the trigonid appears to be a miniature of those in M_1 and M_2. The talonid of M_3 differs from that of *Domnina gradata* in being larger, in having the hypoconid more labial in position, and in having the crest from that cusp extending to the mid-line of the posterior face of the trigonid as in the first and second molars. This, together with the compressed entoconid, serves to form a basin in the heel of the tooth which is relatively larger than in *D. gradata*. Although on M_3 of *D. gradata* the entoconid is either absent or reduced, in this new species it is present as a high, transversely compressed ridge, which is separated from the metaconid by a notch. In this molar, as in the others, there is a better union of the entoconid to the hypoconid by the posterior ridge of the tooth than is seen in *D. gradata*. The antero-external cingulum is relatively better developed on M_3 than on the other molars and passes around the base of the protoconid to unite with the hypoconid. There is no hypoconid cingulum.

Discussion. — COPE (1873c, p. 8) and SCOTT (1894, p. 446) described species of soricids which were subsequently placed as synonyms of *Domnina gradata*, or otherwise disposed of. Although there is no doubt of the correctness of this procedure, it is thought best to review the synonyms to make it clear that none of them will be revived and applied to *D. compressa*.

Miothen gracile COPE (1873b, p. 8) was transferred by its author to *Domnina* (1874a, p. 470) and later assigned by him to *Peratherium huntii* (COPE) (1884a, p. 796). I have not seen the type of this species, but it is evident from COPE's description that it is not *D. compressa*. COPE's *Domnina crassigenis* (1874a, p. 470) [*Miothen crassigenis* (1873b, p. 8)] was placed in the synonymy of *D. gradata* by PATTERSON & MCGREW (1937, p. 248). They stated: "The holotype of *D. crassigenis* (Cope) consists of a pair of incomplete mandibles with heavily worn lower molars. The specimen shows no characters that might serve to separate it from *D. gradata*." COPE (1874a, p. 470) pointed out that the teeth of *D. crassigenis* were less robust than in *D. gradata;* described the third molar as reduced, diamond-shaped and longitudinal, and one-half the size of M_2; and gave dimensions (Table 5). Ten years later COPE (1884a, p. 811) emphasized the equal size of the trigonid and talonid of M_2, and the small size of M_3, it being equal in size to the talonid of M_2. A second set of measurements was given. These descriptions do not fit *D. compressa*, and the only measurement that needs serious consideration is the length of M_3 given in 1884. Concerning this, it is of significance that both COPE and PATTERSON & MCGREW stressed the great amount of wear on the type. Extreme wear on M_3 of *D. gradata* would produce the length given by COPE in 1884 and the description, by comparison to M_2, of the M_3 size given in the text (1884a, p. 811). *Protosorex crassus* was described by SCOTT in 1894 (p. 446) and placed in the synonymy of *D. gradata* by PATTERSON & MCGREW (1937, p. 248). They state that "The description and measurements given by Scott for *P. crassus* indicate that this species must be placed in the synonymy of *D. gradata*." There is nothing in SCOTT's description or measurements that definitely separates *Protosorex crassus* from *D. compressa* or, for that matter, from several soricids. On the other hand, nothing in SCOTT's description demonstrates that the *P. crassus* specimen is more likely to be *D. compressa* than *D. gradata*. Since the unfigured type is lost, however, and the description is essentially generic, there can be no better solution than to consider *Protosorex crassus* a synonym of *D. gradata*. The fact that the type of *P. crassus* came from South Dakota reduces the chance of its being *D. compressa*.

Domnina gradata and *D. compressa* seem to represent two divergent branches that could have developed from *D. thompsoni* of the Chadron. Assuming this to be true, the trend suggested by *D. compressa* was toward the loss of the crest uniting the entoconid and metaconid, retention of a broad heel on M_3 with movement of the hypoconid and hypoconid crest in a labial direction, more rapid or better union of the entoconid with the hypoconid, and greater reduction of the jaw. The trend suggested by *D. gradata* was toward reduction of the heel of M_3 (relative to total size of the tooth), slower loss of the union of the entoconid with the metaconid, slower union of the entoconid with the hypoconid, and less reduction of the jaw. These apparent trends are shown diagrammatically in Figure 15.

Morphologically, *Domnina compressa* seems closer to the modern soricids than is *D. gradata*, and no characters are to be found that would bar it from a position as structural ancestor to the Recent soricids with pigmented teeth.

In the three species mentioned above, the loss of the hypoconulid as a distinguishable entity probably occurred early in their phylogenetic history—perhaps sometime in the Eocene.

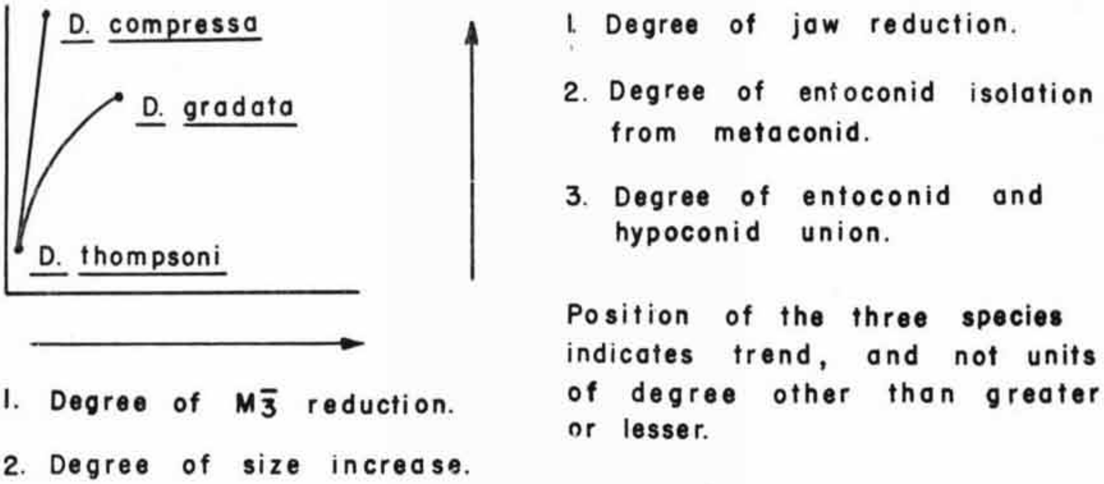


FIGURE 15.—Diagrammatic chart showing trend of changes undergone by *Domnina compressa* and *Domnina gradata* as compared with *Domnina thompsoni*.

FAMILY TALPIDAE MURRAY, 1866

Proscalops miocaenus MATTHEW

Proscalops miocaenus MATTHEW, 1901, p. 375.

Type.—AMNH No. 8949a; Leptauchenia beds, White River formation, Colorado.

The type of this species is a skull and jaws, and is the only reported specimen.

On one occasion, the type of *Proscalops secundus* MATTHEW [21] was referred to under the name *P. miocaenus*, but apparently not with intention to synonymize the names (GREGORY, 1910, p. 238, legend for fig. 17, no. 9).

Proscalops sp. (Small form)

Referred specimen. — Cedar Creek member (middle): No. 8143; left jaw with P_1-P_2, alveolus of P_3, and P_4-M_3; W½ sec. 7, T. 11 N., R. 53 W., Logan County.

No. 8143 represents an unnamed species of *Proscalops*, smaller than *P. miocaenus* and with a relatively smaller M_1 and smaller talonids on the molars. In the Chicago Natural History Museum there is a skull and jaws from the middle Oligocene of Wyoming that resembles this specimen. Specific assignment of No. 8143 is deferred until the Wyoming specimen is prepared and studied.

21. *Proscalops secundus* has never been adequately described. So far as I can ascertain, the type designation and specific name must be cited as figures 3 and 4 of plate 51, and the accompanying legends on page 559 of "The Carnivora and Insectivora of the Bridger Basin Middle Eocene" (MATTHEW, W. D., 1909, Am. Mus. Nat. Hist., Mem., vol. 9, pt. 6). Compared with *P. miocaenus* the major distinguishing features of the type specimen (AMNH No. 13768) are: Skull longer (28 mm.) and wider; M^3 relatively longer (antero-posterior length 1.8 mm., and transverse width 2.14 mm.); paracones, metacones, and protocones of P^4-M^3 broader and more shelflike; and styles more elongate and sharper antero-posteriorly.

Scalopine sp.

Referred specimen. — Cedar Creek member (middle): No. 9224; right humerus lacking proximal articular surfaces; SE¼ sec. 7, T. 11 N., R. 53 W., Logan County.

This bone is approximately three-fourths the size of the humerus of *Scalopus aquaticus machrinoides*, but otherwise does not differ in any respect from that of the Recent form.

I suggest that this typically talpid humerus is associated with *Proscalops*. While the association cannot be proved, at least it weakens the argument (SCHLAIKJER, 1933, p. 23) for association of *Proscalops* with the humerus of *Arctoryctes*—a bone that certainly is not talpid-like.

?INSECTIVORA, *incertae sedis*

Arctoryctes?

Referred specimens. — Cedar Creek member (middle): Nos. 9837-9838; right humerus with damaged capitulum, and left humerus lacking proximal articular surfaces (not associated); W½ sec. 7, T. 11 N., R. 53 W., Logan County. No. 9839; right humerus lacking the medial border; NE¼ sec. 3, T. 11 N., R. 54 W., Logan County.

These humerii are basically similar to the type of *Arctoryctes terrenus* MATTHEW. Unlike the humerus of *A. terrenus*, these specimens have the teres tubercle developed into a distinct process. Together, the teres tubercle and the pectoral process (deltoid process of SCHLAIKJER, 1933 [22]) convert the bicipital

22. The identity of this structure may depend upon the systematic position of *Arctoryctes*. If *Arctoryctes* is an insectivore, particularly a talpid, the structure may be the proximal end of the pectoral crest which has migrated downward to its present position. On the other hand, the process may be truly homologous to the deltoid process seen in other orders. See, for example, the humerii of *Metacheiromys* or *Galliaetatus*.

groove into a deep well-protected channel. These specimens show a fossa similar to the fossa that lies medial to the trochlea on *Scalopus*.

Geolabis rhynchaeus COPE

Geolabis rhynchaeus COPE, 1884a, p. 808.

Type.—AMNH No. 5347; northeastern Colorado.

This genus and species was based on parts of two crania that lacked molars and are yet the only known specimens. COPE (1874a, p. 469) originally thought they might represent members of the genus *Domnina* and in 1884 regarded the specimens as possibly being talpids. SCOTT & JEPSEN (1936, p. 25) placed the genus in the family Talpidae.

ORDER LAGOMORPHA BRANDT, 1855

FAMILY LEPORIDAE GRAY, 1821

Several hundred leporid specimens were collected in northeastern Colorado, and their occurrence was recorded in five-foot units in the measured section of each exposure or closely related exposures.

At present the leporids seem to offer a rather convenient stratigraphic index to the Oligocene beds in northeastern Colorado. Whether or not this will continue to be the case depends upon the results of careful collecting and analysis of the leporid fauna of each exposure and level. The Horsetail Creek member carries only *Palaeolagus intermedius*. In the beds that grade from the Horsetail Creek member into the Cedar Creek member, *Palaeolagus haydeni* and *P. intermedius* are found. Following *P. haydeni* in the section comes *Palaeolagus burkei*, the smallest rabbit of the genus. It survived throughout the middle and upper parts of the Cedar Creek member and, from the meager evidence present, continued on into Whitneyan time along with *P. intermedius*.

It may be pointed out here that enough material now is present from each of the various levels and exposures to give a good picture of tooth wear from immaturity to old age of these rabbits. A survey of the lower teeth of *Palaeolagus intermedius*, *P. haydeni*, and *P. burkei*, each species represented by teeth from a separate and single locality, showed that the stages of wear were not comparable in the three groups. For example, the young of *P. burkei* either shed their deciduous teeth relatively early in life, or else were confined to a habitat that was advantageous to longevity, because few jaws with deciduous teeth were found. Such specific peculiarities may never be explained, but this leporid collection presents many problems for the future student. It is outside the scope of this study to pursue them.

GREEN (1942) studied the Oligocene leporids in the collection of the University of Kansas which included specimens from northeastern Colorado. Unfortunately, he did not have either the stratigraphic control or the quantity of material now present; consequently, no attempt is made to correlate my work with that of GREEN.

Palaeolagus intermedius MATTHEW

Palaeolagus intermedius MATTHEW, 1899, p. 53.

Type.—AMNH No. 8722, upper levels of the White River, at Castle Rock, Cedar Creek, Colorado.

Referred specimens.—Horsetail Creek member: No. 9011; left P_4-M_2; SE¼ sec. 1, T. 10 N., R. 54 W., Logan County. No. 9095; left jaw with P_3-M_2; W½ sec. 30, T. 11 N., R. 51 W., Logan County. No. 9109; six lower jaws; W½ sec. 29, E½ sec. 30, T. 11 N., R. 53 W., Logan County. No. 9129; left maxillary with P^4-M^2, and four fragments of lower jaws; NE¼ sec. 31, T. 11 N., R. 56 W., Weld County. No. 9132; right maxillary and two left lower jaws; N½ sec. 13, T. 11 N., R. 56 W., Weld County.

Horsetail Creek member or Cedar Creek member (lower): No. 9094; right jaw with P_4-M_3; NE¼ sec. 8, T. 11 N., R. 54 W., Logan County. No. 9097; associated upper and lower jaws; SE¼ sec. 17, T. 11 N., R. 65 W., Weld County. No. 9098; same as No. 9097. No. 9099; 4 upper and 20 lower jaws; locality same as No. 9097.

Cedar Creek member (middle): No. 9092; damaged skull; SE¼ sec. 3, T. 11 N., R. 54 W., Logan County. No. 9093; right maxillary with P^2-M^2; center sec. 3, T. 11 N., R. 54 W., Logan County.

The type locality was recorded by MATTHEW (1902b, p. 308) as above. From the evidence in the 1898 field records, I think Castle Rock is in either R. 53 or R. 54, T. 11 N., Logan County.

MATTHEW's record of *Palaeolagus intermedius* from the Leptauchenia zone and the referred specimens in our collections establish the range of this species as throughout the Oligocene in northeastern Colorado.

The teeth of *Palaeolagus intermedius* resemble those of *P. haydeni* more than those of *P. burkei*. Compared with the teeth of *P. haydeni*, the upper teeth of *P. intermedius* are relatively much wider, actually larger, and in the cycle of tooth wear, lose their crescents and hypostria much earlier in life. There is apparently a greater length of time between eruption of successive teeth. In the specimens from the Horsetail Creek member, the length of P^3-M^2 ranges from 8.0 mm. to 8.9 mm., and the length of P_4-M_2 ranges from 6.7 mm. to 7.6 mm. Available material is not adequate to give a reliable range of lengths of the tooth rows for the Cedar Creek specimens. Two lower jaws from the lower part of the Cedar Creek member and two from the middle part give a range in length of 6.8 mm. to 7.0 mm. for P_4-M_2. The length of P^3-M^2 in No. 9092 is 9.0 mm., but the tooth row is distorted so that this measurement may be too large. The length of the P^3-M^2 of No. 9093 is 8.3 mm.

Palaeolagus haydeni LEIDY

Palaeolagus haydeni LEIDY, 1856, p. 89.

Referred specimens.—Cedar Creek member (lower): No. 9091; 25 upper and lower jaws; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County.

Although specimens of *Palaeolagus haydeni* from northeastern Colorado average slightly smaller than typical Nebraskan specimens, the Coloradan specimens are still within the size range of the species. The Coloradan specimens have a range in length of P^3-M^2 from 6.8 mm. to 7.8 mm. and a P_4-M_2 range from 6.0 mm. to 6.6 mm. These measurements afford a ready means of distinguishing this species from other northeastern Colorado species and are unreliable only in very young or very old specimens.

Palaeolagus haydeni is listed as occurring only in the lower part of the Cedar Creek member, where it does so in abundance. One specimen, however, from the upper part of the Horsetail Creek member seems to be referable to this species, and a few specimens occur near the base of the middle part of the Cedar Creek.

Occasionally specimens are found that have an occlusal pattern like that of *Palaeolagus burkei* instead of *P. haydeni* but fall in the size range of *P. haydeni*. Inasmuch as these anomalies occur in the lower levels of the Cedar Creek in association with normal *P. haydeni*, it has been assumed that these large specimens are *P. haydeni*.

Palaeolagus burkei Wood

Palaeolagus burkei Wood, A. E., 1940, p. 325.

Type.—AMNH No. 8704; Leptauchenia beds of northeastern Colorado.

Referred specimens. — Cedar Creek member (middle): No. 9088; anterior part of skull and associated left jaw with P_4-M_3; E½ sec. 3, T. 11 N., R. 54 W., Logan County. No. 9089; anterior part of skull and associated lower jaws; NE¼ sec. 3, T. 11 N., R. 54 W., Logan County.

Vista member: No. 9085; four fragments of lower jaws; E½ sec. 12, T. 11 N., R. 54 W., Logan County.

Palaeolagus burkei is the most easily recognized species of *Palaeolagus* in northeastern Colorado and is especially distinctive in the characters of the skull and upper teeth (Wood, 1940, p. 325). Like the other species in this area, the teeth have a size range that is almost diagnostic. The range in length of P^3-M^2 is from 6.1 mm. to 6.8 mm., and that of P_4-M_2 is from 5.0 mm. to 5.9 mm.

Megalagus turgidus (Cope)

Palaeolagus turgidus Cope, 1873b, p. 4.
Megalagus turgidus, Walker, 1931, p. 234.

Type.—AMNH No. 5635; Tertiary of Colorado.

Referred specimens.—Cedar Creek member: No. 9083; left maxillary; S½ sec. 7, T. 11 N., R. 53 W., Logan County. No. 9084; four lower jaws; NE¼ sec. 3, T. 11 N., R. 54 W., Logan County.

This species is found throughout the Cedar Creek member.

Order RODENTIA Bowdich, 1821

Family ISCHYROMYIDAE Alston, 1876

A considerable number of prosciurine specimens have been referred to *Prosciurus*, and caution has been used by all workers in naming new genera and species. The treatment accorded the prosciurines in this paper is the result of consideration of more than 70 specimens of which more than half were from northeastern Colorado. A new genus is named, and all the smaller specimens have been assigned, tentatively, to *Prosciurus relictus*.

Approximately 150 fragments of upper and lower jaws assignable to *Ischyromys* have been collected by University of Kansas field parties in northeastern Colorado. Of this number the stratigraphic position within the members is known for 85 of the specimens.

Several specimens have been referred, tentatively, to *Titanotheriomys*.

Prosciurus relictus (Cope)

Plate 2, figure *A*; Figure 16

Paramys relictus Cope, 1873c, p. 3.
Prosciurus relictus, Matthew, 1909, p. 105.

Type.—AMNH No. 5360; Tertiary of northeastern Colorado.

Referred specimens.—Cedar Creek member (lower): No. 8340; right maxillary with P^4-M^3. No. 8341; left jaw with M_1-M_3. Both specimens from SW¼ sec. 12, T. 11 N., R. 54 W., Logan County.

Cedar Creek member (middle): No. 8317; left jaw with P_4-M_3. No. 8318; right jaw with P_4-M_2. No. 8321; right jaw with P_4-M_3. No. 8323; left jaw with P_4-M_3. No. 8322; right P^4-M^2. No. 8324; left jaw with P_4-M_3. No. 8325; right jaw with M_1-M_2. Above seven specimens from W½ sec. 7, T. 11 N., R. 53 W., and E½ sec. 12, T. 11 N., R. 54 W., Logan County. No. 8326; right jaw with P_4-M_3. No. 8327; left jaw with P_4-M_2. No. 8333; anterior part of skull with right and left M^2-M^3. No. 8345; anterior part of skull without teeth. Above four specimens from E½ sec. 3, T. 11 N., R. 54 W., Logan County. No. 8328; right maxillary with P^4-M^3. No. 8329; right jaw with P_4-M_3. No. 8330; left jaw with P_4-M_3. Above three specimens from SW¼ sec. 21, T. 11 N., R. 53 W., Logan County. Univ. Colorado Mus. No. 19850; two right lower jaws with P_4-M_3; W½ sec. 7, T. 11 N., R. 53 W., Logan County.

Twenty-five upper and lower jaws of this species from northeastern Colorado and 28 upper and lower jaws from the Brule of Nebraska were available for study.

Enough material was collected from restricted levels and localities to give a good idea of variation in the teeth of *Prosciurus relictus* and to eliminate any doubt about association of the upper and lower teeth.

Variation in length of tooth row, individual teeth (Table 6), and component parts of the teeth occurs, but there does not seem to be any correlation of size variation with stratigraphic position.

The third upper premolar is peglike. The fourth premolar and the molars have well-developed protocones, incipient hypocones, well-developed anterior cingula, but weak or no posterior cingula. Cusps comparable to the parastyle on P^4 tend to develop at the buccal end of the anterior cingula of the molars. The paracone, metacone, metaconule, and protoconule decrease in size in the order listed but all are distinct, with the exception of the metacone and metaconule on M^3. Some mesostyles have crests extending into the valley between the two lophs but never have crests uniting the mesostyle to either the paracone or metacone. The third molar has developed a heel by enlargement of the metacone at the postero-external angle of the tooth. On M^3 the mesostyle is united to the metaconule by a crest. The metacone maintains its union to the metaconule by a crest unless the metaconule is weak or absent, in which case the crest extends to the protoloph, joining it near the protocone.

The upper teeth of *Prosciurus relictus* may be distinguished from those of *P. vetustus* (MATTHEW) by two characters—relatively greater width and the number of "metaconules" present. When more specimens of *P. vetustus* are known, these distinctions may break down, but at present they seem valid. None of the specimens of *P. relictus* have anything that can be considered as a second or double metaconule. In size *P. vetustus* is intermediate between the smaller specimens of *P. relictus* and the larger specimens represented by the type.

The lower teeth of *Prosciurus relictus* have been figured and described (WOOD, 1937, pp. 162, 168-169); therefore, only the variations seen in the present collection of specimens will be discussed. The mesostylid varies in position and attachment to the metaconid and entoconid, although the normal condition is separation from both metaconid and entoconid by notches. Mesostylid crests, if present, extend into the basin of the tooth and may be large. When large, the crests may unite with the hypolophulids. The completeness and strength of the hypolophulid on each tooth is subject to two common variations which are not the result of wear. Some hypolophulids extend transversely across the tooth toward the ectolophid, being either well developed and united to the ectolophid or weak and failing to unite; others turn back toward the posterolophid and unite with that crest, or when weak fail to reach the crest. In some teeth the hypolophulid unites with both ectolophid and posterolophid. The anteroconid may or may not be present on the premolar, and likewise the ectostylids vary on the cheek teeth. The variations listed above are the most prominent and are the ones that could most easily be mistaken as characters that distinguish species.

That these specimens might represent three species has been seriously considered by me. By size the specimens may be segregated into three groups: the first — those the size of the type of *Prosciurus relictus* to which most belong; a second group—all small specimens with narrow teeth; and perhaps a third group—larger in size than the type specimen and having teeth relatively wider. As yet, I cannot (at least to my own satisfaction) correlate these size groups with other morphological variations or with stratigraphic positions. Furthermore, the same condition seems to exist among specimens from the Brule of Nebraska.

Specimen No. 8333 (Pl. 2, fig. *A*; Fig. 16) consists of the preorbital and interorbital parts of a skull. The nasal and lacrimal bones are lost; the premolars and first molars are missing; and the zygomata are lacking back of the maxillaries. Its size is comparable to that of *Glaucomys sabrinus* SHAW. The specimen has a remarkable resemblance in proportions to the skull of *Promylagaulus riggsi* described by MCGREW (1941c, fig. 1). The skull

TABLE 6.—Measurements (in mm.) of *Prosciurus relictus*

	No. 8333		No. 8328	No. 8340
Tooth row length at alveolus	7.5	Crown length of P^3-M^3	6.20	7.50
Premolar to incisor length	8.5	P^4, antero-posterior length	1.77	2.01
Width of palate at P^4	4.3	P^4, transverse width	1.90	2.50
Length of incisive foramina	3.0	M^1, antero-posterior length	1.50	1.80
Width of incisive foramina	2.0	M^1, transverse width	1.93	2.41
Width of rostrum in front of zygomatic structure	7.5	M^2, antero-posterior length	1.56	1.86
		M^2, transverse width	1.95	2.46
Height of skull at M^2	18.0	M^3, antero-posterior length	1.70	2.07
Antorbital width of frontals	16.0	M^3, transverse width	1.80	2.19

	No. 8317	No. 8321	No. 8323	No. 8324	No. 8326	No. 8329	No. 8330	No. 19850[a]	
Crown length of P_4-M_3	7.10	6.80	7.00	7.60	7.20	6.66	6.60	6.60	6.60
P_4, antero-posterior length	1.77	1.59	1.68	1.92	1.77	1.62	1.50	1.62	1.53
P_4, transverse width of anterior lophid	1.14	1.14	1.17	1.14	1.26	1.26	1.08	1.26	1.26
P_4, transverse width of posterior lophid	1.68	1.56	1.56	1.65	1.74	1.53	1.50	1.62	1.59
M_1, antero-posterior length	1.65	1.56	1.65	1.77	1.80	1.62	1.44	1.62	1.53
M_1, transverse width of anterior lophid	1.50	1.35	1.32	1.41	1.50	1.38	1.32	1.44	1.44
M_1, transverse width of posterior lophid	1.65	1.50	1.53	1.65	1.68	1.56	1.50	1.56	1.62
M_2, antero-posterior length	1.95	1.71	1.74	1.95	1.95	1.80	1.68	1.80	1.80
M_2, transverse width of anterior lophid	1.56	1.50	1.47	1.62	1.59	1.53	1.53	1.56	1.50
M_2, transverse width of posterior lophid	1.83	1.71	1.71	1.77	1.80	1.68	1.65	1.74	1.71
M_3, antero-posterior length	2.25+	2.07	2.13	2.25	2.16+	2.07	2.01	2.10	2.10
M_3, transverse width of anterior lophid	....	1.62	1.50	1.65	....	1.56	1.56	1.50	1.50
M_3, transverse width of posterior lophid	....	1.62	1.50	1.65	....	1.41	1.32	1.53	1.44

a. Two specimens from the University of Colorado catalogued under this number.

is shallow vertically and has a short and wide rostrum, narrow palate, and long tooth row (Table 6).

Judging from the structure of the premaxillaries and the matrix in the nasal cavity, the nasal bones were large and heavy, extending as far back as the premolars and overlapping onto the frontals. Anteriorly they were slightly flared out laterally and possibly were flattened and turned downward.

The premaxillary bones, which constitute most of the anterior part of the rostrum, give the anterior part of the skull its characteristic short stubby appearance. Exclusive of the frontal process, the sutural union of the two bones to the maxillaries is essentially in one transverse plane. The frontal process is broad and blunt. Dorso-anteriorly, the inner edge of the bone turns upward to meet the nasal bone. Ventrally, the premaxillaries make up all of the lateral border of the incisive foramen. The median septum is large and heavy and, presumably, is composed of two processes of the premaxillary bones. Because of the short rostrum, the incisive foramina are crowded close to the incisors. No other foramina are discernible on the premaxillaries.

The incisors are heavy and directed ventromedially from each premaxillary. The anterior faces are flatly convex, and each lateral face meets at the rear of the tooth to form a roughly triangular cross section, slightly longer than wide.

Both maxillary bones are complete, except that the zygomatic processes may have lost their extreme tips. Antero-ventrally, the maxillaries form the posterior border of the incisive foramina. The palate is narrow, and the suture between the maxillaries and palatines forms a bow at the anterior end of the second molars. The zygomatic root rises abruptly at the anterior end of the tooth row, and the zygomatic plate shows no forward inclination. Laterally the zygomatic process extends outward and backward, terminating in a slender point. The ventral surface of the process has a groove which is presumed to be the attachment scar for the lateral masseter muscle. At the medial end of the anterior ridge forming the attachment scar, a small protuberance is visible. The infraorbital foramen is roughly oval in shape and relatively large in diameter. The infraorbital canal is elongate anteroposteriorly, and the orbital opening lies above the tooth row in the orbit. The maxillary forms the anterior and ventral borders of the orbit, and internally, the floor and a small part of the median wall. The palatine process is large, because of the relatively large teeth, and resembles *Ischyromys* in this respect. The part composing the medial wall of the orbit is limited to a triangular plate of bone rising from the floor of the orbit and extending upward between the lacrimal and the frontal bones. In the ventro-posterior part of the orbit the maxillary joins the frontal bone and encloses the sphenopalatine foramen. Posterior to this a second foramen is present in the maxillary just anterior to the palatomaxillary suture. M^2-M^3 are similar to those described previously. Comparison of this specimen with the type (a maxillary fragment with teeth) of *P. vetustus* shows no differences worth noting in the maxillary.

The palatine bones are well preserved, lacking only the pterygoid processes. The maxillary process of the palatine bone is united to the maxillary bone by a suture that courses along the lateral border of the palate from M^3 to the anterior end of M^2 where the suture becomes highly sinuous and crosses the palate to the mid-line. Thus, the union of the palatines with the maxillaries makes a suture in the

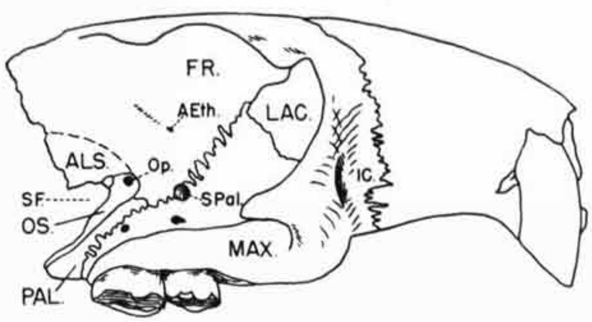


FIGURE 16.—*Prosciurus relictus* (COPE). No. 8333. Lateral view of right side of skull showing structures in the orbital area. *ALS*, alisphenoid. *FR*, frontal. *LAC*, lacrimal. *MAX*, maxillary. *OS*, orbitosphenoid. *PAL*, palatine. *AEth*, anterior ethmoid foramen. *Op*, optic foramen. *SPal*, sphenopalatine foramen. *SF*, sphenoidal fissure. *IC*, infraorbital canal. Approximately × 4.

shape of a U with the base forward on the palate. The double posterior palatine foramina pass through the palatine bone, with the anterior foramen much larger than the posterior one. The rear of the palate is emarginate, each palatine bone having its median edge terminating opposite the mid-point of M^3. There is no evidence of more than an incipient palatine pit posterior to M^3. The orbital process of the palatine is a thin sliver of bone extending up between the maxillary and orbitosphenoid where it meets the frontal and plays little part in forming the floor of the orbit. Posteriorly, the palatine expands downward behind the maxillary and beneath the orbitosphenoid (?presphenoid).

In dorsal view, the frontal bone is twice as wide anteriorly as it is posteriorly, resembling the form seen in *Aplodontia* and *Paramys*. The anterior dorsal border is more or less transverse to the long axis of the skull, but the sutures curve forward slightly at each side. The antero-lateral "wing" of the frontal curves downward on the side to meet the maxillary and the lacrimal to form the antero-dorsal border of the orbit. An incipient postorbital process projects outward from the dorsal surface of the frontal bone. Preservation around the lacrimal canal is poor, but judging from the size of the lacrimal, it is doubtful that the frontal bone assisted in the composition of that canal. The orbital plate of the frontal makes up the posterior part of the inner wall of the orbit and contributes to the formation of at least the upper part of the posterior orbital wall. The orbitosphenoid-frontal suture borders the optic foramen. Ventrally, the orbital plate extends to the orbital process of the maxillary bone and forms the upper border of the sphenopalatine foramen. The plate terminates ventrally as a tongue of bone extending downward between the orbitosphenoid and maxillary bones to meet the orbital process of the palatine bone. About 2 mm. above the sphenopalatine foramen the orbital plate is pierced by the anterior ethmoid foramen, and posterior to it is a groove in the plate which served as a partial passageway for the nerve or blood vessel that coursed across the inner wall of the orbit. Posteriorly, there is no trace of a suture between the dorsal surface of the frontal and the parietal.

Antero-lateral to the "wing" of the frontal is a notch in the border of the orbit. This is not natural, and, although it is now lost, the lacrimal probably fitted into this space and formed the dorsal part of the anterior wall of the orbit.

The orbit is large and open but, unlike the orbit of the squirrels, has a small part formed by bones other than the frontal, maxillary, and lacrimal.

In this specimen the alisphenoid seems to form no more than the postero-ventral wall of the orbit. The position of the alisphenoid-frontal suture has been tentatively determined (Fig. 16).

The orbitosphenoid bone makes up little of the orbital wall and occupies a narrow part of the postero-ventral area of the orbit between the alisphenoid, palatine, and frontal. The optic foramen is small.

Comparison of No. 8333 with maxillaries of *Prosciurus relictus* containing good teeth leaves little doubt as to the identity of this specimen; similarity is shown in teeth, palatal structure, and zygomatic root structure. Also, enough upper and lower teeth of *P. relictus* have been found in the area to remove any doubt as to association.

A poorly preserved, smaller, but similar fragment of skull, No. 8345, lacks arches and teeth. It has been tentatively referred to *Prosciurus*.

PELYCOMYS, new genus

Type species.—*Pelycomys rugosus,* new species.

Distribution.—Chadronian and Orellan beds of northeastern Colorado.

Diagnosis.—Incisors laterally compressed; lower cheek teeth subtrigonal to subrhombic in shape; principal cusps rounded and large; trigonid large, with metalophulid II essentially complete; hypolophulid well developed and separate from posterolophid; metastylid small and fused to metaconid or united to it by a crest; entoconid separated from posterolophid and metastylid by notches.

Pelycomys rugosus, new species

Figure 17

Holotype. — Part of right jaw with M_1-M_3, No. 8343, Vert. Paleont. Coll., Univ. Kansas Mus. Nat. Hist.

Geological age and locality.—Silts of Chadronian age in the Horsetail Creek member of the White River formation at "Flat Top," a prominent butte, in sec. 1, T. 10 N., R. 54 W., Logan County, Colorado.

Diagnosis.—Differs from *Pelycomys placidus* in having trigonids wider; mesoconids and buccal mesolophids weaker or absent; hypoconids larger; metastylids of M_1-M_2 higher on sides of metaconids; and entoconids smaller. Anterior and posterior arms (anterolophid and metalophulid II) of protoconids reaching metaconids and hypolophulids extending across the basins to ectolophids. M_3 is relatively larger than that of *P. placidus*.

Description.—Little of the jaw is preserved, but the specimen indicates that the jaw is relatively deeper and shorter than that of *Prosciurus relictus.* The length of the cheek-tooth series (Table 7) in this new species is slightly less than that of *Cedromus wardi* and *?Prosciurus jeffersoni,* and almost twice the length of the tooth row of *Prosciurus relictus.* The masseteric scar is weak, more like that of *Prosciurus* than *Cedromus.* The teeth of the type specimen are moderately worn.

The base of the incisor indicates that this tooth was compressed laterally, much more so than in *Prosciurus.*

None of the cheek teeth have high cusps, but, like those of *Prosciurus,* the metaconids are highest. The protoconids and entoconids are of equal height, and the hypoconids, although they are expanded and larger than the other cusps, are the lowest in height. Compared with those of *Prosciurus,* the mesoconids, posterolophids, and entoconids are reduced. Unlike *Prosciurus,* the metaconids and hypoconids are not compressed antero-posteriorly. The trigonid pits of the molars are enclosed by the anterolophid and the metalophulid II. Deep notches separate the entoconids from the metastylids, and shallower notches separate the entoconids from the posterolophids. Large and flat-floored transverse valleys extend from the ectolophids to the buccal margins of the teeth. The buccal mesolophids are

TABLE 7.—Measurements (in mm.) of *Pelycomys rugosus*

	No. 8343
Crown length of M_1-M_3	9.40
M^1, antero-posterior length	2.85
M_1, transverse width of anterior lophid	2.55
M_1, transverse width of posterior lophid	2.73
M_2, antero-posterior length	3.20
M_2, transverse width of anterior lophid	3.00
M_2, transverse width of posterior lophid	3.08
M_3, antero-posterior length	4.18
M_3, transverse width of anterior lophid	3.05
M_3, transverse width of posterior lophid	2.71

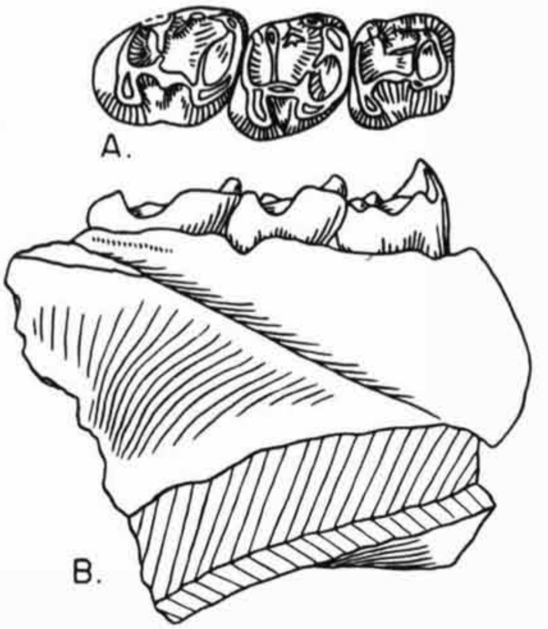


FIGURE 17.—*Pelycomys rugosus*, n. gen. and sp. No. 8343. (*A*) Occlusal view of right M_1-M_3. (*B*) External view of right jaw with teeth. Approximately ×5.

small. The first molar is the smallest, and the third molar is the largest.

On the first molar the anterolophid uniting the protoconid and metaconid is large and similar in shape to that seen on the *Prosciurus* molar. The metalophulid II seems weak and gives the appearance of having been a mutual development from both cusps. The metastylid is small and arises as an attenuated cuspule on the postero-lingual side of the metaconid. A weak ridge extends from the metalophulid II to the hypolophulid closing off the notches between the metaconid and entoconid from the central basin. A small cuspule is developed in the posterior end of this ridge anterior to its union with the hypolophulid. The mesoconid is no more than a swelling in the ectolophid, and has no buccal mesolophid. The hypolophulid is weak.

The trigonid of the second molar is similar in all respects to that of M_1, except that it is not so high. As on M_1, a weak ridge extends antero-posteriorly through the central basin, blocking the base of the deep notch between the metaconid and entoconid. There is evidence of a small cuspule on this ridge opposite the notch. The mesoconid and buccal valley between the protoconid and hypoconid is similar to that on M_1. The hypolophulid is complete and united to the mesoconid.

M_3 has a trigonid similar to that of M_2 but with the metastylid separated from the metaconid by a small notch. The antero-posterior ridge in the central basin of this tooth extends from the metastylid to the median border of the entoconid. The progressive lingual shift of the anterior end of this ridge may be seen in the teeth of this specimen as one observes successively the first, second, and third molars. Although considerable attention has been devoted to this ridge in the description of these teeth, possibly the feature is an individual characteristic and one which should not be relied upon at present to distinguish this species. The mesoconid of the third molar is the only one in the series of molars to show development similar to anything seen in other prosciurine-like rodents. A poorly developed mesolophid extends into the buccal valley between the protoconid and hypoconid. The hypolophulid unites with the ectolophid posterior to the mesoconid. The part of the ectolophid posterior to the hypolophulid does not turn buccally toward the hypoconid as is the case in M_1-M_2, but extends straight back to unite with the posterolophid. The hypolophulid of this tooth is divided by a notch and gives the impression of having developed from the entoconid and ectolophid, respectively. This suggests the mode of origin of the hypolophulid in the prosciurine group. Although the enamel surfaces of the entoconid and posterolophid are damaged, the posterolophid seems to be made up of one cusp, and only a notch separates this element from the entoconid.

Pelycomys placidus, new species

Figure 18

Holotype.—Part of left lower jaw with M_1-M_3, No. 8334, Vert. Paleont. Coll., Univ. Kansas Mus. Nat. Hist.

Referred specimens.—No. 8335; right lower jaw with M_2. No. 8336; left lower jaw with P_4-M_2. Univ. Colorado Mus. No. 19859; right lower jaw with P_4-M_2. All specimens from type locality except No. 19859 which is from the center of sec. 3, T. 11 N., R. 54 W., Logan County.

Geological age and locality.—Silts of Orellan age in the Cedar Creek member of the white River formation in W½ sec. 7, T. 11 N., R. 53 W., Logan County, Colorado.

Diagnosis.—Differs from *Pelycomys rugosus* in having trigonids narrower; mesoconids and buccal mesolophids better developed; hypoconids smaller; metastylids lower on sides of metaconids; entoconids larger; and metalophulid II of molars weaker and lower than anterolophid, and complete.

Description.—The incisors of *Pelycomys* are distinguished by greater compression laterally than in either *Cedromus* or *Prosciurus*. No. 8336 has the best preserved incisor of any of the specimens and shows that the internal face of the tooth is flat, the anterior face is rounded, and the external face is gently curved toward the posterior border of the internal face.

P_4 of the referred specimens has the trigonid damaged, but it can be ascertained that the anterolophid between the protoconid and metaconid was absent and that the metastylid was connected to the side of the metaconid by a crest. The mesoconid is not well developed, and the buccal mesolophid is absent. The entoconid is high and is separated from the posterolophid and metastylid by narrow, deep notches. The ectolophid is united to the hypoconid.

All the molars have the protoconid and metaconid spaced far apart and united by a heavy anterolophid. The metastylid is on the side of the metaconid on all three molars and is united to the metaconid by a small crest. Because of the narrower trigonid, the teeth appear more like those of *Prosciurus* than do the teeth of *Pelycomys rugosus*. The molars differ from one another in the following respects. On M_1 the metalophulid II is a weaker ridge than the anterolophid but is as high; and between them and the protoconid and metaconid, they form the trigonid pit. The entoconid is as high as the protoconid and is separated from the metastylid and posterolophid by narrow, deep notches. The mesoconid is well developed and has a heavy buccal mesolophid extending into the valley or embayment between the protoconid and hypoconid. The hypolophulid on M_1 is complete before wear and unites with the ectolophid and, from the evidence of the referred specimens, is obliterated medially after wear. The posterolophid is well developed and has a large cusp near its union with the hypoconid. The hypoconid on M_1 is well developed but somewhat less so than in the other molars.

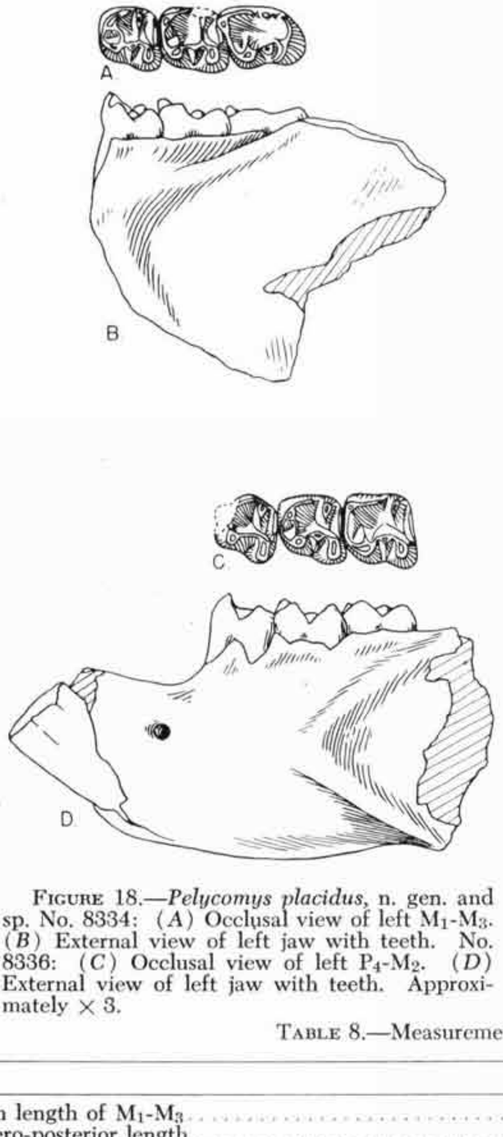


FIGURE 18.—*Pelycomys placidus*, n. gen. and sp. No. 8334: (*A*) Occlusal view of left M_1-M_3. (*B*) External view of left jaw with teeth. No. 8336: (*C*) Occlusal view of left P_4-M_2. (*D*) External view of left jaw with teeth. Approximately × 3.

On M_2 the metalophulid II tends to be weaker than in M_1 and is almost lost on the metaconid side. The entoconid, mesoconid, hypolophulid, and posterolophid are similar to those structures on the first molar. The hypoconid is even larger and more prominent on M_2 than on M_1.

The third molar differs from the other two in many ways. The metalophulid II is incomplete on the metaconid side. The entoconid is not so high as the entoconids on the other molars, and only shallow notches separate it from the metastylid and posterolophid. The mesoconid is larger than the entoconid, and the part of the ectolophid between it and the protoconid is weak. Likewise, the part of the ectolophid between the mesoconid and hypoconid is incomplete, but this may be peculiar to the type specimen, which otherwise would have a complete but weak and low ectolophid. The hypolophulid seems to be absent. On M_3, the hypoconid reaches its greatest development and forms a massive heel as high as the metaconid, which makes up

TABLE 8.—Measurements (in mm.) of *Pelycomys placidus*

	No. 8334	No. 8335	No. 8336	No. 19859[a]
Crown length of M_1-M_3	8.91	....	....	....
I, antero-posterior length	....	....	3.25	....
I, transverse width	....	....	1.80	....
P_4, antero-posterior length	....	....	2.80[b]	2.44
P_4, transverse width of anterior lophid	....	....	2.17[b]	2.00+
P_4, transverse width of posterior lophid	....	....	2.77	2.50
M_1, antero-posterior length	2.75	....	2.80	2.50
M_1, transverse width of anterior lophid	2.35	....	2.50	2.30
M_1, transverse width of posterior lophid	2.70	....	2.94	2.50+
M_2, antero-posterior length	2.90	3.15	3.15	2.80
M_2, transverse width of anterior lophid	2.60	2.70	2.81	2.50
M_2, transverse width of posterior lophid	2.60+	2.86	2.99	2.65
M_3, antero-posterior length	3.85	....	....	....
M_3, transverse width of anterior lophid	2.66	....	....	....
M_3, transverse width of posterior lophid	2.25±	....	....	....

a. University of Colorado Museum.

b. Estimated.

the whole rear of the tooth. An arm from the hypoconid reaches forward to the protoconid enclosing the large mesoconid buccally.

The size of the cheek teeth is given in Table 8.

Pelycomys sp.

Referred specimens.—AMNH No. 8750; left lower jaw with P_4-M_3; Cedar Creek beds, northeastern Colorado (*fide* WOOD, A. E., 1937).

Cedar Creek member (lower): No. 8971; right lower jaw with P_4-M_3; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County.

Cedar Creek member (middle): No. 8344; a first or second left upper molar; SW¼ sec. 21, T. 11 N., R. 53 W., Logan County.

WOOD (1937, p. 170) identified the American Museum specimen as *Prosciurus* cf. *P. saskatchewaensis* (LAMBE). This specimen and No. 8971 are smaller than individuals of *Pelycomys* already described and are larger than large individuals of *Prosciurus relictus*. The narrowness of the incisors, completeness of the metalophulid II, thickness of the metaconids, and small size of the metastylids suggest that the two specimens are referrable to the genus *Pelycomys*. The specimens may be *Pelycomys placidus* but possibly they and the University of Colorado Museum specimen No. 19859, which is referred to *Pelycomys placidus*, are an unnamed species.

No. 8344 is large, 2.7 mm. long and 3.1 mm. wide. There is a parastyle on the buccal end of the anterior cingulum, and a definite hypocone and protoconule are present. Whether or not it is referable to *Pelycomys* remains to be decided but it is a prosciurine tooth comparable in size with the lower teeth of this genus.

Discussion.—The differences in the teeth of *Pelycomys rugosus* and *Pelycomys placidus* are the basis for making two species in this genus. *Pelycomys placidus* has a larger talonid basin than *P. rugosus*. This feature is especially noticeable in M_3 of *P. placidus* which does not have the basin worn, and shows that the absence of crests and lophids from the basin is real. Structurally the enlargement of the basin is seen as a trend that parallels the enlargement of the basin in *Prosciurus*. In *Prosciurus* the enlargement is accomplished by a diagonal elongation of the teeth and loss of the metalophulid II, whereas in *Pelycomys* enlargement is at the expense of metalophulid II and the hypolophulid.

In my opinion *Pelycomys* belongs in the subfamily Prosciurinae (WILSON, 1949b, pp. 77, 92) along with *Prosciurus* and *Sespemys*. Further consideration of this genus and its relations to the genera *Prosciurus* and *Cedromus* will be found in the discussion of *Cedromus*.

Ischyromys typus LEIDY

Ischyromys typus LEIDY, 1856, p. 89.

Referred specimens.—Cedar Creek member (lower and middle): No. 9058; anterior part of skull, mandible, and fragments of skeleton; sec. 28, T. 11 N., R. 53 W., Logan County. No. 9075; left jaw with P_4-M_3; SE¼ sec. 31, T. 12 N., R. 54 W., Logan County. No. 9054; right M_1-M_3; SE¼ sec. 7, T. 11 N., R. 53 W., Logan County. No. 9056; left P_4-M_2; E½ sec. 3, T. 11 N., R. 54 W., Logan County.

Except for eight specimens, all the *Ischyromys* material (more than 100 specimens) has been referred to this species. Nearly all the specimens were collected in pink, sandy silts or silts intimately associated with the sandy silts, indicating to me that the animal inhabited the valley floor.

A trend seen from a study of the vertical distribution of these specimens is increasing length of P_4-M_3 and a change in the shape of the teeth. As typified by No. 9058, specimens found in the lower part of the Cedar Creek member have a length of P_4-M_3 less than 15 mm. and relatively narrow teeth. In the middle part or silty phase of the Cedar Creek member, the specimens, as exemplified by No. 9075, have a length of P_4-M_3 of between 15 and 16 mm. At this level the cheek teeth are narrow or quadrate, and M_1 and M_2 are relatively larger than those found in the lower beds. At the top of this part of the section, specimens, such as Nos. 9054 and 9056, have a length of P_4-M_3 that is more than 16 mm. but otherwise resemble the smaller specimens of *Ischyromys typus*. In length of lower dentition, these and other specimens from this level exceed that of the type of *I. pliacus* and other specimens referred to it. Although these differences have been presented as representing stratigraphic groups, the divisions are not clear-cut. There are variations within each group, but the mean length of the cheek teeth is increasing. More collecting and study is necessary before this apparent increase in size (as shown by increased length of tooth row) and change in the shape of the teeth are satisfactorily demonstrated to be the change of a single phyletic line.

In this apparent chronocline the smaller teeth resemble specimens referred by WOOD to *Ischyromys typus*, and the larger teeth resemble those referred by him to *I. pliacus*, which could be interpreted as indicating that *I. pliacus* is an end product of the *I. typus* line. If part of the material assigned to *I. pliacus* by WOOD is really part of the *I. typus* chronocline, then the remainder of the large specimens, such as those from Pipestone Springs and Thompson Creek referred to *I. pliacus* by WOOD (1937, p. 190), represent a distinct species. BARBOUR & STOUT (1939, pp. 30-32) offer evidence on the stratigraphic occurrence of *I. pliacus* which supports the views that have been presented here. Furthermore, their evidence suggests that the type specimen of *I. pliacus* belongs to the *I. typus* chronocline rather than to the large unnamed species.

Attention is directed here to the type locality of *Ischyromys pliacus* TROXELL. TROXELL (1922, p. 124) gave the geological age and locality as middle Oligocene, Cherry Creek, Colorado. WOOD (1937, p. 190) gave the level as Cedar Creek. I supposed that Troxell wrote Cherry Creek when he meant Cedar Creek, but Dr. Joseph T. Gregory investigated the records at Yale University and stated (letter, April 15, 1950):

The type of *Ischyromys pliacus* Troxell was collected by O. C. Marsh on August 22, 1870 and bears the label Cherry Creek in his hand. According to the map of the route of the 1870 expedition (Schuchert and Levene, "O. C. Marsh, Pioneer in Paleontology," p. 106) the party camped on Lodge Pole Creek north of Fort D. A. Russell, NW of Cheyenne, Wyoming that day. They had come through the Goshen Hole area, up Horse Creek, during the preceding days, and had camped at the mouth of a Cherry Creek, tributary to Horse Creek, on August 20. . . . this data would certainly exclude the Cedar Creek, Colorado, area as the type locality.

Ischyromys troxelli Wood

Ischyromys troxelli Wood, A. E., 1937, p. 191.

Referred specimen.—Horsetail Creek member: No. 9126; right M_2 in fragment of jaw; NE¼ sec. 31, T. 11 N., R. 56 W., Weld County.

This tooth has its antero-posterior length shorter than its width (3.7 mm. × 3.9 mm.), a short anterior protoconid arm, and its median valley open internally. Except for its larger size and relatively greater width, it resembles the teeth referred to *Titanotheriomys*, No. 9113, from the lower part of the Horsetail Creek member in Logan County.

Wood (1937, p. 191) reports the species from the Cedar Creek beds.

Titanotheriomys cf. T. veterior (Matthew)

Referred specimens.—Horsetail Creek member: No. 9043; left P_4-M_2; NE¼ sec. 8, T. 11 N., R. 54 W., Logan County. No. 9052; right M_2-M_3; W½ sec. 30, T. 11 N., R. 51 W., Logan County. No. 9053; right P_4-M_3; sec. 28, T. 11 N., R. 53 W., Logan County. No. 9106; left P_4-M_2; W½ sec. 29, T. 11 N., R. 53 W., Logan County.

In size and pattern these specimens are close to *Titanotheriomys veterior*, the only difference being slightly longer lophids. These specimens were not compared with "*Colotaxis cristatus*" Cope (1873a, p. 1), but the size given by Cope for the type is slightly greater than in our specimens.

Titanotheriomys? sp.

Referred specimens.—Horsetail Creek member: No. 9113; left M_1-M_2; W½ sec. 9, T. 10 N., R. 51 W., Logan County.

Cedar Creek member (lower): No. 9042; right P_4-M_2; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County. No. 9044; left P_4-M_1; locality same as No. 9042.

No. 9113, from the Horsetail Creek member, is the size of a small individual of *Ischyromys typus* but is tentatively assigned to this genus because of the weak anterior protoconid arm and posterior cingulum.

The two specimens from the lower part of the Cedar Creek member are intermediate in size between the specimens compared with *Titanotheriomys veterior* and the small individuals of *Ischyromys typus*. The fourth lower premolars are narrower, relatively, than those in *I. typus*, and the tooth row is estimated to be approximately 14 mm. in length. No. 9044 has a posterior cingulum on M_1 consisting of three distinct cuspules, of which the most external is the largest.

Family EOMYIDAE Depéret & Douxami, 1902

Adjidaumo minutus (Cope)

Gymnoptychus minutus Cope, 1873b, p. 6.

Adjidaumo minutus, Hay, 1899, p. 253.

Type.—AMNH No. 5362; middle Oligocene of Colorado (*fide* Wood, A. E., 1937).

Referred specimens.—Cedar Creek member (lower): No. 8241; left jaw with M_1-M_2; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County. No. 8242; left jaw with I, P_4-M_3; N½ sec. 33, T. 11 N., R. 53 W., Logan County. No. 8243; right jaw with P_4-M_1; SE¼ sec. 17, T. 11 N., R. 65 W., Weld County.

Nos. 8242 and 8243 are similar to the type specimen in size and occlusal pattern. No. 8241 differs from the type in being smaller and in having shorter mesolophids.

Adjidaumo sp. (Small form)

Referred specimens.—Horsetail Creek member: No. 9101; anterior part of right jaw lacking teeth; W½ sec. 29, E½ sec. 30, T. 11 N., R. 53 W., Logan County. No. 9395; right upper cheek tooth; SE¼ sec. 1, T. 10 N., R. 54 W., Logan County.

Neither one of these two specimens is so large as the corresponding parts in specimens of *Adjidaumo minutus;* probably they are some other species. The jaw fragment is lighter and has a shorter diastema than does the type specimen of *Adjidaumo minimus* (Matthew) from the Chadronian beds at Pipestone Springs. The antero-posterior length of the cheek tooth is 1.2 mm., and its transverse width is 1.4 mm. Both the anterior and posterior cingula are well developed and extend across the face and rear of the tooth to unite with the paracone and metacone, respectively.

Paradjidaumo trilophus (Cope)

Gymnoptychus trilophus Cope, 1873b, p. 6.

Paradjidaumo trilophus, Wood, A. E., 1937, p. 244.

Type.—AMNH No. 5401; middle Oligocene, Cedar Creek of Colorado (*fide* Wood, 1937).

Referred specimens.—Horsetail Creek member: No. 9791; left jaw with I, P_4-M_2; E½ sec. 30, T. 11 N., R. 53 W., Logan County.

Cedar Creek member (lower and middle): Nos. 8244-8246; left jaws with P_4-M_2; W½ sec. 7, T. 11 N., R. 53 W., Logan County. No. 8249; right maxillary with P^4-M^2; E½ sec. 3, T. 11 N., R. 54 W., Logan County. No. 8250; right jaw with I, P_4-M_2; E½ sec. 3, T. 11 N., R. 54 W., Logan County. No. 8253; left jaw with I, P_4-M_1; SE¼ sec. 17, T. 11 N., R. 65 W., Weld County. No. 8254; left jaw with P_4-M_3; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County. Univ. Colorado Mus. No. 19860; right jaw with P_4-M_2; locality same as No. 8254. No. 8255; left jaw with P_4-M_3; SW¼ sec. 21, T. 11 N., R. 53 W., Logan County.

More than a dozen specimens of this species were collected in northeastern Colorado, and all compare closely with the type specimen with the exception of Nos. 8244-8246 which are slightly smaller. A comparison of the group with 21 specimens from Sioux County, Nebraska (Nos. 548-565) shows agreement in pattern and size range with exception of the three specimens mentioned.

FAMILY SCIURIDAE GRAY, 1821

Cedromus wardi WILSON

Cedromus wardi WILSON, 1949, p. 29.

Type.—Univ. Colorado Mus. No. 19808; Cedar Creek member (lower), SW¼ sec. 12, T. 11 N., R. 54 W., Logan County, Colorado.

Referred specimen.—No. 8338; right jaw with M_1-M_3; E½ sec. 3, T. 11 N., R. 54 W., Logan County.

Field records show that No. 8338 probably came from the lower part of the Cedar Creek member. The tooth pattern, size of the teeth, and masseteric fossa of this specimen are like that of the type, but the jaw is larger and heavier, being 10 instead of 8 mm. deep at M_1.

Cedromus? sp.

Plate 2, figures *B-C;* Figure 19

Referred specimens. — Cedar Creek member (middle): Univ. Colorado Mus. No. 19852; fragment of left maxillary with P^4-M^1; W½ sec 7, T. 11 N., R. 53 W., Logan County. Cedar Creek member (upper): No. 8342; damaged skull with right P^3-M^3; NE¼ sec. 3, T. 11 N., R. 54 W., Logan County.

These two specimens are provisionally assigned to *Cedromus.* Although I am personally convinced that the association of this material with the lower jaws and teeth of *Cedromus* is correct, the significance of the association is too important to make anything other than a provisional assignment until an actual occlusal association is found.

No. 8342 is an incomplete skull consisting of fragmentary right and left maxillary and palatine bones, right alisphenoid, fused basisphenoid and basioccipital, supraoccipital, exoccipital, mastoid, and parietal bones, which surround a brain case. Both auditory bullae are present but weathered.

In length the posterior part of the skull exceeds that of *Sciurus carolinensis* and is almost as wide and deep, but the brain case lacks the inflated appearance of Recent sciurids (Table 9). The palate is wide. The basicranial-facial axis is bent.

Both maxillary bones have only the palatal and orbital parts preserved. The short, small infraorbital canal lies above P^3-P^4. The zygomatic root originates above P^4 but is too damaged to preserve any details of the zygomatic plate. Because the suture between the maxillary and premaxillary bones lies fairly close to the anterior end of the tooth row, the zygomatic plate probably was not inclined forward to any great extent. The maxillary fragment, No. 19852, shows more of the zygomatic structure; the root seems to be wide and nearer a horizontal position. Both specimens, however, have enough of the zygomatic structure preserved to show that it was much more sciurid-like than prosciurine-like. The incisive foramina probably did not extend back to the suture between the maxillaries and the premaxillaries. The maxillary bone is missing from most of the internal wall of the orbit because of damage, but it is present on the orbital floor. Below the posterior end of the infraorbital canal a small foramen leads into the bone. As a whole, the orbital process of the maxillary resembles that of *Cynomys*, but the part bordering the sphenopalatine canal is higher on the internal wall of the orbit. The palatal processes of the maxillaries produce a broad, flat plate with the suture between the two bones deeply incised.

The palatine bones are represented by the incomplete palatal, orbital, and pterygoid processes. The palatal processes are a continuation of the smooth maxillary part of the palate, and the suture between these bones passes forward along the inner side of M^3 and, curving toward the mid-line, forms a rounded arc that extends forward to the anterior end of M^2. The canal for the palatine artery and nerve has two openings, both on the palatine bone, similar to those seen in *Sciurus*. An extraordinarily large palatine pit, which opens laterally, lies behind M^3. The orbital process of the palatine is similar to that in *Cynomys*. Like the maxillary, this process is damaged, and the full extent of the bone cannot be determined. A small fragment of the frontal bone meets the orbital process, and both bones together with the maxillary enclose the sphenopalatine foramen.[23] A small foramen lies posterior to the sphenopalatine foramen and leads into the palatine bone. The pterygoid process resembles the pterygoid process seen in *Sciurus* but lacks the ridges that extend forward from the pterygoid bone onto the palatine.

Only the lower part of the alisphenoid bone is preserved. The ventral wing flares outward and is in contact with the palatine and pterygoid bones. There is a large masticatory foramen, similar to that seen in *Cynomys*, in the center of this wing. The buccinator foramen lies back of the ventral wing and is just a groove, as in *Cynomys*, or, if damaged, was roofed over by a bar of bone. The alisphenoid turns sharply upward at its posterior end, and, combined with the wall of the basisphenoid and a notch in the auditory bulla, it forms a pit. This pit is not too well preserved, but the usual foramina of this area seem to be concentrated in it. The foramen ovale appears to be separated from the lacerate (median) foramen by a bar of bone.

The auditory bullae are ossified and firmly attached to the skull. In over-all appearance they resemble those of *Sciurus* but differ in having the notches in the antero-medial angle larger, in having

23. In *Ischyromys* and *Heliscomys* the sphenopalatine foramen occupies a similar position. WILSON (1949, p. 38), however, found the foramen to be entirely enclosed by the maxillary bone in the eomyids. In *Prosciurus* the foramen is between the frontal and maxillary bones, and in most sciurids the foramen is between the palatine and maxillary bones.

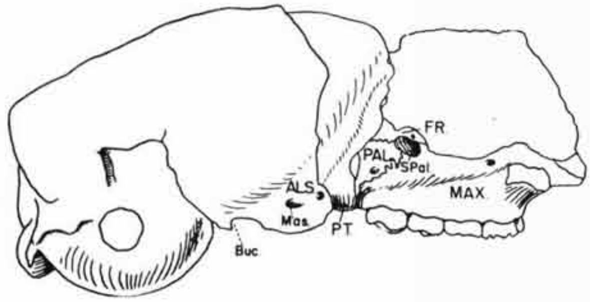


FIGURE 19.—*Cedromus?* sp. No. 8342. Lateral view of right side of skull showing structures in the orbital and basicranial area. *FR*, frontal. *MAX*, maxillary. *PAL*, palatine. *ALS*, alisphenoid. *PT*, pterygoid. *Buc*, buccinator foramen. *Mas*, masticatory foramen. *SPal*, sphenopalatine foramen. Approximately × 1.8.

the posterior ends laterally compressed, and in being less inflated. The lack of inflation in the bullae makes the foramina in this area appear large. The stylomastoid, jugular, and hypoglossal foramina are prominent but otherwise not different from the condition seen in *Sciurus*. Possibly there was a rather large stapedial foramen.

The basisphenoid and basioccipital bones are fused and appear like those of *Sciurus*.

The occipital region of the skull is sciurid-like. The occipital plate is inclined forward but has neither the inflated appearance of *Sciurus* nor the concave shape of *Marmota*.

The mastoids are more pointed at their upper ends than those of *Sciurus*, and their ventral borders are accentuated by grooves that pass to the stylomastoid foramina.

The supraoccipital bone is pointed at its top, and a crest runs along the mid-line from the foramen magnum to the peak.

TABLE 9.—Measurements (in mm.) of *Cedromus?* sp.

	No. 8342	No. 19852[a]
Crown length of P^3-M^3	10.9	....
P^3, antero-posterior length	1.2	....
P^3, transverse width	1.2	....
P^4, antero-posterior length	2.6	2.7
P^4, transverse width	3.0	3.0
M^1, antero-posterior length	2.4	2.7
M^1, transverse width	2.9	3.2
M^2, antero-posterior length	2.4	....
M^2, transverse width	3.1	....
M^3, antero-posterior length	3.0	....
M^3, transverse width	3.0	....

a. University of Colorado Museum.

The occipital condyles are low on the sides of the foramen magnum and, although the bottom of the foramen is damaged, do not appear to extend along it as in *Sciurus*. The paraoccipital processes stand away from the bullae, a feature in common with primitive rodents, but not with most Recent sciurids. The large foramen magnum is acute at the top, and it may be described best as five-sided in outline instead of round or trianguloid.

The parietals are incompletely preserved; but from the evidence of the suture marks on the brain cast, it is thought that, although the frontal-parietal suture was bowed slightly posteriorly, the frontal bone was not set within the dorso-lateral walls of the parietals as in *Sciurus*. There is no evidence of an interparietal bone. The temporal crests are lyrate and are almost united at the posterior end of the parietals. A lambdoid crest is present.

The squamosals are not preserved.

The right cheek teeth are preserved in good condition, and their wear has not been excessive. P^3 is peglike, and P^4-M^2 are triangular in shape. The protocones are large and are attached to the paracones by a crest that varies from weak to strong. Protoconules are absent. The metacones and metaconules are equal in size to the paracones and are united to each other and to the protocones by crests. The mesostyles are low, but distinct, and are united to the paracones and metacones by crests. These crests and the external cingulum enclose the space on each side of the mesostyle, thus forming little pockets between the mesostyles and the neighboring cones. The anterior and posterior cingula on M^1 and M^2 are low, but distinct. On P^4 the anterior cingulum unites with the parastyle. The parastyle on P^4 of No. 8342 is connected to the paracone by a crest, but no such connection is seen on the other specimen (Univ. Colorado Mus. No. 19852).

Hypocones are not developed on any of the teeth.

The description given above applies to the fourth premolar and the first two molars. The third molar is similar to the first and second in having crests uniting the paracone to the protocone, anterior cingulum, and mesostyle, but otherwise it is somewhat modified. The metacone and metaconule are absent, and the posterior cingulum is expanded to form a large heel, thus making a basin between the posterior cingulum and the protoloph. Faint traces of the valley that divided the posterior cingulum from the metaloph are still visible. In structure of

EXPLANATION OF PLATE 2

FIGURE		PAGE
A	*Prosciurus relictus* (COPE). No. 8333. Dorsal, lateral, ventral, and anterior views of anterior part of skull. Approximately × 2.9	52
B	*Cedromus?* sp. No. 8342. Dorsal, lateral, ventral, and posterior views of the posterior part of the skull. Approximately × 1.8	59
C	*Cedromus?* sp. No. 8342. Occlusal view of right P^3-M^3. Approximately × 5.5	60


A
B
C

the talon, the tooth differs radically from the upper third molar of *Prosciurus*. In *Prosciurus*, the posteriorly placed metacone forms the heel but retains a weak connection with a reduced metaconule, which, in turn, retains its connection with the protocone. In addition, the lophlike crests from the mesostyles that extend into the basins in the molars of *Prosciurus* unite in the third molar with the metaconule or the protocone. With the exception of the crest from the mesostyle, both methods of developing the heel are seen in present day sciurids. In Oligocene times heel structure could have well been more stable, and only in more recent times did the sciurids simulate the heel structure pattern of the Prosciurinae.

Wood (1937, p. 163) has described the posterior part of a skull (AMNH No. 1429) which he thought might be that of a prosciurine. This skull differs from No. 8342 in having the palate wider, but this may be caused, in part, by crushing in the American Museum skull. The auditory bullae are narrower transversely at the anterior end, and the notch is not so wide or deep. Posteriorly, where the bullae of No. 8342 are compressed, those of the American Museum skull are wider. The teeth are different, and this skull probably does not belong to the genus *Cedromus* or *Prosciurus* but may belong to the genus *Pelycomys*. The straight basicranial axis of AMNH No. 1429 lends weight to the opinion that it probably belongs to the Prosciurinae rather than the Sciuridae.

The skull of No. 8342 differs from those of primitive rodents in having a bent basicranial-facial axis. The broad palate and large heel of M^3 may be duplicated in the paramyine group. Whether or not the arrangement of the bones around the sphenopalatine foramen is a primitive feature remains to be decided.

No. 8342 differs from *Prosciurus relictus* in having a wider palate and more sciurid-like zygomatic arch. Nothing, however, is definitely known about the basicranial-facial axis in *Prosciurus*. If the skull discussed by Wood is a prosciurine, then the prosciurids do not have a bent axis comparable to that in No. 8342. The differences in the teeth are striking. The teeth of Nos. 8342 and 19852 (Univ. Colorado Mus.) differ from those of *Prosciurus relictus* and *P. vetustus* in having crests connecting the mesostyles with the paracones and metacones, in not having crests extending into the basins of the teeth from the mesostyles, in not having hypocones, in having better developed cingula, in not having protoconules, and in having a different type of heel in M^3.

Wood's description (1937, pp. 164, 171) of *Prosciurus* sp. (Princeton Univ. Mus. Nos. 14241-14242) seems to agree well with the tooth pattern of No. 8342.

The skull of No. 8342 resembles that of *Sciurus* in general shape and in having a bent basicranial-facial axis, a wide palate, a well-developed heel on M^3, and ossified and strongly attached auditory bullae.

Wilson considered the following possible relationships for *Cedromus wardi:* (1) it is a paramyine; (2) it is a prosciurid evolving in the direc-

Table 10.—Summarization of the characters of *Prosciurus, Pelycomys,* and *Cedromus*

	Prosciurus	*Pelycomys*	*Cedromus*
Lower teeth:			
Incisor width	Relatively wide	Most compressed	Medium
Trigonids	Narrow	Wide	Wide
Metastylids	Free	United to metaconid	United to metaconid
Metaconid	Compressed anteroposteriorly	Not compressed	Not compressed
Metalophulid II	Short on all molars	Weak, but complete on M_1-M_2[a]	Short on all molars
Entoconids	Large	Large	Small
Hypoconids, M_1-M_2	Large	Large	Small
Hypoconid, M_3	Large	Large	Large
Posterolophids	Separated from entoconid by notch	Separated from entoconid by weak notch	United to entoconid
Hypolophulid	Present, and tends to unite with posterolophid	Present, and united to ectolophid only[a]	Crest from entoconid turns back in basin
Upper teeth:			
Anterior cingula	Present	Present	Strong
Posterior cingula	Weak	Weak	Moderate
Parastyle on molars	Present	Present	Absent
Hypocones	Present	Present	Absent
Mesostyle	Crest into basin	Crest into basin	Crests to paracone and metacone
Third molar	Mesostyle and metacone united to metaconule by crests; metacone forms heel	?	Mesostyle united to paracone; metacone lost; heel formed by posteroloph

a. Absent in M_3 of Cedar Creek form, showing the extent of basining of M_3 in this species.

tion of a true squirrel type; and (3) it is a very primitive squirrel. He favored the first alternative stating (1949, p. 32) "*Cedromus* is placed in the Ischyromyidae, and tentatively in the Paramyinae because it cannot be distinguished really from members of this group, one of which is now known from a comparable geologic age; it is not like typical *Prosciurus;* and any other assignment is too speculative." *Cedromus* is not like *Prosciurus* or any related genus, and it is like the paramyines. The new material strongly suggests, however, that primitive sciurids existed in the middle Oligocene, and quite possibly *Cedromus* is such a sciurid, with many of its features reflecting the paramyine ancestry of the sciurids. This suggestion is supported by two facts neither of which is proof of relationship: (1) nothing in the tooth pattern or jaw structure of *Cedromus* prevents it from being ancestral to the typical sciurids; (2) primitive sciurids of the size of *Cedromus* are present in the middle Oligocene, represented by upper teeth and skull fragments. Or, to put this in another way—since lower teeth are present which are sciurid-like but not prosciurine-like, and upper teeth and skull fragments are also present which are here assigned to the sciurids, it is only natural to consider an association of the specimens.

That the skull (No. 8342), at least, represents a new species is more than likely, since there is a considerable stratigraphic difference between the level at which the type of *Cedromus wardi* was found and the level of this specimen. The specimens may also differ in size. These differences are not diagnostic, however, and do not justify a new name in this case.

Table 10 summarizes the characters of three genera of structurally similar rodents from northeastern Colorado and strongly suggests that *Prosciurus* and *Pelycomys* are more closely related to each other, structurally at least, than to *Cedromus*.

A comparison of the skulls of *Prosciurus* and *Cedromus*? is not necessary here, as reference to the description of the *Cedromus*? skull will show that they are different.

FAMILY GEOMYIDAE GILL?, 1872

Diplolophus sp.

Referred specimen.—Cedar Creek member (middle): No. 9830; upper M^1; SE¼ sec. 3, T. 11 N., R. 54 W., Logan County.

This lone tooth, the only representative of this genus from northeastern Colorado, is similar in pattern and occlusal wear to the M^1 of No. 9-5-7-36 S. P. of the Nebraska State Museum, which BARBOUR & STOUT (1939, pp. 30-32, fig. 14E) referred to *Diplolophus insolens* TROXELL. However, the tooth is smaller and relatively narrower transversely (antero-posterior length 2.55 mm., and transverse width 2.20 mm. at occlusal surface) than the specimens referred to by BARBOUR & STOUT.

FAMILY HETEROMYIDAE ALLEN & CHAPMAN, 1893

Heliscomys vetus COPE

Heliscomys vetus COPE, 1873c, p. 3.

Type.—AMNH No. 5461; Cedar Creek beds of northeastern Colorado (*fide* WOOD, A. E., 1937).

Referred specimens.—Cedar Creek member (lower): No. 8214; left jaw with M_1. No. 8215; left jaw with P_4-M_1. No. 8216; right jaw with P_4-M_3. No. 8217; left jaw with P_4-M_3. No. 8984; right jaw with P_4-M_3. No. 8985; left jaw with P_4-M_3. No. 8986; left jaw with M_1-M_3. No. 8987; right jaw with M_1-M_2. No. 8988; right jaw with P_4-M_1. No. 8989; left jaw with P_4-M_1. No. 8990; right jaw fragment with P_4. No. 8991; right jaw fragment with P_4. No. 8992; right jaw with P_4-M_1. No. 8993; right maxillary fragment with P^4-M^3. No. 8994; left maxillary fragment with P^4-M^2. No. 8995; left maxillary fragment with P^4-M^1. No. 8996; left maxillary fragment with P^4-M^1. Above 17 specimens from SW¼ sec. 12, T. 11 N., R. 54 W., Logan County. California Inst. Tech. (uncatalogued); right P_4-M_3, right P_4-M_2, right M_1, left P_4-M_2, left I, P_4-M_2. Above five specimens from SE¼ sec. 17, T. 11 N., R. 65 W., Weld County.

The specimens from Logan County were collected at one level and within a few feet of each other. The specimens in the California Institute of Technology were collected by Mr. JAMES MELLINGER of Longmont, Colorado, from a small remnant of channel deposit in sec. 17, T. 11 N., R. 65 W., of Weld County, which has been the source of a considerable microfauna. These specimens undoubtedly represent one species, and they present an unusual opportunity to study the variations present in the teeth.

Heretofore no upper teeth have been known that could be referred to *Heliscomys vetus*. The specimens described here are referred to this species because of their small size and because they were found in association (not occlusal) with lower jaws referred to this species.

The upper premolar is as variable as the lower premolar of the species. The basic pattern is one with an anterior cusp, and three posterior cusps forming a metaloph, of which the metacone and hypocone are nearly equal in size and the entostyle (or lingual cusp) is reduced. No cingula connect any of the cusps, and the valleys are deep, especially between the anterior cusp and the other three cusps. Only one specimen, No. 8995, has a small cuspule on the antero-external base of the anterior cusp. The entostyle is the most variable of the cusps, being prominent in the largest premolar and reduced almost to extinction on the two smallest premolars. In No. 8996 the entostyle is reduced, less than in the two smaller specimens but more than in the largest, and the metacone is unusually large. However, in the smallest specimen the hypocone is largest. There seems to be a definite correlation between the size of the premolar and the amount of reduction of the entostyle.

All of the cusps on M^1, including the internal cingular cusp, are high, prominent, and separated by deep valleys. The internal cingular cusp is opposite the transverse median valley. A cingulum passes across the face of the tooth and the inner side from the paracone to the internal cingular cusp. No other cingula are present. The paracone and metacone are set slightly in advance of the protocone and hypocone.

M^2 is similar to M^1 in pattern, except that the paracone and metacone are not advanced forward in relation to the other cusps.

M^3 has the metacone and hypocone reduced, but the paracone and internal cingular cusp are large and well developed. Wear on the only M^3 in the group prevents determining the size and development of the protocone. Apparently a cingulum connects the paracone and internal cingular cusp on this tooth.

In the lower fourth premolar the entoconid is rather constant in size and shape. The hypoconid is generally equal in size to the entoconid but may be larger. The hypoconulid, present on the posterior edge of the tooth, varies in length and in width across the rear of the tooth. Important and significant variations take place in the anterior part of the tooth. The principal cusp in this part is the metaconid which is always smaller than the hypoconid and entoconid. The protoconid is present in some teeth and lies on the antero-external border of the tooth. The following variations occur:

(1) Protoconid cone-shaped, and almost as large as metaconid; pattern almost symmetrical. Example: California Inst. Tech. specimen.

(2) Protoconid obliquely compressed and much smaller than metaconid; tooth pattern asymmetrical. Examples: Nos. 8215, 8217, 8992, and two California Inst. Tech. specimens.

(3) Metaconid reduced to size of small protoconid. Example: No. 8990.

(4) Metaconid weak and small; protoconid absent; hypoconid larger than entoconid and extended forward into area occupied by protoconid as if seemingly fused with that cusp. Examples: Nos. 8216, 8988, 8989, 8991, and California Inst. Tech. specimen.

The pattern of the first and second lower molars is that of four well-developed primary cusps more or less bordered on three sides by low cingula which develop cusps. The primary cusps are separate from each other, but, with wear, they tend to form lophids. Of the two cingular cusps, the protostylid is larger than the hypostylid, and both are as high as the protoconid and hypoconid cusps. Each stylid is placed slightly posterior to its corresponding primary cusp. The antero-external part of the cingulum is generally well developed and forms a cusp, but sometimes it is weak and reduced. In most of the teeth, the anterior cingulum is united to the antero-internal angle of the protoconid by a crest. Beyond this crest the cingulum is weak and normally fades out on the face of the metaconid. The union of the antero-external part of the cingulum to the protostylid, where both structures are strong, may be broken by a well-developed notch; or, where the cingulum is weak, it may unite to the stylid without the presence of a notch. The notch between the stylids varies in depth. Posterior to the hypostylid the cingulum varies from strong to weak, in some specimens extending across to the posterior face of the entoconid and in others fading out on the posterior face of the hypoconid. A cusp of variable strength develops in the cingulum opposite the opening of the valley between the entoconid and hypoconid. In some specimens it is the strongest part of the cingulum. Approximately two of every three teeth have strong antero-external cingula, anterior cingula united to protoconids, protostylids and hypostylids divided by a deep notch, and weak posterior cingula. In spite of the variations mentioned, the basic pattern of the teeth remains unchanged, being rather close to that of *Heliscomys hatcheri*.

The third lower molar is composed of four well-developed primary cusps, of which the hypoconid and entoconid show slight reduction in size. The protoconid and metaconid are united by an anterior crest. The anterior cingulum is weak on the face of the metaconid, absent at the mid-line of the anterior surface of the tooth, and stronger on the anterior and external faces of the protoconid. Incipient cuspules are formed in positions corresponding to the stylids of the first and second molars. Posteriorly, the cingulum disappears, but a small cuspule is present on the postero-internal face of the entoconid of one specimen. The above description of M_3 represents the optimum condition seen in these specimens (especially No. 8217, which is unworn), and variations consist of weaker development of the structures.

In shape the lower molars generally have the antero-posterior length equal to the transverse width, but they may vary in having the antero-posterior length greater in the first molar, the transverse width greater in the second molar, and either the antero-posterior length or transverse width greater in the third molar (Table 11).

This group of specimens is significant because the range of variation in the teeth encompasses most of the characters used to describe the species of *Heliscomys*. At the same time, the range of variation in the molars is small enough to necessitate keeping the group in one species that exhibits a high degree of variability in the premolars. At present I would doubt the validity of any species based upon differences in the premolar or small differences in the proportions of the molars, unless these differences can be shown by large samples to occur constantly or can be shown to occur with other differences such as geological age, actual size, or relative size among teeth.

Because the specimens represent, at the very most, no more than two populations of the same species, they present evidence on the evolution of the lower premolar in the primitive heteromyids.

As may be seen, the simplest and most complex premolar patterns are present at each of the two localities and are found in both the smaller and larger specimens. A similar range of variation in *Heliscomys hatcheri* was found by A. E. WOOD (1939, p. 555). Different opinions have been advanced as to whether the premolar is losing or gaining cusps. WOOD (1937, p. 211) suggested that in the genus a cusp had been added to the three primary cusps but commented upon the difficulties involved in such a hypothesis in homologizing the cusps with those of other rodents. Later (1939, p. 560) he thought that the specimens of *Heliscomys hatcheri* examined by him suggested that the three-cusped condition was the result of degeneration but did not think the evidence was conclusive. MCGREW (1941b) considered the three-cusped condition to be primitive. WILSON (1949b, p. 115) favored the view that the primitive pattern was one of four cusps and that *Heliscomys* was undergoing reduction of the premolar. The Miocene species, *Heliscomys woodi*, with its reduced three-cusped premolar was cited as an example in support of this view. The specimens from northeastern Colorado support the hypothesis of a four-cusped P_4 in the primitive forms. The fact that the metaconid is small, as in the premolar of No. 8216, argues against its representing a primitive stage in the *Heliscomys* line, inasmuch as an ancestral rodent with a premolar pattern entirely unlike any known early rodent pattern would be required to supply the pattern, or else an extraordinary reversal of trend took place. On the other hand, the premolar of the California Institute of Technology specimen, which has the protoconid cone shaped, is closer to the primitive rodent tooth pattern. Although the sample is small, it is tempting to think that some of the specimens (those with three large cusps and a small protoconid) represent the norm for the group, while the remainder represent the less progressive and the more progressive forms. This hypothesis is a more logical explanation of the premolar evolution in *Heliscomys* than the alternate hypothesis that would explain the extremes of this population as separate phylogenetic lines, which were ancestral respectively to *Heliscomys woodi* and *Proheteromys*. From a purely structural point of view, however, the less progressive, four-cusped specimens of *Heliscomys* do show a closer relationship to *Proheteromys* because they are closer to the premolar pattern of the ancestral rodent that gave rise to *Proheteromys* and *Heliscomys*.

Heliscomys has often been referred to as the ancestor of the heteromyids. In my opinion this genus is an aberrant branch of the *Proheteromys* stock that trended toward reduction of the premolars.

Heliscomys tenuiceps GALBREATH

Heliscomys tenuiceps GALBREATH, 1948, p. 289.

Type.—Vert. Paleont. Coll., Univ. Kansas Mus. Nat. Hist. No. 7702; Cedar Creek member (middle), White River formation, SE¼ sec. 3, T. 11 N., R. 54 W., Logan County, Colorado.

TABLE 11.—Measurements (in mm.) of *Heliscomys vetus*[a]

	No. 8993	No. 8994	No. 8995	No. 8996
Crown length of P^4-M^3	2.85	....	....	....
Alveolar length of P^4-M^3	3.10	....	....	....
P^4, antero-posterior length	0.75	0.51	0.81	0.75
P^4, transverse width	0.78	0.63	0.96	0.90
M^1, antero-posterior length	0.84	0.81	0.93	0.87
M^1, transverse width	1.05	0.84	1.17	1.14
M^2, antero-posterior length	0.72	0.72	....	....
M^2, transverse width	0.92	0.81	....	....
M^3, antero-posterior length	0.54	....	....	....
M^3, transverse width	0.69	....	....	....

	No. 8214	No. 8215	No. 8216	No. 8217	No. 8984	No. 8985	No. 8986	No. 8987	No. 8988	No. 8989	No. 8990	No. 8991	No. 8992	California Institute of Technology specimens				
Crown length of P_4-M_3	....	....	3.00	2.97	2.84	2.91	....	....	....	....	....	....	....	2.89	....	....	....	....
I, transverse width	....	....	....	....	....	....	0.33	....	....	....	....	....	0.45	....	....	....	....	....
P_4, antero-posterior length	....	0.51	0.57	0.60	0.51	0.48	....	....	0.51	0.48	0.45	0.45	0.48	0.54	0.57	0.45	....	0.54
P_4, transverse width	....	0.57	0.66	0.63	0.60	....	....	....	0.57	0.54	0.48	0.51	0.54	0.57	0.60	0.51	....	0.63
M_1, antero-posterior length	0.87	0.78	0.87	0.84	0.87	0.90	0.78	0.90	0.84	0.87	....	....	0.84	0.87	0.84	0.87	0.84	0.87
M_1, transverse width of anterior lophid	0.90	0.78	0.90	0.81	0.84	....	0.78	0.84	0.81	0.87	....	....	0.87	0.84	0.84	0.84	0.81	0.84
M_1, transverse width of posterior lophid	0.84	0.78	0.84	0.81	0.81	....	0.75	0.78	0.84	0.78	....	....	0.90	0.81	0.84	0.81	0.78	0.81
M_2, antero-posterior length	....	....	0.75	0.81	0.75	0.75	0.72	0.84	....	....	....	....	....	0.78	0.87	0.81	....	0.84
M_2, transverse width of anterior lophid	....	....	0.87	0.81	0.87	....	0.81	0.84	....	....	....	....	....	0.84	0.87	0.84	....	0.87
M_2, transverse width of posterior lophid	....	....	0.75	0.78	0.84	....	0.72	0.75	....	....	....	....	....	0.78	0.87	0.75	....	0.78
M_3, antero-posterior length	....	....	0.66	0.69	0.72	0.63	0.63	....	....	....	....	....	....	0.66	....	....	....	....
M_3, transverse width of anterior lophid	....	....	0.72	0.66	0.66	....	0.63	....	....	....	....	....	....	0.63	....	....	....	....
M_3, transverse width of posterior lophid	....	....	0.57	0.57	0.60	....	0.54	....	....	....	....	....	....	0.54	....	....	....	....
Depth of ramus at P_4	....	....	....	....	2.50	....	....	....	2.36	....	....	....	2.40	....	....	....	....	....

a. These measurements were made by grid with a length per unit of 0.03 mm.

In the original description the term sphenofrontal foramen was applied to a foramen in the orbital wall. Further study of this area suggests that this foramen is the anterior ethmoid foramen. It is possible that a fracture line was misinterpreted as a suture; if so, the alisphenoid bone did not extend so far forward as was described. Although either interpretation may be made, it is more in keeping with related groups to consider the foramen as the anterior ethmoid.

Proheteromys? sp.

Referred specimen.—Cedar Creek member (lower): Chicago Nat. Hist. Mus. No. PM381; anterior part of right jaw with I, P_4-M_1; SE¼ sec. 17, T. 11 N., R. 65 W., Weld County.

This specimen is recorded in the Chicago Natural History Museum records as coming from the "Mellinger locality" which is the level and locality cited above (see also Patterson & McGrew, 1937, and my discussion of *Heliscomys vetus*). The evolutionary stage represented by this specimen and the presence of Miocene deposits channeled into the Cedar Creek member at this locality make the exact location and level of this specimen of extreme importance. Neither the matrix nor state of preservation suggests that the specimen came from any bed other than the "Mellinger locality."

Differences from *Heliscomys vetus* are seen in the greater antero-posterior length of the teeth (Table 12); presence of four well-developed cusps corresponding to the three large cusps and small protoconid on the P_4 of *Heliscomys;* presence of a small anteroconid, and behind it, a second larger "anteroconid" that lies between the metaconid and protoconid on P_4; and oblique elongation of the principal cusps of the molars which join to form lophids and an incipient H pattern. Except for a nearer correspondence in size, the specimen differs in the same ways from those of *Heliscomys hatcheri.*

Characters used to distinguish No. PM381 from *Heliscomys* are: larger jaw and incisor; longer tooth row; differences in the premolar pattern; changes in the prominence and development of the cingulum; and differences in the molar occlusal pattern. The tentative assignment of this specimen to *Proheteromys* is made on the basis of similarity of the characters mentioned to those in specimens of *Proheteromys floridanus, P. thorpei,* and *P. nebraskensis.* The four well-developed cusps and

Table 12.—Measurements (in mm.) of *Proheteromys?* sp.

	No. PM381[a]
I, antero-posterior length	1.15
I, transverse width	0.67
P_4, antero-posterior length	0.69
P_4, transverse width	0.66
M_1, antero-posterior length	0.96
M_1, transverse width	0.87
Depth of ramus at P_4	3.30

a. Chicago Natural History Museum.

anteroconid of P_4 and the reduced cingula and obliquely directed cusps of the molars are points in common between No. PM381 and specimens of *Proheteromys*, especially *P. floridanus.* A difference which may prove to be phylogenetically significant is the well-developed anteroconids, a feature which is not so prominent in *Proheteromys.*

A conclusion drawn from the study of the lower jaws of *Heliscomys vetus* is that variation in the cusp pattern of the premolar and that minor differences in the proportions of the molar teeth should not be used to distinguish species in the genus. Inasmuch as the Chicago Museum specimen is close in size to specimens of *Heliscomys,* considerable attention was devoted to determining whether it could be an aberrant individual in a population of *H. vetus* or referable to *H. hatcheri.* For the reasons cited above, these possibilities do not seem likely.

If this specimen came from the exact locality that yielded the *Heliscomys vetus* jaws, then it represents the earliest known record of the *Proheteromys* type of heteromyid and shows the close relationship of this genus to *Heliscomys.*

Family CASTORIDAE Gray, 1821

Agnotocastor coloradensis Wilson

Figure 20

Agnotocastor coloradensis Wilson, 1949, p. 32.

Type.—Univ. Colorado Mus. No. 19809; Cedar Creek member; center of W½ sec. 21, T. 11 N., R. 53 W., Logan County, Colorado.

Referred specimens.—Cedar Creek member (lower): No. 8226; maxillaries with left P^4-M^1 and right M^1-M^2. No. 8227; maxillary with right P^3-M^2. No. 8228; anterior part of crushed skull with right P^4-M^3 and left P^4-M^3. No. 8229; maxillary with right P^3-M^2, right jaw with P_4-M_1, and right jaw with M_1-M_2 (associated). No. 8230; right jaw fragment with P_4-M_2, and fragment of incisor. No. 8231; right jaw fragment with P_4-M_2. No. 8232; frontal bones of skull. No. 8233; left jaw with M_1-M_2. No. 8234; fragment of left maxillary with P^4-M^1, and right jaw with M_1. All specimens from bed of olive-colored silt at type locality.

Additional information concerning this species is contributed by these specimens. No. 8228, a skull fragment, is badly damaged, but enough is preserved to show that the rostrum is relatively long as in *Agnotocastor praetereadens* Stirton. The inclination of the zygomatic plate is similar in the two species, but the posterior end of the zygomatic root of *A. coloradensis* has its origin over the anterior part of P^4. The anterior end of the infraorbital canal is pushed forward on the rostrum and is bordered by a heavy tuberosity as in *A. praetereadens.* Except for the place of origin of the posterior part of the zygomatic root, the preserved part of the skull is similar to that of *A. praetereadens* and totally unlike that of *Eutypomys thomsoni* Matthew.

The lower jaws exhibit the same stubbiness and great depth shown in the type specimen.

The specific characters of the lower teeth, given by WILSON (1949, p. 32), are apparent in the material here reported upon. The fact that none of the incisors are brightly colored lends support to this character cited by WILSON. It should be kept in mind, however, that all of the specimens are from the same locality and level as the type specimen and that, consequently, the dull color of the incisors may reflect only the local conditions of preservation.

The occlusal patterns for the specimens are presented diagrammatically in Figure 20. A certain arbitrary arrangement of the individual tooth rows from youngest to oldest was necessary inasmuch as there are differences in pattern and in rate of eruption and wear of the individual teeth. For example, the entoconid of M_1 of No. 8229 represents a younger individual age than does the entoconid on the M_1 of No. 8230. Yet the M_2 of No. 8229 is in an older stage of wear than that of No. 8230. Such individual variations are to be expected, and a certain amount of subjective judgment in such matters must be used in comparing the specimens.

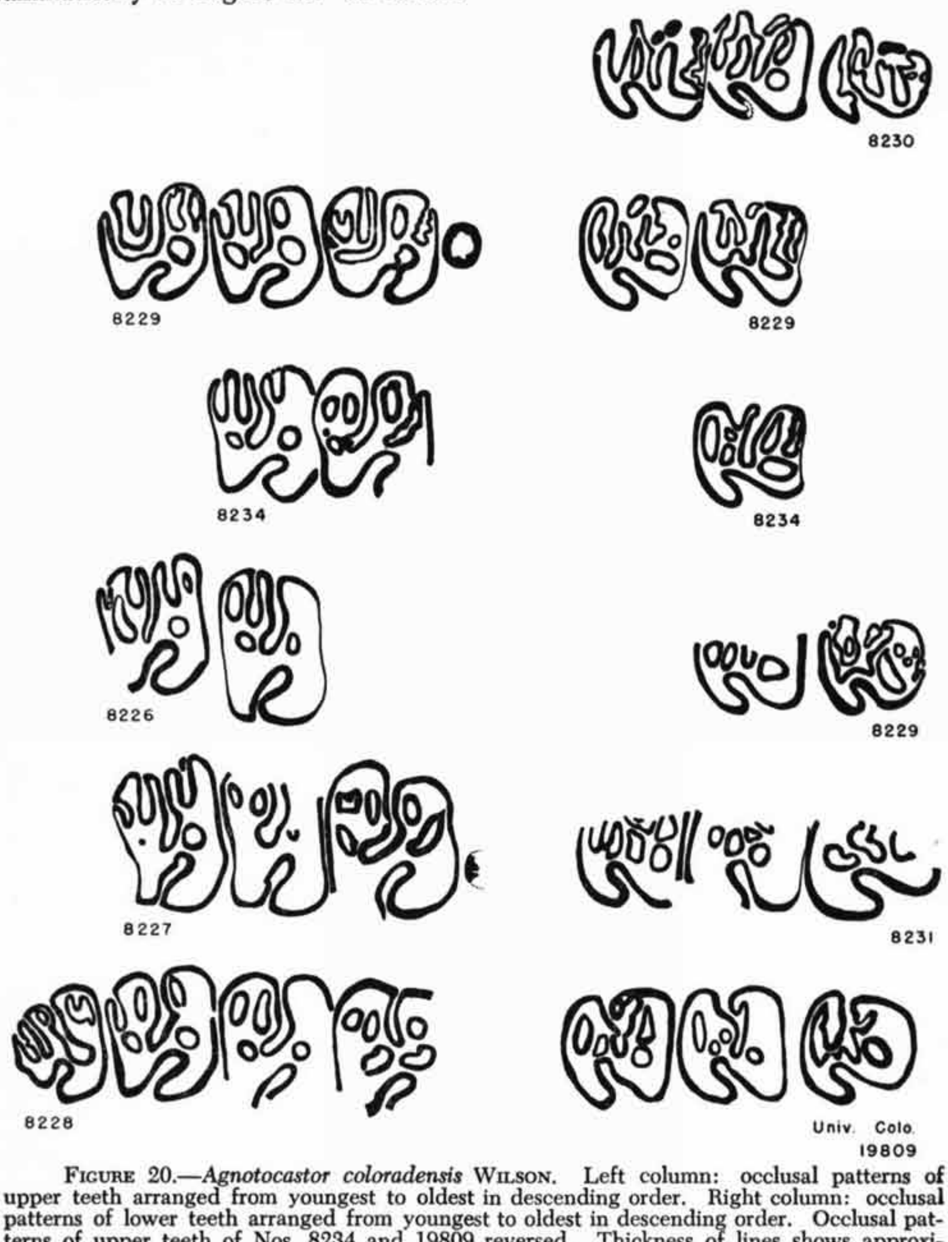


FIGURE 20.—*Agnotocastor coloradensis* WILSON. Left column: occlusal patterns of upper teeth arranged from youngest to oldest in descending order. Right column: occlusal patterns of lower teeth arranged from youngest to oldest in descending order. Occlusal patterns of upper teeth of Nos. 8234 and 19809 reversed. Thickness of lines shows approximate thickness of enamel bands. With exception of M_1 in No. 8230, and P^3 in No. 8227, no reconstruction (dotted lines) of damaged enamel has been attempted. Approximately $\times$ 4.

TABLE 13.—Measurements (in mm.) of *Agnotocastor coloradensis*

	No. 8226	No. 8227	No. 8228	No. 8229	No. 8234	No. 8230	No. 8231	No. 8233
Crown length of P^4-M^3	....	....	15.0+	....	....	....	....	....
I, transverse width	....	....	4.4	....	....	....	....	....
P^3, antero-posterior length	....	1.1	....	1.1	....	....	....	....
P^3, transverse width	....	1.6	....	1.7	....	....	....	....
P^4, antero-posterior length	....	4.3	....	4.2	4.0	....	....	....
P^4, transverse width	....	5.5	5.0	5.2	5.1	....	....	....
M^1, antero-posterior length	3.4	3.4	3.6	3.5	3.3	....	....	....
M^1, transverse width	5.0	....	4.9	4.7	5.2	....	....	....
M^2, antero-posterior length	3.3	3.3	3.5	3.6	....	....	....	....
M^2, transverse width	4.6	4.8	4.9	4.5	....	....	....	....
M^3, antero-posterior length	....	....	3.1	....	....	....	....	....
M^3, transverse width	....	....	4.0	....	....	....	....	....
I, transverse width	....	....	....	....	....	4.0	....	4.0
P_4, antero-posterior length	....	....	....	3.7	....	3.9	4.5	....
P_4, transverse width	....	....	....	4.1	....	4.3	....	....
M_1, antero-posterior length	....	....	....	3.6	3.7	3.7	3.8	3.6
M_1, transverse width	....	....	....	4.2	4.2	4.3	....	4.5
M_2, antero-posterior length	....	....	....	3.7	....	3.8	3.7	....
M_2, transverse width	....	....	....	4.4	....	4.1	....	....
Depth of jaw below middle of P_4	....	....	....	....	....	....	....	15.0

The terminology used in this discussion is the same as that used by WILSON (1949), but my interpretation of the homology of the mesolophid in the lower teeth of this species differs from that of WILSON. WILSON uses the term mesolophid for the anterior arm connecting the entoconid and ectolophid. When observed on the younger individuals of the species, this structure seems not to be a true mesolophid, but instead a hypolophulid I. If this be true, the M_1 and M_2 of No. 8229 suggest that an incipient mesolophid in some teeth meets the hypolophulid and forms the anterior arm. The plasticity of the structures in the area surrounding the mesolophid is demonstrated by No. 8234 which has the metastylid developed to the point where it unites with the mesolophid. This variation suggests an extreme interpretation of the structures that is reminiscent of the condition seen in *Eutypomys*. Perhaps the metastylid cusp (or cusps) and the mesolophid are remnants of a complete mesolophid, which has broken up, with the various parts becoming associated with the metaconid and entoconid.

Like *Agnotocastor praetereadens*, the upper teeth of *A. coloradensis* are elongate transversely (Table 13), and the incisors are convex on their anterior surfaces, but the pattern of the cheek teeth is much more complex and primitive (unless wear has completely removed all trace of the original complexities in the pattern of *A. praetereadens*). Nor do the teeth of *A. coloradensis* have the shape or crenulate complexity of those of *Eutypomys*. The homologies of the posterior parts of the upper teeth seem to be clear, but the crests of the anterior parts are more difficult to homologize with parts of the primitive rodent tooth. For the parts in question, the terms anterior cingulum, protolophule, and mesoloph are used here. Although it might be safer and less confusing to use the terms anterior cingulum, protolophule I, and protolophule II, the use of the term protolophule II would imply that the mesoloph was absent in the upper teeth, an implication that is contrary to the evidence at present. Some of the features of the type specimen, which were not readily decipherable when WILSON described this species, are clarified by the present material. The complexity noted by WILSON (1949, p. 33, last paragraph) in the anterior part of the molars is explained by the structures seen in the molars of the young specimen, No. 8229, which seem to me to be the anterior cingulum, metalophulid I, and metalophulid II. WILSON (p. 34) was uncertain about the completeness of the "hypolophid" in unworn molars but suggested that it resembled the hypolophid of the premolar in this respect. This suggestion is correct, but a union seems to be rapidly formed between the "hypolophid" and the ectolophid. WILSON suggested what the diagnostic features might be of the immediately ancestral beaver pattern, as inferred from *A. coloradensis*. Our additional material permits certain minor changes in and additions to WILSON's statements (p. 34): "(1) early union of the lingual end of the posterolophid with the entoconid, if these were ever separate [These structures were separate and do unite early in life.]; (2) a well-developed mesolophid in the molars, uniting with the entoconid upon wear [This structure has been discussed, and I think that it might be a hypolophulid I uniting with the ectolophid or poorly developed mesolophid.]; (3) relatively incomplete hypolophid [This structure is incomplete, regardless of its identification as a hypolophid or hypolophulid II.]; (4) strong metastylid (or mesostylid) structures [The multiplicity of cusps seen in some of the specimens suggests that both metastylid and mesostylid cusps may be involved or that one or the other may be dominant as an individual variation.]; (5) well developed metalophulid II [This is true.]." WILSON commented upon the incomplete ectolophid in *Eutypomys* which was inconsistent with his comparison of *A. coloradensis* with *Eutypomys*. P_4 of No. 8230 suggests that this separation did exist in *A. coloradensis* and strengthens the case for close association of the eutypomyids and castorids.

Although these new specimens yield more information than has heretofore been available about the primitive castorid tooth pattern, the situation remains as it was in the past: There is enough evidence to hazard tentative decisions about the homologies of the tooth structures and about the ancestral patterns, but not enough to satisfactorily clear up questionable points. The relationships of these teeth to those of the paramyine and sciuravine types are not clarified by the present specimens, inasmuch as they show affinities with both groups.

FAMILY CRICETIDAE ROCHEBRUNE, 1883

The treatment accorded the species in the family Cricetidae, especially *Eumys obliquidens, E. elegans,* and *E. brachyodus,* may seem unusual, but it is presented as an interpretation of the cricetid specimens (approximately 350 that had stratigraphic and areal position well enough known to be useful) from northeastern Colorado.

Eumys obliquidens WOOD

Eumys obliquidens WOOD, A. E., 1937, p. 253.

Type.—AMNH No. 5603; Cedar Creek middle Oligocene beds of Colorado.

Referred specimens. — Cedar Creek member (lower): Nos. 8430 and 8435; right and left lower jaws with M_1-M_3; NE¼ sec. 28, T. 11 N., R. 53 W., Logan County. No. 8484; left jaw with M_1-M_3; NE¼ sec. 8, T. 11 N., R. 54 W. (channel s. s.), Logan County. No. 8462; right jaw with M_1 and M_3; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County.

Eumys elegans LEIDY

Eumys elegans LEIDY, 1856, p. 90.

Referred specimens.—Cedar Creek member: No. 8429; anterior part of skull and left jaw in occlusion; SW¼ sec. 22, T. 11 N., R. 53 W., Logan County. No. 8475; anterior part of skull and right jaw in occlusion; SW¼ sec. 2, T. 11 N., R. 54 W., Logan Conuty. No. 8458; anterior part of skull; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County.

Eumys brachyodus WOOD

Eumys brachyodus WOOD, A. E., 1937, p. 252.

Referred specimens. — Vista member: Univ. Colorado Mus. No. 19870; left jaw with M_1-M_3; SE¼ sec. 8, T. 11 N., R. 53 W., Logan County. No. 8427; left jaw with M_2; SE¼ sec. 8, T. 11 N., R. 53 W., Logan County. No. 8979; left jaw with M_1; NE¼ sec. 17, T. 11 N., R. 53 W., Logan County.

The specimens assigned to *Eumys obliquidens* are like the type in that they have the mesolophid of M_1 longer or as long as the posterior arm of the protoconid and in that the posterior protoconid arms of M_2 and M_3 extend postero-mesiad to unite with the entoconids on either or both teeth. Besides these, other specimens have either short mesolophids and turned-back protoconid arms or have the arm in one tooth turned back and the other forward. One specimen, No. 8452, from the middle of the Cedar Creek member, has a mesolophid on M_1 that reaches the internal surface of the tooth, but on both M_2 and M_3 the protoconid arms are united with the metaconids. These latter examples demonstrate that intergradation exists between this species and others. Another specimen, No. 8436, referred to this species and from the same level and locality as Nos. 8430 and 8435, deserves mention for an unusual construction. In this specimen the mesolophid is longer than the posterior protoconid arm on M_1, equal in length to the posterior protoconid arm on M_2, and absent on M_3 where the posterior protoconid arm turns back to join the entoconid. In size and pattern this specimen resembles *Cricetodon nebraskensis* WOOD. However, to regard the long mesolophids of M_1 and M_2 as a valid generic character seems unreasonable, especially when the specimen concerned occurs within a population which has considerable variation in mesolophid length. So far as the specimens of *E. obliquidens* from northeastern Colorado are concerned, features common to the teeth listed, except No. 8452, are: (1) occurrence at the base of the Cedar Creek member, (2) tendency for the posterior arm of M_2 and M_3 to turn toward the entoconid, and (3) length of the mesolophid on M_1 variable but usually longer than the posterior protoconid arm. The evidence is negative in nature, but I have not found teeth in beds higher in the section that have the protoconid arm directed posteriorly.

Three specimens, Nos. 8429, 8458, and 8475, have been selected to represent the group of specimens that were collected from many points throughout most of the vertical and areal extent of the Cedar Creek member. All seem to be referable to *Eumys elegans.* These have characters of *E. elegans* or at least no characters that would allow reference to any other species. The skull fragment, No. 8458, differs from the other skull fragments assigned to *E. elegans.* The snout is broader and deeper but not longer, thus giving the appearance of shortness. The nasal bones are broader with the lateral borders more sinuous. The teeth are shorter (Table 14). Also, several small jaws with small teeth are present in the deposits, but the occlusal patterns show no constant differences, and they could well be treated as small individual variants of *E. elegans.* Analysis of the size range of large groups of lower teeth shows the possible presence (as part of a bimodal curve) of this "species" in the *Eumys* population.

A. E. WOOD (1937, p. 252) listed *Eumys brachyodus* as occurring in Colorado, and probably in the Oreodon zone. The specimens listed above are the only ones seen by me that duplicate the description of this species in all particulars. In the Orellan

TABLE 14.—Measurements (in mm.) of *Eumys obliquidens, Eumys elegans,* and *Eumys brachyodus*

	E. obliquidens			*E. elegans*			*E. brachyodus*		
	No. 8430	No. 8435	No. 8484	No. 8429	No. 8458	No. 8475	No. 19870[a]	No. 8427	No. 8979
Crown length of M^1-M^3	....	....	....	6.35	6.12	6.53	....	....	....
I, width	....	....	....	1.42	....	1.26	....	....	....
M^1, antero-posterior length	....	....	....	2.70	2.64	2.79	....	....	....
M^1, transverse width	....	....	....	1.90	1.80	1.81	....	....	....
M^2, antero-posterior length	....	....	....	1.92	1.86	1.98	....	....	....
M^2, transverse width	....	....	....	1.86	1.86	1.79	....	....	....
M^3, antero-posterior length	....	....	....	1.56	1.47	1.65	....	....	....
M^3, transverse width	....	....	....	1.89	1.74	1.69	....	....	....
Crown length of M_1-M_3	6.91	6.50	7.05	....	....	6.90	7.02	....	....
I, width	....	1.58	....	1.26	....	....	....	....	....
M_1, antero-posterior length	2.46	2.37	2.52	....	....	2.19	2.34	....	2.31
M_1, transverse width	1.74	1.79	1.78	....	....	1.66	1.99	....	1.75
M_2, antero-posterior length	2.16	2.04	2.19	2.16	....	2.22	2.25	2.32	....
M_2, transverse width	1.98	1.94	1.92	1.99	....	1.91	2.28	2.12	....
M_3, antero-posterior length	2.25	2.01	2.25	2.04	....	2.55	2.25	....	....
M_3, transverse width	1.89	1.82	1.81	1.89	....	1.84	2.08	....	....

a. University of Colorado Museum.

many specimens have one or more of the characters that distinguish *E. brachyodus,* but never all of them. The most common variants are those which show disappearance, with wear, of the inner half of the anterior cingulum on M_2-M_3 without the presence of the other distinguishing characters, and those with one or more of the other distinguishing characters, but with a prominent cingulum. All of these specimens are referred to *E. elegans.* It is of interest that, of the specimens referred to *E. brachyodus* by WOOD, all were from the upper Brule of Nebraska except those for which the level was uncertain, including the Colorado specimens. With the addition of our specimens from the Whitneyan, and in view of the lack of positively identified specimens from the Orellan, an argument for the Whitneyan age of *E. brachyodus* is strengthened. At the same time, identification of any Orellan specimens as *E. brachyodus* is rendered more unlikely.

The lower teeth of these three groups of specimens were arranged stratigraphically and analyzed on the basis of four characters which are presented in tabular form (Table 15).

The variations and trend of changes in the crests uniting the anteroconid, protoconid, and metaconid present a complicated picture. Variation occurs (1) as differences in the strength of the crest connecting the protoconid and anteroconid and (2) in the presence, strength, and direction of the crest leading from the metaconid. The basic pattern of the earliest forms consists of a union of the protoconid to the anteroconid and of a free metaconid. The trend of change is toward the development of a crest from the metaconid that unites first with the crest leading from the protoconid to the anteroconid [as seen in the M_1 of *Cricetodon nebraskensis* figured by WOOD (1937, fig. 68)], shifting subsequently to the anteroconid as is seen in *E. brachyodus.*

To make new species of the variants found in the populations of *Eumys obliquidens, E. elegans,* and *E. brachyodus* (which is, in effect, limiting the range of variation in the species to the scope of the original diagnosis and to the description of the type specimen) is not acceptable in view of the intergradation that exists between the three groups. The simplest interpretation of the variations is that one species, *Eumys elegans,* represents a chronocline in which the mesolophids were shortened and finally lost, the posterior protoconid arms were turned forward and reduced, the connecting crests between the principal cusps and the anteroconid were developed, and the anterior cingula were reduced. In the lower beds specimens possessing certain combinations of these variable characters have been given the names *Eumys obliquidens* and *Eumys elegans.* In the same beds there are specimens which do not possess the complete suite of characters for either of the species but which intergrade with each. Higher in the beds there are not so many of the specimens with the variations that distinguish *E. obliquidens,* but variations appear that finally, when combined, distinguish *Eumys brachyodus.* Also present, of course, is the typical *Eumys elegans.* It might be argued that *E. obliquidens* and *E. brachyodus* represent extreme variations of *E. elegans;* but that these variants represent more than fortuitous combinations of characters that occur normally as variations in *E. elegans* seems indicated by the fact that one type of variant occurs at the bottom of the section and the other at the top. At least the order of occurrence suggests the trend of the changing characters. The specimens may represent a form like *E. obliquidens* evolving into a form like *E. brachyodus,* with the transition stage being called *E. elegans.* I do not see any reason why there could not have been a gradual change of the genetic pattern that would yield *E. elegans* from an ancestor which looked more or less like *E. obliquidens.* Consequently, *E. obliquidens* represents that minor part of the

TABLE 15.—Summarization of the principal changes in the occlusal pattern of the lower teeth of *Eumys*

Stratigraphic position	Progressive shortening and loss of mesolophid on M_1	Tendency for posterior protoconid arm to turn forward and reduce	Tendency for main cusps on M_1 to connect to anteroconid by crests	Reduction of anterior lingual cingulum on M_1
Vista member	No mesolophid	United to metalophid and shortened in length	Both cusps united to anteroconid	Reduced
		Eumys brachyodus (*s. s.*); occurrence rare		
Cedar Creek member (upper part)	No mesolophid	United to metaconid	Protoconid united to anteroconid	Reduced
		Eumys elegans (*s. l.*); occurrence rare		
(middle part)	Frequently small or absent, and rarely longer than posterior protoconid arm	Tendency to turn forward and unite with metaconid	Same as below, but 33 percent have metaconid crest united to protoconid crest	Variable in development
		Eumys elegans (*s. l.*); occurrence common		
(lower part)	Variable, but tends to be long, and frequently longer than posterior protoconid arm	More frequently turned to rear, or is variable on individual teeth	Most have protoconid united to the anteroconid, and metaconid free; 15 percent have arm from metaconid united to protoconid crest; uniting arm or arms are weaker and more frequently absent	Not generally reduced
		Eumys elegans (*s. l.*); occurrence common		
Eumys obliquidens (*s. s.*); occurrence—roughly one of every ten specimens has both the mesolophid longer than the posterior protoconid arm on M_1, and the arm turned back on M_2-M_3				

E. elegans population which falls at the bottom or conservative part of the normal curve. Therefore, it would seem plausible that a minority of the specimens, those bearing brachyodus-like characters that were spreading genetically through the *E. elegans* population, would represent the progressive part of the population which finally found its expression in the late Oligocene as *E. brachyodus*. Until additional specimens of *Eumys* are found at lower stratigraphic levels, it will be impossible to verify the suggested relationship of *E. elegans* and *E. obliquidens*. Unfortunately, eumyine specimens are not common in the upper part of the Cedar Creek member and the Vista member in northeastern Colorado; therefore, the record is equally faulty between *E. elegans* and *E. brachyodus*. The change from *E. elegans* to *E. brachyodus* may have been widespread and gradual. On the other hand, the characters discussed possibly were widespread, but were being swamped, and isolation at some geographic point permitted the combination of these to become established and to gain a foothold as a distinct species. The rarity of specimens in the upper Cedar Creek beds in northeastern Colorado and the abrupt appearance of *E. brachyodus* in the Whitneyan suggest that this is what may have happened. If the specimens of *E. elegans* reported from the Whitneyan of Nebraska are typical, support for this view is strengthened. On the other hand, it could be argued, as it was for *E. obliquidens*, that the Whitneyan specimens of *E. elegans* represent the conservative part of the *E. brachyodus* population.

To arrange *Eumys obliquidens* and *E. brachyodus* as subspecies of *Eumys elegans* without information gained from studies of *Eumys* from other areas would be, in my opinion, an unwarranted and hasty action. Temporarily it seems best to continue using the three specific names for stratigraphic purposes in northeastern Colorado but it should be kept in mind that the groups are part of a chronocline.

Eumys nr. E. exiguus WOOD

Referred specimens.—Cedar Creek member: Nos. 8419-8420; left maxillaries with molars; SW¼ sec. 12, and SE¼ sec. 3, T. 11 N., R. 54 W., Logan County. Nos. 8421-8422; left lower jaws with molars; E½ sec. 3, T. 11 N., R. 54 W., Logan County. Nos. 8423-8424; left lower jaws with molars; W½ sec. 7, T. 11 N., R. 53 W., Logan County. No. 8426; right lower jaw with molars; SW¼ sec. 21, T. 11 N., R. 53 W., Logan County.

These specimens differ from the type specimen of *Eumys exiguus* only in their smaller size (Table 16). In our collection there are 12 specimens from the "middle" Brule of Sioux County, Nebraska, that nicely bridge the size gap between the Coloradan specimens and the type specimen from South Dakota. Whether or not this size cline represents three successive stages leading from a small to a large form is not clearly evident. In northeastern Colorado the small specimens are found in the lower and middle part of the Cedar Creek member. It may be that they are older than the specimens from Nebraska and South Dakota. It seems improbable that the specimens from the three states represent geographic subspecies. To maintain such a view would mean rather close correlation of the beds of the three areas and narrow range of time for existence of the species.

The northeastern Coloradan and the Nebraskan specimens, in general, show the following common features. The upper teeth tend to form a pattern in which the antero-posterior lophs are emphasized, with a consequent weakening of the transverse connections. This antero-posterior strengthening tends to be emphasized on the medial side of the tooth row. There are no connecting crests between the paracones and protocones, but a tendency toward this condition is apparent in some teeth. On M^1 the protocone is united to the very large and well-developed anterocone by a weak crest, and on M^2 and M^3 the paracone and protocone arms unite before joining the anterior cingulum. The hypocone and metacone of M^3 are reduced. The lingual and buccal anterior cingula on M^2 are subequal in size, but the lingual cingulum on M^3 is much reduced. The lower molars have, as rather consistently occurring characters, the mesoconids well developed; no mesolophids on M_2 and M_3; anteroconid of M_1 free or united to metaconid by an anterior metaconid arm; anterior metaconid and protoconid arms on M_2 and M_3 extended anteriorly to the anterior cingulum and never joined to one another; and posterior buccal cingula present on M_1 and M_2. The masseteric scar normally extends to a point below the middle of M_1, but occasionally to a point below the anterior or the posterior roots of that tooth. In most of the specimens the upper border of the masseteric scar is defined by a deep groove extending from the anterior end of the scar to the ascending ramus. In one specimen this groove is absent, and the scar is very faint. In all the specimens, except No. 8426, the jaws are approximately the same size, whereas this one specimen has an unusually large and deep jaw.

All of the upper teeth referred to *Eumys* nr. *E. exiguus* are closely similar to the type of *Leidymys vetus* WOOD. In fact there is no question in my mind but that they represent the same species. Although no occlusal associations were found, there is little doubt that the upper and lower teeth assigned to *Eumys* nr. *E. exiguus* represent the same species. However, to refer all the material to *L. vetus*, when it so closely resembles the type specimen of *Eumys exiguus*, would imply that perhaps this species should be transferred to the genus *Leidymys*—a step that I am not prepared to take based solely on the evidence offered by the material from northeastern Colorado. Likewise, transferring *L. vetus* to the genus *Eumys* or making it synonymous with *Eumys exiguus* is unacceptable, because I think this small species is generically distinct from the species of *Eumys* but am not prepared to say whether or not it should be referred to *Leidymys* or to another genus.

Eumys planidens WILSON

Figure 21

Eumys planidens WILSON, 1949, p. 48.

Type.—Univ. Colorado Mus. No. 19810; Cedar Creek member, White River formation, middle of W½ sec. 7, T. 11 N., R. 53 W., Logan County, Colorado.

Referred specimens.—From the type area and level; No. 8450; right jaw with I, M_1-M_3. No. 8449; left jaw with M_1-M_3.

TABLE 16.—Measurements (in mm.) of *Eumys* nr. *E. exiguus* and *Eumys exiguus*

	LOCALITY OF SPECIMENS				
	Colorado		Nebraska		South Dakota
	No. 8419	No. 8420	No. 8410	No. 8412	No. 12261[a]
Crown length of M^1-M^3	4.89	5.13	....	....	5.82
M^1, antero-posterior length	2.25	2.25	2.40	....	2.72
M^1, transverse width	1.35	1.38	1.65	....	1.74
M^2, antero-posterior length	1.65	1.65	1.62	1.56	1.76
M^2, transverse width	1.38	1.41	1.68	1.77	1.61
M^3, antero-posterior length	1.02	1.32	....	1.47	1.35
M^3, transverse width	1.20	1.26	....	1.32	1.46

	Colorado						Nebraska										South Dakota
	No. 8421	No. 8422	No. 8423	No. 8424	No. 8425	No. 8426	No. 537	No. 539	No. 540	No. 8411	No. 8413	No. 8414	No. 8415	No. 8416	No. 8417	No. 8418	No. 12261[a]
Crown length of M_1-M_3	5.54	5.49	....	....	....	5.49	5.61	5.66	5.56	....	....	....	....	....	....	....	5.92
I, transverse width	....	0.88	0.88	....	....	....	....	....	....	....	1.05	....	....	....	0.75	....	....
M_1, antero-posterior length	2.13	1.95	1.98	....	....	1.98	2.10	2.10	1.95	....	2.28	2.19	2.07	2.25	1.95	2.13	2.20
M_1, transverse width	1.38	1.26	1.26	....	....	1.29	1.32	1.35	1.26		1.30	1.41	1.32	1.41	1.35	1.35	1.46
M_2, antero-posterior length	1.80	1.80	1.80	1.59	1.68	1.74	1.86	1.80	1.80	1.71	1.80	....	1.65	1.80	....	1.80	1.92
M_2, transverse width	1.53	1.44	1.41	1.29	1.44	1.47	1.50	1.50	1.44	1.38	1.59	....	1.35	1.62	....	1.56	1.63
M_3, antero-posterior length	1.62	1.74	....	1.65	....	1.68	1.71	1.71	1.80	1.65	....	....	....	....	....	....	1.71
M_3, transverse width	1.44	1.41	....	1.29	....	1.47	....	1.35	1.47	1.38	....	....	....	....	....	....	1.22

a. American Museum of Natural History. Type of *Eumys exiguus*.

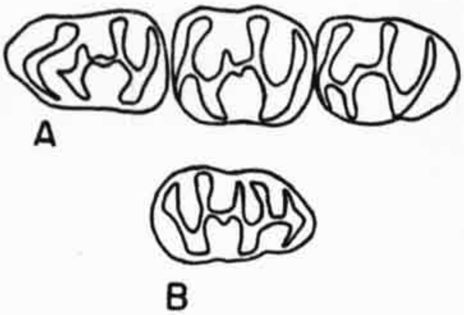


Figure 21.—*Eumys planidens* Wilson. (*A*) Occlusal pattern of M_1-M_3 of No. 8449. (*B*) Occlusal pattern of M_1 of No. 8450. Approximately × 9.

To date the distribution of this species is limited to one exposure at a level about 90-100 feet below the top of the Cedar Creek member.

The additional specimens of this species add to our knowledge of the form. The first lower molar is now known, and the characters listed by Wilson as distinguishing the species are known to be more than age characters.

As in other species of *Eumys*, M_1 is variable. In size and proportion (Table 17) it compares closely with other species of *Eumys*. The occlusal pattern is as follows: The anteroconid has buccal and lingual cingula. The anterior protoconid arm extends to the anteroconid, and the anterior metaconid arm crosses transversely to join the anterior protoconid arm. A variation of this part of the pattern is seen in specimen No. 8449 which has the anterior metaconid arm uniting with the anteroconid and has the anterior protoconid arm and the anterior lingual cingulum absent. The posterior protoconid arm is long and free, but closer to the metaconid than the entoconid. A mesoconid is present, but there is no mesolophid. The entoconid is expanded as in M_2 of the type specimen and is separated from the long posterolophid by a deep notch.

In individually older specimens, as in the younger type specimen, the lower incisor is slender and delicate, the crests of the molars are compressed, and the plane occlusal surface is retained. The most important point, perhaps, is the fact that the lingual cingulum on M_2-M_3 is absent consistently and never was present at any time, although a depression on the face of the tooth is often present at this point. This is emphasized because *Eumys brachyodus* has an incipient lingual cingulum on M_2-M_3, which almost disappears with wear, but those teeth never completely lose all traces of the cingula. An interesting variation is present in M_3 of the two referred specimens. In them, the posterior protoconid arm does not extend transversely beyond the mesoconid crest, whereas the type specimen has this arm extending to the internal border.

Table 17.—Measurements (in mm.) of *Eumys planidens*

	No. 8450	No. 8449
Crown length of M_1-M_3	6.42	6.52
I, width at alveolus	0.85	....
M_1, antero-posterior length	2.25	2.26
M_1, transverse width	1.50	1.54
M_2, antero-posterior length	2.04	2.00
M_2, transverse width	1.78	1.86
M_3, antero-posterior length	1.95	2.20
M_3, transverse width	1.75	1.76

Eumys cf. E. planidens Wilson

Referred specimens. — Cedar Creek member (middle): No. 8472; left jaw with M_1-M_3; SW¼ sec. 2, T. 11 N., R. 54 W., Logan County.

Cedar Creek member (upper): No. 8467; left jaw with I, M_1-M_2; NE¼ sec. 3, T. 11 N.. R. 54 W., Logan County.

No. 8472 possesses the major characters of *Eumys planidens*, but has larger, heavier teeth. It was obtained at approximately the same level as the type specimen.

No. 8467 has the narrow incisors, lack of anterior lingual cingulum, and other features of *Eumys planidens*, but the cusps and crests are heavier and thicker. It was found 20-40 feet below the base of the Whitneyan beds and high above the specimens from the middle part of the Cedar Creek member.

If these specimens represent a phylogenetic succession, the evolutionary change was rapid and parallels a related change in *E. elegans*—*E. brachyodus* in many ways.

Eumys sp.

Referred specimen.—Cedar Creek member (lower): No. 8483; left jaw with M_2-M_3; W½ sec. 4, T. 11 N., R. 54 W., Logan County.

This specimen is an especially large, heavy jaw with large teeth (Table 18), but whether or not it is a large individual of a known species of *Eumys* or an unnamed kind remains to be seen. It has the fundamental *Eumys* pattern with the following characters: M_2 and M_3 with protoconids reduced, anterior lingual cingula weak, ectostylids weakly developed, spurs projecting posteriorly from anterior metaconid arms, weak anteriorly projecting spurs from posterior protoconid arms, mesoconids developed, no mesolophids, and posterolophids separated from entoconids by deep notches; metastylid between posterior protoconid arm and metaconid on M_3; metaconid and entoconid of M_2, and metaconid of M_3 high above plane of crests and other principal cusps; and masseteric scar reaching to anterior end of M_2.

Table 18.—Measurements (in mm.) of *Eumys* sp.

	No. 8343
Crown length of M_1-M_3 at alveolus	8.00
Incisor width back of alveolus	2.00
M_2, antero-posterior length	2.60
M_2, transverse width	2.40
M_3, antero-posterior length	2.75
M_3, transverse width	2.45

Leidymys vetus Wood

Leidymys vetus Wood, A. E., 1937, p. 257.

Type.—AMNH No. 8742; middle Oligocene Cedar Creek beds of Colorado.

This species is discussed in the section on *Eumys* nr. *E. exiguus.*

Variation among the Eumyine Rodents

Individual variation is an important item in any study of the species of *Eumys.* Literally, were one to conceive of every variation as having taxonomic value, there would be dozens of species. However, most of the *Eumys* material has been referred to *E. elegans,* unless there has been strong evidence for making additional species. To date only six species have been named, of which I think two, *E. planidens* and *E. exiguus,* may eventually be removed from the genus or at least separated subgenerically from each other and the other four. The remaining species, with the possible exception of *E. parvidens,* fall into one cline when considered in the light of stratigraphic and areal differentiation and constancy of qualitative and quantitative characters, as has been demonstrated in the discussion of the *Eumys obliquidens-elegans-brachyodus* complex. In each of these three species there were variants in characters other than those listed, and undoubtedly some workers would argue for different species because of these variations. To use one variation to define a species would suggest treating other variations in the same manner and, in the end, would result in breaking down the criteria established for the already existing species.

There were too few upper teeth for a proper study, but as a result of the examination of the series of lower jaws from northeastern Colorado, I would evaluate the characters of the teeth thus: No particular character is of great value unless it has a restricted stratigraphic range or lacks quantitative overlap. In conjunction with the above, the following seems evident: Presence or absence of cingula, good. Strength of development of cingula, poor except in *Eumys brachyodus.* Protoconid arm direction, good. Presence of anterior protoconid and metaconid arms may be good if consistent and correlated with other reliable characters, but present evidence shows much variation. Extra cuspules, crests, spurs, or variation in position of union of cusps, spurs, and lophids, especially on M_3, appear valueless at present. This is also true concerning the upper teeth, especially M^3. The mesolophids are the last of the variable structures to be lost or reduced; that is, they lag behind other changing characters, as may be noticed in *E. elegans* which retained well-developed mesolophids as a variant after the other *E. obliquidens* characters ceased to appear, and were retained as a variant in later *E. elegans* specimens after the *E. brachyodus* characters had appeared.

I think that any future modification of the taxonomy must be by the standards proposed and not by the method of collecting together a group of similar specimens and naming it as new without regard for intergradation or variation.

Order CARNIVORA Bowdich, 1821

Family HYAENODONTIDAE Leidy, 1869

Hyaenodon horridus and *H. crucians* were listed by Cope (1874, p. 9) as present in northeastern Colorado. *H. cruentus* was reported by Matthew (1909, p. 105), and in this paper *H. mustelinus* is added to the faunal list. The specimens of *H. crucians* and *H. mustelinus* in the University of Kansas Museum of Natural History are typical, but there is difficulty in interpreting size range, secondary sexual differences, and structural variations in specimens of *Hyaenodon* cf. *H. cruentus* and *H. horridus.* Specimens larger than *H. crucians,* but having short faces, are assigned to *H.* cf. *H. cruentus.* Specimens larger than *H.* cf. *H. cruentus,* and having a normal length of face, are assigned to *H. horridus.* Nevertheless, in both groups the specimens are consistently smaller when compared with specimens of the two species from other areas.

Hyaenodon horridus Leidy

Hyaenodon horridus Leidy, 1853, p. 392.

Referred specimens. — Cedar Creek member (middle): No. 8138; crushed anterior part of skull; sec. 3, T. 11 N., R. 54 W., Logan County.

Cedar Creek member (upper): Univ. Colorado Mus. No. 19865; crushed skull; SE¼ sec. 8, T. 11 N., R. 53 W., Logan County.

These two skulls are referred to this species primarily on the basis of large size. Both specimens seem to be smaller, however, than the average for *Hyaenodon horridus.*

The skull in the University of Colorado Museum came from a level a few feet below the contact of the Orellan and Whitneyan beds.

Hyaenodon cf. H. cruentus Leidy

Referred specimens. — Cedar Creek member (middle or upper): Nos. 141, 4975; incomplete skulls; possibly from or near sec. 16, T. 11 N., R. 53 W., Logan County.

The skulls of these two specimens, in the parts that can be measured, are larger than any skulls of *Hyaenodon crucians* examined by me but are smaller than the two skulls from northeastern Colorado which were referred to *H. horridus.* When compared with skulls from other areas, it may be seen that Nos. 141 and 4975 are intermediate in size between large skulls of *H. crucians* and those of *H. cruentus.* Besides over-all size, No. 141 and No. 4975 differ from typical *H. cruentus* as follows: the premolars are the size of those in *H. horridus;* the molars are the size of those in *H. crucians;* and the muzzle is shorter than that of *H. horridus.*

Hyaenodon crucians LEIDY

Hyaenodon crucians LEIDY, 1853, p. 393.

Referred specimens. — Cedar Creek member (lower): Univ. Colorado Mus. No. 19862; fragment of right jaw with M_1-M_2; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County. No. 8139; skull and jaws; SW¼ sec. 21, T. 11 N., R. 53 W., Logan County. No. 8140; fragment of right jaw with M_2-M_3; same locality as No. 8139.

The size and other characters of Nos. 8139 and 8140 agree with the type specimen and with the description of the species given by SCOTT & JEPSEN (1936, p. 50). The specimen in the University of Colorado Museum is immature but seems to be referable to this species.

Hyaenodon mustelinus SCOTT

Hyaenodon mustelinus SCOTT, 1894a, p. 499.

Referred specimen.—Cedar Creek member (lower): No. 8142; incomplete skull and jaws; SE¼ sec. 31, T. 12 N., R. 54 W., Logan County.

Although the one specimen known from northeastern Colorado is slightly smaller than the specimens described by SCOTT (1894a, p. 499) and SCOTT & JEPSEN (1936, p. 53), there is little reason to question its reference to *Hyaenodon mustelinus*.

FAMILY CANIDAE GRAY, 1821

Pseudocynodictis paterculus (MATTHEW)

Cynodictis paterculus MATTHEW, 1903, p. 209.
Pseudocynodictis paterculus, CLARK, 1937, p. 312.

THORPE (1922, p. 428) referred specimens in the Marsh Collection from northeastern Colorado to this species.

Pseudocynodictis nr. P. paterculus (MATTHEW)

Referred specimens.—Horsetail Creek member: No. 8173; three fragments of jaws. No. 8174; right jaw fragment with P_4-M_1. No. 8175; left jaw fragment with P_4-M_3. No. 8176; left jaw fragment with M_1-M_2. Above specimens from NE¼ sec. 31, T. 11 N., R. 56 W., Weld County. No. 8179; left P_4-M_2; N½ sec. 33, T. 11 N., R. 53 W., Logan County.

These specimens have several characteristics in which they differ from *Pseudocynodictis gregarius* and seem close to *P. paterculus*. Compared to *P. gregarius:* the talonid of M_1 is higher, and the cusps are more pronounced; M_2 is longer, the basin of the talonid is broader, the hypoconid is higher and more bladelike, and the protoconid and metaconid are much higher than the paraconid; M_3 is larger, and the cusps are more pronounced. On the other hand, the shearing blade of M_1 does not seem to be more transversely directed than in *P. gregarius*, although the blade is directed more transversely in *P. paterculus*. These specimens seem to represent a stage intermediate between *P. paterculus* and *P. gregarius*.

Pseudocynodictis gregarius (COPE)

Canis gregarius COPE, 1873b, p. 3.
Pseudocynodictis gregarius, SCHLOSSER, 1902, p. 50.

Type.—AMNH No. 5297; Tertiary of Colorado.

Referred specimens.—Cedar Creek member (lower): No. 8177; left M_2; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County.

Cedar Creek member (middle): No. 8183; rear part of skull with M^1; W½ sec. 7, T. 11 N., R. 53 W., Logan County. No. 8186; left P_4-M_1; E½ sec. 3, T. 11 N., R. 54 W., Logan County. No. 8187; left ramus with C, P_1, P_4-M_3; SE¼ sec. 31, T. 12 N., R. 54 W., Logan County. No. 8194; right P_4-M_2; W½ sec. 7, T. 11 N., R. 53 W., Logan County.

It is realized that the species of the genus *Pseudocynodictis* have not been adequately characterized. Secondary sexual differences, size range, and stratigraphic position are three items that need to be clarified for the species already named before any more closely related species are described. Stratigraphy is no problem and will go far toward solving the problem of size range if, in the future, collections are made with care to eliminate false associations.

A series of *Pseudocynodictis* specimens ranging from small to large in size are present in the northeastern Colorado Orellan beds. These tend to fall into size groups which are not satisfactorily distinguished in all cases by other features such as structure, locality, or stratigraphic level. Perhaps more exact collecting or better specimens would aid in distinguishing these groups. In this paper, these groups are referred to: *P. lippincottianus* (large), *P. gregarius* (medium, but tending to divide into two groups), and *Pseudocynodictis* sp. (small). The specimens assigned to *P. gregarius* can be divided into deep-jawed forms and shallow-jawed forms, which may represent males and females of that species. Because of structural differences, it is unlikely that one group represents females of *P. lippincottianus* and the other group represents males of the small unnamed species.

Pseudocynodictis lippincottianus (COPE)

Canis lippincottianus COPE, 1873c, p. 9.
Pseudocynodictis lippincottianus, SCHLOSSER, 1902, p. 50.

Type.—AMNH No. 5327; Tertiary of Colorado.

Referred specimens.—Cedar Creek member: No. 120; left lower jaw with C, P_3-M_2; sec. 16, T. 11 N., R. 53 W., Logan County. No. 137; skull and jaws; near sec. 28, T. 11 N., R. 53 W., Logan County. No. 8191; maxillary fragment with left M^1-M^2; SW¼ sec. 21, T. 11 N., R. 53 W., Logan County. No. 8196; left jaw with C, P_2, P_4-M_1; E½ sec. 3, T. 11 N., R. 54 W., Logan County. No. 8199; right jaw with P_1-M_2; W½ sec. 7, T. 11 N., R. 53 W., Logan County.

Cedar Creek member (upper): No. 8200; fragment of left jaw with M_1; NE¼ sec. 3, T. 11 N., R. 54 W., Logan County.

I agree with HOUGH (1948, p. 590) that this species is distinct from *Pseudocynodictus gregarius* but, because of the indeterminate nature of MARSH's specimen, doubt the advisability of making *P. lippincottianus* a synonym of *P. angustidens* (Marsh). Cope (1873c, p. 9) based *P. lippincottianus* on material collected in northeastern Colorado, but he was somewhat doubtful of its validity. The specimens listed above agree with the description of the type given by Cope and differ in several particulars from specimens of *Pseudocynodictis gregarius* from the same area. The skull referred to *P. lippincottianus* is damaged and slightly compressed, but certainly its over-all length was at least 100 mm. and possibly as much as 110 mm. The upper teeth are damaged or missing with the exception of P^1 and P^2, which are similar to those of *P. gregarius.* No. 8191, a left maxillary with M^1-M^2, has been tentatively referred to *P. lippincottianus.* If this reference is correct, then M^1 and M^2 of *P. lippincottianus* are relatively wider than the corresponding teeth of *P. gregarius* (Table 19). The lower jaw of *P. lippincottianus* has the vascular impression or notch very deep and distinct, starting at an acute angle directly below the third molar. The lower molars of *P. lippincottianus* are relatively longer in relation to the premolars than in *P. gregarius.* The hypoconid of M_1 is low, more like that of *Daphoenus* than that of *P. gregarius.*

That *Pseudocynodictus lippincottianus* may represent the males of the species *P. gregarius* seems unlikely since the latter species is about five times as common as the former. Also, there are localities where *P. gregarius* is common but *P. lippincottianus* is absent. In the light of our knowledge of present day canids, it seems improbable that certain areas would be inhabited only by females.

Table 19.—Measurements (in mm.) of *Pseudocynodictis lippincottianus*

	No. 120	No. 8197	No. 8191	No. 137
Length of skull	....	....	....	100–110
M^1, antero-posterior length	....	....	7.0	7.6
M^1, transverse width	....	....	11.0	....
M^2, antero-posterior length	....	....	4.2	....
M^2, transverse width	....	....	6.8	....
Posterior border of lower canine to rear of M_3	44.7	44.2	....	42.0
Length of lower molars	19.8	20.2	....	19.3
Length of lower premolars	24.0	23.4	....	21.7

Pseudocynodictis temnodon (Wortman & Matthew)

Cynodictis temnodon Wortman & Matthew, 1899, p. 130.
Pseudocynodictis temnodon, Matthew, 1918, p. 189.

Matthew (1901, p. 357) referred a specimen from the Leptauchenia zone in Logan County to this species.

Pseudocynodictis sp. (Small form)

Referred specimens. — Cedar Creek member (middle): No. 136; left lower jaw with P_2-M_2; Logan County. No. 8201; skull and jaws; sec. 22, T. 11 N., R. 52 W., Logan County. No. 8202; left M_1; SE¼ sec. 31, T. 12 N., R. 54 W., Logan County. No. 8203; right M_1-M_2; E½ sec. 3, T. 11 N., R. 54 W., Logan County. No. 8204; anterior end right ramus with C, P_3; E½ sec. 3, T. 11 N., R. 54 W., Logan County. No. 8208; left lower jaw with M_2; W½ sec. 7, T. 11 N., R. 53 W., Logan County.

These small jaws and one crushed skull and jaws may represent an unnamed species of the genus *Pseudocynodictis.*

Parictis nr. P. dakotensis Clark

Referred specimen.—Horsetail Creek member: No. 8168; fragment of jaw with heel of M_1 and M_2; N½ sec. 33, T. 11 N., R. 53 W., Logan County.

In size and appearance this specimen corresponds closely to the description of *Parictis dakotensis* Clark. Both teeth have a rugose surface. The heel of M_1 is basined, the entoconid is higher than the hypoconid, and a well-developed fossa is present at the rear of the tooth. M_2 is practically unworn, hence revealing the pattern of the tooth, the structure of which has been poorly known. The trigonid is small and not so high as the heel of M_1. The metaconid is the highest and largest of the cusps; the protoconid is slightly anterior to the metaconid; and the paraconid is reduced to a vestigial cusp. Crests connect all three cusps which are set close together. On the antero-external surface of the trigonid, the cingulum swells into a plump, low cusp. This enlargement of the external side of the tooth has caused the protoconid to appear almost median in position.

Daphoenus cf. D. vetus Leidy

Referred specimen.—Cedar Creek member (middle): No. 8207; anterior part of right jaw with P_4; NW¼ sec. 3, T. 11 N., R. 54 W., Logan County.

Daphoenus hartshornianus (Cope)

Canis hartshornianus Cope, 1873c, p. 9.
Daphoenus hartshornianus, Scott, 1898, p. 361.

Type.—AMNH No. 5296; Tertiary of Colorado.

Referred specimens. — Cedar Creek member: No. 122; part of right lower jaw with M_1-M_2; Chimney Canyon, sec. 3, T. 11 N., R. 54 W., Logan County. No. 165; part of left lower jaw with M_2-M_3; same locality as No. 122. No. 8205; part of right lower jaw with P_4-M_2; W½ sec. 7, T. 11 N., R. 53 W., Logan County. No. 8106; right M_1; locality same as No. 8205.

The stratigraphic assignment of specimens No. 122 and No. 165 is based on H. T. Martin's field notes for the year 1925.

Proamphicyon cf. P. nebraskensis Hatcher

Referred specimen. — Cedar Creek member: No. 138; right lower jaw with P_1, M_1-M_2; "north of Stone Ranch" (*fide* H. T. MARTIN, 1925 field notes). This locality probably is in T. 12 N., R. 55 W., Logan County.

This specimen compares closely with Walker Museum specimen No. 1426, considered by HOUGH (1948, p. 592) to be conspecific with the type. Good occlusion is made with the teeth in a cast of the type skull.

Daphoenocyon? cf. D. dodgei (SCOTT)

Referred specimen. — ?Cedar Creek member: No. 102; part of left lower jaw with P_2-P_4; northeastern Colorado.

This specimen has blunt, broad premolars and a deep ramus like specimen No. 1456 in the Walker Museum. HOUGH (1948, p. 595) referred No. 1456 to *D. dodgei.*

FAMILY MUSTELIDAE SWAINSON, 1835

Palaeogale lagophaga (COPE)

Bunaelurus lagophagus COPE, 1873c, p. 8.
Palaeogale lagophaga, SIMPSON, 1946, p. 12.

Type.—AMNH No. 6812.

Referred specimens. — Cedar Creek member: No. 41; right jaw fragment with M_1; Logan County. No. 8166; left jaw with M_1; W½ sec. 7, T. 11 N., R. 53 W., Logan County.

MATTHEW (1902, p. 140) states that COPE's type came from beds 50 miles east of Pawnee Buttes, which would place the locality in eastern Logan County. This may have been a slight overestimation of the distance, but it does indicate that the locality was some distance east of Pawnee Buttes. SIMPSON (1946, p. 4) lists four specimens (including COPE's type) from northeastern Colorado and refers all to *Palaeogale lagophaga* and to an Orellan age.

FAMILY MUSTELIDAE SWAINSON?, 1835

In 1925 Mr. H. T. MARTIN obtained a lower jaw of a carnivore in "Chimney Canyon," Logan County, Colorado, which he listed in his field notes as "83-B [B refers to beds of Orellan age, E. C. G.]—*Cynodictis* underjaw. lower levels. HM." This specimen, so labeled, remained unnoticed in the University of Kansas collections until recently and is now the type of the following new genus and species.

DRASSONAX, new genus

Type species.—*Drassonax harpagops.*

Distribution.—Cedar Creek member of the White River formation, northeastern Colorado.

Diagnosis.—Mandible short, heavy, and massive; incisors crowded; premolars cingulated, broad, and without accessory cusps; metaconid of M_1 reduced; trigonid of M_2 small; dental formula $_{3,\ 1,\ 4,\ 3}$.

Drassonax harpagops, new species

Figure 22

Holotype. — Left lower jaw with C-M_2, No. 121, Vert. Paleont. Coll., Univ. Kansas Mus. Nat. Hist.

Geological age and locality.—Silts of Orellan age in the Cedar Creek member of the White River formation in "Chimney Canyon," sec. 3, T. 11 N., R. 54 W., Logan County, Colorado.

Diagnosis.—As for the genus.

Description.—The type is a left ramus lacking only the incisors, M_3, tip of the coronoid process, and external end of the mandibular condyle. Its size (Table 20) is about that of the lower jaw of Recent *Martes caurina origenes* (RHOADS). Foramina are present on the external surface of the body of the ramus below P_1, below the space between P_1 and P_2, and below the anterior root of P_3. The masseteric fossa is deep and reaches forward to M_2. The anterior border of the ascending ramus is steep, more like that of the procyonids than of the mustelids, and the antero-internal border is buttressed by a ridge rising from the anterior end of the scar for the temporal muscle. The mandibular condyle of this specimen is especially remarkable in its massiveness and vertical depth. This vertical depth is 4.7 mm., almost twice the depth of the mandibular condyles in comparable-sized *Martes,* and equal to the condyle of male *Martes p. pennanti* (ERXLEBEN), an animal with a jaw almost twice the size of the type of *Drassonax harpagops.* Unfortunately, the complete condyle is not preserved. However, by comparison of width and depth, and angle of the transverse axis of the condyle in relation to the jaw with similar characters in other mustelids, it appears reasonable to assume that the maximum condylar width did not exceed 16 mm. Furthermore, the postero-inferior part of the articulating surface of the condyle gives evidence that the width was between 13 and 14 mm. This is in keeping with the proportions found in *Plesiogulo.* The relationship of the transverse axis of the condyle to the rest of the jaw gives evidence that the animal was broad skulled like *Plesiogulo.* The scars where ligaments attached around the neck and internal end of the condyle are large and prominent. Compared with many mustelids, the condyle is high on the ascending ramus, being at the level of the tooth row. The angular process is deep and marked by well-developed muscle scars. The symphyseal scar involves the whole anterior end of the internal surface of the jaw and extends posteriorly to the posterior end of P_2.

The dental formula is $_{3,\ 1,\ 4,\ 3}$. The tooth row is curving, with a change of direction in the longitudinal axis of P_1-P_3 and M_1-M_2 in relation to P_4. Although this change of direction is difficult to detect without careful inspection, it does foreshadow the type of curve found in *Plesiogulo* and is associated with broad skulls. The change of direction is not like that seen in Recent *Martes,* which is caused by crowding of the teeth and shortening of the jaw.

The presence of all three incisors is uncertain. Although the end of the mandible is preserved in good condition and the alveoli of two incisors are plainly visible, it is possible that a minute pit below the alveolus of the median incisor is not the alveolus of a vestigial first incisor. The alveolus of the second incisor shows that the root was compressed laterally, whereas the alveolus of the third incisor is round. This lateral alveolus, containing the root of the incisor, is below the level of the second incisor and lies next to the infero-internal side of the canine. The crowded condition of these incisors resembles that seen in some extreme cases of crowding found in Recent martens.

The canine is large in diameter, and, although the tip is missing, it appears to be short. It lacks the swelling below the alveolar border that is characteristic of many mustelids.

Only the third and fourth premolars are set close together. All have thick cusps, cingula completely surrounding the bases of the teeth, and no accessory cuspules. With the exception of P_1, all the premolars are double rooted. The enamel surfaces of the premolars are faintly rugose and, to a lesser degree, so are the molars, but not to the extent seen in specimens of *Parictis* SCOTT. Well-developed carinae are present, anteriorly and posteriorly, on all the premolars except P_1, which lacks the anterior one. P_1 is reduced. P_2 is noticeably larger than P_1 and possesses a relatively longer heel than do any of the other premolars. P_3 is slightly larger than P_2, the apex of the principal cusp is more centrally located, and the heel turns outward where it extends slightly beyond the anterior end of P_4. P_4 is like P_3 except that it is much larger and lacks the postero-external bulge of the heel, but it does extend posteriorly beyond the anterior end of M_1.

TABLE 20.—Measurements (in mm.) of *Drassonax harpagops*

	No. 121
Length from anterior alveolar border of canine to rear of mandibular condyle at a point posterior to the ascending ramus	54.7
Depth of mandible at anterior margin of P_3	8.4
Depth of mandible at anterior margin of M_1	8.7
Depth of mandible at anterior margin of M_2	9.9
Width of mandible at heel of M_1	5.0
Greatest depth of mandibular condyle	4.7
Perpendicular depth from neck of condyle to angular process	10.9
Width of ascending ramus from neck of mandibular condyle to posterior margin of M_3	15.0
Length from anterior border of canine alveolus to posterior border of M_3 alveolus	36.2
Length of P_1-P_4	18.4
Length of M_1-M_2	11.9
Length of P_1-M_2	29.5
C, antero-posterior length	3.99
C, transverse width	3.69
P_1, antero-posterior length	2.50
P_1, transverse width	1.80
P_2, antero-posterior length	3.59
P_2, transverse width	2.27
P_3, antero-posterior length	4.79
P_3, transverse width	2.50
P_4, antero-posterior length	5.90
P_4, transverse width	3.01
M_1, antero-posterior length	8.00
M_1, transverse width, trigonid	4.05
M_1, transverse width, talonid	3.58
M_2, antero-posterior length	3.90
M_2, transverse width	2.89

The trigonid of M_1 is slightly higher than P_4. The paraconid is short, stubby, and separated from the protoconid by a small, narrow notch. The protoconid is thick and heavy with the apex of the cusp lateral in position and in line antero-posteriorly with the hypoconid. The protoconid is separated from the metaconid by a minute notch. The metaconid is reduced, but relatively not so much as in *Plesiogulo marshalli* (MARTIN), yet more so than in *Mionictis incertus* (MATTHEW). The cingulum is not so conspicuous on M_1 as it is on the premolars. Its best development is seen on the antero-external surface of the tooth where it reaches from the lateral side of the protoconid to the anterior end of the tooth; between the metaconid and paraconid; and on the external side of the heel. The heel of M_1 is short and has the hypoconid and entoconid cusps elongated to form ridges of about equal height, which have converted the heel into a basin that is open posteriorly. Each ridge is separated from the protoconid or metaconid by a slight notch. A facet of wear on the postero-external surface of the heel might be interpreted as indicating that the M^1 yet retained a well-developed metacone.

M_2 is reduced, its crown is oval, and its pattern is intermediate between that of the primitive canid and that of a typical mustelid. The protoconid and metaconid cusps are marginal, and the smaller metaconid is anterior to the protoconid. A crest connects the two cusps. The paraconid is absent. The hypoconid is large and prominent. The large, basined heel is formed by a crest between the hypoconid and protoconid, together with the rim of the heel extending from the hypoconid to the metaconid. The crests between the protoconid and metaconid, and protoconid and hypoconid still retain minute traces of the notches that formerly separated these cusps.

The alveolus alone represents M_3 in this specimen, but it shows that the tooth was reduced and crowded between M_2 and the ascending ramus. It had not, however, reached the stage represented by the infrequently occurring M_3 in Recent *Martes* and probably was a constant part of the dentition.

Discussion.—This jaw resembles mustelid lower jaws, both fossil and Recent, more than it does the lower jaws of other carnivores in the following combination of characters: (1) crowded incisors, (2) blunt, wide, completely cingulated premolars that lack accessory cuspules, (3) reduced metaconid and talonid of M_1, (4) reduced talonid and height of trigonid of M_2, (5) probable reduced size of M_3, and (6) short, massive mandible with deep, large masseteric fossa. The incisors of this specimen appear much like mustelid incisors in the pattern of their crowding, the reduction of the root of

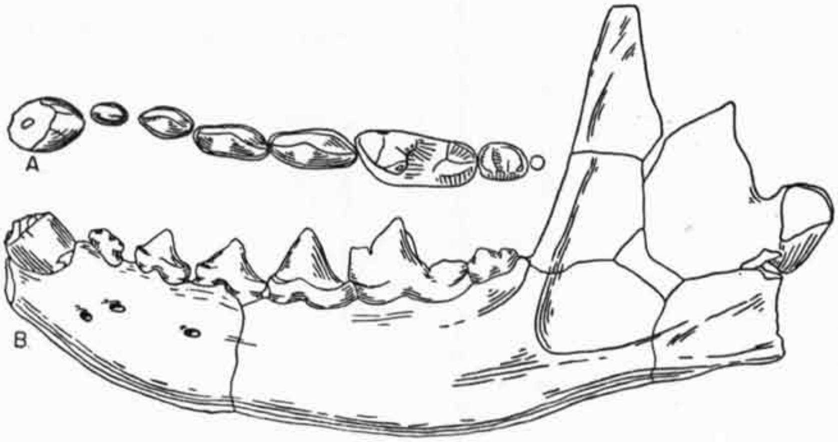


FIGURE 22.—*Drassonax harpagops*, n. gen. and sp. No. 121. (*A*) Occlusal view of left C-M_2. (*B*) External view of left jaw with teeth. Approximately × 2.

the first tooth, the lateral compression of the root of the second, and the retention of a rounded root in the third. The simplicity of the lower premolars, which MATTHEW (1924, p. 129) considered to be a characteristic of the mustelids, is, in *Drassonax*, in direct contrast to the usual canid condition where accessory cuspules are common. The M_1 with its short, narrow heel and reduced metaconid shows a musteline pattern. The tendency for reduction of the lower molars, another mustelid characteristic, would suggest that this specimen is a mustelid and would also eliminate this specimen from an ancestral position for several of the later groups of mustelids. After the lower premolars, the second lower molar probably is next in importance in taxonomic significance. The trend in post-carnassial musteline molars, of course, is reduction, and in the second lower molar there also appear at least two additional trends: (1) the tendency to develop a longitudinal shearing blade, and (2) the tendency of the tooth to round out its shape by expansion of the trigonid and reduction of the talonid. This latter feature, when coupled with the formation of a transverse crest from protoconid to metaconid cusps that are marginal in position, tends to obscure the longitudinal shearing blade. M_2 of *Drassonax* shows the beginning of this second trend, which is not seen in the canids. The third lower molar is not present, but apparently it is small. To state that this specimen is not a mustelid because of the presence of an M_3 would be unwarranted. To limit mustelids to groups that lacked M_3 implies that the loss of M_3 was the first mustelid character to appear — a restriction opposed by the occasional presence of a minute M_3 in Recent mustelids. A combination of characters serves to diagnose the mustelids, and these characters presumably did not appear simultaneously. The mandible, particularly the masseteric fossa and ascending ramus, is much more like those of mustelids than those of canids, especially Oligocene canids, in its form.

Granting that *Drassonax* is a mustelid, the phyletic position of the genus in the family is not questionable. The trend of the M_1 toward reduction of the metaconid cusp, reduction of the heel, and lateral narrowing of the tooth would require reversal for the genus to fit into the phyletic line of any mustelid subfamily except the Mustelinae. Comparison of this specimen with other fossil mustelids eliminates from consideration as possible relatives all forms except the wolverine-like forms of the subfamily Mustelinae—the relationship being closer to *Plesiogulo* than to any of the others.

The presence of *Drassonax* in the middle Oligocene, together with *Palaeogale*, indicates that there were at least two branches of mustelid development at that time. Obviously *Palaeogale* was far ahead of *Drassonax* in jaw reduction and tooth modification. That there were other separate branches or phyletic lines is even more evident in the post-Oligocene fossils. There have been classifications that reflected these phyletic branches (SIMPSON, 1945, p. 113), but SIMPSON rejected the arrangements and used the grouping Mustelinae GILL because he thought that the evidence did not warrant a division at present. In my opinion, the new genus, *Drassonax*, lends weight to the case for establishing at least a gulonine branch but, at the same time, suggests that the genera of the Mustelinae are more closely related to each other than to other groups. SIMPSON has commented (1945, p. 227) upon a possible cause for the difficulties in the mustelid classification—an explosive and rapid divergence of the mustelid stem stock into many phyletic lines, a pattern similar to that followed by the rodents.

Unfortunately, at present this new genus only adds to the heterogeneous nature of the Mustelinae. The conclusion that it shows the existence of another line of mustelids in addition to the weasel-like forms in the Orellan Oligocene, and that it may be ancestral to the wolverine group must be considered as a tentative conclusion which cannot be verified until the skull is known.

FAMILY FELIDAE GRAY, 1821

Dinictis squalidens (COPE)

Daptophilus squalidens COPE, 1873b, p. 2.
Dinictis squalidens, COPE, 1879, p. 170.

Type.—AMNH No. 5335; Cedar Creek area, northeastern Colorado.

MATTHEW (1901, p. 390) referred to this species specimens from the "Cedar Creek beds" of Colorado.

Dinictis felina LEIDY

Dinictis felina LEIDY, 1854a, p. 127.

Referred specimen.—?Cedar Creek member: No. 5045; fragment of jaw with P_4; near sec. 9, T. 11 N., R. 55 W., Logan County.

MATTHEW (1901, p. 389) at first inferred that a species of *Dinictis* larger than *D. squalidens* was to be found in northeastern Colorado, and he later (1910a, p. 310) reported *D. felina* to be present in the Orellan beds.

Although No. 5045 is referred to this species, it is possible that it is a large individual of *D. squalidens*.

Dinictis sp.

Referred specimens.—Horsetail Creek member: No. 9787; fragment of right jaw with M_1; W½ sec. 16, T. 10 N., R. 51 W., Logan County.

Cedar Creek member (middle): No. 8137; incomplete left jaw with damaged teeth; SW¼ sec. 25, T. 12 N., R. 54 W., Logan County.

The tooth from the Horsetail Creek member is near *Dinictis squalidens* in size but has a better-developed metaconid and heel than is seen on Orellan specimens of this species.

No. 8137 is unusual in that, although in size it agrees with small individuals of *Dinictus squalidens*, it has only an incipient flange developed for protection of the upper canine. It and the specimen referred to *D. felina* demonstrate the need for a study and review of this genus in respect to stratigraphic distribution and to individual and geographic variation.

Hoplophoneus primaevus (LEIDY & OWEN)

Machairodus primaevus LEIDY & OWEN, in LEIDY, 1851c, p. 329.
Hoplophoneus primaevus, COPE, 1880, p. 841.

Referred specimen.—?Cedar Creek member: No. 179; damaged skull; Logan County, Colorado.

The specimen listed above is considered to be *Hoplophoneus primaevus*, based on SIMPSON'S (1941) review of the genus. This genus is rare in northeastern Colorado. COPE (1874a, p. 509) mentioned two specimens—the type of *H. oreodontis* and a referred individual. MATTHEW (1901, p. 394) listed a skull as agreeing in form and measurements with LEIDY'S type of *H. primaevus*, and a jaw as corresponding closely to specimens of *H. robustus*. SIMPSON considers all this material to be *H. primaevus*, and HOUGH (1949) supports this view.

ORDER PERISSODACTYLA OWEN, 1848

FAMILY EQUIDAE GRAY, 1821

Mesohippus proteulophus OSBORN

Mesohippus proteulophus OSBORN, 1904, p. 171.

Referred specimens.—Horsetail Creek member: No. 9789; right upper molar; W½ sec. 16, T. 10 N., R. 51 W., Logan County. No. 9790; right upper molar; S½ sec. 36, T. 10 N., R. 59 W., Weld County. No. 9124; fragment of jaw with P_4; N½ sec. 31, T. 11 N., R. 56 W., Weld County.

The hypostyles of Nos. 9789 and 9790 are smaller and simpler than the hypostyles in most specimens of *Mesohippus eulophus*, being intermediate in development between the condition in *M. eulophus* of the Orellan and that described by OSBORN for *M. proteulophus* of the Chadronian. Reference of the specimens to *M. proteulophus* is based on the probability that *M. proteulophus* has as wide a range of variation of the hypostyle as does *M. eulophus*. Furthermore, I feel that the Chadronian members of this chronocline should bear the same name.

Mesohippus eulophus OSBORN

Mesohippus eulophus OSBORN, 1904, p. 173.

Type.—AMNH No. 8791; upper Oreodon zone (Horizon B) of Cedar Creek, Colorado (*fide* OSBORN, 1918).

Referred specimens. — Cedar Creek member: No. 9045; right P^3-P^4, $M^?$; sec. 22, T. 11 N., R. 52 W., Logan County. No. 9046; left P^4-M^2; SW¼ sec. 21, T. 11 N., R. 53 W., Logan County. No. 9047; right lower jaw with P_2-M_2; W½ sec. 7, T. 11 N., R. 53 W., Logan County.

COPE (1874, p. 9) considered *Mesohippus bairdii* LEIDY to be present in northeastern Colorado, and, in addition, he later (1874a, pp. 496-497) recognized two other species, *M. exoletus* (COPE) and *M. cuneatus* (COPE). MATTHEW (1901, p. 357) at first recognized only *M. bairdii*, but later (1909, p. 106) questioned the presence of *M. bairdii* and listed *M. eulophus* OSBORN and *M. exoletus*. OSBORN (1918, p. 50) still later stated that MATTHEW considered *M. eulophus* to be a subspecies or geographic variation of *M. bairdii*. At that time, OSBORN considered COPE'S species to be indeterminate because the types were lost.

The determinable specimens found in the Cedar Creek by me are similar to the type of *Mesohippus eulophus*, and they have been referred to this species. However, the specimens match equally well the description of *M. exoletus* by COPE. With this material at hand, it is rather difficult to understand OSBORN'S treatment of COPE'S species, since the description of *M. exoletus* by COPE contained enough information to make it the basis for a species distinguishable from *M. bairdii*. A solution to the problem of the synonymy of *M. exoletus* and *M. eulophus* probably can be reached by studying large populations of *M. bairdii* and determining its range of variation. Following such a study, were the description of *M. exoletus* still sufficient to distinguish the northeastern Colorado forms, then there would follow the problem of deciding whether or not *M. exoletus* and *M. eulophus* are synonymous. For these reasons I have considered it best to continue to use OSBORN's name, especially since there is a type specimen available for comparison.

In addition to those listed above, there are many specimens consisting of isolated teeth and several without adequate stratigraphic records. From the combined material the following generalizations concerning *Mesohippus eulophus* may be made: (1) all the teeth are larger than those of *M. bairdii;* (2) an internal cingulum is present on the upper teeth; (3) P^4 is wider than M^1; (4) P^1 is reduced more than in *M. bairdii;* (5) the metaconule is not prominent (isolated on P^2 of one specimen); (6) the protoconule is well defined and prominent; (7) the parastyle and mesostyle are very strong; (8) the metastyle is weak or absent; (9) the hypostyle is strong; (10) the metaloph tends to fuse with the hypostyle with wear; (11) the parastyle and paracone are united to the protoloph; (12) there is no definite crochet, but occasionally incipient ones; (13) the maximum transverse diameter of the lower teeth is at P_3-P_4. Some of these characters differ from those listed by OSBORN in diagnosing *M. eulophus*. OSBORN stated that the molars were wider than the premolars and that the protoconule was faint. There is not much question about the large size of the last two lower premolars. They resemble specimens of *Miohippus* in that respect. P^4 is as wide as M^1, and wider in some specimens. The range in diameter is so narrow, however, that variations undoubtedly exist in which the P^4 may have a smaller transverse width. Whether the protoconule should be described as faint or strong appears to depend upon what specimens are used. The fact that the protoloph and metaloph are continuous might tend to make the protoconule less conspicuous than in *Mesohippus bairdii,* for example, but it certainly does not obliterate the conule in any way. Most of the characters show that these specimens are different from *M. bairdii* and indicate an advance over that species toward *Miohippus.*

Mesohippus sp.

Referred specimens.—Horsetail Creek member: No. 9119; fragments of lower teeth; W½ sec. 9, T. 10 N., R. 51 W., Logan County.

These equid remains suggest that a species smaller than *Mesohippus proteulophus* is also present in the Horsetail Creek member.

Miohippus sp.

Referred specimen.—?Vista member: No. 4901; part of right jaw with P_3-M_1, M_3; sec. 3, T. 11 N., R. 54 W., Logan County.

This specimen was collected by H. T. MARTIN in 1925 at Chimney Canyon in Logan County. In color and preservation this specimen resembles the material from the Vista member at this locality. The teeth are comparable in size with those of *Miohippus meteulophus* and are much larger than any specimens of *Mesohippus* from the Cedar Creek member.

Small fragments of teeth have been found by me in the Whitneyan beds, but nothing that is generically determinable.

FAMILY BRONTOTHERIIDAE MARSH, 1873

Megacerops acer (COPE)

Megaceratops acer COPE, 1873a, p. 4.
Megacerops acer, OSBORN, 1929, p. 545.

Type.—AMNH No. 6348; Chadron formation, Horsetail Creek, northeastern Colorado (*fide* OSBORN, 1929).

This species is cited because of the good skeletons from Weld County in the Denver Museum of Natural History.

SCOTT (1941, p. 910) was of the opinion that the genus *Brontops* MARSH was also represented in northeastern Colorado.

Fragments of teeth referable to the Brontotheriidae have been found in the W½ sec. 9, T. 10 N., R. 51 W.; and NE¼ sec. 31, T. 11 N., R. 53 W., Logan County, and in the N½ sec. 31, T. 11 N., R. 56 W., Weld County. A lower jaw from the S½ sec. 1, T. 11 N., R. 54 W., Logan County, appears to be close to *Megacerops.*

FAMILY HYRACODONTIDAE COPE, 1879

Hyracodon nebraskensis LEIDY

Rhinoceros nebraskensis LEIDY, 1850a, p. 121.
Hyracodon nebraskensis, LEIDY, 1856a, p. 92.

Referred specimen.—Cedar Creek member (middle): No. 9050; maxillaries, jaws, and limb bones; E½ sec. 12, T. 11 N., R. 54 W., Logan County.

This is the only specimen from a known level in the Cedar Creek member that is complete enough for comparison with the four species recognized by SINCLAIR (1922). In the P^4 of this specimen the valley between the crests is unblocked, but in the bottom of the valley there is an incipient ridge that may be an undeveloped mure. Only in extreme wear would this ridge have produced anything resembling a blocked valley, and even then it would not have resembled the type of blocked valley seen in *Hyracodon nebraskensis.* P^3 has the two transverse crests well developed, with the anterior one turning back toward the tip of the posterior crest. Here again the valley is blocked only by a low ridge which is not equal in development to the two crests. The valley of P^2 is completely blocked. The stage of wear is similar to that seen in figure 2A of SINCLAIR, 1922. This specimen would fall into the *H. nebraskensis* group as defined by SINCLAIR, although the premolars may best be described as trending toward the *H. leidyanus* type of pattern.

COPE (1873a, p. 2) described *Hyracodon arcidens* from the Oligocene of northeastern Colorado. The type is apparently lost; SINCLAIR (1922, p. 68) judged that COPE's description did not apply to specimen AMNH No. 6309 which was labeled by COPE as the type and which was figured by COPE & MATTHEW (1915, pl. CII). MATTHEW (1901, p. 357), SINCLAIR (1922, p. 68), and H. E. WOOD (1927, p. 26) recognized this speices, but it was placed in synonymy with *H. nebraskensis* (LEIDY) by SCOTT (1941, p. 842). In SINCLAIR's (1922, p. 67) succinct discussion of the status of the species of *Hyracodon* he states: "For systematic and stratigraphic purposes they may be conceived as species, although some might wish to term them subspecies." Lacking knowledge of intermediate stages and in the absence of the blending of the diagnostic characters, SINCLAIR concludes that "they are probably to be regarded as distinct species, on the basis of constant association of constant differences." On the other hand, SINCLAIR also points out that the species might represent the stages in the progressive evolution of the hyracodont line — a chronocline. His comment that ancestor and descendant continued to exist contemporaneously for a time reflects the concept that animal populations are made up of representatives of the ancestral form, the norm or optimum group, and the progressive forms which will be the norm of the next stage. With large quarry populations such a condition might be demonstrated for *Hyracodon*. This type of successive populations could be accepted as a single species. SCOTT's (1941, p. 841) reasons for synonymizing *H. arcidens, selenidens, leidyanus,* and *apertus* with *H. nebraskensis* were: Stratigraphic separation is not possible; it is improbable that four species or subspecies lived "together" in South Dakota and Nebraska; and insufficient allowance has been made for the differences due to age and sex and to an uncommon degree of individual variability. Both SINCLAIR and WOOD thought some stratigraphic division was possible. SCOTT's argument concerning species and subspecies was in the sense observed by neozoologists, but it would not necessarily apply to morphological units as used by WOOD and would be untenable if stratigraphic division exists. SCOTT cited the variation seen in the specimens of *Trigonias* from the Trigonias Quarries in Weld County, Colorado, as an example of the degree of variation one might expect in *Hyracodon*, which is his best reason for synonymizing the five species. Specific designation for each group, if they are but morphological variants of a single species in the sense implied by SCOTT, does not seem desirable. On the other hand, the apparent trend toward formation of the separated and parallel crests in the premolars deserves recognition. So far as I am concerned, a single species with its several subspecies is probably the best means of showing the different stages in the changing premolars, but this view yet remains to be adequately demonstrated.

Hyracodon sp.

Referred specimens.—Horsetail Creek member: No. 9004; fragments of lower molar; N½ sec. 31, T. 11 N., R. 56 W., Weld County. No. 9008; fragments of upper molar; SE¼ sec. 1, T. 10 N., R. 54 W., Logan County. No. 9118; fragments of upper and lower teeth; W½ sec. 9, T. 10 N., R. 51 W., Logan County.

Vista member: No. 9051; right lower jaw and left maxillary with damaged teeth (not associated); SE¼ sec. 8, T. 11 N., R. 53 W., Logan County.

This material is too poor for specific identification, but it does not appear to differ from *Hyracodon nebraskensis* of the Cedar Creek member.

FAMILY RHINOCEROTIDAE OWEN, 1845

Trigonias osborni LUCAS

Trigonias osborni LUCAS, 1900, p. 221.

Referred specimens. — Horsetail Creek member: Univ. Colorado Mus. No. 18000; mandible with complete dentition; Trigonias Quarries, sec. 26 (Lower Quarry), and 27 (Upper Quarry), T. 10 N., R. 57 W., Weld County. No. 9006; left P_3-M_2 in fragment of jaw; N½ sec. 31, T. 11 N., R. 56 W., Weld County. No. 9007; right M_1-M_2; SE¼ sec. 1, T. 10 N., R. 54 W., Logan County.

The occurrence of *Trigonias* in the Chadronian of Weld County has been discussed by GREGORY & COOK (1928), FIGGINS (1934a), H. E. WOOD (1931), MATTHEW (1930, p. 272; 1931, p. 5), and SCOTT (1941, p. 785). There is no reason to repeat in detail all the comments upon the specimens recovered from these quarries. In brief: GREGORY & COOK (1928) reported two varieties of *T. osborni* LUCAS and four new species, *T. hypostylus, T. precopei, T. preoccidentalis,* and *T. taylori.* MATTHEW (1930, 1931) considered only one genus and one species to be present. H. E. WOOD (1931) recognized *T. o. osborni, T. o. precopei* (which included *T. preoccidentalis*), *T. hypostylus, T. taylori,* and described and named as new *T. cooki.* FIGGINS (1934a) reduced all to one species, *T. osborni.* SCOTT (1941) considered two species to be present, *T. osborni* and *T. taylori.*

The specimen in the University of Colorado Museum has very large canines. The length of P_1-M_3 is 205 mm. (occlusal) and 220 mm. (alveolar) on each side.

Caenopus premitis GREGORY & COOK

Caenopus premitis GREGORY & COOK, 1928, p. 19.

Type.—Denver Mus. Nat. Hist. No. 1025 (skull E); Horsetail Creek member, White River formation, Trigonias Quarries, Weld County, Colorado.

This specimen has been discussed by GREGORY & COOK (1928), FIGGINS (1934, 1934a), H. E. WOOD (1931), and H. E. WOOD & A. E. WOOD (1937, p. 132). On present evidence *Caenopus premitis* seems to be older than *C. mitis.*

Caenopus mitis (COPE)

Aceratherium mite COPE, 1874a, p. 493.
Caenopus mitis, COPE, 1880a, p. 611.

Type.—AMNH No. 6325; upper Titanotherium beds of Cedar Creek, Logan County, Colorado (*fide* WOOD, H. E., 1927).

MATTHEW (1901, p. 357) first listed this species from the "Oreodon" beds, but later (1909, p. 104) listed the level as Chadron. The occurrence of *Caenopus mitis* in the Chadron of South Dakota lends weight to the view that the northeastern Colorado specimens are Chadronian in age.

A specimen collected by H. T. MARTIN in 1911 from "Stone Ranch" (NW¼ of T. 11 N., R. 55 W., Logan County; locality data by oral communication from CURTIS HESSE) might be referable to this genus. This specimen, No. 4917, a right lower jaw fragment, has a well-preserved second molar 30.5 mm. long and 17.5 mm. wide. Weak cingula are present on all sides except the internal surface. No cingula are visible on the exposed posterior or internal faces of the unerupted M_3. The depth of the ramus at M_2 is 37.5 mm.

Subhyracodon occidentalis (LEIDY)

Rhinoceros occidentalis LEIDY, 1851b, p. 276.
Subhyracodon occidentale, WOOD, H. E., 1927, p. 63.

Referred specimens.—Cedar Creek member (lower and middle): No. 174; an uncrushed and undistorted anterior part of a skull with complete dentition; ?eastern part of Weld County. No. 8213; mandible with damaged dentition; SE¼ sec. 21, T. 11 N., R. 53 W., Logan County. No. 8363; anterior part of skull with right P^2-M^2; channel sandstones of sec. 9, T. 11 N., R. 55 W., Logan County.

This species was recorded from northeastern Colorado by COPE (1874a, p. 495) as "Several specimens from different localities." A second species from northeastern Colorado, *Hyracodon quadriplicatus* COPE (1873a, p. 1) [*Aceratherium quadriplicatum* (COPE) (1874a, p. 495) and *Anchisodon quadriplicatus* (COPE) (1879a, p. 270)] based on deciduous teeth, was considered indeterminable by H. E. WOOD (1927, p. 68). SCOTT (1941, p. 810) made it a synonym of *Subhyracodon occidentalis*.

The University of Kansas specimens are unusual because of their large size. Both of the skull fragments have teeth the size of those in *Subhyracodon metalophus*, but the occlusal patterns are typical of *S. occidentalis*. The significance of this size and pattern combination must await better and more reliable evidence. This may be a case of increased size preceding pattern change in the evolution toward *S. metalophus* or it may merely record a local population of large *S. occidentalis*.

Rhinocerotid sp.

Referred specimens.—No. 8364; right maxillary with P^2-M^1; N½ sec. 13, T. 11 N., R. 56 W., Weld County. No. 8365; right M^1-M^2; SE¼ sec. 3, T. 11 N., R. 54 W., Logan County.

The Weld County specimen was found in gray-white silt at the base of a channel sandstone, and the other specimen was found 230 feet below the white marker in gray-white silt. Although each was below the main channels in the area, it is difficult to determine whether they were in the upper part of the Horsetail Creek member or lowermost part of the Cedar Creek member.

The teeth of both specimens are slightly smaller than those of *Subhyracodon occidentalis* found in the area and appear somewhat like the teeth of *Trigonias*. If it could be established that the teeth were those of *Trigonias*, this fact would be of considerable aid in determining the Chadronian-Orellan boundary.

ORDER ARTIODACTYLA OWEN, 1848

FAMILY LEPTOCHOERIDAE MARSH, 1894

Stibarus obtusilobus COPE

Stibarus obtusilobus COPE, 1873b, p. 3.

Type.—AMNH No. 6784; "Oreodon beds of northeastern Colorado" (*fide* MATTHEW, 1903, p. 219).

Referred specimens.—Horsetail Creek member: No. 8972; left P_3 in fragment of jaw; W½ sec. 9, T. 10 N., R. 51 W., Logan County. No. 9105; left P_2, M_3; W½ sec. 29, E½ sec. 30, T. 11 N., R. 53 W., Logan County.

The specimens listed above have three large and distinct cusps on the trenchant premolars. The heel of M_3 is narrow and reduced. In size, the teeth are near those of *Leptochoerus spectabilis* and much larger than those of *Stibarus lemurinus*.

No. 8972 is directly comparable with COPE's type, which consists of a lone P_3 in a fragment of bone. Our material and the type (the only known specimens from northeastern Colorado) can be readily distinguished from the large leptochoerids found in the Cedar Creek member, which do not have trenchant and cuspate premolars or reduced third molars. Comment on the characters that distinguish *Stibarus* as a valid genus is made in the discussion of *Stibarus lemurinus*.

The occurrence of *Stibarus obtusilobus* in the Horsetail Creek member may explain its rarity, inasmuch as these beds are relatively barren of fossils.

Stibarus lemurinus (COPE)

Menotherium lemurinum COPE, 1873d, p. 419.
Leptochoerus lemurinus, MATTHEW, 1899, p. 60.
Leptochoerus spectabilis (in part), SCOTT, 1940, p. 368.

Type.—AMNH No. 5349; Oligocene of northeastern Colorado.

Referred specimens.—Horsetail Creek member: Uncatalogued Univ. Colorado Mus. specimen; left M_1; W½ sec. 9, T. 10 N., R. 51 W., Logan County. No. 9225; right maxillary fragment with P^2-M^3; SW¼ sec. 29, T. 11 N., R. 53 W., Logan County.

Cedar Creek member: Univ. Colorado Mus. No. 19863; right P_4-M_1; sec. 7, T. 11 N., R. 53 W., Logan County. No. 9033; right M_1, and left M^2 (not associated); SW¼ sec. 12,

T. 11 N., R. 54 W., Logan County. No. 9230; left M_1-M_2; SE¼ sec. 31, T. 12 N., R. 54 W., Logan County. No. 9231; right M_1-M_3; locality same as No. 9033.

MATTHEW (1901, p. 357) reported the occurrence of *Stibarus lemurinus* in northeastern Colorado as *Leptochoerus lemurinus*. SCOTT (1940, p. 368) considered the type indeterminable and placed *S. lemurinus* in the synonymy of *Leptochoerus spectabilis* LEIDY. However, with the series of northeastern Colorado specimens at hand, there is no difficulty in recognizing the species, either by comparison with the type or with COPE's description.

The distinguishing features of the lower teeth of *Stibarus lemurinus* are: cusps higher than those in *Leptochoerus spectabilis*, S pattern of wear in the molars, narrow M_3, and small size. The upper jaws listed above are referred to this species because of agreement in size. P^2 is elongate and narrow, tricuspid, and much like the second premolar of *Stibarus obtusilobus*. P^3 is about the same size as P^2 (Table 21) but has three external cusps and a fourth internal one which is small, semi-isolated, and opposite the central external cusp. P^4 is molariform and equal to M^1 in size. M^3 is reduced. All the teeth are low crowned. This species is smaller than *S. obtusilobus*. Some supporting evidence for association of these upper and lower jaws is seen in Nos. PM476, PM477, PM481, and P25809 in the Chicago Natural History Museum, which are referable to this species. These Nebraskan specimens consist of upper and lower teeth collected from a single locality.

This species is placed in the genus *Stibarus* because of the narrow tricuspid condition of P^2 and the similarity of the lower molars of *S. lemurinus* to those of *S. montanus*.

Several features appear on the teeth of *Stibarus*

TABLE 21.—Measurements (in mm.) of *Stibarus lemurinus*

	No. 9225	No. 9231	No. 19863[a]
Crown length of P^2-M^3	29.7	....	....
P^2, antero-posterior length	7.2	....	....
P^2, transverse width	2.4	....	....
P^3, antero-posterior length	7.1	....	....
P^3, transverse width	4.7	....	....
P^4, antero-posterior length	4.2	....	....
P^4, transverse width	6.4	....	....
M^1, antero-posterior length	4.6	....	....
M^1, transverse width	6.4	....	....
M^2, antero-posterior length	4.1	....	....
M^2, transverse width	6.0	....	....
M^3, antero-posterior length	3.2	....	....
M^3, transverse width	4.6	....	....
P_4, antero-posterior length	....	....	6.1
P_4, transverse width	....	....	3.4
M_1, antero-posterior length	....	4.8	4.8
M_1, transverse width	....	3.7	3.7
M_2, antero-posterior length	....	4.2	....
M_2, transverse width	....	3.6	....
M_3, antero-posterior length	....	4.7	....
M_3, transverse width	....	3.1	....

a. University of Colorado Museum.

that are diagnostic for the genus. The upper and lower anterior premolars are cuspate and trenchant. The heel of M_3 is reduced. A distinct paraconid is present on the molars, although lost with wear.[24] A character that may prove of value, if it can be demonstrated to be fairly constant, is the S pattern of wear in the lower molars. In *Stibarus* the S is formed by a crest that unites the hypoconid and metaconid, whereas in *Leptochoerus* the union is generally between the hypoconid and protoconid. The distinction is not great, and a little variation in *Leptochoerus* will result in the hypoconid uniting with the metaconid but no S pattern results from wear. SCOTT (1940, p. 372) indirectly referred to the S pattern when he described the lower molars of *Stibarus*: "The anterior half of the crown, consisting of two conical cusps, rises somewhat above the posterior half, suggesting the tuberculo-sectorial pattern; the posterior half is an obscurely-indicated crescent, which opens internally."

Leptochoerus spectabilis LEIDY

Leptochoerus spectabilis LEIDY, 1856, p. 88.

Referred specimens.—Cedar Creek member: No. 9226; left P^2-M^3; sec. 22, T. 11 N., R. 52 W., Logan County. No. 9228; left P_3-M_3; SW¼ sec 21, T. 11 N., R. 53 W., Logan County. Univ. Colorado Mus. No. 19855; left M^1-M^2; W½ sec. 7, T. 11 N., R. 53 W., Logan County.

Vista member: No. 9014; left M_1-M_3; NE¼ sec. 17, T. 11 N., R. 53 W., Logan County.

Unlisted from the Cedar Creek member are numerous fragments of upper and lower jaws containing from one to three teeth.

The specimens are referred to this genus and species because none differ greatly from comparative material of *Leptochoerus spectabilis*, and the third lower premolar does not resemble that of *Stibarus obtusilobus*. MATTHEW (1901, p. 357) reported finding *Leptochoerus spectabilis* in northeastern Colorado.

No. 9226 has a thin second premolar (Table 22) that is essentially a single cusp with the most minute anterior and posterior cuspules.

TABLE 22.—Measurements (in mm.) of *Leptochoerus spectabilis*

	No. 9226
Crown length of P^2-M^3	35.3
P^2, antero-posterior length	8.1
P^2, transverse width	3.7
P^3, antero-posterior length	8.3
P^3, transverse width	7.3
P^4, antero-posterior length	5.6
P^4, transverse width	8.6
M^1, antero-posterior length	5.0
M^1, transverse width	7.9
M^2, antero-posterior length	4.5
M^2, transverse width	7.3
M^3, antero-posterior length	3.9
M^3, transverse width	5.5

24. *Leptochoerus* shows no indication, even on unworn teeth, that the paraconids were so well developed.

FAMILY ENTELODONTIDAE LYDEKKER, 1883

Archaeotherium ramosus (COPE)

Elotherium ramosum COPE, 1874, p. 27.
Archaeotherium ramosus, CAMP, WELLES, & GREEN, 1949, p. 251.

Type.—AMNH No. G393; northeastern Colorado.

Archaeotherium potens (MARSH)

Amnodon potens MARSH, 1893, p. 410.
Archaeotherium potens, CAMP, WELLES, & GREEN, 1949, p. 251.

Type.—Yale Univ., Peabody Mus. Nat. Hist. No. 12042; northeastern Colorado.

TROXELL (1920, p. 431) questionably referred the latter of these two species to the "upper Brule," and SCOTT (1940, pp. 440-441) gave the same general age assignment for both species. MATTHEW (1901, pp. 356-357) tentatively referred material from the Horsetail Creek and Cedar Creek members to *Archaeotherium ramosus* but did consider (1909, p. 106) a Whitneyan age a possibility. Inasmuch as neither species has been found outside of Colorado and, for that matter, no additional specimens of *A. potens*, it is difficult to judge exactly where the types may have been collected. Nevertheless, if the locality of MARSH's collecting in 1870 was in the Chalk Bluff area of Weld County, as I am inclined to think it was, then the type of *A. potens* probably is not from the upper Oligocene. Likewise, COPE's specimen probably came from Weld County, and therefore from Horsetail or Cedar Creek beds.

Additional evidence bearing on the problem is seen in a mandibular symphysis of the "Pelonax-type" in our collection (No. 8289) which was collected by H. T. MARTIN, probably in 1925. This specimen has written upon it, apparently in MARTIN's handwriting, "*Elotherium* N.E. Colorado Miocene." The matrix is so much like that seen in channel sandstone in sec. 9, T. 11 N., R. 55 W., Logan County, assigned to beds of the Horsetail Creek member or lowest part of the Cedar Creek member, and so unlike any matrix seen in the Miocene, that this rather flimsy evidence is introduced for what it may be worth as indicative of a late Chadronian or early Orellan age for the subgenus.

Archaeotherium mortoni LEIDY

Archaeotherium mortoni LEIDY, 1850, p. 90.

Referred specimens.—Horsetail Creek member: Denver Mus. Nat. Hist. collection of skeletons from Weld County.
Cedar Creek member: No. 7728; skull and mandible; NE¼ sec. 3, T. 11 N., R. 54 W., Logan County.

This species is well known from the Chadronian beds of Weld County where the Denver Museum of Natural History has collected excellent specimens. Most of the fragmental material from the Horsetail and Cedar Creek members has been referred to *Archaeotherium mortoni* despite small differences in pattern and size of the teeth.

Archaeotherium crassum (MARSH)

Elotherium crassum MARSH, 1873, p. 487.
Archaeotherium crassum, TROXELL, 1920, p. 375.

Type.—Yale Univ., Peabody Mus. Nat. Hist. No. 12020; titanothere zone, northeastern Colorado.

The type of this species has been assigned, questionably, to beds of Orellan age (TROXELL, 1920, p. 375), but MARSH (1893, p. 408) mentioned associated titanothere bones. MATTHEW (1901, pp. 356-357) tentatively assigned material from beds of both Chadronian and Orellan age to this species. The only occurrence of *Archaeotherium crassum* outside of northeastern Colorado is a specimen, referred to this species by CLARK (1937, p. 304), from the middle member of the Chadron of South Dakota.

FAMILY TAYASSUIDAE PALMER, 1897

Perchoerus nr. P. minor COOK

Referred specimens.—Horsetail Creek member: No. 8237; fragment of jaw with P_4-M_1; N½ sec. 31, T. 11 N., R. 56 W., Weld County. No. 9000; left M_1-M_2; W½ sec. 9, T. 10 N., R. 51 W., Logan County.

Heretofore this genus has been unknown from northeastern Colorado, and it is unfortunate that of the specimens collected none are satisfactory for reliable specific identification.

The two specimens from the Chadronian beds are referred to *Perchoerus minor* because of their small size (Table 23) and simple tooth pattern.

Perchoerus nr. P. nanus (MARSH)

Referred specimens.—Cedar Creek member (lower): No. 8236; fragment of maxillary with P^4-M^1; SW¼ sec. 21, T. 11 N., R. 53 W., Logan County.
Vista member: Univ. Colorado Mus. No. 19873; incomplete left lower jaw containing P_3-M_3, and crushed right jaw with part of P_1; SE¼ sec. 8, T. 11 N., R. 53 W., Logan County.

Assignment of these specimens to *Perchoerus nanus* is only in recognition of their small size. No. 8236 has teeth smaller than those in specimens of *P. probus* LEIDY.

Typical of material from the Vista member, specimen No. 19873 has undergone distortion and damage during preservation. The incisors are crushed. The roots of the canines are present, and they indicate that these teeth were large and triangular in cross section. The first premolar is single rooted, and it is much closer to the canine than to the second premolar. The root of P_2 indicates that this tooth was smaller than P_3. P_3 is exceptionally short and trenchant. It has a well-developed, postero-internal, basined heel. P_4 is partly molariform, with the metaconid almost as well developed as the protoconid. The paraconid is low and is united to the protoconid by a crest. The heel of P_4, like that of P_3, is the widest part of the tooth and is basined linguad of the hypoconid. M_1 is much worn and

TABLE 23.—Measurements (in mm.) of *Perchoerus* nr. *P. minor*, *Perchoerus* nr. *P. nanus*, and *Perchoerus nanus*

	P. nr. *P. minor*		*P.* nr. *P. nanus*		*P. nanus*
	No. 8237	No. 9000	No. 8236	No. 19873[a]	No. 11784[b]
P^4, antero-posterior length	....	....	8.6	....	....
P^4, transverse width	....	....	10.8	....	....
M^1, antero-posterior length	....	....	10.2	....	....
M^1, transverse width	....	....	10.6	....	....
Crown length of P_1-M_3	....	....	....	80.0[c]	....
Crown length of P_3-M_3	....	....	....	62.6	....
Crown length of M_1-M_3	....	....	....	43.1	....
P_3, antero-posterior length	....	....	....	8.6	9.5
P_3, transverse width	....	....	....	4.5	....
P_4, antero-posterior length	10.5	....	....	10.7	11.0
P_4, transverse width	5.6	....	....	7.0	....
M_1, antero-posterior length	10.5	10.2	....	11.3	....[d]
M_1, transverse width	7.9	7.6	....	7.6	....
M_2, antero-posterior length	....	11.3	....	12.1	12.2
M_2, transverse width	....	8.6	....	9.3	....
M_3, antero-posterior length	....	....	....	18.3	15.2
M_3, transverse width	....	....	....	9.5	....
Depth of ramus at P_2	....	....	....	25.0	....
Depth of ramus at M_3	....	....	....	32.0	....

a. University of Colorado Museum.

b. Dr. JOSEPH T. GREGORY kindly supplied the measurements of the type specimen of *Perchoerus nanus* (Yale Univ., Peabody Mus. Nat. Hist. No. 11784). SCOTT's (1940, p. 503) measurements of the teeth of the type specimen were based on MARSH's illustration (1894, p. 271, fig. 28) of the specimen.

c. Estimated.

d. Damaged.

damaged, and most of the enamel has been weathered away. Enough of the tooth remains to show that it was bilophodont and that there was some complicated folding of the enamel about the cusps. M_2 is larger than M_1 and equally worn and weathered; it has a cingulum on the anterior face of the metaconid, and each lophid shows a complicated folding of the enamel on the anterior face. M_3 is weathered but not greatly worn. The metaconid has an anterior cingulum. Practically no valleys separate the cones of the metalophid and hypolophid, but the transverse valley between the two lophids is easily seen. This transverse valley is divided by a faint crest which unites the two lophids and runs from the hypoconid to the internal side of the protoconid. The third lobe is united to the hypoconid by a similar crest. The third lobe is large and seems to consist of one cusp. A small tubercle lies between the third lobe and the entoconid on the internal border of the tooth, thus enclosing a basin. On the external border, two small tubercles lie between the third lobe and the hypoconid. Although the rest of the teeth are the size of those of *Perchoerus nanus*, or smaller, M_3 is equal in size to M_3 of *P. probus*. The symphysis is long and seems to reach back to P_2; the ramus is thick and sturdy.

The most unusual features of No. 19873 are the shortness of P_3 and the unusual length of M_3 in relation to P_4-M_2, when compared with specimens of *P. probus*, *P. nanus*, and *P. minor* (Table 23). The specimen may be *P. probus*, rather than *P. nanus*, or it may be an unnamed species—a possibility enhanced by the relative sizes of the teeth, especially M_3. The M_1 and M_2 of *P. socialis* (MARSH) from the John Day beds of Oregon are also similar in size to this Whitneyan specimen, but other comparisons are not possible.

FAMILY ANTHRACOTHERIIDAE GILL, 1872

Heptacodon sp.

Referred specimen.—Cedar Creek member (middle): No. 8235; left jaw with P_4-M_3; N½ sec. 5, T. 11 N., R. 54 W., Logan County.

This is the first known occurrence of the genus in northeastern Colorado and seemingly only the second record of a lower jaw. The types for all species of *Heptacodon* are based on upper teeth and skulls, and none have lower jaws. The only other lower jaw known, AMNH No. 1360, was referred to *H. occidentalis* SCOTT by SCOTT (1940, p. 484) because of geological age (lower Brule), but he makes it plain that the jaw could equally well be assigned to *H. curtus* MARSH of the upper Brule. No. 8235 agrees with the description of AMNH No. 1360 in pattern and size, the dimensions of the teeth being, in all cases, within 1 mm. of those given by SCOTT (1940, p. 485).

Anthracotheriid sp.

Referred specimen.—Horsetail Creek member: No. 9788; fragment of upper molar; W½ sec. 16, T. 10 N., R. 51 W., Logan County.

This fragment of tooth is similar to the M^2 of *Bothriodon* but is insufficient to assign it, unequivocally, to this genus.

FAMILY AGRIOCHOERIDAE LEIDY, 1869

Agriochoerus antiquus LEIDY

Agriochoerus antiquus LEIDY, 1850a, p. 122.

Referred specimen.—No. 5029; anterior part of skull with cheek dentition; according to catalogue data this specimen was collected by H. T. MARTIN in northeastern Colorado.

Although the matrix and type of preservation is that seen in northeastern Colorado specimens, the reference of this particular specimen to a Colorado locality must remain in doubt because it was not catalogued by MARTIN personally and was not listed in his field notes. This, in itself, would not be of importance were it not that a second specimen, No. 206, is listed in the Museum records as coming from northeastern Colorado, but its preservation and matrix resembles material from South Dakota much more than from Colorado.

In size and other characters No. 5029 agrees closely with descriptions of *Agriochoerus antiquus*.

No. 206 deserves mention because of its large size. Although the dentition is the size of that in *Agriochoerus antiquus*, the skull has a length from the premaxillary to the occipital condyle that must have exceeded 235 mm. The sagittal crest is well developed; it has a relatively deep depression between the bifurcated anterior ends. The orbital region was probably wide, but the muzzle is narrow as in *A. antiquus*.

Agriochoerus cf. A. ryderanus (COPE)

Referred specimen. — ?Cedar Creek member: No. 112; fragment of left maxillary with M^1-M^3 (M^3 damaged); western Logan County.

Our catalogue states that this specimen was collected by H. T. MARTIN from "Cedar Creek." MARTIN's field notes, and the associated fossils collected on the same day, indicate that the specimen came from the Cedar Creek member somewhere in T. 11 N., R. 55 W., Logan County. It is my opinion that the reference to Cedar Creek by MARTIN did not mean the Cedar Creek member, inasmuch as he generally used letters of the alphabet to indicate horizons. Evidently MARTIN's, and probably MATTHEW's, concept of Cedar Creek was that of the stream draining this area and not the Cedar Creek of today, which lies to the south.

TABLE 24.—Measurements (in mm.) of *Agriochoerus* cf. *A. ryderanus*

	No. 112	No. 4955
Crown length of M^1-M^3	....	35.8
M^1, antero-posterior length	9.6	10.9
M^1, transverse width	10.5	11.7
M^2, antero-posterior length	12.8	12.4
M^2, transverse width	14.1	13.7
M^3, antero-posterior length	14.0[a]	14.3
M^3, transverse width	16.0[a]	17.0

a. Estimate based on badly damaged tooth.

No. 112 has the first molar relatively reduced. Otherwise the teeth do not differ in any respect from those of *Agriochoerus ryderanus*. The dimensions (Table 24) of the upper molars of No. 4955, a skull and associated right ramus of *A. ryderanus* from the John Day formation of Oregon, are given for comparative purposes.

FAMILY MERYCOIDODONTIDAE THORPE, 1923

The use of cranial dimensions and proportions for discriminating the various species and subspecies of *Merycoidodon*, as utilized by BUMP & LOOMIS (1930), THORPE (1937), and SCOTT (1940), was found to be unsatisfactory in studying the specimens from northeastern Colorado.

Using the criteria of size of skull and shape of nasals suggested by COPE (1884, p. 511), the merycoidodont skulls from northeastern Colorado fall into two groups — those of smaller size with the nasals acute posteriorly, *Merycoidodon gracilis;* and those of larger size with the nasals obtuse posteriorly, *Merycoidodon culbertsonii*. However, the specimens of each species show variation that does not permit further separation into subspecies (or additional species) as was done by COPE and others. The groups established by them seemingly represent selected variants of the total population.

Because the exact stratigraphic position is not known, the series of skulls and jaws of *Merycoidodon* from northeastern Colorado collected by H. T. MARTIN for the University of Kansas is not listed under the referred specimens.

Merycoidodon culbertsonii LEIDY

Merycoidodon culbertsonii LEIDY, 1848, p. 47.

Referred specimens.—Horsetail Creek member: No. 8496; left M^3; SE¼ sec. 1, T. 11 N., R. 54 W., Logan County. No. 9108; lower jaws; W½ sec. 29, E½ sec. 30, T. 11 N., R. 53 W., Logan County. No. 9128; lower jaws; NE¼ sec. 31, T. 11 N., R. 56 W., Weld County.

Cedar Creek member: No. 9141; damaged skull; NW¼ sec. 3, T. 11 N., R. 54 W., Logan County.

With the materials at hand it is difficult to recognize the subspecies of *Merycoidodon culbertsonii* by the criterion established by COPE, which does no more than differentiate the specimens with larger teeth [*M. c. culbertsonii* (COPE)] from those with smaller teeth [*M. c. periculorum* (COPE)]. Specimens from the Horsetail and Cedar Creek members show, seemingly, the same vertical range for both size groups, which suggests that selected variants make up the two subspecies. On the other hand, lack of material prevents a final answer to the problem of vertical range, and because it is unsettled there yet remains the possibility that the mean size of *M. culbertsonii* was increasing, with *M. c. periculorum* representing the earlier stage and *M. c. culbertsonii* the later stage. This is not indicated by the limited evidence at hand, but the idea warrants further investigation.

THORPE (1937) thought *M. c. periculorum* to be a small geographic variant or mutant confined mainly to Colorado, and he pointed out that this would not support the view that it could be the female of the more widespread *M. c. culbertsonii*. The contention of BUMP & LOOMIS (1930) that *M. periculorum* is a distinct species is not supported by present evidence. That *M. c. periculorum* represents the smaller individuals of the *M. culbertsonii* population appears to be the best supported possibility at present.

Merycoidodon gracilis (LEIDY)

Oreodon gracilis LEIDY, 1851a, p. 239.
Merycoidodon gracilis, HAY, 1902, p. 666.

Referred specimens.—Horsetail Creek member: No. 9107; fragments of upper and lower jaws; W½ sec. 29, E½ sec. 30, T. 11 N., R. 53 W., Logan County.

Cedar Creek member: No. 9143; skull; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County. No. 9144; damaged skull and jaws; SW¼ sec. 21, T. 11 N., R. 53 W., Logan County. No. 9145; left P^4-M^2; SW¼ sec. 21, T. 11 N., R. 53 W., Logan County. No. 9147; skull; NE¼ sec. 28, T. 11 N., R. 53 W., Logan County.

This species may be recognized by its posteriorly acute nasals and small size of the skull. Some of the specimens have the broad frontals and length of skull that are attributed to *Merycoidodon affinis* LEIDY, but the size of the teeth is within the range of large *M. gracilis*. Like specimens of *Merycoidodon culbertsonii*, these specimens indicate a wide range of variation in size for the species. The specimens from this area which THORPE (1937) referred to *M. affinis* may be the males of *M. gracilis*, but it appears more likely that they are merely large variants of both sexes of *M. gracilis*.

Eporeodon major (LEIDY)

Oreodon major LEIDY, 1854, p. 55.
Eporeodon major, MARSH, 1875, p. 250.

MATTHEW reported (1901, p. 396) *Eporeodon major* as occurring in the Leptauchenia beds of northeastern Colorado. The specimens collected by the American Museum were described as a variety, *E. m.* var. *cedrensis* MATTHEW, because of their consistently smaller size.

No additional identifiable specimens have been found.

Leptauchenia decora LEIDY

Leptauchenia decora LEIDY, 1856, p. 88.

Referred specimens.—Vista member: No. 8497; right P^4-M^1, right M^1-M^3, left P_1-P_2; NE¼ sec. 3, T. 11 N., R. 54 W., Logan County.

MATTHEW (1901, p. 357) referred specimens from Colorado to this species. Our material is too incomplete to do more than make approximate measurements, but these measurements indicate that the specimens agree in size with those of typical *Leptauchenia decora*.

FAMILY CAMELIDAE GRAY, 1821

Eotylopus sp.

Referred specimens.—Horsetail Creek member: No. 8974; left M^1. No. 9116; left M^1-M^3. Both specimens from W½ sec. 9, T. 10 N., R. 51 W., Logan County.

Dr. PAUL O. MCGREW kindly compared the maxillary fragment No. 9116 with the type specimen of *Eotylopus reedi* MATTHEW and assures me that the specimen undoubtedly belongs to the genus. On the other hand, the strong internal cingula of the molars and the prominent internal pillar on M^3 lead Dr. MCGREW to think that the specimen is probably specifically different from *Eotylopus reedi*. Because of Dr. MCGREW's interest in this group, the material is referred to him for further study.

This discovery of *Eotylopus* in late Chadronian beds extends the range of this primitive genus upward and firmly establishes its presence in the Oligocene.

Poëbrotherium wilsoni LEIDY

Poëbrotherium wilsoni LEIDY, 1847, p. 322.

Referred specimens.—Cedar Creek member: Univ. Colorado Mus. No. 19123; skull and jaws; northwest of Sterling, Colorado. No. 9027; right jaw with P_1, P_3-M_3; SW¼ sec. 12, T. 11 N., R. 54 W., Logan County. No. 9028; right jaw with I_1, C-M_3; sec. 28, T. 11 N., R. 53 W., Logan County. No. 9029; right jaw with P_1-M_3; NW¼ sec. 3, T. 11 N., R. 54 W., Logan County. No. 9030; left M_1-M_3; sec. 28, T. 11 N., R. 53 W., Logan County.

This species has been found throughout the Cedar Creek member in numbers almost equal to those of the oreodonts. Considerable variation exists in the depth of the jaws part of which is owing to age and perhaps part to sex. Some variation is seen in the anterior teeth, but the cheek teeth seem remarkably constant. Notable in this respect are Nos. 9027, 9028, and 9029. These three specimens have light jaws, smaller diastemata, and trenchant canines and first premolars, while the cheek teeth are indistinguishable from specimens with larger jaws and caniniform canines and first premolars. Some specimens suggest, and better material may demonstrate, that the shallow jaws with trenchant canines and first premolars grade into the condition seen in the larger specimens of *Poëbrotherium wilsoni*. A possible conclusion is that these are small variants or females of *P. wilsoni*.

Among the specimens collected by H. T. MARTIN in northeastern Colorado are two poorly preserved skulls, Nos. 1 and 190. These two skulls seem to have no, or very small, lacrimal vacuities as compared with other northeastern Colorado specimens, and the depth of the skull is perhaps less than in other specimens.

Poëbrotherium labiatum COPE

Poëbrotherium labiatum COPE, 1881, p. 271.

Type.—AMNH No. 6520; Cedar Creek beds, head of

Cedar Creek, Logan County, Colorado (*fide* COPE & MATTHEW, 1915).

Referred specimen.—?Cedar Creek member (lower): No. 9031; left jaw with C, P_4-M_3; sec. 28, T. 11 N., R. 53 W., Logan County.

This species seems to be confined to the lowest Cedar Creek beds or upper part of the Horsetail Creek member, for nothing of comparable size has been found in higher beds. *Poëbrotherium labiatum* is distinctive in size (Table 25), although of the same general relative proportions as *P. wilsoni*, and there does not seem to be any intergradation between the two species.

The apparent restriction of *Poëbrotherium labiatum* to the lowest part of the Cedar Creek member, whereas the remains of *P. wilsoni* are found throughout the silty phase of the Cedar Creek member, would argue against the possibility of *P. labiatum* being the male of *P. wilsoni*. A ratio of about one specimen of *P. labiatum* to twenty specimens of *P. wilsoni* further suggests that the two kinds are two species instead of different sexes of the same species.

Poëbrotherium sp.

Referred specimens.—Horsetail Creek member: No. 8492; left M^1-M^3; SE¼ sec. 1, T. 10 N., R. 54 W., Logan County. No. 9026; right M^2; N½ sec. 31, T. 11 N., R. 56 W., Weld County. No. 9115; left jaw with P_4-M_3; W½ sec. 9, T. 10 N., R. 51 W., Logan County.

Specimens Nos. 8492 and 9026 and specimens of *Poëbrotherium wilsoni* are closely similar except that the former are smaller and have weaker styles.

No. 9115 has molars smaller than those of *Poëbrotherium wilsoni*, and the heel of M_3 relatively reduced. However, P_4 is relatively large—almost as large as the P_4 of *P. labiatum* (Table 25).

MATTHEW (1901, p. 422) commented upon finding a hind foot of *Poëbrotherium* in the "Titanotherium Beds" that was somewhat longer and about one-fourth heavier than "either" [*P. wilsoni* and *P. labiatum*] of the known species.

Protomeryx campester MATTHEW

Protomeryx campester MATTHEW, 1901, p. 422.

Type.—AMNH No. 8969; Leptauchenia beds, Colorado.
Referred specimen.—?Cedar Creek member: No. 133; mandible; sec. 3, T. 11 N., R. 54 W., Logan County.

Our specimen was found in 1925 by CURTIS HESSE and was recorded in the field notes as coming from "high" in the Orellan beds. On the basis of geographic locality alone it is possible that the specimen came from the Vista member, which is somewhat difficult to recognize at places in Chimney Canyon. Of course, the same statement is equally applicable to the age assignment given to the type specimen by MATTHEW. Our specimen is undoubtedly later than the silty phase of the middle part of the Cedar Creek member.

No. 133 is practically identical to the type in size and proportions.

One feature of *Protomeryx campester*, not mentioned by MATTHEW, is the smaller P_2-P_4/M_1-M_3 ratio as compared with species of *Poëbrotherium*. All the specimens of *Poëbrotherium* from north-

TABLE 25.—Measurements (in mm.) of *Poëbrotherium wilsoni*, *Poëbrotherium labiatum*, and *Poëbrotherium* sp.

	Poëbrotherium sp.			*P. wilsoni*		*P. labiatum*
	No. 8492	No. 9026	No. 9115	No. 9029	No. 19123[a]	No. 9031
Crown length of M^1-M^3	32.4	....	....	....	....	....
P^4, antero-posterior length	7.4	....	....	....	....	....
P^4, transverse width	....[b]	....	....	....	....	....
M^1, antero-posterior length	9.0	....	....	....	....	....
M^1, transverse width	10.4	....	....	....	....	....
M^2, antero-posterior length	11.3	11.5	....	....	....	....
M^2, transverse width	11.4	9.8	....	....	....	....
M^3, antero-posterior length	13.3	....	....	....	....	....
M^3, transverse width	12.1	....	....	....	....	....
Crown length of P_2-M_3	....	....	....	60.0	60.0	....
Crown length of M_1-M_3	....	....	34.2	36.5	35.5	43.5
P_2, antero-posterior length	....	....	....	7.6	7.7	....
P_2, transverse width	....	....	....	2.0	2.5	....
P_3, antero-posterior length	....	....	....	8.1	8.9	....
P_3, transverse width	....	....	....	2.8	3.4	....
P_4, antero-posterior length	....	....	9.5	7.9	8.9	10.0+
P_4, transverse width	....	....	3.8	3.1	4.0	4.7
M_1, antero-posterior length	....	....	9.6	10.7	9.0	11.4
M_1, transverse width	....	....	6.2	6.4	6.4	7.1
M_2, antero-posterior length	....	....	10.5	11.5	11.1	13.4
M_2, transverse width	....	....	7.1	7.3	7.7	8.2
M_3, antero-posterior length	....	....	13.8	14.7	15.9	19.5
M_3, transverse width	....	....	7.0	6.4	7.7	8.3
Depth of ramus at M_2	....	....	13.5	14.7	20.4	21.6

a. University of Colorado Museum.
b. Damaged.

eastern Colorado have a P_2-P_4/M_1-M_3 ratio that falls between 0.66 and 0.68, whereas the referred specimen and type of *P. campester* have a ratio of 0.57.

Attention is directed to a footnote by STOCK (1935, p. 122) in which *Protomeryx cedrensis* MATTHEW (1901) is made a synonym of *Protomeryx campester*.

FAMILY HYPERTRAGULIDAE COPE, 1879

Hypertragulus calcaratus (COPE)

Leptauchenia calcarata COPE, 1873b, p. 7.
Hypertragulus calcaratus, COPE, 1873d, p. 419.

Type.—AMNH No. 6518; Oligocene of northeastern Colorado.

Referred specimens.—Cedar Creek member: No. 9036; upper and lower teeth of several individuals (apparently representing one herd of animals); at boundary between secs. 17-18, T. 11 N., R. 55 W., Logan County.

Hypertragulus calcaratus is confined to the Cedar Creek member in northeastern Colorado. No noticeable differences were found in the specimens from the various levels.

Leptomeryx esulcatus COPE

Leptomeryx esulcatus COPE, 1889a, p. 154.

Referred specimens.—Horsetail Creek member: No. 9104; left P^2-M^2 and left P_2-M_3; W½ sec. 29, E½ sec. 30, T. 11 N., R. 53 W., Logan County.

Cedar Creek member (middle): No. 8998; right jaw with P_2-M_3; W½ sec. 7, T. 11 N., R. 53 W., Logan County.

MATTHEW (1903, p. 223) and CLARK (1937, p. 323) discussed P_3 of this species and pointed out that the internal ridge is connected with the heel in this species as opposed to the condition in *Leptomeryx evansi* where the external ridge connects with the heel. This is the only constant character that distinguishes the two species. MATTHEW thought the average size of *L. esulcatus* was greater, which may be true, but the specimens from northeastern Colorado seen by me have a size range similar to that of *L. evansi*, and it is doubtful if the average size is much different.

Specimens of *Leptomeryx* are not rare in the Chadronian beds of northeastern Colorado, but few have P_3 present, so that it cannot be determined whether *L. esulcatus* is the only member of the genus present in the Horsetail Creek beds.

Leptomeryx evansi LEIDY

Leptomeryx evansi LEIDY, 1853, p. 394.

Referred specimens.—Cedar Creek member: No. 9034; right P^2-M^3, P_3-M_3, left P^4-M^3, P_3-M_3 (in occlusion); at boundary between secs. 17-18, T. 11 N., R. 55 W., Logan County.

Vista member: No. 9013; left P^4-M^2; NE¼ sec. 17, T. 11 N., R. 53 W., Logan County.

No. 9034 is one of the largest of several hundred specimens of this species which I collected in northeastern Colorado. No. 9013 is slightly smaller, but otherwise similar to other specimens of this species.

Leptomeryx sp. (Small form)

Referred specimen.—Cedar Creek member: No. 9035; left M^1-M^3; center sec. 3, T. 11 N., R. 54 W., Logan County.

No. 9035 has an M^1-M^3 length of 16 mm. as compared with a length of 20.7 mm. in the specimen (No. 9034) referred to *Leptomeryx evansi*. In addition, this small specimen lacks the strong tubercle that is seen at the base of the postero-internal lobe of the molars in *L. evansi*, and the M^1 is relatively much smaller.

That there is a species of *Leptomeryx* smaller than *L. evansi* or *L. esulcatus* in the Cedar Creek member seems rather certain, but until enough material is collected to allow positive correlation of differences in occlusal pattern and in premolar and molar sizes, and to permit determination of the range of variation, this small species must remain undescribed. Perhaps this small species was the one MATTHEW (1902c, p. 314) had in mind when he mentioned a small, undescribed form from the Leptauchenia beds of northeastern Colorado.

Hypisodus minimus (COPE)

Leptauchenia minima COPE, 1873b, p. 8.
Hypisodus minimus, COPE, 1873d, p. 419.

Type.—AMNH No. 6543; Oligocene, northeastern Colorado.

Referred specimens. — Cedar Creek member (lower and middle): No. 8281; right and left P^4-M^3; SE¼ sec. 21, T. 11 N., R. 53 W., Logan County. No. 9040; associated upper and lower cheek teeth; locality same as No. 8281.

I have collected specimens of this species from all levels of the Cedar Creek member up to within 100 feet of the top of the beds. No. 9130 from the upper part of the Horsetail Creek member may be referable to this species.

In dental pattern these specimens correspond in general with the description given by SCOTT (1940, pp. 533-535), but the range in size includes specimens which are smaller than those indicated by his measurements, although none are as small as comparable teeth of *Hypisodus alcer* TROXELL. Another point of difference from SCOTT's description concerns P_2. Judged by the presence of alveoli in the Cedar Creek specimens, only one has a diastema between P_2 and P_3, whereas three do not; P_2 is not shed early in life, if at all, and was double rooted.

Of great interest is the rate of growth seen in the series of lower jaws and maxillaries. Apparently the permanent dentition was erupted before the jaws and skull attained full development, and M_1 was developing roots before the last deciduous tooth was shed. No upper or lower teeth were observed which did not have, at least, incipient roots—a statement also applicable to the Chadronian and Whitneyan species from northeastern Colorado. These observations are not wholly in

TABLE 26.—Measurements (in mm.) of *Hypisodus* sp. (Form A)[a]

			No. 8271		
Crown length of M^1-M^3	....	....	....	....	12.1
M^1, antero-posterior length	....	....	....	....	4.0
M^1, transverse width	....	....	....	....	2.9
M^2, antero-posterior length	....	....	....	....	4.35
M^2, transverse width	....	....	....	....	2.6
M^3, antero-posterior length	....	....	....	....	4.5
M^3, transverse width	....	....	....	....	2.3
Crown length of M_1-M_3	....	....	....	....	12.8
M_1, antero-posterior length	3.6	3.7	3.5	....	3.4
M_1, transverse width	2.1	....	2.2	....	2.1
M_2, antero-posterior length	....	4.3	3.7	....	3.8
M_2, transverse width	....	....	2.3	....	2.5
M_3, antero-posterior length	....	....	....	5.9	5.6
M_3, transverse width	....	....	....	2.3	2.15

a. The measurements are arranged so that the youngest specimen is at the left, and the oldest at the right of the table. All measurements were made at the occlusal surface. The transverse measurements of the upper molars were made from the antero-internal crescent to the external rib.

agreement with those of SCOTT, who thought that roots were developed in the molars only in old age. In my opinion, much could be gained by a study of the teeth of this genus with a view toward correlating growth of the skull, root development, tooth pattern, tooth size, and geological age. Comparisons already made between specimens from the Horsetail Creek and Cedar Creek members indicate possibilities in this study.

Hypisodus sp. (Form A)

Referred specimens.—Horsetail Creek member. No. 8271; five partial lower jaws containing one to three molars, and a left maxillary with P^4-M^3; NE¼ sec. 31, T. 11 N., R. 56 W., Weld County. No. 8285; left M_3; SE¼ sec. 1, T. 10 N., R. 54 W., Logan County. No. 8286; right M_3; W½ sec. 9, T. 10 N., R. 51 W., Logan County. No. 8973; left P^4-M^3; W½ sec. 9, T. 10 N., R. 51 W., Logan County. No. 9110; left M_2-M_3; W½ sec. 29, E½ sec. 30, T. 11 N., R. 53 W., Logan County.

?Horsetail Creek member: No. 8269; right maxillary fragment with M^1-M^3, and left lower M_3 (not associated); SE¼ sec. 17, T. 11 N., R. 65 W., Weld County.

Although the occurrence of *Hypisodus* in Chadronian beds is surprising, it is not entirely unexpected. The discoveries of CLARK (1937), and the stratigraphic position of some of the fossils in northeastern Colorado have already indicated that a large part of the fauna once thought to be restricted to Orellan beds also lived in Chadronian times.

Noteworthy characteristics of the teeth compared to those of *Hypisodus minimus* are: well-developed parastyle and rib on the antero-external crescent of all the molars; equally well-developed metastyle on the third molar; shorter crowns; and larger size (Table 26).

Hypisodus sp. (Form B)

Referred specimens.—Upper 40 feet of Cedar Creek member, and Vista member: No. 9037; right P_4-M_3; SW¼ sec. 2, T. 11 N., R. 54 W., Logan County. No. 9038; left M^3; sec. 22, T. 11 N., R. 52 W., Logan County. No. 9039; left P_4-M_2; E½ sec. 12, T. 11 N., R. 54 W., Logan County.

These teeth are large like those described from the Chadronian beds, but they lack the strongly developed styles. In size, they approach *Hypisodus* sp. (from the "Uppermost Brule" of E. Nebraska) mentioned by SCOTT (1940, p. 535).

THE MIOCENE FAUNA

Relatively little Miocene material was collected by me in northeastern Colorado and much of that which was collected adds nothing new to a knowledge of the species other than to clarify the stratigraphic position of some.[25]

Four species from the Marsh Collection at Yale University—*Proheteromys parvus, Nothocyon vulpinus, Mesocyon robustus,* and *Pseudaelurus marshi* —are listed, but it should be kept in mind that these specimens may not be from northeastern Colorado.

CLASS **OSTEICHTHYES**

Teleostean, sp. indet.

Referred specimen.—Pawnee Creek formation (Eubanks local fauna): No. 9252; maxillary; NE¼ sec. 1, T. 10 N., R. 59 W., Weld County.

This bone is damaged, but it is similar to the maxillary of a carp.

CLASS **REPTILIA**

ORDER **TESTUDINES** BATSCH, 1788

FAMILY **TESTUDINIDAE** GRAY, 1825

Testudo osborniana HAY

Testudo osborniana HAY, 1904, p. 504.

Type.—AMNH No. 5868; Pawnee Creek beds, northeastern Colorado.

25. Subsequent to the writing of this paper, a considerable number of Miocene specimens were collected. These are being prepared for study and should answer some of the questions posed in the faunal discussion and in the following pages.

Gopherus pansa (HAY)

Testudo pansa HAY, 1908, p. 420.
Gopherus pansa, WILLIAMS, 1950, p. 26.

Type.—AMNH No. 5869; Pawnee Creek beds, northeastern Colorado.

Specimens that approach the size of *Testudo osborniana* or *Gopherus pansa* have been found by me in bed No. 5 of measured section XIV in the Pawnee Creek formation at Martin Canyon. Smaller specimens of *Testudo* or *Gopherus* have been found in beds containing *Ustatochoerus* and *Merychippus* west of Sand Canyon.

CLASS AVES

Passerine, sp. indet.

Referred specimen.—Pawnee Creek formation (Martin Canyon local fauna): No. 9831; distal end of left tarsometatarsus; Quarry A, Martin Canyon, NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

CLASS MAMMALIA

ORDER INSECTIVORA BOWDICH, 1821

FAMILY ERINACEIDAE BONAPARTE, 1838

Brachyerix spp.

Referred specimens.—Pawnee Creek formation (Martin Canyon local fauna): No. 9358; outer half of left M^1; NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.
Pawnee Creek formation (Kennesaw local fauna): No. 9175; left M^1 in fragment of maxillary; SW¼ sec. 26, T. 12 N., R. 55 W., Logan County.

These specimens have been referred to the genus *Brachyerix* but because of their large size they probably are not referable to *Brachyerix macrotis* MATTHEW.

Only the outer half of No. 9358 is preserved and it shows a low, rounded paracone and metacone with the cingulum and styles having about the same degree of development as in *Brachyerix macrotis.*

No. 9175 is less worn than the corresponding tooth in *Brachyerix macrotis* and shows the four principal cusps to be sharp pointed with the paracone highest. The cingulum is absent except for the parastyle and metastyle which show greater development than in *B. macrotis* or No. 9358. The zygomatic arch is lighter than the arch in *B. macrotis* but occupies a position similar to that in *Brachyerix;* that is to say, the arch arises opposite M^1 and not farther back as in *Erinaceus europaeus.* Dimensions of No. 9175 are: length (parastyle to metastyle)—4.6 mm.; length (protocone to hypocone)—3.7 mm.; greatest width (protocone to parastyle)—4.5 mm.

Comparison of No. 9175 with the M^1 of *Erinaceus* shows the teeth to be similar in pattern and size except for the more reduced cingulum on No. 9175. The tooth is much larger than M^1 of *Parvericus montanus* KOERNER, and it is difficult to determine how much difference in pattern exists without comparison of the actual specimens. Differences between this tooth and M^1 in the type of *Metechinus nevadensis* MATTHEW are seen in the less concave borders and more quadrate shape of the former. Because of these differences, the tooth was referred to *Brachyerix* rather than to *Metechinus.*

FAMILY SORICIDAE GRAY, 1821

Soricid, ?n. gen. and sp.

Referred specimens.—Pawnee Creek formation (Martin Canyon local fauna): No. 9280; right 1st, 2nd, and 3rd upper teeth in fragment of bone. No. 9281; left upper incisor. No. 9282; posterior part of right jaw. No. 9341; fragment of left lower incisor. NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

These specimens were collected from Quarry A and are considered, tentatively, to be individuals of one species. If this be true, the soricid is an unusual and unnamed kind. It is left unnamed pending further exploration of the deposit.

The base of the first upper tooth overlaps the bone and has a basal cuspule as in other soricids. The tooth broadens anteriorly where a cuspule on the inner edge forms a second and smaller prong alongside the pointed principal cusp, thus producing a rather inefficient chisel-like cutting edge. The root of this tooth is deeply grooved on the inner surface, giving the impression of fused roots.

The second upper tooth is relatively broad, with the principal cusp close to the outer border. Two small cusps on the inner border form a "protocone" and a "hypocone," the first being united to the principal cusp by a ridge. Together these structures and the encircling cingulum make an incipient basin in the postero-internal part of the tooth.

The third upper tooth is relatively small but has a well-formed heel.

The posterior part of the lower incisor does not differ basically from the lower incisors of other soricoids: the upper surface is flattend and bordered by ridges; the sides converge below to give the tooth a roughly triangular shape; and the enamel is thick and rugose.

None of the teeth fluoresce under ultraviolet light.

No. 9282, the lower jaw fragment, does not have any part of the horizontal ramus preserved, but the broken edge of the fragment suggests that the missing part was shallow and weak. The coronoid process is narrow antero-posteriorly and rounded at the tip. No intertemporal fossa is present. The angular process is damaged. The condyle is undivided, and the supero-internal border is more concave than in similar structures of *Crocidura.* The neck of the condyle is short.

Without question these fragments (if associated) represent a new genus and species but do not suggest the affinities of the animal with other shrews. The undivided condyle and type of reduction seen in the first three upper teeth suggest a crocidurine shrew, whereas the lack of an intertemporal fossa is a character found only in *Heterosorex delphinensis* GAILLARD (middle Miocene, Europe), considered to be a soricine shrew.

FAMILY TALPIDAE GRAY, 1825

Talpid sp.

Referred specimen.—Pawnee Creek formation (Martin Canyon local fauna): No. 9359; left M_1 or M_2; NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

This tooth, belonging to a large talpid, has well-developed cingula on its anterior and posterior faces and between the protoconid and hypoconid. A small ectostylid is present, anterior to the entoconid. The paraconid is compressed and close to the metaconid. The antero-posterior length of the tooth is 3.2 mm., or 2.6 mm. exclusive of the anterior and posterior cingula, and 2.4 mm. wide.

This specimen, although larger and proportionately wider, represents a species that could well be the structural ancestor of *Hesperoscalops* HIBBARD, which differs principally in having higher crowned teeth and more reduced anterior and posterior cingula.

Cf. Condylura

Referred specimens.—Pawnee Creek formation (Kennesaw local fauna): Nos. 9840-9841; left humerii; W½ sec. 26, T. 12 N., R. 55 W., Logan County. No. 9842; right humerus; SW¼ sec. 26, T. 12 N., R. 55 W., Logan County.

Pawnee Creek formation (Vim-Peetz local fauna): No. 9843; left humerus; W½ sec. 28, T. 12 N., R. 55 W., Logan County.

Nos. 9840 and 9841 compliment each other in respect to missing parts. Both specimens represent the same species and differ from the humerus of *Condylura cristata* in having the shaft slightly wider and heavier. The length of No. 9840 is 13.25 mm., which is 0.5 mm. longer than the humerus of a specimen of *Condylura cristata* from Michigan.

Nos. 9842 and 9843 possibly represent a second species of the genus represented by Nos. 9840 and 9841. Although both specimens lack the proximal articular surfaces, they seem to be shorter than the humerus of *Condylura cristata.* The shaft is intermediate in width and thickness between the sizes of the shaft of *C. cristata* and Nos. 9840 and 9841.

ORDER LAGOMORPHA BRANDT, 1855

FAMILY OCHOTONIDAE THOMAS, 1897

Oreolagus nr. O. nebrascensis MCGREW

Figure 23

Referred specimens.—Pawnee Creek formation (Martin Canyon local fauna): Nos. 9285, 9335-9337; lower cheek teeth. Nos. 9338-9339; upper incisors. No. 9356; right P^3. No. 9286; right ?M^1. No. 9340; upper deciduous molar. No. 9287; left jaw with I, P_4-M_1. No. 9815; right jaw with P_4-M_1. No. 9829; right P_3. All specimens from NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

These specimens closely resemble *Oreolagus nebrascensis* in the following characters: the size is about the same (Table 27); the diastema is shorter than the cheek tooth row; the masseteric scar is faint and extends to a point below the posterior pillar of M_2; the anterior mental foramen is anterior to P_3; the posterior mental foramen is below M_1; and P_4, M_1, and M_2 are similar in pattern to those described by MCGREW. Despite the absence of P_3, the alveolus of No. 9287 shows that the tooth was approximately as long as it was wide. A small ridge of bone on the antero-external corner of the alveolus suggests that P_3 had only one fold like that seen in *Oreolagus*—a supposition supported by No. 9829, an isolated right P_3 from Quarry A that has a single fold (Fig. 23, *B*) and, presumably, belongs to this species. The incisor is missing from the type of *O. nebrascensis*, but MCGREW (1941a, p. 38), basing his judgment upon the alveolus, described the upper surface of the incisor as evenly rounded. In No. 9287, the incisor is flat on the internal surface (Fig. 23, *C*), is roughly triangular in shape, and extends back to a point below P_4.

In addition to the jaws found in Quarry A several isolated first and second lower molars were collected, which are listed with the referred specimens. The occlusal patterns of these isolated molars and those of the teeth of Nos. 9287 and 9815 resemble the patterns figured by MCGREW for the holotype of *Oreolagus nebrascensis*, with the exception of their having a greater concavity to the antero-external surface of the anterior pillar. In this one feature the molars from Martin Canyon resemble the teeth of *O. nevadensis* (KELLOGG). This may well be an individual age character, however. At no place along the axis of the teeth do the antero-posterior and transverse dimensions vary more than 0.1 mm. The dimensions of these isolated teeth reflect the one probably significant difference between these teeth and those of the type of *O. nebrascensis* — relatively greater antero-posterior length.

Assignment of the upper teeth found in Quarry A to the species represented by the lower jaws must remain tentative, although the association appears valid. The upper incisor (Fig. 23, *F*) has a groove similar to that seen in *Ochotona*. P^3 has the antero-external part of the tooth reduced, as in *Ochotona*, and the anterior arm of the crescent opens upon the grooved antero-external surface. The hypostria is continuous to the bottom of the root and is partly filled with cement. The permanent upper molar, No. 9286, is probably an M^1. The occlusal pattern of this tooth (Fig. 23, *E*) shows the hypostria to be deep, partly filled with cement, and, like the external groove, continuous to the bottom of the tooth. A faint trace of a small, J-shaped, crescentic valley is present which has its inner end posterior to the apex of the hypostria. The protocone and hypocone have sharp inner borders like those on the teeth of *Ochotona*. No. 9286 is smaller but resembles in pattern the specimen from the late Miocene of Oregon referred to *Oreolagus*(?), n. sp. by WALLACE (1946, p. 125). The tooth is well advanced in development over the upper teeth of *Amphilagus antiquus* POMEL, as figured by VIRET (1929, fig. 12), in that the hypostria is deeper and the tooth more hypsodont. The tooth is also well advanced beyond the condition seen in *Desmatolagus*, which was suggested by MCGREW (1941a) as an ancestor to *Oreolagus*, but nothing in the structure of this one tooth prevents it from being derived from the type of tooth seen in *Desmatolagus*.

The importance of these specimens is dependent upon their belonging to the same species. If the association is valid and the material belongs to *Oreolagus*, it gives us additional knowledge of the upper teeth and indicates the relationship of this genus to the ochotonids—a point of doubt. The type of groove in the upper incisor, and the sharp edges of the inner cusps of the upper molar resemble the corresponding structures in *Ochotona*. However, these are not strictly diagnostic characters that may be used to assign the material to the Ochotonidae, although the specimens do not resemble the known Miocene leporids. Probably of more importance in indicating the relationship of this genus is the comparison of the Martin Canyon material with the specimens reported by WALLACE (1946). As will be recalled, prior to 1946 the genus *Oreolagus* was known by lower jaws whose characteristics suggested ochotonid affinities. In 1946 WALLACE reported the discovery of a maxillary with P^3-M^2 which had several ochotonid features, and a ramus with M_1-M_2 that resembled those of *Oreolagus*. Presumably not enough of the ramus was preserved to assign unequivocally the specimen to that genus. However, concerning these specimens WILSON (1949a, p. 56) commented: "If the genus

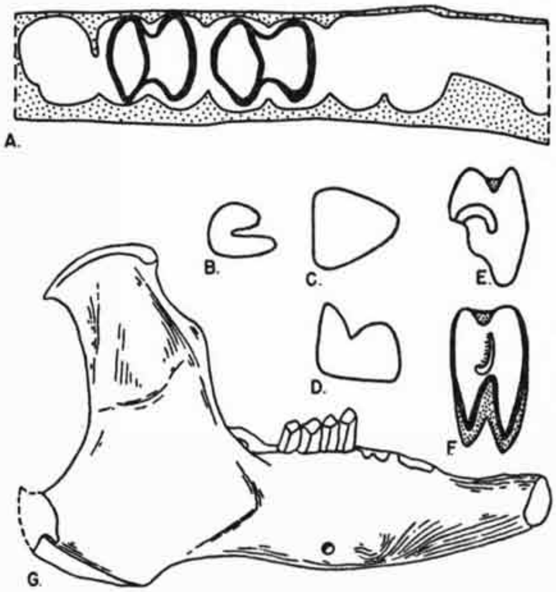


FIGURE 23.—*Oreolagus* nr. *O. nebrascensis*. (*A*) Dorsal view of left ramus of No. 9287 showing alveolus of P_3, occlusal pattern of P_4-M_1, alveolus of M_2, and mandibular foramen. (*B*) Occlusal pattern of right P_3 No. 9829. (*C*) Cross section of left lower I No. 9287 at alveolus. (*D*) Cross section of left upper I No. 9338 at alveolus. (*E*) Occlusal pattern of right P^3 No. 9356. (*F*) Occlusal pattern of right ?M^1 No. 9286 (external border reconstructed). (*G*) External view of right jaw No. 9815 with P_4-M_1. *A-F*, approximately × 6.8; *G*, approximately × 2.5.

TABLE 27.—Measurements (in mm.) of *Oreolagus* nr. *O. nebrascensis*

	No. 9338	No. 9339	No. 9356	No. 9286	No. 9340
I, transverse width	1.56	1.30	....	....	....
P^3, antero-posterior length	....	....	1.47	....	....
P^3, transverse width	....	....	2.20	....	....
?M^1, antero-posterior length	....	....	....	1.50	....
?M^1, transverse width	....	....	....	2.30	....
dM, antero-posterior length	....	....	....	....	1.30
dM, transverse width	....	....	....	....	2.40

	No. 9287	No. 9335	No. 9336	No. 9337	No. 9285	No. 9815	No. 9829
Alveolar length of P_3-M_2	7.85	....	....	....	....	....	....
I, transverse width at alveolus	1.59	....	....	....	....	....	....
P_3, antero-posterior length of alveolus	1.50	....	....	....	....	....	....
P_3, transverse width of alveolus	1.57	....	....	....	....	....	....
P_3, antero-posterior length	....	....	....	....	....	....	1.07
P_3, transverse width	....	....	....	....	....	....	1.30
P_4, antero-posterior length	1.65	....	....	....	....	....	....
P_4, transverse width	1.65	....	....	....	....	....	....
M_1, antero-posterior length	1.80	....	....	....	....	1.86	....
M_1, transverse width	1.75	....	....	....	....	1.88	....
M_2, antero-posterior length	....	....	....	....	....	1.83	....
M_2, transverse width	....	....	....	....	....	1.82	....
M_1 or M_2, antero-posterior length	....	1.89	1.90	1.80	1.85	....	....
M_1 or M_2, transverse width	....	2.00	1.80	1.70	1.72	....	....
Depth of ramus at M_2	6.50	....	....	....	....	6.35	....

represented at Beatty Buttes is properly assigned to *Oreolagus*, the question of ochotonid affinities for the latter may be solved." It seems that the upper and lower teeth from Martin Canyon are at least generically similar to those from Beatty Buttes. This would indicate that the teeth from Beatty Buttes belonged to *Oreolagus* and that the association of the upper and lower teeth from Martin Canyon is valid—a conclusion not as circuitous as it seems when one considers that no other lagomorphs are known from either fauna, and that the chances of the association of the upper teeth of one genus with the lower teeth of a second genus in both faunas would be a coincidence that appears rather remote. This association is further substantiated by the *Oreolagus* material (mentioned in the discussion of the Martin Canyon local fauna) from southeastern Fremont County, Wyoming, in beds equivalent to the "lower Snake Creek." These specimens consist of two upper third premolars like those from Martin Canyon and a lower third premolar referable to *Oreolagus*.

I think that the argument for assignment of *Oreolagus* to the Ochotonidae is strengthened to the point where *Oreolagus* may be referred to that family. The upper incisors and molars from Quarry A in Martin Canyon are similar to those of *Ochotona* and are the only lagomorph remains that have been found in the quarry along with the lower jaws of *Oreolagus*. The similarity of these specimens to those from other faunas shows that the association is not fortuitous.

Until the range of variation of *Oreolagus nebrascensis* is known, it is thought best not to consider the material from Martin Canyon as conspecific with the type. The fact that most of the lower teeth are longer than wide, whereas *O. nebrascensis* has teeth wider than long, may or may not be significant. This may be an individual variation, as is suggested by the one tooth from Martin Canyon that is wider than long and by P_4 of No. 9287 which has the length equal to the width.

FAMILY LEPORIDAE GRAY, 1821

Hypolagus sp.

Referred specimen. — Pawnee Creek formation (Vim-Peetz local fauna): No. 9805; proximal end of left femur; NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

ORDER RODENTIA BOWDICH, 1821

FAMILY MYLAGAULIDAE COPE, 1881

Mesogaulus paniensis (MATTHEW)

Figure 24

Mylagaulus paniensis MATTHEW, 1902b, p. 299.

Mesogaulus paniensis, COOK & GREGORY, 1941, p. 551.

Type.—AMNH No. 9361; base of Loup Fork beds (Pawnee Creek beds), Courthouse Butte, near Pawnee Buttes, Colorado.

Referred specimens.—Pawnee Creek formation (Martin Canyon local fauna): No. 9197; right P_4. No. 9292; left P^4. No. 9293; left P_4. No. 9294; left M_2. No. 9364; left P_4. No. 9370; left P_4. All specimens from NE¼ sec. 27, T. 11 N., R. 53 W., Logan County. No. 160; anterior part of skull, and lower jaws; northeastern Colorado.

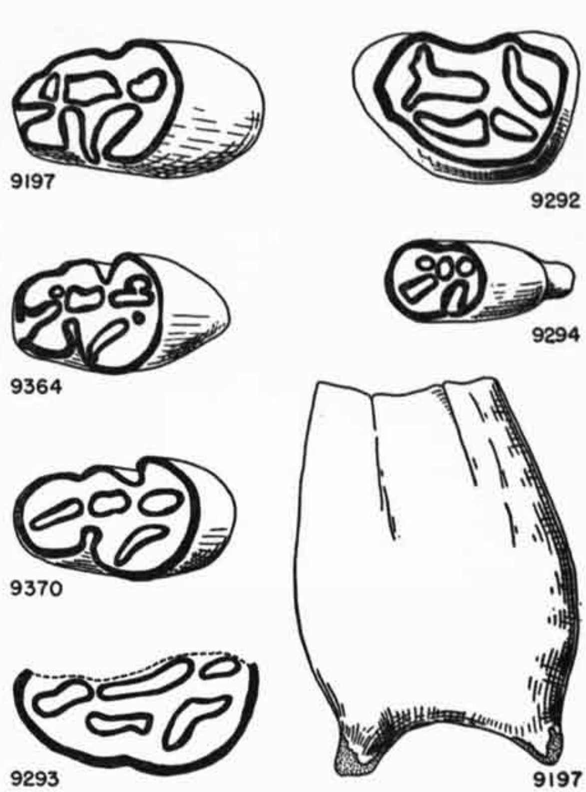


FIGURE 24.—*Mesogaulus paniensis* (MATTHEW). Occlusal patterns of Nos. 9197, right P_4 (reversed); 9292, left P^4; 9293, left P_4; 9294, left M_2; 9364, left P_4; 9370, left P^4; and internal view of No. 9197. The lower premolars are arranged vertically with the youngest at the top, and the oldest at the bottom. Approximately × 4.

Reference of these teeth and the skull to *Mesogaulus paniensis* is based on size of the teeth and similarity of occlusal pattern.

The crowns of all the teeth tend to be plump and bulbous, and the roots are small. Some of the teeth have traces of cement, reported to be absent on the type specimen. On the basis of occlusal pattern, antero-posterior length of occlusal surface, and depth of crown, the four lower premolars range in individual age from No. 9197, the youngest, through Nos. 9364 and 9370 to No. 9293, the oldest. This series gives a good picture of the development and loss of lakes in P_4 (Fig. 24). P^4, No. 9292, belonged to an old individual, as indicated by the occlusal pattern, yet there remains a considerable amount of crown—suggesting that the tooth was more hypsodont than P^4 in *Mesogaulus praecursor* COOK & GREGORY. No. 9294 is considered to be an M_2 on the basis of the angle of occlusal wear, size, presence of a pressure facet on the anterior face,

TABLE 28.—Measurements (in mm.) of *Mesogaulus paniensis*

	P_4, No. 9197	P_4, No. 9364	P_4, No. 9370	P_4, No. 9293	P^4, No. 9292	M_2, No. 9294
Antero-posterior occlusal length	5.1	5.1	5.9	8.2	6.5	3.2
Maximum antero-posterior length	8.6	7.0	8.3	8.2	6.7	3.6
Occlusal surface to notch between roots	9.9	8.2	8.1	6.0	....	....
Occlusal surface to tip of roots	11.7	10.7	10.7	8.8	10.3	....
Maximum transverse width	4.3	4.1	4.1	4.2	5.7	2.75

shape of tooth, and similarity to the M_2 in No. 160. The measurements in Table 28 show the changes in proportion of P_4 that take place with wear. Compared with a closely related species, *Mesogaulus praecursor*, *M. paniensis* shows an increase in size and hypsodonty and a simplification of the occlusal pattern in an earlier, or total, loss of some of the smaller lakes.

No. 160 consists of the damaged anterior part of the skull with left I, P^3-P^4, and right P^4 preserved. In size and proportions this specimen resembles the skull of *Mesogaulus vetus* more than that of *Mylagaulus laevis*. The lower jaws lack the posterior parts, but the dentition is complete except for the right M_2. There is no definite record of the locality or level in northeastern Colorado from which this specimen was collected. The appearance of the matrix and the preservation of the bone is similar to that of specimens of the Martin Canyon fauna collected from the nodular silts (horizon D of MATTHEW) at Martin Canyon. T. M. STOUT, of the University of Nebraska, has completed a study of this specimen in conjunction with his work on the mylagaulids and will present a detailed description and discussion of the material.

Ceratogaulus rhinocerus MATTHEW

Ceratogaulus rhinocerus MATTHEW, 1902b, p. 299.

Type.—AMNH No. 9456; Loup Fork (Pawnee Creek beds) of Colorado.

Mylagaulus laevis MATTHEW

Mylagaulus laevis MATTHEW, 1902b, p. 298.

Type.—AMNH No. 9043; Loup Fork (Pawnee Creek beds) Cedar Creek, Logan County, Colorado.

Referred specimens.—Pawnee Creek formation (Kennesaw local fauna): No. 9154; left P^4; W½ sec. 27, T. 12 N., R. 55 W., Logan County. No. 9155; right P_4; W½ sec. 27, T. 12 N., R. 55 W., Logan County. No. 9174; left P_4-M_2; SW¼ sec. 26, T. 12 N., R. 55 W., Logan County. No. 9808; damaged skull, lower jaws, and postcranial skeleton; SW¼ sec. 26, T. 12 N., R. 55 W., Logan County. No. 9807; anterior part of skull without cheek teeth; W½ sec. 27, T. 12 N., R. 55 W., Logan County.

No. 9807 is of more than usual interest because of the slight callosity appearing on the anterior one-half of each nasal bone.

Mylagaulus sp.

Referred specimens.—Pawnee Creek formation (Vim-Peetz local fauna): No. 9267; right P_4; E½ sec. 28, T. 12 N., R. 55 W., Logan County. No. 9801; right and left P^4; W½ sec. 28, T. 12 N., R. 55 W., Logan County.

No. 9267 is a relatively unworn specimen and is larger than any of the teeth referred to *Mylagaulus laevis* (Table 29). The occlusal pattern of this specimen is the same as that figured by GAZIN (1932, pl. 6, fig. 5, upper right specimen), who comments that the specimens from Skull Spring are larger than the type of *Mylagaulus laevis*. No. 9267 seems to be approximately the same size as the specimens from Skull Spring.

TABLE 29.—Measurements (in mm.) of *Mylagaulus* sp.

	No. 9267
P_4, maximum antero-posterior length	11.2
P_4, antero-posterior length of occlusal surface	6.0
P_4, maximum transverse width	5.4
P_4, maximum crown depth	14.9

FAMILY SCIURIDAE GRAY, 1821

Sciurus sp.

Figure 25

Referred specimen.—Pawnee Creek formation (Martin Canyon local fauna): No. 9290; right jaw with P_4, M_2-M_3; NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

This specimen is referred to *Sciurus* (*s. l.*) in order to emphasize its similarity to the jaws of tree squirrels. The tooth pattern bears features common to those of chipmunks, tree squirrels, and ground squirrels; but the brachyodont cheek teeth, narrow incisor, deep and heavy ramus, short diastema, and large inferior pterygoid fossa suggest a closer relationship to the tree squirrels than to the other groups.

Figure 25 shows most of the features discernible on this specimen, and the reconstructed parts are added primarily to prevent any misinterpretation of the figure. The masseteric fossa ends anteriorly below P_4 and is well defined ventrally by a sharp ridge. However, the upper border is poorly defined. The anterior tip of the fossa encloses a roughened area, which is less depressed than the remainder of the fossa. Table 30 gives the dimensions of this specimen.

P_4 has the protoconid and metaconid almost equal in development, set close together, and only slightly

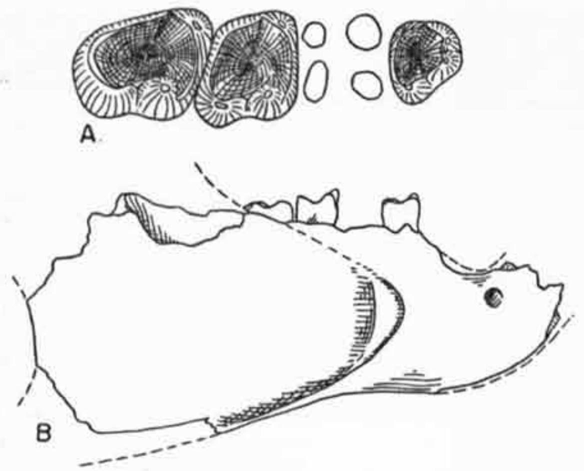


FIGURE 25.—*Sciurus* sp. No. 9290. (*A*) Occlusal view of right P_4, M_2-M_3. Approximately $\times$ 7.5. (*B*) External view of right jaw with teeth. Approximately $\times$ 3.4.

higher than the hypoconid. No anteroconid is present. The hypoconid is large and swollen, united to the protoconid by a weak (practically divided) ectolophid, and united to the entoconid by a posterolophid. A metastylid is present on the side of the metaconid and is separated from the entoconid by a notch.

M_2 is roughly quadrate in shape, with the entoconid angle more rounded and reduced than are the other corners. The metaconid is well developed and the highest of the cusps, and it has a strong anterolophid extending across the face of the tooth. The protoconid and hypoconid are of approximately equal development and are connected by a weak ectolophid bearing a small mesoconid. An incomplete metalophulid II extends into the basin of the tooth and fails to reach the metaconid. A posterolophid unites with the weak, but distinct, entoconid. The metastylid is separated from the metaconid by a notch deeper than that which separates the structure from the entoconid.

M_3, like M_2, has the metaconid highest. The anterolophid is thick and heavy. The protoconid is similar to the protoconid of M_2 in size, but smaller

TABLE 30.—Measurements (in mm.) of *Sciurus* sp.

	No. 9290
Crown length of P_4-M_3	6.70
I, antero-posterior length at diastema	2.71
I, transverse width at diastema	1.32
P_4, antero-posterior length	1.37
P_4, transverse width of anterior lophid	1.00
P_4, transverse width of posterior lophid	1.37
M_2, antero-posterior length	1.65
M_2, transverse width	1.98
M_3, antero-posterior length	2.40
M_3, transverse width	1.95
Depth of ramus at P_4	6.40

7—3493

than the hypoconid of M_3. The metalophulid II is weaker than the arm on M_2. The ectolophid is weak, but the mesoconid is better developed on this tooth than on M_2. The hypoconid is large and inflated, this swollen condition continuing along the posterolophid to the entoconid, which is not discernible as more than a swelling on the rim of the basin. The metastylid is poorly developed and separated from the metaconid and entoconid by notches of equal size.

Sciurid sp.

Referred specimens.—Pawnee Creek formation (Martin Canyon local fauna): No. 9291; fragments of right and left lower incisors (not associated); NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

The narrow and deep incisors (Table 31) suggest a sciurid, larger than *Sciurus niger* and more closely related to the tree squirrels than to other sciurids.

TABLE 31.—Measurements (in mm.) of Sciurid sp.

	No. 9291 Right incisor	Left incisor
Antero-posterior length	4.35	4.20
Transverse width	2.10	2.00

FAMILY HETEROMYIDAE ALLEN & CHAPMAN, 1893

Proheteromys parvus (TROXELL)

Diplolophus parvus TROXELL, 1923, p. 158.
Proheteromys parvus, WOOD, A. E., 1935, p. 170.

Type.—Yale Univ., Peabody Mus. Nat. Hist. No. 10362; ?Miocene of northeastern Colorado (*fide* WOOD, A. E., 1935).

Unfortunately, the type of this species does not have a reliable locality or age record. WOOD (1935, p. 171) discussed this problem and concluded that TROXELL's age assignment of middle Oligocene was incorrect.

Proheteromys spp.

Referred specimens.—Pawnee Creek formation (Martin Canyon local fauna): No. 9288; fragment of right jaw with P_4-M_1. No. 9289; left ?M^2. Both specimens from Quarry A, NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

Pawnee Creek formation (Kennesaw local fauna): No. 9159; right jaw with I, P_4-M_1; W½ sec. 27, T. 12 N., R. 55 W., Logan County.

No. 9289 is an isolated tooth which is questionably identified as an M^2 because of its size (Table 32) in relation to the lower jaw from the same site. This tooth has two well-developed lophs, each composed of two cusps, united at the lingual edge by a single cusp that blocks the transverse valley. Compared with the first or second upper molar of *Heliscomys*, this tooth shows a relative increase in width and reduction in length, a loss of the anterior cingulum, and better-developed lophs.

No. 9288, like No. 9289, was recovered from the matrix of Quarry A at Martin Canyon. Whether or not it represents the same species as No. 9289 is, of course, unknown; but the stage of development of both specimens, when compared with *Heliscomys*, appears to be about the same. P_4 has four equally developed conical cusps and a small anteroconid, which is more closely associated with the metaconid than with the protoconid. Weak ridges unite the metaconid, entoconid, and hypoconid and also connect the anteroconid to both the metaconid and the protoconid. These ridges do not seem to form the X pattern found in the *Perognathus* line. A hypoconulid is present on the posterior margin of the tooth. The metaconid and protoconid are not set so closely together as in other specimens of *Proheteromys*, but this is probably because of their large size and the development of the anteroconid, which extends back as a ridge between them. M_1 has an occlusal pattern that does not differ greatly from that described for *Proheteromys?* (Chicago Nat. Hist. Mus. No. PM381) from the Cedar Creek fauna, except as follows: the lophodont structure is better developed; the anterior cingulum is weaker; the notch between the protostylid and hypostylid is broader and deeper; and the posterior cingulum is absent. That P_4 of No. 9288 may be deciduous does not seem likely.

These specimens from Quarry A are referred to *Proheteromys* in a broad sense—actually as a structural stage between the ancestor of *Proheteromys* and *Heliscomys*, and the later forms such as *Peridiomys*. With the discovery of more material, it is becoming increasingly difficult to fit the size, structural pattern, and geological age of individual species and specimens now assigned to *Proheteromys* into a simple evolutionary scheme that would maintain *Proheteromys* as a taxonomic unit in the sense in which it is used at present.

No. 9159 is weathered and the tooth pattern is poorly preserved, but the following details seem evident. The incisor is asulcate. Both cheek teeth are subhypsodont. P_4 has four prominent cusps. M_1 is composed of a well-developed metalophid and hypolophid united buccally and possibly also at the center of the tooth. Both lophids retain vestiges of the component cusps, the one on the lingual end of the metalophid being especially prominent. In addition, an anterior cingulum composed of several cusps seems to be present. Because of its weathered condition, the structural details of this specimen are difficult to discern, but it does show that a small heteromyid (Table 32) was present in the Kennesaw local fauna.

TABLE 32.—Measurements (in mm.) of *Proheteromys* spp.

	No. 9289	No. 9159	No. 9288
?M^2, antero-posterior length	0.74	....	....
?M^2, transverse width	1.05	....	....
I, transverse width	....	0.60	....
P_4, antero-posterior length	....	0.65	0.84
P_4, transverse width	....	0.60	0.69
M_1, antero-posterior length	....	0.90	1.05
M_1, transverse width	....	1.00	0.95

Peridiomys sp.

Referred specimen.—Pawnee Creek formation (Kennesaw local fauna): No. 9177; right P^4-M^1; SW¼ sec. 26, T. 12 N., R. 55 W., Logan County.

The teeth of this specimen are relatively unworn, and the metaloph of P^4 and both lophs of M^1 show their tricuspid origin. The lophs of M^1 are not united. In pattern and size (Table 33), the teeth are close to those of *Peridiomys oregonensis* (GAZIN) if allowance is made for wear. MATTHEW described *P. rusticus*, based on a lower jaw, from the "lower Snake Creek" beds of Nebraska. No. 9177 may represent the upper teeth of that species.

TABLE 33.—Measurements (in mm.) of *Peridiomys* sp.

	No. 9177
Crown length of P^4-M^3 at alveolus	5.30
P^4, antero-posterior length	1.35
P^4, transverse width	1.61
M^1, antero-posterior length	1.24
M^1, transverse width	1.58

FAMILY CASTORIDAE GRAY, 1821

Monosaulax curtus (MATTHEW & COOK)

Dipoides curtus MATTHEW & COOK, 1909, p. 381.
Monosaulax curtis, STIRTON, 1935, p. 420.

Referred specimen.—Pawnee Creek formation (Eubanks local fauna): Univ. Colorado Mus. No. 19836; right lower jaw with P_4-M_3; north of Pawnee Buttes in sec. 21, T. 10 N., R. 59 W., Weld County.

This specimen is identical to the type of *Monosaulax curtus*.

Monosaulax nr. M. curtus (MATTHEW & COOK)

Referred specimens.—Pawnee Creek formation (Martin Canyon local fauna): No. 9196; right P_4 and part of incisor (not associated). No. 9283; right P_4-M_2. No. 9284; right M_3. All specimens from NE¼ sec. 27. T. 11 N., R. 53 W., Logan County.

These specimens represent a species as small as *Monosaulax curtus* and similar to *M. curtus* in most respects. The occlusal pattern of the fourth premolars from Martin Canyon differs in having a crescent-shaped parafossettid resembling that of *M. pansus* (COPE). P_4 of No. 9283 has, in addition, a small fossettid anterior to the parafossettid which is lost early in wear. In all of the teeth, except the well-worn M_3 the hypoflexid appears to be shorter and wider than those of *M. curtus*.

Amblycastor? sp.

STIRTON (1935 p. 413) states that two beaver teeth from the Pawnee Creek beds (those reported by MATTHEW, 1902b, p. 305, figs. 12-13) "appear to belong to this genus." The specimen designated as figure 12 (AMNH No. 9364) came from 10 feet above the base of the Pawnee Creek formation, three miles west of Pawnee Buttes, Weld County. So far as can be determined, the other specimen came from the Pawnee Creek formation, Pawnee Buttes.

FAMILY ZAPODIDAE COUES, 1875

Plesiosminthus? clivosus, new species

Figure 26

Holotype.—Left lower jaw with M_1-M_3, No. 9279, Vert. Paleont. Coll., Univ. Kansas Mus. Nat. Hist.

Geological age and locality.—Silts of Hemingfordian age in the Pawnee Creek formation, Quarry A, NE¼ sec. 27, T. 11 N., R. 53 W., Logan County, Colorado.

Diagnosis.—The lower molars of this species are characterized by small size (Table 34); rounded principal cusps; and well-developed internal arm of the anterior cingulum, posterior protoconid arm, and metastylid. When more specimens of this species are known, it may be possible to emend this diagnosis of the lower teeth and cite characters confined to single teeth.

Description.—Only the body of the jaw, lacking the inferior border, and the three molars are preserved. The scar for the masseter muscle extends forward to the anterior root of M_1, and the lower border is prominently marked by a ridge. The mental foramen lies anterior to M_1. There seems to be an inferior dental foramen on the damaged internal surface of the jaw above the angle of the jaw and below the root of the incisor.

The molars are short crowned, and all the structures comprising the occlusal surface are in one plane, except the protoconid, metaconid, and entoconid on M_1, and the metaconid and entoconid on M_2 and M_3, which extend above this plane. An anteroconid is present on all three teeth. It is free and small on M_1 but is united by ridges to both the protoconid and metaconid on M_2 and M_3. In both M_2 and M_3 a strong crest forming the internal arm of the anterior cingulum passes from the anteroconid along the anterior face of the molar and unites with the anterior face of the metaconid. On the same two teeth a weak external arm extends downward from the anteroconid to unite with the base of the protoconid. A strong posterior protoconid arm unites the protoconid and metaconid in all three teeth, thus forming a deep pit on M_2 and M_3. The mesoconid is large and roughly rhomboidal in shape on all the teeth and lacks a well-developed union with the protoconid. Posteriorly the mesoconid is connected to the crest that unites the hypoconid and entoconid, the union being closer to the latter cusp. Well-developed mesostylids, united to the metaconids by low ridges, are present on M_1 and M_2. However, the mesostylid on M_3 is weak

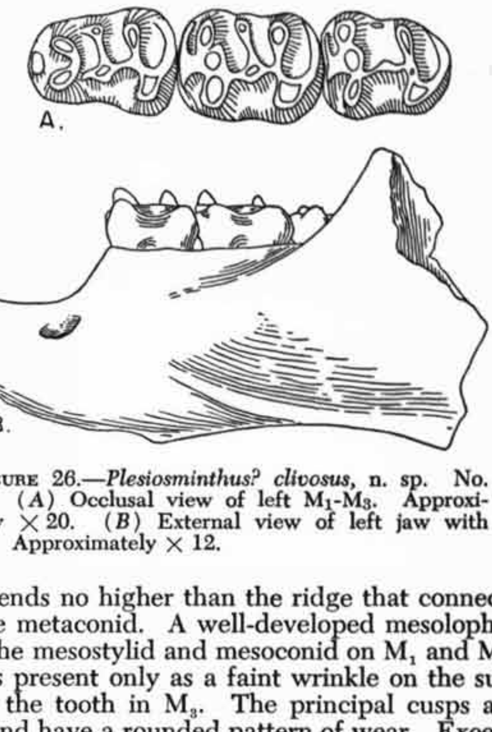


FIGURE 26.—*Plesiosminthus? clivosus*, n. sp. No. 9279. (*A*) Occlusal view of left M_1-M_3. Approximately × 20. (*B*) External view of left jaw with teeth. Approximately × 12.

and extends no higher than the ridge that connects it to the metaconid. A well-developed mesolophid unites the mesostylid and mesoconid on M_1 and M_2, but it is present only as a faint wrinkle on the surface of the tooth in M_3. The principal cusps are round and have a rounded pattern of wear. Except for the protoconid on M_1, the protoconid and hypoconid on all teeth are slightly posterior to the metaconid and entoconid.

Grooved upper incisors, No. 9295, also from Quarry A, are similar in cross section and enamel structure to the upper incisors of *Plesiosminthus schaubi* VIRET (SCHAUB, 1930, p. 621, fig. 4) but, without association, cannot be assigned to *Plesiosminthus? clivosus.*

Discussion.—It seems unlikely that this North American zapodid from the middle Miocene is congeneric with the lower Miocene zapodid of western Europe. Yet, until the upper teeth are found or enough material is collected to determine something of the range of variation of the structures on the lower teeth, it is advisable to refrain from naming a new genus. The similarities between this specimen and the European specimens of *Plesiosminthus* are evident, but, of course, these similarities may be those common to the plesiosminthid group. The differences between the two, especially those cited in the diagnosis, may be sufficient to dis-

TABLE 34.—Measurements (in mm.) of *Plesiosminthus? clivosus*

	No. 9279
Crown length of M_1-M_3	2.85
M_1, antero-posterior length	0.99
M_1, transverse width	0.72
M_2, antero-posterior length	0.99
M_2, transverse width	0.76
M_3, antero-posterior length	0.87
M_3, transverse width	0.72

tinguish the material generically; but with the range of variation recognized by SCHAUB in the species of *Plesiosminthus*, it is difficult (with one specimen) to select characters with any assurance that they will continue to be significant when more specimens are found.

ORDER CARNIVORA BOWDICH, 1821

FAMILY CANIDAE GRAY, 1821

Nothocyon vulpinus MATTHEW

Nothocyon vulpinus MATTHEW, 1907, p. 183.

THORPE (1922, p. 430) described and named as a "new mutant" *Nothocyon vulpinus coloradoensis*, which he based on a specimen (Yale Univ., Peabody Mus. Nat. Hist. No. 12812) from the "lower Miocene, Pawnee Buttes, Colorado." Concerning this specimen, Dr. JOSEPH T. GREGORY has informed me that it was part of a shipment of fossils from Pine Bluff, Wyoming, received in 1873, which included some Oligocene material from Gerry's Ranch (see account of *Phalacrocorax mediterraneus* for locality of Gerry's Ranch) and Pawnee Buttes. Inasmuch as Arikareean beds are unrecognized in the Pawnee Buttes area, but may be present in the Gerry Ranch area, it is suggested that the locality record is incorrect and that this specimen is from Gerry's Ranch —if in truth it is from Colorado.

Mesocyon robustus MATTHEW

Mesocyon robustus MATTHEW, 1907, p. 185.

THORPE (1922, p. 429) referred a specimen from Gerry's Ranch, Weld County, to this species. The importance of this specimen, like *Nothocyon*, lies in its possible stratigraphic value in indicating the presence of Arikareean beds in western Weld county. It is as yet, so far as I know, the only vertebrate fossil to support such a possibility. If Arikareean beds are present, they probably represent an extension of the Arikareean beds known in southeastern Wyoming.

Tomarctus brevirostris COPE

Tomarctus brevirostris COPE, 1873b, p. 2.

Type.—AMNH No. 8302; Pawnee Creek beds of northeastern Colorado (*fide* MATTHEW, 1924).

Tomarctus temerarius (LEIDY)

Canis temerarius LEIDY, 1858, p. 21.
Tomarctus temerarius, MATTHEW, 1924, p. 98.

This species was listed by MATTHEW (1901, p. 358; 1924, p. 71) as part of the Pawnee Creek fauna, which, of course, at that time included material from Martin Canyon. Although MATTHEW did not refer to the specimens by number, there is in the American Museum of Natural History material from "horizon E" in Martin Canyon which may have been the specimens MATTHEW had in mind. The specimen (No. 9220) listed below as *Tomarctus* sp. may well belong to this species.

Tomarctus sp.

Referred specimens.—Pawnee Creek formation (Martin Canyon local fauna): No. 9342; right M^1; NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.
Pawnee Creek formation (Vim-Peetz local fauna): No. 9220; left P^4; NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

No. 9342 is smaller than most specimens of *Tomarctus*, being 13.9 mm. wide when measured along a line through the hypocone and paracone. The metacone is damaged and no maximum antero-posterior measurement can be obtained, but the diameter at the conules is 7.95 mm. This indicates that the specimen had the proportions of *T. confertus* MATTHEW, but it differs from this species, and others, in having small and delicate cusps.

No. 9220 has a maximum length of 17.1 mm. and a width of 6.9 mm. The protocone is reduced and lies well forward on the side of the tooth, having a position similar to that seen in *Tomarctus confertus* or *T. optatus* MATTHEW. This tooth, like No. 9342, although nearly the same size as P_4 in *T. optatus*, appears more slender and delicate.

MATTHEW reported *Tomarctus* cf. *T. temerarius* from beds in Martin Canyon which he assigned to DARTON's horizon D and E. No. 9342 came from the surface of Quarry A which would place it in horizon D as recognized by MATTHEW, and No. 9220 came from beds (No. 5 of measured section XIV) near the top of the section in horizon E.

Leptocyon vafer (LEIDY)

Canis vafer LEIDY, 1858, p. 21.
Leptocyon vafer, MATTHEW, 1918, p. 190.

Referred specimen.—Pawnee Creek formation (Kenne-

TABLE 35.—Measurements (in mm.) of *Leptocyon vafer*

	No. 9157 left	No. 9157 right
Crown length of P_1-M_3	45.4	....
C, antero-posterior length at alveolus	4.8	....
C, transverse width at alveolus	3.5	....
P_1, antero-posterior length	2.9	....
P_1, transverse width	1.4	....
P_2, antero-posterior length	5.9	6.1
P_2, transverse width	2.4	2.1
P_3, antero-posterior length	7.1	7.1
P_3, transverse width	2.7	2.7
P_4, antero-posterior length	7.9	8.1
P_4, transverse width	3.2	3.3
M_1, antero-posterior length	12.2	12.2
M_1, transverse width	5.0	5.0
M_2, antero-posterior length	6.6	....
M_2, transverse width	4.3	....
M_3, antero-posterior length	2.5	....
M_3, transverse width	2.2	....
Depth of ramus at M_1	11.0	12.7

saw local fauna): No. 9157; left ramus with C-M_3, and part of right ramus with P_2-M_1; W½ sec. 27, T. 12 N., R. 55 W., Logan County.

In size (Table 35) and other characters this specimen agrees with the description of the type and the referred specimen of *Leptocyon vafer* from the *Merychippus paniensis* zone of the lower Snake Creek fauna.

Euoplocyon sp.

MATTHEW (1924, p. 71) lists this genus as occurring in the Pawnee Creek fauna.

Amphicyon sinapius MATTHEW

Amphicyon sinapius MATTHEW, 1902a, p. 288.

Type.—AMNH No. 9358; Loup Fork (Pawnee Creek beds), three miles northeast of Pawnee Buttes, Weld County, Colorado.

Amphicyon reinheimeri COOK

Amphicyon reinheimeri COOK, 1926, p. 29.

Type.—Denver Mus. Nat. Hist. No. 823; Pawnee Creek beds, E. C. Davis Ranch, six miles west of Pawnee Buttes, Weld County, Colorado.

The type locality of this species is in an area where there are exposures of the Pawnee Creek formation carrying equivalents of the Kennesaw and Martin Canyon local faunas.

FAMILY URSIDAE GRAY, 1825

(?)Ursavus pawniensis FRICK

(?)*Ursavus pawniensis* FRICK, 1926, p. 106.

Type.—AMNH no. 20801; Pawnee Creek Miocene, Tapir Hill, Pawnee Buttes, northeastern Colorado.

MATTHEW (1902a, p. 285) referred AMNH No. 9454, a carnassial and other fragments from northeastern Colorado, to ??*Ursavus* sp. but never specifically mentioned it again in faunal lists or discussions. Neither did FRICK refer to the specimen when he described (?)*Ursavus pawniensis*. I cannot determine which specimen MATTHEW had in mind when he included the entry "?*Ursavus* (Pawnee Creek)" in a chart (1929, p. 480) showing the phylogeny of the Ursidae.

FAMILY PROCYONIDAE BONAPARTE, 1850

Phlaocyon leucosteus MATTHEW

Phlaocyon leucosteus MATTHEW, 1899, p. 54.

Type.—AMNH No. 8768; American Museum Merycochoerus Quarry, Martin Canyon, Logan County, Colorado.

Concerning this specimen, WORTMAN & MATTHEW (1899, p. 131) wrote: "It represents a new and aberrant genus of Dogs, the characters pointing clearly in the direction of the Raccoons, so that if we adopt the genealogical conception of a family it must be placed in the Procyonidae, although it is nearer to such primitive Dogs as *Cynodictis* than to the modern Raccoons." HOUGH (1948a, p. 97) confirmed the close relationship of the specimen to the canids, but she pointed out that the procyonid-like characters could be the results of parallelism or convergence and would not necessarily indicate procyonid ancestry. Because of this and the similarities of the auditory region, she placed the genus in the family Canidae and denied any relationship to the Procyonidae.

On the other hand, McGREW (1937a, 1938a, 1941) has considered the Procyonidae, including *Phlaocyon*, to be a highly diversified family held together by the fundamental similarities of the dental pattern.

Cynarctus saxatilis MATTHEW

Cynarctus saxatilis MATTHEW, 1902a, p. 281.

Type.—AMNH No. 9453; Loup Fork (Pawnee Creek beds), Cedar Creek, Colorado.

FAMILY MUSTELIDAE SWAINSON, 1835

Plionictis ogygia (MATTHEW)

Mustela ogygia MATTHEW, 1901, p. 383.
Plionictis ogygia, MATTHEW, 1924, p. 135.

Type.—AMNH No. 9042; Pawnee Creek beds, Cedar Creek, Logan County, Colorado.

Referred specimens.—Pawnee Creek formation (Kennesaw local fauna): No. 9271; right M_1 in fragment of jaw; E½ sec. 27, T. 12 N., R. 55 W., Logan County. No. 9810; left P_4-M_2 and right C, P_3 in fragments of jaws; SW¼ sec. 26, T. 12 N., R. 55 W., Logan County.

Pawnee Creek formation (Vim-Peetz local fauna): No. 9800; left I^1-P^1, P^4-M^1, right C-P^1, M^1, and left P_3-M_1, right C, P_2-P_4; W½ sec. 28, T. 12 N., R. 55 W., Logan County, Colorado.

No. 9271 is an unworn tooth similar to the type in structure but approximately 18 percent smaller in size—being 6.15 mm. long and 2.9 mm. wide. The first lower molars of the other two specimens are intermediate in size between No. 9271 and the molar of the type specimen.

Plionictis parviloba (COPE)

Aelurodon mustelinus COPE, 1873, p. 1.
Mustela parviloba, COPE, in SCOTT & OSBORN, 1890, p. 71.
Plionictis parviloba, MATTHEW, 1924, p. 135.

The present location of the type specimen of this species is unknown. MATTHEW (1924, p. 135) considered the specimen to have come from the Pawnee Creek beds.

Leptarctus primus LEIDY

Leptarctus primus LEIDY, 1856c, p. 311.

Referred specimen.—Pawnee Creek formation (Kennesaw local fauna): No. 9153; skull (lacking basicranial region) and lower jaws; W½ sec. 27, T. 12 N., R. 55 W., Logan County.

This skull is the same size as the skull (AMNH

TABLE 36.—Measurements (in mm.) of *Leptarctus primus*

	No. 9153[a]
Crown length of C-M^1	28.7
C, antero-posterior length	5.1
C, transverse width	4.1
P^2, antero-posterior length	3.1
P^2, transverse width	2.4
P^3, antero-posterior length	4.0
P^3, transverse width	3.8
P^4, antero-posterior length	7.7
P^4, transverse width	7.7
M^1, antero-posterior length	7.3
M^1, transverse width	7.6
Crown length of C-M_2	33.6
C, antero-posterior length	4.5
C, transverse width	4.0
P_2, antero-posterior length	2.9
P_2, transverse width	2.1
P_3, antero-posterior length	4.2
P_3, transverse width	3.6
P_4, antero-posterior length	6.0
P_4, transverse width	4.1
M_1, antero-posterior length	9.8
M_1, transverse width	5.2
M_2, antero-posterior length	4.4
M_2, transverse width	4.0
Depth of ramus at rear of M_1	13.0

a. Right tooth row.

No. 18241) from the "lower Snake Creek" beds referred to *Leptarctus primus* by MATTHEW (1924, p. 139). However, the temporal crests are less divergent in No. 9153. Another difference is seen in the greater length and width of P^4 when compared with the teeth in LEIDY's type and in the Snake Creek skull. Compared with AMNH No. 18270, a lower jaw from the Snake Creek beds that has been referred to the species, the jaw of No. 9153 is heavier and has P_4 and M_1 wider but not longer antero-posteriorly (Table 36). Comparison of this specimen with *Leptarctus progressus* SIMPSON from the Pliocene of Florida can be made only on the basis of P^4. The only significant similarity of the Colorado specimen to SIMPSON's figure and description (1930, p. 186, fig. 19) is seen in the relatively greater width. The two teeth differ in that the specimen from Colorado lacks all traces of a cingulum other than the prominent anterior cuspule, which seems to be approximately twice as wide as the cuspule on *L. progressus;* the external surface is not so broad as that on *L. progressus;* and possibly the metacone was much better developed. The width of P^4 in the skull from northeastern Colorado equals its length; therefore, it is intermediate in proportion between *L. primus* and *L. progressus,* but closer to the latter. From the evidence of the specimens of *Leptarctus* from the Miocene and Pliocene, one would judge that the width of P^4 was not a geographic nor an evolutionary trend, unless in the latter case two separate lines of development are represented—a circumstance certainly not reflected by any other structures in the skull. This suggests that the wider teeth might be the result of sexual or individual variation. It is possible also that the slope of the external face and the size of the protocone are related to transverse width.

Because of the similarity in tooth structure, length of tooth row, and length of skull in No. 9153 and *Leptarctus primus,* and despite the wider teeth of No. 9153, I think that it belongs to the species *L. primus.* From the evidence of the shorter tooth row and wide teeth in the Coloradan specimen, it may be concluded that *L. progressus,* with its wide and short tooth, was closer to *L. primus* than to *L. wortmani* MATTHEW, which has longer teeth. Although some of the differences between *L. primus* and *L. progressus* are probably the result of geographic variation and different geologic age, the greater width of the teeth in *L. progressus* and the differences associated with greater width may be the result of secondary sexual or individual variation.

FAMILY FELIDAE GRAY, 1821

Pseudaelurus intrepidus LEIDY

Pseudaelurus intrepidus LEIDY, 1858, p. 22.

So far as can be determined, COPE collected material from northeastern Colorado referable to this species, which MATTHEW (1924, p. 72) referred to the Pawnee Creek fauna.

Pseudaelurus marshi THORPE

Pseudaelurus marshi THORPE, 1922, p. 446.

THORPE (1922, p. 446) referred a specimen from the "middle or upper Miocene" of "northwest" Colorado to this species. However, the correct locality, according to the Yale Peabody Museum records, is Gerry's Ranch, Weld County, Colorado.

ORDER PROBOSCIDEA ILLIGER, 1811

The list of proboscidean species from northeastern Colorado is presented using SIMPSON'S (1945) generic and suprageneric taxonomy and OSBORN's assignment of species. This appears to be the best method of recording and keeping clear the pertinent data on the material from the area. FRICK (1933) referred all the proboscidean material, except that mentioned under *Serridentinus productus,* to *Serridentinus proavus* (COPE); but OSBORN (1936) considered four species, *Serridentinus productus* COPE, *Serridentinus proavus* (COPE), *Rhynchotherium rectidens* OSBORN, and *Mammut (Miomastodon) merriami* OSBORN, to be present.

FAMILY GOMPHOTHERIIDAE CABRERA, 1929

Serridentinus proavus (COPE)

Mastodon proavus COPE, 1873c, p. 10.
Serridentinus proavus, OSBORN, 1936, p. 403.

Type.—AMNH No. 8523; Pawnee Buttes, Weld County, Colorado (*fide* OSBORN, 1936).

Concerning the age of this specimen OSBORN (1936, p. 403) wrote:

The typical (lower) Pawnee Creek beds (*Merychippus sejunctus* zone) of the late Middle Miocene yield traces of mastodon, fragments of a humerus and tooth, and part of a lower jaw found at the head of Two Mile Creek (F. B. Loomis, letter of November 5, 1920). The (upper) Pawnee Creek beds (*Protohippus* zone), perhaps early Pliocene, also yield simple grinding teeth similar to the type of *M. proavus* (F. B. Loomis, 1921). We cannot be certain whether the type of "*Mastodon*" *proavus* comes from the lower "*Merychippus sejunctus*" or from the upper "*Protohippus*" zone of the Pawnee Creek.

However, it was OSBORN's opinion that this species was from the upper zone, which he stated to be upper Miocene. This is the same level and age to which he assigned *Rhynchotherium rectidens* OSBORN, and above the level assigned to *Mammut merriami* (OSBORN).

Serridentinus productus (COPE)

Mastodon productus COPE, 1874b, p. 221.
Serridentinus productus, OSBORN, 1923, p. 2.

FRICK (1933, p. 609) listed several specimens from the Pawnee Buttes area of Weld County, which he doubtfully thought might represent (?)*Amebelodon paladentatus* (COOK) collected from middle Pliocene deposits near Wray, Yuma County, Colorado. Most of the material is not adequate for purposes of identification, and no stratigraphic position is given. OSBORN (1936, p. 440), in some supplementary observations on the genus *Serridentinus*, referred one of these specimens (left M_3, F:AM No. 23336) to *Serridentinus productus*. Subsequent summaries of the proboscidean species in OSBORN's monograph, however, fail to mention this referred specimen.

Rhynchotherium rectidens OSBORN

Rhynchotherium rectidens OSBORN, 1923, p. 3.

Type.—AMNH No. 9366; upper Miocene, Pawnee Creek horizon, eight miles west of Pawnee Buttes on Davis Ranch, Weld County, Colorado.

FRICK (1933, p. 612) placed this species in synonymy of *Serridentinus proavus*. OSBORN (1936, p. 489) discussed such a possible synonymy without taking notice of FRICK's action.

FAMILY MAMMUTIDAE CABRERA, 1929

Mammut merriami (OSBORN)

Mastodon merriami OSBORN, 1921, p. 6.
Mammut merriami, HAY, 1930, p. 630.

OSBORN (1936, p. 156) referred to this species proboscidean material from northeastern Colorado which FRICK (1933, p. 612) assigned to *Serridentinus proavus*.

The stratigraphic level for these specimens was referred to by OSBORN (1936, p. 403) as "the classic Pawnee Creek horizon of Colorado" of "middle Miocene" age, which would be his *Merychippus sejunctus* zone or lower Pawnee Creek beds.

Proboscidean, sp.?

Referred specimens. — Pawnee Creek formation (Kennesaw and Vim-Peetz local faunas): Nos. 9148-9152; fragments of teeth and bones; secs. 28 and 36, T. 12 N., R. 55 W., and sec. 31, T. 12 N., R. 54 W., Logan County.

Pawnee Creek formation (?Vim-Peetz local fauna): No. 9201; fragment of tooth; NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

One of the critical specimens from Martin Canyon is a fragment of proboscidean tooth, No. 9201. Although recorded (tentatively) as belonging to the Vim-Peetz local fauna, this specimen was found by Dr. ROBERT WILSON and me on the surface of an exposure of nodular silts at the same level as and not far from the site of Quarry A. It seems unlikely that this specimen was part of the Martin Canyon local fauna. On the other hand, it seems rather coincidental that in two instances (for a similar occurrence see the discussion of *Teleoceras* sp.) specimens of immigrant genera were found under circumstances that would suggest that the arrival in North America of these genera had been set at too late a date, or that the age of the beds containing the Martin Canyon local fauna had been seriously misjudged.

ORDER PERISSODACTYLA OWEN, 1848

FAMILY EQUIDAE GRAY, 1821

Parahippus pawniensis GIDLEY

Parahippus pawniensis GIDLEY, 1907, p. 932.

Type.—AMNH No. 9085; "horizon D" (of MATTHEW 1901), Martin Canyon, Cedar Creek, Logan County, Colorado (*fide* AMNH catalogue records).

Referred specimens.—Pawnee Creek formation (Martin Canyon local fauna): No. 7730; left P_3-M_2. No. 9198; upper molar and fragments of lower teeth. No. 9375; two left upper molars. Univ. Colorado Mus. Nos. 19842 and 19847; right upper molars. Above specimens from NE¼ sec. 27, T. 11 N., R. 53 W., Logan County. No. 9212; two upper and two lower cheek teeth; W½ sec. 22, T. 11 N., R. 52 W., Logan County.

In pattern and size these teeth range from those similar to the type of *Parahippus pawniensis* to specimens that approach *P. coloradensis* in pattern and equal it in size, especially No. 9212. AMNH No. 8961a, the *Parahippus* tooth found in the American Museum Merycochoerus Quarry at Martin Canyon, is also similar to these teeth in size and pattern.

Parahippus coloradensis GIDLEY

Parahippus coloradensis GIDLEY, 1907, p. 932.

Type.—AMNH No. 9040; Pawnee Buttes, Weld County, Colorado (*fide* AMNH catalogue records).

Referred specimens indicate that earlier authors considered *Parahippus pawniensis* and *Parahippus* *coloradensis* to be unchanging morphological types that coexisted over a considerable span of time in the Miocene. However, the range of variation seen in the *Parahippus* teeth from Martin Canyon suggests that *P. coloradensis* might be only a part of the *Parahippus pawniensis* population. If No. 9210, discussed in this paper as ?*Merychippus* sp., is referable to *Parahippus*, then this view is considerably strengthened. On the other hand, *P. coloradensis* has been described as more advanced than *P. pawniensis*, so it would appear reasonable to think that *P. pawniensis* represents a population of horses that evolved into a population typified by *P. coloradensis*, if they are not conspecific. When enough specimens of *Parahippus pawniensis* and *P. coloradensis* with stratigraphic records are known, it may be possible to determine the relationship of these two species and the bearing of this relationship on the correlation of the beds in the Pawnee Creek formation.

Some features that point out possibilities concerning the relationship and time span of these two species deserve comment. The "upper Rosebud" and "upper Harrison" localities in South Dakota and Nebraska, respectively, which Osborn cites (1918, p. 75) for occurrences of these species, are probable equivalents of the Martin Canyon "horizon D." Nothing referable to either species has been reported as coming from either the Sheep Creek or Snake Creek faunas. Although Osborn listed both species as coming from the "*Ticholeptus-Merychippus* zone" of Pawnee Buttes (Osborn's Classical Pawnee Creek level; *M. paniensis* zone; or Pawnee Creek A), the type of *Parahippus pawniensis* came from "horizon D" at Martin Canyon. The association of *P. coloradensis* with *M. paniensis* has not been demonstrated, and the parahippine teeth that have been found associated with *M. paniensis* at Pawnee Buttes are not specifically identifiable. Consequently, a parahippine younger than *P. coloradensis* possibly is present at Pawnee Buttes in the Eubanks local fauna. In brief the most likely suggestions are: (1) the species are conspecific and limited to the early Hemingfordian; (2) the species are conspecific and range through the Hemingfordian and early Barstovian time span, but their presence or absence is controlled by facies differences or limited distribution; or (3) one species evolved into the other, and their presence or absence is due to time and facies differences or limited distribution.

Hypohippus osborni Gidley

Hypohippus osborni Gidley, 1907, p. 930.

Type.—AMNH No. 9407; Pawnee Creek beds, 8 miles west of Pawnee Buttes, northeastern Colorado.

Referred specimens.—Pawnee Creek formation (?Kennesaw local fauna): No. 9169; two upper cheek teeth; SW¼ sec. 26, T. 12 N., R. 55 W., Logan County.

These specimens consist of two damaged and worn teeth which are clearly referable to the genus *Hypohippus*. Reference to the species *H. osborni* is based on size, the teeth being smaller than those of *H. affinis* Leidy and larger than those of *H. equinus* Scott.

Both specimens were found as float in beds bearing the Kennesaw local fauna, but under circumstances that make it possible that they came from higher beds.

On the Merychippine Specimens from Northeastern Colorado

The collection of merychippine material obtained by me in northeastern Colorado is highly unsatisfactory. Less than 100 specimens were collected, of which only two finds had associated upper and lower teeth, and in only nine instances were there more than two teeth preserved. Of the remaining specimens more than half were badly worn, weathered, or incomplete. The collection of *Merychippus* material made by H. T. Martin for the University of Kansas Museum of Natural History contains some excellent specimens but lacks stratigraphic and locality data, which makes it useless for this work.

The difficulties encountered in attempting to identify the specimens suggest that the range of variation in the species is rather large—perhaps great enough to allow synonymizing of some forms. Unfortunately, not enough material with accurate stratigraphic data is available to accomplish such a study, especially in the manner that species of *Merychippus* from the West Coast have been studied.

Poor as this collection may be, it nevertheless does show features that seem significant. As a whole, the milk teeth and occlusal patterns of the permanent teeth of the merychippines in the Vim-Peetz local fauna are more like those of the Pliocene, while the crown heights are distinctly shorter.

Merychippus paniensis (Cope)

Hippotherium paniense Cope, 1874, p. 12.
Merychippus paniensis, Gidley, 1907, p. 890.

Type.—AMNH No. 8249; Pawnee Creek formation, Pawnee Buttes, northeastern Colorado (*fide* Osborn, 1918).

Referred specimens.—Pawnee Creek formation (Eubanks local fauna): No. 3125; skull and jaws; northeastern Colorado. Nos. 9233 and 9240; left P^2 and left upper molar (possibly associated); Pawnee Buttes volcanic ash layer, NE¼ sec. 1, T. 10 N., R. 59 W., Weld County.

No. 3125 was collected by H. T. Martin, and its position in the Pawnee Creek section is unknown.

Merychippus sejunctus (Cope)

Protohippus sejunctus Cope, 1874, p. 15.
Merychippus sejunctus, Hay, 1902, p. 618.

Type.—AMNH No. 8291; Pawnee Creek formation, Pawnee Buttes, northeastern Colorado (*fide* OSBORN, 1918).

Referred specimens.—Pawnee Creek formation (Eubanks local fauna): No. 9238; right M^1. No. 9811; left I_1-I_3, C, P_2-M_1 in fragment of jaw. Both specimens from NE¼ sec. 1, T. 10 N., R. 59 W., Weld County.

Merychippus sphenodus (COPE)

Hippotherium sphenodus COPE, 1889, p. 449.
Merychippus sphenodus, GIDLEY, 1907, p. 908.

Type.—AMNH No. 8281; Pawnee Creek formation, Pawnee Buttes, northeastern Colorado (*fide* OSBORN, 1918).

Referred specimens.—Pawnee Creek formation (Kennesaw local fauna): No. 9164; left P^2; W½ sec. 27, T. 12 N., R. 55 W., Logan County. No. 9173; right P^2; SW¼ sec. 26, T. 12 N., R. 55 W., Logan County. No. 3122; right P^2-M^3; northeastern Colorado. No. 9167; right P_3-M_2; W½ sec. 27, T. 12 N., R. 55 W., Logan County. No. 9178; left upper molar and right lower molar (associated); W½ sec. 27, T. 12 N., R. 55 W., Logan County. No. 9172; palate with all teeth except left molars; SW¼ sec. 26, T. 12 N., R. 55 W., Logan County.

OSBORN (1918, p. 112) designated a skull (Princeton Univ. Mus. No. 12291) as the neotype of this species.[26] The locality from which this Princeton specimen was obtained seems to be approximately the same as that from which I collected the referred specimens listed above, with the exception of No. 3122 which was collected by H. T. MARTIN.

No. 3122 is smaller than the type or neotype but has an occlusal pattern similar to that of the neotype. Nos. 9164 and 9173 differ from the type in having the protocone united with the protoconule.

Merychippus republicanus OSBORN

Merychippus republicanus OSBORN, 1918, p. 125.

Referred specimen. — Pawnee Creek formation (Vim-Peetz local fauna): No. 9802; right P^2-M^3; W½ sec. 27, T. 12 N., R. 55 W., Logan County.

No. 9802 is the best of several specimens collected from the level of the Vim-Peetz local fauna in the exposures west of Sand Canyon. This specimen has an occlusal pattern close to that of *Neohipparion coloradense*, but the crowns of the teeth are short and curved.

Merychippus labrosus (COPE)

Protohippus labrosus COPE, 1874, p. 13.
Merychippus labrosus, HAY, 1902, p. 617.

Type.—AMNH No. 8266; Pawnee Creek formation, Pawnee Buttes, northeastern Colorado (*fide* OSBORN, 1918).

GIDLEY (1907, p. 891) considered this species to be "of rather uncertain standing."

Merychippus proparvulus OSBORN

Merychippus proparvulus OSBORN, 1918, p. 117.

Type.—AMNH No. 9394; Pawnee Creek beds, Pawnee Buttes, northeastern Colorado.

Merychippus eoplacidus OSBORN

Merychippus eoplacidus OSBORN, 1918, p. 114.

Type.—AMNH No. 9397; Pawnee Creek beds, Pawnee Buttes, northeastern Colorado.

Merychippus eohipparion OSBORN

Merychippus eohipparion OSBORN, 1918, p. 117.

Type.—AMNH No. 9402; Pawnee Creek beds, Pawnee Buttes, northeastern Colorado.

Merychippus proplacidus (OSBORN)

Protohippus proplacidus OSBORN, 1918, p. 139.
Merychippus proplacidus, STIRTON, 1940, p. 182.

Type.—AMNH No. 9115b.

This specimen is listed as having been collected from the "Upper Pawnee Creek beds," Sand Canyon, head of Pawnee Creek, Logan County, by BARNUM BROWN in 1898. The locality "head of Pawnee Creek" was a *lapsus* on OSBORN's part and should have been "head of Cedar Creek." STIRTON (1940, p. 182) tentatively considered that the specimen might be a "lower Pawnee Creek" form. Possibly this species is synonymous with one of the species of *Merychippus* known by permanent teeth.

Merychippus campestris GIDLEY

Merychippus campestris GIDLEY, 1907, p. 928.

Type.—AMNH No. 9096.

GIDLEY gave the number of the type as 9069 and the age and locality as middle Miocene, Pawnee Creek formation, Pawnee Buttes, Colorado. OSBORN (1918, p. 114) repeated this information and pointed out that the specimen was collected by W. D. MATTHEW in 1898 (an error since MATTHEW did not collect at Pawnee Buttes in 1898). The American Museum records, in MATTHEW's handwriting, state that the type specimen of this species was collected by MATTHEW in 1898 from the Pawnee Creek beds, horizon D, at Martin Canyon, Cedar Creek, Colorado. The specimen number given by GIDLEY seems to be a typographical error inasmuch as the records and the description of the material indicate that specimen No. 9096 is the type.

While there is no reason to doubt that this specimen came from the Martin Canyon area, MATTHEW's assignment to "horizon D" appears to have been an error. The type and referred specimens bear a resemblance to *Pliohippus* that suggests a horse greatly advanced over anything known from beds of Hemingfordian age. In my opinion the level of occurrence probably was "horizon E" (Vim-Peetz local fauna of this paper).

MATTHEW (1901, p. 359) reported a specimen of "*Pliohippus mirabilis*" which would indicate the

26. Although OSBORN wrote "Amer. Mus. 1291" for the neotype, reference to page 114 and the legend for plate 12 leaves no doubt as to what specimen he had in mind.

presence of an advanced protohippine in the Logan County area, but it is not known whether or not the specimen referred to by MATTHEW was the same *Pliohippus* (AMNH No. 9093) which OSBORN mentioned as being associated with *Neohipparion coloradense*. Another specimen that might fit into this advanced protohippine group is AMNH No. 9459, referred to *Merychippus campestris* by OSBORN (1918, p. 114) and recorded as coming from the uppermost beds at Cedar Creek, 40 miles north of Sterling, Colorado. Possibly the "*Pliohippus*" and referred specimens of *M. campestris* are the same species. The general similarity of *M. campestris* to *Pliohippus* (OSBORN, 1918, pp. 114, 146), and the almost imperceptible intergradation of *Pliohippus* with the protohippine species of *Merychippus*, commented upon by STIRTON (1940, p. 190), suggest that these specimens are transitional between typical protohippine and pliohippine horses.

Merychippus sp. (Advanced protohippine)

Referred specimens. — Pawnee Creek formation (Vim-Peetz local fauna): No. 9803; left P_2; W½ sec. 27, T. 12 N., R. 55 W., Logan County. No. 9804; external wall of lower cheek tooth; NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

These teeth show little more than that the protohippine horses at this level had not reached a stage of development typical of the horses of the lower Clarendonian.

?**Merychippus** sp.

Referred specimen. — Pawnee Creek formation (Martin Canyon local fauna): No. 9210; fragment of upper molar preserving only the metaloph and part of the metacone; NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

This specimen was collected at Quarry A in Martin Canyon. The metaloph shows multiple plications similar to those seen in *Merychippus paniensis* and *M. sphenodus* and better developed than those of *M. primus* and *M. gunteri*. The fragment indicates a tooth nearly the size of *M. primus* in anteroposterior and transverse diameters. However, it seems to have been shorter crowned.

Calippus sp.

Referred specimens. — Pawnee Creek formation (Kennesaw local fauna): No. 3131; right P^3-M^2; northeastern Colorado. No. 7731; incomplete left M^2; NE¼ sec. 31, T. 12 N., R. 54 W., Logan County. No. 9166; right M_2; W½ sec. 27, T. 12 N., R. 55 W., Logan County. No. 9188; right M_3; SW¼ sec. 25, T. 12 N., R. 55 W., Logan County.

These teeth, because of their pattern and small size, are referred to *Calippus*. However, they are not referable to any known species of this genus, having less crown height and being more curved than in other species.

In antero-posterior and transverse diameters, these specimens are similar to the teeth of *Merychippus westoni* SIMPSON. Also, as in the teeth of *M. westoni*, the protocone of P^3 is more internal in position than the hypocone, and less so on the others. Unlike *M. westoni*, the protocone is strongly united to the protoconule in every specimen.

The specimens also bear some similarity to *Calippus* sp.?[27] of HESSE (1936, p. 65) from the Clarendonian Pliocene of Oklahoma but seem to be more primitive and of a different species.

FAMILY **CHALICOTHERIIDAE** GILL, 1872

?**Macrotherium matthewi** (HOLLAND & PETERSON)

Moropus matthewi HOLLAND & PETERSON, 1913, p. 230.
?*Macrotherium matthewi*, MATTHEW, 1929, p. 519.

Cotypes.—AMNH Nos. 9076, 9077, 9078, 9080; Pawnee Creek horizon, Martin Canyon, Cedar Creek, Colorado. AMNH No. 9368; Loup Fork horizon, near Pawnee Buttes, Weld County, Colorado.

Referred specimen. — Pawnee Creek formation (Martin Canyon local fauna): No. 9378; right ?P_4 (damaged); NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

The stratigraphic position of the chalicothere remains collected by MATTHEW (Nos. 9076-9080) cannot be exactly determined to my satisfaction. MATTHEW stated (1901, p. 359), "It appeared probable that the heavy beds of coarse gravel filling erosion valleys are connected with these upper beds [horizon E or bed No. 5 of measured section XV, Fig. 6] rather than with the finer concretionary sandstones [bed No. 4 of measured section XV, Fig. 6] and are continuous with the shingle bed overlying the latter *rather than the one* [bed No. 3 of measured section XV, Fig. 6] *underneath it* [italics mine, E. C. G.]. The *Moropus* and other species should therefore also be added to this list [fauna of horizon E]." In the N½ of sec. 27 the relationship of the channels are as MATTHEW described them, but the American Museum records state that MATTHEW collected the chalicothere remains at the "gravel hill west of spring," which appears to have been one of the exposures near Sand Butte and west of Willow Spring (the only spring in the immediate area, in N½ sec. 34, and one with a long and well-known history). In this locality at least some, if not all, of the coarse gravel beds are thought to be associated with the fine concretionary sandstones or the underlying rubble bed.

No. 9378 was found near the base of the fine concretionary sandstones, and it must be kept in mind, on the surface. Although it appears improbable, the possibility of the specimen drifting down to this level cannot be overlooked, since MATTHEW thought his specimens came from the higher level.

There is much to suggest that the chalicotheres were part of the Martin Canyon local fauna found in the concretionary sandstones: the probability

27. *Calippus* sp.? was based on one of 17 specimens catalogued under No. 3736 in the University of Kansas Museum of Natural History. Some of the remaining 16 teeth in lot No. 3736 and part of a collection of much larger teeth catalogued under No. 3738 in this Museum were referred to *Nannippus* sp.? by HESSE (1936, p. 64). Inasmuch as the remaining 16 teeth in No. 3736 are also referable to *Calippus* sp.?, I think that at least part of the discussion of *Nannippus* sp.? by HESSE refers to the species represented by *Calippus* sp.?.

that MATTHEW collected his material near Willow Spring where there are channel gravels older than those to which he assigned the specimens; and the mixed fauna of the gravels (as given by MATTHEW, 1901, p. 358) which suggests that he had the channels confused. The level from which the Pawnee Butte specimen was collected cannot be determined.

Unfortunately, chalicotheres are much too rare as individuals to allow conclusions based on their presence or absence in a fauna. However, the absence of chalicotheres from the lower Snake Creek fauna, which has many forms in common with the Pawnee Creek fauna, is suggestive that they occur in the Martin Canyon fauna but not the Pawnee Creek fauna in northeastern Colorado.

FAMILY **TAPIRIDAE** BURNETT, 1830

Tapiravus? sp.

Referred specimen.—AMNH no. 9367; upper jaw fragment with two premolars.

Mrs. RACHEL H. NICHOLS brought this specimen to my attention and supplied the following data: "A. M. no. 9367, labeled '*Tapir*', . . . found at Davis' Ranch, Weld Co., Colo., in Pawnee Creek beds, by Loomis, 1901." Presumably it is the same specimen referred to by MATTHEW (1901, p. 445) as *Tapiravus*(?). FRICK (1926, p. 106) reported that a specimen of *Tapirus* had been collected in the Pawnee Buttes area in 1922 from beds containing *Merycodus* and *Merychippus*. This specimen seems to be lost, but these reports indicate that Miocene tapirids were present in northeastern Colorado.

FAMILY **RHINOCEROTIDAE** OWEN, 1845

Diceratherium? persistens (OSBORN)

Caenopus persistens OSBORN, 1904a, p. 318.
Diceratherium? persistens, WOOD, H. E., 1927, p. 72.

Type.—AMNH No. 9081; middle (p. 318), or upper (p. 326) Miocene of northeastern Colorado (OSBORN, 1904a).

American Museum records state that the specimen was collected in 1898 from the Loup Fork beds, Pawnee Creek, Colorado. However, the catalogue number and the year of collection indicate that the locality would probably be either the Martin Canyon or Sand Canyon area in Logan County.

This specimen has been discussed by WOOD (1927, p. 72) and MATTHEW (1932, p. 418), but neither author offers a satisfactory taxonomic allocation of the type specimen. WOOD thought that the specimen was a female dicerathere, but specifically indeterminate. MATTHEW thought the skull characters too primitive to fall into any of the genera *Aphelops*, *Peraceras*, or *Teleoceras*, but "might be compared with '*Diceratherium*' *palaeosinense* of the Chinese Pliocene, which is not *Diceratherium* but not readily referable to any described genus." WOOD considered the age of the specimen to be middle Miocene, whereas MATTHEW gave the age as upper Miocene. The age may have influenced the thinking of each author.

Aphelops profectus (MATTHEW)

Aceratherium profectum MATTHEW, 1899, p. 71.
Aphelops profectus, MATTHEW, 1901, p. 358.

Type. — AMNH No. 9082; Loup Fork of northeastern Colorado.

American Museum records state that this specimen was obtained from "horizon D," Martin Canyon [NE¼ sec. 27, T. 11 N., R. 53 W., Logan County].

Aphelops profectus is known only by the one lower jaw. Possibly our material from Martin Canyon that is listed under *Aphelops* sp. belongs to this species.

Aphelops megalodus (COPE)

Aceratherium megalodus COPE, 1873, p. 1.
Aphelops megalodus, COPE, 1873, p. 1.

Type.—AMNH No. 8292; Pawnee Buttes, Colorado (*fide* OSBORN, 1904).

This specimen probably came from the Eubanks local fauna in the Pawnee Creek formation, but the vertical range of the species is unknown. STIRTON (1936, p. 190) thought that possibly this species belonged to the "upper Pawnee Creek fauna" of northeastern Colorado. MATTHEW (1924, p. 150) tentatively listed it in the Sheep Creek fauna and more certainly in the *M. paniensis* zone of the lower Snake Creek fauna. He considered *Aphelops megalodus* to be more primitive than the Pliocene species. More recently HENSHAW (1942, p. 95) stated that *A. megalodus* was more primitive than the late Miocene rhinoceroses of the Tonapah fauna. Although the species may have survived into the latest Miocene or early Pliocene, an earlier age for the form seems more probable.

Aphelops spp.

Referred specimens.—Pawnee Creek formation (Martin Canyon local fauna): No. 9376; right dM^3; NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

Pawnee Creek formation (Eubanks local fauna): No. 9250; left P_3. No. 9812; paroccipital and exoccipital bone. No. 9813; astragalus. All three specimens from Pawnee Buttes ash layer, NE¼ sec. 1, T. 10 N., R. 59 W., Weld County.

Pawnee Creek formation (Vim-Peetz local fauna): No. 7734; damaged left tibia; NE¼ sec. 27, T. 11 N., R. 53 W., Logan County. No. 9799; cuneiform; W½ sec. 29, T. 12 N., R. 55 W., Logan County.

No. 9376 agrees in size and shape with the corresponding milk tooth figured by MATTHEW (1918, p. 206, fig. 13) from the Snake Creek beds. This specimen, and other rhinocerotid fragments from the Martin Canyon fauna, seem advanced in comparison with *Diceratherium*.

The premolar from Pawnee Buttes is 49.5 mm. long and 27.7 mm. wide.

The tibia from the Vim-Peetz local fauna belonged to an individual that perhaps exceeded *Aphelops mutilus* in size.

Teleoceras medicornutus OSBORN

Teleoceras medicornutus OSBORN, 1904a, p. 319.

Type.—AMNH No. 9832; OSBORN gave the locality of the type specimen as 25 miles north of Pawnee Buttes. There does not seem to be any evidence in the American Museum records for any locality other than 15 feet above the base of the Loup Fork, 15 miles northeast of Grover, Weld County, Colorado.

MATTHEW (1932, p. 418) thought that *Aphelops planiceps* OSBORN (1904a, p. 321), from northeastern Colorado, probably was synonymous with this species.

Teleoceras spp.

Referred specimens. — Pawnee Creek formation (Vim-Peetz local fauna): No. 9795; right radius. No. 9796; left humerus. No. 9797; left nasal bone. Above specimens from W½ sec. 29, T. 12 N., R. 55 W., Logan County. No. 9389; nasal bones; NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

Except for their smaller size, Nos. 9795-9797 resemble the respective structures in *Teleoceras fossiger*.

No. 9389, consisting only of the blunt, fused nasal bones with a well-developed callosity, most closely fits the nasals of *Teleoceras medicornutus*. The assignment of this specimen to the Vim-Peetz local fauna must be tentative for the present. It was found by Dr. ROBERT WILSON on the surface of "horizon D" beds a few feet above the University of Kansas Quarry A. The topography of the area seemingly precludes deriving the specimen from younger beds by drifting; therefore, its presence on "horizon D" beds cannot be explained unless it was carried in by human agency.[28]

ORDER ARTIODACTYLA OWEN, 1848

FAMILY TAYASSUIDAE PALMER, 1897

Tayassuid sp.

Referred specimens.—Pawnee Creek formation (Martin Canyon local fauna): No. 9325; canine. No. 9347; fragment of upper molar. NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

These specimens and some unprepared material indicate that a peccary as small as *Perchoerus* was present in Quarry A.

FAMILY MERYCOIDODONTIDAE THORPE, 1923

The post-Oligocene oreodonts from northeastern Colorado have been discussed recently by SCHULTZ & FALKENBACH (1940, 1941, 1947). These authors reidentified the material collected by earlier workers with but little change other than to assign specimens regarded by MATTHEW (1901, p. 412) as pertaining to "*Merycochoerus rusticus*" to *Ustatochoerus medius* (LEIDY).

Ustatochoerus medius (LEIDY)

Merychyus medius LEIDY, 1858, p. 26.

Ustatochoerus medius, SCHULTZ & FALKENBACH, 1941, p. 23.

Referred specimens.—Pawnee Creek formation (Kennesaw local fauna): No. 9809; palate and lower jaws; SW¼ sec. 26, T. 12 N., R. 55 W., Logan County.
Pawnee Creek formation (Vim-Peetz local fauna): No. 9186; skull, jaws, atlas, and axis; W½ sec. 28, T. 12 N., R. 55 W., Logan County.

Isolated teeth and fragments of bone, probably referable to this species, are not uncommon in the basal 50 feet of the Pawnee Creek formation west of Sand Canyon, Logan County, but good specimens are rare.

Ustatochoerus? schrammi SCHULTZ & FALKENBACH

Ustatochoerus? schrammi SCHULTZ & FALKENBACH, 1941, p. 49.

SCHULTZ & FALKENBACH (1941, p. 50) have referred specimens from the "basal part of the Ogallala deposits (lower Valentine)," Pawnee Creek area, Weld County [29] to this species.

Ustatochoerus sp.

Referred specimen.—Pawnee Creek formation (Eubanks local fauna): No. 9814; left P_2; NE¼ sec. 1, T. 10 N., R. 59 W., Weld County.

Merycochoerus proprius magnus (LOOMIS)

Merycochoerus magnus LOOMIS, 1924, p. 28.

Merycochoerus proprius magnus, SCHULTZ & FALKENBACH, 1940, p. 286.

Referred specimens.—Pawnee Creek formation (Martin Canyon local fauna): No. 9206; right lower jaw with teeth. No. 9363; muzzle of skull with canines and anterior premolars. No. 9392; damaged skull and mandible. Specimens from NE¼ sec. 27, T. 11 N., R. 53 W., Logan County. No. 9213; left P_2, M_2, M^3, and right M_2. No. 9214; fragments of left M^3. No. 9276; right P_3 and M_3. Last three specimens from sec. 22, T. 11 N., R. 52 W., Logan County.

In addition to the well-known *Merycochoerus proprius magnus* slab (AMNH No. 8968) from the lowest Miocene exposures at Martin Canyon, there are several specimens (AMNH Nos. 9051-9053, 9055, 9057-9058, and 9064) from the nodular silts (horizon D of MATTHEW) above the beds containing No. 8968. These specimens were assigned by MATTHEW (1901, p. 401) to *Merycochoerus proprius*. Later (1909, p. 115) he listed the *Merycochoerus* of northeastern Colorado as *M.* cf. *M.*

28. All doubt concerning the age of this specimen was dispelled with the discovery of a nearly complete skull and some limb bones of a teleocerine in Quarry A in the summer of 1952. The nasal bones of the newly discovered skull are similar in all respects to the nasals found by WILSON. Therefore, Teleocerine sp. should be added to the Martin Canyon local fauna.

29. The authors state Logan County, but this is evidently a *lapsus*.

proprius. To just which specimens (or all?) MATTHEW was referring at this time is unknown. SCHULTZ & FALKENBACH referred AMNH No. 9052 to *Merycochoerus p. magnus* but did not commit themselves on the remaining specimens. From the same locality and level as AMNH Nos. 9051-9064, several specimens have been collected in recent years, of which the three best are listed above. No. 9206, a lower jaw, was examined by Mr. CHARLES FALKENBACH and considered to be close to *Merycochoerus matthewi* LOOMIS (personal communication). Mr. FALKENBACH pointed out, however, that the assignment of lower jaws to species of *Merycochoerus* was a precarious practice subject to error (at this time the other specimens had not been prepared). No. 9363 also agrees in size and description with *Merycochoerus matthewi*, but No. 9392 has the size and appearance of *M. p. magnus*. The specimens were collected from the immediate vicinity of the University of Kansas Quarry A and stratigraphically within a few feet of each other. It is questionable whether Nos. 9206 and 9363 represent anything more than sexual or individual variants of *Merycochoerus p. magnus*.

Merychyus elegans LEIDY

Merychyus elegans LEIDY, 1858, p. 25.

Referred specimens.—Pawnee Creek formation (Martin Canyon local fauna): No. 9207; mandible. No. 9312; left M^2, and right M_1-M_3. No. 9313; left M^2. All from NE¼ sec. 27, T. 11 N., R. 53 W., Logan County. No. 9378; left P_4; sec. 22, T. 11 N., R. 52 W., Logan County.

For the most part, the specimens collected by the American Museum party of 1898 were subsequently discussed by MATTHEW (1901, p. 418), LOOMIS (1924, p. 34), COLBERT (1943, p. 303), and SCHULTZ & FALKENBACH (1947, p. 202). Insofar as I can determine, the University of Kansas specimens from Martin Canyon came from the same beds as the specimens collected by the American Museum party.

SCHULTZ & FALKENBACH (1947, p. 202) referred AMNH Nos. 9442-9444 from Pawnee Buttes, Weld County to *Merychyus elegans*. They also tentatively referred a specimen from Weld County to the subspecies *M. elegans bluei*.

FAMILY CAMELIDAE GRAY, 1821

Camelid specimens were collected from most of the Miocene localities in northeastern Colorado, but none of the fragments were sufficiently complete to permit specific identification or, with few exceptions, even generic identification. No. 9248, fragments of foot bones, from the Pawnee Buttes volcanic ash layer in the NE¼ sec. 1, T. 10 N., R 59 W., Weld County, probably belongs either to *Protolabis heterodontus* or to *Protolabis angustidens*.

Protolabis fissidens (COPE)

Procamelus fissidens COPE, 1876, p. 145.
Protolabis fissidens, MATTHEW, 1924, p. 190.

Type.—AMNH No. 8297; Pawnee Creek beds, northeastern Colorado (*fide* MATTHEW, 1901).

Protolabis heterodontus (COPE)

Procamelus heterodontus COPE, 1873d, p. 420.
Protolabis heterodontus, COPE, 1876, p. 145.

Type.—AMNH No. 8296; Pawnee Creek beds, near Pawnee Buttes, Weld County, Colorado (*fide* COPE & MATTHEW, 1915).

Protolabis angustidens (COPE)

Procamelus angustidens COPE, 1874, p. 20.
Protolabis angustidens, MATTHEW, 1899, p. 74.

Type.—AMNH No. 8294; Pawnee Creek beds near Pawnee Buttes, Weld County, Colorado (*fide* COPE & MATTHEW, 1915).

Protolabis longiceps MATTHEW

Protolabis longiceps MATTHEW, 1909, p. 115.

Type.—AMNH No. 9108; Pawnee Creek beds (horizon D), Cedar Creek, northeastern Colorado.

The record of occurrence of this type specimen in "horizon D" refers to MATTHEW's "horizon D" at Sand Canyon, Logan County, and indicates that the specimen is probably late Barstovian in age.

Alticamelus leptocolon MATTHEW

Alticamelus leptocolon MATTHEW, 1909, p. 115.

Type.—AMNH No. 9116; brown Miocene sandstone, Sand Canyon, Cedar Creek, Colorado.

In the designation of the type of this species MATTHEW (1909, p. 115) referred to specimens discussed (1901, pp. 427-428) as *Procamelus robustus*, and including AMNH Nos. 9112, 9112a, 9114, 9116, 9117. Later (1924, p. 187) MATTHEW stated that the type was No. 9115. Dr. G. G. SIMPSON and Mrs. RACHEL NICHOLS kindly investigated this problem for me and found that MATTHEW (1924, p. 187) had described the material numbered AMNH 9116, but used the number 9115. The use of number 9115 was a typographical error, and the correct number for the type is 9116.

Alticamelus giraffinus MATTHEW

Alticamelus giraffinus MATTHEW, in MATTHEW & COOK, 1909, p. 402.

Type.—AMNH No. 9109; Pawnee Creek formation; SW¼ sec. 25, T. 12 N., R. 55 W., Sand Canyon, Logan County, Colorado.

Referred specimens. — Pawnee Creek formation (Vim-Peetz local fauna): Nos. 9793-9794; ulna and distal end of radius; W½ sec. 29, T. 12 N., R. 55 W., Logan County.

Originally, MATTHEW (1901, p. 430) referred the type specimen to *Alticamelus altus*. This specimen was found by H. T. MARTIN. MARTIN later pointed out the site to CURTIS HESSE, who subsequently gave the locality information to Dr. ROBERT WILSON.

The referred material is assigned to this species because of its size.

FAMILY CERVIDAE GRAY, 1821

Little identifiable cervid material was found in the Pawnee Creek formation. Recovered teeth are generally comparable to specimens from the Sheep Creek beds.

Blastomeryx gemmifer (COPE)

Merycodus gemmifer COPE, 1874, p. 22.
Blastomeryx gemmifer, COPE, 1877, p. 350.

Type. — AMNH No. 8301; Pawnee Creek fauna (*fide* MATTHEW, 1924).

Blastomeryx cf. B. elegans MATTHEW & COOK

Referred specimen. — Pawnee Creek formation (Martin Canyon local fauna): Univ. Colorado Mus. No. 19837; right P^4-M^3. Nos. 9209, 9318, 9319, 9346; isolated upper molars. All specimens from NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

Isolated teeth of this form and of *Blastomeryx* cf. *B. medius* were numerous in the University of Kansas Quarry A at Martin Canyon.

Blastomeryx cf. B. medius MATTHEW

Referred specimen. — Pawnee Creek formation (Martin Canyon local fauna): No. 9316; left jaw with P_4-M_3; NE¼ sec. 27, T. 11 N., R. 53 W., Logan County.

Barbouromeryx pawniensis FRICK

Barbouromeryx pawniensis FRICK, 1937, p. 133.

Type.—F:AM No. 31290; two miles west of Mastodon Quarry, Pawnee Creek, Weld County, Colorado.

Dromomeryx pawniensis FRICK

Dromomeryx pawniensis FRICK, 1937, p. 115.

Type.—F:AM No. 31297; near Pawnee Buttes, Pawnee Creek, Weld County, Colorado.

The *Dromomeryx borealis* of the Pawnee Creek fauna (MATTHEW, 1924, p. 72) was referred to this species by FRICK.

Cranioceras pawniensis FRICK

Cranioceras pawniensis FRICK, 1937, p. 93.

Type.—F:AM No. 31294; middle horizon, west of Buttes, Pawnee Creek, Colorado.

FAMILY ANTILOCAPRIDAE GRAY, 1866

No merycodonts other than *Ramoceros osborni* were reported by MATTHEW from northeastern Colorado, and nothing identifiable, other than this same species, has been found by any University of Kansas party in beds of the Pawnee Creek formation.

Merycodus furcatus (LEIDY)

Cosoryx furcatus LEIDY, 1869, p. 173.
Merycodus furcatus, HAY, 1902, p. 683.

Meryceros warreni (LEIDY)

Cervus warreni LEIDY, 1858, p. 23.
Meryceros warreni, FRICK, 1937, p. 354.

Meryceros minor FRICK

Meryceros minor FRICK, 1937, p. 403.

FRICK (1937) has reported the above three species from northeastern Colorado. He gives no indication of the age of the beds except to state that they were late Tertiary.

Ramoceros osborni (MATTHEW)

Merycodus osborni MATTHEW, 1904, p. 107.
Ramoceros osborni, FRICK, 1937, p. 328.

Type. — AMNH No. 9476; middle Miocene (Pawnee Creek beds), northeastern Colorado.

Referred specimen. — Pawnee Creek formation (Vim-Peetz local fauna): No. 9183; left horn; W½ sec. 28, T. 12 N., R. 55 W., Logan County.

No. 9183 was removed from indurated, coarse, channel sandstone approximately 10 feet above the base of the Pawnee Creek formation.

THE PLIOCENE FAUNA

One early Clarendonian species of mammal is known from northeastern Colorado. Possibly some of the species assigned to the Barstovian faunas have a range in time extending into the Clarendonian, but until the Sand Canyon local fauna (*i. e.*, *Neohipparion coloradense*) is associated with a definite set of beds, little can be done about this problem.

The Kimball member of the Ogallala formation in northeastern Colorado has not yielded any fossil material.

CLASS MAMMALIA

ORDER PERISSODACTYLA OWEN, 1848

FAMILY EQUIDAE GRAY, 1821

Neohipparion coloradense (OSBORN)

Hipparion coloradense OSBORN, 1918, p. 183.
Neohipparion coloradense, HESSE, 1936, p. 62.

Type. — AMNH No. 9094; upper Pawnee Creek beds, Sand Canyon, Logan County, Colorado.

Attention has already been given to the problem of the locality and level of this specimen in the discussion of the Sand Canyon local fauna.

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