EARLY PLEISTOCENE PRE-GLACIAL AND GLACIAL ROCKS AND FAUNAS OF NORTH-CENTRAL NEBRASKA

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BULLETIN

OF THE

AMERICAN MUSEUM OF NATURAL HISTORY

VOLUME 148 : ARTICLE 1 NEW YORK : 1972

BULLETIN OF THE AMERICAN MUSEUM OF NATURAL HISTORY
Volume 148, article 1, pages 1–148, figures 1–60, tables 1–21

Issued July 10, 1972
Price: $6.25 a copy

Printed in Great Britain by Lund Humphries

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ABSTRACT

A STUDY of the early Pleistocene rocks of the non-glaciated region of north-central Nebraska shows that a paleovalley fill (Keim Formation, new name) that contained the Sand Draw local fauna was preglacial. The stratigraphic position of the overlying Long Pine Formation, new name, is significant because it is the first evidence of a fluvioglacial outwash in the area. Two later sets of deposits overlie the Long Pine Formation: Duffy and Pettijohn formations, new names. The source of the gravel in the Long Pine Formation has been a matter of conjecture, some geologists believing it to be the Black Hills, and others the Rocky Mountains. Supporting evidence for either provenience is lacking. Devonian fossils in the Long Pine Gravel indicate that the source was to the north-northeast near Lake Winnepegosis in Manitoba.

The Sand Draw local fauna, previously considered Nebraskan (first continental glacier) or Aftonian (first interstadial), correlates with other Blancan faunas, and is the most diverse and northern known of Blancan time. The following groups comprise the fauna: 42 taxa of molluscs, 14 taxa of ostracodes, 10 taxa of fishes (*Chaenobryttus serratus*, new species), four taxa of amphibians, 14 taxa of reptiles (*Geochelone oelrichi*, new species), at least 10 taxa of birds, and 35 taxa of mammals. The mammalian fauna has these new forms: a shrew, *Planisorex dixonensis*, new genus; four rodents, *Spermophilus boothi*, new species; *Spermophilus meltoni*, new species; *Ophiomys magilli*, new species; *Ophiomys fricki*, new species; and a mustelid, *Buisnictis burrowsi*, new species.

Some of these fossils indicate that the early Pleistocene climate was warmer than the present one, subhumid, with evapo-transpiration about equal to average annual precipitation. Presence of the large land tortoise, *Geochelone*, is evidence that the temperature seldom, if ever, dropped below 0°C. Pollen from the Keim Formation is definitely not of glacial type.

INTRODUCTION

MORRIS F. SKINNER

THE PRESENT REPORT deals with the early Pleistocene geology and paleontology of north-central Nebraska lying just north of the Sand Hills in Brown and Keya Paha counties. The area is important because it was peripheral to the first, or Nebraskan, continental glacial advance. The main objectives of this study are: (1) to present the complex geologic history of the early Quaternary sediments and to review briefly the local pre-Tertiary and Tertiary clastic sedimentary strata; (2) to define lithologically four new Pleistocene formations; (3) to describe the faunas from three of these formations, remains of which have been added to the Frick Collection from 1927 to 1969, and to the University of Michigan Collection from 1966 to 1968; and (4) to correlate these early Pleistocene faunas with faunas from chronologically equivalent deposits in the Great Plains. The age of these outcrops and their contained faunas has been the subject of past conjecture; some workers believed them to be pre-Nebraskan, some Nebraskan, and others Aftonian. Present stratigraphic and faunal studies point to a pre-Nebraskan and early Nebraskan age, times during which the fauna survived and presumably surmounted the vicissitudes of climate and sedimentary changes brought about by conditions associated with the advancing glacier.

Objectives of nearly equal importance are: (1) to indicate the probable source of the Long Pine gravel outwash; and (2) to show by geologic profiles that the present-day Niobrara River system and terraces were formed after the deposition of the early Pleistocene rocks and not during deposition, as some geologists have implied.

Childs Frick founded and directed the activities of the Frick Laboratory of the American Museum of Natural History. His interest in the Pleistocene began in 1916 and continued to be a major interest throughout his lifetime. The beginning of Pleistocene work in Brown County, Nebraska, started in 1927 when Frick commissioned J. H. Quinn and me to collect fossils. From that time to the present, annual studies and collecting on Pleistocene outcrops in the area have been carried out by my field assistants and me.

Claude W. Hibbard's first visit to the area was in 1948. Thereafter, he made many stopovers with University of Michigan field parties going to and from more western areas. Hibbard's primary interests were collecting molluscs and searching for Pleistocene outcrops that contained microvertebrates. During the summers of 1967 and 1968, Hibbard conducted University of Michigan field parties on collecting trips to various Pleistocene outcrops in the area. His sites and those that I established for the Frick Laboratory are described in the present paper. Hibbard and his party carried on intensive matrix washing programs to recover invertebrates and microvertebrates, so that all possible data could be gleaned from these deposits. In the summer of 1969 Hibbard and I restudied the Pleistocene geology of the area. The interpretation of the geology as it is presented herein has been greatly strengthened by our combined field work.

Eight orders of Mammalia are represented in the early Pleistocene deposits. Of equal interest are the pollen, molluscs, ostracodes, fishes, amphibians, reptiles, and birds. A biota of so varied a nature called for the collaboration of specialists on the flora, invertebrates, and lower vertebrates. Hibbard furnished the extensive mammalian studies, except for the horses, which I provided. Hibbard also prepared the section on the correlation, age, and paleoecology of the Sand Draw local fauna, in relation to other Blancan faunas.

Extensive studies were made by E. Gutentag on the ostracodes, Gerald Smith and John Lundberg on the fishes, Alan Holman on the amphibians and reptiles, and Alan Feduccia and Patrica Vickers Rich on the birds. Identifications important to the study of the area were made by Paul S. Martin and Roger Batten. Martin identified pollen in a matrix sample that was in direct association with the *Stegomastodon* Quarry fauna. Batten identified pre-Pleistocene invertebrates that furnished a clue to the source of the glacial outwash gravel sheet. I have prepared the section on the geology.

Detailed localities that are associated with stratigraphic sections, quarries, prospecting localities where faunas were collected, and washing sites have been placed in a separate list following the geology.

ABBREVIATIONS AND METHODS

The following abbreviations are used to designate institutional collections and localities:

AMNH, the American Museum of Natural History
AMNH(M), the American Museum of Natural History, Modern Mammals
BEG, Bureau of Economic Geology, The University of Texas, Austin
CIT, formerly the California Institute of Technology; collection now housed in Los Angeles County Museum
CM, Carnegie Museum
DWT, Dwight W. Taylor mollusc localities in Brown County, Nebraska
F:AM, Frick American Mammals, the American Museum of Natural History
FM, Field Museum (formerly Chicago Natural History Museum)
KU, Kansas University
KUMNH, Kansas University Museum of Natural History
TMM, Texas Memorial Museum=BEG, Bureau of Economic Geology
UF, University of Florida
UM-K, University of Michigan in Kansas locality
UM-KU, University of Michigan-Kansas University locality
UMMP V, University of Michigan Museum of Paleontology, Vertebrates
UMMZ, University of Michigan Museum of Zoology
UM-Nebr., University of Michigan in Nebraska locality
UNSM, University of Nebraska State Museum
USGS, United States Geological Survey
USNM, United States National Museum (National Museum of Natural History, Smithsonian Institution)
WT, West Texas
YPM, Yale Peabody Museum, Yale University,

In the course of fossil collecting in the Pleistocene deposits in Brown and Keya Paha counties, I have measured 72 stratigraphic sections, most of which were made before contour maps were available. Thicknesses of stratigraphic units were determined from Locke Level measurements. My standard practice was to start stratigraphic sections at the lowest point, water level where possible, and carry the section to the highest elevation in the local area. Pre-contour elevations thus established have now been referred to current contour maps. Formational contacts established by this method usually match within one contour interval.

The following United States Geological Survey Nebraska Quadrangles, 7.5 minute series (topographic), scale 1:24,000, were used for plotting data: Ainsworth, Ainsworth SW, and Ainsworth NW, 1954; Dutch Creek, 1949; Long Pine, 1954; Bassett NW, 1949; Meadville, 1948; Meadville NW and NE, 1964; Huddle Table, 1950; Springview, Springview SE and NW, 1964; Burton, 1964. United States Geological Survey Nebraska Quadrangles, 15-minute series (topographic), scale 1:62,500 for Norden, 1950, and Wood Lake, 1950, were used for the northern and western part of the study area.

ACKNOWLEDGMENTS

MORRIS F. SKINNER AND CLAUDE W. HIBBARD

In the course of this work assistance came from many people. We are deeply indebted to Childs Frick for his patronage and guidance and to the many field men in his employ who have assisted Skinner during the past 44 years. The following local residents of Brown County generously gave us access to their property: Messrs. Oscar Booth, Earl C. Burrows, Harold Duffy, Harold M. Johnson, Ray Keim, Clair Keim, Wilbur Magill, Carleton Pettijohn, Jr., Paul Plate, and Jack Robertson. Mr. Elmer Lucht gave us the use of his feed lot along Bone Creek for a matrix washing and drying area. Messrs. Dale Hall, Wiley Lentz, Wilbur Magill, and Alvin Quinn donated specimens for this study.

A National Science Foundation Grant (project GB-5450) provided funds for Hibbard to work in Brown County during the summers of 1967 and 1968 and for the services of research assistant William A. Akersten (who also assisted in the 1967–1968 field work) and Miss Alice R. Ballard (ARB), Mr. Marvin J. Schmid (MJS), and Mrs. Margaret S. Stevens (MSS), artists. Hibbard is indebted to the 1967 field crew, Messrs. Roger D. Willis, Orville Bonner, and Gerald P. Larson; and the 1968 field crew, Messrs. Robert K. Carr, W. Bruce Cornet, Jr., Ronald D. Oesch, R. Roger Pryor, Clifford J. Prentice, Jr., and Danny N. Walker. Members of the Department of Vertebrate Paleontology, the American Museum of Natural History, have shown many courtesies in the field and in the laboratory.

In the Department of Vertebrate Paleontology Dr. Bobb Schaeffer gave assistance freely throughout the work. We gratefully acknowledge his efforts and the care and concern of our colleagues. Dr. Richard H. Tedford read the several revisions of the geological, paleoecological and correlation sections; Dr. Malcolm C. McKenna read the manuscript in its entirety and Dr. Eugene S. Gaffney reviewed the section on the amphibians and reptiles; Mr. Ted Galusha, Mr. Beryl Taylor, Dr. Robert J. Emry, and Miss Marlyn Mangus made valuable suggestions which greatly improved the presentation. Mr. Ray Gooris prepared the geologic sections, maps, and correlation chart, and illustrated many of the fossil mammals. Mrs. Shirley M. Skinner aided in the preparation of the manuscript.

The following lent specimens under their care: Drs. R. G. Van Gelder and Sydney Anderson, the American Museum of Natural History; Drs. William A. Clemens, Jr. and Theodore H. Eaton, Jr., the University of Kansas, Museum of Natural History; Drs. W. H. Burt and Emmet T. Hooper, the University of Michigan, Museum of Zoology; and Mr. Walter W. Dalquest, Midwestern University of Texas. Acknowledgments are also found in the individual reports.

GEOLOGY

MORRIS F. SKINNER

PREVIOUS WORK

EARLIER WORK on the geology and paleontology of this area has been done by Lugn (1934, 1935), McGrew (1944), and Taylor (MS, 1958, 1960, and 1966).

In the course of statewide Pleistocene studies, Lugn and E. H. Colbert, members of the 1928 University of Nebraska field party, accompanied Quinn and me on reconnaissances of Brown County, covering both Pliocene and Pleistocene deposits. Lugn's (1934, 1935) observations of this area, which were intended to be preliminary, admittedly lacked detail, and in the light of later research needed clarification.

During the 1930's and early 1940's, Quinn, Bryan Patterson, and McGrew, then of the Field Museum of Natural History at Chicago, made brief visits to the area to prospect in the Pleistocene outcrops of Sand Draw, an intermittent stream bed north of Ainsworth, in Brown County. McGrew described the Sand Draw local fauna in 1944 and correlated it with Blancan faunas in the West and the Southwest. He noted the significance of this early Pleistocene area and its peripheral position to the more eastern glacial areas, equating the age of the deposits with the Aftonian interglacial period. In a later paper McGrew (1948) referred to all Blancan faunas as pre-Nebraskan, although he did not refer to the Sand Draw specifically.

In 1952 I collected from the Pleistocene of Brown County molluscs that I sent to Taylor (then a graduate student of Savage, University of California, Berkeley) for use in a section of his Master's thesis. This thesis, completed in 1954, was preceded by Taylor's own trip in 1953, for the purpose of investigating the stratigraphic relationships of these localities. He also collected more mollusc samples that he included in later invertebrate faunal reports (Taylor, 1958, 1960, 1966). In a paper on the late Cenozoic molluscan faunas from the High Plains, Taylor (1960) concluded that the molluscs indicated a transitional Nebraskan and Aftonian assemblage that lived under moderately cool summer conditions and that the large turtle (*Geochelone*) indicated warmer winters than those of present-day north-central Nebraska.

Fossils from the Brown County Pleistocene deposits are in the Frick Collection, the American Museum of Natural History, New York; the Field Museum of Natural History, Chicago; Illinois State Geological Survey, Urbana; Museum of Zoology and Museum of Paleontology, University of Michigan, Ann Arbor; University of Nebraska, Lincoln.

In addition to those authors already noted who have published on the Sand Draw local fauna are the following: Frick, 1933, 1937; Schultz, 1934; Osborn, 1936; Hibbard, 1956, 1957; Jehl, 1966; Fichter, 1970; Feduccia, 1970. The Sand Draw fauna and locality have been referred to in various guide books but no details have been given.

REGIONAL SETTING

Figure 1

The area discussed in this report covers about 800 square miles in north-central Nebraska in northern Brown and southern Keya Paha counties. The largest area of grassed-over sand dunes in North America borders the southwestern and southern part of the study area. The Sand Hills, as they are called, stretch from the Niobrara Valley southward to the Platte Valley in a nearly continuous expanse. Numerous freshwater lakes between the dune troughs are a striking feature of the sand-hill topography.[1] Smith (1965) made significant observations on dune shapes, climatic conditions, and ages.

The deeply entrenched Niobrara River bisects the study area. Tablelands south of the Niobrara

[1]The Sand Hills are the result of comparatively recent eolian erosion and probably represent a long late Wisconsin, or an early Holocene drought cycle. Pollen studies by Sears (1961) showed that Hackberry Lake in the Sand Hills has been in existence for about 5000 years.

River are further dissected by young headward eroding streams in deep canyons. Plum Creek flows north and then diagonally northeast to the river through the western part of the area; Sand Draw, an intermittent stream, trends northeasterly to join Bone Creek, a tributary of Long Pine Creek. On the eastern side of the area, Long Pine Creek flows almost straight north to the Niobrara River after leaving its partially pirated southeasterly trending headwaters.

The Niobrara River and its tributaries have cut through all the early Pleistocene rocks and the Tertiary (fig. 3A); therefore its entrenchment could not have preceded or even paralleled early Pleistocene deposition. The initial entrenchment of the Niobrara River started in medial Pleistocene. Piracies and diversions of minor headward eroding tributaries in the northern half of Brown County have profoundly changed the former east-trending drainage patterns to the present, extremely complex, north-trending pattern (fig. 2). Figure 2 illustrates only a small part of the late Pleistocene diversions that have occurred along the northern border of the state. The early Pleistocene filling and later entrenchment reflects regional conditions that involved the entire Missouri River Basin to the east, as well as the local elevations.

On the north side of the area a remnant of a former plain, locally known as the Springview Table, separates the Niobrara and Keya Paha rivers. On the south the Springview Table is dissected by small headward eroding streams in deep canyons that are cutting back from the Niobrara River. Gently graded valleys border the north side of the Springview Table and drain northward into the Keya Paha River. Outwash gravels from an early Pleistocene glaciation (Nebraskan), overlain by a thin mantle of Holocene soil, cover most of the Springview Table. The glacial lobe that was the source of these gravels lay almost due north. Although later glaciations did not directly affect this region, the results of such glaciations can be observed in the lower reaches of the Elkhorn Valley about 120 miles to the south and east, where Nebraskan and Kansan tills, as well as loess deposits, have been described by Frankforter (1950).

The greatest elevation in the area is 2820 feet on the sand dunes near the line between Brown and Cherry counties just north of Plum Creek (fig. 1, southwest corner of map). Elevational differences of stream drainages range from 1950 feet on the Niobrara River at the eastern Brown County line to 2700 feet on Plum Creek (fig. 1, southwest corner of map); this is a drainage drop of 750 feet in about 40 miles and explains, in part, the erosion that produced the deep canyon and exposures in the region. Long Pine Creek drops from 2380 feet at the Duffy type section (fig. 6) to 1930 feet at its junction with the Niobrara River, dropping 450 feet in about 18 miles, an average of 25 feet per airline mile.

PLEISTOCENE GEOLOGY: SUCCESSION OF EVENTS

Figures 1–3

In latest Pliocene time, the area that is now northern Brown and southern Keya Paha counties was a broad flat plain with gently degrading, shallow valleys, showing none of the present-day features, such as the Sand Hills or the Niobrara River drainage system and its tributaries, Plum, Long Pine, and Bone creeks (fig. 3A). These are manifestations of later events. Lugn (1934, p. 352; 1935, pp. 193–195) thought that the Niobrara River drainage system was in existence in early Pleistocene. The stratigraphy as it is now known does not substantiate this belief.

During latest Hemphillian or earliest Blancan time, valley incision of a dominant drainage system (hereafter referred to as the Keim paleovalley) was completed. Substantiating data for a post-Hemphillian assignment are found in the faunas derived from beds exposed in the Deep Creek drainage at Bear Tooth Slide (a field locality term, see fig. 4), and in outcrops on the eastern side of Long Pine Creek, immediately opposite the mouth of Rattlesnake Gulch.

Streams in the Keim paleovalley were running primarily on middle Pliocene rocks, specifically on the Cap Rock Member of the Ash Hollow Formation. The Keim paleovalley had a broad trunk river with an approximate gradient of 10.4 feet to the mile (fig. 3C). Since no swift water channel deposits are found, the

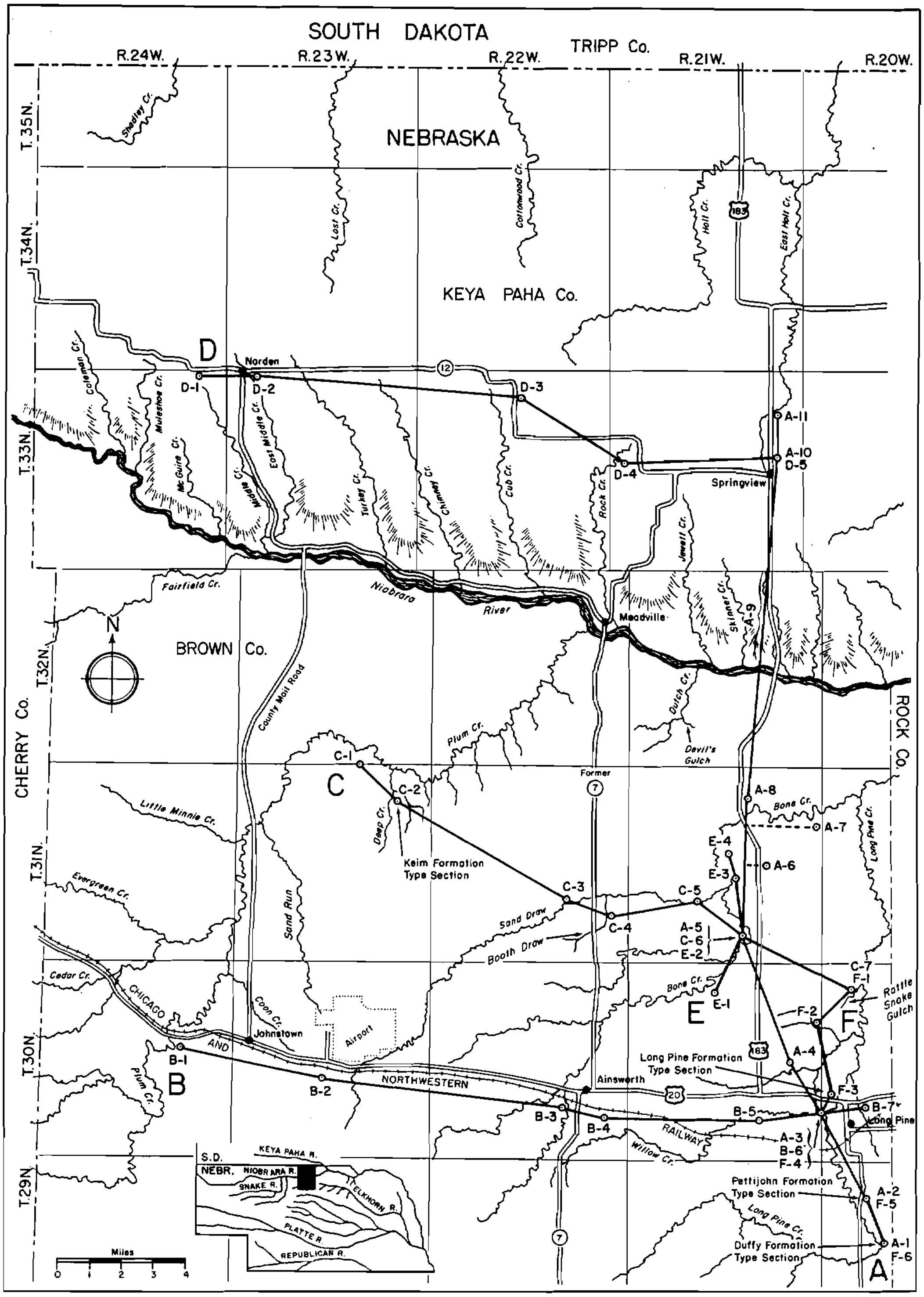


FIG. 1. Map of northern Brown and southern Keya Paha counties in north-central Nebraska, showing locations of profiles A–F in figure 3.

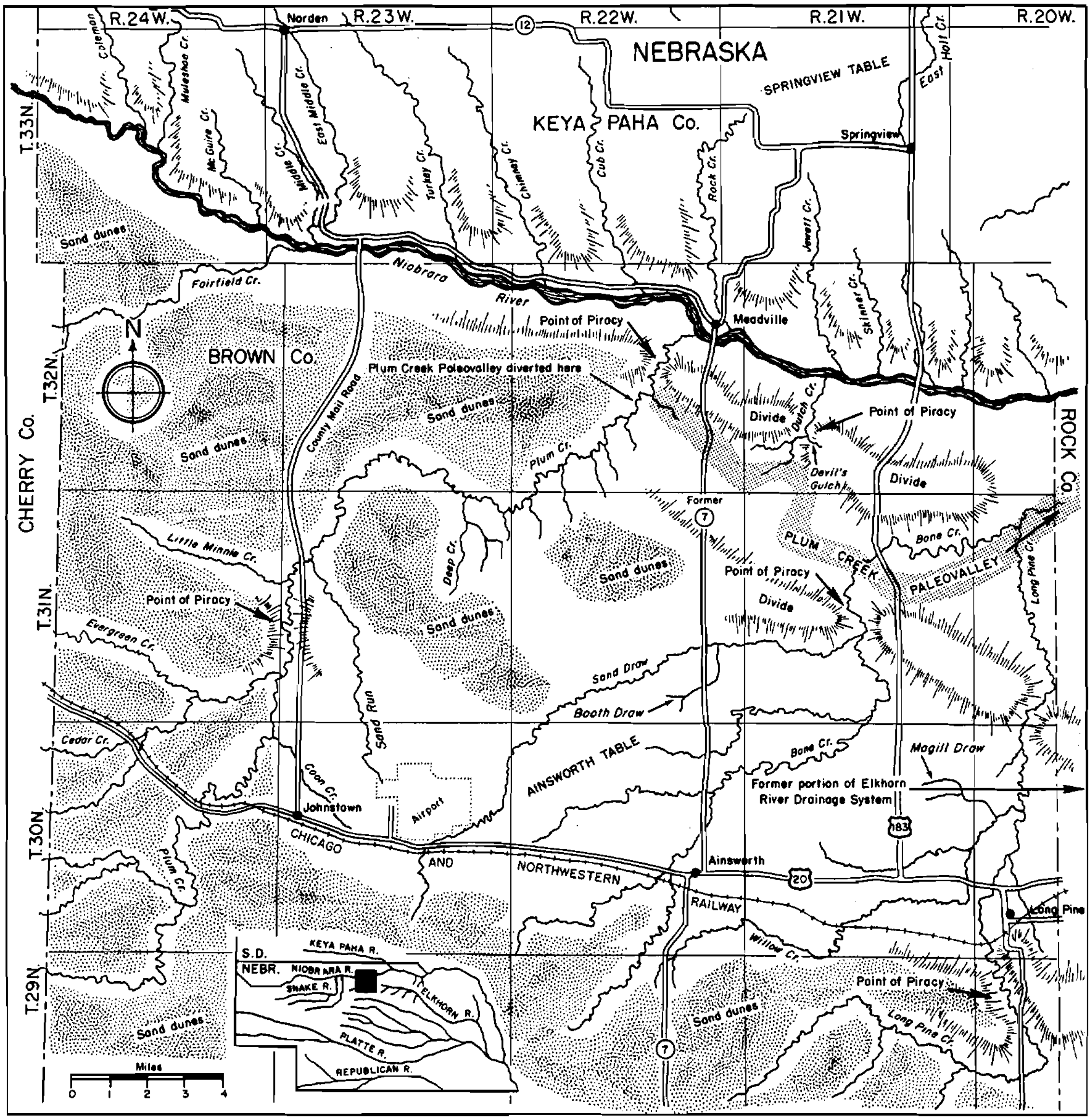


FIG. 2. Map of parts of Brown and Keya Paha counties in north-central Nebraska, showing points of stream piracies and diversions, and the Plum Creek paleovalley in post-medial Pleistocene. Note Recent dune areas.

competence of the stream, except during periods of flood water, was apparently insufficient to carry particles greater than fine sand and silt. Small clasts derived from the Ash Hollow Formation are included in some of the basal channels, but no igneous pebbles or Rocky Mountain gravels have been found.

Events related to the beginning of continental glaciation (i.e. Nebraskan) probably initiated aggradation in the Keim paleovalley. Increased plant growth, a greatly increased stream load, decreased rainfall, valley obstruction to the east, or any number of unknown events may have triggered the aggradation cycle. We know that the elevations of the present-day contacts between the overlying fluvioglacial gravels (Long Pine Formation, new name, see page 24) and the deposits that filled the Keim paleovalley indicate gentle gradients. As the gradient of the paleovalley was reduced, meanders formed that could have produced oxbow lakes filled with fine sand, carbonaceous silts, and clays. When filled (based on present elevations) the Keim paleovalley gradient was about 6.7 feet per mile versus the original 10.4 feet per mile (fig. 3C) before filling. These gradients are based on the elevations of the contacts as they exist today. We have no way of knowing how much, if any, regional uplift took place during the later part of the Pleistocene. The entrenchment of the Niobrara River, however, suggests that uplift has taken place. (See also Smith, present paper, pp. 52–54). This entrenchment may also be associated, in part, with the downcutting of the Missouri River system during the later part of the Pleistocene, thus leaving regional uplift and downcutting or a combination of both as cause for the entrenchment. The landscape probably resembled the present, little-dissected, broad Elkhorn Valley south of the towns of Atkinson and O'Neill, Nebraska.

The first evidence of continental glaciation in northern Brown and southern Keya Paha counties is the fluvial gravel sheet (Long Pine Formation, new name, p. 24) that completely covered the deposits in the Keim paleovalley and the bordering Pliocene uplands (fig. 3A–D). The southward extent of this gravel sheet is unknown, but it has been recognized in stock and irrigation wells in undissected hay flats south of the heads of Bone and Long Pine creeks where it underlies the edge of the Sand Hill belt. The gravels extend eastward and northward beyond the study area.

An interstadial phase of the first glaciation may be represented by the deposits of fine brown sand, silt, and clay, from 30 to 70 feet thick, that immediately overlie the gravel sheet. This deposit (Duffy Formation, new name, p. 28) is overlain by another thin gravel sheet (Pettijohn Formation, new name, p. 29) that is only locally preserved within the area. This last gravel sheet extends eastward in Rock County along the south side of the Elkhorn Valley and beyond for an unknown distance, and may also be related to the first period of glaciation, or may represent a later event. Faunal evidence for the age of the last gravel sheet is lacking, but a few fossils have been collected from the first gravel sheet and from the intervening fine sediments. No soils or tills have been observed in the entire sequence.

Long after the deposition of these early Pleistocene sediments, the Niobrara River drainage system was initiated (fig. 3A), and still later an extremely dry cycle resulted in the present configuration and deposition of the latest Wisconsin, or early Holocene Sand Hills that lie to the south and west of the study area. Rare examples of giant beaver (*Castoroides*), dire wolf, and mammoth have been found only in the upper terraces of the Niobrara River and the Plum Creek paleovalley (figs. 2, 3A). Much of the relief of the present eastern Niobrara River drainage basin has been developed since about Illinoian time. Except for the Sand Hills, this region has generally undergone degradation since the early Pleistocene events that took place just before and during what is now called the Nebraskan glaciation. The Pearlette Ash, which is widespread to the south in Kansas and in eastern Nebraska, has never been found in this part of north-central Nebraska.

The present drainage is highly complicated by stream piracy, as shown by the diverted drainages along the northern border of Nebraska. The deeply entrenched Niobrara River and its headward eroding tributaries have captured the shallow, formerly southeast-trending drainages and diverted them northward where they are now deeply entrenched within the area (fig. 2). This later stream erosion has made it possible to examine the earlier Pleistocene formations, to collect their contained fossils, and to determine the topography of several ancient land surfaces upon which later formations were deposited.

The cause of entrenchment of the Niobrara River has multiple explanations such as: (1) regional uplift, (2) increased development of the Missouri River system during the late Pleistocene, and (3) change in overall rainfall to the west. The stream piracy now taking place is clearly a late development. Many of the diversions occurred after the events that resulted in the sand dunes.

STRATIGRAPHY

PRE-QUATERNARY DEPOSITS ALONG U.S. HIGHWAY 183 NORTH OF THE NIOBRARA RIVER

Figures, 1, 3A

Sedimentary rocks that crop out in the report area range in age from Cretaceous through Pleistocene. Cretaceous rocks, as well as Miocene and Pliocene deposits, are found along the Niobrara River, at the mouth of Plum Creek, and along Long Pine and Bone creeks. Road cuts on the north side of the Niobrara River along U.S. Highway 183 in sections 2, 11, 14, T. 32 N., R. 21 W., southern Keya Paha County, Nebraska, afford one of the better opportunities to examine the stratigraphic sequence of the Cretaceous Pierre Shale and the later Cenozoic deposits. A continuous set of outcrops extend north and south for about 3 miles along the highway and permit a detailed examination and description of each lithologic unit.

CRETACEOUS SYSTEM

PIERRE FORMATION

A maximum of 180 feet of Pierre Shale is exposed at the U.S. Highway 183 locality. Thin, limy concretionary zones show that the beds dip slightly, but outcrops are not extensive enough to determine the strike, and no attempt was made to determine the exact degree of the dip. This outcrop and others near Meadville,[1] some 6 miles upriver to the west, show that the surface formed on the Pierre Shale in pre-Tertiary time had over 100 feet of relief locally, and was usually overlain by the early Miocene Rosebud Formation (as defined by Skinner, Skinner, and Gooris, 1968).

TERTIARY SYSTEM

Oligocene

CHADRON FORMATION

At the Highway 183 site just north of the Niobrara River, the Pierre Shale Formation is overlain by an outcrop that is lithologically referable to the Chadron Formation; on the Chadron, in direct superposition, is the Rosebud Formation. This outcrop (one of the most easterly occurrences of a Chadron outlier known was brought to my attention by Vincent H. Dreeszen, Nebraska State Geologist, soon after the highway was constructed in 1955. At that time he believed the entire outcrop was Brule Formation, whereas I believed that it was Rosebud Formation. Subsequent work at Turtle Butte, about 22 miles north-northwest, shows that both Chadron and Rosebud formations are in superposition on the west end of Turtle Butte and are similar in lithology to their presumed equivalents along Highway 183 (Skinner, Skinner, and Gooris, 1968).

The Chadron Formation at the Highway 183 site is a yellowish buff clay with brown iron oxide-stained zones interspersed with purplish red stains that suggest a condition similar to the Interior paleosol at the top of the Pierre Shale as developed in the Big Badlands. The major part of this outcrop is composed of greenish gray, black manganese-stained, semi-bentonitic clay that peels and cracks on the surface and has the characteristic clear quartz sand grains. A few waterworn pebbles of brown ironstone and fossil fragments, identifiable only to class Mammalia, were found just above the Chadron-Pierre contact. A small number of atypical rockrose crystals are present in the outcrop. The next closest outlier of Chadron rocks that is well enough exposed for lithologic allocation is about 25 miles northwest in the Keya Paha River Valley just north of the Millboro post office, but within sight of the Turtle Butte.

Miocene

ROSEBUD FORMATION

The fine-grained, horizontally bedded, pinkish tan to gray siltstones of the Rosebud Formation are easily distinguished from the gray-green rough-weathering, mineral-stained clay of the Chadron Formation. Two adjacent outcrops along Highway 183 on the hill just north of the Niobrara River, show more than 75 feet of Rosebud Formation. The lower outcrop is composed of fine, tan to pinkish gray, horizontally bedded, sandy siltstone that grades to a browner color, and has more crumbly weathering and a slightly coarser texture toward the top. The uppermost outcrop grades from a browner

[1] Meadville is a former post office and unincorporated village on the north side of the Niobrara River in the north half of the SW. ¼, sect. 12, T. 32 N., R. 21 W., Keya Paha County, Nebraska.

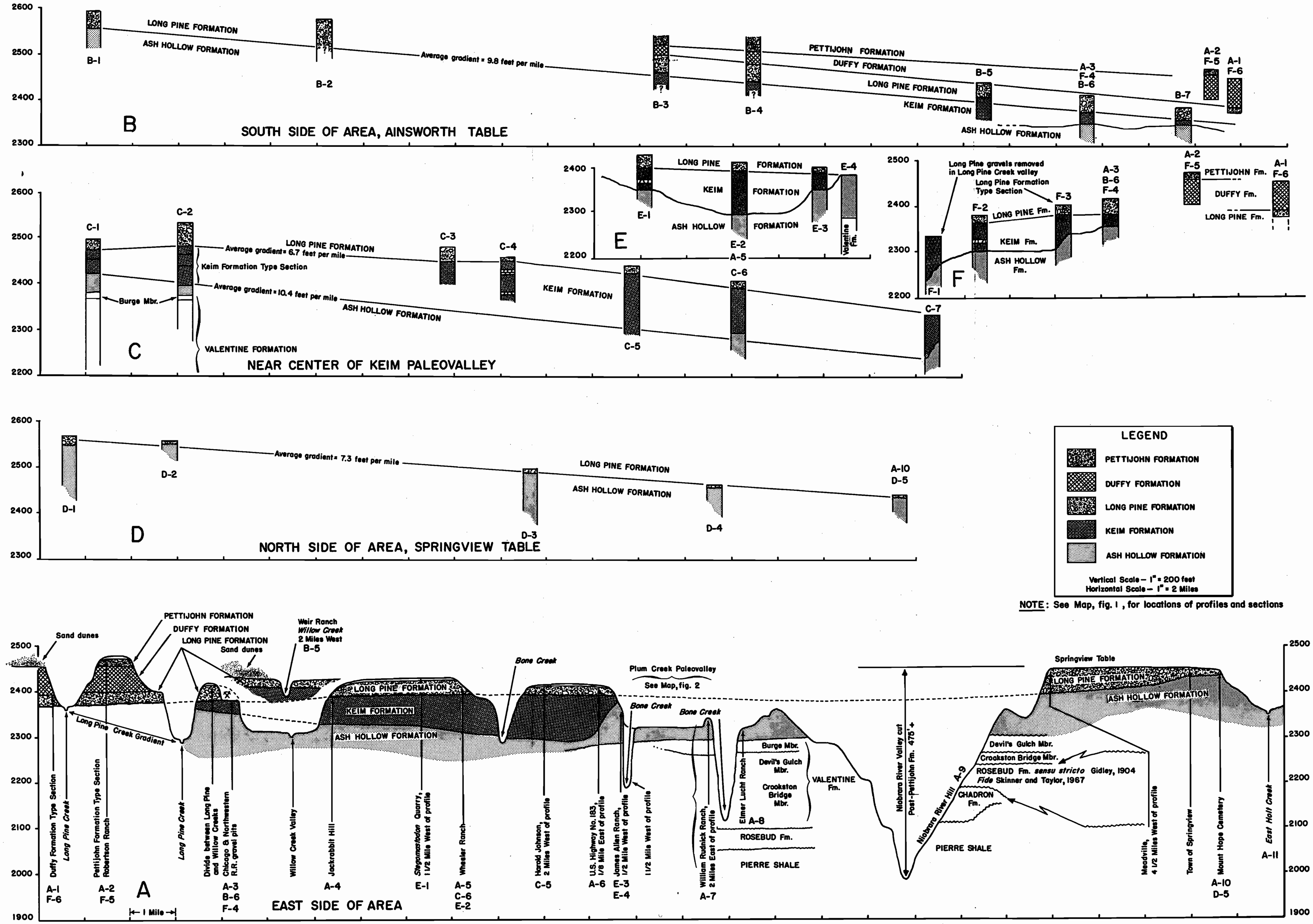


FIG. 3. Profiles showing relationship of early Pleistocene deposits to older beds. Profile A, present topographic relief in relation to the geology. Profile B, south side of area, Ainsworth Table. Profile C, near center of Keim Paleovalley. Profile D, north side of area, Springview Table. Profiles B, C, and D illustrate northwesterly-southeasterly gradient. Profiles E and F show north-south relief of Keim Paleovalley.

colored siltstone to a greenish yellow harder siltstone toward the top.

In north-central Nebraska and south-central South Dakota the Rosebud Formation usually is observed in direct superposition on the Pierre Shale; therefore, the outcrop on Highway 183 is interesting because halfway up the hill the Rosebud Formation is superposed directly on the Chadron Formation, with an abrupt local erosional relief of 25 feet. During post-Chadronian at this locality, a period of erosion may have removed the Brule Formation (presupposing it had been present) before Rosebud rocks were deposited. The fine tan siltstones of the Rosebud Formation can be seen lapping against and over a former hill (erosional remnant) composed of Chadron rocks. The extent of pre-Rosebud erosion around the former hill is unknown. A recently formed wash on the east side of the highway shows that less than 3 feet of Chadron Formation is left above the Pierre Shale at the deepest part of the local relief. The Nebraska State Highway Department has an extensive borrow pit in the Rosebud Formation here.

On the Rudnick ranch (fig. 3A), about 5½ miles south in the valley of Bone Creek, the Rosebud Formation, resting on the Pierre Shale, is 100 feet lower in elevation than on the Chadron Formation at the Highway 183 site. A maximum of 90 feet of Rosebud Formation is present along Highway 183; at Meadville about 6 miles west along the Niobrara River where the Rosebud Formation also rests on the Pierre Shale, there is at least 190 feet. This set of deposits has been mapped on the 1969 "Geologic Bedrock Map of Nebraska" (Nebraska Geological Survey) (Burchett, 1969) as Oligocene. I think this is an error. The Rosebud (early Miocene) is well exposed from Long Pine Creek west as far as the Cornell Dam just northeast of Valentine. These outcrops resemble closely the Rosebud sediments in the type area where they overlie the Oligocene (Chadron and Brule formations).

Pliocene

Valentine Formation

On the hill north of the Niobrara River along Highway 183, the upper part of the Rosebud Formation grades from fine tan silts to a greenish yellow hard siltstone that is about the same color as the overlying Valentine Formation. Therefore, the erosional contact between the Rosebud and Valentine formations is not so distinct as it is between the Chadron and Rosebud formations, although the hiatus is greater. Evidence of the deposition of Brule, Gering, Monroe Creek, and Harrison formations is completely lacking in the study area; these formations were deposited in southwestern South Dakota and western Nebraska.

The Rosebud and Valentine formations, in spite of color similarity, are easily separated by weathering and other lithologic characteristics. At the Niobrara River hill site, the lower part of the Valentine Formation is a fine, gray to yellowish well-sorted sand with scattered cemented spots. I believe this deposit represents the uppermost part of the Crookston Bridge Member. In turn, this set of rocks grades upward into the finer yellowish clay-filled sand of the Devil's Gulch Member of the Valentine Formation.

The best and most typical examples of the Valentine Formation on Highway 183 are 5½ miles south of the Niobrara River. Outcrops along a road cut on the north side of the Bone Creek hill on the Lucht ranch show the loose unconsolidated sand of the Crookston Bridge Member overlain by the yellowish clay-filled sand of the Devil's Gulch Member, which in turn is unconformably overlain by the loose sand and small gravels of the Burge Member of the Valentine Formation. In the early 1950's the Frick Laboratory developed a quarry in the Burge Member at this spot that produced more than 700 mammalian specimens. Lucht Quarry, as it is called, now lies buried under the center of Highway 183.

In the vicinity of Bone Creek, post-Rosebud erosion had developed a topographic relief of at least 100 feet before the Valentine deposition was started. Consequently, the elevation of the Rosebud-Valentine contact is not only 100 feet lower on Bone Creek than on the Niobrara River hill but also the Crookston Bridge Member of the Valentine Formation is about 100 feet thicker on Bone Creek than on the Niobrara River hill, approaching the thickness usually observed.

Ash Hollow Formation

The Cap Rock Member of the Ash Hollow Formation is widespread over the study area, and, as the name implies, is a resistant, well-cemented gray-weathering rock unit that usually forms the rims of canyons along the entrenched streams. The thickness of the preserved part of the Ash Hollow Formation above the Cap Rock is variable for it has been subjected to erosion at various times since Clarendonian (medial Pliocene). Little evidence is left of the post-Clarendonian erosion except for local, deeply incised fluvial cuts filled with later channel deposits, such as that illustrated on the Deep Creek section (fig. 4).

The Cap Rock Member is separated from the underlying Valentine Formation (either the Devil's Gulch or the Burge members) by an erosional unconformity. Biostratigraphic evidence indicates that the hiatus represented by this unconformity was of short duration. Weathering and erosional characters are particularly well shown at the Bone Creek site on Highway 183 where the Cap Rock forms the rim of the entrenched Bone Creek and crops out on the divide between the creek and the Niobrara River.

The regional dip and strike of the base of the Ash Hollow (strike: 22° east of north; dip: 8.45 feet per mile) bears a general relationship to the early Pleistocene drainage pattern before later Pleistocene piracies of the Niobrara River system took place.

QUATERNARY

Pleistocene Deposits

KEIM FORMATION, NEW NAME

Type Section: The type section is on the west fork of Deep Creek in the E. ½, sect. 11, T. 31 N., R. 23 W., Brown County, Nebraska (figs. 1, 4). A new name, Keim Formation, is used for a sedimentary rock unit composed of fine sand, silt, clay and limestone of latest Pliocene or earliest Pleistocene (pre-Nebraskan) age that unconformably overlies the Pliocene Valentine and Ash Hollow formations, and is unconformably overlain by the Long Pine Formation, new name (Nebraskan). The type locality is on the Ray Keim ranch and the formation is named after the Keim ranches in the type area, as shown on United States Geological Survey Quadrangle sheet, Ainsworth NW, 1954 ed., 7.5 minute series. Mr. Frank Keim (deceased), his sons, Ray and Clair, have extended every courtesy to those who have reconnoitered their land for geologic studies and fossil collecting.

A new name has been assigned to these deposits because they are lithologically unlike any other sedimentary rock unit of this age in Nebraska and southern South Dakota.

Lithologic Characters: The Keim Formation is made up of fine sand, silt, soft, black carbonaceous lake clay and silts with many fresh water shells and limestones, some well-sorted clean quartz sand channel deposits, occasional clay beds, and some sandstone. Only a few clasts larger than sand grains are included in the matrix. Where exposed, the base of the formation (often stained tan to reddish tan) rests with erosional unconformity upon either the Valentine or Ash Hollow formations, depending on the location of the outcrop within the paleovalley. The black carbonaceous silt with freshwater shells was deposited in numerous swamps or small lakes. In some places the carbonaceous clay and silt grade laterally into soft freshwater limestone, and in other places into clean, fine quartz sand, a condition illustrated in the section for Booth Draw (fig. 5). The sediments in the vicinity of the *Stegomastodon* Quarry are similar, but here the black carbonaceous silts grade laterally into a pure white diatomite.

Extent and Distribution: During its formation, the paleovalley, which was later filled with Keim Formation, was the dominant drainage system of northern Brown County with an average gradient of 10.4 feet per mile. This figure is based on current elevations (fig. 3C). The Keim Formation that filled the paleovalley is 6 to 7 miles wide in places and extends for at least 20 miles northwest-southeast (fig. 7). Only by closely spaced drill holes could the Keim Formation be traced beyond the outcrop area, and no such project has been attempted. Westward extensions of the Keim Formation in the canyons of the Niobrara River have not been found.

The base of the Keim paleovalley can be observed in outcrops in the canyons of Deep and Plum creeks, the lower part of the Sand Draw, Bone and Long Pine creeks, and their tributaries. The formation is thickest on the Harold Johnson ranch (fig. 3C-5) 1½ miles above the mouth of the Sand Draw in the NW. ¼, NE. ¼, sect. 29, T. 31 N., R. 22 W., Brown County, where 132 feet of Keim Formation is exposed.

The northern border of the Keim paleovalley shows exceptionally well in outcrops along Bone Creek valley on the James Allen ranch north of the junction of Sand Draw and Bone Creek (fig. 3E-3, E-4). Within the limits of sections 21 and 22, T. 31 N., R. 21 W. (fig. 1), Brown County, the Valentine and Ash Hollow forma-

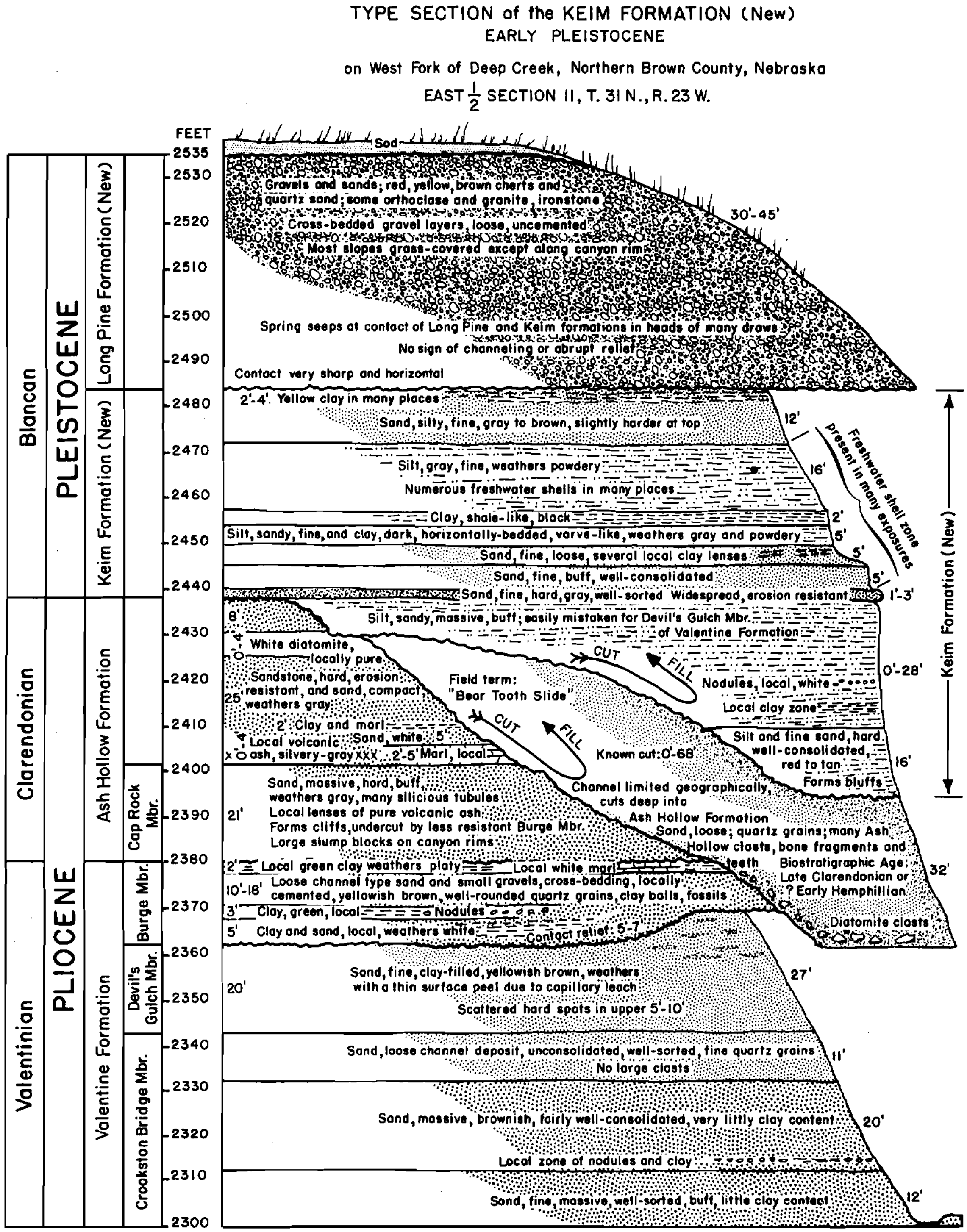


FIG. 4. Stratigraphic section of sediments on the west fork of Deep Creek, the type locality for the Keim Formation, new name, showing relationship of deposits referred to the Pliocene. See also figures 3C-2 and 7.

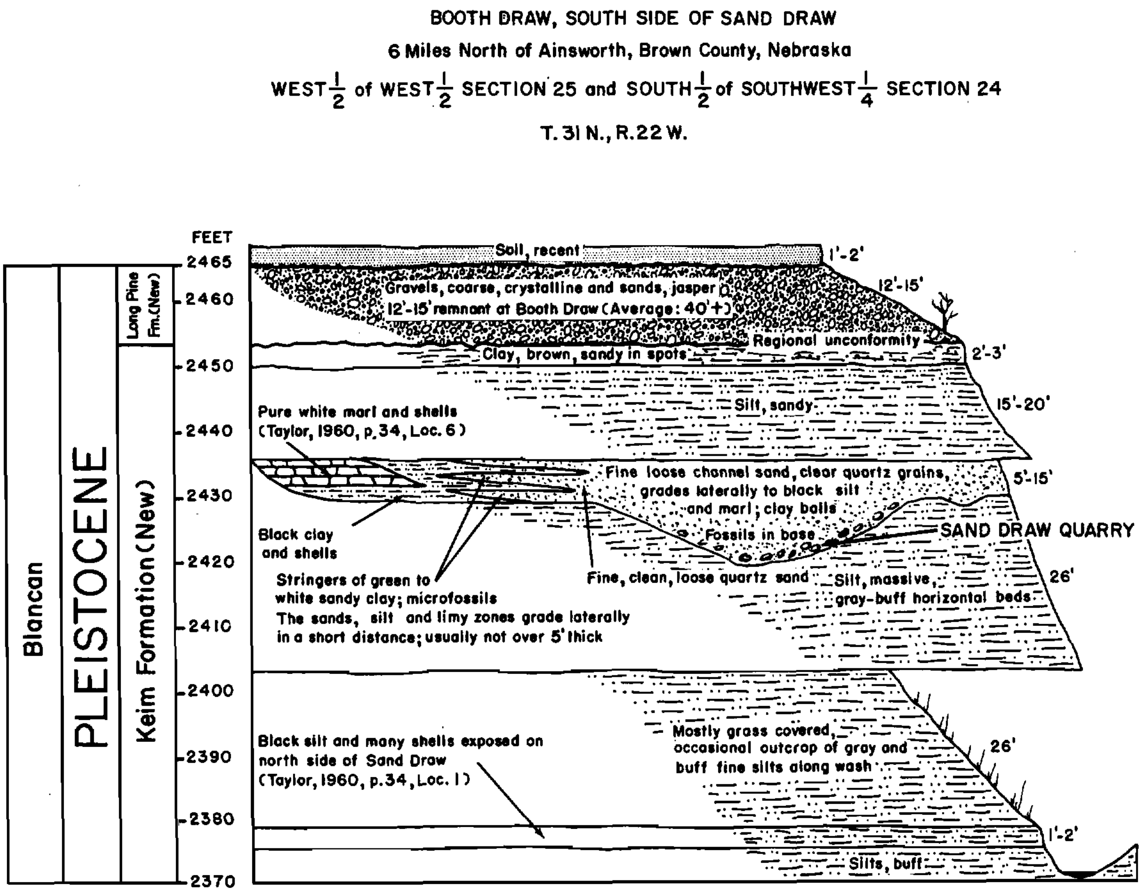


FIG. 5. Stratigraphic section of Pleistocene exposures in Booth Draw on the south side of the Sand Draw, showing interfingering, lateral facies, superposition and elevations of beds within the Keim Formation. This is the main source of McGrew's (1944) fauna. See also figure 7.

tions compose the north wall of the Keim paleovalley. Southward, the Ash Hollow Formation and part of the Valentine Formation have been eroded away and replaced by 100 to 130 feet of the Keim Formation. The southern border of the paleovalley in which the Keim Formation was deposited is exposed along the valley walls of the recent drainages of Willow and Long Pine creeks west and south of the town of Long Pine. Some of the most accessible outcrops are along road cuts of U.S. Highway 20 just north of the town of Long Pine, where the type section of the Long Pine Formation, new name, can also be seen. It is here that the Keim Formation thins rapidly and is overlain by the Long Pine Gravel.

The surface of the paleovalley containing the Keim Formation was of generally low relief, with a few places of bold relief, some of which can be seen in outcrops on Willow Creek, Rattlesnake Gulch, and along tributaries of Long Pine Creek where the most eastern outcrop of the Keim Formation is exposed. A broad trunk river with an even flow and meanders that produced oxbow lakes probably carried the fine sand and silt of the Keim Formation.

FOSSIL LOCALITIES: The following localities are in Brown County, Nebraska:

Booth Draw and the Sand Draw Quarry (figs. 3C-4, 5, 7): Booth Draw is a short south-trending tributary of the Sand Draw originating on the Oscar Booth ranch 5 to 6 miles north of Ainsworth. Outcrops of the Keim Formation have yielded a significant fauna from this area. In 1948 I located a small concentration of fossils in a channel deposit in the upper part of the Keim Formation, on the east side of Booth Draw (E. C. Burrow's ranch), in the southeast corner, NW. ¼, NW. ¼, sect. 25, T. 31 N., R. 22 W. I named this concentration the Sand Draw Quarry. This quarry is about a quarter of a mile north of the outcrops shown on McGrew's photograph (1944, fig. 14), in his report on the Sand Draw fauna, which was principally collected from the Keim Formation on Booth Draw. Two mollusc localities reported by Taylor (1960, p. 34) are in this immediate vicinity. I collected the samples for Taylor's Locality 1 from 59 feet lower in the Keim section than those from Taylor's Locality 6 (fig. 5).

The *Stegomastodon* Quarry (figs. 3E-1, 7): This quarry is in the southwest corner, SW. ¼, SE. ¼, sect. 4, T. 30 N., R. 21 W., about 4½ miles northeast of Ainsworth, in a small tributary draw or drainage way, about one-eighth of a mile south of Bone Creek. Most of the fossils were collected from a very black carbonaceous silt in the Keim Formation (fig. 3E-1), where they apparently accumulated in a swamp or peat bog. The silt deposit grades laterally to a clean, well-sorted loose channel sand to the west, whereas 100 yards down the draw to the north the silt grades to a nearly pure white diatomite.

Part of the fossil-producing matrix and the sand and diatomite rest directly on Pliocene rocks. The stratigraphic placement of the fauna would be difficult to determine without the profiles (fig. 3A, C, E) which show that the quarry assemblage accumulated during the later phases of Keim deposition.

James H. Quinn and J. Furneau discovered the *Stegomastodon* Quarry in 1933 and turned it over to me, as Frick was then studying proboscideans. I collected the type of *Stegomastodon primitivus* Osborn, an uncrushed skull (F:AM 25000) from the clean well-sorted sand lateral to the carbonaceous silt, and also constructed the quarry map published by Osborn (1936, fig. 676). Other skulls, mandibles, and postcranial elements of *S. primitivus* from the quarry were crushed and flattened by the compression of the black, greasy, carbonaceous silt that surrounded them. A sample of matrix from around one of these crushed skulls was sent to Paul Martin for pollen analysis (see p. 36 this paper).

Magill Ranch or Prospecting Locality 278 (figs. 3F-2, 7): This site is named for the former owners, Lee Magill (deceased) and his son Wilbur, whose interest served to add important specimens to the collections. The current owners, Mr. and Mrs. Paul Plate, have generously permitted us to continue our work in the area. The Magill Ranch locality is on a small, tributary wash extending northwest from its junction with Willow Creek, 2½ miles north and one-fourth of a mile west of the town of Long Pine, in the NW. ¼, SE. ¼, sect. 12, T. 30 N., R. 21 W., eastern Brown County. Outcrops along the wash consist primarily of Keim Formation overlying Pliocene rocks, and are overlain by the Long Pine Gravel. Here the base of the Keim Formation (a red sandy clay) is well exposed, and is in erosional contact with the Ash Hollow Formation, which is overlain by a loose sand channel, from which I collected a *Stegomastodon* skull. Directly overlying this channel is a bed of freshwater, carbonaceous, white-weathering clay that grades, in places, to pure limestone (fig. 3F-2). This clay has also been the source of a well-preserved example of *Equus* (*Dolichohippus*) *simplicidens* and numerous microfossils (UM-Nebr. 3–67). Although the Keim Formation is only 55 feet thick at this locality, it has yielded many fossils, probably because it has undergone rapid erosion from seasonal freshets at this site.

Other fossil sites in the Keim Formation are isolated prospects. Localities for these are given in Systematics with the specimens and in the detailed list of locations (pp. 30–35).

LONG PINE FORMATION, NEW NAME

Type Section: The type section is in the NW. ¼, sect. 30, T. 30 N., R. 20 W., Brown County, Nebraska (figs. 6, 7), along road cuts on both sides of U.S. Highway 20, where it crosses Long Pine Creek northwest of the town of Long Pine. I apply the formal name, Long Pine Formation, to an early Pleistocene (Nebraskan) sedimentary rock unit, composed of cross-bedded sand and gravel, resting unconformably on either the Keim Formation (latest Pliocene or earliest Pleistocene pre-Nebraskan), or upon the Ash Hollow Formation, medial Pliocene. The Long Pine Gravel is overlain by a deposit of fine sand and silt, also of early Pleistocene (Nebraskan) age. I have used the name Long Pine Gravel as a field term since the late twenties. (See United States Geological Survey, Long Pine Quadrangle, 7.5 minute series, topographic, 1954 edition.)

The Long Pine Gravel has not been correlated lithologically with gravel sheets in eastern Nebraska and southeastern South Dakota. Profiles showing the relationship between the Long Pine Formation and the underlying Keim or Ash Hollow formations demonstrate the stratigraphic sequence and permit an interpretation of early Pleistocene (Nebraskan) near glacial faunas.

LITHOLOGIC CHARACTERS: The Long Pine Formation is composed of unconsolidated, moderately coarse sand and gravel, with pebbles up to 3 inches in diameter. Most of the sand is composed of chert and quartz grains transported and sorted by water. Larger pebbles are mostly jasper and harder secondary rocks, such as clay ironstone, but well-rounded pebbles of granite, orthoclase, and sandstone are also present. The sheetlike nature of the Long Pine Formation suggests that it was a fluvioglacial outwash. None of the phenomena commonly associated with a terminal moraine, such as glacial erratics and till, has been observed in the area. Eighty miles east in Knox County, till and scattered glacial erratics of probable Nebraskan age are present (Lugn, 1935, pp. 62–63).

Fresh outcrops of Long Pine Gravel show a sequence of cross-bedded sand and gravel from the base to the top. Coarser gravel lenses occur haphazardly throughout the sheet, suggesting a fluvial fanlike outwash from a continuous buildup. During the 1940's when the Chicago and Northwestern Railroad Gravel Pit (just south of the type section) was being quarried, I observed compact, greenish clay lenses up to 3 feet thick or more and up to 100 feet long. These lenses occurred at various levels within the gravel sheet, and were sharply defined with very little or no interfingering. If such a lens were encountered in a drill cutting, it would certainly alter the interpretation of the Long Pine Formation, and suggest that more than one gravel sheet was present.

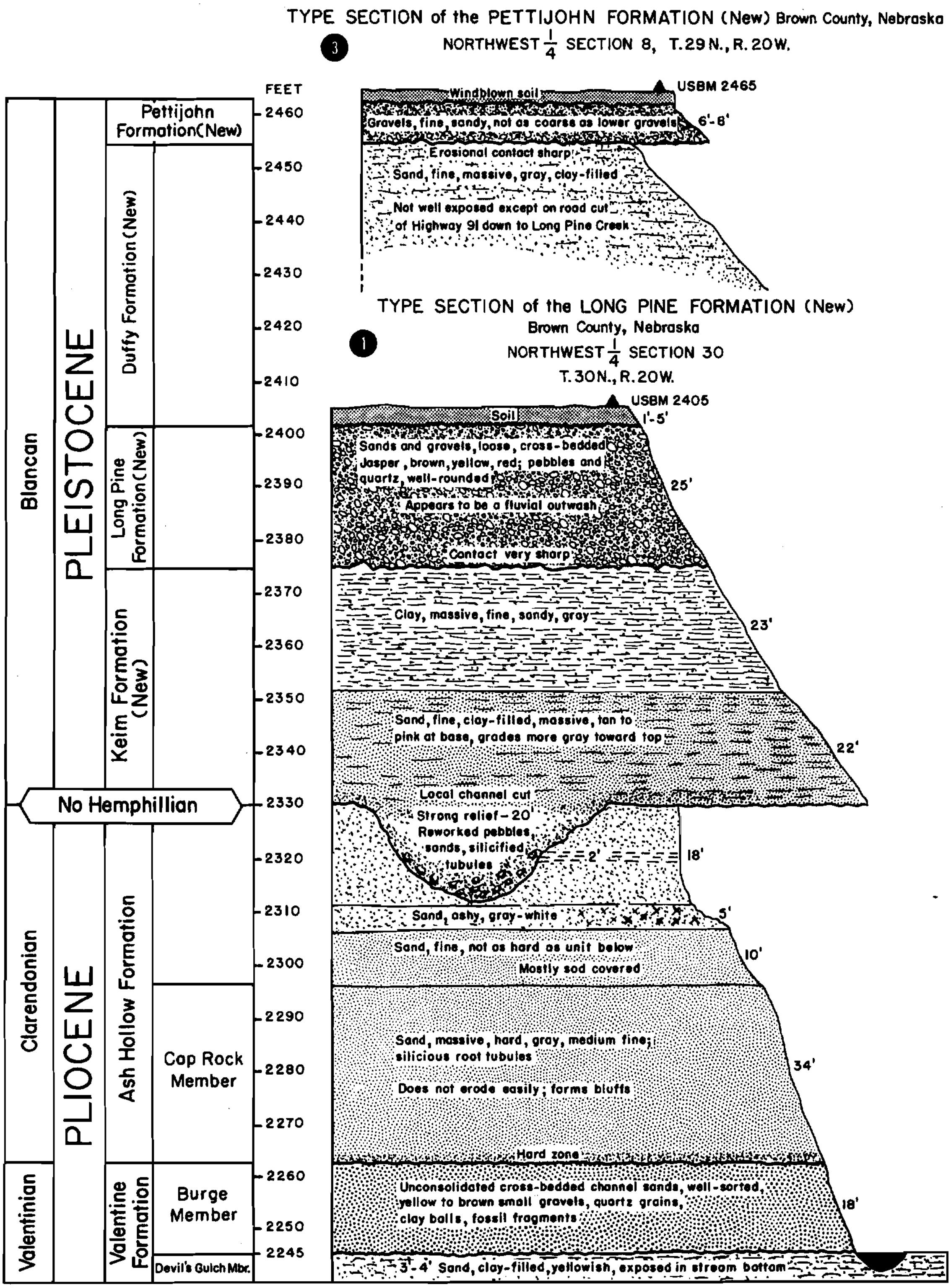
EXTENT AND DISTRIBUTION: The Long Pine Formation is present over most of the northern part of Brown and southern Keya Paha counties, but it thins rapidly to the west and seldom is observed west of eastern Cherry County, Nebraska. The eastern extent of the formation has not been determined or studied in the detail necessary for lithologic correlation with other gravel sheets in eastern Nebraska, but the red (Sioux) quartzite that is present in the more eastern gravels has not been observed in the Long Pine Formation. The southern extension of the Long Pine Gravel could be determined only by extensive drilling programs with accurate elevational controls that are now lacking.

SOURCE OF THE LONG PINE GRAVEL: The most likely source of rocks serving as indicators in the Long Pine Gravel seems to be from north-northeast, probably from the vicinity of Lake Winnipegosis in southern Canada about 600 miles north. According to Roger Batten (personal commun.), "The chert pebbles collected at the Alvin Quinn Gravel Pit in Brown County contain a varied marine invertebrate fauna which appears to be dominantly Devonian and Mississippian. Several buff-colored pebbles contain specimens of a strophomenid brachiopod which is restricted to the Devonian and a species of what probably is *Cyrtospirifer*. Along with these species are trepostome bryozoans and tabulate corals resembling *Thamnopora*. Most of the species are suggestive of the fauna found in the Devonian Manitoba Group of Canada. Because of this similarity and the lack of Devonian rocks northwest of Brown County in the Black Hills, it would be reasonable to conclude that the chert pebbles were derived from north or northeast of Brown County.

"Other chert pebbles contain a rich and varied fauna of foraminifera which suggest a Mississippian age; no fusulinids are present. This type of assemblage is found in the Pahasapa Formation in the Black Hills as well as in the regions north of Brown County and hence cannot be used to indicate the direction of the chert pebble source."

The Long Pine Gravel fluvial outwash probably was derived from the Nebraskan glacial lobe that terminated north of the Missouri River, possibly near an area now occupied by the town of Chamberlain, South Dakota. In that event the fluvioglacial outwash would have been transported about 100 miles southward from the glacial front, far enough to make rounded waterworn pebbles; no striated pebbles have been found.

Red (Sioux) quartzite, a common component of Nebraskan and Kansan aggregates in eastern Nebraska, is found as far south as Omaha and Lincoln, but has not been found in the Long Pine Formation. The apparent absence of Sioux quartzite minimizes the possibility of a more eastern provenience for the north-central Nebraska deposits.


TYPE SECTION of the PETTIJOHN FORMATION (New) Brown County, Nebraska
3
NORTHWEST 1/4 SECTION 8, T.29N., R.20W.
Windblown soil
USBM 2465
Gravels, fine, sandy, not as coarse as lower gravels
6'-8'
Erosional contact sharp
Sand, fine, massive, gray, clay-filled
Not well exposed except on road cut of Highway 91 down to Long Pine Creek
TYPE SECTION of the LONG PINE FORMATION (New)
Brown County, Nebraska
1
NORTHWEST 1/4 SECTION 30
T.30N., R.20W.
USBM 2405
Soil
1'-5'
Sands and gravels, loose, cross-bedded
Jasper, brown, yellow, red; pebbles and quartz, well-rounded
Appears to be a fluvial outwash
Contact very sharp
25'
Clay, massive, fine, sandy, gray
23'
Sand, fine, clay-filled, massive, tan to pink at base, grades more gray toward top
22'
Local channel cut
Strong relief - 20'
Reworked pebbles, sands, silicified tubules
2'
18'
Sand, ashy, gray-white
5'
Sand, fine, not as hard as unit below
Mostly sod covered
10'
Sand, massive, hard, gray, medium fine; silicious root tubules
Does not erode easily; forms bluffs
34'
Hard zone
Unconsolidated cross-bedded channel sands, well-sorted, yellow to brown small gravels, quartz grains, clay balls, fossil fragments
18'
3'-4' Sand, clay-filled, yellowish, exposed in stream bottom
FEET
2460
2450
2440
2430
2420
2410
2400
2390
2380
2370
2360
2350
2340
2330
2320
2310
2300
2290
2280
2270
2260
2250
2245
Blancan
PLEISTOCENE
Pettijohn Formation (New)
Duffy Formation (New)
Long Pine Formation (New)
Keim Formation (New)
No Hemphillian
Clarendonian
PLIOCENE
Ash Hollow Formation
Cap Rock Member
Valentinian
Valentine Formation
Burge Member
Devil's Gulch Mbr.

Clay ironstone pebbles found in the Quinn Gravel Pit and throughout the Long Pine Formation also may have been glacially transported from a northeastern Precambrian area. The Black Hills, however, cannot be eliminated as a possible source of some of the reworked Precambrian rock and chert originally included in channel deposits of the Chadron and Brule formations lying east of the Black Hills. Lag concentrates from the coarser aggregates in these Oligocene sediments might have lain in the path of a glacial advance and outwash streams, and incorporated later in the Long Pine Formation.

Speculation that all Long Pine Gravel was derived from the Black Hills is basically unsound. Inasmuch as Devonian rocks are not known in the Black Hills, this region cannot be the source of the Devonian fossils in pebbles in the Long Pine Formation. Garnet normally found as lag residue in gravel derived from schists in the Black Hills has not been recognized as a component of the Long Pine Formation. And yet concentrations of garnet sand are found in medial Pliocene deposits in north-central Nebraska. For example, a channel deposit in the Ash Hollow Formation (a Frick site, the Xmas Quarry of 1934 and 1936) has small concentrations of garnet sand.

The high permeability of the Long Pine Gravel makes it an excellent aquifer and reservoir for irrigation water within the study area. The Niobrara River and its tributaries act as drainage trenches for the Long Pine gravel sheet near the Ainsworth and Springview tables. Here the gravel is normally dry but it is saturated to the south under the Sand Hills (fig. 1), which acts as a collecting area that recharges the gravels.

The recently developed irrigation project in the Ainsworth area eventually will recharge

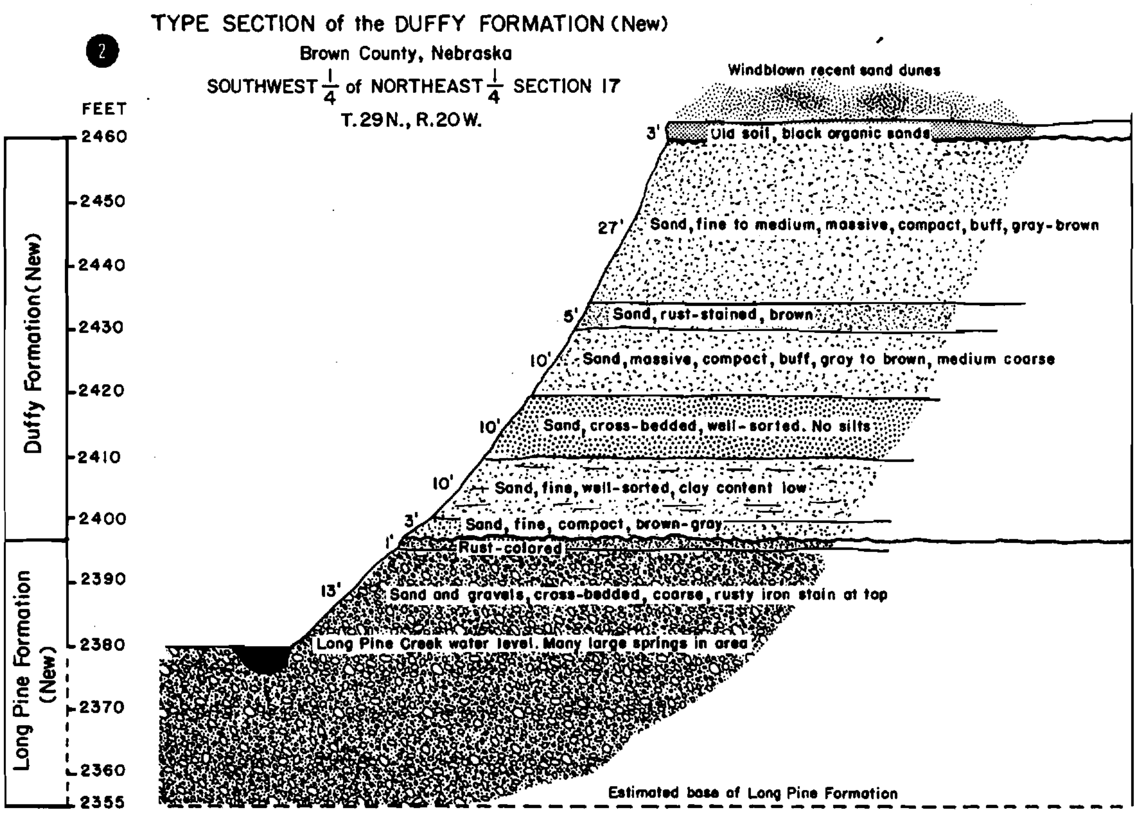


FIG. 6. (THIS PAGE AND OPPOSITE PAGE.) Stratigraphic sections of the type localities of the Long Pine (1), the Duffy (2), and the Pettijohn (3) formations, new names, showing superposition and elevations of deposits. See also figure 7.

some of these dry table areas. The effects of irrigation are already showing in the Sand Draw, which has changed from an intermittent to a permanent stream during the irrigation season.

Fossil Localities: Chicago and Northwestern Railroad Gravel Pit (figs. 3A-3, 7): This locality is about half a mile south of the type section in the NE. ¼, SE. ¼, sect. 25, T. 29 N., R. 21 W., Brown County, Nebraska. (See also Locations, p. 30–35.) In 1948 I collected a complete *Stegomastodon* skull from the base of the Long Pine Formation from this gravel pit. This and other *in situ* specimens described in the faunal section of this paper came from the same pit, which then had a working face almost half a mile long. Such finds are significant because they cannot be part of the glacial debris. The completeness of these large specimens leaves little doubt that large animals were living in or near the area, and that forage (probably willows) must have been available. It is not likely that a vigorously aggrading gravel sheet would have supported much plant life.

Several sand and gravel companies use the Long Pine Gravel for road metal. Two of these, the Hall and the Quinn gravel pits, some 7 miles west of Ainsworth, are the source of the invertebrate-bearing cherts described by Batten (p. 25, this paper), as well as vertebrates.

Locations for isolated fossil prospects in the Long Pine Formation are given in the section on Systematics with the specimens and in the Locations (pp. 30–35).

DUFFY FORMATION, NEW NAME

Type Section: The type section is on the east side of Long Pine Creek in the SW. ¼, NE. ¼, sect. 17, T. 29 N., R. 20 W., Brown County, Nebraska, about 3 miles south of the town of Long Pine (figs. 3A, B, F, 6, 7). A new name, Duffy Formation, is here used for a glaciofluvial sedimentary rock unit composed of buff to brown, rust-stained fine sand, silt, and clay of early Pleistocene age, that unconformably overlies the early Pleistocene Long Pine Formation, and is unconformably overlain by either the Pettijohn Formation, new name, or by the Sand Hills. These formations, Duffy, Long Pine, and Pettijohn are referable to the Nebraskan. The Duffy Formation derives its name from the Duffy ranch where the type section and best known outcrops are located.

A new name has been assigned to these deposits because the Duffy Formation is lithologically unlike any Pleistocene deposits in the area or in the more eastern and southern areas of Nebraska. Lack of outcrops makes correlation with deposits in other areas difficult until drilling programs such as those carried on by the Bureau of Reclamation during the 1950's for the Ainsworth irrigation project are undertaken by state or federal agencies.

I have not observed a till or a soil beneath the Duffy Formation, or on the surface of the underlying Long Pine Formation. The absence of such an indicator suggests that the Duffy Formation represents an interstadial stage of short duration. This is also borne out by the lack of faunal change in the Keim, Long Pine, and Duffy formations.

Lithologic Characters: The Duffy sediments are soft, unconsolidated buff or brown sand and clay-filled silt that appear to have been glaciofluvially transported by a low-velocity stream. The Duffy Formation seldom forms bluffs, being much less compact than the finer-grained sand and silt of the Keim Formation. Good outcrops can be observed near the type locality only, for Duffy sediments erode easily or form gentle slopes that soon become sod-covered, even in the canyons. The contact of the Duffy Formation and the underlying Long Pine Gravel is always abrupt and can be observed at intermittent outcrops from the Duffy ranch on Long Pine Creek to west of the Long Pine water tower on the east side of the Long Pine Creek canyons. Here heads of washes afford an opportunity to examine the general lithology, although the sediments are mostly sod-covered.

In 1939 I drilled an irrigation well in the SW. ¼, sect. 25, T. 30 N., R. 22 W., Brown County, (figs. 1, 3 between B-3 and B-4) and encountered what seemed to be an anomalous condition: 10 feet of compact green clay at the base of the Duffy Formation rested directly on the Long Pine Gravel and produced a "perched" water table. I do not know the extent and distribution of this clay, but I assume that it is part of the Duffy Formation and not the Long Pine Formation because Duffy sand and silt grade into the clay beneath, which abruptly contacts the Long Pine Gravel.

Extent and Distribution: Erosion has not exposed the major part of the Duffy Formation, but it is found above the Long Pine Gravel under most of the Ainsworth Table on the heads of Bone, Long Pine, and Willow creeks wherever stock and irrigation wells are drilled. In 1970 the reshaping of Highway 20 borrow pits between Long Pine and Ainsworth exposed the Duffy and Long Pine Gravel contact, showing Duffy sediments to be well developed between Willow Creek and Ainsworth to the west. Apparently the Duffy sediments thin out toward Johnstown to the west (fig. 7). The eastern extent of the Duffy Formation is unknown but it is present southeast of Long Pine on the south side of the Elkhorn Valley in Rock County, where it weathers to form a tillable soil that contrasts sharply with the overlying Sand Hills.

Fossil Locality: Very few fossils have been recovered from the limited outcrops of the Duffy Formation. Two partial skulls and jaws of a small gopher, a few tooth fragments of *Stegomastodon*, and the lower jaw of a large camel referable to *Gigantocamelus* were collected from the type locality of the Duffy Formation.

PETTIJOHN FORMATION, NEW NAME

Type Section: The type section is in the northwest quarter of section 8, T. 29 N., R. 20 W., Brown County, Nebraska, 2 miles south of the town of Long Pine (figs. 6, 7). The name Pettijohn Formation is here used for a glaciofluvial gravel sheet that rests unconformably on the early Pleistocene Duffy Formation, and is overlain by either the Sand Hills or surface soil. This formation is named for the Carleton Pettijohn holdings along the course of Long Pine Creek, in the area selected for the type set of deposits, since it is in this area that the stratigraphic sequence can be demonstrated.

A new name has been assigned to this gravel sheet because of its stratigraphic position and relationship to other Pleistocene sedimentary units in north-central Nebraska. The Pettijohn Gravel may represent the final phase of a fluvial outwash of the Nebraskan glacial advance. No fossils have been collected from it to give a clue to age. Because no tills, ash deposits, paleosols or loesses have been encountered in the entire sequence of these early Pleistocene formations (i.e. Keim, Long Pine, Duffy, and Pettijohn), I postulate that the Pettijohn Gravel is a stadial of the first continental advance, the Nebraskan, and that the source was northeast, possibly an outwash from the same source as the Long Pine Gravel.

Lithologic Characters: The Pettijohn Formation is dominantly a fine, well-sorted, pea-sized gravel and sand of fine rounded chert and quartz grains, with larger pebbles not so numerous as in the Long Pine Formation. Generally speaking, the Pettijohn Gravel is finer than the Long Pine Gravel, but has the same mineral makeup, that is, jasper, clay ironstone, quartz, granite, and orthoclase. No Sioux (red) quartzite is present.

Extent and Distribution: Pettijohn Gravel is present near the surface to the south, west, and east of Ainsworth, and is also found in cuttings from stock and irrigation wells (fig. 3B). It is found on hilltops east of the type area in western Rock County, Nebraska, on the south side of the Elkhorn Valley just beyond the mapped area (fig. 2), but how much farther east is not known. This gravel is often referred to in drilling records as the "first" or "top gravel" and is usually devoid of water on the Ainsworth Table in the northern part of Brown County, because of the high permeability of the underlying Duffy sand and silt.

Where the Pettijohn Gravel extends southward under the Sand Hills on the heads of Long Pine, Willow, and Bone creeks, the increased elevation of the water table saturates the entire sequence of Pleistocene deposits. The gradient of the water table is in a general southwest-northeast direction. The high permeability of the Sand Hills and limited surface drainage results in an ideal catchment area that increases the elevation of the hydrostatic head. From here the water percolates toward lower groundwater levels on the Ainsworth Table and areas drained by the entrenched Niobrara River and its tributaries where surface runoff and less permeable soil limit groundwater recharge.

Contacts of the base of the Pettijohn Gravel with the Duffy Formation may be observed southwest of Ainsworth, south and east of Long Pine, and elsewhere along farm road cuts on the Ainsworth Table. Apparently the Duffy sediments thin out to the west toward Johnstown and the Pettijohn sediments thicken. In the late 1940's an irrigation well dug by Dan Carpenter in the center of the northwest quarter, sect. 14, T. 30 N., R. 23 W., Brown County, showed some evidence that the Long Pine and Pettijohn gravels coalesce and become one gravel sheet. This may be the case also at the Quinn Gravel Pits, south of the Ainsworth Airport, but this can only be determined by well drilling. The area was extensively drilled before the development of the Ainsworth Irrigation District. These drilling records are preserved in the Bureau of Reclamation Archives.

LOCATIONS FOR PROFILE POINTS, TYPE SECTIONS, AND COLLECTING SITES IN BROWN AND KEYA PAHA COUNTIES, NEBRASKA

The following geologic and geographic data are given in this section for brevity in citing source data for specimens, for convenience in map and profile reference, and to avoid repetition of basic or pertinent data. Profile points are based on stratigraphic sections in the same detail as the illustrated sections in figures 4, 5, and 6. Locations are given for collecting sites in the present study for the Frick Laboratory, the University of Michigan, and Taylor's 1960 mollusc localities.

Reference to Frick Prospecting Localities needs some explanation. In 1938 I assigned "Prospecting Locality" numbers to areas along drainages and likely outcrops on buttes or plains. These localities, however, have only geographic meaning, as stratigraphic zonation is given for each specimen carrying its own subnumber. Prospecting localities may comprise an area 5 or 6 miles long (e.g. Snake River in Cherry County, Nebraska) or may cover a drainage contained within 160 acres (e.g. Magill ranch). For example, Prospecting Locality 28 in Deep Creek, Brown County, Nebraska, covers about 3 miles of drainages that contain sediments referable to the Valentine, Ash Hollow, Keim, and Long Pine formations.

This has proved a workable system for collating isolated specimens collected over the years. A prospecting locality catalog is maintained with the Frick Collection, making it possible to locate data for all specimens from each prospecting locality. Involved in this system are specimens in more than 850 boxes from more than 515 prospecting localities.

BROWN COUNTY: Profile A. South-north, east side of area (figs. 1, 3).

Profile point A-1 =F-6, SW. $\frac{1}{4}$, NE. $\frac{1}{4}$, sect. 17, T. 29 N., R. 20 W. Type section of Duffy Formation overlying Long Pine Formation; exposures east side Long Pine Creek; west facing outcrops. Base of Duffy Formation, 2396 feet (figs. 1, 3, 6, 7).

Profile point A-2 =F-5, NW. $\frac{1}{4}$, NW. $\frac{1}{4}$, sect. 8, T. 29 N., R. 20 W. Type section of Pettijohn Formation overlying Duffy Formation (fig. 6); outcrops east state highway 55 on Jack Robertson ranch. Base of Pettijohn Formation, 2455 feet (figs. 1, 3, 7).

Profile Point A-3 =B-6 =F-4, NE. $\frac{1}{4}$, SE. $\frac{1}{4}$, sect. 25, T. 29 N., R. 21 W. Willow Creek and north end of Chicago and Northwestern (C & NW) railroad gravel pit. Ash Hollow Formation overlain by Keim Formation, overlain by Long Pine Formation. Base: Keim Formation, 2355 feet; Long Pine Gravel, 2375 feet (figs. 1, 3, 7).

Profile Point A-4, NW. $\frac{1}{4}$, NW. $\frac{1}{4}$, sect. 24, T. 30 N., R. 21 W. Jackrabbit Hill (local name); exposures in west-trending wash leading to Willow Creek. Ash Hollow Formation overlain by Keim Formation, overlain by Long Pine Gravel. Base: Keim Formation, 2315 feet; Long Pine Gravel, 2390 feet (figs. 1, 3).

Profile point A-5 =C-6 =E-2, SE. $\frac{1}{4}$, NW. $\frac{1}{4}$, sect. 34, T. 31 N., R. 21 W. Bone Creek, Gerdan Wheeler ranch. Ash Hollow Formation overlain by Keim Formation, overlain by Long Pine Gravel. Base: Keim Formation, 2295 feet; Long Pine Gravel, 2392 feet (figs. 1, 3).

Profile point A-6, NE. $\frac{1}{4}$, SE. $\frac{1}{4}$, sect. 22, T. 31 N., R. 21 W. Road cut on U. S. 183, south side Plum Creek paleovalley (fig. 2, $\frac{1}{8}$ mile east of profile). Top of Keim Formation, overlain by Long Pine Gravel. Base of Long Pine Gravel, 2390 feet (figs. 1, 3).

Profile point A-7, NE. $\frac{1}{4}$, SE. $\frac{1}{4}$, sect. 12, T. 31 N., R. 21 W. Bone Creek, William Rudnick ranch, 2 miles east of Profile A. Exposed: Pierre Shale, Rosebud Formation, Valentine Formation, and lower part of Ash Hollow Formation. Base: Rosebud Formation, 2050 feet; Valentine Formation, 2097 feet; Ash Hollow Formation, 2257 feet (figs. 1, 3).

Profile point A-8, NE. $\frac{1}{4}$, NW. $\frac{1}{4}$, sect. 10, T. 31 N., R. 21 W. Bone Creek, Elmer Lucht ranch, site of Lucht Quarry in the Burge Member of the Valentine Formation. Valentine Formation overlain by Ash Hollow Formation. Base of Ash Hollow Formation, 2267 feet (figs. 1, 3).

KEYA PAHA COUNTY: Profile point A-9, sects. 14, 11, 2, T. 32 N., R. 21 W. Niobrara River hill, U.S. 183 road cuts on north side of river. Fresh exposures show Pierre Shale overlain by ?Chadron referred sediments, Rosebud, Valentine, Ash Hollow formations, and Long Pine Gravel at top. 1970 exposures covered. Base: ?Chadron referred, 2110 feet; Rosebud Forma-

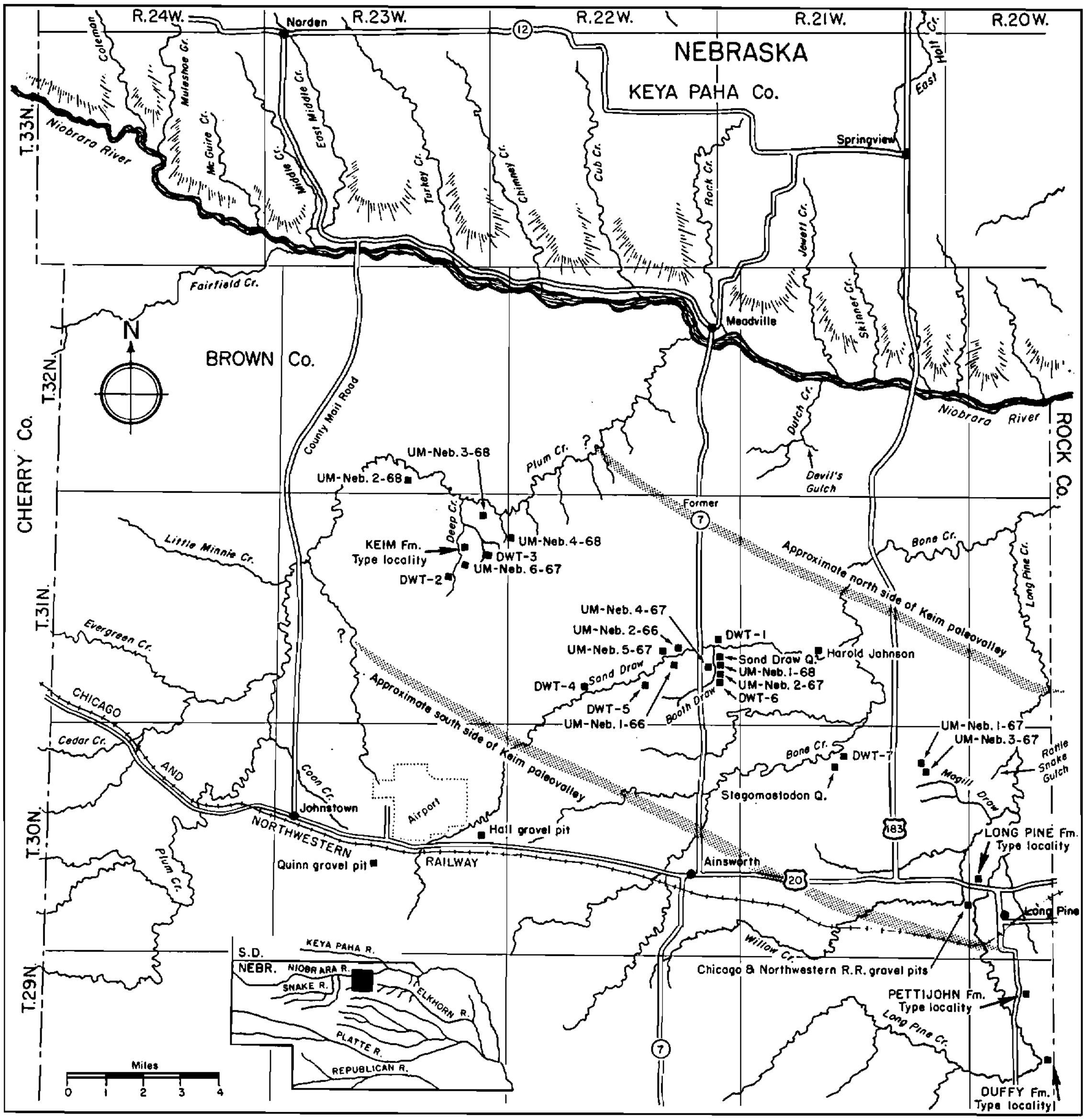


FIG. 7. Map of northern Brown County, showing Frick Laboratory and University of Michigan localities and Dwight Taylor (DWT) invertebrate localities. See also list of localities, p. 30.

tion, 2187 feet; Valentine Formation, 2235 feet; Ash Hollow Formation, 2300 feet; Long Pine Gravel, 2390 feet (figs. 1, 3).

Profile point A-10 =D-5, NW. $\frac{1}{4}$, NW. $\frac{1}{4}$, sect. 13, T. 33 N., R. 21 W. Mount Hope Cemetery, 1 mile north of Springview, east side of U. S. 183. Ash Hollow Formation overlain by Long Pine Gravel. Base of Long Pine Gravel, 2438 feet (figs. 1, 3).

Profile point A-11, NW. $\frac{1}{4}$, NW. $\frac{1}{4}$, sect. 12, T. 33 N., R. 21 W. East Holt Creek, north end of profile. No exposures in bottom of valley (figs. 1, 3).

BROWN COUNTY: Profile B. West-east, south side of area, Ainsworth Table (figs. 1–3).

Profile point B-1, NE. $\frac{1}{4}$, SW. $\frac{1}{4}$, sect. 14, T. 30 N., R. 24 W. Plum Creek, east side, $2\frac{1}{2}$ miles west of Johnstown; main outcrop on south side

U.S. 20 road cut. Ash Hollow Formation overlain by Long Pine Gravel. Base of Long Pine Gravel, 2559 feet (figs. 1, 3).

Profile point B-2, SE. $\frac{1}{4}$, SE. $\frac{1}{4}$, sect. 21, T. 30 N., R. 23 W. Alvin Quinn Gravel Pit, an extensive wash gravel operation. Long Pine Gravel reported to be 80 feet thick and water saturated. Base of Long Pine Gravel, ?2510 feet (figs. 1, 3).

Profile point B-3, NW. $\frac{1}{4}$, SE. $\frac{1}{4}$, sect. 26, T. 30 N., R. 22 W. M. F. Skinner Irrigation Well No. 3. Well log record shows trace of Pettijohn Formation, 30 feet of Duffy sand and silt, over 30 feet of Long Pine Gravel resting on a compact clay (?Keim Formation). Base of Long Pine Gravel, 2461 feet (figs. 1, 3).

Profile point B-4, NE. $\frac{1}{4}$, S.E. $\frac{1}{4}$, sect. 25, T. 30 N., R. 22 W. M. F. Skinner Irrigation Well No. 4. Well log record shows 2 feet of soil, 12 feet of Pettijohn Gravel, 25 feet of Duffy sand and silt, and 35 feet of Long Pine Gravel. Base: Pettijohn Formation, 2507 feet; Duffy Formation, 2480 feet; Long Pine Gravel, 2446 feet (figs. 1, 3).

Profile point B-5, NW. $\frac{1}{4}$, SW. $\frac{1}{4}$, sect. 26, T. 30 N., R. 21 W. Willow Creek, east of Weir School; 25 feet of Keim Formation overlain by 18 feet of Long Pine Gravel. Base of Long Pine Gravel, 2407 feet (figs. 1, 3).

Profile point B-6 =A-3 =F-4, NE. $\frac{1}{4}$, SE. $\frac{1}{4}$, sect. 25, T. 30 N., R. 21 W. Willow Creek and Chicago and Northwestern (C & NW) railroad gravel pit. Base: Keim Formation, 2355 feet; Long Pine Gravel, 2375 feet, with at least 41 feet exposed (figs. 1, 3, 7).

Profile point B-7, NW. $\frac{1}{4}$, NW. $\frac{1}{4}$, sect. 29, T. 30 N., R. 20 W. U.S. 20 road cut northeast of Long Pine shows Ash Hollow, Keim and Long Pine formations. Base: Keim Formation, 2340 feet; Long Pine Gravel, 2359 feet (figs. 1, 3).

Profile C. Northwest-southeast, near center of Keim paleovalley (figs. 1, 3).

Profile point C-1, SE. $\frac{1}{4}$, SE. $\frac{1}{4}$, sect. 34, T. 32 N., R. 23 W. Clair Keim ranch, south side of Plum Creek. Exposed: Valentine, Ash Hollow, Keim, and Long Pine formations. Base: Burge Member of Valentine Formation, 2378 feet; Ash Hollow Formation, 2383 feet; Keim Formation, 2435 feet; Long Pine Gravel, 2474 feet (figs. 1, 3).

Profile point C-2, E. $\frac{1}{2}$, sect. 11, T. 31 N., R. 23 W. Type section of Keim Formation (figs. 4, 7), west fork of Deep Creek, Ray Keim ranch. Exposed: Valentine, Ash Hollow formations, ?Hemphillian channel, Keim and Long Pine formations. Outcrops of Deep Creek extensively studied. Base: Burge Member Valentine Formation, 2362 feet; Ash Hollow Formation, 2380 feet; Keim Formation, 2395 feet; Long Pine Gravel, 2483 feet; also see "Bear Tooth Slide" (fig. 4), 2360 to 2430 feet (figs. 1, 3).

Profile point C-3, NW. $\frac{1}{4}$, NW. $\frac{1}{4}$, sect. 26, T. 31 N., R. 22 W. Sand Draw, north side. Keim Formation overlain by Long Pine Gravel. Base of Long Pine Gravel, 2454 feet. See University of Michigan micro site No. 5–67 (figs. 1, 3, 7).

Profile point C-4, W. $\frac{1}{2}$, W. $\frac{1}{2}$, sect. 25, S. $\frac{1}{2}$, SW. $\frac{1}{4}$, sect. 24, T. 31 N., R. 22 W. Booth Draw and Sand Draw Quarry (fig. 5). Keim Formation overlain by Long Pine Gravel. At this site McGrew (1944) obtained the major part of his fauna. Base of Long Pine Gravel, 2453 feet (figs. 1, 3, 7).

Profile point C-5, NW. $\frac{1}{4}$, NE. $\frac{1}{4}$, sect. 29, SW. $\frac{1}{4}$, SE. $\frac{1}{4}$, sect. 20, T. 31 N., R. 21 W. Sand Draw, Harold Johnson ranch; large south-facing bluff on north side of Sand Draw; Keim Formation overlain by Long Pine Gravel; greatest thickness Keim Formation, 130+ feet; near base, 2290 feet; base of Long Pine Gravel, 2422 feet (figs. 1, 3).

Profile point C-6 =A-5 =E-2, SE. $\frac{1}{4}$, NW. $\frac{1}{4}$, sect. 34, T. 31 N., R. 21 W. Bone Creek, Gerdan Wheeler ranch. Base: Keim Formation, 2295 feet; Long Pine Gravel, 2392 feet (figs. 1, 3).

Profile point C-7 =F-1, SE. $\frac{1}{4}$, SE. $\frac{1}{4}$, sect. 6, T. 30 N., R. 20 W. Rattlesnake Gulch, a deep, west-trending, short drainage on the west side of Long Pine Creek. Valentine, Ash Hollow, Keim formations exposed. Long Pine Gravel removed by erosion in Long Pine Creek Valley where sections of outcrops measured. Base of Keim Formation, 2239 feet (figs. 1, 3, 7).

Keya Paha County: Profile D. West-east, north side of area, Springview Table (fig. 2).

Profile point D-1, NW. $\frac{1}{4}$, NW. $\frac{1}{4}$, sect. 12, T. 33 N., R. 24 W. Norden Cemetery; Ash Hollow and Long Pine formations exposed south of cemetery along road cut. One of the most westerly outcrops known of Long Pine Gravel. Base of Long Pine Gravel, 2570 feet (figs. 1, 3).

Profile point D-2, NW. $\frac{1}{4}$, NE. $\frac{1}{4}$, sect. 6, T. 33 N., R. 23 W. Head of East Middle Creek, east of Norden. Exposed along road cuts: Ash Hollow Formation overlain by 6 to 7 feet of Long Pine Gravel; this contact may be observed for more than 5 miles along state highway 12. Base of Long Pine Gravel, 2555 feet (figs. 1, 3).

Profile point D-3, SE. ¼, SE. ¼, sect. 3, T. 33 N., R. 22 W., 2 miles north of Pine Knoll on state highway 12 road cut: Ash Hollow Formation overlain by Long Pine Gravel. Base of Long Pine Gravel, 2490 feet (figs. 1, 3).

Profile point D-4, NW. ¼, NE. ¼, sect. 18, T. 33 N., R. 21 W. East side of Rock Creek on state highway 12 road cut (1969): Ash Hollow Formation overlain by 6 to 7 feet of Long Pine Gravel. Base of Long Pine Gravel, 2460 feet (figs. 1, 3).

Profile point D-5 =A-10, NW. ¼, NW. ¼, sect. 13, T. 33 N., R. 21 W. Mount Hope Cemetery, 1 mile north of Springview, Nebraska. Base of Long Pine Gravel, 2438 feet (figs. 1, 3).

BROWN COUNTY: Profile E. South-north, across Keim paleovalley (fig. 7).

Stegomastodon Quarry to Allen Ranch

Profile point E-1, SW. ¼, SE. ¼, sect. 4, T. 30 N., R. 21 W. *Stegomastodon* Quarry, south side of Bone Creek. Ash Hollow Formation overlain by Keim Formation, overlain by Long Pine Gravel. Base: Keim Formation, 2367 feet; *Stegomastodon* Quarry faunal zone in Keim Formation, 2375 feet; Long Pine Gravel, 2402 feet (figs. 1, 3).

Profile point E-2 =A-5 =C-6, SE. ¼, NW. ¼, sect. 34, T. 31 N., R. 21 W. Gerdan Wheeler ranch, Bone Creek. Base: Keim Formation, 2295 feet; Long Pine Gravel, 2392 feet (figs. 1, 3).

Profile point E-3 =SE. ¼, NW. ¼, sect. 22, T. 31 N., R. 21 W. Bone Creek, quarter-mile south of James Allen ranch. Exposed: Valentine, Ash Hollow, lower part Keim formations. Base of Keim Formation, 2350 feet. See A-6 for contact of Long Pine Gravel, half-mile east by north; these gravels removed in valley (figs. 1, 3).

Profile point E-4, SE. ¼, SE. ¼, sect. 16, T. 31 N., R. 21 W. Bone Creek, James Allen ranch; large south-facing bluff on east side of creek. Exposed: Valentine and Ash Hollow formations. North side of Keim paleovalley (fig. 7); Keim Formation absent and Long Pine Gravel removed by erosion. Base of Ash Hollow Formation, 2295 feet; top of preserved Ash Hollow Formation, 2375 feet (figs. 1, 3).

Profile F. North-south. Keim paleovalley, east side of area (figs. 1, 3).

Profile point F-1 =C-7, SE. ¼, SE. ¼, sect. 6, T. 30 N., R. 20 W. Rattlesnake Gulch, a deep west-trending, short drainage on west side of Long Pine Creek. Exposed: Valentine, Ash Hollow, and Keim formations. Long Pine Gravel removed in valley of Long Pine Creek where stratigraphic sections of outcrops were measured. Base of Keim Formation, 2239 feet (figs. 1, 3, 7).

Profile point F-2, SE. ¼, SE. ¼, sect. 12, T. 30 N., R. 21 W. Magill ranch (now, 1970, Paul Plate ranch). First large, northwest-trending wash above the mouth of Willow Creek. Exposed: Ash Hollow, Keim, and Long Pine formations. Extensive fossil fauna from this area. Base: Keim Formation, 2305 feet; Long Pine Gravel, 2360 feet (figs. 1, 3, 7).

Profile point F-3, NW. ¼, sect. 30, T. 30 N., R. 20 W. Type section of Long Pine Gravel (fig. 6) on Long Pine Creek, road cut on U.S. 20. Exposed on west side of Long Pine Creek: Burge Member of Valentine Formation at creek level, Ash Hollow, Keim, Long Pine formations. Base: Ash Hollow Formation, 2263 feet; Keim Formation, 2311 feet; Long Pine Gravel, 2375 feet.

Profile point F-4 =A-3 =B-6, NE. ¼, SE. ¼, sect. 25, T. 29 N., R. 21 W. Chicago and Northwestern (C & NW) gravel pit. Base: Keim Formation, 2355 feet; Long Pine Gravel, 2375 feet (figs. 1, 3, 7).

Profile point F-5 =A-2, NW. ¼, NW. ¼, sect. 8, T. 29 N., R. 20 W. Type section of Pettijohn Formation (fig. 6), resting on Duffy Formation, east side of Long Pine Creek. Base of Pettijohn Formation, 2455 feet (figs. 1, 3, 7).

Profile point F-6 =A-1, SW. ¼, NE. ¼, sect. 17, T. 29 N., R. 20 W. Type section of Duffy Formation (fig. 6), resting on Long Pine Gravel, overlain by dune sand, east side of Long Pine Creek. Base of Duffy Formation about 2396 feet. This elevation is estimated because the outcrops are about 1½ miles south of area covered by contour map.

LOCATIONS FOR UNIVERSITY OF MICHIGAN COLLECTING SITES

BROWN COUNTY, NEBRASKA

UM-NEBR. 1–66:

NE. ¼, SE. ¼, NW. ¼, sect. 26, T. 31 N., R. 22 W. About 5½ miles north of Ainsworth on east side of a Sand Draw tributary, 2200 feet east and 1600 feet south of the northwest corner of section 26. See U.S.G.S. Dutch Creek Quadrangle, 1950, scale, 1:24,000, Brown County. Keim Formation, base of upper snail zone; 2440 feet elevation. Also part of Frick Prospecting Locality 277. Near profile point C-3 (figs. 1, 3, 7).

UM-NEBR. 2–66:

SE. ¼, SE. ¼, SW. ¼, sect. 23, T. 31 N., R. 22 W. Bluff about 6 miles north of Ainsworth on north side of Sand Draw near section line. Same quadrangle as UM-Nebr. 1–66. Keim Formation below upper snail zone; 2440 feet elevation. Part of Frick Prospecting Locality 277. Near profile point C-3 (figs. 1, 3, 7).

UM-Nebr. 1–67:

NW. ¼, NW. ¼, SE. ¼, sect. 12, T. 30 N., R. 21 W. About 2¾ miles north and 1 mile west of Long Pine on former Magill ranch (now, 1970, Paul Plate ranch); a short reentrant draw on north side of Magill Draw. See U.S.G.S. Long Pine Quadrangle, 1954, scale 1:24,000, Brown County. Keim Formation, 2360 feet elevation. Part of Frick Prospecting Locality 278. Near profile point F-2 (figs. 1, 3, 7).

UM-Nebr. 2–67: Washing site for two tons of matrix.

NE. ¼, SW. ¼, NW. ¼, sect. 25, T. 31 N., R. 22 W. About 6 miles north of Ainsworth, east side of Booth Draw, 1800 feet south and 975 feet east of northwest corner of section 25. Same quadrangle as UM-Nebr. 1–66. Keim Formation, sand at base of marl; 2432 feet elevation. Part of Frick Prospecting Locality 277 and site of McGrew's (1944) Sand Draw local fauna (figs. 1, 3). Near profile point C-4 (figs. 5, 7).

UM-Nebr. 3–67: Washing site for three tons of matrix.

NW. ¼, NW. ¼, SE. ¼, sect. 12, T. 30 N., R. 21 W. About 2¾ miles west of Long Pine on the former Magill ranch (see UM-Nebr. 1–67 for data). Keim Formation, marl zone in bottom of Magill Draw; 2355 feet elevation. Part of Frick Prospecting Locality 278. Near profile point F-2 (figs. 1, 3, 7).

UM-Nebr. 4–67:

E. ½, SE. ¼, NW. ¼, sect. 25, T. 31 N., R. 22 W. Booth Draw general area on Earl Burrows ranch (see UM-Nebr. 2–67 for data). *Geomys* material mainly from surface above marl and below Long Pine Formation; 2435–2450 feet elevation. Part of Frick Prospecting Locality 277. Near profile point C-4 (figs. 1, 3, 5, 7).

UM-Nebr. 5–67:

SE. ¼, NW. ¼, NW. ¼, sect. 26, T. 31 N., R. 22 W. About 6 miles north of Ainsworth, north side of Sand Draw, 800 feet south and 400–600 feet east of the northwest corner of section 26. See U.S.G.S. Dutch Creek Quadrangle, 1949, scale, 1:24,000, Brown County. Keim Formation, 2430–2440 feet elevation. Part of Frick Prospecting Locality 277. Near profile point C-3 (figs. 1, 3, 7).

UM-Nebr. 6–67:

SE. ¼, SE. ¼, SE. ¼, sect. 11, T. 31 N., R. 23 W. West branch of Deep Creek on Ray Keim ranch, 6 miles west and 8 miles north of Ainsworth, 200 feet west and 350–450 feet north of the southeast corner of section 11. See U.S.G.S. Ainsworth Northwest Quadrangle, 1954, scale, 1:24,000, Brown County. Keim Formation; fish remains at 2448–2453 feet elevation. Sand Draw local fauna. Part of type outcrops of Keim Formation (fig. 4). Part of Frick Laboratory Prospecting Locality 28. Near profile point C-2 (figs. 1, 3, 7).

UM-Nebr. 1–68: Washing site for five tons of matrix.

NE. ¼, SW. ¼, NW. ¼, sect. 25, T. 31 N., R. 22 W. East side Booth Draw, 1650 feet south and 950 feet east of the northwest corner of section 25. (See UM-Nebr. 2–67 for remaining data.) Keim Formation; fauna from just below marly zone at 2432 feet elevation and lateral to Frick Sand Draw Quarry (fig. 5). This is part of McGrew's (1944) faunal site and also part of Frick Prospecting Locality 277.

UM-Nebr. 2–68: Washing site for one ton of matrix.

NW. ¼, SE. ¼, SE. ¼, sect. 34, T. 32 N., R. 23 W. South side of Plum Creek, Clair Keim ranch, 7 miles west and 10 miles north of Ainsworth. Same quadrangle as UM-Nebr. 6–67. Deposit on west-facing hill in pine trees on east side of small draw. Keim Formation; fauna from 25 feet below contact of Long Pine Gravel in fine carbonaceous silt; 2453 feet elevation. Part of Frick Prospecting Locality 28 (figs. 1, 3). Profile point C-1 (fig. 7).

UM-Nebr. 3–68: Washing site for one ton of matrix.

SW. ¼, NE. ¼, SW. ¼, sect. 1, T. 31 N., R. 23 W. South side of Plum Creek, Ray Keim ranch; outcrop on former road to creek, 1610 feet north and 1799 feet east of southwest corner of section 1. Keim Formation; fauna from dark carbonaceous silt 45 feet below Long Pine Gravel and 25 feet above base of Keim Formation at 2432 feet elevation. See Ainsworth Quadrangle data with UM-Nebr. 2–68 (fig. 7).

UM-Nebr. 4–68: Washing site for one ton of matrix.

NE. ¼, NE. ¼, NE. ¼, sect. 12, T. 31 N., R. 23 W. South side of Plum Creek, Bill White Canyon, Ray Keim ranch, about 9 miles north and 5 miles west of Ainsworth, 620 feet south and 300 feet west of northeast corner of section 12. Same quadrangle as UM-Nebr. 6–67. Outcrop on west-facing hill on east side of trail. Keim Formation; fauna from dark carbonaceous silt, 22 feet above base of formation and 31 feet below contact with Long Pine Gravel at 2432 feet elevation. Part of Frick Prospecting Locality 28 (fig. 3). About 1 mile east of Profile point C-2 (fig. 7).

LOCATIONS FOR D. W. TAYLOR'S 1960 MOLLUSCAN FAUNAS IN BROWN COUNTY, NEBRASKA

DWT 1:

SE. ¼, SW. ¼, sect. 24, T. 31 N., R. 22 W. Taylor (1960, p. 34) stated: ". . . exposure on north side of Sand Draw at mouth of second wash downstream from bridge on former State Highway 7; locally reddish marly spot, 75 feet below unconformity." See U.S.G.S. Dutch Creek Quadrangle, 1950, scale, 1:24,000, Brown County. Keim Formation, elevation 2375 feet. Part of Frick Prospecting Locality 277. Sample collected by Skinner, October, 1952. See present report. Booth Draw stratigraphic section, figures 5, 7.

DWT 2:

NW. ¼, NE. ¼, sect. 14, T. 31 N., R. 23 W. Taylor (1960, p. 34) stated: "(USGS Cenozoic loc. 19090), exposures at head of West Fork of Deep Creek; sandy layer in thin-bedded sand and clay layers about 38 feet below unconformity." See U.S.G.S. Ainsworth Northwest Quadrangle, 1954, scale, 1:24,000, Brown County. Keim Formation, near type section, elevation about 2451 feet. The unconformity is between the Long Pine and Keim formations. Present report, figures 4, 7.

DWT 3:

NE. ¼, SW. ¼, sect. 12, T. 31 N., R. 23 W. Taylor (1960, p. 34) stated: ". . . exposure on east side of Middle Fork of Deep Creek; thin-bedded sand and dark-gray clay, 35 feet–40 feet below unconformity." Same quadrangle as for DWT 2. Keim Formation, near type section, elevation at 2448 feet. Other data, including figures, are the same as for DWT 2. Sample collected by Taylor and Skinner, June 13, 1953.

DWT 4:

SW. ¼, N.W. ¼, sect. 33, T. 31 N., R. 22 W. Taylor (1960, p. 34) stated: ". . . exposure on north side of Sand Draw; marly silt, 21–22 feet below unconformity." Same Quadrangle as for DWT 2. This site is in the bottom of Sand Draw, Keim Formation, elevation at 2454 feet. Sample from site collected by Skinner, October, 1952 (fig. 7).

DWT 5:

SE. ¼, SW. ¼, sect. 27, T. 31 N., R. 22 W. Taylor (1960, p. 34) stated: ". . . exposures on small draw near earth dam; marly silt, 18–20 feet below unconformity; mollusks from this locality were listed by McGrew (1944, p. 36) as 'from an exposure 2 miles west of Sand Draw.' Baker (1938, p. 130) reported the snails by error as from the exposure on Sand Draw." Same quadrangle as for DWT 2. Keim Formation, elevation, about 2449 feet. Sample collected by Skinner, October, 1952 (fig. 7).

DWT 6:

SW. ¼, NW. ¼ and NW. ¼, SW. ¼, sect. 25, T. 31 N., R. 22 W. Taylor (1960, p. 34) stated: "(USGS Cenozoic loc. 19091). Exposures along first wash south of Sand Draw on former State Highway 7. Marly sand and tan silt . . . 8–15 feet below unconformity. This wash is not the Sand Draw proper . . . but a small tributary to it . . . Mollusks from this locality were listed by McGrew (1944, p. 36) as from the 'Sand Draw exposure,' and by Baker (1938, p. 131) by error . . . as from 2 miles west of the Sand Draw exposure." This is Booth Draw of the present report (figs. 5, 7). Keim Formation, elevation, 2434 feet. Part of Frick Prospecting Locality 277. Same quadrangle as for DWT 1. Samples collected by Skinner in 1952 and by Taylor and Skinner in 1953.

DWT 7:

SW. ¼, SE. ¼, sect. 4, T. 30 N., R. 21 W. Taylor (1960, p. 34) stated: "Exposure on Bone Creek near *Stegomastodon* Quarry." Sample from Keim Formation in first draw east of quarry at an elevation of about 2385 feet. See U.S.G.S. Ainsworth Quadrangle, 1954, scale, 1:24,000 Brown County. See present report figure 3 and profile point E-1 (fig. 7). Sample collected by Taylor and Skinner, June, 1953.

SYSTEMATICS

SAND DRAW FLORA

POLLEN

Paul S. Martin, Geoscience Department, the University of Arizona, analyzed the pollen in a matrix sample taken from the zygomatic arch of a *Stegomastodon* skull collected in the *Stegomastodon* Quarry. Martin (personal commun.) stated, "The *Stegomastodon* sample is very rich in pollen. Preservation is only fair – I've certainly missed some grasses; 200 grains were counted.

"The sample contains somewhat more *Artemisia* and less Chem-amas but otherwise resembles Sear's postglacial profile from Hackberry Lake in Nebraska Sand Hills (Sears, Sci. 134: 2038). In the absence of much conifer pollen it's certainly not a glacial-type record. It seems remarkable to find a browsing elephant in a deposit with such little tree pollen. Of course there might have been cottonwoods nearby – preservation of *Populus* pollen is often very poor.

	Common Name	Percentage
"Trees:		
Pinus	Pine	10.5
Abies	Fir	0.5
Juniperus(?)	Juniper	1.0
Herbs and Shrubs:		
Graminese	Grasses	38.0
Artemisia	Sage	31.0
Long-spine Compositae	Sunflower family	5.5
Short-spine Compositae	Ragweed	8.0
Chenopodiaceae +*Amaranthus*	Goosefoot, Amaranth group	2.5
Typha or *Sparganium*(?)	Cat tail	1.5
Onagraceae	Evening Primrose family	1.0
Umbellifeae	Carrot family	0.5"

DIATOMS

Samples of diatomaceous earth were collected from a lateral extension of the *Stegomastodon* Quarry. Analysis of these samples has not been published.

SAND DRAW FAUNA

CLASS GASTROPODA

Taylor (1960, p. 33) reported 23 genera and 29 species from the Keim Formation, Sand Draw local fauna. See Taylor, 1965 (pp. 597–607) and Taylor, 1966 (pp. 132–133) for taxonomic changes. Taylor (1960, p. 34) discussed the age and paleoecology of the Sand Draw molluscan local fauna.

CLASS PELECYPODA

Two genera and six species were reported by Taylor (1960, p. 33) and Herrington and Taylor (1958, p. 7) from the Keim Formation, Sand Draw local fauna. Taylor (1966, pp. 95–96) discussed the age of the Sand Draw local fauna.

ANALYSIS OF OSTRACODES FROM THE SAND DRAW FAUNAL LOCALITIES[1]

E. D. GUTENTAG[2]

FRESH-WATER OSTRACODES from four Sand Draw faunal sites in Brown County, Nebraska, are represented by 14 species. The ostracodes suggest that the sites represent shallow pond environments of Pleistocene age.

The identification and interpretation of the ostracode faunule presented here are part of a detailed paleontologic study of the Sand Draw local fauna. The listing of the ostracode faunule and the inferred habitat are presented in the present paper to aid in the general study of the stratigraphic and ecologic significance of the Sand Draw local fauna.

FAUNAL DATING

In the classical geologic sense, animals having a short stratigraphic range over a wide geographic area are most valuable as guide fossils. For the Tertiary and Quaternary deposits, mammals are the most reliable group of stratigraphic guide fossils because of their rapid evolutionary rate and wide dispersal (Hibbard et al., 1965). Ostracodes evolved far more slowly than mammals, but their sensitivity to climatic change is an important indicator of environmental conditions. Some forms may become extinct locally while still living in areas having a more favorable environment. Many of the species of ostracodes that lived in the central High Plains during early Pleistocene time are living today in the Prairie provinces of Canada. Assemblages of species characteristic of temporary or permanent bodies of water and warm or cold environments provide information that aids in understanding the sequence of events corresponding to the life cycle of the fossils. Benson (1967) showed that the transiency of certain extant forms during short intervals in the past makes them useful as guide fossils. Taylor (1960) indicated that once a sequence of climatic changes has been verified for a given region by vertebrate data, any group of fossils that infer similar environmental conditions can be placed in this sequence. Thus, ostracodes as well as other elements of the fauna found in association with mammalian guide fossils can be used to correlate similar deposits when the vertebrates are not present.

OSTRACODE FAUNULE

Ostracodes, although numerous in some Tertiary and Quaternary faunas of the High Plains, have not been sampled widely in Nebraska. Staplin (1963a, 1963b) identified ostracodes from the Sappa Silt of late Kansan age in Harlan County, south-central Nebraska. In southwestern Kansas, where the succession of Pliocene and Pleistocene deposits is well dated by mammal and molluscan faunas, ostracodes have been placed in the established stratigraphic sequence by Gutentag and Benson (1962) and listed by Miller (1966) and Schultz (1967) as supplemental data.

At the Sand Draw sites, much information can be gleaned from the identification and interpretation of the ostracode faunule, namely, (1) the relationship of the three reference sites to the original Sand Draw site, (2) the age of the deposits at the Sand Draw sites based on Ostracode data collected from deposits at other sites that have been dated by other elements of the fauna or by stratigraphic markers in the High Plains region, and (3) the ecology of the Sand Draw faunal sites.

To determine the relationship of the reference sites to the type Sand Draw, the four sites in the study area have been compared with respect to the ostracode species contained in common. These data are summarized in table 1. UM-Nebr. 1–68 has three out of six species conspecific with UM-Nebr. 2–68, five out of six conspecific with UM-Nebr. 3–68, and four out of six conspecific with UM-Nebr. 4–68. UM-Nebr. 2–68 has three out of seven species conspecific with UM-Nebr. 3–68, and seven out of nine conspecific with UM-Nebr. 4–68. UM-Nebr. 3–68 has four out of seven species conspecific with UM-Nebr. 4–68.

The data from table I have been used to determine the taxonomic similarity, T (table 2), by the equation $T=\frac{100C}{N}$ where C is the number of species common to two faunas, and

[1] Publication authorized by the Director, United States Geological Survey.

[2] United States Geological Survey, Garden City, Kansas.

TABLE 1
OCCURRENCE OF OSTRACODES IN THE SAND DRAW FAUNAL LOCALITIES

	UM-Nebr. 1–68	UM-Nebr. 2–68	UM-Nebr. 3–68	UM-Nebr. 4–68
Candona acuta Hoff, 1942	X	—	X	—
Candona caudata Kaufmann, 1900	—	X	—	X
Candona crogmaniana Turner, 1894	X	X	X	X
Candona lactea Baird, 1850	X	X	—	X
Candona nyensis Gutentag and Benson, 1962	X	—	X	—
Candona renoensis Gutentag and Benson, 1962	X	X	X	X
Candona cf. *C. sappaensis* (Staplin), 1963	X	—	X	X
Candona truncata Furtos, 1933	—	X	X	X
Cypricercus tuberculatus (Sharpe), 1908	—	X	—	X
?*Cypricercus* sp.	—	X	—	—
Cypridopsis vidua (O. F. Müller), 1776	—	—	—	X
Eucypris cf. *E. crassa* (O. F. Müller), 1785	—	—	X	—
Eucypris cf. *E. rava* Furtos, 1933	—	X	—	—
Physocypria pustulosa (Sharpe), 1897	—	X	—	X

TABLE 2
TAXONOMIC SIMILARITY INDICES OF OSTRACODES FROM THE SAND DRAW FAUNAL LOCALITIES

	UM-Nebr. 1–68	UM-Nebr. 2–68	UM-Nebr. 3–68	UM-Nebr. 4–68
UM-Nebr. 1–68 (N=6)	—	50	83	67
UM-Nebr. 2–68 (N=9)	50	—	43	78
UM-Nebr. 3–68 (N=7)	83	43	—	57
UM-Nebr. 4–68 (N=9)	67	78	55	—

N is the number of species in the smaller fauna. The range of indices is 0 to 100. A similarity index of 100 indicates that all species in the smaller fauna are found in common in the larger fauna. Numbers less than 100 indicate lesser degrees of similarity, and a similarity index of 0 indicates that no species are common to both faunas.

The indices of faunal similarity (table 2) reveal that UM-Nebr. 1–68 (type locality of the Sand Draw fauna) is markedly similar to UM-Nebr. 3–68 with slightly lesser degrees of similarity to UM-Nebr. 2–68 and UM-Nebr. 4–68.

On the basis of the contained ostracodes, the three reference sites generally have greater affinities with the type Sand Draw ostracodes of UM-Nebr. 1–68 than with one another. These sites are judged to be correlative with the Sand Draw site.

The age of the deposits at the Sand Draw sites can be approximated by comparing their faunule with ostracodes from other sites that have been dated by guide fossils other than ostracodes or stratigraphic marker beds. The Sand Draw ostracodes can be compared with late Pliocene Cottrell Pasture local fauna from Meade County, southeastern Kansas; late Kansan Sappa Silt faunule from Harlan County, Nebraska; and faunules from other sites that were dated by their relationship to the Pearlette Ash Member (stratigraphic marker bed) of the Sappa Formation.

The late Pliocene Cottrell Pasture local fauna was dated by molluscs (Miller, 1964). The Cottrell Pasture local fauna includes *Candona crogmaniana*, *C. lactea*, *C. renoensis*, *C. truncata*, *Cypridopsis vidua*, and *Physocypria pustulosa* in common with the Sand Draw ostracodes.

The late Kansan ostracode faunule (Staplin, 1963b) from the Sappa Silt site was dated by relation to the Pearlette Ash Member. The faunule contains *Candona lactea*, *C. sappaensis*, and *Cypridopsis vidua* in common with the Sand Draw local fauna. The Harlan County site does not contain the varied ostracode species found in the same stratigraphic position at a site in Reno

County, south-central Kansas (Gutentag and Benson, 1962), which contains *Candona crogmaniana*, *C. renoensis*, *C. nyensis*, *Cypricercus tuberculatus*, and *Cypridopsis vidua* in common with the Sand Draw local fauna. The faunule from the Reno County site are comparable with the ostracode faunule associated with the Pearlette stratigraphic marker studied by Benson (1967) and Gutentag and Galli-Olivier (1969).

On the basis of the contained ostracodes, *Candona acuta*, *C. caudata*, *C. nyensis*, *C.* cf. *C. sappaensis*, and *Cypricercus tuberculatus* are found in the Pleistocene Kansan deposits and are absent from the late Pliocene Cottrell Pasture local fauna.

The species not found in common suggest that either evolution has occurred after late Pliocene time or new species have been introduced into the region prior to late Kansan time. Thus, the ostracodes found in the Sand Draw sites contain elements representing both late Pliocene and late Kansan and could be considered as post-late Pliocene and pre-late Kansan. This age designation concurs in part with the designation by Taylor (1960) based on the molluscan faunule collected at comparable sites. Taylor stated that the molluscan faunule was either transitional Nebraskan and Aftonian or possibly interstadial Nebraskan. Because of the great distance between dated sites, however, it may be reasonable to assign only a Pleistocene age to Sand Draw ostracode fauna.

HABITAT

The ostracodes found at the Sand Draw sites represent, for the most part, a permanent pond assemblage. This assemblage probably inhabited shallow ponds, maximum depths from 4 to 8 feet, that had abundant vegetation.

The faunal sites are interpreted as representing ponds of several different sizes. UM-Nebr. 1–68 and UM-Nebr. 3–68 can be interpreted as representing deeper ponds or the deeper part of large shallow ponds because of a lack of associated cyprids that inhabit shallow water. UM-Nebr. 2–68 and UM-Nebr. 4–68 containing cyprids can be interpreted as representative of shallow ponds that have been partially affected by seasonal drying.

All samples contained *Candona crogmaniana* and *C. renoensis*. *Candona renoensis* is considered by Delorme (1969) generally to be indicative of a temporary pond species living in water of low salinity with a bottom temperature range of 0–31°C. *Candona crogmaniana* was considered by Staplin (1963a) to represent permanent as well as temporary ponds. It was also reported living on the bottom of Lake Mendota, Madison, Wisconscin.

No tropical or southern ostracodes, such as *Chamydotheca* or *Herpetocypris*, are in the Sand Draw local fauna. Neither are species indicating glacial or Arctic conditions, such as *Cytherissa lacustris* Sars, 1863, in the assemblage. Assuming that *Candona nyensis* and *C. rawsoni* Tressler, 1957 were conspecific, Delorme (Klassen, Delorme, and Mott, 1967) considered *C. rawsoni* (*C. obtusa* Bronstein, 1947 of authors) to be the best indicator of a humid climate for that local basin. Therefore, the best estimate at the present time is that the Sand Draw ostracodes reflect a climate slightly cooler than the Cottrell Pasture local fauna, which contains *Herpetocypris reptans* Brady and Norman, 1889.

THE SAND DRAW FISH FAUNA

G. R. SMITH[1] AND J. G. LUNDBERG[2]

FISH REMAINS from the Sand Draw local fauna represent at least nine species in eight families. None of the fossils belongs to an evolutionary line unrepresented on the Plains today. The amount of morphological change between species of the Sand Draw local fauna and their Recent counterparts is measurable in two cases and negligible in a third for which adequate samples are in hand. The systematic account of the identified fossils is followed by a brief discussion of environmental implications.

ORDER SEMIONOTIFORMES

FAMILY LEPISOSTEIDAE

GENUS *LEPISOSTEUS* LACÉPÈDE, 1803

Lepisosteus LACÉPÈDE, 1803, p. 331.

DIAGNOSIS: Upper Cretaceous to Recent fishes with rhomboidal ganoid scales, elongate jaws, subdivided maxilla; paired vomer; most bones of oral and pharyngeal cavity bearing teeth; ossified and opisthocoelous vertebrae.

TYPE SPECIES: *Lepisosteus gavialis* Lacépède= *Esox osseus* Linnaeus.

Lepisosteus sp. indet.

MATERIAL: Miscellaneous scale fragments, UMMP V57517, UM-Nebr. 2-66; UMMP V57827, UM-Nebr. 6-67 (fig. 7).

DISCUSSION: The fragments available are not sufficient to enable specific identification. On the basis of fossil and Recent distribution records it would appear that the fossils possibly represent *Lepisosteus osseus* (Linnaeus), 1758, which is found in the region today.

ORDER OSTEOGLOSSIFORMES

FAMILY HIODONTIDAE

GENUS *HIODON* LESUEUR, 1818

Hiodon LESUEUR, 1818, p. 364.

DIAGNOSIS: Pleistocene and Recent hiodontid fishes with 55–61 vertebrae; eight to 10 branchiostegal rays; 23–32 principal anal rays; dorsal insertion slightly in advance to behind anal insertion; head length into standard length about 4.0–4.8 times; pelvic fins shorter than pectorals and not reaching anal insertion (after Cavender, 1966).

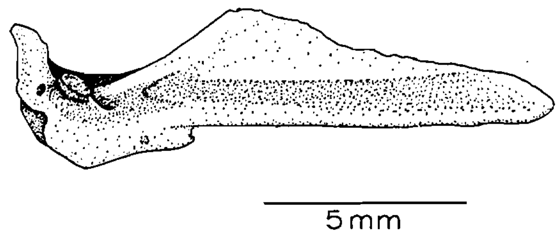


FIG. 8. Fossil *Hiodon* cf. *alosoides*, left articular, UMMP V57843.

TYPE SPECIES: *Hiodon tergisus* Lesueur, 1818.

Hiodon cf. *alosoides* (Rafinesque, 1819)
Figure 8

MATERIAL: Two left articulars, UMMP V57843, UM-Nebr. 6-67 (fig. 7).

DISCUSSION: The fossil articulars are attributed to *H. alosoides* on the basis of the continuous, prominent ridge connecting the coronoid process with the lateral edge of the postdorsal process. *Hiodon tergisus* Lesueur, 1818, has the lateral ridge interrupted by a lateral process of the endosteal articular (of Ridewood, 1904). The lateral placement of the foramina of the sensory canal is also more like *H. alosoides*. The fossil elements differ in minor details from their Recent counterparts but the differences are too slight to justify nomenclatural recognition on the basis of so few specimens.

The present range of *H. alosoides* extends westward on the central Plains almost to the locality from which the fossils were taken. *Hiodon alosoides* is more successful in sand-bottomed Plains streams than is *H. tergisus*.

ORDER CYPRINIFORMES

FAMILY CATOSTOMIDAE

GENUS *ICTIOBUS* RAFINESQUE, 1820

Ictiobus RAFINESQUE, 1820, p. 55.

DIAGNOSIS: Pliocene to Recent catostomid fishes with frontoparietal fontanelle large; frontoethmoid fontanelle reduced; supraorbital bones present; dermal surface of pterotic narrowly

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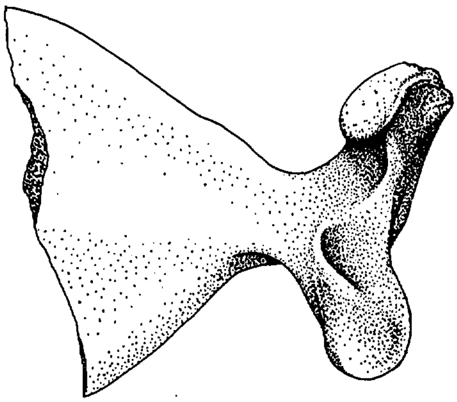

FIG. 9. Fossil *Ictiobus cyprinellus*, anterior half of left maxilla, UMMP V57830.

rectangular and not broadly in contact with parietal; posttemporal fossa large; opercles deeply striated.

TYPE SPECIES: *Amblodon bubalus* Rafinesque.

Ictiobus cyprinellus (Valenciennes, 1844)

Figures 9, 10

DIAGNOSIS: Gnathic ramus of dentary elongate, slender, not strongly curved mediad; maxilla with anteroventral process directed anteriorly; hyomandibular elongate, not strongly decurved.

MATERIAL: Miscellaneous opercles, UMMP V56467 pt., V57310, V57311, V57320, V57382, V57889; preopercles, UMMP V57831; quadrate, UMMP V57833; articulars, UMMP V57835; dentaries, UMMP V57828, V57829; maxilla, UMMP V57830; posttemporal, UMMP V57826; epiotic, UMMP V57836; postcleithrum, UMMP V57834; cleithrum, UMMP V56467 pt.; crushed partial skull with scales, opercular series, cleithra, pectoral fin base, hyomandibular, postcleithra, and Weberian apparatus, UMMP V56468; left frontal, UMMP V57958; miscellaneous elements, UMMP V57832; maxillae and pelvic bone, UMMP V57302, UM-Nebr. 2–67, 6–67, and 1–68 (fig. 7).

DISCUSSION: The Sand Draw species of *Ictiobus* possesses each of the diagnostic characteristics in a form identical with that of Recent *I. cyprinellus*, indicating no measurable morphological change in this species during the Pleistocene. All bones available are similar to their counterparts in Recent *Ictiobus cyprinellus*.

The Recent distribution of *Ictiobus cyprinellus* in Nebraska is restricted to the eastern half of the state in low-elevation, large-river habitat.

FAMILY CYPRINIDAE

GENUS *PIMEPHALES* RAFINESQUE, 1820

Pimephales RAFINESQUE, 1820, p. 52.

DIAGNOSIS: Pleistocene to Recent cyprinid fishes with pharyngeal tooth formula 0,4–4,0; dorsal fin rounded with eight rays; usually seven anal rays; dorsal scales progressively smaller anteriorly; mouth small, horizontal or oblique.

TYPE SPECIES: *Pimephales promelas* Rafinesque.

Pimephales cf. *promelas* Rafinesque, 1820

MATERIAL: Miscellaneous pharyngeals and teeth, UMMP V57172, V57379, V57953; UM-Nebr. 1–68.

DISCUSSION: Of several kinds of cyprinid pharyngeals in the Sand Draw local fauna, only those resembling *Pimephales promelas* in the extreme curvature of the arch, the grinding surface of the teeth, and the tooth formula 4–4, are identified at this time. *Pimephales promelas* is a Plains species, inhabiting unstable or quiet-water situations. It is a colonizing species, tolerant of silt and turbidity, but not of cyprinid competitors. It appears to be the most abundant cyprinid in the Sand Draw local fauna.

Incertae sedis

MATERIAL: Miscellaneous fragments of cyprinid pharyngeals UMMP V57379, V57954, V57955, V57956, V57957; UM-Nebr. 2–67, 1–68, 4–68.

ORDER SILURIFORMES

FAMILY ICTALURIDAE

GENUS *ICTALURUS* RAFINESQUE, 1820

DIAGNOSIS: Oligocene to Recent ictalurid fishes with transverse crest of supraoccipital not emarginated and tilted obliquely backward or vertical; posterior process of supraoccipital usually broad but variable in length; lateral edge of sphenotic bone extending forward to or beyond level of epiphyseal bar; lateral ethmoid wing usually long and slender (short in *Ictalurus melas*, *I. nebulosus*, and *I. natalis*); parasphenoid stem below orbit narrow and tapered posteriorly; ascending wing of parasphenoid straight (not twisted dorsally and medially); descending wing of frontal large; dorsal edge of adductor crest on hyomandibular at or above level of opercular facet; anterodorsal process of hyomandibular large; supraneural not ankylosed to first dorsal

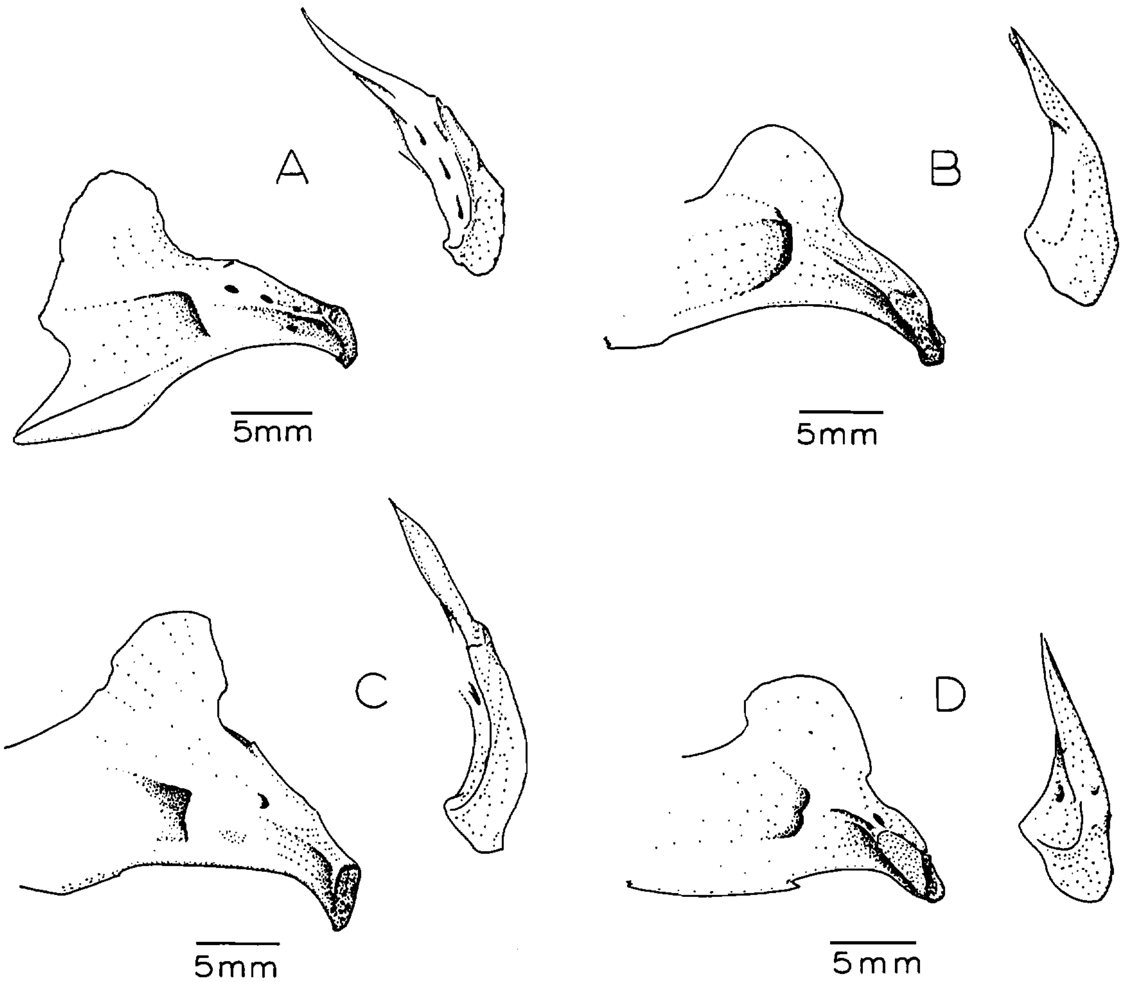

FIG. 10. Comparison of fossil and Recent dentaries of *Ictiobus* species. Left dentaries are shown in mesial (below) and dorsal (above) views. A. *Ictiobus cyprinellus*, UMMP V57829 (Sand Draw 1f., Brown Co., Nebraska). B. *Ictiobus niger*, UMMZ 87646 (Pickaway Co., Ohio). C. *Ictiobus cyprinellus*, UMMZ 182021 (Wayne Co., Michigan). D. *Ictiobus bubalus*, UMMZ 169032 (Camden Co., Missouri). The gnathic ramus is short in *I. bubalus* and *I. niger* (deflected mediad in *I. niger*) and elongate in *I. cyprinellus*. The morphology of the fossil form is indistinguishable from that of Recent *I. cyprinellus*.

basal; first and second dorsal fin basals usually robust, facets on second flat or shallowly concave; anterior limb of fourth transverse process usually greatly expanded distally; fourth neural spine usually greatly elongated; transcapular ligament of supracleithrum completely ossified; posterior process of cleithrum usually long and ornamented with small bony tubercles.

SUBGENUS *AMIURUS* GILL, 1862

Amiurus GILL, 1862, p. 44.

DIAGNOSIS: Oligocene to Recent ictalurid margin of skull roof anterior to level of epiphyseal bar and dorsolateral trough on edge of frontal below exit of infraorbital canal; bony fishes with muscle crests on frontal meeting horizontal shelves on orbitosphenoid greatly enlarged; anteroventral crest of dentary enlarged and elongated to symphysis; posterior edge of coronoid process steeply inclined at all stages of development; premaxilla broad and in many cases bearing small posterior process near

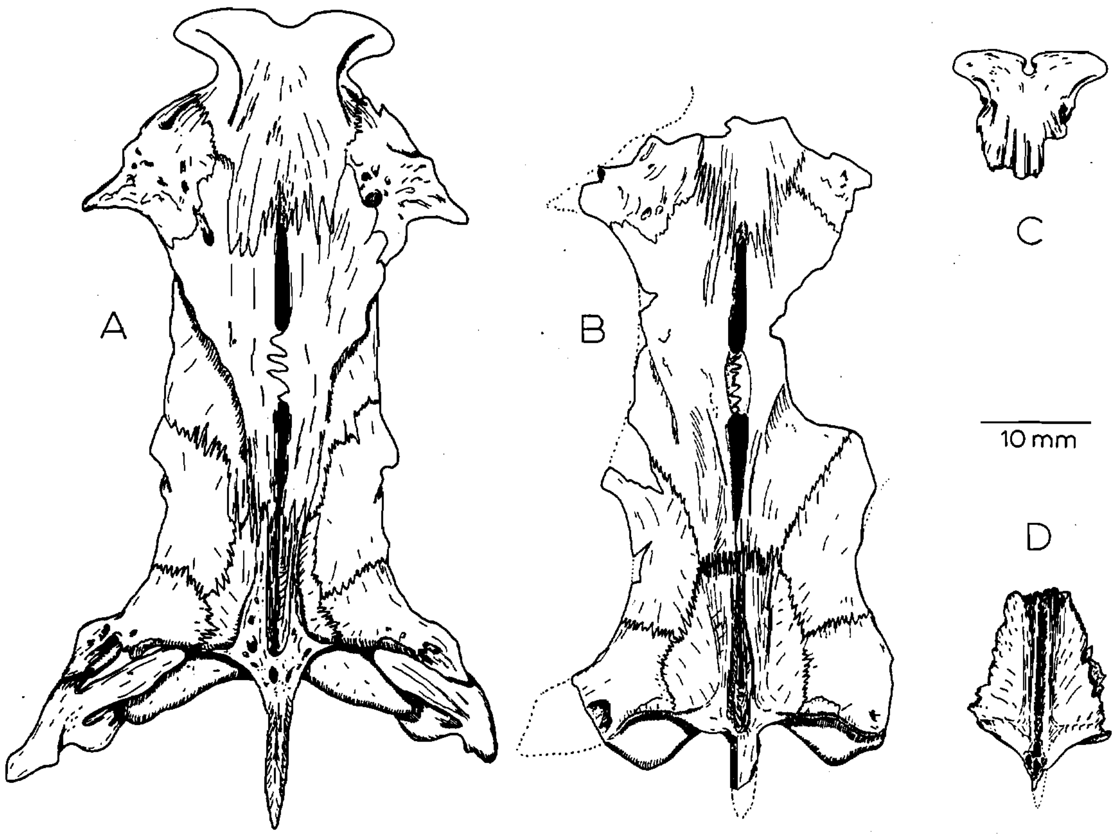

FIG. 11. A. *Ictalurus melas*, dorsal view of skull, UMMZ 189296. B–D. *Ictalurus sawrockensis*. B. Dorsal view of skull, UMMP V57959. C. Dorsal view of supraethmoid bone, UMMP V37101. D. Dorsal view of supraoccipital bone, UMMP V57167.

midline; adductor tentaculi muscle well developed; dorsal keel of ceratohyal enlarged; proximal posterior dentations of pectoral spines invariably antrorse to erect and arise from dorsal half of spine shaft.

TYPE SPECIES: *Silurus cupreus* Rafinesque, 1820 =*Pimelodus natalis* Lesueur, 1819.

Ictalurus (*Amiurus*) *sawrockensis* Smith, 1962
Figures 11–14

Ictalurus benderensis SMITH, 1962, pp. 517–518, fig. 9.

REMARKS: Smith (1962) described two species of bullhead catfishes from the late Pliocene Rexroad Formation of Kansas. These are *I. sawrockensis* from the Sawrock Canyon local fauna and *I. benderensis* from the Rexroad local fauna and the Bender local fauna. Based on additional comparisons to both living and fossil ictalurids, it is apparent that only a single species of bullhead is represented in the Rexroad Formation. The name of this species, employing precedence of position, is chosen as *Ictalurus sawrockensis* Smith (1962, pp. 514–515, fig. 6). The bullhead from the Sand Draw local fauna is referable to this species, as is the one from the Dixon local fauna of Kansas. Because of the availability of additional material an expanded diagnosis and a redescription are presented below. The relationship of this species to living bullheads is also discussed.

HOLOTYPE: UMMP V37066, left pectoral spine, 12.6 mm long.

MATERIAL: Sawrock Canyon Local.

Sawrock Canyon local fauna: pectoral spines, UMMP V37065, V37067; miscellaneous bones, UMMP V37068.

Rexroad local fauna: miscellaneous bones, UMMP V37072, V37074, V37084, V37087,

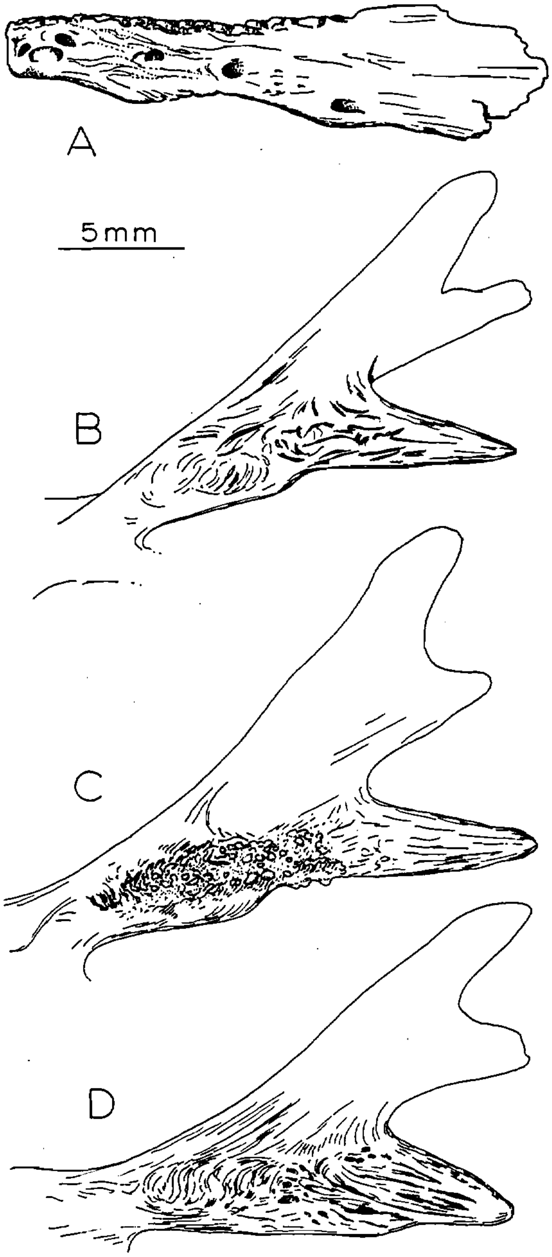

FIG. 12. A. *Ictalurus sawrockensis*, left dentary bone, UMMP V57378, lateral view, scale 5 mm. B. *Ictalurus melas*, left cleithrum, UMMZ 173108-S4, lateral view. C. *Ictalurus nebulosus*, left cleithrum, UMMZ 183022-S2, lateral view. D. *Ictalurus sawrockensis*, left cleithrum, UMMP V57162, lateral view.

V37098; pectoral spines, UMMP V37085, V37086, V37088, V37089, V37099–V37103, V37107, V44304, V45381.

Bender local fauna: pectoral spines, UMMP V37104, V37664, V44305.

Dixon local fauna: pectoral spines, UMMP V32075, V47668; jaw bones, UMMP V47671; urohyal, UMMP V47673; miscellaneous bones, UMMP V47669, V47670.

Sand Draw local fauna: miscellaneous bones, UMMP V52229, V57147, V57160, V57161, V57167, V57170, V57230, V57233, V57237, V57254, V57312, V57374, V57376; jaw bones, UMMP V57378; dentaries, UMMP V57315; hyomandibulars, UMMP V57182; supraoccipitals, UMMP V57175; urohyals, UMMP V57181; partial skulls, UMMP V57304, V47959, V57960; coracoid, UMMP V57985; pectoral girdle and spine, UMMP V57144; pectoral girdle bones, UMMP V57162; pectoral spines, UMMP V57271, V57375; pectoral and dorsal spines, UMMP V57143; dorsal spine, UMMP V57295. Supraoccipital and vertebra, F:AM 87479.

DIAGNOSIS: A species of *Ictalurus*, subgenus *Amiurus* Gill, 1862 (bullheads), distinguished from other members of its subgenus by the combination of the following features: supraoccipital process moderately short and wide, with deeply pitted surface in adults; vertical transverse crests along posterior margin of skull roof; dorsal surface of pterotic with deep pits; supraethmoid cornua with mesial processes; minimum dorsal supraethmoid width equal to, or slightly less than, width of single cornu; metapterygoid length less than twice its minimum depth; vertical lamina of urohyal usually longer than horizontal lamina; posterior (humeral) process of cleithrum with no, or weakly developed, tuberculations; anterior dentations of pectoral spine strong and extensive; posterior dentations of pectoral spine moderate in number and strength, often multicuspid, slightly retrorse or erect distally, and few and antrorse proximally; length of extensor fossa of coracoid (see below) contained about one and three-fourths times in its width; six or seven transverse ridges on horizontal lamina of coracoid.

DESCRIPTION: The following description is based on all available material (Lundberg, 1970). *Ictalurus sawrockensis* is known almost entirely from disarticulated but uncrushed bones. The only articulated specimens are three partial skulls from the Sand Draw local fauna, UMMP V57304, V57959, and V57960.

Width of the neurocranium across the sphenotics, and depth at the basioccipital, contained in the dorsomedian skull length about three times. Skull roof slightly arched or flattened; lateral ethmoids, postorbital processes of the sphenotics, and pterotics are prominent lateral projections from the skull. Supraethmoid and snout broad; supraethmoid cornua bear sharp mesial projections, the cleft between the cornua is deep and round. Dorsal surface of short lateral ethmoid usually sculptured with coarse, reticulating ridges, its posterior margin not truncated or raised (indicating that the levator arcus palatini muscle did not extend anterior to the eye). Frontals bear moderately developed, oblique crests that meet the edge of skull roof at the level of the epiphyseal bar. Frontals broad, posterior and lateral to oblique crests, with slightly concave or straight margins. Anterior cranial fontanelle open. Posterior cranial fontanelle narrowed (rarely closed) by development of longitudinal muscle crests on supraoccipital and frontals. Crests on supraoccipital sculptured at the base of the supraoccipital process with longitudinal ridges or deep pits or both. Supraoccipital process moderately broad and short; its tip tapered, not forked. Surface of supraoccipital process in adults usually sculptured with deep pits. Margins of supraoccipital process continuous with vertical transverse crests that run laterally along the rear edge of the skull on posttemporals and pterotics. Dorsal surface of pterotic sculptured with moderately deep pits.

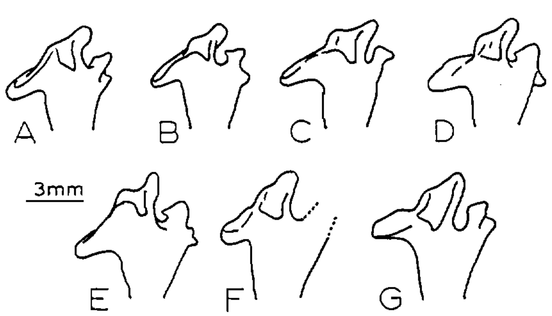

FIG. 13. Variation in form of the pectoral spine base. A–D. *Ictalurus melas*. A. UMMZ 152529-S (Missouri), B. UMMZ 146628-S (California, introduced). C. UMMZ 134864 (Kansas). D. UMMZ 169025-S (Michigan). E–G. *Ictalurus sawrockensis*. E. UMMP V57375 (Sand Draw local fauna). F. UMMP V37067 (Sawrock Canyon local fauna). G. UMMP V37088 (Rexroad local fauna).

Prevomer T-shaped, broad anteriorly. Muscle scar of adductor arcus palatini situated above level of ventral surface of parasphenoid. Parasphenoid tapered below orbit. Broad horizontal shelves on vertical walls of orbitosphenoid.

Cranial facet for hyomandibular runs across sphenotic and pterotic parallel with lateral edge of skull roof; well-developed lateral process on pterosphenoid for articulation with anterior process of hyomandibular.

Premaxilla broadly rectangular (width about three times its length), covered with close-set villiform teeth; its sublateral process not produced caudad. Dentary bears moderately strong anteroventral crest; first pore of mandibular sensory canal remote from symphysis. Steep posterior (articular) edge of coronoid process. Rodlike palatines, very short. Hyomandibular broad, with long metapterygoid suture, quadrate-hyomandibular suture present. Levator arcus palatini muscle crest prominent and sharp; a short, rounded process developed above opercular facet for insertion of adductor hyomandibularis muscle; external foramen for truncus hyomandibularis nerve large and slightly removed from mandibularis notch; a strong vertical muscle scar developed anterior to this foramen for origin of adductor mandibulae muscle.

Preopercle concave externally; a deep groove, for the mandibularis branch of the truncus hyomandibularis, leads from an external foramen in preopercle to hyomandibular-preopercle suture. Least depth of metapterygoid contained in its length about one and three-fourths times. Endopterygoid platelike, but its relative size cannot be determined. Elements of the hyoid bar and operculum differ in no way from those in most living species of the subgenus *Amiurus*. Vertical lamina of urohyal often slightly longer than horizontal lamina.

Weberian complex as in living bullheads; short vertical lamina developed between third and fourth neural spines. Dorsal fin basals relatively weakly developed; dorsal spine bears few or no anterior and posterior dentations.

Upper limb of supracleithrum posteriorly truncated. Posterior process of the cleithrum without strong tubercles. (In the Sand Draw

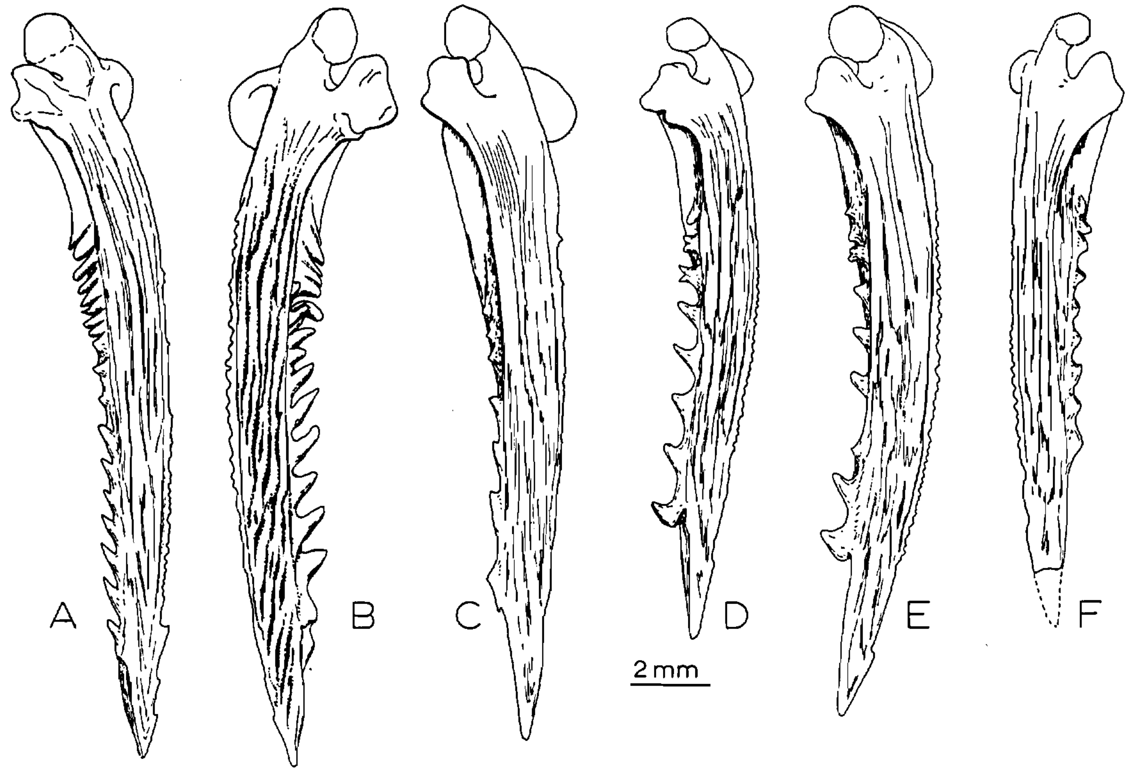

FIG. 14. Pectoral spines. A. *Ictalurus natalis*, UMMZ 171788. B. *Ictalurus nebulosus*, UMMZ 171787–S. C. *Ictalurus melas*, UMMZ 169035-S. D–F. *Ictalurus sawrockensis*. D. UMMP V57375 (Sand Draw local fauna). E. UMMP V45381 (Rexroad local fauna). F. UMMP V37067 (Sawrock Canyon local fauna).

sample the process is usually sculptured with ridges and grooves only; tubercles are rarely present. In the Sawrock Canyon, Bender, Rexroad, and Dixon samples the tuberculation of the process is more extensive.) Coracoid with short, vertical ventral lamina; six or seven strong sutures developed between the coracoids at their symphysis. Length of extensor fossa of the coracoid contained in its width, as measured along posterior edge, about one and three-fourths times. (In Catfishes the dorsal surface of the coracoid is slightly covered anteriorly by the cleithrum. The exposed portion of the coracoid is here termed the extensor fossa as this is the major site of origin of the extensor muscles of the pectoral spine.)

Pectoral spine with few anterior distal serrae, becoming rounded with growth; a median row of prominent, more or less regularly spaced, anterior dentations along most of the length of the spine shaft. Posterior dentations moderate in strength and number. Distally the dentations are usually regularly spaced, erect to slightly retrorse, and often slightly multicuspid; proximally the dentations are crowded, more irregular, and attached only to the dorsal half of the shaft of the spine.

COMPARISON OF SAMPLES AND RELATIONSHIPS

To distinguish the Sawrock Canyon sample from the Rexroad and Bender samples Smith (1962) used characters of the pectoral spine base and shaft. In the Rexroad and Bender samples the proximal crest on the anterior process of the spine base is elevated, whereas it is only slightly arched in the Sawrock Canyon sample. This feature appears to hold for most individuals. Within species of living bullheads, however, details of the shape of the processes and facets on the pectoral-spine base are variable (fig. 13). The difference in this feature between the Sawrock Canyon and Rexroad samples is not any greater than that between local populations of extant species. Similarly, the shape of the spine shaft, straight versus curved, is also highly variable within Recent species, and there is some variability in this feature within the fossil samples themselves. Accordingly, we do not regard these differences between the fossil samples as evidence for separation at the species level.

The number of distal, regularly spaced, posterior dentations on the pectoral spine also varies in the samples of *I. sawrockensis*. Spines from the Sawrock Canyon sample average a slightly greater number of these dentations than those from the other samples (fig. 14). The Rexroad and the Sand Draw samples are intermediate in this feature between the Sawrock Canyon sample and Recent *I. melas* (Rafinesque, 1820). *Ictalurus melas* among living bullhead species has the fewest number of posterior dentations. Because of the high intraspecific variability in this feature, however, we cannot give it much taxonomic weight.

In all of its known osteological features *Ictalurus sawrockensis* falls well within the limits of variation of the modern bullheads, subgenus *Amiurus*, and possesses the character states (where they are known) that uniquely define *Amiurus*, i. e., strong anteroventral crest on the dentary, and steeply elevated posterior margin of the coronoid process.

Among living species of *Amiurus*, *I. melas*, the black bullhead, and *I. nebulosus* (Lesueur, 1819), the brown bullhead, appear to share a more recent common ancestry than either does with any other species (Lundberg, 1970). In addition to a strong overall similarity, these two bullheads have in common a combination of advanced features that is not found elsewhere within the Ictaluridae, e. g., reduced size of the endopterygoid; short, deep metapterygoid; deeply pitted pterotic; deeply pitted supraoccipital process; strong, vertical transverse crests along the posterior margin of the skull; long vertical lamina of the urohyal; long cleithral symphysis; and long coracoid extensor fossa. Where they are known *Ictalurus sawrockensis* possesses these features.

Ictalurus melas is distinguished from all other living bullheads in its possession of the following advanced characteristics: supraethmoid cornua with no mesial processes; supraethmoid cleft broad and shallow; posterior (humeral) process of the cleithrum with no, or very few, tuberculations; anterior dentations of pectoral spine few and weak; posterior dentations of pectoral spine usually very weak and spaced irregularly. *Ictalurus nebulosus* also has many unique characters within *Amiurus*: extremely long cleithral symphysis; extremely long coracoid extensor fossa; weakly developed or no secondary coracoid keel (a ridge present in other ictalurids medial to the scapular foramen); posterior dentations of the pectoral spine are usually very strong; premaxillary teeth few in number and relatively large; long slender process on the hyomandibular for insertion of the adductor hyomandibularis muscle.

The external surface of the posterior (humeral) process of the cleithrum is sculptured in all ictalurids. Usually this ornamentation consists of bony tubercles developed on more or less longitudinally oriented ridges. Among the living bullheads, only *Ictalurus melas* has these tubercles very weakly developed or absent. In the Sand Draw sample the tubercles are usually very reduced or absent, but some individuals have more extensive ornamentation of the process than any specimen of *I. melas* examined. In this feature the Sand Draw sample may be intermediate between Recent *I. melas* and the older *I. sawrockensis* samples. In the Dixon, Bender, Rexroad, and Sawrock Canyon samples the posterior process is generally more strongly ornamented. Within each of these samples, however, there are individuals that have weakly developed tubercles, and the tubercles are usually less well developed than in other bullhead species except *I. melas*. This trend toward reduction of the tuberculation on the posterior process of the cleithrum is an advanced feature that the fossil form shares with *I. melas*, and we take this as evidence of a close relationship between the two. The fossil has none of the unique features of *I. nebulosus*, and the other features of *I. sawrockensis* appear to be a combination of character states that are primitive for the *melas-nebulosus* group. Thus, although it cannot be proved that *I. sawrockensis* is a direct ancestor of modern *I. melas* there are as yet no known features (specializations) of the former that would exclude it from that position.

Smith (1962) believed *I. sawrockensis* to be related to *I. natalis* (Lesueur, 1819), the yellow bullhead. Of all other species of the subgenus *Amiurus*, *I. natalis* is probably most closely related to the *melas-nebulosus* group. The yellow bullhead shares with this group: broad, flattened nasal bones; a shortened supraoccipital process; and at least moderately shortened metapterygoid and palatine bones. As outlined above, *I. sawrockensis* has these features plus additional apparently derived characters of the *melas-nebulosus* group. In addition, the fossil form has none of the many unique characters of the yellow bullhead, e. g., posteriorly truncated lateral ethmoid; closed posterior cranial fontanelle; broad lateral crests on a very reduced supraoccipital process; weak levator arcus palatini crest; anterior mandibular pore near jaw symphysis; and concave lateral margin of the frontal bone. The strength of the posterior dentations of pectoral spines is similar in *I. sawrockensis* and *I. natalis*. But in *I. natalis* the number of dentations is usually much greater, and these tend to be more strongly retrorse. In addition, *I. natalis* has more anterior distal serrae on the pectoral spine than other species of *Amiurus*.

The hypothesis here proposed, then, is that *I. sawrockensis* is an extinct species of *Amiurus* close to, or perhaps even on the line leading to the modern black bullhead, *I. melas*. The center of distribution of *I. melas* is presently the Great Plains. *Ictalurus sawrockensis* is known only from this region, *Ictalurus melas* is the commonest bullhead in quiet, silty waters.

Ictalurus melas is not known to overlap in time with *I. sawrockensis*. The earliest record for the black bullhead is Kansan (Lundberg, 1970), and it is the most common bullhead preserved in later Pleistocene deposits from the Great Plains and Texas (C. L. Smith, 1954, 1958; Uyeno and Miller, 1962; G. R. Smith, 1963; Uyeno, 1963; Swift, 1968; Lundberg, 1970).

ORDER PERCIFORMES

FAMILY CENTRARCHIDAE

GENUS *CHAENOBRYTTUS* GILL, 1864

Chaenobryttus Gill, 1864, p. 192.

Diagnosis: Pleistocene to Recent lepomine centrarchid fishes with anterodorsal angle of dentary about 90 degrees; ventromesial border of articular longer than distance from posterior canal pore to anteroventral point of retroarticular; angle and crest at neck of maxilla only weakly developed; premaxillary processes short, distance from dorsal tip to ends of teeth less than half maxillary length; vomer with numerous small teeth, in at least 15×5 rows; grooved depression for attachment of cheek muscles along inner angle of preopercle; preopercle with postventral crenulae; supramaxilla well developed; lacrimal subrectangular with postventral serrae; endopterygoid, ectopterygoid, glossohyal, and posterior basibranchial with teeth; dorsal protuberances of supraethmoid separate, lateral.

Type Species: *Calliurus melanops* Girard =*Pomotis gulosus* Cuvier, 1829.

***Chaenobryttus serratus*, new species**

Figures 15, 16

Diagnosis: A lepomine centrarchid with (1) square, truncated anterior end of the dentary; (2) lower edge of articular longer than distance from posterior canal pore to anteroventral point of retroarticular; (3) low crest above angle at neck of maxilla; (4) short premaxillary processes; (5) vomer with numerous small teeth; (6) deep ridge for attachment of cheek muscles along inner angle of preopercle but with much stronger preopercular serrae and (7) indented posterodorsal border of opercle unlike adult *C. gulosus*. The first five of the above characters are similar to *Ambloplites* Rafinesque, 1820, and *Chaenobryttus gulosus*, and with (6) separate *C. gulosus* and *C. serratus* from all species of *Lepomis*.

Holotype: UMMP V57952, left preopercle.

Type Locality and Horizon: The holotype, left preopercle, UMMP V57952, is from the Keim Formation, east side of Booth Draw, SW. ¼, NW. ¼, sect. 25, T. 31 N., R. 22 W., 1800 feet south and 975 feet east of the northwest corner of section 25, Brown County, Nebraska. Collected by C. W. Hibbard and party, summer, 1968 (fig. 7).

Material: Opercles, UMMP V57177, V57855, V57923, V57924, V57937, V57941; opercular fragments, UMMP V57857, V57859; preopercles, UMMP V57856, V57861, V57873, V57912; subopercles, UMMP V57858, V57940; quadrates, UMMP V57891, V57892; articulars, UMMP V57874, V57876, V57878, V57920, V57939; dentaries, UMMP V57869, V57870, V57881, V57893, V57909, V57922, V57930, V57938; premaxillae, UMMP V57894, V57908, V57913; maxillae, UMMP V57176, V57870, V57890, V57901, V57910; prevomers, UMMP V57907, V57942; basioccipitals, UMMP V57875, V57895, V57921; pharyngeals, UMMP V57867; posttemporals, UMMP V57896,

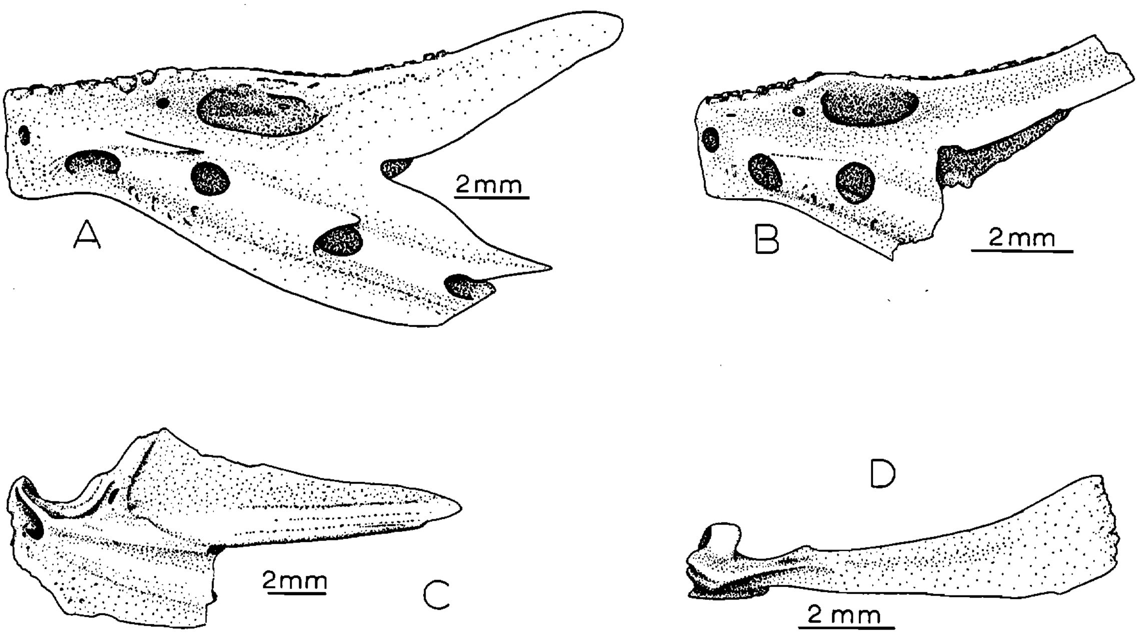

FIG. 15. Jaw bones of *Chaenobryttus serratus* and *Chaenobryttus gulosus*. A. *Chaenobryttus gulosus*, left dentary, UMMZ 126354 (Washtenaw Co., Michigan). B–D. *Chaenobryttus serratus* (Sand Draw lf., Brown Co., Nebraska). B. Left dentary, UMMP V57870. C. Right articular, UMMP V57876. D. Right maxilla, UMMP V57176.

V57900; supracleithra, UMMP V57863, V57865, V57866, V57871; cleithra, UMMP V57862, V57864, V57868, V57887, V57899, V57911, V57919; urohyals, UMMP V57918; scales, UMMP V57860; one set of associated elements, including subopercle, opercle, preopercle, spines, and scales, UMMP V57935; miscellaneous elements, UMMP V57160, V57170, V57931, V57932, V57933; localities UM-Nebr. 2–67, 1–68 (fig. 7).

DESCRIPTION: The preopercle is 17.5 mm. in overall length from the anterodorsal corner of the upper limb to the anterior point of the lower limb. The four ventral sensory pores are large, well developed, with elevated surfaces, and edges largely entire. There are 26 ventral and postventral serrae; the dorsal limb of the preopercle lacks serrations. The grooved depression for the origin of the adductor mandibulae is 1.2 mm. wide at the inner angle of the preopercle, and is more extensive than in any other sunfish except *Archoplites* Gill, 1861. This ridge is distinctive for *Chaenobryttus serratus* and *C. gulosus* (see Diagnosis).

DISCUSSION: The study of the fossil centrarchids from the Sand Draw local fauna required a re-evaluation of *Chaenobryttus kansensis* Hibbard, 1936, which we find to be a species of *Lepomis* on the basis of the wide-angled, toothless ectopterygoid, the high crest above the angle of the neck of the maxilla, the acute anterodorsal angle of the dentary, and the smooth, noncrenulate preopercle. This species was incorrectly synonymized with *C. gulosus* by Branson and Moore, 1962. A more complete analysis of the species in relation to other fossil and Recent centrarchids is being prepared by Ted Cavender.

Chaenobryttus serratus appears to be the closest known relative of *C. gulosus*. It is, in turn, intermediate between *C. gulosus* and *Ambloplites rupestris* (Rafinesque), 1817, retaining the primitive notch in the postdorsal border of the opercle as does the latter species. The species of *Chaenobryttus* are similar in some other respects to *Lepomis cyanellus* Rafinesque, 1819 (see below). Bailey et al., 1970, treat *Chaenobryttus* as a subgenus of *Lepomis* on the basis of hybrid evidence and external similarities between *C. gulosus* and *L. cyanellus*. Evidence against this synonymy is presented in the diagnoses and discussion above. The hybrid evidence can also be interpreted otherwise (Hester, 1970). Acceptance of an

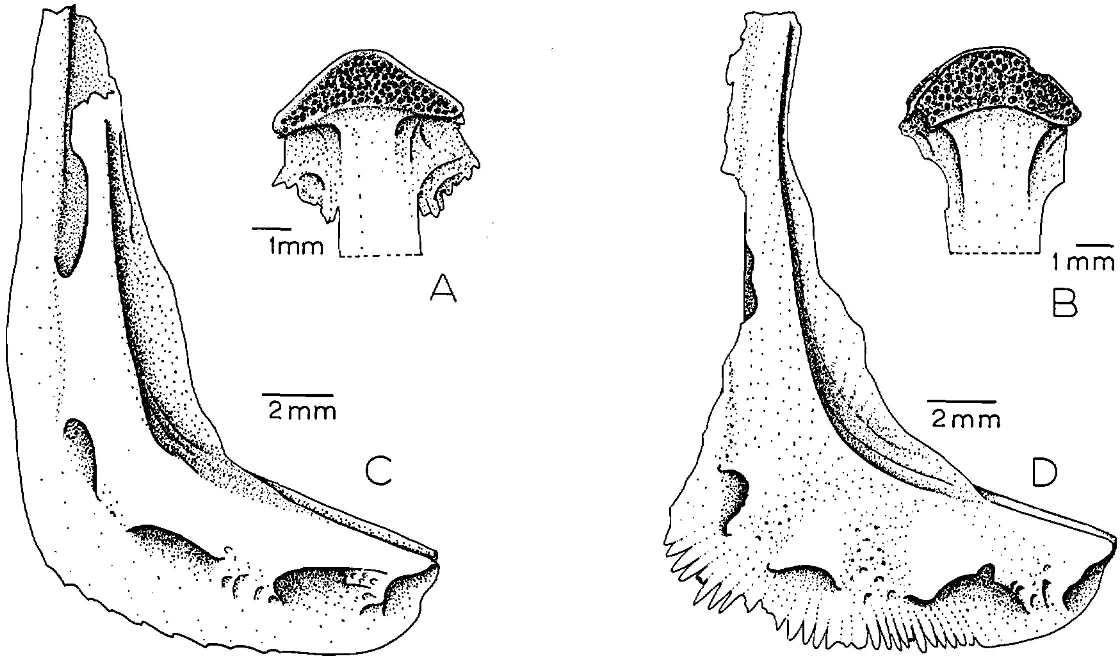

FIG. 16. Comparison of prevomers and preopercles of *Chaenobryttus gulosus*, UMMZ 126354 (Washtenaw Co., Michigan) and *C. serratus*, UMMP V57942 and V57952 (Sand Draw lf., Brown Co., Nebraska). A. Prevomer, *Chaenobryttus gulosus*, UMMZ 126354. B. Prevomer, *Chaenobryttus serratus*, UMMP V57942. C. Preopercle, *Chaenobryttus gulosus*, UMMZ 126354. D. Left preopercle (image reversed), *Chaenobryttus serratus*, UMMP V57952, type.

expanded *Lepomis* should probably await the diagnosis of such a taxon.

Chaenobryttus gulosus is found associated with abundant aquatic vegetation in still, soft-bottomed habitats at low elevation. It is not indigenous to western Nebraska, being limited in its western dispersal on the plains at about the 200 m. contour.

GENUS *LEPOMIS* RAFINESQUE, 1819

Lepomis RAFINESQUE, 1819, p. 420.

DIAGNOSIS: Pliocene to Recent lepomine fishes with anterodorsal angle of dentary 70–80 degrees; ventromesial border of articular shorter than distance from posterior canal pore to anteroventral corner of retroarticular; angle and crest at neck of maxilla well developed; premaxillary process long, distance from dorsal tip to ends of teeth longer than one-half maxillary length; vomer with fewer than 4×15 rows of teeth; preopercle without grooved depression for attachment of cheek muscles; supramaxilla reduced; lacrimal without serrae; endopterygoid, ectopterygoid, glossohyal, and basibranchials without teeth.

TYPE SPECIES: *Labrus auritus* Linnaeus.

Lepomis cf. *humilis* (Girard, 1858)

Figure 17

MATERIAL: Prevomer, UMMP V57944; dentary, UMMP V57943; (?) parasphenoid, UMMP V57926; localities UM-Nebr. 2–67, 1–68 (fig. 7).

DISCUSSION: The dentary, with large sensory canal pores and a *Lepomis*-like anterodorsal angle is similar to that of *Lepomis humilis*. If the fossils represent this species, they suggest an early form with less extreme development of the large pores. The prevomer has a reduced number of teeth in *L. humilis*. *Lepomis humilis* is a prominent inhabitant of turbid streams and ponds on the plains.

?*Lepomis cyanellus* Rafinesque, 1819

MATERIAL: Various centrarchid elements, including fragmentary lacrimals, UMMP V57928; dentaries, UMMP V57936; parasphenoids, UMMP V57916; pharyngeals, UMMP V57903; and hyomandibulars, UMMP

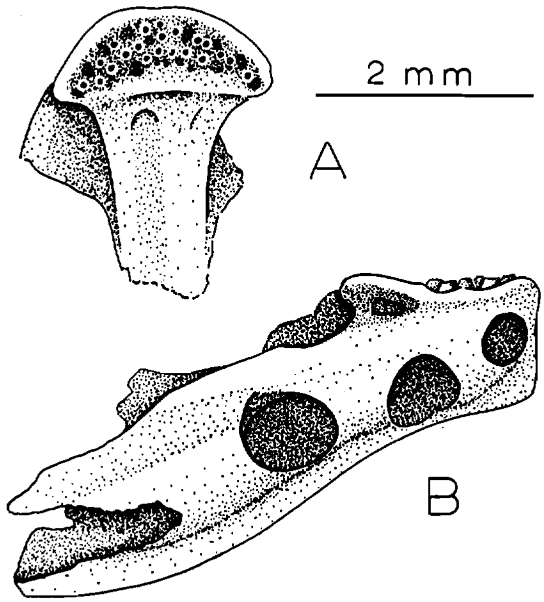

FIG. 17. *Lepomis* cf. *humilis* (Sand Draw lf., Brown Co., Nebraska). A. Prevomer, UMMP V57944. B. Dentary, UMMP V57943.

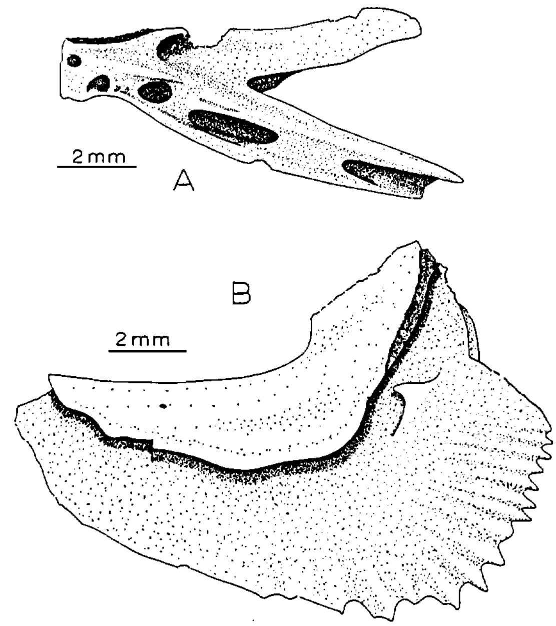

FIG. 18. *Morone chysops* (Sand Draw lf., Brown Co., Nebraska). A. Dentary, UMMP V57945. B. Preopercle, UMMP V57950.

V57904, V57917; localities UM-Nebr. 1–68, 2–67 (fig. 7).

DISCUSSION: The above materials do not appear to belong to either *Chaenobryttus serratus* or *Lepomis humilis*. They correspond well with *Lepomis cyanellus* but the samples are few and fragmentary and a confident identification is not warranted. It is possible that these elements belong to *Chaenobryttus serratus* described herein. If so, they represent evidence for greater similarity between *Chaenobryttus* and *Lepomis* in these bones than is apparent in Recent samples. The clearcut features of *Lepomis* are the sharp posteroventral ridge on the parasphenoid and the dorsal point on the lateral ridge of the hyomandibular.

FAMILY PERCICHTHYIDAE

GENUS *MORONE* MITCHILL, 1814

Morone MITCHILL, 1814, p. 17.

DIAGNOSIS: Pleistocene to Recent percichthyid fishes with the combination of: supraoccipital crest a simple, vertical lamina; dorsal and anal pterygiophores in three parts; two separate uroneurals (see Gosline, 1966, for discussion of these characters and diagnosis of the family Percichthyidae).

TYPE SPECIES: *Morone pallida* Mitchill =*Perca americana* Gmelin.

Morone chrysops (Rafinesque, 1820)

Figure 18

MATERIAL: Dentaries, UMMP V57837, V57850, V57877, V57945; articulars, UMMP V57839, V57849; preopercles, UMMP V57848, V57950; premaxillae, UMMP V57844, V57852, V57888; maxillae, UMMP V57851; posttemporal, UMMP V57841; frontals, UMMP V57946; parasphenoids, UMMP V57947; cleithrum and corocoid, UMMP V57948; supracleithrum, UMMP V57842; opercles, UMMP V57949; hyomandibular, UMMP V57951; urohyal, UMMP V57303; pelvic spines, UMMP V57853; spines, UMMP V57838; miscellaneous elements, UMMP V57309; localities UM-Nebr. 2–67, 6–67, 1–68, 4–68 (fig. 7).

DISCUSSION: *Morone chrysops* is identified by the serrate preopercle with an open sensory canal; the angle of the dorsomesial ridge of the lower arm of the cleithrum (related to the specific character given by Woolcott, 1957); the long, slender urohyal with a high dorsal lamina and a low, anteriorly directed anterodorsal process; the slender but truncate dentary with small canal pores and small teeth; the distinctive arrangement of ridges and pores on the dorsal surface of the frontal (Woolcott, 1957); and the truncate anterior end of the tooth patch, small inner teeth at the mesial edge, and short maxillary process of the premaxilla.

Morone chrysops occurs in large rivers, oxbows, and lakes usually over firm bottom. Its western distributional limit on the plains, through central Texas and eastern Oklahoma, Kansas, Nebraska, and South Dakota, appears to be restricted to areas in which annual precipitation exceeds normal evaporation and transpiration.

FAMILY SCIAENIDAE

GENUS *APLODINOTUS* RAFINESQUE, 1819

Aplodinotus Rafinesque, 1819, p. 418.

Diagnosis: Pleistocene freshwater scianids with pharyngeal bones united; large, blunt, paved lower pharyngeal teeth; lower jaw without barbels; preopercle slightly serrate; nine to 12 abdominal vertebrae and 13 to 20 caudal vertebrae.

Type Species: *Aplodinotus grunniens* Rafinesque, 1819.

Aplodinotus grunniens Rafinesque, 1819

Material: Anal spines, UMMP V57314; dorsal spines, UMMP V57846; otoliths, UMMP V57313, V57845; localities UM-Nebr. 6–67, 4–68 (fig. 7).

Discussion: *Aplodinotus grunniens* is identified on the basis of the large, distinctive anal spines and pterygiophores; the distinctive otoliths; and the striate dorsal spines.

The weathered aspect of some of the fossil bones of this species suggests that it usually lived upstream from the environment of deposition, probably in association with firmer bottom and mollusc habitat.

Aplodinotus grunniens is an inhabitant of large waters on the plains. It is tolerant of moderate turbidity. Distributional records in Nebraska (before widespread introduction of this species) are restricted to the eastern third of the state in association with the Missouri River and larger tributaries.

PALEOECOLOGY OF SAND DRAW FISHES

The Sand Draw fish fauna includes two ecological associations: (1) large-river and lake fishes restricted to lower elevations and more permanent aquatic habitats than occur in

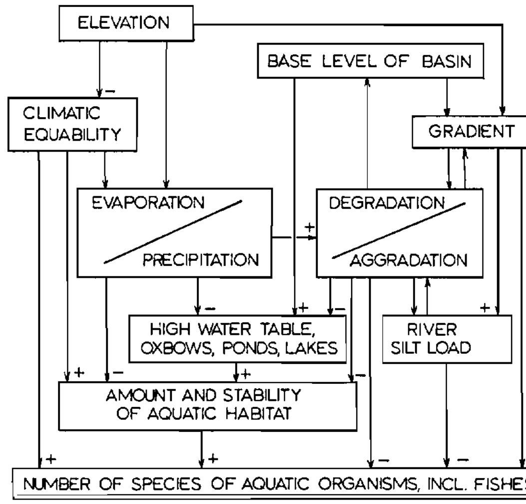

Fig. 19. Schematic diagram of interaction of factors influencing species distributions in streams of the Great Plains. The number of species in a section of stream is determined proximally by the amount and stability of aquatic habitat and factors that control current and silt load. The more remote influences are indicated in the top of the diagram. Arrows and signs indicate direction and sign of influence.

Brown County, Nebraska presently, and (2) prairie and plains species characteristic of small streams and lakes. Group 1 species are *Hiodon* cf. *alosoides*, *Ictiobus cyprinellus*, *Morone chrysops*, and *Aplodinotus grunniens*. These species do not occur near the fossil locality, but are at least potential inhabitants of the Missouri River area just 60 miles to the northeast, and 1000 feet lower in elevation. The present limitation of the distribution of these species plus *Chaenobryttus* on the plains seems to involve some subset or combination of the following interrelated conditions: increased elevation and gradient, excess of evaporation over precipitation, decreased cover vegetation, increased silt load in the rivers, and increased temperature fluctuation (fig. 19).

Several of the Group 1 species are able to exist in impoundments at elevations over 2400 feet on the plains today. Their occurrence in this special environment experimentally tests and cancels out the negative effects of each of the adverse factors in figure 19, except elevation, and demonstrates that some combination of these factors other than elevation per se prevents existence of these species on the high plains under natural conditions. The westward extension of Group 1 species in the lower Kansas River, 350 miles to the southeast (Cross, 1967), despite high silt load and sand bottom, suggests that gradient and amount and stability of aquatic habitat (fig. 19) are the critical limiting factors in this region. Brown County, Nebraska, lacks suitably large, stable waters at low gradient now, but must have had this habitat to support the Sand Draw fish fauna. Four general factors shown in figure 19 might be variables that differed enough in the past to allow abundant, stable aquatic habitat in late preglacial times in Brown County:

(1) Lower elevation, 500 to 1000 feet lower than the present, would contribute to the low gradient and permanence necessary to enable presence of Group 1 fishes, but there is little evidence of Pleistocene uplift of the area (see below).

(2) Climatic equability. Less temperature fluctuation, in combination with more abundant aquatic habitat (these factors would contribute to each other locally), would enable Group 1 fishes to exist, if the gradient was lower, even at 2400 feet in elevation. Evidence for less seasonality in earlier Pleistocene and late Tertiary environments has been presented by Hibbard (1955, 1960) and Axelrod (1967). Independent increase in the amount of low-gradient aquatic habitat is still required.

(3) Evaporation-precipitation differential. Increase in the volume of aquatic habitat would result if precipitation exceeded evaporation, as in central Iowa, and unlike central Nebraska. However, it is doubtful that increased effective precipitation could create a habitat favorable to Group 1 fishes if the area had the present high gradient. Furthermore, there is faunal evidence (see below, and subsequent papers, the present volume) against a strong excess of precipitation over evaporation at the time the fauna lived.

(4) Gradient. It is clear that absence of suitable large-water habitat in Brown County today is partly due to the extreme gradient between the elevation of the habitat and that of the base level of the present drainage, the Missouri River, 60–150 miles away and 1000 feet lower in elevation. Whatever drainage existed when the Sand Draw fauna lived was of relatively lower gradient and must have been connected to the central drainage (probably the Mississippi through the preglacial Des Moines or Iowa River) by low gradient fluvial habitat in order to enable dispersal of the Group 1 fishes. The Group 1 species live today in the lower Kansas River with a valley gradient of about 2 feet per mile and all are known from the Missouri River or its larger tributaries with valley gradients of about 1.25 feet per mile. Assuming drainage through the preglacial Des Moines River, the drop in elevation between the Sand Draw local fauna and Des Moines, Iowa, averages between 3.5 and 5.0 feet per mile, depending on whether the elevation at Des Moines was near 800 feet, as at present, or 500 feet as suggested by Horberg (1956). Skinner (see present paper, p. 21) has measured the slope at the top and bottom of the Keim Formation at about 6.7 and 10.4 feet per mile. The actual habitat gradient on such a slope could have been about 4–6 feet per mile with meanders. With few exceptions, these fishes are not found in gradients as steep as this even in well-watered environments. The presence of Group 1 fishes in the Sand Draw local fauna suggests that the preglacial slope between the Sand Draw and the Central Lowlands basin was probably less concave than that illustrated by Horberg (1956), who showed a profile with a steep increase in gradient to the west, in eastern Nebraska. Such an increase would have involved an extensive reach with slope of more than 10 feet per mile, as at the present time, and this would have excluded favorable habitat for Group 1 fishes.

The resolution of this dilemma depends partly on the validity of the interpretation of preglacial elevation in central Iowa, based primarily on evidence for Pleistocene uplift in the driftless area (Trowbridge, 1954). Assuming a preglacial elevation of 500 feet for the Des Moines River near Des Moines, the fish evidence requires a similarly lower elevation, perhaps 2000 feet, at the site of existence of the Sand Draw fish fauna. Otherwise, the elevation differential would require a slope too steep for habitation by these fishes. This hypothesis requires that any Pleistocene uplift in the Central Lowlands be matched by uplift in north-central Nebraska, perhaps as a part of epeirogenic uplift in the Rocky Mountains, as proposed by Cook (1960).

An alternative hypothesis assumes elevations at about their present levels in central Iowa and north-central Nebraska during the time of deposition of the Keim Formation and subsequently. Under these assumptions, the fish evidence simply requires a much less concave slope in the drainage profile between the faunal site and the Central Lowlands. Drainage to the east-southeast, through the area now drained by the Elkhorn River, is a possibility. This hypothesis supposes that much of the present profile concavity and gradient in the Missouri River basin in northeastern Nebraska probably resulted from degradation associated with the recurrent torrential volumes of meltwater from the north during subsequent glacial recessions. Similar alternatives, not explored here, involve the possibility of low-gradient drainage to the northeast, across subsequently glaciated regions, to Hudson Bay (but see Flint, 1955).

Group 1 fishes suggest ecological conditions similar to those described by Taylor (1960) for his horizon B molluscan fauna. The sites richest in Group 1 fishes are UM-Nebr. 6–67 and 4–68, which correspond stratigraphically, but not in facies, to Taylor's localities 2 and 3, respectively (Taylor, 1960, p. 34).

The second ecological group of fishes in the Sand Draw local fauna includes *Pimephales* cf. *promelas*, *Ictalurus sawrockensis* (possibly an ancestor of *I. melas*), and *Lepomis* cf. *humilis*. These species are represented today by inhabitants of small streams and generally quiet waters on the plains. In Iowa they are abundant and widespread in lakes, ponds, sloughs, and low gradient streams (Harlan and Speaker, 1956). In Kansas they inhabit streams, especially less stable streams not dominated by other species (Cross, 1967). Group 2 species are widespread and common on the plains and probably exist in Brown County, Nebraska, today. The ecology and distribution of *Lepomis cyanellus* associate it with Group 2.

Group 2 fishes suggest ecological conditions similar to those indicated by the molluscs of Taylor's (1960) horizon C. The quarries richest in Group 2 fishes are UM-Nebr. 2–67 and 1–68, which are 22 feet below the Long Pine Gravel and correspond stratigraphically, but not in facies, to Taylor's locality 6 (Taylor, 1960, p. 32).

The Sand Draw local fauna lacks many cool-water elements that occurred in plains faunas in Kansas and Oklahoma later in the Pleistocene (C. L. Smith, 1954, 1958; G. R. Smith, 1963). Assuming no individual or average change in ecological requirements of the species in the Sand Draw fish fauna, it is inferred that they occupied a low-gradient, large-river, or oxbow habitat in a climatic region of higher equability, no cooler than temperatures at present, and with average annual evapo-transpiration about equal to average annual precipitation. These conditions require a large drainage upstream, probably to the northwest (for which there is no sedimentary evidence), or a lake, and either lower local elevation with subsequent uplift, or low-gradient, meandering drainage to the central lowlands basin to the southeast.

ACKNOWLEDGMENTS

Dr. Claude W. Hibbard has been especially helpful at all stages of preparation of this work. Drs. Reeve M. Bailey and Ted Cavender have provided many helpful suggestions, but do not necessarily agree with taxonomic conclusions reported here. Mr. John Moseley prepared several of the figures while supported by NSF Grant GB-14871 to Dr. Robert R. Miller.

Collection of specimens deposited at the Museum of Paleontology, University of Michigan, was supported by National Science Foundation Grant GB-5450 to Dr. C. W. Hibbard.

AMPHIBIANS AND REPTILES

J. ALAN HOLMAN[1]

Most of the herpetological fossils in the Sand Draw fauna represent six species of turtles, but one salamander, three anurans, four lizards, and five snakes are also present. Two extinct tortoises (*Geochelone*) are discussed: a giant form which is specifically indeterminate, and a remarkable, new small form. Four fossil species have living representatives that occur south of the study area reaching the northern limits of their distribution in northern Kansas or southern Nebraska.

CLASS AMPHIBIA

ORDER URODELA

FAMILY AMBYSTOMATIDAE

GENUS *AMBYSTOMA* TSCHUDI, 1838

Ambystoma Tschudi, 1838, p. 92 (the extensive synonymy of this genus is detailed in Tihen, 1958, pp. 31, 32).

Type Species: *Lacerta subviolacea* Barton, 1804 (by monotypy =*maculatum*).

Distribution: Oligocene, Pliocene, and Pleistocene, North America. Recent, southern Alaska and extreme southern Labrador southward to the southern part of the central plateau of Mexico.

Diagnosis: See Tihen, 1958, pages 32, 33.

Ambystoma tigrinum (Green, 1825)

Salamandra tigrina Green, 1825, p. 116.
Ambystoma tigrina: Baird, 1849, p. 284.

Distribution: Pliocene and Pleistocene, North America. Recent, central Alberta and Saskatchewan south to Hernando County, Florida and Puebla, Mexico except in areas where there are no substrates suitable for burrowing.

Diagnosis: See Tihen, 1958, pages 33–35.

Referred Material: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, type area of the Sand Draw Fauna: UMMP V52232, two vertebrae; UMMP V57322, two vertebrae. UM-Nebr. 1–66: UMMP V57259, four skull fragments, 48 vertebrae, three humeri, two partial pelvic girdle elements, and four postcranial fragments. UM-Nebr. 2–66: UMMP V57244, two vertebrae. UM-Nebr. 4–67: UMMP V57384, 106 vertebrae, one humerus, one femur, and one postcranial fragment; UMMP V57249, one humerus and one postcranial fragment; UMMP V57250, an associated skeleton including pieces of several dermal roofing bones, jaw elements, an otic capsule, 11 vertebrae, two portions of either side of the pelvic girdle, a partial femur, both humeri, and miscellaneous scraps of vertebrae and limbs. UM-Nebr. 6–67: UMMP V57319, 81 vertebrae, two humeri, one femur, four partial pelvic girdle elements, and eight postcranial fragments. UM-Nebr. 1–68: UMMP V57168, two dentaries, one otic capsule, two skull fragments, seven humeri, one femur, two partial pelvic girdle elements; UMMP V57169, 422 vertebrae; UMMP V59810, five vertebrae. UM-Nebr. 4–68: UMMP V57231, one vertebrae and one humerus.

Discussion: The numerous *Ambystoma* elements are all indistinguishable from living *A. tigrinum*. Numerous larval forms are represented in the fauna, but there is no evidence of neotenic forms (see Tihen, 1955 and 1958, for criteria for the identification of *Ambystoma tigrinum* on the basis of osteology, and Tihen, 1942, for criteria for the identification of neotenic forms of fossil *A. tigrinum*). The largest fossil bones were but slightly larger than a modern *A. tigrinum* from Woodford County, Illinois with a total length of 245.0 mm.

Ambystoma tigrinum occurs in Brown County, Nebraska, today (Hudson, 1942).

ORDER ANURA

FAMILY PELOBATIDAE

GENUS *SCAPHIOPUS* HOLBROOK, 1836

Scaphiopus Holbrook, 1836, p. 85.
Spea Cope, 1866a, p. 81.

Type Species: *Scaphiopus solitarius* Holbrook, 1836, =*holbrooki*.

Distribution: Oligocene to Pleistocene, North America. Recent, southwestern Canada to southern Mexico.

Diagnosis: See Auffenberg, 1956, page 6.

Scaphiopus cf. *Scaphiopus bombifrons* Cope, 1863

Referred Material: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, type area of the Sand Draw fauna: UMMP

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V59906, one fragmentary sacrococcyx. UM-Nebr. 4–67; UMMP V57383, one fragmentary sacrococcyx; UMMP V59907, one ilium. UM-Nebr. 1–68: UMMP V59908, one fragmentary sacrococcyx.

DISCUSSION: These fragmentary elements of spadefoots are tentatively assigned to *Scaphiopus bombifrons* but are slightly larger than a modern *S. bombifrons* (snout-vent length, 38.0 mm.) from Trego County, Kansas. The validity of the dorsal protuberance of the ilium as a character to distinguish between *Scaphiopus* species has been questioned by Kluge (1966), but I (Holman, 1970) believe that the size and shape of this part is diagnostic in most modern skeletons of *S. bombifrons.* The single fossil ilium from the Sand Draw fauna is similar to the ilia of modern *S. bombifrons* of the same size in the development of the dorsal protuberance.

Scaphiopus bombifrons has been reported from the modern fauna of the extreme northern part of Custer County, Nebraska, (Hudson, 1942) and undoubtedly occurs in Brown County, Nebraska, today.

FAMILY RANIDAE

GENUS *RANA* LINNAEUS, 1758b

Rana LINNAEUS, 1758b, p. 210.

TYPE SPECIES: *Rana temporaria* Linnaeus, 1758b.

DISTRIBUTION: Miocene to Pleistocene, Europe, Africa, Asia, and North America. Recent, worldwide except for southern South America, southern and central Australia, New Zealand, and eastern Polynesia.

DIAGNOSIS: See Holman, 1962, pages 256–257.

Rana catesbeiana Shaw, 1802

Rana catesbeiana SHAW, 1802, p. 106, pl. 33.

DISTRIBUTION: Pleistocene, North America. Recent, eastern North America (except the southern one-third of Florida) north to the Maritime Provinces, Quebec, southern Ontario, and southeastern Manitoba; west through most of Kansas, Nebraska, and Oklahoma, and through Texas to the lower Rio Grande.

DIAGNOSIS: See Tihen, 1954, pages 218–220.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 4–67: UMMP V59909, one ilium. UM-Nebr. 1–68: UMMP V59910, one sphenethmoid and one ilium. UM-Nebr. 2–68: UMMP V57296, one ilium.

DISCUSSION: These fossil ilia resemble modern *R. catesbeiana* and differ from modern *R. pipiens* and *R. areolata* in having a precipitous rather than a gentle slope of the posterodorsal border of the ilium into the dorsal acetabular expansion. The fossil sphenethmoid is assigned to *R. catesbeiana* on the basis of size. A male modern *Rana catesbeiana* skeleton from McLean County, Illinois is from a frog with a snout-vent length of 130.0 mm. and has the greatest posterior width of its sphenethmoid 4.9 mm.; that of the Sand Draw fossil frog is 5.0 mm.

Rana catesbeiana has been reported from the modern fauna of Keya Paha County, Nebraska, (Hudson, 1942) and undoubtedly occurs in Brown County, Nebraska, today.

Rana pipiens Schreber, 1782

Rana pipiens SCHREBER, 1782, p. 185, pl. 4.

DISTRIBUTION: Miocene (?) to Pleistocene, North America. Recent, eastern North America north to about latitude 60° N., west to the Great Basin, and southeastern California, south throughout Mexico and to Panama.

DIAGNOSIS: See Tihen, 1954, pages 218–220.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 1–66: UMMP V59912, one scapula; UMMP V57262, one ilium. UM-Nebr. 4–67: UMMP V59911, one trunk vertebra, two sacral vertebrae, and four ilia; UMMP V57248, one humerus, two ilia, and one tarsometatarsus. UM-Nebr. 1–68: UMMP V59934, eight maxillary fragments, five dentaries, four trunk vertebrae, two scapulae, 13 humeri, one radio-ulna, and five ilia; UMMP V59913, one sacral vertebra. UM-Nebr. 5–67: UMMP V57282, one sphenethmoid, one scapula, one urostyle, and three ilia. UM-Nebr. 6–67: UMMP V57308, three ilia. UM-Nebr. 2–68: UMMP V57296, one ilium. UM-Nebr. 3–68: UMMP V57238, one dentary, two maxillary fragments, one trunk vertebra, and one radio-ulna. UM-Nebr. 4–68: UMMP V57231, one humerus.

DISCUSSION: These fossil ilia resemble modern *R. pipiens* and differ from modern *R. catesbeiana* in being smaller and in having a gentle rather than a precipitous slope of the posterodorsal border of their ilial crest into the dorsal acetabular expansion. The fossils are similar to modern *R. pipiens* and differ from modern *R. areolata* (*R. a. areolata*, *R. a. circulosa*, and *R. a. aesophus*) on the basis that the vastus prominence of Holman (1965) is narrower, more rounded, and less extensive.

Proportionally two of the sacral vertebrae are similar to modern *R. pipiens* and differ from modern *R. catesbeiana*, *R. grylio*, and *R. heckscheri* (Tihen, 1954, fig. 1, p. 219) in the lengths of their centra, 2.6 mm. (UMMP V59913) and 2.7 mm. (UMMP V59911), and in having a ratio of the width of the centrum divided into the length of the centrum of 0.87 in both bones.

Another sacral vertebra (UMMP V59911) is procoelous, and to my knowledge represents the first record of a fossil or modern *Rana pipiens* with a procoelous sacral vertebra, although the condition has been reported in two modern *Rana catesbeiana* (Holman, 1963b). The fossil is definitely *Rana* with the backswept, cylindrical sacral diapophyses of this genus. It resembles *R. pipiens* rather than *R. catesbeiana*, *R. grylio*, and *R. heckscheri* in having a centrum width of 4.2 mm. and a ratio of the width of the centrum divided by the intercotylar space of 8.4 (Tihen, 1954, fig. 2, p. 220).

Rana pipiens occurs in Brown County, Nebraska today (Hudson, 1942).

CLASS REPTILIA

ORDER TESTUDINES

FAMILY KINOSTERNIDAE

GENUS *KINOSTERNON* SPIX, 1824

Kinosternon Spix, 1824, pl. 12.

Type Species: *Kinosternon longicaudatum* Spix, 1824, =*scorpioides*.

Distribution: Pliocene and Pleistocene, North America. Recent, eastern and southwestern United States south through Central and South America.

Diagnosis: See Carr, 1952, page 89.

Kinosternon flavescens (Agassiz, 1857)

Platythyra flavescens Agassiz, 1857, p. 430, pl. 5.

Kinosternon flavescens: Stejneger and Barbour, 1917, p. 111.

Distribution: Pliocene and Pleistocene, North America. Recent, Texas to Arizona, and northern Mexico, north to Utah and Colorado and through Oklahoma and Kansas to Nebraska; a relict population occurs in western Illinois.

Referred Material: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, type area of the Sand Draw fauna: UMMP V52171, one peripheral, one hypoplastron, and two hypoplastra; UMMP V52221, one nuchal, one hypoplastron, one peripheral, and one pygal; UMMP V56440, two nuchals, one hypoplastron, and one xiphiplastron; F:AM 87463, one scapula, one epiplastron, one hypoplastral fragment, three xiphiplastral fragments, two costals, and five peripherals. UM-Nebr. 4–67: UMMP V57256, one dentary, two humeri, one ulna, and one femur. UM-Nebr. 5–67: UMMP V57279, one nuchal. UM-Nebr. 1–68: UMMP V57163, two dentaries, 12 vertebrae, three coracoids, eight humeri. eight scapulae, four femora, four nuchals, six neurals, four pygals, two costals, 41 peripherals, five epiplastra, five hyoplastra, and one hypoplastron.

Discussion: Terminology for turtle elements follows Zangerl (1969). A large amount of additional *Kinosternon flavescens* material has recently been reported from the Sand Draw fauna by Fichter (1970). *Kinosternon flavescens* does not occur in the area today. In fact, the only valid records of its occurrence in Nebraska are along the Republican River drainage in the extreme southern part (Hudson, 1942).

FAMILY EMYDIDAE

GENUS *CHRYSEMYS* GRAY, 1844

Chrysemys Gray, 1844, p. 27.

Type Species: *Testudo picta* Schneider, 1783.

Distribution: Pliocene to Pleistocene, United States. Recent, southern Canada and the eastern three-fourths of the United States (except for most of the Southeast Coastal Plain) south to extreme northern Mexico.

Diagnosis: See Galbreath, 1948, page 271, columns 1, 2.

Chrysemys picta (Schneider, 1783)

Testudo picta Schneider, 1783, p. 348.

Chrysemys picta: Gray, 1855, p. 32.

Distribution: Pleistocene, United States. Recent, same as for genus.

Diagnosis: See Galbreath, 1948, page 271, column 1.

Referred Material: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, type area of the Sand Draw fauna: UMMP V59914, one nuchal and one hypoplastron; UMMP V59915, one nuchal, three epiplastra, one hypoplastron, and one entoplastron; F:AM 87464, one nuchal and one hypoplastron. UM-Nebr. 4–67: UMMP V57635, one nuchal and one hypoplastron; UMMP V59916, one pubis, one tibia, and one costal. UM-Nebr. 5–67: UMMP V57279, one nuchal and one hypoplastron. UM-Nebr. 1–68: UMMP V59917, one nuchal, one epiplastron, and five hypoplastra.

DISCUSSION: Bone representing two kinds of aquatic emydid turtles are present in the Sand Draw fauna. The majority of the fossils are indistinguishable from the modern species, *Chrysemys picta*, but three bones represent another aquatic emydid turtle. Criteria for distinguishing the *C. picta* bones from the other aquatic emydid are given in the following section.

Chrysemys picta occurs in Brown County, Nebraska, today (Hudson, 1942).

Pseudemys sp.

DISTRIBUTION: Oligocene(?) to Pleistocene, North America. Recent, New England to Brazil and the West Indies.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, type area of the Sand Draw fauna: UMMP V59918, one partial nuchal; UMMP V56441, one posterior peripheral. UM-Nebr. 1-66: UMMP V56461, one epiplastron.

MEASUREMENTS (in MM.): Greatest thickness of nuchal (UMMP V59918) at posterior end of cervical scute 9.0; length of its cervical scute 28.0; greatest width of its cervical scute 10.7; Greatest width of epiplastron (UMMP V56461) 54.8; greatest length 58.8; midline suture length 39.0; greatest thickness 13.6. Greatest length of peripheral (UMMP V56441) 52.7; greatest width 28.1; greatest thickness 10.8.

DISCUSSION: I choose to recognize the genus *Pseudemys* (as in Zangerl, 1969) rather than to combine *Pseudemys* with *Chrysemys* (as in McDowell, 1964, and Rose and Weaver, 1966).

Although the large partial nuchal lacks the sculpturing of species of modern *Pseudemys*, the double-toothed posterior peripheral is similar to modern *Pseudemys scripta* (Weaver and Robertson, 1967, p. 54, fig. 1) and the epiplastron shows detailed similarity to modern *Pseudemys scripta*. Moreover, the size of the Sand Draw *Pseudemys* material is similar to that of the form called *Pseudemys scripta bisornata* Cope by Preston (1966).

Following are criteria used for distinguishing the Sand Draw *Pseudemys* fossils from the Sand Draw *Chrysemys picta* bones.

The nuchal of the Sand Draw *Pseudemys* is distinguished from those of *C. picta* by the much larger size of the *Pseudemys*. Several smaller, thinner nuchals are identical to modern *C. picta*.

The epiplastron of the Sand Draw fossil *Pseudemys* is similar to modern *P. scripta* in having one principal notch on the anterior edge just internal to the lateral impression of the first marginal shield and followed internally by several weak serrations. Other Sand Draw epiplastra are similar to modern *C. picta* in being smaller than the *Pseudemys* fossil, and in having the principle notch less distinct and the serrations more distinct than in modern *P. scripta*.

The hypoplastra of modern *P. scripta* are larger and thicker and have a relatively narrower inguinal scute than in modern *C. picta*. All the Sand Draw aquatic emydid hypoplastra are assigned to *C. picta*.

The fossil *Pseudemys* peripheral bone is double-toothed as in *P. scripta*. Modern *C. picta* peripheral bones are all single-toothed.

The size of the Sand Draw *Pseudemys* material as well as its thickness, and the unsculptured nature of the nuchal is similar to *Pseudemys scripta bisornata* of Preston (1966, fig. 1). Unfortunately, the ratio of the width of the cervical scute to the width of the nuchal bone, a character used by Preston to define *P. s. bisornata*, cannot be used in the Sand Draw material because the nuchal is incomplete.

Weaver and Robertson (1967) combined the taxon *Trachemys bisornata* Hay as well as four other fossil species of *Trachemys* as *Chrysemys* (equals *Pseudemys* of this paper) *scripta petrolei* (Leidy) which they perceived as a large Rancholabrean temporal subspecies of *Chrysemys* (equals *Pseudemys* of this paper) *scripta*. But Weaver and Robertson did not deal with Preston's (1966) large amount of pre-Rancholabrean (Irvingtonian) *P. scripta bisornata* material from Knox County, Texas that Preston points out is distinguished not only by its larger size, but by characters of the nuchal bone, from modern subspecies of the *P. scripta* complex.

No unequivocal present-day records of *Pseudemys* are known from Nebraska. Hudson (1942) cited a single, highly questionable, record of *Pseudemys scripta* for Adams County in the southern part of the state.

FAMILY TESTUDINIDAE

GENUS *GEOCHELONE* FITZINGER, 1836

Geochelone FITZINGER, 1836, pp. 111, 112, 122 (the synonymy of this genus is listed in Loveridge and Williams, 1957, p. 221).

TYPE SPECIES: *Testudo stellata* Schweigger

= *Testudo elegans* Schoepff, 1792 (designated by Fitzinger, 1843).

DISTRIBUTION: Tertiary, Europe, Asia, Africa, North America. Miocene to Pliocene, South America. Pleistocene, North America and West Indies. Recent, Galapagos Islands, South America, Africa, Madagascar, some islands in the Indian Ocean.

DIAGNOSIS: See Loveridge and Williams, 1957, pages 221–222.

SUBGENUS *CAUDOCHELYS* AUFFENBERG, 1963

Caudochelys AUFFENBERG, 1963a, pp. 69–70.

TYPE SPECIES: *Testudo crassiscutata* Leidy, 1889.

DISTRIBUTION: Eocene to Pleistocene, North America.

DIAGNOSIS: See Auffenberg, 1963a, pp. 69–70.

Caudochelys sp.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, type area of the Sand Draw fauna: UMMP V59920, four large shell fragments; UMMP V59921, one costal; UMMP V56443, two large carapace fragments; UMMP V57060, one peripheral; UMMP V57062, three partial costals; UMMP V57063, one costal. Bejot locality on the south side of Jackrabbit Hill NW. ¼, sect. 24, T. 30 N., R. 21 W., 1925 feet east and about 500 feet south of the NW. corner of sect. 24: UMMP V57397, two large pieces of shell. Burrow's (Johnson's) Ranch just north of section line, SW. ¼, sect. 20, T. 31 N., R. 21 W.: UMMP V59922, one neural, one peripheral, one costal, and 18 shell fragments; UMMP V57396, one costal. Prospecting Locality 512, Hall Gravel Pit: F:AM 87460, one peripheral. Prospecting Locality 278, Magill Farm, high in the section: UMMP V56425, one large plastral piece. Prospecting Locality 489, Quinn Gravel Pit: F:AM 87461, one partial peripheral and three other pieces of shell. Sand Draw, channel along the north line of the SW. ¼. NE. ¼, sect. 29, T. 31 N., R. 21 W.: UMMP V56458, one costal, one peripheral, and two carapace pieces; UMMP V56463, two large pieces of a carapace.

The material is too fragmentary for specific identification, but definitely represents one of the huge land tortoises of the subgenus *Caudochelys* (Auffenberg, 1963a). These large land tortoises are important fossil finds as it must be assumed they lived in areas of frost-free environments (Hibbard, 1960).

SUBGENUS *HESPEROTESTUDO* WILLIAMS, 1950

TYPE SPECIES: *Testudo osborniana* Hay, 1908.

DISTRIBUTION: Eocene to Pleistocene, North America.

DIAGNOSIS: See Williams, 1950, page 25.

Geochelone (Hesperotestudo) oelrichi,
new species
Figures 20–24

TYPE: UMMP V56298. Long Pine Formation, from the northwest corner of the Wilbur Magill pasture on the north side of a short reentrant of the main draw in the NW. ¼, SE. ¼, sect. 12, T. 30 N., R. 21 W., Brown County, Nebraska, Long Pine Quadrangle.

PARATYPES: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, type area of the Sand Draw local fauna: UMMP V59919 one fragmentary nuchal; UMMP V59923, one hypoplastron and two plastral and two carapace fragments; UMMP V59924, three peripherals and two costals; UMMP V56437, one large piece of shell; UMMP V56442, one costal; UMMP V57061, one partial costal; F:AM 87458, one hypoplastron; F:AM 87462, one neural and five costal fragments. Sand Draw Quarry: UMMP V57327, one costal. Reworked channel in the Sand Draw: UMMP V56459, neural fused to two costals. UM-Nebr. 1-66: UMMP V56462, one partial costal. UM-Nebr. 4–67: UMMP V57634, one partial costal. UM-Nebr. 5–67: UMMP V59925, two partial costals. UM-Nebr. 1-68: UMMP V59926, one costal. Magill pasture, locality of type specimen: UMMP V59927, one partial nuchal, several partial peripherals, some fragmentary pieces of shell and postcranial bones, some dermal ossicles of the forearm, three phalanges; UMMP V57222, one costal.

DISTRIBUTION: Long Pine and Keim formations, Brown County, Nebraska.

ETYMOLOGY: The species is named in recognition of the studies on fossil tortoises by Dr. Thomas M. Oelrich.

DIAGNOSIS: Tortoise of the *Geochelone* (*Hesperotestudo*) *turgida* group that appears to be a continuation of the evolutionary chronocline of *Geochelone turgida* (Cope) of the medial Pliocene and *Geochelone riggsi* (Hibbard) of the early part of the late Pliocene and appears to be the largest tortoise of this chronocline. *Geochelone oelrichi* also differs from *G. turgida* and *G. riggsi* in having less vaulted, thicker, more rugose shell and pronounced rounded knobs on third marginal shields of each side of carapace. Strongly differs from *Geochelone johnstoni* Auffenberg of Randall County, Texas, another small tortoise of early Pleistocene age, not only in being thicker-shelled and more rugose, but also in completely different nature of plastron. Axillary region deeply incised, border of plastron between axillary incision and epiplastral lip rounded; epiplastral lip huge, bulbous beak; xiphiplastron strongly notched. In *G. johnstoni* axillary region not incised, border of plastron between axillary region and epiplastral lip straight, epiplastral lip of moderate size and thickness, only weakly produced ventrally; xiphiplastron very weakly notched.

Description and Comparison of the Holotype

The holotype of *G. oelrichi* is one of the most complete specimens of the subgenus *Hesperotestudo* known. This fossil consists of: (1) most of the anterior one-half of a partially crushed carapace; (2) nearly a complete plastron; (3) a partial skull and hyoid fragments; and (4) a portion of the internal skeleton including part of the cervical region, a partial right pectoral girdle, nearly a complete left pectoral girdle and limb, and a right humerus disassociated from the skeleton. The complete left limb offers a unique opportunity to study the carpals of a *Geochelone* of the *turgida* group. The "suggested terminology" of Zangerl (1969, p. 315, fig. 1, p. 320, fig. 5) is used here for the epidermal shields and dermal bones of the shell.

The Shell

The shell of *Geochelone oelrichi* is compared with that of tortoises of the *G. turgida* group only in the section on size. In other sections *G. oelrichi* is compared with *G. turgida* and *G. riggsi*, other turtles of the same evolutionary line. Occasionally, *G. oelrichi* is compared with *G. johnstoni*, a small tortoise of the early Pleistocene of Texas, but thought to be of a different evolutionary line.

Size: *Geochelone oelrichi* is among the largest of the *Geochelone* (*Hesperotestudo*) *turgida* group; one specimen of seven *G. incisa* from the late Pleistocene of Florida is larger. The measurement that best reflects the size of *G. oelrichi* is the greatest straight-line length of the plastron, 258.0 mm. The plastron length in the holotype of *G. turgida* is 216.0 mm. and 190.0 mm. in the holotype of *G. riggsi*. *Geochelone alleni* Auffenberg of the late part of the medial Pliocene of Florida has a plastral length of 219.0 mm., whereas *G. incisa* (Hay) of the late Pleistocene of Florida has a plastral length that ranges from 192.0–264.0 mm. (mean, 211.6 mm.) in seven specimens (Auffenberg, 1963a). *Geochelone wilsoni* from the late Pleistocene of Texas has a carapace length of 226.0 mm. (Milstead, 1956), thus it was a smaller tortoise than *G. oelrichi*. *Geochelone equicomes* (Hay) is known only from fragmentary material, but is a much smaller turtle than *G. oelrichi* based on the thickness of its epiplastral lip which is 27.0 mm. (Hay, 1917, p. 40, pls. 1, 2). The thickness of the epiplastral lip of *G. oelrichi* is 42.0 mm. Other measurements of the shell of *G. oelrichi* compared with *G. turgida*, *G. riggsi*, and *G. johnstoni* are given in table 3.

General Proportions: The top of the carapace of *G. oelrichi* has been partially crushed. Nevertheless, the peripheral margin of the anterior end of the carapace as seen in anterior view (fig. 20), that part of the carapace least distorted by crushing, appears less curved than in *G. turgida* and *G. riggsi*, indicating a more depressed, less domelike shell in *G. oelrichi*. The plastron of *G. oelrichi* is oval in outline, except for the bulbous epiplastral lip and the incised xiphiplastron.

Rugosity: *Geochelone oelrichi* has a more rugose shell than either *G. turgida* or *G. riggsi*, and a much more rugose shell than *G. johnstoni*. The rugosity in *G. oelrichi* is a reflection of: (1) the depth of the grooves marking the edges of the epidermal shields; (2) the sharp growth ridges on the epidermal shield areas; (3) the knobs on some of the marginals; and (4) the projecting shelves on some of the marginals. The rounded knobs on the third marginals appear to be unique to *G. oelrichi*.

Growth Ridges: There are five growth ridges on the epidermal shield areas of *G. oelrichi*. This is noteworthy when *G. oelrichi* is compared with the holotypes of *G. riggsi* and *G. johnstoni* both of which have nine growth ridges on their epidermal shield areas and are smaller tortoises. These growth ridges seem to be a function of seasonal changes in metabolic activity in turtles (Zangerl, 1969). The holotype of *G. oelrichi* is that of an adult animal as there is complete fusion of its costal and peripheral bones (see Auffenberg, 1962, p. 627, and Auffenberg, 1963a, p. 72, fig. 12).

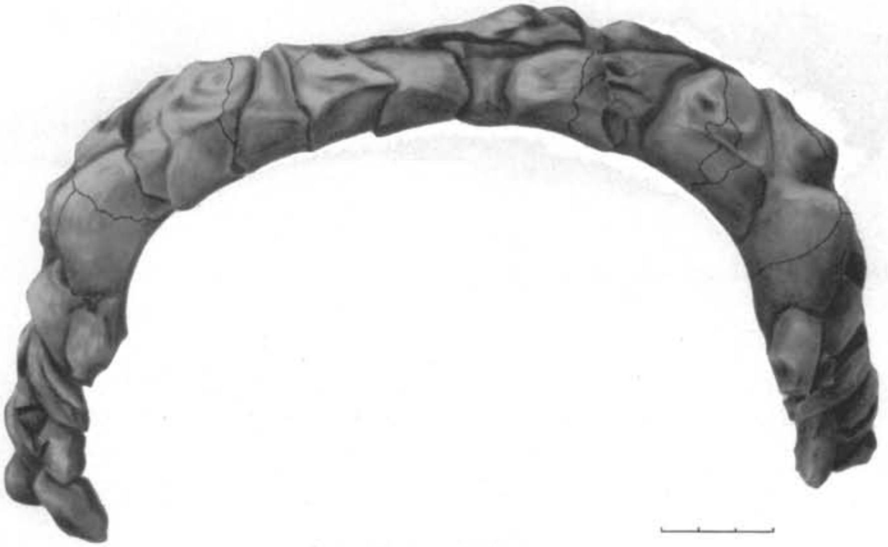

FIG. 20. *Geochelone oelrichi*, new species, carapace of the type, UMMP V56298. Anterior view. Line equals 30 mm.

PLASTRAL CHARACTERS: Plastral characters (figs. 21, 22) show that *G. oelrichi* is closely related to *G. turgida* and *G. riggsi* and distantly related to *G. johnstoni*. The epiplastral lip is much enlarged and swollen, strongly indented anteriorly, keeled ventrally, and it is about as high as long in *G. turgida*, *G. riggsi*, and *G. oelrichi*. In *G. johnstoni* the epiplastral lip is not nearly so enlarged or swollen, is very weakly indented anteriorly; only weakly keeled ventrally, and not nearly so high as long. In *G. turgida*, *G. riggsi*, and *G. oelrichi* the axillary region of the plastron is strongly notched and the border of the plastron between the axillary incision and the epiplastral lip is rounded, with the hyoplastral bones of this region greatly thickened. But in *G. johnstoni* the axillary region is virtually unnotched, the border of the plastron between the axillary region and the epiplastral lip is straight, and the hyoplastral bones of the region are thin.

An interesting feature of all of the *G. turgida* and *G. riggsi* fossils that I have seen, and one that is especially pronounced in *G. oelrichi*, is an excavation on the dorsal surface of the epiplastral bone that encroaches on the posterior wall of the epiplastral beak or lip. In *G. oelrichi* the skull appears to fit into this excavation; in life the head might have rested in this excavation when retracted into the shell.

The bones of the hypoplastron and xiphiplastron of *G. oelrichi* are not so thickened as the more anterior bones of the plastron, but they are much thicker than the hypoplastron and xiphiplastron of *G. johnstoni*. The xiphiplastra of *G. turgida*, *G. riggsi*, and *G. oelrichi* are all strongly notched, whereas the xiphiplastron of *G. johnstoni* is weakly notched.

MEASUREMENTS AND RATIOS OF THE SHELL: Measurements of the shell of *G. oelrichi* compared with measurements of *G. turgida*, *G. riggsi*, and *G. johnstoni* are given in table 1. The sulci that mark the edges of the epidermal shields are much more pronounced than the sutures between the bones in the fossils, thus it is easier to measure the epidermal shield areas than to measure the bones. Length, width, and height measurements all reflect greatest lengths, widths, and heights, with the exception of the measurements of the epiplastral lip which go from the posterior wall of the lip along the midline to the anterior notch. Most ratios taken from these measurements reflect characters already discussed (i.e., ratios of xiphiplastral notch length to width show that the length of the notch is about one-half of its width in *G. turgida*, *G. riggsi*, and *G. oelrichi*, and less than one-fourth of its width in *G. johnstoni*) or these ratios do not indicate important differences and thus are not presented here. But some ratios used by other

FIG. 21. *Geochelone oelrichi*, new species, plastron of the type, UMMP V56298. Lateral view. Line equals 30 mm.

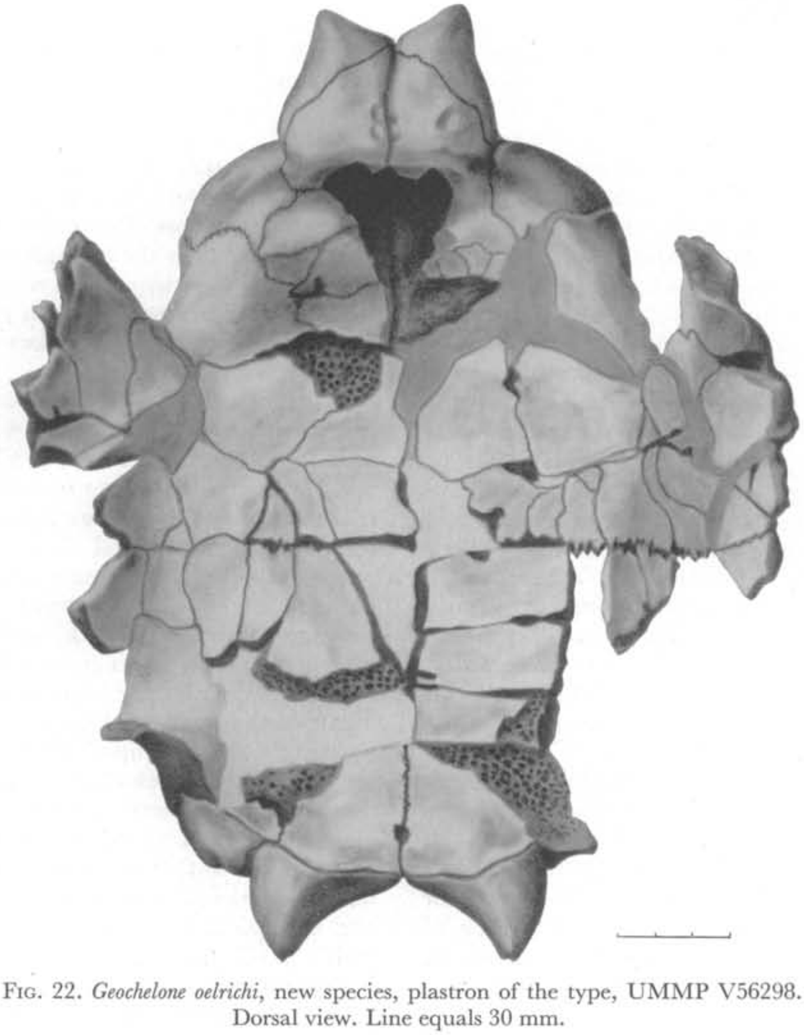

FIG. 22. *Geochelone oelrichi*, new species, plastron of the type, UMMP V56298. Dorsal view. Line equals 30 mm.

FIG. 23. *Geochelone oelrichi*, new species, partial skeleton of the type, UMMP V56298. Ventral view. Line equals 30 mm.

workers to separate tortoises of this group may be of some importance in the definition of *G. oelrichi*. The length of the interfemoral sulcus divided by the length of the interanal sulcus is 2.8 in *G. oelrichi*, 1.9 in *G. riggsi*, and 1.6 in *G. johnstoni*. The length of the interanal sulcus divided by the length of the xiphiplastral notch is 0.5 in *G. oelrichi*. This ratio is 0.5–0.8 in *G. turgida*, 0.8 in *G. riggsi*, and 1.4 in *G. johnstoni*. The ratio of the length of the abdominal scute divided into the length of the pectoral scute is 0.55 in *G. oelrichi*, 0.32 in *G. turgida*, 0.30 in *G. riggsi*, and 0.28 in *G. johnstoni*.

THE SKULL

The skulls of *Geochelone turgida* and *G. riggsi* are poorly known. A complete skull of *G. incisa* of the *G. turgida* group, but thought to be in another evolutionary line, is figured by Auffenberg (1963a, p. 64, fig. 4). The skull of *G. johnstoni* is unknown.

The skull of *G. oelrichi* (fig. 23) is badly crushed and parts of it are missing or difficult to interpret. Enough of a skull is present to show that the head was small in relation to the rest of the animal. The width of the skull at the level of the maxillary-mandibular junction is 30.7 mm.; the width of the front foot through the first and fifth digits is 44.2 mm. In dorsal view, the premaxillae, maxillae, prefrontals, postfrontals, and parietals are all present, at least in part. But these bones are badly caved-in, and the orbital area on the right side is obliterated. The narrow supraoccipital process is visible. The maxillae and the mandibles are the most complete bones of the skull; but some of the features are difficult to see because the jaws are closed. In ventral view, many of the palatal bones are missing, and the rest are so crushed that it is difficult or impossible to define the individual bones. The body of the hyoid is definable although crushed. Moreover, the slim anterior pair of hyoid horns are present, although they have their outlines largely obscured.

It is difficult to compare the crushed skull of *G. oelrichi* with that of other tortoises in the group. But the outline of the margin of the maxilla is much more concave and the posterior margin of the maxilla is much more downswept than in *G. incisa* (Auffenberg, 1963a, p. 64, fig. 4). The mandible of *G. oelrichi* does not appear to show any particularly distinctive characters when compared to *G. incisa* or *G. riggsi*, but measurements indicate the mandible of *G. oelrichi* is much larger than a specimen of *G. riggsi* (UMMP V31191) from the late Pliocene Rexroad Formation of Meade County, Kansas.

MEASUREMENTS (IN MM.): Greatest width through mandibular rami in *G. oelrichi* 32.7, in *G. riggsi* 19.8. Measurements compared with those of skull of *G. incisa* are given in table 4.

POSTCRANIAL SKELETON

PRECORACOID: Only the medial portion of the right precoracoid is present. The left precoracoid is wide and flattened in an anteroposterior direction. Little detail can be discerned as the precoracoid is deeply buried in the matrix. The width of the precoracoid at the edge of the glenoid cavity is 18.0 mm., whereas this width is 10.0 mm. in *Geochelone riggsi* (KU 7404) from the late Pliocene Rexroad Formation of Meade County, Kansas. The medial height of the precoracoid just lateral to the medial end is 9.2 mm. in *G. oelrichi*, and 6.3 mm. in the *G. riggsi* specimen.

CORACOID: Both coracoids are present, but the left coracoid is the most complete. The left coracoid is about four times as wide at its proximal end as at its distal end. The bone is similar in shape to that of a *Geochelone riggsi* specimen (KU 7404) from the late Pliocene of Kansas. In *G. oelrichi* the greatest proximal width of the coracoid is 41.2 mm.; the greatest distal width is 10.5 mm.; and the greatest length is 45.0 mm. In *G. riggsi* the greatest proximal width is 26.0 mm.; the greatest distal width is 9.1 mm.; and the greatest length of the bone is 33.2 mm.

HUMERUS: Both humeri are present in the holotype. The left humerus is associated with the relatively complete left pectoral girdle and limb; the right one lies below the position of the pectoral girdle and has its distal end broken and its proximal end imbedded in the matrix. The humeri of *G. oelrichi* are short and stout and have the shaft strongly curved. The external process on the proximal end is much longer than the internal process. The head is rounded and has a distinct neck. Although much of both humeri are embedded in the matrix, they are similar to those of *G. riggsi* (KU 7404). The width of the head in *G. oelrichi* is 15.8 mm.; the distance from the anterior surface of the head to the end of the external process is 35.6 mm.; the narrowest width of the shaft is 10.1 mm.; the greatest length is 74.4 mm. In *G. riggsi* the width of the head is 11.2 mm.; the distance from the anterior surface of the head to the end of the external process is 24.8 mm.; the narrowest width of the shaft is 8.3 mm.; and the greatest length of the humerus is 53.8 mm.

RADIUS: The radius of *G. oelrichi* has a complex distal end with several grooves for the articulation of the carpals. Only the left radius is present on the holotype, and it is associated with the outer elements of the left pectoral girdle and forelimb. The radius is much longer than the ulna in *G. oelrichi*. In *G. oelrichi* the radius is displaced anteriorly over the top of the carpals so that its carpal articular surfaces are visible.

ULNA: The ulna of *G. oelrichi* is much shorter and broader and much less constricted at its middle than its radius. Only the left ulna is preserved in the fossil. The proximal part of the ulna of *G. oelrichi* is covered by dermal ossicles.

MEASUREMENTS (IN MM.): Width of precoracoid at edge of glenoid cavity 18.0; medial height of precoracoid just lateral to medial end 9.2. Greatest proximal width of coracoid 41.2; greatest distal width of coracoid 10.5; greatest length of coracoid 45.0. Width of head of humerus 15.8; distance from anterior surface of head of humerus to end of external process 35.6; narrowest width of humeral shaft 10.1; greatest length of humerus 74.4. Proximal width of radius 13.7; width at narrowest portion of radial shaft 7.4; greatest distal width of radius 15.3. Width at narrowest portion of shaft of ulna 11.5; greatest distal width of ulna 17.2.

DERMAL OSSICLES: Large dermal ossicles cover the anterior part of the forelimb and there seems to be little question that if the arms were drawn over the front of the retracted head complete frontal protection would be afforded. The largest of the dermal ossicles of the holotype is 12.0 mm. high and 12.0 mm. wide.

THE CARPUS

The carpus (figs. 23, 24) of *Geochelone oelrichi* differs from that of several Recent genera, including the genus *Geochelone* (Auffenberg, 1966a, figs. 4–7), and from fossil *Stylemys*, in that it lacks fusion in its subradial and subulnar elements, having a free radiale, proximal centrale, intermedius, and ulnare. In fact, *G. oelrichi* has a carpal pattern that is similar to the hypothetical primitive tortoise of Auffenberg (1966a, p. 163, fig. 1d) in its subradial and subulnar region. Among recent forms, *G. oelrichi* appears to show some similarities to some species of *Gopherus* (Auffenberg, 1966a, p. 168, fig. 3)

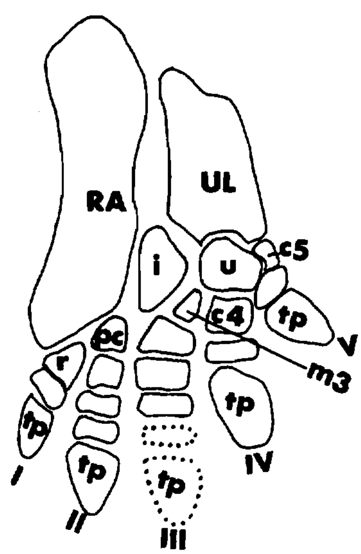

FIG. 24. *Geochelone oelrichi*, new species, diagram of left forelimb of type, UMMP V56298.

Abbreviations: c, carpals; i, intermedium, m; medialia; pc, proximal centrale; r, radiale; RA, radius; tp, terminal phalanges; u, ulnare; UL, ulna. Digits are numbered I–V.

not only in the subradial and subulnar region of the carpus but also in the fusion of some of the distal elements of the carpus (at least in digits I, IV, and V) and in the migration of carpal 5 to a position as the basal element of Digit V.

Digit I is supported by only one subradial element, the radiale. There is only one bone between the radiale and the terminal phalanx, thus there is a reduction from the situation in the hypothetical primitive tortoise of Auffenberg which has three elements between the radiale and the terminal phalanx. Some *Gopherus* species (Auffenberg, 1966a) show a reduction in the distal elements of Digit I, but in every case a proximal element from the next lateral digit tends to enter into the support of Digit I.

Digit II is supported by only one subradial element, the proximal centrale. Three elements lie between the proximal centrale and the terminal phalanx. There are four elements between the proximal centrale and the terminal phalanx in the hypothetical primitive tortoise and three in some *Gopherus*.

Digit III is supported proximally by the intermedium. But it also derives some support from the ulna by way of a small element here interpreted as the medialium 3. This small bone lise between the intermedium and the ulnare. Three bones follow the intermedium and medialium 3, but the subterminal and the terminal phalanges are missing. There are two bones from the fossil site that may represent these missing elements, but they are of a somewhat different texture and color than the fossil. The five elements that lie between the intermedium and the terminal phalanx are a larger number of elements than in the hypothetical primitive tortoise, which has four, or in *Gopherus*, which has three.

Digit IV is supported by only one subulnar element, the ulnare. There are only two elements between the ulnare and the terminal phalanx. In the hypothetical primitive tortoise the intermedium supports Digit IV and there are three elements between it and the terminal phalanx. *Gopherus* Digit IV may be supported by either one or two subulnar elements, but there are always two elements between the subulnar elements and the terminal phalanx.

In Digit V it appears that carpal 5 has migrated to a position under the ulna where it acts as the proximal subulnar bone for the support of Digit V. This also is the situation in several *Gopherus* species. There is only one element between the proximal subulnar bone and the terminal phalanx as in most *Gopherus*. In the hypothetical primitive tortoise there are three elements between the proximal subulnar bone (interpreted as the ulnare) and the terminal phalanx.

WAS THE FORELIMB OF *Geochelone oelrichi* MODIFIED FOR BURROWING?

Auffenberg (1966a) mentioned conditions in recent *Gopherus* that he associated with digging specializations: (1) the foot and lower leg are flattened anteroposteriorly, and (2) carpus flexion is reduced by both the flattened articular surfaces of the carpal elements and by a strong ligamentous sheet over the entire carpus and adjacent to the brachium. The fossil has the lower leg flattened anteroposteriorly and the articular surfaces of the carpal elements are flat. It is impossible to demonstrate the ligamentous sheath, but there are other factors to take into consideration relative to the status of *G. oelrichi* as a burrower. Although the limbs are large in comparison to the small head, they are proportionally small when compared to the great bulky shell. It is difficult to imagine a turtle with these proportionally small limbs digging such extensive burrows as *Gopherus*. Importantly, no fossils of the *Geochelone turgida* group have ever been found in burrows as have fossils of *Gopherus* (Hibbard, personal commun.). But it does seem possible that the front feet might have been used for digging in sandy banks or for enlarging burrows, such as the badger, for use by the tortoises. There is a distinct difference in relative size between the hand and forearm of *G. oelrichi* and of *Gopherus* (based on *G. polyphemus*). In *G. oelrichi* the hand is almost as long as the forearm and the radius and ulna are stout. In *Gopherus* the hand is only about half as long as the forearm and the radius and ulna are slender.

Comments on Paratype Material: It is difficult to compare this fragmentary material with the holotype. Almost all of these bones are from tortoises as large and as rugose as the type.

A right hypoplastron (UMMP V59923) appears to be from a tortoise that was larger than the type specimen, although the type plastron is somewhat incomplete in this region. Measurements of hypoplastron (UMMP V59923) are as follows: greatest external length 65.5 mm., greatest internal length 52.5 mm., greatest width 64.5 mm., greatest thickness 25.4 mm.

PHYLETIC RELATIONSHIPS

Because of the amazing preservation in the postcranial skeleton, *Geochelone oelrichi* is one of the most complete tortoises known of the *Geochelone (Hesperotestudo) turgida* group. Turtles of the *G. turgida* group (Auffenberg, 1962, 1963a) range, in North America, from medial Pliocene to late Wisconsin and are arranged as to their general occurrence as follows:

Great Plains

Geochelone turgida (Cope). Medial Pliocene of Dickens County, Texas (Cope, 1892b; Oelrich, 1957; Auffenberg, 1962, 1963a).

Geochelone riggsi (Hibbard). Medial Pliocene of Seward County, Kansas (Hibbard, 1944; Oelrich, 1957; Auffenberg, 1962, 1963a).

Geochelone oelrichi. Present paper. Early Pleistocene (pre-Nebraskan glaciation) of Brown County, Nebraska.

Geochelone johnstoni Auffenberg. Early Pleistocene (pre-Nebraskan glaciation) of Randal County, Texas (Auffenberg, 1962). The listing of the type locality of *G. johnstoni* as being "Tule" County by Auffenberg (1962) and repeated by Holman (1969a, p. 176) is an error.

Geochelone equicomes (Hay). Late Pleistocene (Sangamon) of Meade County, Kansas (Hay, 1917; Auffenberg, 1962). Known from fragments only.

South Texas

Geochelone wilsoni (Milstead). Late Pleistocene (Wisconsin) of Bexar County, Texas (Milstead, 1956; Auffenberg, 1963a). Auffenberg (1964, p. 10) mentioned that he had seen a specimen from southeastern Oklahoma from a site with a C-14 date of 10,000 B. P., but gave no other information.

Florida

Geochelone alleni Auffenberg. Late medial Pliocene of Alachua County, Florida (Auffenberg, 1966b).

Geochelone incisa (Hay). Pleistocene (?Sangamon or Illinoian) of Marion County, Florida (Hay, 1916; Auffenberg, 1962, 1963a).

The discovery of *Geochelone oelrichi* during the same time interval as *G. johnstoni* requires modification of the phylogenetic sequences proposed by Auffenberg in 1963a and 1966b for tortoises in the *G. turgida* group. The large number of differences between *G. oelrichi* and *G. johnstoni* have already been noted.

Auffenberg (1963a, p. 91) first envisioned a *turgida* to *riggsi* to *johnstoni* to *incisa* evolutionary sequence in which several trends from Pliocene to Pleistocene were noted including: (1) increase in size; (2) decrease in shell thickness; (3) decrease in rugosity of shell; and (4) additional complexity of a supracaudal buckler.

This sequence was modified in 1966 by the discovery of a relatively non-rugose tortoise, *G. alleni*, from late medial Pliocene of Florida. At this time Auffenberg (1966b) envisioned two evolutionary lines: (1) a western line: *turgida* to *riggsi* to *johnstoni* to *wilsoni*; and (2) an eastern line: *alleni* to *incisa*. Auffenberg believed that the Kansas form, *G. equicomes* from the Sangamon is closely related to *incisa* and was a northwestern extension of this form into Kansas in the Sangamon.

After studying these tortoises I agree that there are two evolutionary lines in the *turgida* group, a western and an eastern, but I would further reconstruct Auffenberg's model. As diagrammed in figure 25, I would recognize (1) a *turgida* line in the Great Plains of very rugose, thick-shelled turtles with huge epiplastral beaks that begins with *G. turgida* of the late medial Pliocene, continues with *G. riggsi* of the early part of the late Pliocene, and culminates in *G. oelrichi* of the early Pleistocene (pre-Nebraskan glaciation) of Nebraska, a form that is the largest and the most rugose, and has the most swollen epiplastral beak; and (2) an *alleni* line of smoother shelled tortoises with smaller epiplastral beaks that begins with *G. alleni* of the late medial Pliocene of Florida; but I would have this line giving rise to an eastern line culminating in *G. incisa* of the Pleistocene of Florida and a western line that goes through a sequence of *G. johnstoni* of the early Pleistocene, *G. equicomes* of the Sangamon, and culminates in *G. wilsoni* of the late Wisconsin of Texas and Oklahoma.

The carpus of *G. oelrichi* is so primitive and otherwise so different from other members of the genus *Geochelone* that the subgeneric status of the *G. turgida* group might be questioned. It will be important to recover carpi of other fossil tortoises of this group.

Geochelone (Hesperotestudo) sp. indet.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska, from the red zone in the SW. ¼, SW. ¼, SE. ¼, sect. 20, T. 31 N., R. 21 W.: UMMP V56454, a right epiplastron and other plastron and carapace bones including a

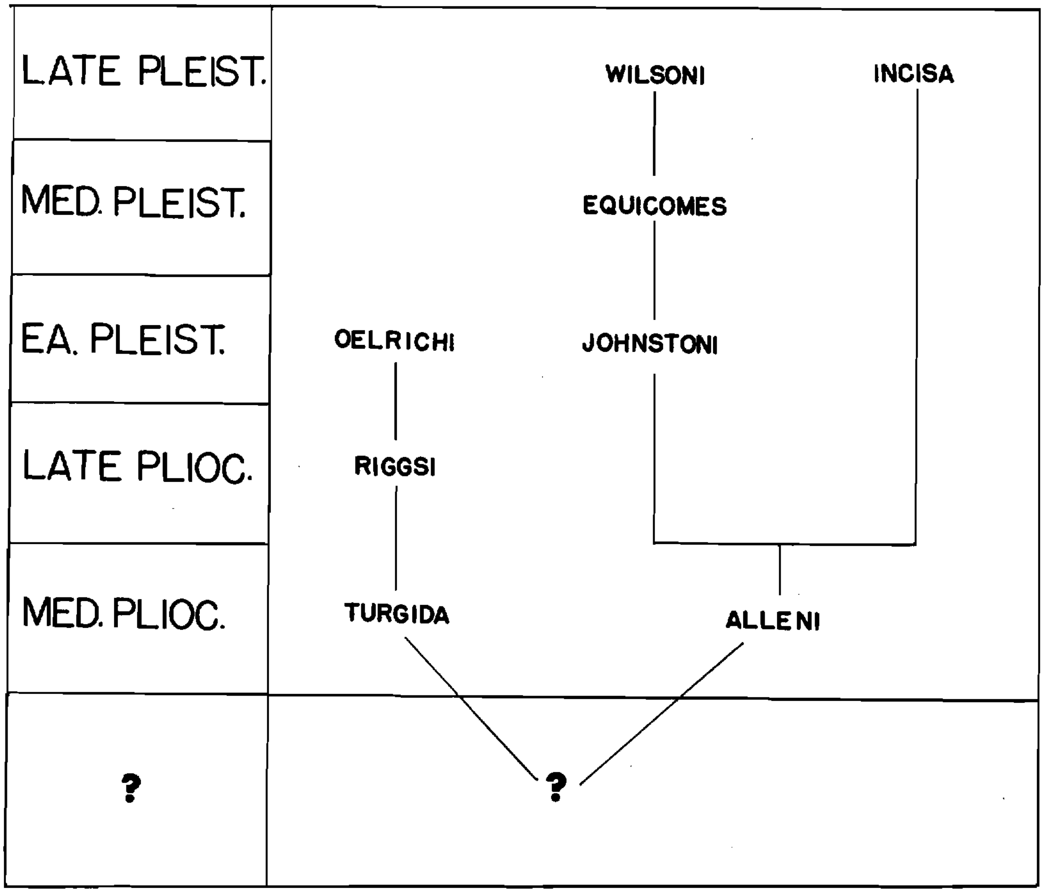

FIG. 25. Hypothetical phylogenetic relationships of tortoises of the *Geochelone turgida* group.

femur and part of a scapula evidently from a single individual.

DISCUSSION: This specimen represents a small tortoise of the *turgida* group, probably a young *G. oelrichi*. Because it died young, it is presumably not so rugose as the other Sand Draw small tortoises.

FAMILY TRIONYCHIDAE

Trionyx sp.

DISTRIBUTION: (?)Jurassic to Pleistocene, Europe, Africa, and North America. Recent, Asia, Africa, North America, East Indies.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska, from the Diatomite (Snail Zone) on the east side of Rattlesnake Gulch SE. ¼, sect. 6, T. 30 N., R. 20 W.: UMMP V46089, partial shell including pieces of a plastron and carapace.

DISCUSSION: None of the pieces is complete enough for specific identification (see Webb, 1962, pp. 473–476).

ORDER SQUAMATA

FAMILY IGUANIDAE

GENUS ?*SCELOPORUS* SP. INDET.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 2–68: UMMP V57292, a fragmentary right dentary with three teeth.

DISCUSSION: This small iguanid dentary is questionably referred to the genus *Sceloporus*. The teeth are higher crowned and slenderer than those of *Sceloporus undulatus*, the species that occurs in Brown County, Nebraska, today (Hudson, 1942).

GENUS *PHRYNOSOMA* WIEGMANN, 1828

Phrynosoma WIEGMANN, 1828, p. 367 (the extensive synonomy and taxonomic history of the genus is given in Reeve, 1952, pp. 821–822).

TYPE SPECIES: *Lacerta orbicularis* Linnaeus, 1766 (designated by Fitzinger, 1843).

DISTRIBUTION: Miocene to Pleistocene, North America. Recent, western and southwestern North America to Guatemala.

DIAGNOSIS: See Etheridge, 1964, pages 621–622, figure 2d.

Phrynosoma cornutum (Harlan, 1825)

Agama cornutum HARLAN, 1825, p. 299, pl. 20.

Phrynosoma cornutum: GRAY, 1831, p. 45 (the extensive synonymy of *Phrynosoma cornutum* is detailed in Reeve, 1952, pp. 893–897).

DISTRIBUTION: Pliocene to Pleistocene, North America. Recent, Kansas, western Arkansas, and Missouri, southeastern Colorado, southward and southwestward through Oklahoma, Texas (except for the eastern forests), New Mexico, and southeastern Arizona; also in adjacent states in northern Mexico.

DIAGNOSIS: See Holman, 1969b, page 207.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 1–68: UMMP V59928, a complete right and two fragmentary principal horns.

DISCUSSION: These long principal horns are indistinguishable from those of *Phrynosoma cornutum*. Today, the Texas horned lizard occurs well south of the fossil locality, the nearest records being in northern Kansas (Hudson, 1942; Smith, 1956).

FAMILY TEIDAE

GENUS *CNEMIDOPHORUS* WAGLER, 1830

Cnemidophorus WAGLER, 1830, p. 154.

TYPE SPECIES: *Cnemidophorus murinus* Gray, 1845.

DISTRIBUTION: Miocene and Pliocene, North America. Recent, northern United States to southern Brazil, both on the mainland and on neighboring islands.

DIAGNOSIS: See Burt, 1931, pages 14–15.

Cnemidophorus cf. *sexlineatus* (Linnaeus, 1766)

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 4–68: UMMP V59929, a trunk vertebra.

DISCUSSION: The trunk vertebrae of *Cnemidophorus* are characteristic in having extremely prominent zygosphenal articular processes and neural spines low along the top of the neural arches, which extend as sharply pointed projections posterior to the neural arches. The vertebra is so similar in detail to modern *C. sexlineatus* that the fossil is tentatively assigned to that species. *Cnemidophorus sexlineatus* occurs in Brown County, Nebraska today (Hudson, 1942).

FAMILY SCINCIDAE

GENUS *EUMECES* WIEGMANN, 1834

Eumeces WIEGMANN, 1834, p. 36.

TYPE SPECIES: *Scincus pavimentatus* Geoffroy Saint-Hilaire, 1827.

DISTRIBUTION: Oligocene to Pleistocene, North America. Recent, southeastern Asia, southwestern Asia, northern Africa, the Bermuda Islands and southern Canada to Panama.

DIAGNOSIS: See Smith, 1946, page 340.

Eumeces obsoletus (Baird and Girard, 1852)

Plestidon obsoletum BAIRD AND GIRARD, 1852, p. 129.

Eumeces obsoletus: COPE, 1875, p. 45.

DISTRIBUTION: Pleistocene, North America. Recent, southeastern Utah, Colorado, and southern Nebraska, south through Kansas, Oklahoma, western Texas, New Mexico, and eastern Arizona; also in northern Mexico.

DIAGNOSIS: See Holman, 1966, page 375.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 5–67: UMMP V59930, trunk vertebra. UM-Nebr. 1–68: UMMP V57164, partial right maxilla.

DISCUSSION: These remains are assigned to *Eumeces obsoletus* on the basis of their large size and detailed similarity to the modern species. The maxillary teeth of the fossil and modern *E. obsoletus* are higher crowned and taper less abruptly to a point than in modern *E. laticeps*. The fossil maxillary represents an animal with a snout-vent length well in excess of 100 mm. The trunk vertebra (greatest length 7.0 mm.) represents a much larger lizard than the one represented by the maxillary bone. The Great Plains skink occurs south of the fossil locality today, inhabiting the southern border of Nebraska (Hudson, 1942).

FAMILY COLUBRIDAE

GENUS *NATRIX* LAURENTI, 1768

Natrix LAURENTI, 1768, p. 73.

TYPE SPECIES: *Natrix vulgaris* Laurenti, 1768.

DISTRIBUTION: Pliocene, North America. Pleistocene, Europe, Asia, North America. Recent, Cosmopolitan.

DIAGNOSIS: This huge genus is impossible to define because only isolated skeletal elements are known. Fossil identifications are usually made on a specific basis (see Discussion).

Natrix sipedon (Linnaeus, 1758)

Coluber sipedon Linnaeus, 1758b, p. 219.
Natrix sipedon: Kirsch, 1895, p. 333.

Distribution: Pleistocene to Recent, eastern North America.

Diagnosis: See the third paragraph in Discussion below.

Referred Material: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, type area of the Sand Draw fauna: UMMP V33048, 46 vertebrae, probably from a single individual. UM-Nebr. 4–67: UMMP V57385, two vertebrae.

Discussion: Regional terminology for snake vertebrae is from Bullock and Tanner (1966); other terminology is from Auffenberg (1963b). Brattstrom (1967) identified vertebrae from the Sand Draw fauna (UMMP V33048) as *Natrix* sp. These vertebrae represent *Natrix sipedon*, assignable to *Natrix* rather than to *Thamnophis* because of their larger size and higher neural spines. Only two large *Natrix* species similar to the fossils occur even remotely near the locality today. *Natrix sipedon sipedon* was reported by Hudson (1942) from Valentine, Cherry County, Nebraska, about 40 miles west of the Sand Draw in Brown County. The other is *Natrix erythrogaster transversa* from north-central Kansas. These two species are easily separated from each other on the basis of their lumbar vertebrae. In eight *Natrix erythrogaster transversa* (two juveniles and six adults) and *N. e. erythrogaster*, the neural spines are much higher than in seven *Natrix sipedon sipedon* (three juveniles and four adults) and one *N. s. pleuralis*. There seems to be no overlap in this character.

In fact, the lower neural spine of *Natrix sipedon* (see Conant, 1963, p. 33 for the content of this taxon) appears to distinguish it from all other United States water snakes of the genus *Natrix*, including *N. cyclopion*, *N. taxispilota*, *N. rhombifera*, *N. erythrogaster*, and the closely related *N. fasciata*.

The fossils are similar to modern *N. sipedon* in this character, thus it seems possible that either *N. sipedon* and *N. fasciata* had already diverged by early Pleistocene time, or that *N. sipedon* mav be the more primitive of the two.

Thamnophis sp.

Distribution: Pliocene to Pleistocene, North America. Recent, southern Canada to Costa Rica.

Referred Material: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, type area of the Sand Draw fauna: UMMP V36659, six vertebrae. UM-Nebr. 4–67: UMMP V59931, five vertebrae. UM-Nebr. 1–68: UMMP V59932, nine vertebrae.

Discussion: Brattstrom (1967) identified six vertebrae (UMMP V36659) as *Thamnophis* species. I have assigned additional vertebrae to *Thamnophis*, but I am unable to assign any of these to species.

Genus *Heterodon* Latreille, 1802

Heterodon Latreille, 1802, p. 32.

Type Species: *Heterodon platirhinos* (=*platyrhinos*) Latreille, 1802.

Distribution: Pliocene and Pleistocene, North America. Recent, New Hampshire west to Montana and south through the Gulf States; also in northern Mexico.

Diagnosis: See Holman, 1962, page 259.

Heterodon platyrhinos Latreille, 1802

Heterodon platyrhinos Latreille, 1802, p. 32.

Distribution: Pleistocene, North America. Recent, eastern and southern United States.

Diagnosis: See Holman, 1963a, page 162.

Referred Material: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, type area of the Sand Draw fauna: UMMP V36660, 10 vertebrae.

Discussion: These vertebrae were identified by Brattstrom (1967). The species has been reported from Cherry County, Nebraska, today (Hudson, 1942), thus it probably occurs in Brown County at present.

Coluber or *Masticophis* sp. indet.

Referred Material: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, type area of the Sand Draw fauna: UMMP V52233, two vertebrae. UM-Nebr. 4–67: UMMP V59933, 21 vertebrae. UM-Nebr. 4–67: UMMP V59933, 21 vertebrae; UMMP V57257, two vertebrae.

Discussion: These vertebrae represent either *Coluber* or *Masticophis*. *Coluber constrictor* occurs in Brown County, Nebraska, today; and *Masticophis flagellum* is known to occur only in Hitchcock County, along the Republican River in the southern part of Nebraska today (Hudson, 1942).

Genus *Elaphe* Fitzinger, 1833

Elaphe Fitzinger, 1833, text and pl. 27.

TABLE 3

Shell Measurements (in Millimeters) of Four Species of Fossil *Geochelone*[a]

	G. turgida	*G. riggsi*	*G. oelrichi*	*G. johnstoni*
Carapace length	—	170	—	235
Plastron length	216	190	258	219
Epiplastral lip height	—	27	42	28
Epiplastral lip height at midline	29	24	41	33
Epiplastral length	50	48	78	49
Epiplastral width	48	41	58	46
Entoplastral length	—	46	58	42
Entoplastral width	59	48	75	42
Xiphiplastral length	51	48	64	34
Xiphiplastral width	54	42	56	48
Xiphiplastral external height	—	20	23	16
Xiphiplastral midline thickness	—	9	13	9
Xiphiplastral notch length	19	18	24	12
Xiphiplastral notch width	55	41	57	58
Gular length	38	39	60	41
Humeral length	—	49	64	38
Pectoral length	20	15	31	19
Abdominal length	63	50	58	68
Femoral length	—	37	49	27
Anal length	42	29	35	17
Anal width	38	26	37	32
Anterior lobe length	—	60	86	59
Posterior lobe length	—	40	57	44
Bridge length	—	90	115	116
Nuchal bone greatest width	—	47	70	63
Nuchal bone anterior width	—	35	49	34
Cervical scute length	—	10	18	13
Cervical scute anterior width	—	—	12	6
Cervical scute posterior width	—	8	13	6

[a]*Geochelone turgida* estimated from Oelrich, 1957, figure1, p. 229; all *G.johnstoni* measurements from Auffenberg (1966a) except for length of epiplastral lip.

Type Species: *Elaphe parreysii* Fitzinger, *in* Wagler, 1833, =*quatuorlineata.*

Distribution: Miocene to Pleistocene, Europe and North America. Recent, Europe, Asia, the Malay Archipelago, and central eastern United States south to Costa Rica.

Diagnosis: No generic diagnosis is attempted for this large genus; only isolated skeletal elements are known. Fossil identifications are usually made on a specific basis (see Holman, 1968, p. 156).

Elaphe vulpina (Baird and Girard, 1853)

Scotophis vulpinus Baird and Girard, 1853, p. 75.

Elaphe vulpinus: Ruthven, 1909, p. 116.

Distribution: Pliocene and Pleistocene, North America. Recent, eastern Nebraska to southern Ontario and western Ohio, and northern Wisconsin and Michigan south to the Wabash River.

Diagnosis: See Holman, 1968, page 156.

Referred Material: Keim Formation, Brown County, Nebraska: UM-Nebr. 3-67: UMMP V57220, one vertebra; UMMP V57219, one vertebra.

Measurements: One of the fossil vertebrae (UMMP V57220) is from a very large *E. vulpina* and its measurements are compared with those of a specimen with a length of 135 cm. from Fulton County, Illinois. The measurements of the Illinois specimen are in parentheses: length through zygapophyses 9.3 mm. (7.4 mm.); height through neural spine 8.5 mm. (7.7 mm.); width through accessory processes 12.9 mm. (10.7 mm.); width through postzygapophyses 10.8 mm. (8. 5 mm.).

Discussion: Characters for the identification of *E. vulpina* are given by Holman (1968, p. 156).

TABLE 4

COMPARATIVE MEASUREMENTS (IN MILLIMETERS) OF SKULLS OF *Geochelone oelrichi* AND *Geochelone incisa*

	G. oelrichi UMMPV56298[a]	*G. incisa* UF3141
Snout to end of supra-occipital process	54	51
Width at posterior end of maxilla	34	33
Maxillary edge to highest part of frontal	19	18
Width of nasal opening	9	12

[a]Type.

The fox snake is thought to extend west along the river courses today to about the area of the fossil deposit (Lynch, *in litt.*).

CONCLUSIONS

The Sand Draw amphibians and reptiles, other than the two extinct tortoises (*Geochelone*), are indistinguishable from living species, although *Pseudemys* cf. *P. scripta bisornata* may have been a distinct subspecies. But the herpetofauna is not one that would be typical of the area today, for with the exception of the two tortoises and the fox snake, *Elaphe vulpina*, the herpetofauna is one that is typical of Kansas rather than Nebraska, with the nearest area where all these Sand Draw amphibians and reptiles can be found living together today is north-central Kansas. The fox snake is either absent from Kansas today or occurs only in its northeastern tip (Smith, 1956), but Lynch (*in litt.*), believed that it may reach the Ainsworth area of Nebraska along the river courses. The giant tortoise indicates that the area was probably relatively frost free (Hibbard, 1960).

The ecological setting for the Sand Draw herpetofauna may have been a slowly moving stream with marshy edges and surrounded by sandy flats. Possibly the dominant trees of the flats were willows and cottonwoods. The stream and adjacent marshy edge would have been inhabited by *Ambystoma tigrinum* (larval forms are present in the fauna), *Rana catesbeiana*, *Rana pipiens*, *Kinosternon flavescens*, *Chrysemys picta*, *Pseudemys* sp., *Trionyx* sp., *Thamnophis* sp., and *Natrix sipedon*. The stream must have had at least some permanent pools to account for the presence of the bullfrog (*R. catesbeiana*) and the water turtles. The sandy flats bordering the stream would have been inhabited by *Scaphiopus bombifrons*, *Sceloporus* sp., *Phrynosoma cornutum*, *Cnemidophorus sexlineatus*, *Eumeces obsoletus*, *Heterodon platyrhinos*, *Coluber* or *Masticophis*, and *Elaphe vulpina*. The two extinct land tortoises probably also frequented the upland situation.

ACKNOWLEDGMENTS

I should like to thank Dr. Claude W. Hibbard and Mr. Morris F. Skinner for the privilege of studying fossil material collected and curated by them. Mr. Billy R. Harrison of the Panhandle Plains Historical Society graciously lent the type specimen of *Geochelone johnstoni* for study. Miss Karen Smith made the drawings of the new tortoise.

CLASS AVES

J. ALAN FEDUCCIA[1] AND PAT VICKERS RICH[2]

ONLY A FEW bird remains have been recovered from the Keim Formation. Jehl (1966) reported the occurrence of four species from two localities in Brown County, Nebraska: Prospecting Locality 277 and UM-Nebr. 5–67 in the Sand Draw. Feduccia (1970) reported four additional birds from four localities, also in Brown County: Prospecting Locality 28 on Deep Creek, and three within Prospecting Locality 277 (including two UM-Nebr. localities, 4–67 and 1–68 in Booth Draw, also a part of the Sand Draw. See fig. 7 and list of localities, pp. 30–35). The total avifauna is summarized below.

ORDER PODICIPEDIFORMES

FAMILY PODICIPEDIDAE

GENUS *PODICEPS* LATHAM, 1787

Colymbus LINNAEUS, 1758b, pp. 135–136 (in part).
Podiceps LATHAM, 1787, p. 294.

TYPE SPECIES: *Colymbus cristatus* Linnaeus, 1758b.

DISTRIBUTION: Early Miocene to Recent, worldwide.

DIAGNOSIS: See Murray, 1967, page 278.

Podiceps auritus (Linnaeus) Zarudny and Loudon, 1902

Colymbus auritus LINNAEUS, 1758b (in part).
Podiceps auritus (Linnaeus, 1758b): ZARUDNY AND LOUDON, 1902, p. 186.

TYPE: Linnaeus, 1758b, cited no specimen or number.

DISTRIBUTION: Recent, holarctic; Pleistocene, North America (Tennessee, Florida, California, Nebraska), Europe (Hungary and Italy), and Asia (Mongolia).

DIAGNOSIS: Medium-sized grebe; tibiotarsus distinctly smaller than that of *Podiceps parvus* (medial Pleistocene, Fossil Lake, Oregon); distinctly larger than that of *P. dominicus* and *P. caspicus*.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, W. ½, NW. ¼, sect. 25, T. 31 N., R. 22 W.: UMMP V52225, left tibiotarsus.

MEASUREMENTS (IN MM.): UMMP V52225: width of proximal end greater than 7.6; depth of shaft, proximal end, 5.7; width of shaft, proximal end, 4.8; width, external articular surface, ± 5.3.

REMARKS: Jehl (1966) reported the occurrence of Horned Grebe (*P. auritus*), but incorrectly cited UMMP V52225 as a right tarsometatarsus; it is instead, a left tibiotarsus.

Podiceps dixi from the medial Pleistocene of Florida is known only from the proximal end of a carpometacarpus. This element indicates that *P. dixi* was somewhat larger than *P. auritus* (Brodkorb, 1963, p. 54), but no meaningful comparison can be made to the Sand Draw grebe, represented only by a tibiotarsus.

Based on the habits of the modern Horned Grebe, its occurrence in the Keim sediments indicates that ponds, streams, and perhaps even large lakes were present at, or near the Sand Draw during the early Pleistocene.

ORDER CICONIIFORMES

FAMILY CICONIIDAE

GENUS *CICONIA* BRISSON, 1760

Ardea LINNAEUS, 1758b, p. 142 (in part).
Ciconia BRISSON, 1760, p. 48.

DISTRIBUTION: Recent, Old World; early Pliocene, Greece; late Pliocene to late Pleistocene, North America.

DIAGNOSIS: No inclusive diagnosis of the synsacrum has been published for all the genera within the Ciconiidae (see Remarks for *Ciconia maltha*).

Ciconia maltha L. Miller, 1910

TYPE: UCMP 11202, left tarsometatarsus.

DISTRIBUTION: Late Pliocene to late Pleistocene, North America, Cuba.

DIAGNOSIS: See Miller, 1910, page 442.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, W. ½, NW. ¼, sect. 25, T. 31 N., R. 22 W.: UMMP V52599, partial synsacrum (sacral and caudal vertebrae section).

MEASUREMENTS (IN MM.): UMMP V52599: Width across ventral surface of vertebra at sacral-caudal junction 9.6.

REMARKS: Jehl (1966) was hesitant to assign a synsacrum from the Keim Formation to

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Ciconia maltha, because (1) at that time the Asphalt Stork was known only from the late and medial Pleistocene, and (2) the Sand Draw specimen was fragmentary. *Ciconia maltha*, however, has now been reported from the late Pliocene of Idaho (Feduccia, 1967) and Arizona (Phillips, 1968). As it is the only large stork known from the Pleistocene, and the Keim synsacrum is definitely a large ciconiid, we assume it is *C. maltha*. Ciconiid synsacra are distinctive in having two well-defined, narrow ridges bordering a central depression on the ventral surface of the sacral vertebrae.

Ciconia maltha is a common Pleistocene species in North America, known from California, Idaho, Florida, Cuba (Brodkorb, 1963), and now Nebraska. Miller (1932) believed it to be most closely related to the recent *C. ciconia* of Europe and *Euxenura galatea* of South America. The latter species inhabits wet, open savannas, large marshes, and wet meadows on the Argentine pampas (Wetmore, 1926). Miller (1925) pointed out, however, that storks in both Old and New worlds can be found frequently in drier areas, especially during insect outbreaks, such as the locust invasions in Palestine and Argentina, and therefore should not be used as indicators of a wet habitat. Thus, the Sand Draw stork is not particularly useful as a habitat indicator.

Presuming that its habits are similar to those of the modern species of ciconiids, *C. maltha* may be useful as a climatic indicator, however. All of the modern stork species occur either in areas of warm climate (temperate or warmer), or in the case of the northern nesters (which nest as far north as latitude 60°), migrate south during the winter. The most northern wintering area for any of the storks (i. e. *C. c. boyciania*) is in northern Korea, Japan, and eastern China, where the most severe climatic regime is temperate (Dc climate of Trewartha, 1968). The present climate of eastern and central Nebraska is also a Dc type. Thus, if *C. maltha* resided in the Sand Draw area during the winter, climate at the extreme was much as it is today in Nebraska. If the stork, however, was only a summer nester, the climate could have been as rigorous as a boreal type (E of Trewartha, 1968), typical of continental Canada today.

ORDER ANSERIFORMES

FAMILY ANATIDAE

?*Cygnus* sp. or ?*Olor* sp.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: near the *Stegomastodon* Quarry in Prospecting Locality 263, SW. ¼, sect. 4, T. 30 N., R. 21 W., talus of the "marly" zone below the Long Pine Gravel: F:AM 87483, left tarsometatarsus fragment.

REMARKS: The Keim tarsometatarsus is similar to that of *Olor hibbardi*, *Olor buccinator*, and *Cygnus olor*, but is more robust than that of *C. columbianus*, the only other swan of similar size. Due to its incompleteness, however, the Keim specimen cannot be assigned to a species.

GENUS *BRANTA* SCOPOLI, 1769

Anas LINNAEUS, 1758b, p. 123 (in part).
Branta SCOPOLI, 1769, p. 67.

TYPE SPECIES: *Anas bernicla* Linnaeus, 1758b.

DISTRIBUTION: Recent, holarctic; early Pliocene to late Pleistocene, western North America.

DIAGNOSIS: See Woolfenden, 1961, page 49.

Branta canadensis (Linnaeus) Scopoli, 1769

Anas canadensis LINNAEUS, 1758b, p. 123.
Branta canadensis (Linnaeus, 1758b): SCOPOLI, 1769, pp. 67–69.

TYPE: Linnaeus, 1758b, cited no specimen or number.

DISTRIBUTION: Recent, holarctic, primarily nearctic; early Pleistocene, Nebraska.

DIAGNOSIS: Although overlap in size occurs, coracoid attains larger dimensions than those of *B. nigricans*, *B. bernicula*, and *B. leucopsis*.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 5–67: UMMP V52170, left coracoid.

MEASUREMENTS (IN MM.): UMMP V52170: Length from head to internal distal angle 65; depth of head 13.6; length (dorsoventral) of glenoid facet 18.4; width of glenoid facet 10.0; diameter of scapular facet 5.6; length from procoracoid to head 23.3; maximum depth of sternal facet 8.0; depth of shaft across scapular facet 12.1; width of shaft across scapular facet 13.0; minimum width of shaft, 9.5; minimum depth of shaft, 5.9.

REMARKS: Jehl (1966) reported the presence of Canada Goose (*B. canadensis*).

No direct comparisons can be made with the medial Pleistocene *Branta propinqua* (Fossil Lake, Oregon), represented by a humerus, or *B. dickeyi*, represented by a tibiotarsus from the late Pleistocene of California. The humerus of *B. propinqua* is much smaller than that of even the smallest subspecies of *B. canadensis*. In contrast, the tibiotarsus of *B. dickeyi* represents a bird larger than *B. canadensis*.

GENUS *ANAS* LINNAEUS, 1758b

TYPE SPECIES: *Anas platyrhynchos* Linnaeus, 1758b.

DISTRIBUTION: Recent, worldwide; late Oligocene, Kazakstan, Czechoslovakia; Miocene, palaearctic, Africa; Pleistocene, holarctic, Madagascar, New Zealand, Mauritius.

DIAGNOSIS: See Woolfenden, 1961, pages 13, 52.

Anas sp.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 1–68: UMMP V57158, right coracoid.

MEASUREMENTS (IN MM.): UMMP V57158: Length from head to internal distal angle 34.0; depth of head 4.1; length (dorsoventral) of glenoid facet 6.9; width of glenoid facet 3.8; diameter of scapular facet 2.7; length from procoracoid to proximal end of head 8.8; maximum width of sternal facet 14.2; minimum width of shaft 3.7; minimum depth of shaft 2.4.

REMARKS: In 1970 Feduccia assigned a coracoid (UMMP V57158) to *Anas discors*. We have only classified this element to the generic level due to its size overlap with coracoids of several teal species (i.e. *A. discors*, *A. cyanoptera*, *A. carolinensis*, *A. crecca*, and *A. formosa*). These species are difficult, if not impossible, to separate on the basis of a single postcranial element.

GENUS *BUCEPHALA* BAIRD, 1858

Anas LINNAEUS, 1758b, p. 124 (in part).
Bucephala BAIRD, 1858, pp. 788, 795.

TYPE SPECIES: *Anas albeola* Linnaeus, 1758b.

DISTRIBUTION: Recent, holarctic; early Pliocene, Florida; Pleistocene, holarctic.

DIAGNOSIS: See Woolfenden, 1961, pages 71–72.

Bucephala cf. *albeola* (Linnaeus) Baird, 1858

Anas albeola: LINNAEUS, 1758b.
Bucephala albeola: BAIRD (*in* Baird, Cassin, and Lawrence), 1858, p. 795.

TYPE: Baird (1858) listed several United States National Museum catalogue numbers, but did not designate a type specimen or number.

DISTRIBUTION: Recent, northern North America; Pleistocene, North America.

DIAGNOSIS: Small species of *Bucephala*; femur distinctly smaller than those of *B. clangula* and *B. islandica*. (See Remarks below.)

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, W. ½, NW. ¼, sect. 25, T. 31 N., R. 22 W.: UMMP V52597 and UMMP V52598, two partial femora.

MEASUREMENTS (IN MM.): UMMP V52597: Width of proximal end 8.9; diameter of head 5.0; depth of trochanter, greater than 6.2; least width of shaft 3.3; least depth of shaft 3.8; length from proximal end of head to proximal end of rotular groove approximately 30.2. UMMP V52598: Maximum width of distal end 8.4; width of popliteal area 3.3; depth of internal condyle 5.8; depth of external condyle 6.6; maximum width of rotular groove approximately 6.1.

REMARKS: Jehl (1966) reported the presence of two femora representing the Bufflehead (*B. albeola*). *Bucephala fossilis* from the Palm Spring Formation (southern California) is of similar size, but is based on a carpometacarpus only, and thus cannot be meaningfully compared to the Keim femora. We have, therefore, tentatively referred those femora to *B. albeola*.

GENUS *OXYURA* BONAPARTE, 1826

TYPE SPECIES: *Anas jamaicensis* Wilson, 1824.

DISTRIBUTION: Recent, cosmopolitan; early Pleistocene, Nebraska; medial Pleistocene, California, Texas.

DIAGNOSIS: See Woolfenden, 1961, pages 19–21.

Oxyura sp.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 1–68: UMMP V57157, left humerus.

MEASUREMENTS (IN MM.): UMMP V57157: Total length slightly greater than 62.3; maximum width of proximal end 13.5; palmoanconal depth of head approximately 4.6; length of deltoid crest 14.3; minimum width of shaft 3.8; maximum width of distal end 8.8.

REMARKS: Feduccia (1970) incorrectly referred this left humerus (UMMP V57157) to the Blue-Winged Teal (*A. discors*). The Sand Draw humerus, however, differs from those of the genus *Anas* in the following characters: the pneumatic fossa is shallow and closed; the shaft is more slender; the deltoid crest is lower and more rounded than that in *Anas*, not extending so far palmad.

We are convinced that the humerus is, instead, that of *Oxyura*, a stiff-tailed duck, due to its shallow pneumatic fossa, which hardly reaches the head; the presence of numerous foramina in the walls of the pneumatic fossa; its low, gently curved deltoid crest; and its extremely slender shaft that flares widely at its proximal end.

The Sand Draw *Oxyura* very closely resembles *O. jamaicensis* in both size and morphology. *Oxyura bessomi*, a medial Pleistocene species from the Palm Spring Formation of California and the Seymour Formation of Texas, is not represented by a humerus. Its carpometacarpus, however, indicates a bird about the size of *O. jamaicensis*. The recent *O. dominica* appears to be a distinctly smaller species, but we have been unable to measure a sufficient sample to prove this.

ORDER GRUIFORMES

FAMILY RALLIDAE

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 4–67: UMMP V57019, dorsal end right coracoid.

MEASUREMENTS (IN MM.): UMMP V57019: Length from proximal end of head to coracoidal fenestra 4.5; depth of head 2.0; length of glenoid facet 2.8; width of glenoid facet 1.8; diameter of scapular facet 1.3; length from procoracoid to proximal end of head 2.8; minimum width of shaft 1.8; minimum depth of shaft 1.3.

REMARKS: The following characters distinguish the Sand Draw coracoid as that of a rallid: a broad glenoid facet that is twisted externally from the dorsal plane of the coracoid and projects far externally; a brachial tuberosity that is not undercut; the absence of a pneumatic fossa or pneumatic foramina on the proximal end; a deep triosseal canal that extends about halfway down the ventral surface of the shaft; a highly recurved procoracoid; a coracoidal fenestra near the midline of the shaft; a nearly parallel-sided shaft (in dorsal view) that flares broadly near its distal end; a deeply excavated sterno-coracoidal impression.

The Keim coracoid (UMMP V57019) is that of a small rail the size of *Laterallus* or *Coturnicops*, but we have been unable to examine a large enough sample of modern rails to determine its generic affinities.

ORDER STRIGIFORMES

FAMILY STRIGIDAE

GENUS *SPEOTYTO* GLOGER, 1842

Strix MOLINA, 1782, p. 263 (in part).
Speotyto GLOGER, 1842, p. 226.

TYPE SPECIES: *Strix cunicularia* Molina, 1782.

DISTRIBUTION: Recent, Nearctic and Neotropical; late Pliocene to early Pleistocene, North America.

DIAGNOSIS: See Howard, 1929, pages 362–364; Shufeldt, 1900; Ford, 1966, pages 473–474.

Speotyto cunicularia Molina, 1782

Strix cunicularia MOLINA, 1782.
Speotyto megalopeza FORD, 1966, p. 473.
Speotyto cunicularia intermedia FEDUCCIA, 1970, p. 333.

TYPE: Molina, 1782, cited no specimen or number.

DISTRIBUTION: Same as for genus.

DIAGNOSIS: See Ford, 1966, pages 473–474.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, NW. ¼, NW. ¼, sect. 26, T. 31 N., R. 22 W.: UMMP V57018, proximal end of left tarsometatarsus.

MEASUREMENTS: See Feduccia, 1970.

REMARKS: The Burrowing Owl from the Sand Draw was originally named *S. cunicularia intermedia* by Feduccia (1970) and described as an intermediate form in a temporal cline from the Pliocene *S. megalopeza* Ford (1966) to the modern *S. cunicularia*. Manuel Plenge of Lima, Peru, through correspondence with Ned K. Johnson of the Museum of Vertebrate Zoology, Berkeley, pointed out that the name *S. c. intermedia* was used for a living Burrowing Owl by Corey (1915).

Measurements of several individuals in the living subspecies of *S. cunicularia* by us and Kenneth E. Campbell, Jr., indicate that the tarsometatarsus of the living species cannot be distinguished from the Nebraska Pleistocene Burrowing Owl. We, therefore, do not recognize the Sand Draw *Speotyto* as a temporal subspecies of *S. cunicularia*. Only one other species, *S. megalopeza* (late Pliocene, Rexroad fauna of Kansas), has been proposed (Ford, 1966) within *Speotyto*. As Feduccia (1970) suggested, however, and we have subsequently confirmed, the recent species, *S. cunicularia*, is so variable that *S. megalopeza* cannot be distinguished from it, particularly on the basis of a single tarsometatarsus.

The presence of a Burrowing Owl in the Sand Draw fauna indicates the near proximity of plains to the site of deposition as well as a climate no more rigorous than that of southern Canada today, the present northern range of *Speotyto cunicularia.*

ORDER PASSERIFORMES

REMARKS: Several fragmentary bones represent small passerines but are unidentifiable beyond order.

CONCLUSIONS

The Keim Formation has produced a small but taxonomically diverse avifauna comprised of at least nine species representing six orders of birds: *Podiceps auritus, Ciconia maltha,* ?*Cygnus* sp. or ?*Olor* sp., *Branta canadensis, Bucephala* cf. *albeola, Anas* sp., *Oxyura* sp., a rallid, and *Speotyto cunicularia,* as well as unidentified passeriforms. Most species (grebe, swan, goose, duck) are water birds and suggest the presence of a large body or bodies of water (lake or large pond) with marginal marshes in Brown County during the early Pleistocene. Eggshell fragments, common in the Keim Formation (Feduccia, 1970) probably are from these lake and streamside nesters. The stork and rallid may have been inhabitants of either a marsh or grassland, savanna environment. The Burrowing Owl, however, indicates the near proximity of prairies or open plains and further suggests the climate during the early Pleistocene in northern Nebraska was no more rigorous than that in southern Canada today, the present northern range of *Speotyto cunicularia.*

CLASS MAMMALIA

CLAUDE W. HIBBARD

I HAVE FOLLOWED McKenna (1969) in the arrangement of the mammalian orders, except that I have placed the Lagomorpha after the order Insectivora instead of after the Order Rodentia. The Order Perissodactyla is placed after the Order Artiodactyla because it is treated by Skinner.

Taxa from the Keim, Long Pine, and Duffy formations are held together in this section. These formations are in superposition in a small area, and the taxa represented in all three formations (e.g. *Equus* (*Dolichohippus*) and *Stegomastodon*), show only slight morphological changes, or none at all.

The Sand Draw mammalian local fauna, represented by 35 genera and 31 species from the Keim Formation, is the largest known from the early Pleistocene of North America. McGrew (1944) first reported the Sand Draw local fauna, an assemblage recovered only from the Keim Formation. The overlying Long Pine Formation has yielded only six taxa, and the Duffy Formation, only two.

In the summer of 1967 outcrops of the Keim Formation were examined for remains of small vertebrates, but we failed to locate a concentration. Therefore we prospected for sites that seemed suitable for screen washing. Two sites were opened in 1967 and four more in 1968. (See the list of localities for detailed information on sites and matrix tonnage.) The Elmer Lucht ranch on Bone Creek was used for matrix drying and screen washing. This method of recovering microfossils (Hibbard, 1949) yielded most of the taxa new to the Sand Draw local microfauna.

ORDER INSECTIVORA

FAMILY SORICIDAE

GENUS *SOREX* LINNAEUS, 1758

TYPE SPECIES: *Sorex araneus* Linnaeus, 1758a.

DISTRIBUTION: Pliocene to Recent, Europe and North America; Recent, Asia.

DIAGNOSIS: See Repenning, 1967, page 31.

Sorex sandersi Hibbard, 1956

Figure 26

Sorex sandersi HIBBARD, 1956, p. 179.

TYPE: UMMP V31976, right lower jaw with canine (first unicuspid or first antemolar) to M_3. Ballard Formation (early Pleistocene), Big Springs ranch, UM-K2-53, SE. ¼, sect. 23, T. 32 S., R. 29 W., Meade County, Kansas.

DISTRIBUTION: Sanders local fauna, Meade County, Kansas, and Sand Draw local fauna, Brown County, Nebraska. Early Pleistocene.

DIAGNOSIS: See Hibbard, 1956, page 179.

REFERRED MATERIAL: From the Keim Formation, Brown County, Nebraska, UM-Nebr. 1-68: UMMP V57058, complete left lower jaw (fig. 26C); UMMP V57059, partial right lower jaw with M_1–M_3; UMMP V57080, partial right lower jaw with P_4–M_3.

MEASUREMENTS (IN MM.): UMMP V57058: From tip of incisor to posterior border of condyle 10.9. See table 5 for other measurements.

DESCRIPTION AND DISCUSSION: The apex of the crown of the first lower unicuspid of UMMP V57058 (fig. 26A) is close to the anterior edge of P_4, as in the type. The posterior part of the ramus (fig. 26B) just below the ventral articular facet (see Gaughran, 1954, for terminology) is not so broad as in the type; however, the two right rami (UMMP V57079 and V57080) agree with the type in this area.

The coronoid spicule on UMMP V57079 is situated as it is in the type; in the other two specimens it is slightly more ventral.

Only the anterior mandibular foramen is present. It is situated in the Keim specimens as it is in the type and in *Sorex taylori* Hibbard (1938). The mental foramen is located either just anterior to the anterolabial root of M_1 or just below that root.

At the Rexroad local fauna (KU 3) in Meade County, Kansas, there was exposed by erosion an artesian spring sand tube in the fall of 1958 or the spring of 1959, from which a number of jaws of *Sorex taylori* were recovered. One of these (UMMP V41130), includes part of an incisor, the first lower unicuspid and P_4–M_3. The unicuspid and P_4 are more worn in this specimen than in the type of *S. sandersi* or in UMMP V57058. In young adults of *S. taylori* the apex of the crown of the first lower unicuspid is close to the anterior edge of P_4. Other characteristics of the jaw and teeth indicate that *S. sandersi* was probably derived from *S. taylori*, or from a closely related species. The lower jaw of *S. sandersi* is heavier than that of *S. taylori*, and the

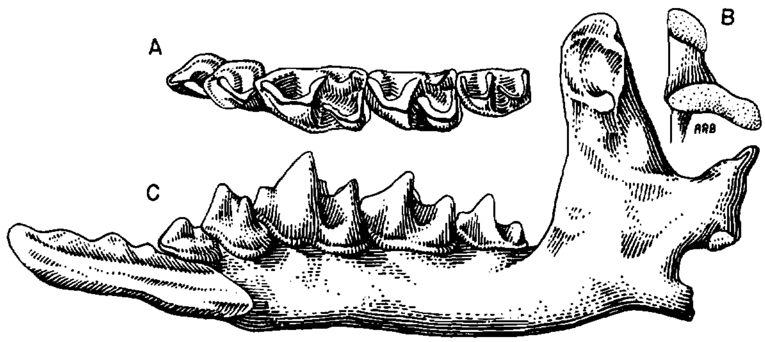


FIG. 26. *Sorex sandersi*, left lowerjaw, UMMP V57058. A. Occlusal view, first unicuspid-M_3. B. Posterior view of condyle. C. Labial view of lower jaw. Approximately $\times$ 10.

TABLE 5
MEASUREMENTS (IN MILLIMETERS) OF THE TEETH OF *Sorex sandersi*

	UMMP V57058	UMMP V57079	UMMP V57080	UMMP V31976[a]
I–M_3				
Length	7.12	—	—	—
U_3–M_3				
Length	5.00	—	—	5.13[b]
P_4–M_3				
Length	4.47	—	4.36	4.57
M_{1-3}				
Length	3.73	3.64	3.61	3.77[b]
M_1				
Length	1.51	1.42	1.53	1.47
M_2				
Length	1.20	1.25	1.22	1.30
M_3				
Length	0.99	1.04	1.01	1.05

[a]Type.
[b]This measurement differs slightly from that given in original description, which was made by caliper. All specimens in the present study were measured by a Gaertner Measuring Microscope.

talonids of M_1–M_3 are not so wide as the trigonid; in *S. taylori* they are more nearly the same width. The P_4 of *S. taylori* is relatively wider than that of *S. sandersi*.

Sorex sp.
Figure 27

REFERRED MATERIAL: From the Keim Formation, Brown County, Nebraska: UM-Nebr. 3-67: UMMP V57718, a fragmentary left lower jaw with M_1–M_2 broken away just posterior to the alveoli of M_3 (fig. 27). UM-Nebr. 1-68: UMMP V57146, fragmentary left lower jaw

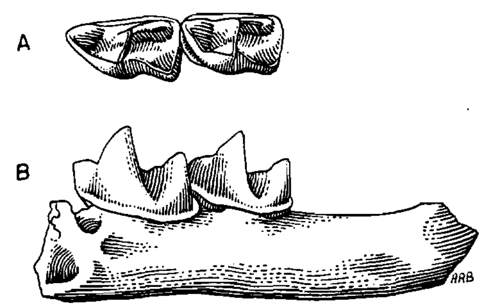


FIG. 27. *Sorex* sp., part of left lower jaw, UMMP V57718. A. Occlusal view M_1, M_2. B. Labial view of jaw. Approximately $\times$ 12.5.

with P_4–M_3.

MEASUREMENTS (IN MM.): UMMP V57146: length of P_4–M_3 4.17; M_1–M_3 3.52.

DISCUSSION: The jaw and teeth of UMMP V57718 are more robust than those from the Cudahy fauna, assigned by Paulson (1961) to *Sorex cinereus* Kerr, 1792, and those of *S. cinereus* in the University of Michigan collection. In size the specimen resembles one of the fragmentary jaws (UMMP V31973) from the Dixon local fauna (Hibbard, 1956).

UMMP V57146 was found in association with specimens of *Sorex sandersi*, and may be a small individual of *S. sandersi*. It should be noted, however, that the teeth are narrower.

PLANISOREX,[1] NEW GENUS

Sorex Linnaeus, 1758a (in part). HIBBARD, 1956.

TYPE SPECIES (MONOTYPIC): *Sorex dixonensis* (Hibbard, 1956).

DISTRIBUTION: Belleville Formation, Kingman County, Kansas; Keim Formation, Brown County, Nebraska. Early Pleistocene.

[1]Latin: *plani*, plain, and *sorex*, shrew.

DIAGNOSIS: Anterior edge of infraorbital foramen above posterior two-thirds of P^4 ending posteriorly between first and second labial roots of M^1; M^1 and M^2 possessing distinct hypocones not observed in any other genus of shrew. M_1 and M_2 rectangular having heavy labial and lingual cingula. Talonid of M_3 broad, basined, almost as large as slightly compressed trigonid. Only anterior mandibular foramen present.

Planisorex dixonensis (Hibbard, 1956)

Figure 28

Sorex dixonensis HIBBARD, 1956, pp. 162–163.

TYPE: UMMP V31986, posterior part of a left lower jaw, bearing M_1–M_3. From the Dixon farm, SW. ¼, sect. 12, T. 29 S., R. 8 W., Kingman County, Kansas. Belleville Formation.

DIAGNOSIS: Same as for the genus.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 2–68: UMMP V57083, partial right jaw; UM-Nebr. 3–68: UMMP V57234, fragmentary palate with partial right and left jaws; UM-Nebr. 6–67: UMMP V57305, partial right jaw.

LOWER DENTITION: Dental formula, 1-2-3. The incisor has two cusplets on the labial edge, the posterior is very small (fig. 28E). The position of the mental foramen is variable; in the holotype and UMMP V57083, it is below the middle of M_1; in UMMP V57234, it is below the posterolabial edge of P_4.

The last unicuspid (P_4) is shaped as in *Sorex*, but has a much more pronounced labial cingulum. M_1 and M_2 are distinguished by their rectangular shape (narrow in comparison to length), and have pronounced anterolabial, labial, and lingual cingula.

The last molar (M_3) has a broad, basined talonid, the anteroposterior length of which nearly equals that of the trigonid (fig. 28B). Compared to other shrews of similar size, the metaconid is nearer to the paraconid.

Only the anterior mandibular foramen is present. The attachment of the mandibular condyles to the horizontal ramus is broad and two articular facets are present. The lingual emargination (Repenning, 1967, p. 4) is intermediate between that of *Blarina* and *Sorex*.

UPPER DENTITION: The dental formula is unknown. A greatly reduced last unicuspid is present and is anteroposteriorly compressed and wedge-shaped with the acute angle projected labially (fig. 28D). P^4 is slightly excavated posteriorly but M^1 and M^2 are not. A distinct hypocone is present on P^4, and on M^1 and M^2 the hypocones are well developed and situated on the posterior lingual corners. However, M^1 and M^2 lack the deep lingual reentrant between the protocone and hypocone as observed in *Sorex fumeus* Miller, 1895.

The infraorbital foramen is above the posterior two-thirds of P^4 and ends posteriorly between the first and second labial roots of M^1. M^1 and M^2 have three labial roots, whereas specimens of *Blarina*, *Cryptotis*, *Paracryptotis*, and *Notiosorex* that have been examined, have two labial roots on these teeth. Some species of *Sorex* have two labial roots on M^1 and M^2, others (e.g. *Sorex araneus* Linnaeus, 1758) have three. The position of the infraorbital foramen is similar to that of *Paracryptotis rex* Hibbard, 1950

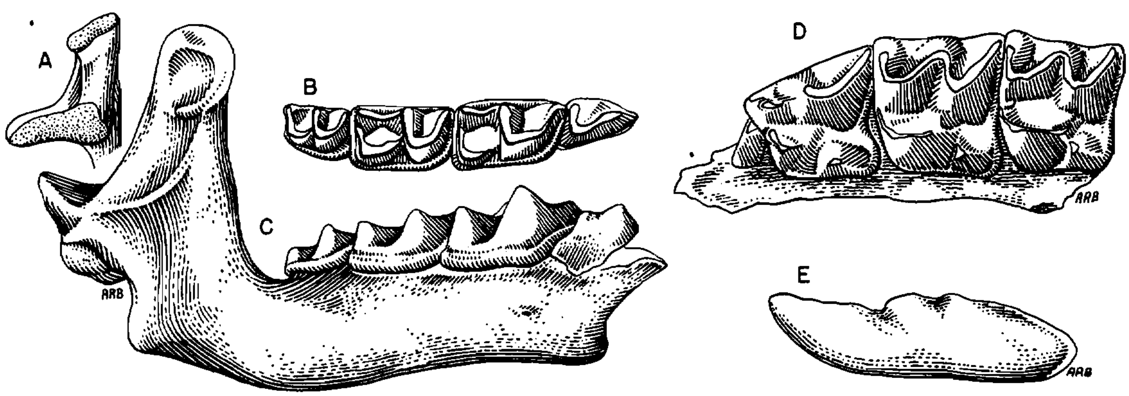


FIG. 28. *Planisorex dixonensis*, partial right lower jaw, UMMP V57083, and part of left maxillary and left lower incisor, UMMP V57234. A. Posterior view of condyle. B. Occlusal view P_4–M_3. C. Labial view of lower jaw. × 10. D. Occlusal view, last upper unicuspid–M^2. E. Labial view of left lower incisor. Approximately × 12.5.

TABLE 6
MEASUREMENTS (IN MILLIMETERS) OF THE TEETH OF *Planisorex dixonensis*, NEW GENUS

	UMMP V57083	UMMP V57234	UMMP V31968[a]
$I–M_2$			
Length	—	6.40	—
$P_4–M_3$			
Length	4.95	—	—
$M_1–M_3$			
Length	4.06	—	3.99
M_1			
Length	1.87	—	1.87
Width[b]	1.09	0.92	0.97
M_2			
Length	1.68	—	15.4
Width	1.06	0.95	0.95
M_3			
Length	1.10	—	0.93
$P^3–M^2$			
Length	—	4.06	—
P^4			
Length	—	1.34	—
M^1			
Length	—	1.34	—
Width	—	1.41	—
M^2			
Length	—	1.28	—
Width	—	1.43	—

[a]Type. This specimen was remeasured.
[b]All widths are maximum.

and *Suncus varius* (Smuts, 1832) where the foramen ends just anterior to the first labial roots of M^1.

FAMILY TALPIDAE

GENUS *SCALOPUS* GEOFFROY SAINT-HILAIRE, 1803

TYPE SPECIES: *Sorex aquaticus* Linnaeus, 1758a.

DISTRIBUTION: Pleistocene and Recent, eastern North America.

DIAGNOSIS: See Jackson, 1915, pages 28–30.

Scalopus aquaticus (Linnaeus), 1758a
Figure 29

Sorex aquaticus LINNAEUS, 1758a, p. 53.
Sc(alops) aquaticus: FISCHER, 1829, p. 249.
Scalopus aquaticus Linnaeus: JACKSON, 1915, p. 28.

DISTRIBUTION: Eastern United States, Mississippi Valley, west to the southeastern corner of Wyoming, south through eastern half of Texas to Brownsville and adjacent Tamaulipas, Mexico. Fossils are known from the late

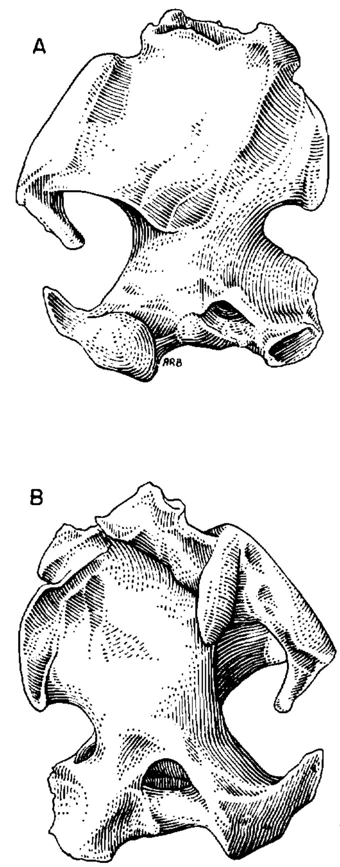


FIG. 29. *Scalopus aquaticus*, right humerus, UMMP V57300. A. Anterior view. B. Posterior view. Both ×3.

Pleistocene deposits of Arkansas, Florida, and Pennsylvania.

DIAGNOSIS: See Jackson, 1915, pages 32–54.

REFERRED MATERIAL: From the Keim Formation, Brown County, Nebraska: UM-Nebr. 1–68: UMMP V57148, distal end of a left scapula; Wilbur Magill ranch, SE. $\frac{1}{4}$, SE. $\frac{1}{4}$, SE. $\frac{1}{4}$, sect. 12, T. 30 N., R. 21 W.: UMMP V57221, part of a right humerus; UM-Nebr. 5–67: UMMP V57274, right ulna and part of left humerus; UM-Nebr. 4–67: UMMP V57300 (fig. 29) large right humerus, UMMP V57646, smaller right humerus and associated fragments, UMMP V57309, part of a right jaw of an old individual with M_2 and alveoli for P_3, P_4, M_1, and M_3.

MEASUREMENTS (IN MM.): UMMP V57274: greatest length 19.8. UMMP V57309: M_2 length 2.78, width 2.03.

REMARKS: These specimens are the earliest fossil records of the eastern mole in North America.

ORDER LAGOMORPHA

FAMILY LEPORIDAE

Hypolagus sp. or *Pratilepus* sp.
Figure 30

REFERRED MATERIAL: From the Keim Formation, Brown County, Nebraska: Near the *Stegomastodon* Quarry in the SW. ¼, sect. 4, T. 30 N., R. 21 W.: F:AM 87457, fragmentary left lower jaw with P_4–M_3; UM-Nebr. 2-66: UMMP V57268, left P^2; UM-Nebr. 3-67, washing site on the Magill ranch: UMMP V57207, right and left P^2; UM-Nebr. 1-68: UMMP V57145, left P^2.

DESCRIPTION: The fragmentary left lower jaw of an adult rabbit (F:AM 87457) represents an unnamed species with an occlusal pattern distinct from Recent *Lepus*, although the dentition is as large as that of *Lepus alleni* Mearns, 1890 and *L. townsendii* Bachman, 1839. I have questioned the generic assignment because P_3 is missing; however, the position of the base of the incisor is more like that of *Pratilepus* than any other late Pliocene genus.

In F:AM 87457 the base of the incisor ended at the posterior edge of P_3 and dorsal to the lower half of P_4. In *Pratilepus vagus* (Gazin, 1934) and *P. kansasensis* Hibbard, 1939, the incisor also ends at the posterior edge of the trigonid of P_3. Dawson (1958, p. 46) stated that in *Hypolagus parviplicatus*, "the swelling over the incisor on the medial surface of the jaw terminates below the trigonid of P_3, in a position nearly the same as in *H. vetus* (Kellogg)."

In *Hypolagus* cf. *vetus* (UMMP V49712) from the Hagerman fauna, the incisor ends at the posterior edge of the trigonid of P_3. In *H. regalis* (UMMP V29678) from the Rexroad local fauna, the incisor ends at the anterior edge of P_3. In *H. limnetus* Gazin, 1934 (UMMP V54782) from the Hagerman fauna, the incisor ends near the posterior edge of the trigonid of P_3.

The P_4–M_2 of F:AM 87457 is distinguished by the shorter width of the talonid in comparison to the trigonid. The lingual face of the talonid of P_4–M_2 forms an acute angle (fig. 30A). In F:AM 85457 the transverse width of the trigonid, in proportion to the talonid, is more similar to *Hypolagus brachygnathus* Kormos (UMMP V34906) from Kadzielna, Kielce, Poland, than to the late Pliocene forms from North America. Moreover, the labial edge of the talonid of *H. brachygnathus* (Sych, 1965, fig. 5) does not extend so far labially as in *Hypolagus* cf. *vetus* and *H. regalis*, nor is the lingual edge of the talonid as round where it joins the trigonid. (See Hibbard, 1939, fig. 3; 1969, fig. 2.)

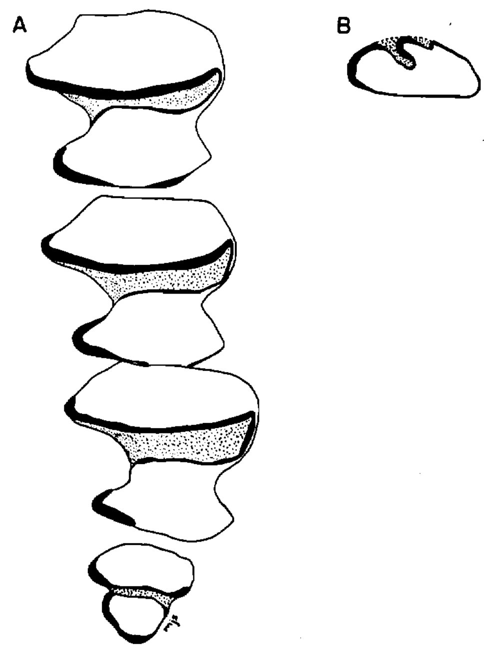


FIG. 30. *Hypolagus* or *Pratilepus*, lower and upper teeth. A. Occlusal view, left P_4–M_3, F:AM 87457. B. Occlusal view, left P^2, UMMP V57145. Approximately ×6.

A right and a left P^2 (UMMP V57207) from a washing site at the Magill ranch are judged to be of a young adult because the premolars taper slightly from the base toward the occlusal surface. Each tooth has a deep median reentrant angle and a very shallow labial groove. Another left P^2 (UMMP V57268) lacks the very shallow labial groove of UMMP V57207. Still another left P^2, UMMP V57145 (fig. 30B) of an adult rabbit has the shallow labial groove observed in UMMP V57207.

DISCUSSION: A large *Hypolagus* has been reported only from two early Pleistocene faunas: Schultz, Lueninghoener, and Frankforter (1951) from the Broadwater fauna of western Nebraska and Johnston and Savage (1955) from the Cita Canyon local fauna of northwestern Texas.

A small *Hypolagus* sp., represented by a left P_3 (UMMP V31955) was reported by Hibbard

TABLE 7
MEASUREMENTS (IN MILLIMETERS) OF THE LOWER TEETH OF F:AM 87457, CF. *Hypolagus* SP. OR *Pratilepus* SP.

	Length	Trigonid Width	Talonid Width
P_4	3.80	4.44	3.46
M_1	3.65	4.52	3.20
M_2	4.04	4.23	2.94
M_3	2.21	2.24	1.16
P_4–M_3	13.00	—	—

(1956, fig. 8D) from the Deer Park local fauna.

Both *Hypolagus* and *Pratilepus* have a P^2 with a deep median reentrant angle and a very shallow labial groove. Hibbard (1969) was unable to distinguish isolated second premolars of the two genera. No associated lower and upper dentitions of *Pratilepus kansasensis* have been recovered.

Two large Pleistocene hares are known: *Lepus benjamini* Hay, 1921 (see Dice, 1932, p. 382) and *L. giganteus* Brown, 1908. *Lepus giganteus* is based on a fragment of a skull with two teeth from the Conard Fissure of Arkansas. The isolated upper incisors from the Conard Fissure should be examined carefully because there is part of an upper incisor (UMMP V38429) from the brown sand wedge in the Sanders gravel pit (S. ½, sect. 25, T. 1 N., R. 34 E., Roosevelt County, near Portales, New Mexico) that has a groove and enamel pattern similar to the *Lepus* (*Macrotolagus*) group (Lyon, 1904, fig. 44). Crook and Harris (1958, p. 241) reported an upper incisor with the same enamel pattern as *Lepus* (new species?) from Texas.

ORDER RODENTIA

FAMILY SCIURIDAE

GENUS *SPERMOPHILUS* F. CUVIER, 1825

TYPE SPECIES: *Mus citellus* Linnaeus.

SUBGENUS *OTOSPERMOPHILUS* BRANDT, 1844

TYPE SPECIES: *Spermophilus* (*Otospermophilus*) *grammurus* (Say, 1823).

DISTRIBUTION: Medial Mocene to Recent, southwestern North America.

DIAGNOSIS: See Howell, 1938, page 43.

***Spermophilus* (*Otospermophilus*) *boothi*,**[1] new species

Figure 31

TYPE: UMMP V57273, fragments of skull, premaxillaries with incisors, maxillaries with right and left P^3–M^3 and a right lower jaw with incisor and P_4–M_3. The skull was badly broken, having been encased with the jaw in a calcium carbonate concretion within fine sand. The concretion was broken down with acetic acid so that the fragments could be examined.

TYPE LOCALITY AND LITHIC UNIT: UM-Nebr. 2–66 from a bluff near the section line in the southeast corner, SE. ¼, SW. ¼, sect. 23, T. 31 N., R. 22 W., Brown County, Nebraska. Keim Formation.

DISTRIBUTION: Known only from the type specimen, a member of the Sand Draw local fauna.

DIAGNOSIS: Largest known ground squirrel in subgenus *Otospermophilus*, about size of *Spermophilus undulatus* (Pallas, 1779). Teeth low-crowned, similar to those of *Spermophilus variegatus* (Erxleben, 1777), but masseteric tubercles larger. Part of infraorbital foramen missing dorsally, but ventral part large as in *S. undulatus*. P^3 conical, simple, about one-fourth size of P^4, lacking anterior cingulum. Posterior cingulum slightly developed.

MEASUREMENTS (IN MM.): UMMP V57273: Rostral width across incisors 12.0; anterior width of nasals 9.0; right incisive foramen length 4.5; width across supraorbital notches of frontals 14.5; anterior edge of P^3 alveolus to ventral opening infraorbital foramen 3.2. See table 8 for dental measurements.

DESCRIPTION: The rostrum is broad. Only the right premaxillary with the incisor is in contact with the nasals, which extend to the premaxillary-frontal suture. Depressions for the cheekpouch muscles are deep, and the interpremaxillary foramen (Hill, 1935) is equal in size to the largest foramen in *S. undulatus*. A depression is present anterior to P^3 for the attachment of part of the masseter superficialis.

The parastyles of P^4–M^2 do not change direction to join the protocones, whereas in *S. mcgheei* (Strain, 1966), the parastyle of P^4, which is larger than that of *S. boothi*, does change direction and joins the protocone. In *S. boothi* P^4, the metaloph does not join the protocone. Both metacone and metaconule are separated by a shallow valley and a mesostyle is present on P^4–M^3 (fig. 31C).

The coronoid process, the coronoid and mandibular notches are more like those of *S. variegatus*, although the jaw of the type of *S.*

[1] For Oscar Booth.

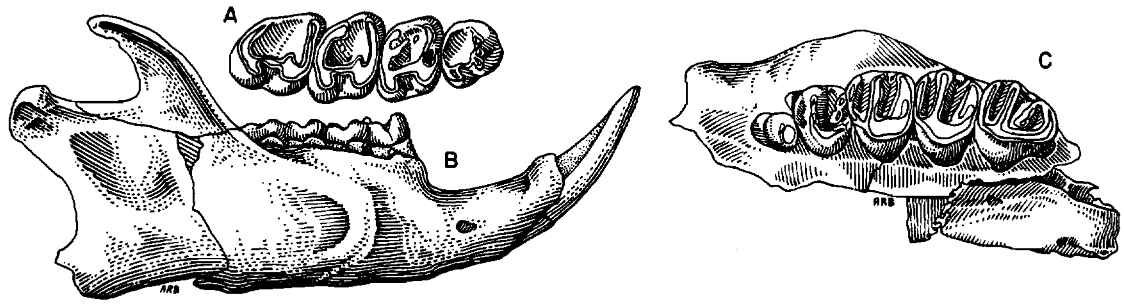


FIG. 31. *Spermophilus* (*Otospermophilus*) *boothi*, new species, right lower jaw and left maxillary of type, UMMP V57273. A. Occlusal view of right P_4–M_3. Approximately ×3. B. Labial view of jaw. ×2. C. Occlusal view, P^3–M^3, and fragment of maxillary. Approximately ×3.

boothi is the size of a large *S. undulatus* (fig. 31B). The P_4–M_2 are greater in width than in length. Reentrant valleys between the protoconids and entoconids of P_4–M_3 are broader than either *S. variegatus* or *S. undulatus*. In shape, P_4 resembles a parallelogram rather than a trapezoid and has a large protoconid that extends close to the metaconid.

TABLE 8
MEASUREMENTS (IN MILLIMETERS) OF THE DENTITION OF THE TYPE OF *Spermophilus* (*Otospermophilus*) *boothi*, NEW SPECIES

UMMP V57273	Length Right	Length Left	Width Right	Width Left
I	3.60	3.50	2.40	2.40
P^3	1.51	1.46	1.55	1.47
P^4	2.67	2.68	2.97	2.78
M^1	3.03	3.02	3.65	3.81
M^2	2.90	2.98	3.92	3.93
M^3	3.48	3.52	3.79	3.63
P^3–M^3	13.33	—	—	—
I	3.20	—	2.20	—
P_4	2.77	—	2.88	—
M_1	2.85	—	3.45	—
M_2	2.96	—	3.67	—
M_3	4.65	—	3.93	—
P_4–M_3	12.30	—	—	—

Spermophilus (?Subgenus) ***johnsoni***,[1] new species

Figure 32

TYPE: F:AM 87466, a left lower jaw with incisor and well-worn P_4–M_3 of an adult. Collected in the summer of 1955 by Morris F. Skinner from the Keim Formation, 5 feet below the Long Pine Formation in Frick Prospecting Locality 277 in the W. ½, NW. ¼, sect. 25, T. 31 N., R. 22 W., Brown County, Nebraska.

[1] For Harold Johnson.

PARATYPE: UMMP V57387, part of right lower jaw with P_4–M_2 from UM-Nebr. 2–67.

DISTRIBUTION: Keim Formation, Brown County, Nebraska.

DIAGNOSIS: The size of *Spermophilus undulatus* but with deeper jaw and wider P_4–M_3; shorter-jawed than either *S. franklini* (Sabine, 1822) or *S. boothi*.

REFERRED MATERIAL: SW. ¼, SW. ¼, sect. 20, T. 31 N., R. 21 W., from just north of Sand Draw in road cut along west edge of sect. 20: UMMP V56499, right maxillary with P^3–M^3. SW. ¼, SE. ¼, sect. 20, T. 31 N., R. 21 W., from northwest of high bluff and just below red zone at this place: UMMP V57326, part of right maxillary with M^2–M^3.

MEASUREMENTS (IN MM.): Type, F:AM 87466: Depth of jaw at mid P_4 on lingual side 19.0; posterior edge of M_3 to anterior edge of articular head of condyle 10.0 (in *S. boothi* 13.56); width of narrowest part of ascending ramus below articular condyle 3.0 (in *S. boothi* 4.5). See table 9 for measurements of upper dentition and table 10 for measurements of lower dentition.

DESCRIPTION: The teeth of the type are well worn, but even so the occlusal surface of P_4 is distinctly trapezoidal. No evidence of an anterior cingulum is observed on P_4 (fig. 32A, B). The P_4 of the paratype, UMMP V57387 (fig. 32C) is also trapezoid-shaped; the protoconid is slightly larger than the metaconid and the hypoconid is largest; a narrow notch separates the protoconid and metaconid, and anterior to this notch is an anterior cingulum. A small

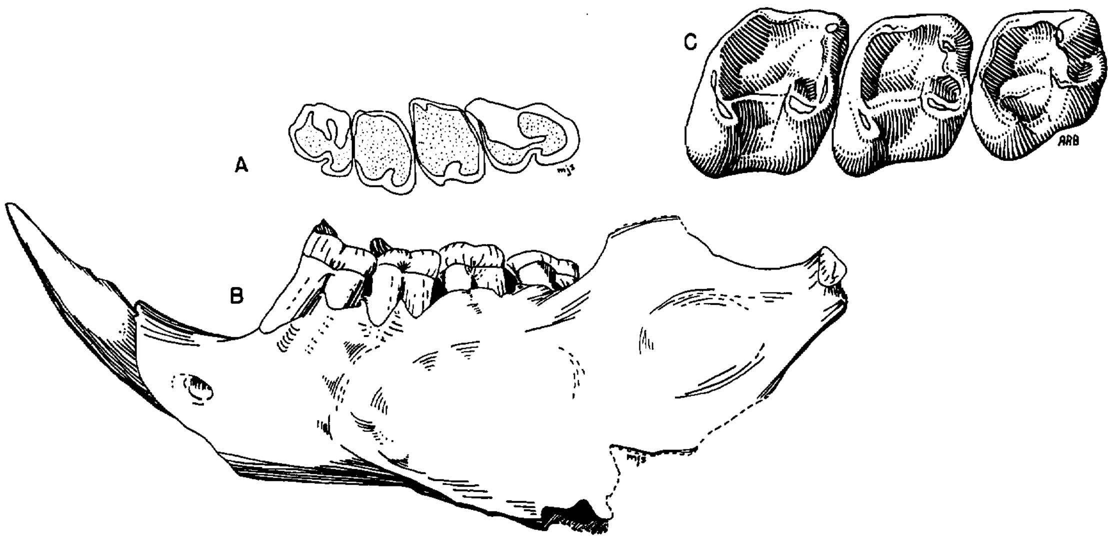


FIG. 32. *Spermophilus johnsoni*, new species, left lower incisor, P_4–M_3 of type, F:AM 87466; right P_4–M_2 of paratype, UMMP V57387. A. P_4–M_3. Occlusal view. B. Type jaw. Labial view. A, B approximately ×3. C. Right P_4–M_2. Occlusal view. Approximately ×6.

mesostylid is present on P_4–M_2; of these only M_1 has an anterior cingulum.

Part of a right maxillary (UMMP V56499) with P^3–M^2 was recovered from a coprolite, probably that of a coyote. The P^3 is oval and only one-third as large as P^4, but both P^3 and P^4 are slightly larger than the same teeth of *S. boothi*, new species. P^3 has a slight anterior cingulum and a pronounced posterolingual cingulum. The parastyle of P^4 is larger than that of *S. boothi* and shifts direction to join the protocone as in *S. mcgheei*. On P^4 a large metaconule fills the posterior part of the reentrant between the protoloph and metaloph; the metaloph does not join the protocone. The masseteric tubercle is smaller than that of *S. boothi*. A deep depression is present just ahead of P^3.

In UMMP V56499 the labial edge of the metaloph of M^1 and the root that supports it are broken away. P^4 has no mesostyle; on M^1 this area of the tooth is missing, but M^2 has a small mesostyle. On M^1 and M^2 the metaconules are enlarged. In this specimen P^4–M^2 are slightly higher crowned than those of *S. boothi*.

In Recent species of *Spermophilus* no variation has been observed so great as that between UMMP V56499 and *S. boothi* in the position of the infraorbital foramen, the P^3 and P^4. *Spermophilus johnsoni* may represent a specialized line of ground squirrels. I am unable to assign it to a subgenus.

The maxillary of a young adult (UMMP V57326) is referred to *S. johnsoni* because the metaconule of M^2 is enlarged and connected to the distinct metacone by a narrow ridge of enamel. The metaloph of M^2 does not join the

TABLE 9

MEASUREMENTS (IN MILLIMETERS) OF THE UPPER TEETH OF *Spermophilus johnsoni*, NEW SPECIES

	UMMP V56499	UMMP V57326
P^3		
Length	1.72	—
Width	1.66	—
P^4		
Length	2.91	—
Width	3.39	—
M^1		
Length	3.03	—
Width	—	—
M^2		
Length	3.09	3.35
Width	3.88	3.94
M^3		
Length	—	3.90
Width	—	3.84

TABLE 10
MEASUREMENTS (IN MILLIMETERS) OF THE LOWER TEETH OF *Spermophilus johnsoni*, NEW SPECIES

	F:AM 87466[a]	UMMP V57387
Incisor		
Length	2.70	—
Width	1.90	—
P_4		
Length	2.77	3.10
Width	3.12	3.06
M_1		
Length	2.48	3.78
Width	3.53	3.30
M_2		
Length	2.98	3.05
Width	3.61	3.65
M_3		
Length	4.71	—
Width	3.51	—
P_4–M_3 length	12.17	—
Depth of jaw at mid P_4	19.0	—

[a]Type

protocone, and M^3 does not have as pronounced a mesostyle or metaloph as the M^3 of *S. boothi.*

DISCUSSION: At least two large ground squirrels are present in the Sand Draw local fauna. Upper dentition may or may not belong to *S. johnsoni*, but they are here referred to *S. johnsoni* on size. It is fairly certain that they are not *S. boothi.*

Spermophilus (?Subgenus) **_meltoni,_**[1]
new species
Figure 33

TYPE: UMMP V52167, partial right maxillary with P^3–M^1, right upper incisor, left P^4, most of frontal, partial right jaw with incisor and P_4–M_3, proximal ends of femora, distal end of left tibia, right humerus, proximal end of left radius, and left ulna. Collected July 26, 1965, by Claude W. Hibbard from the upper part of the Keim Formation, above the snail zone (fig. 5); NE. ¼, NW. ¼, sect. 26, T. 31 N., R. 22 W., Brown County, Nebraska.

PARATYPE: UMMP V56411, partial skeleton including femora, parts of tibiofibulae, left humerus, parts of ulnae, right radius, and left lower jaw with incisor, P_4–M_3. Collected June 28, 1966, by William G. Melton from the Keim Formation; SE. ¼, NW. ¼, sect. 26, T. 31 N., R. 22 W., Brown County, Nebraska.

[1]For William G. Melton.

DISTRIBUTION: Keim Formation, Brown County, Nebraska.

DIAGNOSIS: Intermediate in size between *S. franklini* and *S. mexicanus* (Erxleben, 1777). Premolar three more than one-third size of P^4; protocones of P^4 and M^1 not enlarged (broadened). Strong parastyle on P^4 extending less than one-half distance across anterior part toward protocone, and although parastyle of M^1 extends farther, it does not quite reach the protocone. This is in contrast to *S. cochisei* (Gidley, 1922) which is the size of *S. meltoni* but the parastyles of P^4 and M^1 join the protocone. No mesostyle present on P^4–M^1 of *S. meltoni*; narrow valley separating protoloph and metaloph of P^4 and M^1.

REFERRED MATERIAL: UM-Nebr. 4–67: UMMP V57298, fragment of right lower jaw with P_4; UMMP V52222, part of left lower jaw with incisor, P_4, and alveoli of M_1–M_3.

MEASUREMENTS (IN MM.): Type, UMMP V52167: Humerus, length 29.0, width 8.0 (fig. 33A, B); left ulna, length 34.0 (fig. 33C). Paratype, UMMP V56411: Right femur, length 33.0; left humerus, length 26.70.

DESCRIPTION: In the type, most of the right frontal is present, showing an infraorbital foramen instead of a notch. A slight shelf is posterior and medial to a prominent postorbital process, a character that thus far has been duplicated only in *Spermophilus spilosoma* Bennett, 1833. The left detached P^4 agrees with the right in size and shape but both of these premolars and M^1 are so worn that it is not possible to say that the metaloph joined the protocone. The wear, however, suggests that the metaloph probably joined the protocone.

The posterior part of the jaw is missing. The teeth are in an adult stage of wear (fig. 33D, E) and the protoconids are worn down to the level of the hypoconids. Premolar four has no anterior cingulum and the hypoconid is as large or larger than the protoconid (table 11).

As in *Spermophilus lateralis* (Say, 1823), the lesser trochanter is close to the head of the femur and the third trochanter is nearly as large, but is closer to the lesser trochanter than in *Spermophilus franklini.*

The paratype, UMMP V56411, is a part of a skeleton of a young adult. When present, the epiphyses of the limbs are not fused to the shafts. Premolar four has no anterior cingulum (fig. 33F, G); a large metaconid is slightly

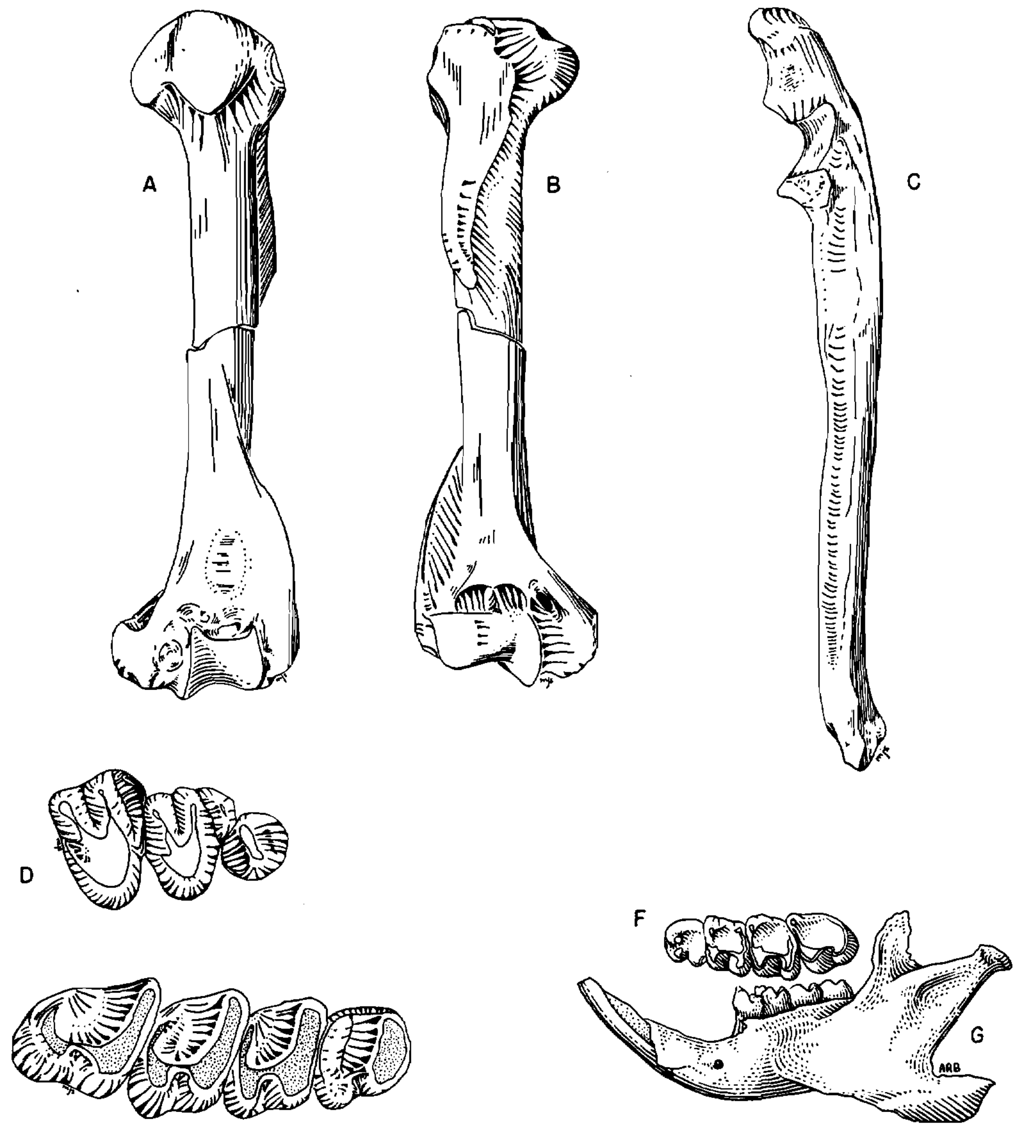


FIG. 33. *Spermophilus meltoni*, new species. A–E. Right humerus, left ulna, right P^3–M^1 and right P_4–M_3 of type, UMMP V52167. A, B. Right humerus. A. Anterior view. B. Posterior view. C. Left ulna. Lateral (external) view. A–C $\times$3. D. Right P^3-M^1. Occlusal view. E. Right P_4–M_3. Occlusal view. F, G. Left P_4–M_3 of paratype, UMMP V56411. F. Occlusal view. $\times$3. G. Labial view. $\times$1.5.

anterior to the protoconid, not directly opposite as in *Spermophilus richardsoni* (Sabine, 1822). Protoconids and metaconids of P_4–M_2 are broad at the base, forming a V-shaped entrance to the reentrant valley between these cusps. Characteristics of the lower jaw, dentition, and skeletal elements agree with those of the holotype.

DISCUSSION: A fragment of a right jaw with P_4 (UMMP V57298) agrees with the type and paratype. Part of a left jaw with incisor, P_4 and alveoli of M_1–M_3 (UMMP V52222) is the size of the type and paratype; P_4 is slightly worn, but differs from other specimens of *S. meltoni* in having a deep, narrow groove that separates the protoconid and metaconid. This groove is shallow on the anterior part of the enamel, but extends almost to the base of the crown.

TABLE 11

MEASUREMENTS (IN MILLIMETERS) OF THE DENTITION OF *Spermophilus meltoni*, NEW SPECIES

	UMMP V52167[a] Length	UMMP V52167[a] Width	UMMP V56411[b] Length	UMMP V56411[b] Width
Upper Dentition				
Incisor	2.30	1.50	—	—
P^3	1.40	1.51	—	—
P^4	3.05	2.48	—	—
M^1	2.16	2.98	—	—
Lower Dentition				
Incisor	2.10	1.80	2.30	2.00
P_4	2.11	2.13	1.97	2.29
M_1	1.76	2.44	2.02	2.52
M_2	2.08	2.51	2.14	2.71
M_3	2.63	2.43	2.74	2.50
P_4–M_3	8.57	—	8.55	—

[a]Holotype.
[b]Paratype.

It is not certain to which subgenus *Spermophilus meltoni* should be assigned, but it seems to be more closely related to the subgenus *Ictidomys* than to any of the other subgenera.

FAMILY GEOMYIDAE

GENUS *GEOMYS* RAFINESQUE, 1817

TYPE SPECIES: *Geomys pinetis* Rafinesque, 1817.

DISTRIBUTION: Late Pliocene to Recent, North America.

DIAGNOSIS: See Merriam, 1895, page 109.

Geomys quinni McGrew, 1944

Figure 34

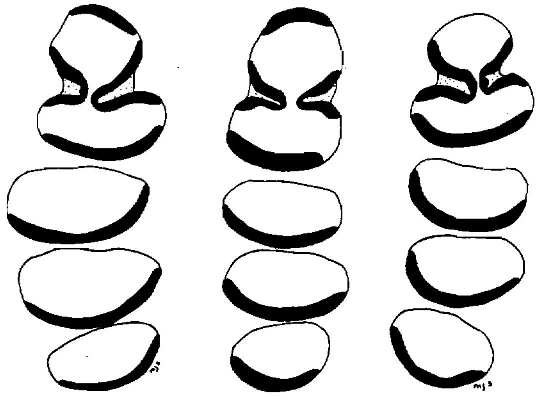
Geomys quinni McGrew: FRANZEN, 1947, p. 56, pl. A, fig. 5. HIBBARD, 1956, p. 174.

TYPE: FM P27011, skull with complete dentition, but lacking posterior part of braincase and occiput, associated left mandible, complete (McGrew, 1944). From Booth Draw, 6 miles north of Ainsworth, Brown County, Nebraska.

DISTRIBUTION: Keim Formation, Brown County, Nebraska; Ballard Formation, Meade County, Kansas.

DIAGNOSIS: See McGrew, 1944, page 49.

REFERRED MATERIAL: From the Keim Formation, Prospecting Locality 277 (includes UM-Nebr. 1–66, 2–66, 2–67, 4–67, 5–67, and 1–68): F:AM 87467, part of skull and parts of six left and six right lower jaws. Locality 1–66: UMMP V56412, part of skull and fragmentary associated lower jaws. Locality 2–66: UMMP V57243, part of skull and part of associated lower jaws; UMMP V57270, parts of three lower jaws. Locality 4–67: UMMP V44671, associated lower jaws; UMMP V52168, V52169, parts of four lower jaws; UMMP V56378, part of skeleton with skull and lower jaws; UMMP V57241, part of skull, associated lower jaws, radius, and ulna; UMMP V57246, parts of eight lower jaws; UMMP V57402, parts of three palates; UMMP V58812, right lower jaw; UMMP V59811, left lower jaw. UM-Nebr. 5–67: UMMP V57276–V57278, parts of four jaws; UMMP V52168, V52169, parts of four jaws. UM-Nebr. 1–68: UMMP V57166, part of palate. Most of these specimens were surface finds. Prospecting Locality 263 (near *Stegomastodon* Quarry): F:AM 87470, part of a right and a left lower jaw; F:AM 87469, part of a right lower jaw. *Stegomastodon* Quarry: F:AM 47468A, parts of skull and parts of associated lower jaws; F:AM 47468B, anterior part of skull and associated right lower jaw; F:AM 47468C, part of left lower jaw. These specimens were taken above the muck layer. Prospecting Locality 278 (Magill ranch): F:AM 47471, parts of two skulls, four right lower jaws, and six left lower jaws; UMMP V56403, part of skull and right lower jaw.



A B C

FIG. 34. *Geomys quinni*, lower dentitions. Occlusal views. A. Left P_4–M_3, UMMP V59811. B. Right P_4–M_3, UMMP V58812. C. Right P_4–M_3, UMMP V52168. Approximately ×6.

MEASUREMENTS (IN MM.): Of four palates representing young adults to old individuals, the occlusal lengths of P^4–M^3 range from 7.27 (UMMP V57166) to 9.23 (UMMP V57402);

average occlusal length 8.34. Lower incisors vary in width from 2.70 to 3. 80, upper incisors from 2.90 to 3.50. Occlusal lengths of P_4–M_3 of six lower jaws range from 7.50 (F:AM 87471) to 8.80 (F:AM 87467); average occlusal length, 8.20.

DESCRIPTION: The characters of the skull and the dental pattern of the upper teeth are like those of the type. Some individual variation was observed in the occlusal pattern of P_4 but the majority of the lower fourth premolars have occlusal patterns like that of the type (e.g. UMMP V59811, fig. 34A), where only a very narrow lingual dentine tract and a broad labial dentine tract are present on the anteroloph. Two P_4s (UMMP V59812) have broad lingual tracts (fig. 34B). One right lower jaw with P_4–M_3 (UMMP V52168), with an occlusal length of 7.86 mm., has a P_4 with no anterior enamel band on the anteroloph (fig. 34C).

DISCUSSION: This pocket gopher is the most common rodent in the Keim Formation, occurring chiefly above the upper snail zone and below the Long Pine Formation (fig. 5). Those from the lowest level of the formation are from the *Stegomastodon* Quarry. The entire collection, however, has no skull or lower jaw so complete as the type described and figured by McGrew (1944, fig. 16). Complete dentitions are also rare.

The type and cotypes of *Geomys bisulcatus* Marsh, 1871, from a later Pleistocene deposit near Camp Thomas, July 18–23, 1870, along the Loup Fork River in Nebraska, have been restudied. The type series is small and fragmentary and does not furnish data on size changes that are due to age, within the species. Both time and individual age affect the deepening of the temporal pit between the lingual side of the ascending ramus and M_3. A population of *G. bisulcatus* from the later Pleistocene type area should be expected to have a deeper temporal pit than *G. quinni*.

Hibbard (1967, p. 123) stated, "the pit in *G. quinni* and in *G. bisulcatus* Marsh from the Pleistocene of Nebraska, . . . is developed as in Recent *G. bursarius*." The following correction is made: in only two lower jaws of *G. quinni*, both old adults, does the pit approach the depth it does in large adults of *G. bursarius* (Shaw, 1800). In all *G. quinni* specimens, the pit is broader than in Recent *G. bursarius*. Young *G. bursarius* have shallow pits. No *Geomys quinni* was found with so deep a temporal pit as observed in large old individuals of *Geomys bursarius*.

Geomys sp.

REFERRED MATERIAL: From the Duffy Formation (early Pleistocene), Duffy ranch, Brown County, Nebraska: F:AM 87472, anterior part of skull with incisors, right P^4 and M^1, left P^4–M^3; F:AM 87473, fragmentary skull with left incisor, left P^4–M^2, right P^4–M^1, lower jaws with incisor, P_4–M_3.

DISCUSSION: F:AM 87472 was taken approximately 5 feet above the top of the Long Pine Formation and F:AM 87473 was taken 60 feet above the top of the Long Pine Formation. Both specimens came from the same exposure.

The skulls are broken, so it is impossible to compare the diastemal and muzzle regions with *Geomys quinni*. The specimens are intermediate in size between the youngest (smallest) and the old adult (largest) of *G. quinni*. It is impossible to tell whether they are adult or young adult specimens. A better series is needed for comparison with fossil and living species.

FAMILY HETEROMYIDAE

GENUS *PRODIPODOMYS* HIBBARD, 1939

TYPE SPECIES: *Dipodomys kansensis* Hibbard, 1937.

DISTRIBUTION: ?Late Miocene to early Pleistocene, North America.

DIAGNOSIS: See Hibbard, 1939, page 458.

Prodipodomys centralis (Hibbard, 1941a)

Figure 35

Liomys centralis HIBBARD, 1941a, p. 349, fig. 8.
Prodipodomys rexroadensis HIBBARD, 1954, p. 228.

TYPE: KUMNH 4589, part of left ramus bearing incisor, P_4–M_1 and alveolus of M_2 from KU-3 of the Rexroad Formation, Meade County, Kansas.

DISTRIBUTION: Late Pliocene Rexroad Formation and early Pleistocene Ballard Formation, Meade County, Kansas; early Pleistocene Keim Formation, Brown County, Nebraska.

DIAGNOSIS: Larger than *Prodipodomys kansensis* and *Prodipodomys*? *minor* (Gidley, 1922), and smaller than *P. idahoensis* Hibbard, 1962. Teeth rooted, no dentine tracts along sides of teeth at base; unworn pattern of P_4 approaches closely pattern of unworn P_4 of *Liomys* Merriam, 1902.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: *Stegomastodon* Quarry: F:AM 87427, a partial skull, lower jaws and associated right pes. UM-Nebr. 3-67: UMMP V57205A–C, a left P^4, left P_4 and M_1 or M_2.

DESCRIPTION: The skull and lower jaws

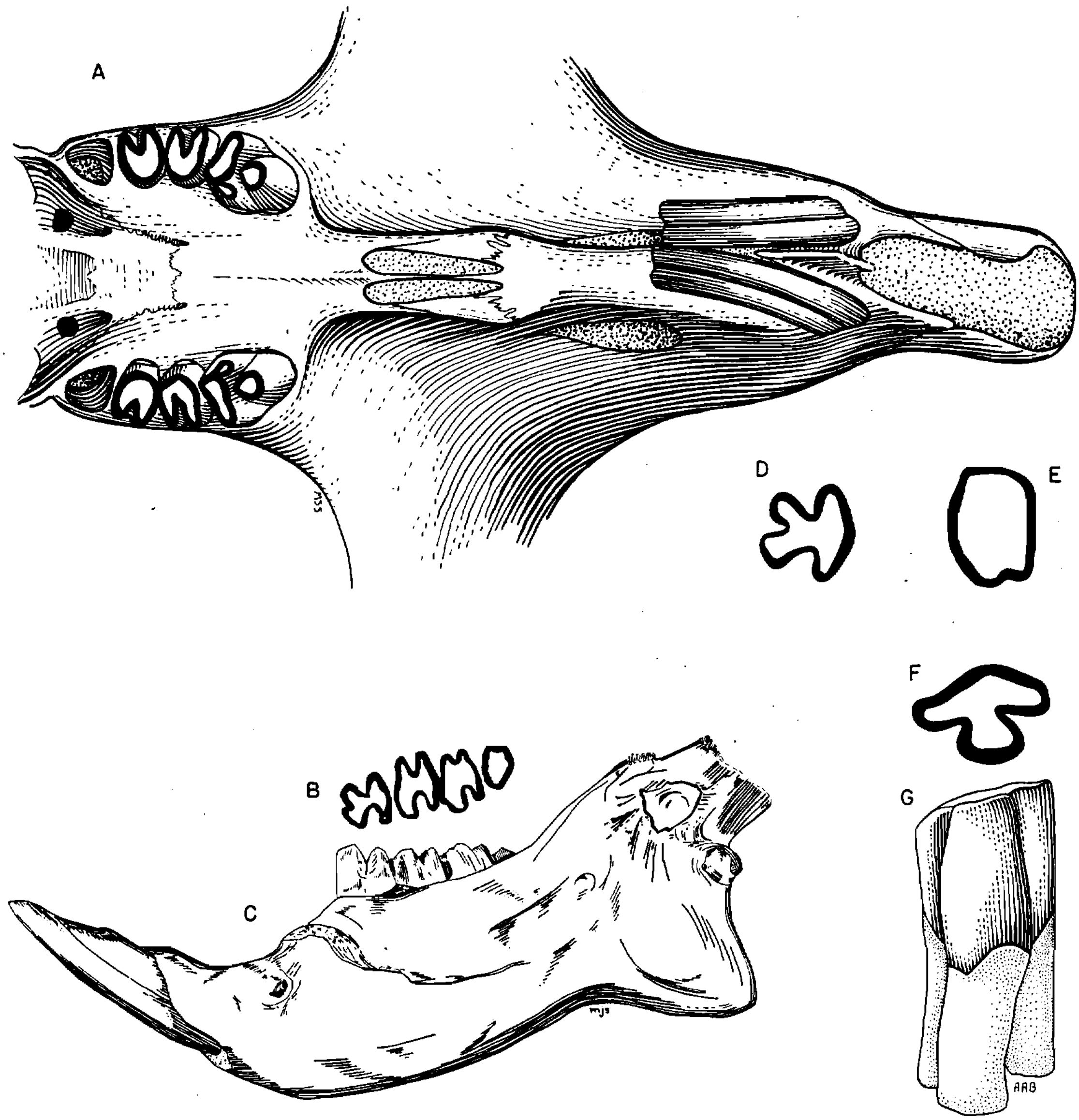


FIG. 35. *Prodipodomys centralis*, partial skull, lower jaw, F:AM 87427, and isolated teeth. A. Ventral view, anterior part of skull with incisors and P_4–M_2. ×6. B. Occlusal view, left P_4–M_3. C. Labial view, left jaw. Approximately ×6. D. Occlusal view, left P_4, UMMP V57205a. E. Occlusal view, left M_1 or M_2, UMMP V57205b. F. Occlusal view, left P^4, UMMP V57205c. G. Anterior view, left P^4, UMMP V57205c.

(F:AM 87427) of this primitive kangaroo rat are the best known. The tip of the nasals extends 5.47 mm. beyond the edge of the deeply grooved upper incisors, a greater distance than observed in *Dipodomys ordii* Woodhouse, 1853. A prominent tubercle for the origin of the masseter superficialis is 3.66 mm. ahead of the anterior edge of the P^4 alveolus. The anteroloph of P^4 is still separated from the posteroloph (fig. 35A) and the labial cusp of the anteroloph and posteroloph has not completely worn down, so that the dentine of each loph is not joined.

The enamel patterns of M^1 and M^2 are C-shaped. On the labial side of M^1 a reentrant enamel valley extends over one-half the width of the occlusal surface; this reentrant is not so deep as on the smaller M^2. The right M^2 was removed to show a large, broad anterolabial root, fused at its base to the large posterolingual root, about opposite the small, distinct posterolabial root. No dentine tracts are on the sides of the teeth, although the enamel extends farther upward on the labial side than on the lingual.

In *Prodipodomys centralis* the masseteric ridge is similar to *Dipodomys ordii*, but in *P. centralis* it ends in a pronounced knob that is more anterior to P^4 than in *D. ordii*, and extends above the ventral surface of the diastema. Also, the mental foramen is closer to the masseteric knob (crest) and more dorsally placed than in *D. ordii*.

On the labial side of the left jaw (fig. 35C) a single, large mandibular foramen is posterior to M_3; on the right jaw, a second small foramen is lingual to the mandibular foramen. In contrast, most *D. ordii* have the mandibular foramen located in a pit, although in some, the pit is not developed and the large mandibular foramen is covered dorsally by a thin shelf of bone. In *P. centralis* a slight depression occurs dorsally and labially to the mandibular foramen, but is not so deeply depressed as in *Etadonomys tiheni* Hibbard, 1943.

The three isolated teeth, UMMP V57205, left P^4, P_4, and M_1 or M_2 (fig. 35D, E) appear to be from one individual. Even though the occlusal surfaces of these teeth are more worn than those of F:AM 87427, their size and characters are those of *Prodipodomys centralis*.

A study of the Rexroad specimens of *Prodipodomys kansensis* recovered since 1953 clearly shows that *Liomys centralis* is a young *Prodipodomys*. Part of a left lower jaw with incisor, P_4, and M_1 (UMMP V45480) from UM-K3-53, has a slightly more advanced wear than the holotype of *Liomys centralis*, but it is obvious that the two are the same genus and species. The alveolar length of P_4–M_1 (UMMP V45480) is 3.06 mm.; the transverse width of M_1 is 1.46 mm.

Discussion: *Prodipodomys idahoensis* has more hypsodont teeth with shallower labial and lingual reentrant angles than *P. centralis*. The mental foramen and the anterior knob of the masseteric ridge are more ventrally situated than in *Prodipodomys centralis*. In *P. centralis*, the occurrence of the shallow depression labial to the mandibular foramen indicates a relationship to the more advanced *Etadonomys tiheni* from the later Borchers local fauna. *Prodipodomys centralis* is thought to be a generalized form that continued on into the Pleistocene after the development of the more advanced *P. idahoensis*. The same can be observed between the tooth development of the Recent *Dipodomys ordii* and *D. compactus* True, 1889.

TABLE 12

Measurements (in Millimeters) of the Dentition of *Prodipodomys centralis*

	F:AM 87427 Length	Width
P^4	1.17	1.61
M^1	1.15	1.48
M^2	1.00	1.24
P^4–M^2 [a]	4.32	—
P^4–M^3 alveolar length	5.27	—
Distance between alveoli P^4–P^4 right and left	—	2.80
Distance between alveoli M^3–M^3 right and left	—	3.50
P_4	1.15	1.37
M_1	1.07	1.59
M_2	1.06	1.47
M_3	0.77	0.99
P_4–M_1	2.27	—
P_4–M_3	4.05	—
Anterior tip lower jaw to capsular process [b]	11.29	—

[a] Anterior alveolus P^4 to posterior edge M^2.
[b] In reference to incisor.

FAMILY CASTORIDAE

GENUS *DIPOIDES* SCHLOSSER, 1902

Type Species: *Dipoides problematicus* Schlosser, 1902 (P_4, pl. 1, fig. 20).

Distribution: Pliocene, Eurasia; medial Pliocene and Pleistocene, North America.

Diagnosis: See Stirton, 1935, page 440.

Dipoides rexroadensis Hibbard and Riggs, 1949

Figure 36A, B

Dipoides rexroadensis Hibbard and Riggs, 1949, p. 835. Woodburne, 1961, p. 69.

Type: KUMNH 7693, left upper molar, ?M^1, from the Rexroad Formation (late Pliocene) in Keefe Canyon, SW. ¼, SW. ¼, sect. 34, T. 34 S., R. 30 W., Meade County, Kansas.

Distribution: Late Pliocene, Rexroad Formation, Meade County, Kansas KU-3, KU-22, and UM-K3-53, and early Pleistocene Keim Formation, Brown County, Nebraska.

Diagnosis: See Woodburne, 1961, page 72.

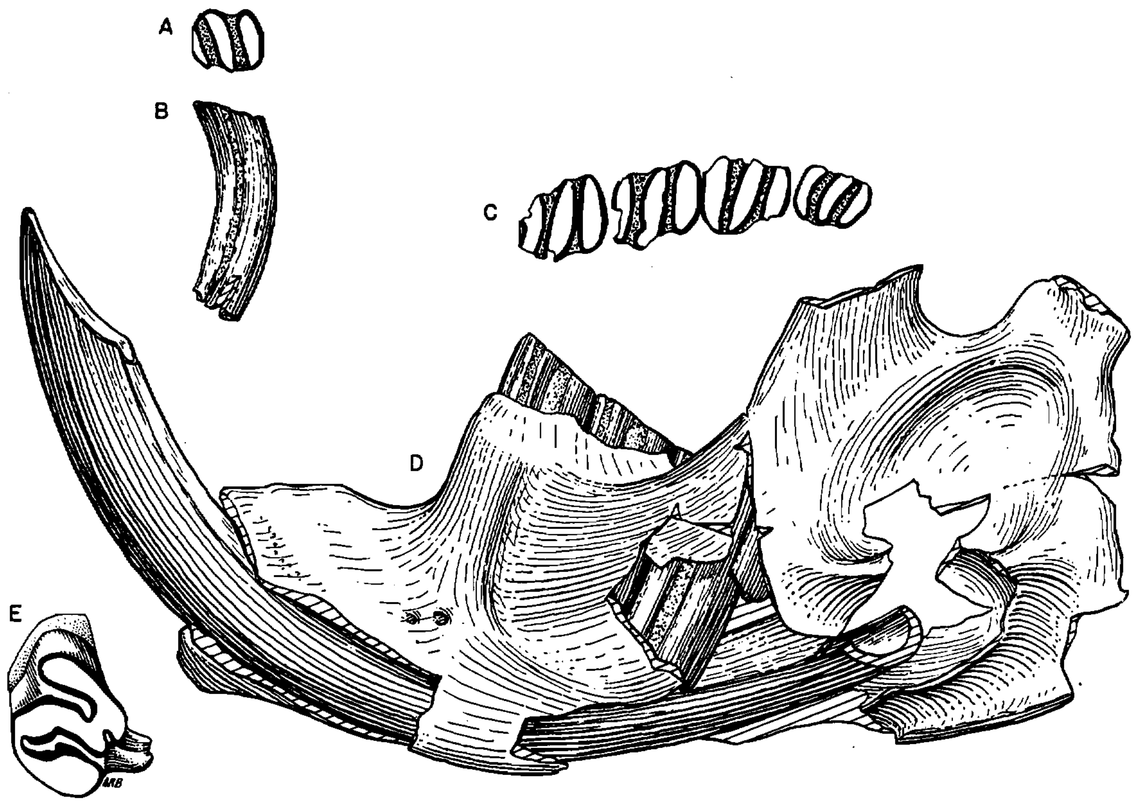


FIG. 36. A, B. *Dipoides rexroadensis*, right M^1 or M^2, reversed, F:AM 87477. A. Occlusal view. B. Lingual view. ×1. C–E. *Procastoroides sweeti*, part of right lower jaw, reversed, F:AM 87405. C. Occlusal view, P_4–M_3. D. Labial view, jaw. ×1. E. Occlusal view, left deciduous P^4, UMMP V57226. ×3.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Sand Draw Quarry: F:AM 87477, right M^1 or M^2 (fig. 36A, B).

MEASUREMENTS (IN MM.): F:AM 87477: M^1 or M^2 of adult, crown length 25.5, occlusal length 8.8, width 7.65.

DISCUSSION: This beaver is poorly known from Blancan local faunas. F:AM 87477 is larger than the type from the Rexroad local fauna, but is too small for an adult *Procastoroides* from the Sand Draw local fauna. Whether it represents a larger individual within the size range of *Dipoides rexroadensis*, or a new form, cannot be determined until a larger and better series is recovered.

GENUS *PROCASTOROIDES* BARBOUR AND SCHULTZ, 1937

Eocastoroides HIBBARD, 1938, p. 244.

TYPE SPECIES: *Procastoroides sweeti* Barbour and Schultz, 1937.

DISTRIBUTION: Late Pliocene and early Pleistocene, North America.

DIAGNOSIS: See Woodburne, 1961, page 83.

Procastoroides sweeti Barbour and Schultz, 1937

Figure 36C–E

Procastoroides sweeti BARBOUR AND SCHULTZ, 1937, p. 6. HIBBARD, 1956, p. 174. WOODBURNE, 1961, p. 76.

Eocastoroides lanei HIBBARD, 1938, p. 244.

Procastoroides lanei (Hibbard): HIBBARD, 1941b, p. 279. HIBBARD AND RIGGS, 1949, p. 836.

TYPE: UNSM 100-12-36S.P., skull, and UNSM 164-12-6-36S.P., left ramus, from Broadwater Quarry 3, NW. ¼, sect. 21, T. 19 N., R. 47 W., Morrill County, Nebraska.

DISTRIBUTION: Late Pliocene and early Pleistocene, Kansas, Nebraska, and Texas.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Prospecting Locality 28: UMMP V56417, part of left jaw with M_1–

M_2; UMMP V57400, V57401, right astragali; UMMP V56453, atlas; UMMP V57285, left and right M^1. UM-Nebr. 4–68: UMMP V57226, left dP^4 (fig. 36E). Prospecting Locality 277: F:AM 87405, fragmentary right mandible with incisor, P_4–M_3 and part of left mandible with incisor, P_4–M_1 (fig. 36C, D), 8 feet below the Long Pine Gravel. Surface finds: F:AM 87475, fragments of femur, ulna, radius, one lower and one upper incisor. Prospecting Locality 278: F:AM 87476, partial femur.

Measurements (in Mm.): UMMP V57400: astragalus, greatest length 34.6. UMMP V57401: astragalus, greatest length 32.0, greatest width 31.5. See table 13 for measurements of the lower jaw and teeth of *Procastoroides sweeti* type and F:AM 87405.

Remarks: This large beaver was reported by McGrew (1944) from the Sand Draw local fauna. McGrew's specimen, a right P^4–M^2 (FM P26165) was figured by Woodburne (1961, fig. 3G).

TABLE 13

Measurements (in Millimeters) of the Lower Jaw and Teeth of *Procastoroides sweeti* Barbour and Schultz

	F:AM 87405	UNSM 164–12–6–36 S.P.[a]
Incisor		
Width, greatest	11.6	11.5
Depth, greatest	12.6	—
P_4		
Length, occlusal	12.4	15.0
Width, occlusal	10.4	10.5
M_1		
Length, occlusal	12.2	13.0
Width, occlusal	10.6	10.0
M_2		
Length, occlusal	12.0	12.0
Width, occlusal	10.6	10.5
M_3		
Length, occlusal	10.9	10.0
Width, occlusal	8.8	0.0
P_4–M_3 length, occlusal	48.0	49.0
Depth of jaw along labial side anterior to P_4	49.5	46.0
Length, posterior edge of condyle to tip of incisor	150.00	156.00

[a]Measurements for this referred specimen are from Barbour and Schultz, 1937, page 7.

FAMILY MURIDAE

SUBFAMILY CRICETINAE

GENUS *ONYCHOMYS* BAIRD, 1858

Type Species: *Hypudaeus leucogaster* Wied-Neuwied, 1840.

Distribution: Medial Pliocene to Recent, western North America.

Diagnosis: See Baird, 1858, page 458.

Onychomys sp.

The grasshopper mouse is known only from an isolated right M_1 and M_2 (UMMP V57210) from the Keim Formation at UM-Nebr. 3-67. The M_1 is badly eroded but the M_2 is about the size of *Onychomys gidleyi* Hibbard, 1941, from the Rexroad local fauna.

GENUS *BENSONOMYS* GAZIN, 1942

Type Species: *Eligmodontia arizonae* Gidley, 1922.

Distribution: Medial Pliocene to early Pleistocene, southwestern North America.

Diagnosis: About the size of living *Eligmodontia typus* Cuvier, 1837, of South America, which has a four-rooted M_1. *Bensonomys* has only two roots on M_1. Tooth pattern is more similar to *Eligmodontia* than *Peromyscus*, a case of parallel development.

Bensonomys meadensis Hibbard, 1956

Figure 37A

Bensonomys meadensis Hibbard, 1956, p. 186.

Type: UMMP V31981, right lower jaw with M_1–M_3, Ballard Formation, Big Springs Ranch, Locality UM-K2-53, Meade County, Kansas.

Distribution: Earliest Pleistocene, Ballard Formation, Meade County, Kansas, and Keim Formation, Brown County, Nebraska.

Diagnosis: See Hibbard, 1956, page 186.

Referred Material: Keim Formation, Brown County, Nebraska: UM-Nebr. 2-67: UMMP V57394, left maxillary with M^1. UM-Nebr. 1-68: UMMP V57081, part of right lower jaw with M_1–M_2 and UMMP V57429, part of left maxillary with M^1–M^2.

Measurements (in Mm.): UMMP V57429 (fig. 37A): M^1–M^2 length 2.6. UMMP V57081: M_1–M_2 length 2.7. UMMP V57394: M^1 length 1.56.

Description: The dental characters of the referred specimens are like those of the type and paratypes from Meade County, Kansas. A moderately deep anterior groove divides the

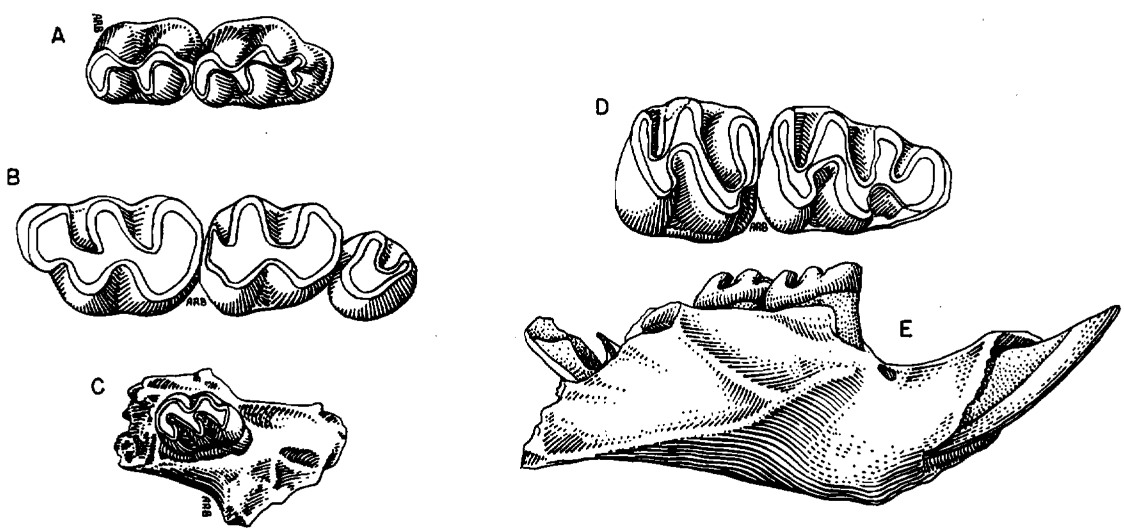


FIG. 37. Cricetine rodents. A. *Bensonomys meadensis*, left M^1–M^2, UMMP V57429. Occlusal view. B. *Peromyscus* cf. *P. kansasensis*, left M^1–M^3, UMMP V57059. Occlusal view. A, B approximately ×12.5. C. *Neotoma* sp., partial left maxillary with M^1, UMMP V57078. Ventral view. ×3. D, E. *Sigmodon medius*, partial right jaw, incisor, M_1–M_2, UMMP V57056. D. Occlusal view. Approximately ×12.5. E. Labial view. ×6.

anterocone of M^1 into two unequal conules, the larger of which is the labial. Bordering the two labial reentrant angles is a cingulum with a small style opposite the anterior labial angle (e.g. UMMP V57429).

The lower jaw is of an old adult and only the outline of the cusps remain. A deep anterior groove divided the anteroconid of M_1 into two distinct conulids. The anterior end of the masseteric crest is placed as in the type of *Bensonomys meadensis* and the mental foramen is dorsally placed anterior to the root of M_1.

GENUS *PEROMYSCUS* GLOGER, 1841

TYPE SPECIES: *Peromyscus arboreus* Gloger, 1841 =*Mus sylvaticus noveboracensis* Fischer, 1829.

DISTRIBUTION: Late Pliocene to Recent, North America.

DIAGNOSIS: See Osgood, 1909, page 33.

Peromyscus cf. *P. kansasensis* Hibbard, 1941a

Figure 37B

Peromyscus kansasensis HIBBARD, 1941a, p. 352, fig. 11.

TYPE: KUMNH 4597, incomplete right ramus, incisor, M_1–M_3. Late Pliocene, Rexroad Formation, Meade County, Kansas, KU-3.

DISTRIBUTION: Late Pliocene and early Pleistocene, Meade County, Kansas, and Keim Formation, Brown County, Nebraska.

DIAGNOSIS: See Hibbard, 1941a, p. 352.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 1–68. UMMP V57059, left maxillary with M^1–M^3.

MEASUREMENTS (IN MM.): UMMP V57059: M^1 length 2.02; M^2 length 1.43; M^3 length 0.90; M^1–M^3 anteroposterior length 4.23; M^1–M^3 occlusal length 4.02.

DESCRIPTION AND DISCUSSION: In UMMP V57059 (fig. 37B) the internal and external reentrant valleys between the cusps of the molars are broad and have neither styles nor lophs; there is no evidence of an anterior groove on the anterior cusp. A series of adult *Peromyscus leucopus* (Rafinesque, 1818) and *P. gossypinus* (Le Conte, 1853) shows as much variation in size as that noted between the type of *P. kansasensis* and UMMP V57059. Because these two specimens are within the size range of a Recent species and have, in common, broad internal and external reentrant valleys without styles, lophs, stylids, and lophids, they are thought to be the same species. A larger series is needed from both localities to show variation in both populations. Hibbard (1968, p. 10) gave the length of M_1–M_3 for *P. kansasensis* as 4.4. mm.; it should have been 4.1 mm.

GENUS *NEOTOMA* SAY AND ORD, 1825a

TYPE SPECIES: *Mus floridanus* Ord, 1818.

DISTRIBUTION: Medial Pliocene to Recent, North America.

DIAGNOSIS: See Goldman, 1910, page 13.

Neotoma sp.

Figure 37C

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 4–67: UMMP V52223, right lower jaw with M_1. UM-Nebr. 1–68: UMMP V57078 (fig. 37C), partial left maxillary with M^1; UMMP V57078a, two right M^2s.

MEASUREMENTS (IN MM.): UMMP V52223: M_1 length 3.76, width 2.21. UMMP V57078: M^1 length 3.55, width 2.66.

DISCUSSION: These teeth of the fossil packrat are slightly higher crowned than those of *Neotoma* (*Paraneotoma*) *quadriplicatus* (Hibbard, 1941) and larger than those of *Neotoma taylori* Hibbard, 1967, from the Borchers local fauna. The Sand Draw specimens represent a new species for the Plains region, but M_3 and M^3 are needed to be certain of the relationship to other fossil species. When known, M_3 will probably have an S-pattern.

GENUS *SIGMODON* SAY AND ORD, 1825b

TYPE SPECIES: *Sigmodon hispidus* Say and Ord, 1825b.

DISTRIBUTION: Late Pliocene to Recent, southern North America; Recent, South America.

DIAGNOSIS: See Say and Ord, 1825b, page 352.

Sigmodon medius Gidley, 1922

Figure 37D, E

Sigmodon medius GIDLEY, 1922, p. 120: MARTIN, 1970, p. 1505.

Sigmodon intermedius HIBBARD, 1938, p. 247.

Sigmodon minor GIDLEY: CANTWELL, 1969 (in part), p. 375.

TYPE: USNM 10519, part of right lower jaw, M_1–M_3, from about 2 miles southwest of Benson, Cochise County, Arizona.

DISTRIBUTION: Late Pliocene, Arizona and Kansas; early Pleistocene, Kansas and Nebraska.

DIAGNOSIS: Intermediate in size between *Sigmodon curtisi* Gidley, 1922, and *S. minor* Gidley, 1922; smaller than modern *S. hispidus*, which has higher crowned teeth and four-rooted M_1; third root present on labial side of M_1 between large anterior and posterior roots; third root small to vestigial.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 1–68: UMMP V57056, partial jaw with M_1–M_2 (fig. 37D, E).

MEASUREMENTS (IN MM.): UMMP V57056: M_1 occlusal length 2.02; M_2 occlusal length 1.47.

DESCRIPTION AND DISCUSSION: The teeth of UMMP V57056 are more brachydont than those of *Sigmodon hispidus*, but the dental characters are like those of *S. medius* from Meade County, Kansas. This extends the range of fossil *Sigmodon* 300 miles northward from McPherson County, Kansas, where it is known from the Kentuck assemblage (Hibbard, 1952). I erroneously reported the Kentuck specimen as *Sigmodon hispidus*, whereas it is the size of *S. curtisi* and has only three roots on M_1.

I follow Martin (1970) in considering *Sigmodon intermedius* a synonym of *S. medius* Gidley. I do not accept Cantwell (1969) in the assignment of the form to *Sigmodon minor* Gidley. *Sigmodon hilli* Hibbard has only two roots on M_1, or a very vestigial labial root on M_1. The characteristics of the M_1 are distinct from those of *Sigmodon medius* from the Rexroad, Sanders, and Sand Draw local faunas. I have not studied the roots on M_1 of *Sigmodon minor* and until the characteristics of the roots of M_1 of *Sigmodon minor* are made known I shall consider *Sigmodon hilli* as a distinct species. *Sigmodon curtisi* from the same locality as *S. minor* has three well-developed roots on M_1.

The following taxa of mammals were taken in association with *Sigmodon medius* at UM-Nebr. 1–68: *Sorex sandersi*, *Sorex* sp., *Scalopus aquaticus*, ?*Hypolagus* sp. or ?*Pratilepus* sp., *Geomys quinni*, *Bensonomys meadensis*, *Peromyscus* cf. *P. kansasensis*, *Neotoma* sp., *Ogmodontomys p. poaphagus*, and *Buisnictis burrowsi*, new species.

SUBFAMILY ARVICOLINAE

GENUS *NEBRASKOMYS* HIBBARD, 1957

TYPE SPECIES: *Nebraskomys mcgrewi* Hibbard, 1957.

DISTRIBUTION: Late Pliocene and early Pleistocene, Kansas; early Pleistocene, Nebraska.

DIAGNOSIS: Small vole with rooted teeth; smaller than *Ophiomys taylori* (Hibbard, 1959); small vole with M_1 having three alternating triangles and anterior loop; first and second alternating triangles of M_1–M_3 open and nearly confluent. Mental foramen just anterior to anterior root of M_1, near dorsal surface of diastemal region.

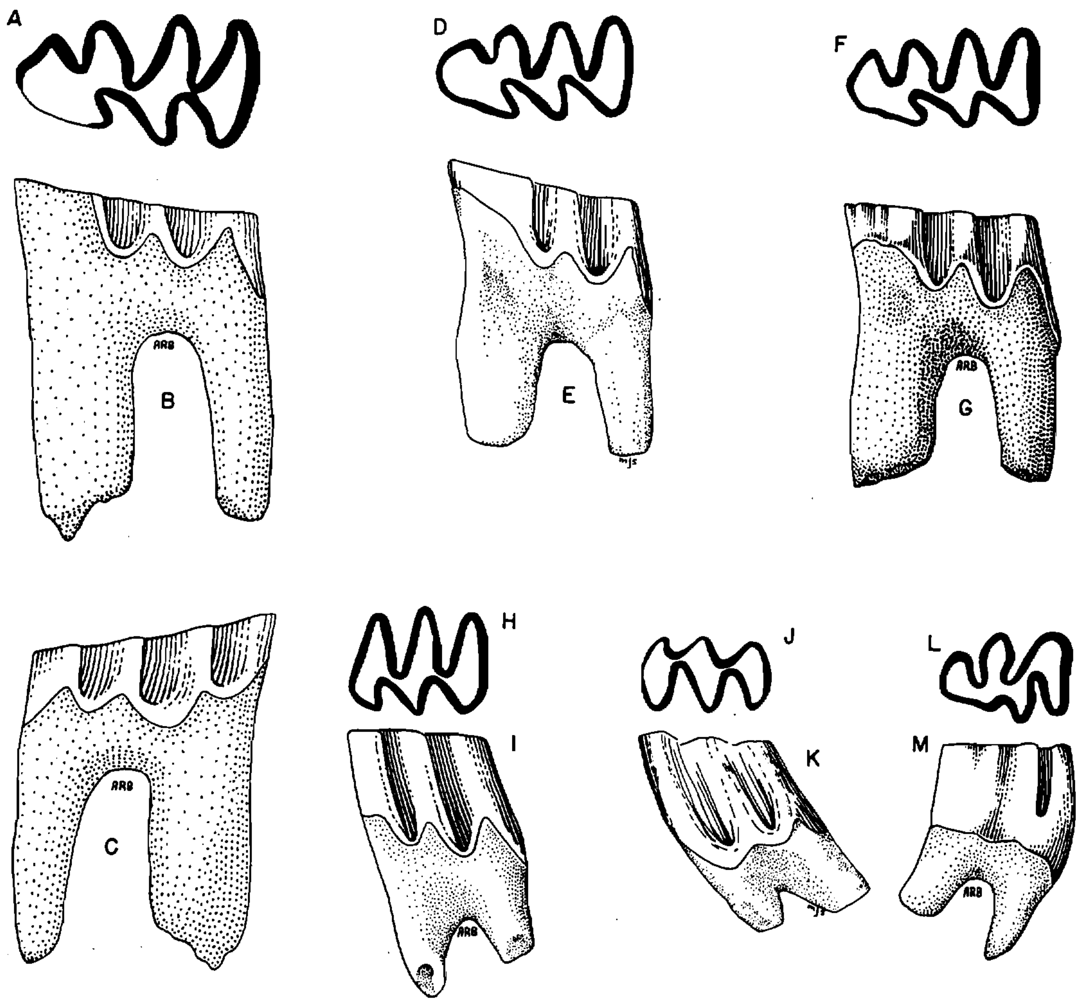


FIG. 38. *Nebraskomys mcgrewi*, isolated teeth. A–C. Left M_1, topotype, UMMP V56942. A. Occlusal view. B. Labial view. C. Lingual view. D, E. Left M_1, UMMP V57287a. D. Occlusal view. E. Labial view. F, G. Left M_1, UMMP V57084. F. Occlusal view. G. Labial view. H, I. Left M_2, UMMP V57287b. H. Occlusal view. I. Labial view. J, K. Right M_3, UMMP V59823. J. Occlusal view. K. Lingual view. L, M. Left M^3, UMMP 57227. L. Occlusal view. M. Labial view. All approximately $\times$ 12.5.

Nebraskomys mcgrewi Hibbard, 1957
Figure 38

Nebraskomys mcgrewi HIBBARD, 1957, p. 43, figs. 2A, B.

TYPE: UMMP V25610, part of right lower jaw with incisor, M_1, and alveoli of M_2 from Keim Formation, Prospecting Locality 277, W. ½, NW. ¼, sect. 25, east side of Booth Draw, Brown County, Nebraska.

DISTRIBUTION: Late Pliocene, Rexroad Formation, and early Pleistocene, Belleville Formation, Kingman County, Kansas. Early Pleistocene, Keim Formation, Brown County, Nebraska.

DIAGNOSIS: Size of *Nebraskomys rexroadensis* Hibbard (1970a) with higher dentine tracts on labial side of lower molars, and first and second triangles of M_2 opposite.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: UM-Nebr. 2-67: UMMP V56942, left M_1. UM-Nebr. 2-68: UMMP V57286, left and right M_1; UMMP V57287A–B, left M_1 and M_2; UMMP V59823, right M_3. UM-Nebr. 3-68: UMMP V57235, left M_1 and right M^2; UMMP V57299, left M_1. UM-Nebr. 4-68: UMMP V57084, left M^1; UMMP V57227, right M^1 and M^2, left M^3; UMMP V57301, two left M_1s.

MEASUREMENTS (IN MM.): Type, UMMP V25610, M_1 and eight M_1s of referred specimens: occlusal length ranges from 1.93 to 2.28 and averages 2.07. UMMP V57299, an immature M_1 is smallest; UMMP V56942, an old adult is largest. UMMP V57287B, left M_2: occlusal length 1.45. UMMP V59823, M_3: occlusal length 1.32. UMMP V57227, right M^1, occlusal length 1.97. UMMP V57235, M^2, length 1.53. UMMP V57227, M^2, length 1.66. UMMP V57227, M^3, length 1.50.

LOWER DENTITION: The descriptions of occlusal patterns are of isolated teeth: The enamel is of uniform thickness. M_1 consists of a posterior loop, three alternating triangles, and an anterior loop (fig. 38A, D, F). In young specimens, a narrow dentine tract connects the posterior loop with the first triangle and this dentine tract becomes narrower as the tooth wears. The first and second alternating triangles become more confluent with wear. The third triangle opens broadly into the anterior loop. The M_1 has no prism fold. Immature M_1 has three very shallow labial grooves that extend two-thirds of the distance down the crown of the tooth toward the base of the enamel. Dentine tracts are higher on the labial side than on the lingual (fig. 38B, C).

The left M_2, UMMP V57287 (fig. 38H, I) consists of a posterior loop and four alternating triangles. The first and second triangles are completely confluent with the salient angles of the two nearly opposing triangles. The lingual triangles are nearly twice the size of the labial triangles and the third and fourth triangles are confluent, giving the tooth the appearance of having an anterior loop.

The right M_3, UMMP V59823 (fig. 38J, K) consists of a posterior loop and four alternating triangles. In adult specimens the alternating triangles are confluent and become opposite, thus giving a pattern of three connected loops. The lower teeth have two well-developed roots in adult specimens.

UPPER DENTITION: The right M^1 (UMMP V57227) is from a young adult. The roots are missing. The tooth consists of an anterior loop and four alternating triangles.

Two M^2s are of young adult specimens. The bases of the crowns are closed off but the roots are missing. The M^2 consists of an anterior loop and three alternating triangles.

A left M^3, UMMP V57227 (fig. 38L, M) is of an old adult and consists of an anterior loop, two alternating triangles, and a posterior loop. Two well-developed roots are present.

DISCUSSION: *Nebraskomys mcgrewi* from the Dixon local fauna of Kingman County, Kansas is known from isolated left M_2 and M_3, UMMP V54151 (Hibbard, 1970a, fig. 1M, N) and from the Belleville Formation, Republic County, Kansas, by a right M_2, UMMP V59817. This microtine rodent is rare. Its ancestor, *Nebraskomys rexroadensis* is known from 13 isolated teeth collected at KU-3 of the Rexroad local fauna, Meade County, Kansas. *Nebraskomys mcgrewi* is thought to be ancestral to the small microtine, *Atopomys texensis* Patton (1965) found in later Pleistocene deposits of Texas.

GENUS *OGMODONTOMYS* HIBBARD, 1941

TYPE SPECIES: *Ogmodontomys poaphagus* Hibbard, 1941a.

DISTRIBUTION: Medial Pliocene, Seward County; late Pliocene and early Pleistocene, Meade County, Kansas; early Pleistocene, Brown County, Nebraska.

DIAGNOSIS: See Hibbard, 1941a, page 362.

Ogmodontomys poaphagus poaphagus Hibbard 1941

Figure 39

Ogmodontomys poaphagus HIBBARD, 1941a, p. 363, pl. 3.

TYPE: KUMNH 4594, maxillaries, premaxillaries, incisors, right and left M^1–M^3. KU-3, W. ½, SW. ¼, sect. 22, T 33 S., R. 29 W., Meade County, Kansas. Late Pliocene, Rexroad Formation.

DIAGNOSIS: See Zakrzewski, 1967b, page 144.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, SE. ¼, sect. 25, T. 31 N., R. 22 W., east side of Booth Draw: UMMP V52224, left jaw with M_1–M_3 (fig. 39). UM-Nebr. 2-66: UMMP V57266, right M^1. UM-Nebr. 2-67: UMMP V57388, left M^1, M^2, right M^3, two right M_2s. UM-Nebr. 4-67: UMMP V52228, left M^2; UMMP V57247, left M^1. UM-Nebr. 1-68: UMMP V57082, five left M_1s, three left M_2s, five left M_3s, six right M_1s, four right M_2s, four right M_3s, four left M^1s, four left M^2s, one left

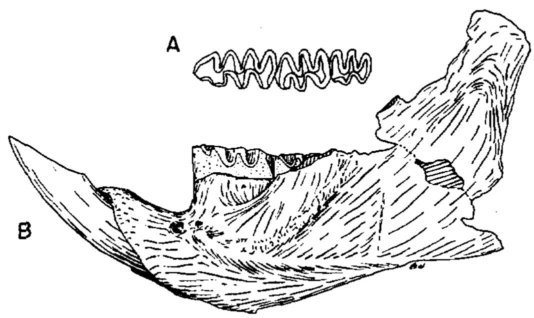


FIG. 39. *Ogmodontomys poaphagus poaphagus*, left jaw, incisor, M_1–M_3, UMMP V52224. A. Occlusal view. B. Labial view.

M^3, three right M^1s, three right M^2s and two right M^3s.

DESCRIPTION AND DISCUSSION: This vole was first reported by Zakrzewski (1967b, p. 148, fig. 5) from a left lower jaw with M_1–M_3 (UMMP V52224) taken by Philip Bjork from a lateral facies of the Sand Draw Quarry horizon (fig. 7) in the type area of the Sand Draw local fauna along Booth Draw. The anteroposterior length of M_1–M_3 is 7.82 mm.

The teeth are the size of *Ogmodontomys p. poaphagus* and have the same dental characteristics. M^1 and M^2 are three-rooted. Four M^3s were recovered, three of which had the two anterior roots fused, but with two distinct openings. The only difference between the Sand Draw population and those from the Rexroad (KU-3) in Meade County, Kansas, is that the two anterior roots of M^3 show greater fusion near the base of the crown.

It is interesting that *Ogmodontomys* was found only in this small area and at the same general horizon. None were recovered at the four other washing sites, where *Pliopotamys* remains were taken. It is possible that *Ogmodontomys* did not inhabit areas occupied by the more aquatic *Pliopotamys*. A similar condition was suggested by Zakrzewski (1969) in the replacement of *Cosomys* by *Pliopotamys* in the upper part of the Hagerman local fauna of Idaho.

GENUS *OPHIOMYS* HIBBARD AND ZAKRZEWSKI, 1967

TYPE: ?*Mimomys parvus* Wilson, 1933. CIT 1369. Upper part of Glenns Ferry Formation, early Pleistocene, NE. ¼, sect. 15, T. 4 S., R. 2 E., southeast side of Jackass Butte, Owyhee County, Idaho.

DISTRIBUTION: Late Pliocene to early Pleistocene, Idaho, Elmore, Owyhee, and Twin Fall counties from Glenns Ferry Formation; Kansas, Meade County, Ballard Formation and Kingman County, Belleville Formation; Nebraska, Brown County, Keim Formation.

DIAGNOSIS: See Hibbard and Zakrzewski, 1967, p. 258.

***Ophiomys magilli*,**[1] new species
Figures 40, 41

TYPE AND PARATYPES: Type, UMMP V57187, left M_1. Paratypes, UMMP V57194, six left M_1s and six right M_1s; UMMP V59818, right M_1; UMMP V59819, left M_1. Early Pleistocene Keim Formation, base of snail zone in bottom of draw, UM-Nebr. 3–67, S.E. corner, sect. 12, T. 30 N., R. 21 W., Magill ranch, Brown County, Nebraska.

DISTRIBUTION: Type locality only.

DIAGNOSIS: Rooted molars, lacking cement, with very short dentine tracts. First lower molar with three alternating triangles and complicated anterior loop. Smaller than *Ogmodontomys poaphagus* and larger than *Ophiomys taylori*, but with higher crowned teeth for its size. Apex of second and third lingual and second labial reentrant angles constricted and directed more sharply anteriorly. Thinned enamel on anterior borders of these reentrant angles. These characters distinguish *Ophiomys magilli* from known species of *Ogmodontomys*, *Cosomys*, and *Ophiomys*.

REFERRED MATERIAL: From type locality: UMMP V57188, right M^1; UMMP V57189, right M^2, M^3; UMMP V57190a–b, left M_2, M_3; UMMP V57193, nine left and seven right M^1s, 11 left and two right M^2s, six left and four right M_2s, four left M_3s; UMMP V57195, eight left and two right M^3s.

MEASUREMENTS (IN MM.): Type, UMMP V57187, left M_1: occlusal length 2.58; width 1.26; crown height (measured on posterior loop) 3.17. UMMP V57187, V57194, V59818, and V59819, 15 M_1s: occlusal length ranges from 2.61 to 2.95 and averages 2.71; greatest occlusal width ranges from 1.21 to 1.48. UMMP V57193 and V57188, 17 M^1s: occlusal length ranges from 2.17 to 2.50 and averages 2.31; greatest occlusal width ranges from 1.22 to 1.48 and averages 1.35.

LOWER DENTITION: The type (UMMP V57187) is a left M_1 of a young adult and consists of a posterior loop, three alternating closed

[1] For Wilbur Magill.

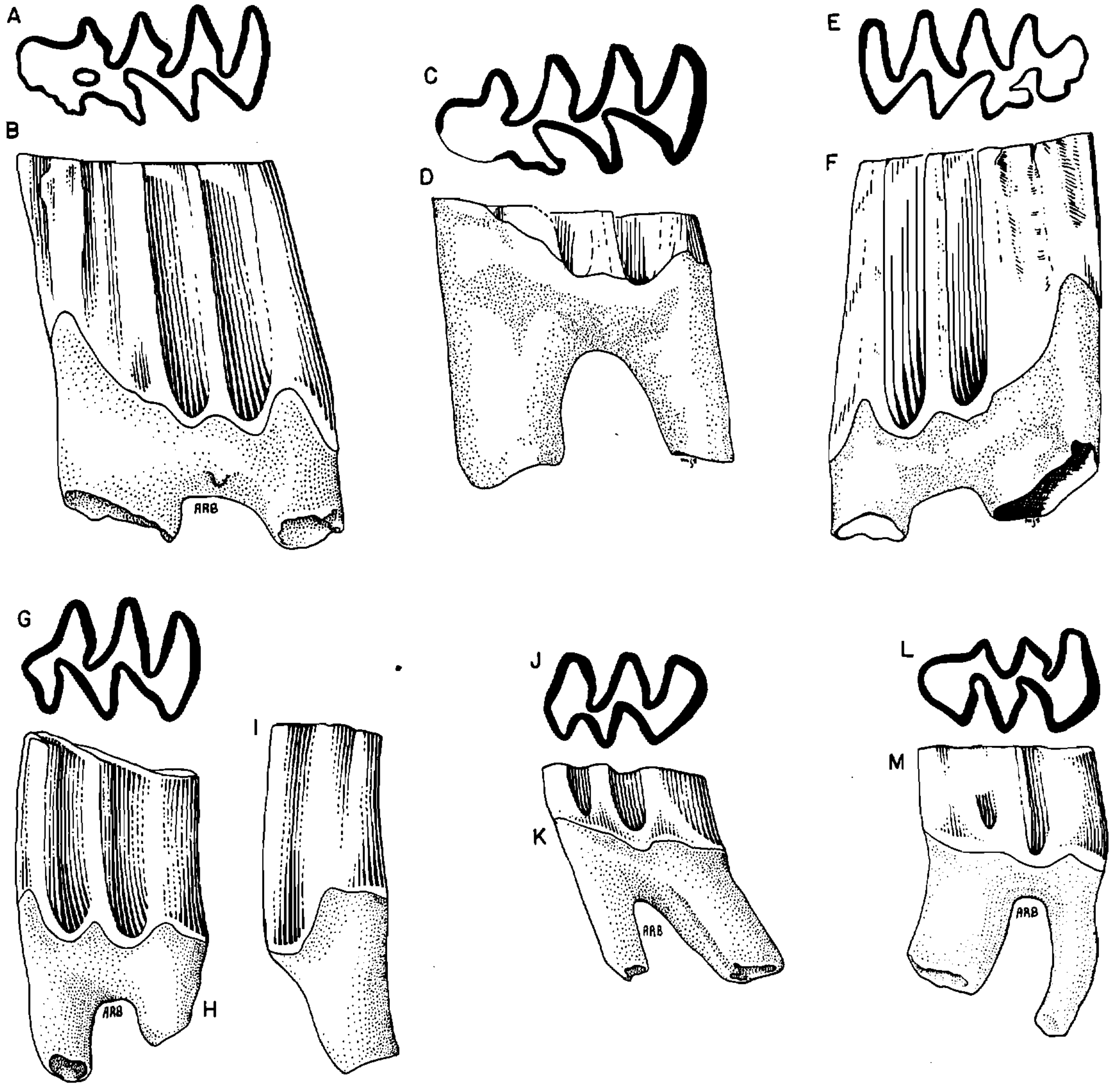


FIG. 40. *Ophiomys magilli*, isolated teeth. A, B. Left M_1, type, UMMP V57187. A. Occlusal view. B. Labial view. C–M. Topotypes. C, D. Left M_1, UMMP V59819. C. Occlusal view. D. Labial view. E, F. Right M_1, UMMP V59818. E. Occlusal view. F. Labial view. G–I. Left M_2, UMMP V57190a. G. Occlusal view. H. Labial view. I. Posterior view. J, K. Left M_3, UMMP V57190b. J. Occlusal view. K. Labial view. L, M. Right M^3, UMMP V57189. L. Occlusal view. M. Labial view. All approximately × 12.5.

triangles with the fourth and fifth alternating triangles forming part of the anterior loop (fig. 40A, B). A deep pit is present on the anterior loop. The other first lower molars range in age from a young adult UMMP V59818 (fig. 40E, F) to an old adult (UMMP V59819, fig. 40C, D) and agree with the type in occlusal pattern. Two of the teeth have prism folds and two have an enamel ridge (see Hibbard and Zakrzewski, 1967, fig. 1L). Nine (60 per cent) of the 15 M_1s have an enamel pit. The lower molars are two-rooted.

M_2 (UMMP V57190) consists of a posterior loop and four alternating triangles, and M_3 consists of a posterior loop and three alternating triangles (fig. 40G–K).

UPPER DENTITION: M^1 consists of an anterior loop and four alternating triangles, a typical

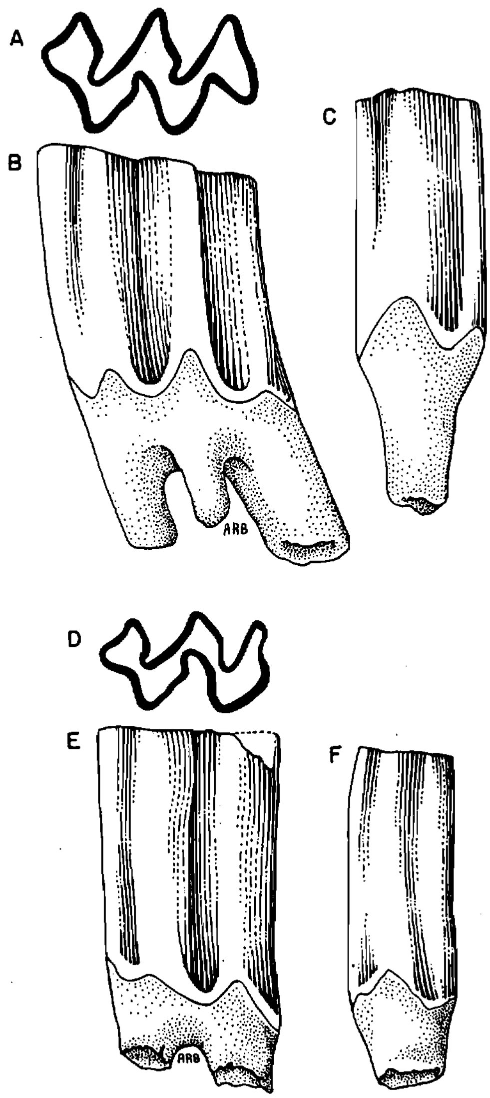


FIG. 41. *Ophiomys magilli*, new species, isolated teeth topotypes. A–C. Right M^1, UMMP V57188. A. Occlusal view. B. Lingual view. C. Posterior view. D–F. Right M^2, UMMP V57189. D. Occlusal view. E. Lingual view. F. Posterior view. All approximately ×12.5.

microtine occlusal pattern. All M^1s have three roots, the lingual being much the smallest (fig. 41A–C).

M^2 has an anterior loop and three alternating triangles (fig. 41D–F). Both M^1 and M^2 lack the reentrant pit on the lingual side (Zakrzewski, 1969, fig. 7C), which occurs in *Pliophenacomys*, *Phenacomys*, and to some extent, in *Cosomys*. On M^2 the number of roots vary; i.e. eight have three roots, one has the two anterior roots fused for most of their length (the lingual root is small), and the other six have two roots.

M^3 consists of an anterior loop, two alternating triangles, and a posterior loop (fig. 40L, M). The tooth has two roots.

DISCUSSION: A perfect lower jaw and a palate of *Ophiomys magilli*, new species, would contribute greatly to the understanding of the relationship of this microtine to others belonging to the genera *Ogmodontomys* and *Ophiomys*.

This microtine may represent a new genus, but I have assigned it to the genus *Ophiomys* on one characteristic, the absence of a dentine tract on the base of the apex of the first labial triangle (second alternating) of M_1 and M_2 and the labial side of the posterior loop of M_2. This characteristic is consistent in the other species of *Ophiomys* except in *O. meadensis*. *Ophiomys meadensis* has an incipient dentine tract on the first labial triangle of M_1 and M_2 in some individuals as observed in *Ogmodontomys sawrockensis* from the Sawrock Canyon local fauna of Hemphillian age.

It is considered that *Ophiomys* branched off from an *Ogmodontomys* stock early in the medial Pliocene. *Ophiomys magilli* appears to belong to a stock that did not develop the fourth or fifth alternating triangle on M_1. Hibbard and Zakrzewski (1967) were able to show in the populations of *O. taylori* from the late Pliocene of Idaho that a trend in the development from three triangles on M_1 to four and five triangles in later populations. There is no evidence of the development of a fourth triangle in *O. magilli*. The number of M_1s recovered of *O. magilli* is too small to be certain that the presence of a fourth triangle did not occur in the population. The presence of the pit on M_1 is greater than the occurrence found on specimens of *Ogmodontomys* from the late Pliocene and early Pleistocene. This vole was found only at locality UM-Nebr. 3–67.

Ophiomys fricki,[1] new species

Figure 42

TYPE AND PARATYPE: Type, a left M_1, UMMP V57288 (fig. 42A–C) and paratype, a left M_2, UMMP V59822 (fig. 42D, E), were collected in the summer of 1968 by Skinner, Hibbard, and party. Clair Keim ranch (UM-

[1] For Childs Frick.

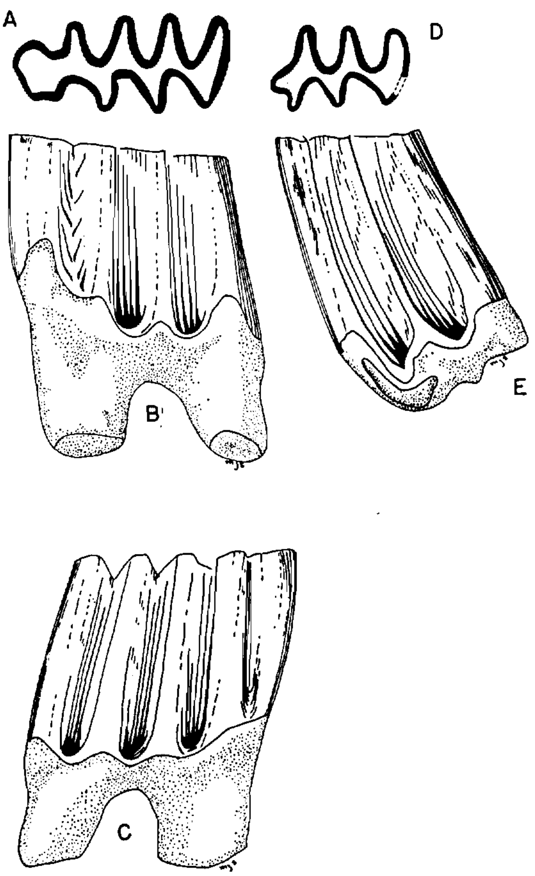


FIG. 42. *Ophiomys fricki*, new species, isolated teeth. A–C. Type, left M_1, UMMP V57288. A. Occlusal view. B. Labial view. C. Lingual view. D, E. Topotype, left M_2, UMMP V59822. D. Occlusal view. E. Labial view.

Nebr. 2–68), west-central side SE. ¼, SE. ¼, sect. 34, T. 32 N., R. 23 W., Brown County, Nebraska. Keim Formation.

DISTRIBUTION: Known only from type locality.

DIAGNOSIS: Small vole about size of *Nebraskomys mcgrewi*, with rooted molars lacking cement; M_1 consisting of posterior loop, five alternating and confluent triangles, and simple anterior loop; no dentine tract at base of apex of first labial triangle (second alternating triangle), apices of lingual reentrant angles broad, at right angle to longitudinal occlusal plane of tooth.

MEASUREMENTS (IN MM.): Type, UMMP V57288: M_1, occlusal length 2.24, greatest occlusal width 1.08. Paratype, UMMP V59822: M_2, occlusal length 1.50, width 1.20.

DESCRIPTION AND DISCUSSION: Both the type and paratype are from a young adult. M_1 of the type consists of a posterior loop, five confluent and alternating triangles, and a simple anterior loop. The apices of the fourth lingual and third labial reentrant angles are rounded and opposite. In the type of *Ophiomys meadensis* (Hibbard, 1956) the second and third lingual reentrants swing slightly forward, whereas in a young specimen of *Nebraskomys mcgrewi* (UMMP V57299) the apex of the second lingual reentrant swings more sharply forward. In *Ophiomys fricki* the occlusal pattern of M_1 is similar to *O. meadensis* but smaller, and dentine tracts are more poorly developed than in *Nebraskomys mcgrewi*. The paratype of *O. fricki* (UMMP V59822) is the left M_2, consisting of a posterior loop and four confluent alternating triangles.

The upper dentition of *Ophiomys fricki*, new species, is unknown but it should resemble that of a small *O. meadensis*. *Ophiomys fricki* should have branched off from the *Ophiomys* stock at about the same time as the larger *O. meadensis*. *Ophiomys fricki* is much smaller and is not so advanced as the larger vole described as *Ophiomys magilli*.

GENUS *PLIOPOTAMYS* HIBBARD, 1938

Neondatra HIBBARD, 1938, p. 251.

TYPE SPECIES: *Pliopotamys meadensis* Hibbard, 1938.

DISTRIBUTION: Late Pliocene, Glenns Ferry Formation, Idaho. Early Pleistocene, Kansas, Ballard Formation, Meade County, and Belleville Formation, Kingman County. Early Pleistocene, Nebraska, Keim Formation, Brown County, and Broadwater Formation, central and eastern part of state.

DIAGNOSIS: See Hibbard, 1938, pages 249, 251; Hibbard, 1941b, page 291.

Pliopotamys meadensis Hibbard, 1938
Figure 43

Pliopotamys meadensis HIBBARD, 1938, p. 249. HIBBARD, 1941b, p. 291.

Neondatra meadensis HIBBARD, 1938, p. 251.

TYPE: KUMNH 3846, part of right mandible with incisor, M_1, and M_2, from Ballard Formation, KU-1, Meade County State Park, Kansas. (See Hibbard, 1956, p. 175.)

DISTRIBUTION: Early Pleistocene, Kansas, Ballard Formation, Meade County and Belleville Formation, Kingman County. Early Pleis-

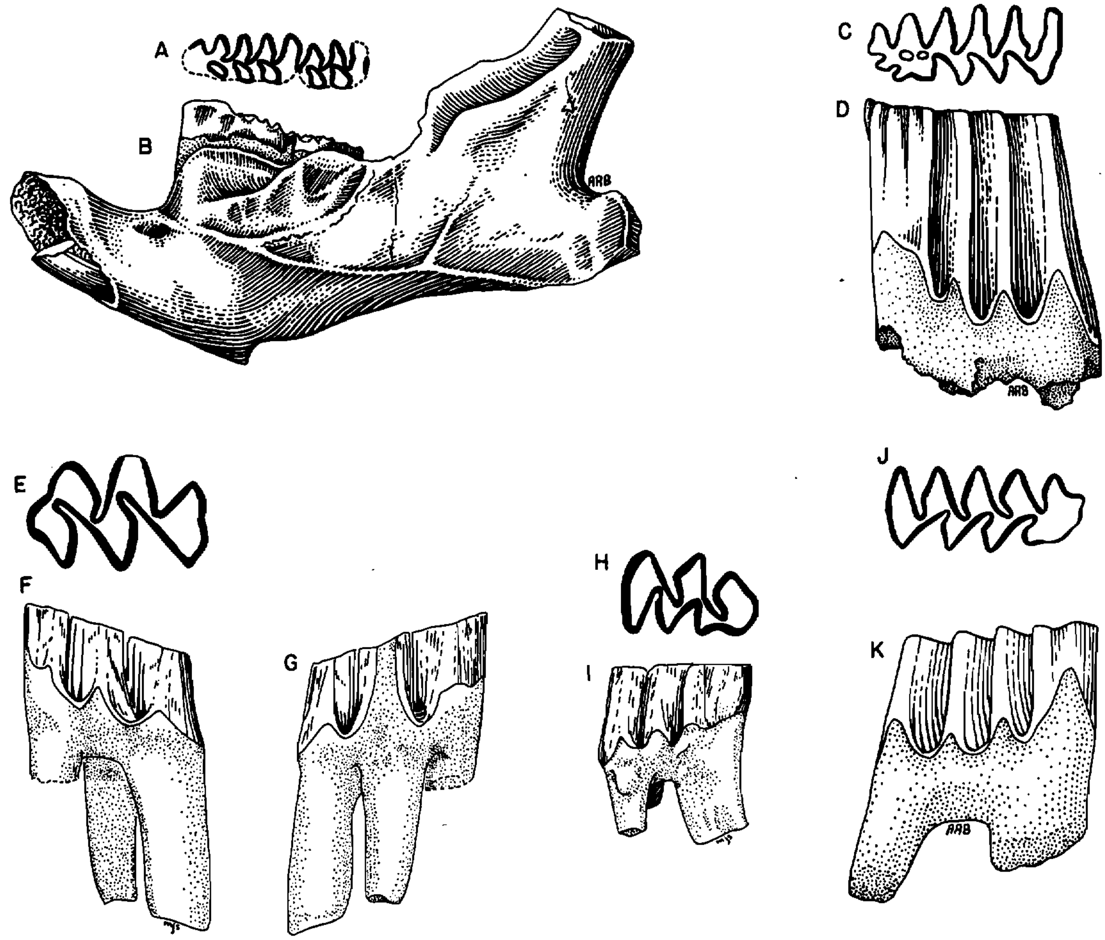


FIG. 43. *Pliopotamys meadensis*, left lower jaw and isolated teeth. A, B. M_1–M_2, UMMP V57085. A. Occlusal view. B. Labial view. A, B $\times 3$. C, D. Left M_1, UMMP V57086. C. Occlusal view. D. Labial view. E–G. Left M^1, UMMP V56927. E. Occlusal view. F. Labial view. G. Lingual view. H, I. Right M^3, UMMP V56928. H. Occlusal view. I. Labial view. J, K. Right M_1, UMMP V56926. J. Occlusal view. K. Labial view. C–K $\times 6$.

tocene, Nebraska, Keim Formation, Brown County.

DIAGNOSIS: See Hibbard, 1938, pages 249, 251 and Hibbard, 1941b, page 291.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, Taylor Locality 1: UMMP V32047, left M^3. Prospecting Locality 278, NE. $\frac{1}{4}$, SE. $\frac{1}{4}$, sect. 12, T. 30 N., R. 21 W., from snail zone: UMMP V56928, right M^3. Prospecting Locality 28, middle fork of Deep Creek: UMMP V56926, right M_1; UMMP V57085, part of left jaw, M_1–M_2. UM-Nebr. 2–68: UMMP V57086, left M_1; UMMP V57294, left M_1, M_2, right and left M^1, right M^2, M^3. UM-Nebr. 4–68: UMMP V56927, left M^1; UMMP V57225, right M^3, left M^1.

MEASUREMENTS (IN MM.): Occlusal length, M_1: UMMP V56926, 4.17; UMMP V57085, 4.41; UMMP V57086, 4.90; UMMP V57294, 5.19. Dentine tract on labial side anterior loop: UMMP V57086, 1.68; UMMP V56926, 1.53. Greatest length of dentine tract in *P. minor* (Wilson, 1933) from Hagerman local fauna 0.41. A specimen higher in Glenns Ferry Formation (USGS Cen. Loc. 20455) had dentine tract height of 0.76 (Zakrzewski, 1970, p. 27). UMMP V57085, M_2, occlusal length 3.23.

UMMP V56927, M^1, occlusal length 3.70. Dentine tract on first lingual triangle (interrupted), length 2.00. UMMP V57294, M^1, occlusal length (old adult) 3.70, (young adult) 3.15; dentine tract young adult 1.17. UMMP V57249, M^2, occlusal length 2.95. UMMP V56928, M^3, occlusal length 2.95.

DESCRIPTION: This vole, largest of the microtines in the Sand Draw local fauna, is little known from the Keim Formation. *Pliopotamys meadensis* differs from all species of *Ondatra* in the lack of cement in the reentrant valleys of the teeth. In *P. meadensis* the labial dentine tracts of the lower teeth and the lingual dentine tracts of the upper teeth are incipient. Dentine tracts are absent on the lingual side of the lower teeth and on the labial side of the upper teeth.

M_1 consists of a posterior loop and five alternating triangles and an anterior loop, which is more complicated in immature and young adults (fig. 43A–D). In young adults the fifth alternating triangle opens wider into the anterior loop than in old adults (fig. 43J, K). Enamel on the labial side of the anterior loop above the small dentine tract is thinner than the rest of the occlusal enamel. M_2 consists of a posterior loop and four alternating triangles. Very short labial dentine tracts are present. No lower third molars were recovered.

All upper teeth are three-rooted. M^1 consists of an anterior loop and four alternating triangles. M^2 consists of an anterior loop and three alternating triangles. M^3 consists of an anterior loop, three alternating triangles and a posterior loop (fig. 43H, I). A left M^3, UMMP V32047, was figured by Hibbard (1956, fig. 5G).

DISCUSSION: Hibbard and Zakrzewski (1967) considered *Pliopotamys* as ancestral to *Ondatra*. A fauna containing transitional specimens is still unknown. Whether or not the development of cement is sudden in the phylogeny of this group is not known. Left M^1 (fig. 43E–G) has the best-developed lingual dentine tract so far observed in *Pliopotamys*. It is possible that a population in the Sand Draw local fauna gave rise to later individuals that possessed higher dentine tracts.

The arrival of *Pliopotamys* in the Plains seems to have displaced the smaller *Ogmodontomys* which may have had aquatic tendencies. Zakrzewski (1970) stated, regarding the Hagerman local fauna, "It is noteworthy that whenever *Cosomys* is abundant at a locality *Pliopotamys* is rare. At the top of the section *Pliopotamys* becomes the dominant microtine and *Cosomys* drops out (fig. 11). Because of these facts it is postulated that *Cosomys* and *Pliopotamys* were competing for the same niche, *Pliopotamys* eventually displacing *Cosomys*."

GENUS *PLIOPHENACOMYS* HIBBARD, 1938

Phenacomys (*Pliophenacomys*) HIBBARD, 1938, p. 248.
Pliophenacomys HIBBARD, 1950.

TYPE SPECIES: *Pliophenacomys primaevus* Hibbard, 1938.

DISTRIBUTION: Late Pliocene and early Pleistocene, Kansas; early Pleistocene, Nebraska.

DIAGNOSIS: Vole the size of *Phenacomys ungava* Merriam, 1889. Rooted teeth, lacking cement, but dentine tracts on molars. M_1 consisting of posterior loop, five alternating triangles and anterior loop; lingual posterior reentrant pit on M^1 and M^2. Pits absent on upper teeth of *Ogmodontomys*, *Ophiomys*, and *Pliopotamys*; pit present on *Phenacomys* and to some extent in *Cosomys*. See Zakrzewski, 1969, page 22, fig. 7C.

Pliophenacomys primaevus Hibbard, 1938

Figures 44, 45

Pliophenacomys primaevus HIBBARD, 1938, p. 248, pl. 1, fig. 5.

TYPE: KUMNH 3905, right jaw, incisor, M_1, and M_2, KU-2, SE. $\frac{1}{4}$, NE. $\frac{1}{4}$, NW. $\frac{1}{4}$, sect. 22, T. 33 S., R. 29 W., Meade County, Kansas. Late Pliocene from top of Rexroad Formation.

DISTRIBUTION: Known only from late Pliocene and early Pleistocene, Kansas and early Pleistocene, Keim Formation, Brown County, Nebraska.

DIAGNOSIS: Same as genus.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, SW. $\frac{1}{4}$, NW. $\frac{1}{4}$, sect. 26, T. 31 N., above snail zone (fig. 5): UMMP V59815, left M^2, one right and one left M^3, parts of two left M_1s, one right and two left M_2s, and three left M_3s. These teeth were recovered from a fossil owl pellet in association with 77 teeth of *Pliolemmus*. UM-Nebr. 1–66: UMMP V57258, left M_2 and M_3. UM-Nebr. 2–66: UMMP V57256, right M^1. UM-Nebr. 3–67: UMMP V57017, left M_1 (fig. 44A–C); UMMP V57183, right M_1 (fig. 44D–F); UMMP V57186, left M^1 (fig. 44G–I); UMMP V57191A–C, left M^1, M^2, M^3 (fig. 45A–I); UMMP V57192, two left and two right M_1s; three left M_2s, left M_3, two right and one left M^1s, six right and one left M^2s, three

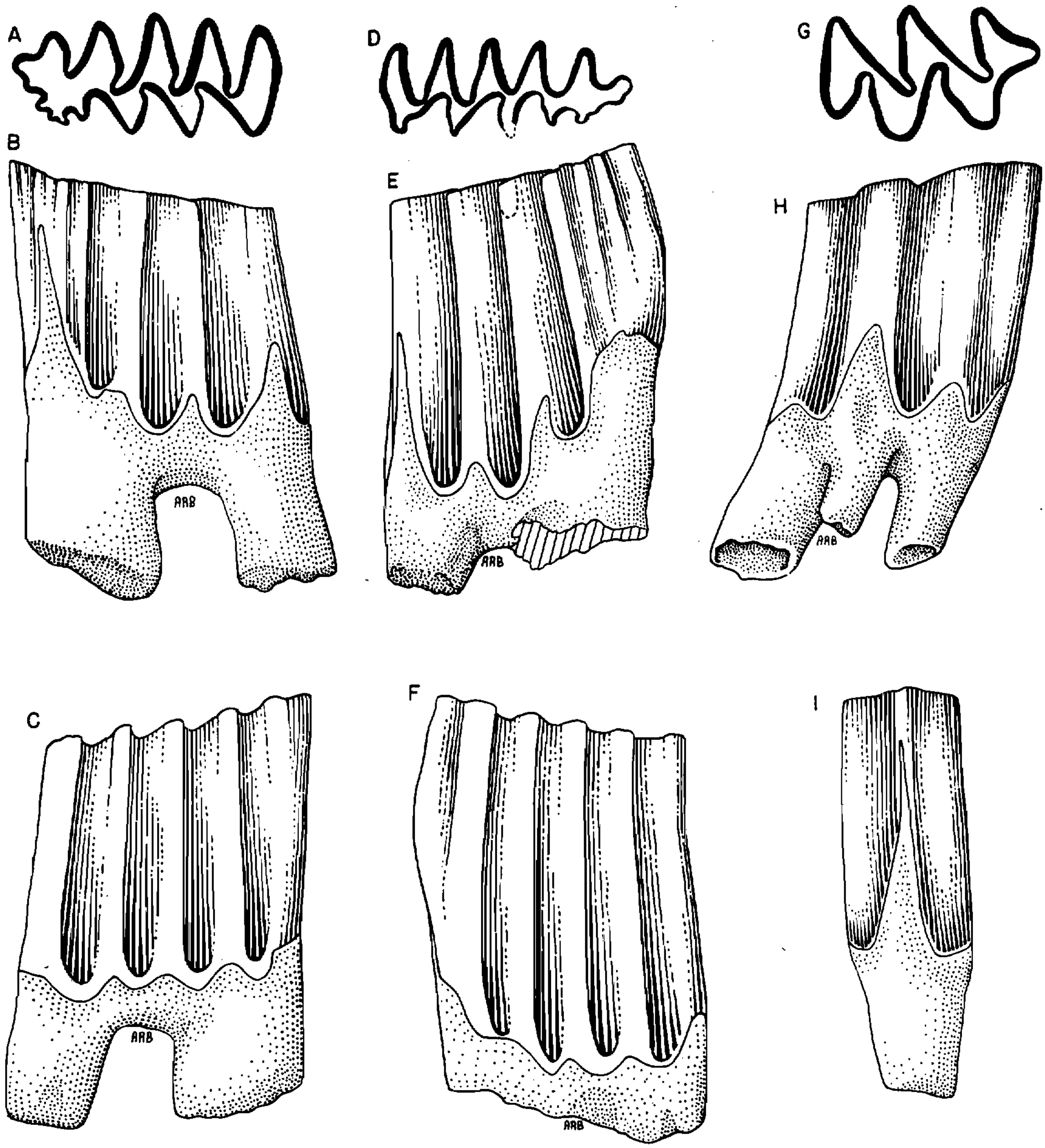


FIG. 44. *Pliophenacomys primaevus*, isolated teeth. A–C. Left M_1, UMMP V57017. A. Occlusal view. B. Labial view. C. Lingual view. D–F. Right M_1, UMMP V57183. D. Occlusal view. E. Labial view. F. Lingual view. G–I. Left M^1, UMMP V57186. G. Occlusal view. H. Lingual view. I. Posterior view. All approximately $\times 12.5$.

right M^3s. UM-Nebr. 2–68: UMMP V57293, left M^3. UM-Nebr. 4–48: UMMP V57228, right M^1.

MEASUREMENTS (IN MM.): KUMNH 3905, type, M_1: occlusal length 2.90; UMMP V57017 and V57192, five M_1s: occlusal length 2.77, 2.81, 2.83, 2.87, 3.02. UMMP V57186, M^1: occlusal length 2.58. UMMP V57191, M^2: occlusal length 1.96.

DESCRIPTION: The first lower molar consists of

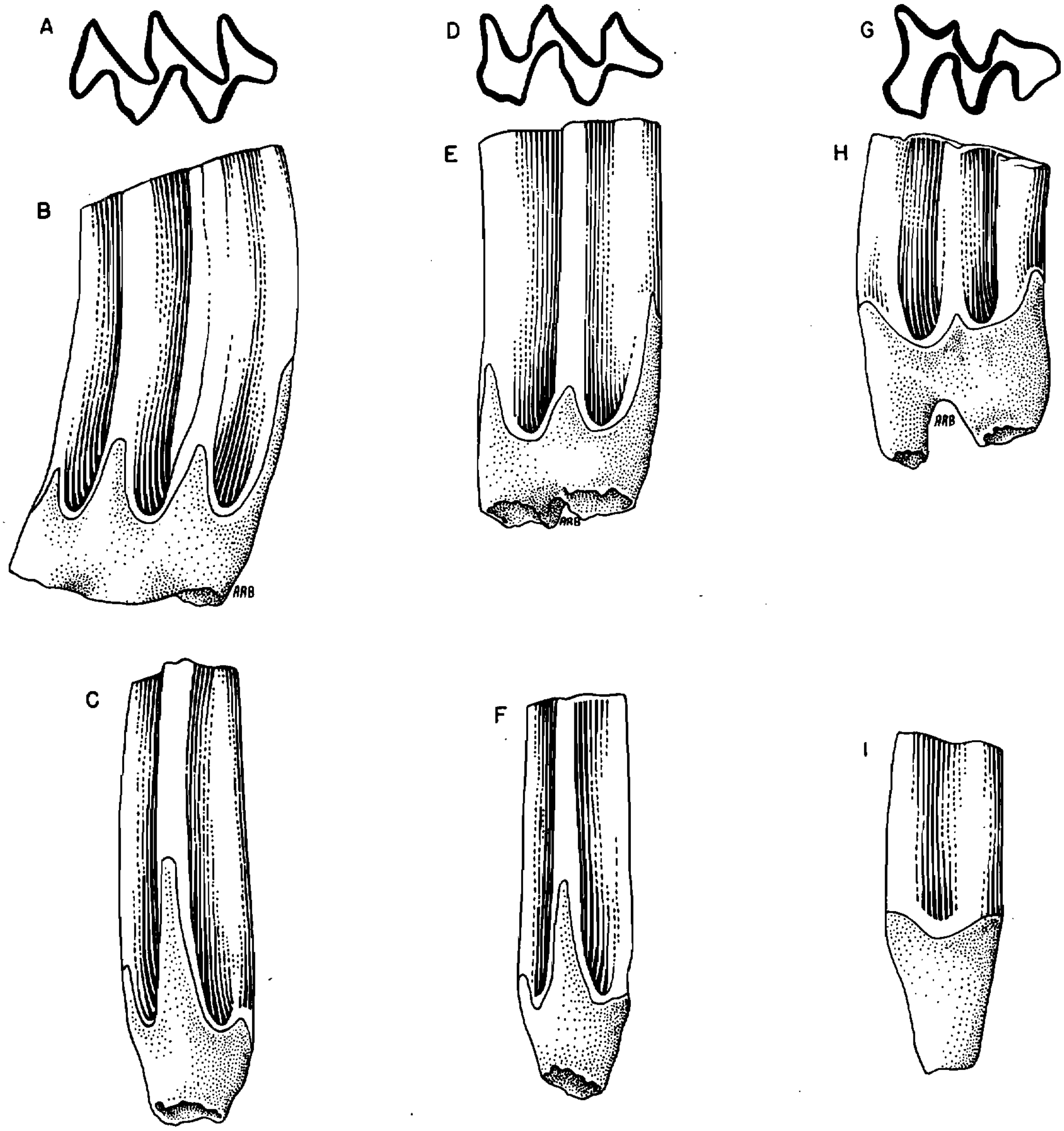


FIG. 45. *Pliophenacomys primaevus*, isolated teeth, UMMP V57191. A–C. Left M^1. A. Occlusal view. B. Lingual view. C. Posterior view. D–F. Left M^2. D. Occlusal view. E. Lingual view. F. Posterior view. G–I. Left M^3. G. Occlusal view. H. Lingual view. I. Anterior view. All approximately $\times 12.5$.

a posterior loop, five alternating triangles, and an anterior loop. In immature and young adult specimens, a dentine tract extends well up the labial side of the loop, or on the beginning of a small sixth alternating triangle that becomes part of the anterior loop (fig. 44B). Development of the dentine tracts can be seen at the base of the first and second labial alternating triangles. A well-developed dentine tract extends upward on the labial side of the posterior loop (fig. 44D). Development of these dentine tracts occurs on the type of *Pliophenacomys primaevus*, KUMNH 3905 and on the topotype, KUMNH 5975. These dentine tracts were not observed at the time the type was described (Hibbard, 1938), but they were noticed some years later.

The second lower molar consists of a posterior loop and four alternating triangles. The third and fourth triangles are broadly confluent. A dentine tract extends upward on the small fourth triangle, over one-half the crown height of a young specimen. In older specimens this tooth has an interrupted enamel pattern. Some M_2s have a well-developed dentine tract on the labial side of the posterior loop, and an incipient dentine tract on the lingual side of the loop.

M_3 has a well-developed dentine tract on the anterolabial side of the anterior loop.

M^1 consists of an anterior loop and four alternating triangles. A dentine tract extends over three-fourths the length of the posterior face of the fourth triangle where that tooth rests against the anterior loop of M^2 (figs. 44I, 45C). A well-developed lingual reentrant pit is also present where the third alternating triangle joins the fourth triangle on the labial side (fig. 45C).

M^2 consists of an anterior loop and three alternating triangles. Short dentine tracts occur on the lingual side of the tooth but a better developed dentine tract is on the posterior edge of the third triangle where it rests against M^3 (fig. 45D–F). The lingual reentrant pit is well developed.

M^3 has a large anterior loop because it is joined by the greatly reduced first alternating triangle. The first lingual triangle is followed by the posterior loop (fig. 45G–I). Short dentine tracts are on the lingual side of the anterior loop and the posterior face of the posterior loop. The third upper molar has two roots.

Discussion: *Pliophenacomys* is well known from the Fox Canyon local fauna, although it is unknown from the later Rexroad faunal sites, except for KU-2, Meade County, Kansas. KU-2 was an artesian sand tube (Hibbard, 1950, pl. 2, fig. 1), just north of KU-2A, but slightly higher stratigraphically. The spring basin and part of the tube had been removed by erosion. How much higher the formation extended is not known. It is possible that the KU-2 deposit is the age of the Bender local fauna that occurs above the Rexroad caliche and just below the overlying Ballard Formation.

GENUS *PLIOLEMMUS* HIBBARD, 1938

Type Species: *Pliolemmus antiquus* Hibbard, 1938.

Distribution: Early Pleistocene, Kingman and Meade counties, Kansas and Brown County, Nebraska.

Diagnosis: See Hibbard, 1956, page 191.

Pliolemmus antiquus Hibbard, 1938

Figure 46

Pliolemmus antiquus Hibbard, 1938, p. 247, pl. 1, fig. 7.

Type: KUMNH 3889, part of right mandible, with incisor, M_1, and M_2, Ballard Formation (early Pleistocene), KU-1, Meade County State Park, Kansas.

Distribution: Early Pleistocene, Kingman and Meade counties, Kansas and Keim Formation, Brown County, Nebraska.

Diagnosis: See Hibbard, 1956, page 191. Also: a vole the size of *Microtus* (*Pedomys*) *ochrogaster* (Wagner, 1842), with interrupted enamel pattern on upper and lower molars in old adult stage of wear. Posterolateral palatine pits large, median posterior palatine process free from median borders of pits. M^3 consisting of anterior loop, closed lingual triangle, and posterior loop rectangular to hourglass in shape. Cheek teeth evergrowing and without cement in reentrant angles. M_1 consisting of posterior loop, seven alternating triangles, and anterior loop. M_2 curved labially and resting against side of jaw.

Referred Material: Keim Formation, Brown County, Nebraska: UM-Nebr. 1–66: UMMP V57260, left M_3. UM-Nebr. 2–66: UMMP V57267, left jaw, M_1–M_2 (fig. 46C, D). UM-Nebr. 3–67: UMMP V57184, left M_1–M_3 (fig. 46A); UMMP V57185, left M^1–M^3 (fig. 46B); UMMP V57186, left M^1; UMMP V57196, parts of two left jaws, M_1–M_2; UMMP V57197, part of right jaw, M_1–M_2; UMMP V57198, isolated right M_1–M_3s; UMMP V57199, isolated right M^1–M^3s; UMMP V57200, isolated left M_1–M_3s; UMMP V57201, isolated left M^1–M^3s. UM-Nebr. 2–68: UMMP, V57290, three teeth. Prospecting Locality 277, SW. ¼, NW. ¼, sect. 26, T. 31 N., R. 22 W.: UMMP V59813, 77 isolated complete molars.

Measurements (in Mm.): UMMP V57184, V57196, V57197, V57198, V57200, V57267, 13 M_1s: occlusal length varies from 2.88 to 3.47 and averages 3.11. UMMP V57196A, V57196B, and V57267, fragmentary jaws with M_1–M_2: occlusal lengths 4.44, 4.84, 5.03. UMMP V57184, M_1–M_3 (associated): occlusal length: M_1, 3.39; M_2, 1.70; M_3, 1.42.

Description and Discussion: Adult lower and upper molars have dentine tracts on the

FIG. 46. *Pliolemmus antiquus*, teeth and partial left jaw with M_1–M_2. A. Left M_1–M_3 (associated) UMMP V57184. Occlusal view. B. Left M^1–M^3 (composite), UMMP V57185. Occlusal view. A, B approximately × 12.5. C, D. Partial left jaw, UMMP V57267. C. Occlusal view. D. Labial view. ×6.

labial and lingual sides. M_1 consists of a posterior loop and seven alternating triangles and an anterior loop. On M_1 of young specimens the dentine tract on the anterior part of the anterior loop and the two dentine tracts on the posterior loop extend the length of the tooth; other labial and lingual dentine tracts, however, do not reach the occlusal surface. M_2 consists of a posterior loop and four alternating triangles; M_3 consists of a posterior loop and four alternating triangles; the third and fourth triangles are confluent.

M^1 consists of an anterior loop and four alternating triangles; M^2 has an anterior loop and three alternating triangles; M^3 consists of an anterior loop, two alternating triangles, and a posterior loop; the second alternating triangle is confluent with the posterior loop. No enamel encloses the posterior border of M^3 which varies from a broad area to a very narrow area; M^3 shows the greatest amount of variation of any of the molars.

Next to *Geomys quinni*, *Pliolemmus antiquus* was the most common rodent in the Sand Draw local fauna; parts of at least 22 individuals were found at five localities in the Keim Formation. This vole is little known from Kansas. Southern Kansas may have been near the southern limits of its range. So far there is no evidence of the ancestor of this highly specialized vole. The oldest stratigraphic record is from the Bender local fauna (Taylor, 1960, p. 31, locality 1C). A left M^2 (UMMP V45823) was recovered in the summer of 1961. A left M^3 (UMMP V60020) was taken in the summer of 1970. The earliest record of another microtine with evergrowing molars in the Plains is *Synaptomys* (*Synaptomys*) *rinkeri* Hibbard, 1956, from the Dixon local fauna.

ORDER EDENTATA

SUBORDER XENARTHRA

FAMILY MYLODONTIDAE

Genus and Species Undetermined

Figure 47

MATERIAL: F:AM 87456, left metacarpal III from the surface of the Long Pine Formation, about 4 miles north of Long Pine, Brown County, Nebraska, on the east side of Pine Creek. The specimen is well fossilized and similar to a right metacarpal III, described and figured by Stock (1925, p. 125, fig. 84).

Measurements (in Mm.): F:AM 87456: greatest length 105.2, greatest depth of shaft across outer surface 40.0, least transverse width 35.5.

ORDER CARNIVORA

FAMILY CANIDAE

GENUS *CANIS* LINNAEUS, 1758a

Type Species: *Canis familiaris* Linnaeus, 1758a.

Distribution: Medial Pliocene to Recent, North America; Pleistocene to Recent, Eurasia; Recent, worldwide.

Diagnosis: See G. S. Miller, 1912, page 304.

Canis lepophagus Johnston, 1938

Figure 48

Canis lepophagus Johnston, 1938, p. 383, pls. 1–3.

Type: WT 881, skull, lacking mandible, type locality of Cita Canyon beds in Stratum No. 2. Center of W. ½, sect. 164, Block 6, Randall County, Texas. Early Pleistocene.

Distribution: Late Pliocene, Idaho and Kansas; early Pleistocene, Randall County, Texas and Brown County, Nebraska.

Diagnosis: See Johnston, 1938, page 385.

Referred Material: UMMP V57321, fragments of skull and parts of lower jaws; right premaxillary and parts of maxillary contain I^1 and I^3, part of canine, P^1–P^2 alveoli, P^3, P^4, and part of M^1; left lower jaw with part of canine, P_3–M_3; P_1–P_2 lost in life (fig. 48); depth of left jaw below P_2 less than right jaw with P_2, posterior root of P_3, P_4, and part of M_1. Recovered by Wiley Lentz, east of Jackrabbit Hill in NW. ¼, sect. 24, T. 30 N., R. 21 W., Brown County, Nebraska, from near top of Keim Formation.

Measurements: See table 14.

Discussion: This specimen is assigned to *Canis lepophagus* on the presence of the deep palatal pit lingual to P^4. One hundred and twenty-two recent adult coyote skulls were examined in the University of Michigan Museum of Zoology Collection. These specimens were collected in Mexico and throughout the United States and none of these had so deep a palatal pit as UMMP V57321. In this specimen the pit is as deep as in specimens reported by Bjork (1970), from the Hagerman local fauna, but UMMP V57321 is larger and the premolars are not so crowded as those from the Hagerman fauna.

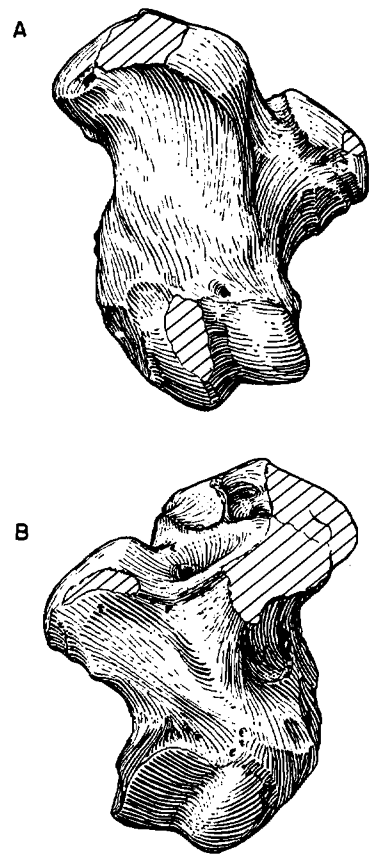


Fig. 47. Family Mylodontidae. Genus and species indet., left metacarpal III, F:AM 87456. A. Posterior view. B. Anterior view. × ½.

In many respects the specimen helps to bridge the gap between *Canis lepophagus* and *C. latrans* Say, 1823. In UMMP V57321 the protocone of P^4 is reduced and more like that of Hagerman specimens than of *C. latrans*. It is well known, however, that almost any kind of protocone can be observed in a large series of Recent coyote skulls.

Fig. 48. *Canis lepophagus*, left lower jaw, canine, P_3–M_3, UMMP V57321. A. Occlusal view. B. Labial view. × ½.

TABLE 14
MEASUREMENTS (IN MILLIMETERS) OF *Canis lepophagus*, UMMP V57321

	Length	Width
P^3	12.40	4.30
P^4	20.70	9.40
P_3	11.40	4.50
P_4	13.00	4.80
M_1	21.50	8.20
M_2	9.50	7.30
M_3	5.00	4.60
Back of canine to P_4	49.50	—
Back of canine to posterior border of M_3	86.80	—
Depth of jaw below M_1, 23.60		

GENUS *BOROPHAGUS* COPE, 1892a

Hyaenognathus MERRIAM, 1903, p. 278.

TYPE SPECIES: *Borophagus diversidens* Cope, 1892a.

DISTRIBUTION: Late Pliocene and early Pleistocene, North America.

DIAGNOSIS: See Stirton and Vanderhoof, 1933, page 176.

Borophagus diversidens Cope, 1892a

Figure 49

Borophagus diversidens COPE, 1892a, p. 1028.

TYPE: TMM 18578, part of left ramus with alveolus of P_2, P_3, and most of P_4. Blanco beds, Blanco Canyon, Crosby County, Texas.

DISTRIBUTION: Early Pleistocene, Plains region of the United States, and southward into Mexico.

DIAGNOSIS: Lower incisors crowded; I_1 reduced; canine crowded between incisors and P_2; P_2 and P_3 greatly reduced and peg-shaped; P_4 large, sloping posteriorly, lacking accessory tubercules, with extremely broadened posterior base. M_1 large, protoconid and paraconid making up four-fifths of tooth, metaconid weak to absent; heel short, entoconid smaller than reduced hypoconid; M_2 small with low small cusps, metaconid joining protoconid; M_3 peg-shaped. Lower jaw short, massive, with greatly reduced symphysis.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Prospecting Locality 278, NW. $\frac{1}{4}$, SE. $\frac{1}{4}$, sect. 12, T. 30 N., R. 21 W.: F:AM 67117, part of right lower jaw, alveoli, canine, P_2–P_3, P_4–M_2, and alveolus of the single-rooted M_3 (fig. 49); F:AM 67118, right M_1 lacking talonid.

MEASUREMENTS: See table 15.

REMARKS: This large bone-crushing dog is represented by two specimens from the Keim Formation. The characters of the lower jaw and dentition are like those of *Borophagus diversidens* (CM 9495) anterior part of a left lower jaw, bearing the alveoli of the incisors, canine, alveolus of P_2, and P_3–M_1 (Hibbard, 1950, fig. 18), taken 7 miles northeast of Crosbyton, Texas. See measurements, table 14.

TABLE 15
MEASUREMENTS (IN MILLIMETERS) OF *Borophagus diversidens*

	F:AM 67117	CM 9495[a]
P_3 alveolus, length	10.50	—
P_4		
Length	20.50	20.60
Maximum width	—	16.10
M_1		
Length	35.00	35.20
Maximum width	15.20	14.50
M_2		
Length	11.00	—
Maximum width	9.00	—
M_3 root, transverse width	3.00	—
P_4–M_2, alveolar length	65.00	—
Length, posterior border I_3 alveolus to posterior border M_2	97.20	—
Depth, symphysis below I_3 alveolus	40.00	—
Depth, ramus between P_3–P_4, labial side	39.00	—
Depth, ramus between M_1–M_2, labial side	41.50	—
Width (transverse) ramus below P_4	23.00	—

[a]Measurements after Hibbard, 1950, p. 161.

FAMILY MUSTELIDAE

GENUS *TRIGONICTIS* HIBBARD, 1941a

TYPE SPECIES: *Trigonictis kansasensis* Hibbard, 1941a.

DISTRIBUTION: Late Pliocene and early Pleistocene, North America.

DIAGNOSIS: See Hibbard, 1941b, page 273.

Trigonictis idahoensis (Gazin, 1934)

Lutravus (?) *idahoensis* GAZIN, 1934b, p. 138, fig. 1.

Canimartes? idahoensis (Gazin): GAZIN, 1937, p. 364.

Trigonictis kansasensis HIBBARD, 1941a, p. 344, fig. 5a, 5b. MCGREW, 1944, p. 53. ZAKRZEWSKI, 1967a, p. 294.

Trigonictis idahoensis (Gazin, 1934): BJORK, 1970, p. 22.

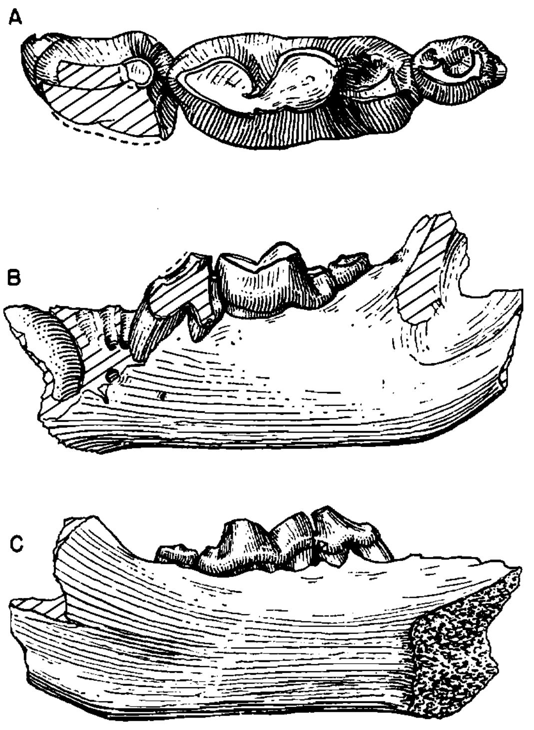


FIG. 49. *Borophagus diversidens*, partial right lower jaw with P_4–M_2 (reversed), F:AM 67117. A. Occlusal view. $\times 1$. B. Labial view. C. Lingual view. B–C $\times \frac{1}{2}$.

TYPE: USNM 12030, part of left lower jaw with P_4, M_1, M_2. Late Pliocene, Glenns Ferry Formation, T. 7 S., R. 13 E., Twin Falls County, near Hagerman, Idaho.

DISTRIBUTION: Same as for genus.

DIAGNOSIS: See Gazin, 1934, page 138.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, W. $\frac{1}{2}$, NW. $\frac{1}{4}$, sect. 25, T. 31 N., R. 22 W.: F:AM 87401, left M_1; FM P25294, part of left maxillary with M^1.

MEASUREMENTS (IN MM.): F:AM 87401: greatest length, M_1, 14.6.

REMARKS: This mustelid, poorly known from the Keim Formation, is much like the South American grison.

Trigonictis cookii (Gazin, 1934)
Figure 50

Lutravus (?) *cookii* GAZIN, 1934b, p. 142, fig. 2.
Canimartes? *cookii* (Gazin): GAZIN, 1937, p. 364.
Trigonictis cookii (Gazin, 1934): ZAKRZEWSKI, 1967a, p. 293.

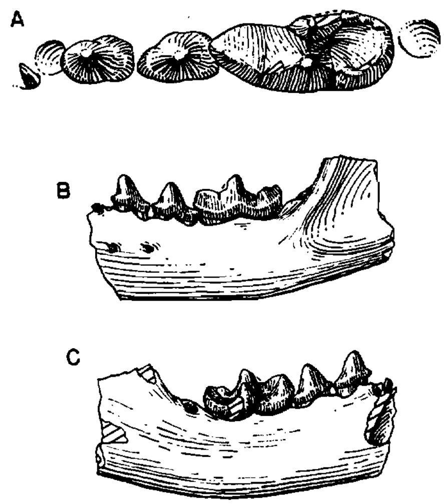


FIG. 50. *Trigonictis cooki*, partial left jaw, canine, P_2 alveoli, P_3–M_1, and alveolus M_2, F:AM 49160. A. Occlusal view. $\times 2$. B. Labial view. C. Lingual view. B, C $\times 1$.

DISTRIBUTION: Upper Pliocene, Glenns Ferry Formation, Idaho; early Pleistocene, Keim Formation, Brown County, Nebraska.

DIAGNOSIS: See Gazin, 1934b, page 142.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, SW. $\frac{1}{4}$, NW. $\frac{1}{4}$, sect. 25, T. 31 N., R. 22 W.: F:AM 49160, part of left lower jaw, canine, and P_2 alveoli, P_3–M_1, M_2 alveolus (fig. 50); F:AM 87484, part of right lower jaw, P_4–M_2 alveoli. Prospecting Locality 278, NW. $\frac{1}{4}$, SE. $\frac{1}{4}$, sect. 12, T. 30 N., R. 21 W.: F:AM 49163, part of left lower jaw, P_3 alveolus, P_4–M_1, M_2 alveolus.

MEASUREMENTS (IN MM.): F:AM 49160: greatest length M_1, 11.9; greatest length P_3–M_1, 22.7. F:AM 49163: greatest length M_1, 12.5; greatest length P_4–M_1, 12.6.

REMARKS: These three specimens are the first record of *Trigonictis cookii* from the Plains region. Before this they had only been known from the Hagerman local fauna, Twin Falls County, Idaho.

GENUS *TAXIDEA* WATERHOUSE, 1838

TYPE SPECIES: *Meles labradorius* Gmelin = *Ursus taxus* Schreber, 1778.

DISTRIBUTION: Late Pliocene to Recent, North America. Present distribution northern Alberta, south into Mexico, eastern Ohio, west to Pacific Coast.

DIAGNOSIS: See Hall, 1936, page 77.

Taxidea cf. *T. taxus* (Schreber, 1778)
Figure 51

Taxidea taxus (SCHREBER, 1778, pp. 520–521).

DISTRIBUTION: Keim Formation, Brown County, and same as for the genus.

REFERRED MATERIAL: Type area of Sand Draw local fauna, SW. ¼, NW. ¼, sect. 25, T. 31 N., R. 22 W.: FM P26946, right lower jaw with P_3, M_1–M_3. Prospecting Locality 277, SW. ¼, NW. ¼, sect. 25, T. 31 N., R. 22 W.: F:AM 62915, partial skull with right canine, alveolus left canine, alveoli of right and left P^2, P^3, part of right P^4; left P^4 and M^1 present.

MEASUREMENTS (IN MM.): F:AM 62915: Distance, posterior border canine alveolus to posterior border glenoid process 67.5; distance from border canine alveolus to posterior edge M^1, 56.6; length P^4 from anterior edge parastyle to posterior edge metacone 12.8; greatest width M^1, 11.3; greatest labial length crown M^1, 15.2; greatest lingual length crown M^1, 13.5; distance from posterior border canine alveolus to posterior edge P^4, 25.3.

DESCRIPTION AND DISCUSSION: FM P26946 and F:AM 62915 are immature badgers, both recovered about 200 yards south of the Sand Draw Quarry in the Keim Formation. In F:AM 62915 (fig. 51) P^4 has a distinct parastyle, paracone, metacone, protocone, and a well-developed hypocone; a cingulum is present at the base of the crown. The first upper molar is triangular in outline and has a heavier cingulum than Recent specimens; the parastyle is strongly developed, there is a distinct conule on the antero-internal cingulum, the anterior oblique crest consists of three conules coalesced with the parastyle; the posterior oblique crest consists of three conules, two of which are in the area of the hypocone and metacone; the talonid is basined. In F:AM 62915 M^1 is larger than those observed in a series of fossil and Recent specimens. But all that remains of the skull indicates that it is smaller proportionally to the size of the dentition than those of large adult males.

A series of 28 badger skulls, all with P^4s, were examined. Seven are from late Pleistocene deposits of Alaska. Recent examples include two from Arizona, one from British Columbia, one from California, one from Iowa, one from Minnesota, 10 from Nebraska, one from Utah, two from Texas, one from Wisconsin, and one from Wyoming.

The largest M^1 observed was of a young male from Wisconsin [AMNH(M) 138401]. This molar had a labial length of 14.7 mm., an anterior width (maximum) of 11.5 mm., and a lingual length (maximum) of 12.2 mm.

The dental patterns of M^1s have a large amount of variation, P^4s less. No specimen was observed with so large a P^4 as the one from the Sand Draw fauna. If additional specimens are found from deposits equivalent in age to the Keim Formation and show the strong development of conules on M^1 and have the large P^4, they should be treated as representatives of a distinct subspecies.

GENUS *BUISNICTIS* HIBBARD, 1950

TYPE SPECIES: *Buisnictis meadensis* Hibbard, 1950 (=*Brachyprotoma breviramus* Hibbard, 1941a, p. 340).

DISTRIBUTION: Medial Pliocene to early Pleistocene, western North America.

DIAGNOSIS: See Hibbard, 1954, page 225.

Buisnictis burrowsi,[1] new species
Figure 52

TYPE: F:AM 87402, right and left rami; right jaw with I_1 alveolus, I_2–I_3, canine, P_2–M_2, left jaw has posterior part of canine alveolus, P_2–P_3 alveoli, P_4–M_2, and associated left upper canine. Prospecting Locality 277, SW. ¼, NW. ¼, sect. 25, T. 31 N., R. 22 W., 5 feet below Long Pine Formation from a sand channel in the Keim Formation, Brown County, Nebraska.

PARATYPES: F:AM 25214, part of left lower jaw, canine, P_2–P_4 alveoli, M_1, and alveoli of M_2. Sand Draw Quarry, Keim Formation. UMMP V57152A–B, left P^4 and M^1 (fig. 52D), UM-Nebr. 1–68.

DISTRIBUTION: Keim Formation, Brown County, Nebraska.

DIAGNOSIS: Small short-faced skunklike mustelid with four-rooted M_1 that has a greatly reduced metaconid.

FIG. 51. *Taxidea* cf. *T. taxus*, left P_4–M_1, F: AM62915. Occlusal view. ×2.

[1] For Earl Burrows.

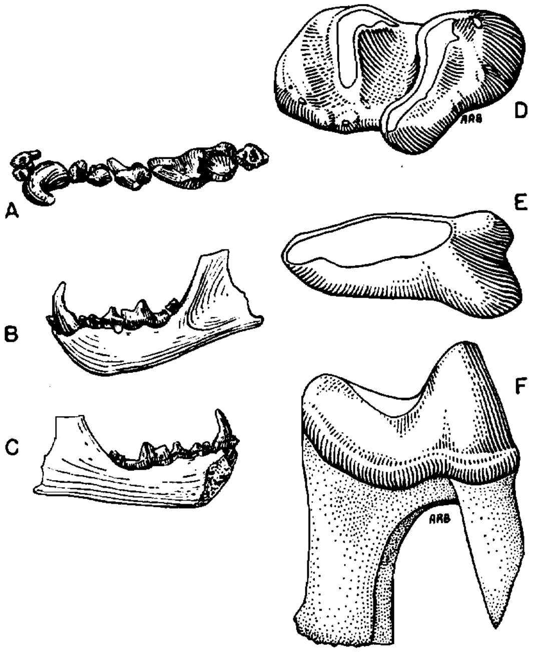


FIG. 52. *Buisnictis burrowsi*, new species. A–C. Partial right jaw of type (reversed), F:AM 87402. A. Occlusal view. ×2. B. Labial view. C. Lingual view. B, C ×1. D. Left M^1, UMMP V57152A. Occlusal view. E, F. Left P^4, UMMP V57152B. E. Occlusal view. F. Labial view. D–F approximately ×6.

DESCRIPTION: *Buisnictis burrowsi* is an advanced species of the genus near the size of *B. breviramus.* The alveolus of I_1 indicates that I_1 was smaller than I_2; P_2–P_3 are triangular in outline and P_2 is set obliquely in the jaw with the posterior root on the lingual side and the anterior root along the posterolabial side of the canine. The metaconid of M_1 is represented by a slight ridge extending upward from the lingual base of the crown, is supported by the lingual root, and becomes a part of the protoconid. A deep valley separates the posterolingual edge of the trigonid from the entoconid, and a shallow groove separates the entoconid and hypoconid. The talonid is not as basined as that of *B. breviramus.*

In the type (F:AM 87402, fig. 52A–C), the right and left P_4–M_2 share the same characters with one exception: on the left jaw the anterior root of P_2 is in the same alveolus on the labial side as the anterior root of P_3.

The dentition of *Buisnictis burrowsi* is more sectorial than that of *Spilogale*, especially P^4 (fig. 52E, F), which is most distinctive in *Buisnictis.* (See Hibbard, 1950, p. 164.) In one paratype (F:AM 25214) the left M_1 has a better developed metaconid than that of the type but not so well developed as the metaconid of *Buisnictis breviramus.* (Length of M_1 is 6.5 mm.) In the other paratype (UMMP V57152A) the anterior lingual root and protocone are missing on P^4; the parastyle of P^4 is small and situated on the anterolabial base of the paracone.

TABLE 16
MEASUREMENTS (IN MILLIMETERS) OF THE DENTITION OF *Buisnictis burrowsi*, NEW SPECIES

	F:AM87402[a]
Length	
I_2 to posterior edge M_2	4.8
Posterior border canine alveolus to anterior edge M_1	5.2
M_1	
Length	5.4
Length of trigonid	3.8
Width through base of protoconid	2.7
Width across posterior border of talonid	2.76
M_2	
Width	1.66
Depth of ramus, labial side, at anterior edge M_1	5.65

[a]Type.

GENUS *SATHERIUM* GAZIN, 1934b

TYPE SPECIES: *Lutra priscinaria* Leidy, 1873.

DISTRIBUTION: Late Pliocene and early Pleistocene, North America.

DIAGNOSIS: See Gazin, 1934b, page 144.

Satherium priscinaria (Leidy, 1873)
Figure 53

Lutra priscinaria LEIDY, 1873, p. 316, pl. 31, fig. 4.

Satherium priscinaria Leidy: BARBOUR AND SCHULTZ, 1937, p. 8, fig. 4.

TYPE: USNM 662, right tibia. Sinker Creek, Idaho.

DISTRIBUTION: Same as for genus.

DIAGNOSIS: Same as for genus.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: Prospecting Locality 277, NW. ¼, sect. 26, T. 31 N., R. 22 W.: F:AM 87403, right tibia with lateral condyle broken away (fig. 53).

MEASUREMENTS (IN MM.): F:AM 87403:

Tibia, greatest length inside 133.0, medial articular length 125.0, greatest transverse width distal end 24.1, greatest anteroposterior width distal end 16.3, greatest transverse width, middle of shaft 8.9, greatest anteroposterior width at middle of shaft 16.4.

DISCUSSION: This specimen is near the size of a right tibia from Sinker Creek, Idaho, that Leidy described in 1873. The distal end of Leidy's specimen (pl. 31, fig. 4) does not show enough detail for adequate comparison with the Sand Draw specimen. In F:AM 87403 the groove for the flexor tendons on the posterior side of the proximal end is deep, and the tibial crest is well developed and flexed laterally. The nutrient foramen is situated just ventrally to the tip of the tibial crest on the lateroposterior surface of the tibia.

In 1937 Barbour and Schultz described *Satherium priscinaria middleswarti* from Broadwater Quarry No. 3, Morrill County, Nebraska. They reported a partial skull and right lower jaw, and as our specimen is a tibia, no comparison is possible. The Sand Draw specimen is the first tibia complete enough to be assigned to Leidy's type, *Lutra priscinaria.*

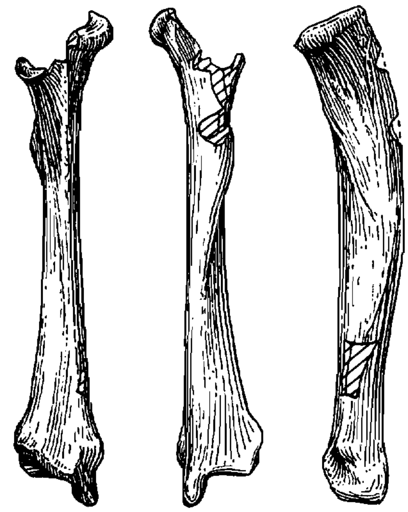


FIG. 53. *Satherium priscinaria*, right tibia (reversed), F:AM 87403. A. Posterior view. B. Anterior view. C. Lateral view. × ½.

FAMILY FELIDAE

GENUS *ISCHYROSMILUS* OR *DINOBASTIS*

Figure 54

A right P_4 (F:AM 87404) was recovered from the Sand Draw Quarry. The P_4 consists of three cusps (fig. 54A–C). A strong lingual cingulum extends well up on the posterior cusp. The anterior edges of the middle cusp (protoconid) and posterior cusp are serrated. The greatest anteroposterior length of this tooth is 20.9 mm., the greatest width is 10.4 mm., and the height of the protoconid is 15.5 mm. Dr. Charles S. Churcher, Royal Ontario Museum, Toronto, Canada, examined this specimen and in a letter dated May 28, 1969, stated, "My suggestion is that either you have an early form of *Smilodon* or an *Ischyrosmilus* . . ."

Part of a femur (FM P26164) reported by McGrew (1944) as *Smilodon* appears to belong to *Ischyrosmilus* or *Dinobastis.*

The front end of a right lower jaw (F:AM 69357) with the symphysis, alveoli of I_1–/C and P_3 (fig. 54D). The specimen was taken by Skinner in 1961 from the Long Pine Formation at Frick Prospecting Locality 278 on the Lee Magill ranch. The depth of the alveolus of I_1 is about one-half the depth of I_2 and the alveolus of I_3 is deeper than that of I_2. The incisors are not set in a transverse line as in *Smilodon,* but are set at an angle from I_1 to the anterior edge of the canine. There are three mental foramina. The anterior foramen is much the largest and located below the diastema. Two posterior foramina are situated under the roots of P_3. The anterior root of P_3 is smaller than the posterior root.

MEASUREMENTS (IN MM.): Depth of symphysis at midline 60.0; greatest depth of jaw below alveolus of canine 58.8; depth of jaw below anterior alveolus of P_3, 37.0; length of diastema between canine and P_3, 28.0; greatest thickness of jaw below diastema 12.8.

ORDER PROBOSCIDEA

FAMILY GOMPHOTHERIIDAE

GENUS *STEGOMASTODON* POHLIG, 1912

Rhabdobunus HAY, 1914, p. 374.

TYPE SPECIES: *Mastodon mirificus* (Leidy, 1858, p. 12). Loup Fork of the Platte River, Nebraska, *fide* Leidy. Now known as Middle Loup *fide* Skinner.

DISTRIBUTION: Late Pliocene to medial Pleistocene, North America.

DIAGNOSIS: See Osborn, 1936, page 667.

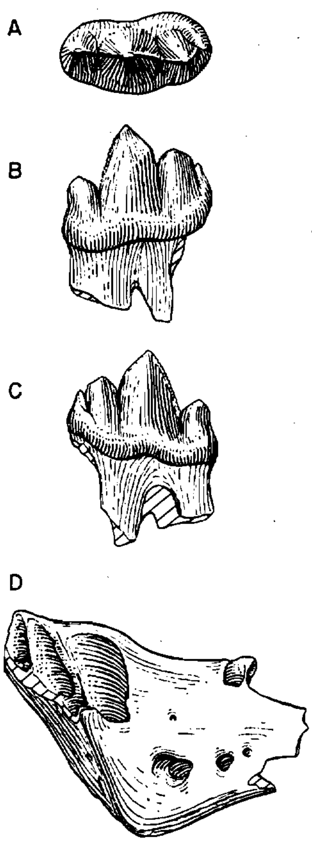


FIG. 54. *Ischyrosmilus* or *Dinobastis*. A–C. Right P_4 (reversed), F:AM 87404. A. Occlusal view. B. Lingual view. C. Labial view. A–C $\times$ 1. D. Anterior part of right jaw (reversed), F:AM 69357. Labial view. $\times \frac{1}{2}$.

Stegomastodon primitivus Osborn, 1936
Stegomastodon primitivus OSBORN, 1936, p. 726.

TYPE: F:AM 25000, palate with tusks, right M^3 and left M^2 and M^3, about 75 feet from the northwest corner of the *Stegomastodon* Quarry (Osborn, 1936, p. 728, fig. 676), Keim Formation, early Pleistocene, Brown County, Nebraska.

DISTRIBUTION: Known only from the early Pleistocene, Nebraska.

DIAGNOSIS: See Osborn, 1936, page 726.

REFERRED MATERIAL: Brown County, Nebraska: *Stegomastodon* Quarry, Keim Formation: Osborn, 1936, page 728, reported parts of nine skulls and five mandibles from a peaty deposit lateral to a layer of diatomite (fig. 3E–I). UM-Nebr. 2-66: UMMP V56413, a tibia (greatest length 445.0 mm.). Long Pine Formation: Prospecting Locality 63, Chicago and Northwestern Railroad Gravel Pit: F:AM 25725, mandible with M_3s; F:AM 25722, immature mandible with dP_4–M_1. Prospecting Locality 277: F:AM 25725A, M_3 (see Frick, 1933, p. 626).

Savage (1955) stressed the need for a quantitative analysis of the *Stegomastodon* specimens from the *Stegomastodon* Quarry but such a study is beyond the scope of this report. *Stegomastodon rexroadensis* Woodburne, 1961, from the Rexroad fauna is more primitive than *S. primitivus*, in which the trefoils of the molars are more complex.

ORDER ARTIODACTYLA

FAMILY TAYASSUIDAE

GENUS *PLATYGONUS* LE CONTE, 1848

TYPE SPECIES: *Platygonus compressus* Le Conte, 1848.

DISTRIBUTION: Late Pliocene and Pleistocene, North America; Pleistocene, South America.

DIAGNOSIS: See Le Conte, 1848, page 272.

Platygonus sp.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: FM P15519, metatarsal IV, lacking proximal end. Prospecting Locality 263, NW. $\frac{1}{4}$, sect. 9, T. 30 N., R. 21 W.: F:AM 87478, part of left ramus, P_3 broken, P_4–M_3 (old adult). Prospecting Locality 277, W. $\frac{1}{2}$, NW. $\frac{1}{4}$, sect. 25, T. 31 N., R. 22 W.: F:AM 87407, worn right canine, partial right humerus, right metacarpal III, partial right tibia, distal end of fibula, right astragalus, right partial metatarsal IV, left metacarpal III, left tibia, partial left fibula, left metatarsal III, associated carpals, tarsals, phalanges, and patella, from clay zone, 4 feet below Long Pine Formation; F:AM 87408, left P_4, below marl zone, mouth of Sand Draw.

MEASUREMENTS (IN MM.): F:AM 87478: P_4–M_3, alveolar length 94.0; M_1–M_3, greatest length 60.0; M_1, length near base of enamel 27.5; width anterior lobe M_1, 15.5. F:AM 87407: right metacarpal III, articular length 64.0; left tibia, articular length 160.0; left metatarsal III, articular length 65.3; right astragalus, greatest length 39.2.

REMARKS: Remains of peccary are not common, but they are present throughout the Keim Formation. The few that have been recovered are specifically indeterminate but indicate that a stocky-legged individual referable to *Platygonus* was a constituent of the Sand Draw fauna.

Williston (1894) gave an excellent description of the skeleton of *Platygonus* based on parts of nine individuals.

FAMILY CAMELIDAE

GENUS *GIGANTOCAMELUS* BARBOUR AND SCHULTZ, 1939

Pliauchenia Cope, 1893 (in part).

Pliauchenia (*Megatylopus*): Matthew and Cook, 1909 (in part). (*P. spatula* referred to the subgenus *Megatylopus*.)

Type Species: *Gigantocamelus spatulus* (Cope, 1893).

Distribution: Late Pliocene and early Pleistocene, North America.

Diagnosis: See Barbour and Schultz, 1939, page 20.

Gigantocamelus spatulus (Cope, 1893)

Pliauchenia spatula Cope, 1893, p. 70, pl. 21, figs. 1, 2.

Gigantocamelus fricki Barbour and Schultz, 1939, p. 20.

Gigantocamelus spatula (Cope): Meade, 1945, p. 531.

Gigantocamelus spatulus (Cope, 1893): Hibbard and Riggs, 1949, p. 844.

Type: Number and whereabouts unknown to me. Partial mandible with symphysis, I_1, P_1, P_3–M_3. Blanco Formation (early Pleistocene), Mount Blanco, Crosby County, Texas. Cope (1893, p. 73) stated, "I excavated the specimen of *Pliauchenia spatula* from the side of a bluff near Mount Blanco, Texas."

Distribution: Late Pliocene, Rexroad Formation, Meade County, Kansas; early Pleistocene, Keim and Duffy formations, Brown County, Broadwater Formation, Lisco County, Nebraska; and Blanco Formation, Crosby County, Texas.

Referred Material: Keim Formation, Brown County, Nebraska, *Stegomastodon* Quarry: F:AM 24900, immature right ramus with deciduous premolars, germs for P_4–M_3, semiarticulated fore and rear limbs; F:AM 24901, 24908, rami of young individuals; F:AM 24898, ramus of old individual. Near *Stegomastodon* Quarry: F:AM 25056, partial metacarpal. Magill ranch in a channel below the marl: F:AM 87424, distal end of femur. Deep Creek: F:AM 24906, radius and ulna, base of the Keim Formation; F:AM 87425, distal half of a metatarsal, talus below the marl. Sand Draw: F:AM 87482, left radius and ulna, lower red zone in channel deposit. Booth Draw: F:AM 87426, P_1, upper part of Keim Formation. Duffy Formation, Brown County, Nebraska, Prospecting Locality 479, 3¼ miles south of Long Pine: F:AM 87481, partial mandible, left M_1 (partial)–M_3, right M_2–M_3, 35 feet above Pine Creek, 20 feet above the Long Pine Gravel Formation.

Measurements (in Mm.): F:AM 24900: metacarpal length 400.0, metatarsal length 444.0. F:AM 24906: radius and ulna articular length 678.0, transverse width at mid shaft 88.0, anteroposterior width 53.0, greatest transverse width distally 127.5, transverse width proximally 110.0.

Discussion: I have not followed Webb (1965, p. 35) in synonymizing *Gigantocamelus* with *Titanotylopus* because I have been unable to compare the type of *Titanotylopus nebraskensis* Barbour and Schultz (1934) with a series of *Gigantocamelus spatulus*. Hibbard and Riggs (1949) observed strong sexual dimorphism among lower dentitions assigned to *G. spatulus* (i.e., large canines in males, small in females, and lack of P_1 in females). Furthermore, the generic and specific assignment is still to be made of a long thoracic vertebra (length 785 mm.), found in association with dentitions assigned to *G. spatulus* (Hibbard and Riggs, 1949, fig. 7B). The University of Texas collection from the Blanco local fauna, Crosby County, Texas, also contains a long thoracic vertebra and large long limbs (Univ. Texas Nos. 31179–20 and 31179–28) of a camel, taller than *Gigantocamelus spatulus*, neither of which was found associated with dentitions. At least two genera of large camels lived during the early Pleistocene in North America, but until dentition and postcranial elements are found in unequivocal association, I am holding *Gigantocamelus* as a distinct genus.

Camelops sp.

Distribution: Pleistocene, North America.

Referred Material: Keim Formation, Brown County, Nebraska, Sand Draw: F:AM 87412, 87414, two astragali; F:AM 87413, calcaneum and astragalus (table 16); F:AM 87415, left calcaneum; F:AM 87416, 87417, distal ends of two left tibiae. Magill ranch, 10 feet below the marl: F:AM 87418, proximal end of metatarsal.

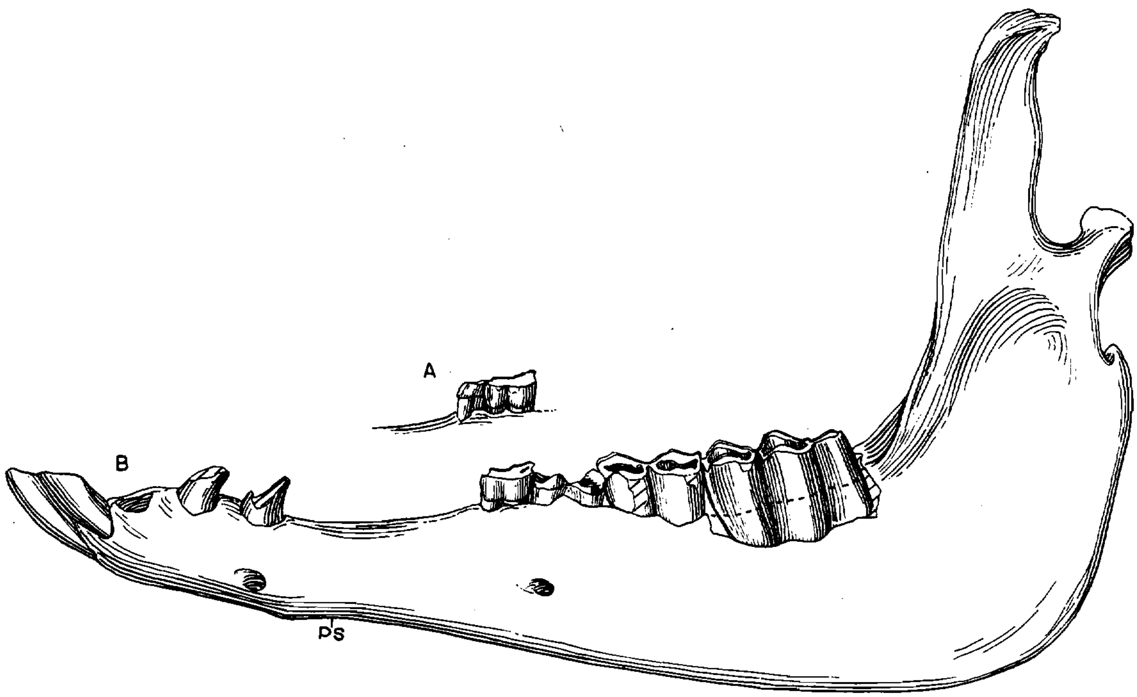


FIG. 55. *Tanupolama* sp., F:AM 25063. A. Right P_3–P_4. Lingual view. B. Left jaw I_1, I_2, alveolus of I_3, canine, P_1, P_4–M_3. Labial view. Approximately $\times \frac{1}{2}$.

MEASUREMENTS: See table 17.

Tanupolama sp.

Figure 55

DISTRIBUTION: Medial Pliocene through Pleistocene, North America.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska, Booth Draw: F:AM 25063, mandible of a young adult male (fig. 55); F:AM 87420, right M_2; F:AM 25058, an incisor, part of a phalanx, and part of a slender right metatarsal. *Stegomastodon* Quarry: F:AM 24910, right P_4–M_3 may be associated with F:AM 24911, left M_1–M_3; F:AM 24912, right M_2–M_3 and left M_2; F:AM 87419, dP^3. Near *Stegomastodon* Quarry: F:AM 25064, M_2. Sand Draw: F:AM 87422, symphysis, alveoli of right and left incisors and P_1; F:AM 87423 (table 17), an astragalus, at an elevation of 2300 feet in the lowermost part of the Keim Formation.

MEASUREMENTS (IN MM.): F:AM 25058: metatarsal (lacking epiphyses) 371.5; estimated length 395; greatest anteroposterior width, 35.5; greatest transverse width 26.7.

DISCUSSION: The mandible (F:AM 25063) of a young adult male is larger than the type of *Tanupolama americana* (Wortman, 1898), but is about the size of *T. blancoensis* Meade, 1945, except that it (F:AM 25063) has more hypsodont teeth. A small P_3 is present on the right side (fig. 55A).

TABLE 17

MEASUREMENTS (IN MILLIMETERS) OF ASTRAGALI OF *Gigantocamelus*, *Camelops*, AND *Tanupolama* FROM THE KEIM FORMATION

	Length[a]	Width[a]
Gigantocamelus sp.		
F:AM 24900	108.0	68.5
Camelops sp.		
F:AM 87413	80.5	55.7
Tanupolama sp.		
F:AM 87423	62.9	42.5

[a]Greatest length and width measurements were made at the same points by orthogonal projection.

TABLE 18
MEASUREMENTS (IN MILLIMETERS) OF THE LOWER JAWS AND DENTITIONS OF *Tanupolama* SP., *Tanupolama americana*, AND *Tanupolama blancoensis*

	Tanupolama sp. F:AM 25063 (W2)[b]	*T. americana* AMNH 2784[a] (W1)[b]	*T. blancoensis* BEG 31181–126[a]
Width across right I_1 and I_2	23.8	18.7	—
Canine			
Greatest anteroposterior length	10.0	8.3	—
Greatest transverse width	6.8	4.0	—
Median length, tip of incisors to posterior border of condyle	320.0	—	—
P_1–P_4 diastema	55.9	61.0	—
P_1–Canine diastema	7.5	12.0	—
P_1			
Length	12.0	7.7	—
Width	6.8	3.7	—
P_3			
Length	6.4	—	—
Width	5.0	—	—
P_4			
Length	14.5	15.2	18.0
Width	8.8	8.7	8.9
M_1			
Length	19.4	15.8	26.6
Width	15.5	14.3	15.4
M_2			
Length	26.8	24.0	32.5
Width	17.6	14.3	16.8
M_3			
Length	40.2	33.2	40.0
Width	14.9	13.2	15.0
P_4–M_3 occlusal length	101.0	88.0	—
P_4–M_3 alveolar length	103.0	90.5	—

[a]Holotypes.
[b]Wear, from Skinner (1942, p. 189): W1, anterior fossette of first molar worn away and posterior fossette wearing smaller; W2, posterior fossette of first molar gone and anterior fossette of second molar wearing smaller.

FAMILY CERVIDAE

The distal end of a large right tibia (F:AM 87409) was taken from the Keim Formation in the type area of the Sand Draw local fauna. The maximum transverse width of the distal end of the tibia is 43.0 mm. and the maximum anteroposterior width is 31.0 mm. At the distal end it is the size of *Rangifer* Smith, 1827.

FAMILY ANTILOCAPRIDAE

Antilocaprid sp.

REFERRED MATERIAL: Keim Formation, Brown County, Nebraska: *Stegomastodon* Quarry: F:AM 31749, right ramus. Prospecting Locality 277, W. ½, NW. ¼, sect. 25, T. 31 N., R. 22 W.: F:AM 87411, distal end of radius and ulna. Prospecting Locality 278, NW. ¼, SE. ¼, sect. 12, T. 30 N., R. 21 W.: F:AM 87410, distal end metapodial.

MEASUREMENTS (IN MM.): F:AM 31749: P_2–M_3 occlusal length 63.7. F:AM 87410: metacarpal, greatest transverse width distal end 29.7; greatest anteroposterior width 14.9; F:AM 87411, distal end, greatest transverse width 25.7; greatest anteroposterior width 19.6.

ORDER PERISSODACTYLA

MORRIS F. SKINNER

FAMILY EQUIDAE

GENUS *NANNIPPUS* MATTHEW, 1926

Hipparion (*Nannippus*) MATTHEW, 1926, p. 165.

?*Nannipus* sp.: STIRTON, 1933, p. 572 (First elevation to generic rank, but used in reference to *Nannippus gratus*.)

TYPE SPECIES: *Nannippus phlegon* (Hay, 1899).

DISTRIBUTION: Late Pliocene (Hemphillian) to early Pleistocene, North America. ?Late Pleistocene, Florida.

DIAGNOSIS: See Matthew, 1926, and Stirton, 1940, pages 185–186.

Nannippus phlegon (Hay, 1899)
Figure 56

Equus minutus COPE, 1893, pp. 67–68, fig. 8 (a homonym).

Equus phlegon HAY, 1899, p. 345 (replacement for Cope's homonym).

TYPE: BEG 18586, lower molar. Cope (1893, p. 67) stated that the type specimen "came from near the middle of the series from Mount Blanco." Mount Blanco is in Crosby County, Texas. Most authors believe the type was collected from the Blanco Formation (early Pleistocene).

DIAGNOSIS: Same as for genus.

REFERRED MATERIAL: Long Pine Formation, Chicago and Northwestern Railroad Gravel Pit (fig. 7), Brown County, Nebraska: F:AM 87436, a left M^3, sectioned.

MEASUREMENTS (IN MM.): F:AM 87436 (fig. 56A, B): left M^3 length on crown 21.5; length 11 mm. below crown 20.1; width on crown 15.0; width 11 mm. below crown 17.5; height, greatest preserved 71.5; estimated height 81.0.

DISCUSSION: This distinctive group of small *Hipparion*-like equids (i.e. upper molars with isolated protocones) is poorly known. The type lower molar (BEG 18586) is partial, but shows the distinctive characters of small size, greatly expanded metaconid-metastylid column, and thin investment of cement. In 1924 Matthew collected additional associated specimens from a small pocket at the type locality, Mount Blanco, Crosby County, Texas, that included a partial skull, several jaws, detached teeth, and isolated limb elements. The dentition shows the characters of the type; the referred metapodials are slender and antelope-like. Other dentitions and limb elements have been found in widely separated localities in Arizona, Nebraska, Kansas, Texas, Old Mexico, and Honduras. A private collector, Roy Burgess, has presented me with a partial lower jaw of *Nannippus* sp. that he collected from a canal bank (*in situ*) near Port Charlotte, Florida.

The practice of assigning all small forms of *Hipparion*-like equids to *Nannippus* without careful consideration of other characters clouds the relationship of many of the dwarf forms and prevents the recognition of true *Nannippus*. For example, *Griphippus gratus*, which has quite different skull, dental, and postcranial characters, has often been assigned to *Nannippus*.

GENUS *EQUUS* LINNAEUS, 1758a

I include most of the Pleistocene and all living horses in the genus *Equus* because the morphological similarities are obvious. In order to compare clusters of closely related extinct and living species I have used previously named generic and subgeneric groups and treated them as subgenera of *Equus*. Some authors have separated taxonomically distinct Pleistocene equids without noting the morphologic similarity to living forms. In fact nearly every living species and some varieties have been made the type species of genera and subgenera. In view of the relatively short time covered by the Pleistocene it seems reasonable to infer that certain species groups of *Equus* have existed for some 3½ million years. *Mesohippus* is recognized over a span of some 15 million years and *Pliohippus* about nine million. The paleontologist working with bones and the neomammalogist working primarily with external characters (hide) and geographic distribution must reach a compromise if the recently extinct (Pleistocene) and living equids are to have taxonomic stability.

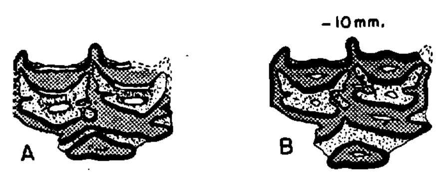


FIG. 56. *Nannippus phlegon*, left M^3, F:AM 87436. A. Occlusal crown view. B. Sectioned M^3, occlusal view. ×1.

SUBGENUS *DOLICHOHIPPUS* (HELLER, 1912)

Equus (*Megacephalon*) HILZHEIMER, 1912a, June 5, p. 83 (*Megacephalon*, the name of a bird, and therefore a homonym. Would have had five months priority over *Dolichohippus*).

Dolichohippus HELLER, 1912 (November 2, p. 1; here treated as a genus).

Equus (*Grevya*) HILZHEIMER, 1912b, November 29, p. 476 (Hilzheimer corrected his homonym, but Heller's name, *Dolichohippus*, had been published 27 days earlier).

Equus (*Ludolphozecora*) GRIFFINI, 1913, p. 382 (Griffini attempted to correct Hilzheimer's homonym).

Plesippus MATTHEW, 1924, p. 1 (Cope's species, *Equus simplicidens* and Merriam's *E. proversus* cited as examples [syntypes]. Gazin, 1936, p. 292, fixed the type species as *Plesippus simplicidens*).

Megacephalonella STRAND, 1943, p. 216 (Strand, unaware of the 30-year-old homonym, corrected Hilzheimer's name, *Megacephalon*).

TYPE SPECIES: *Equus grevyi* Oustalet, 1882. Quinn (1955, p. 46) erroneously cited *E. grevyi* as the genotypic species of *Hippotigris*. The type of *Hippotigris* is *H. zebra* Smith, 1841, the living mountain zebra.

DISTRIBUTION: Extinct in Pleistocene, North America; living, Ethiopia and northern Kenya.

DIAGNOSIS: See Heller, 1912, pages 1–3.

Equus (*Dolichohippus*) is compared here to these subgenera of *Equus*: Living *E.* (*Equus*), *E.* (*Hippotigris*) or mountain zebra, *E.* (*Pseudoquagga*) or plains zebra, *E.* (*Hemionus*) or Mongolian kiang, and *E.* (*Asinus*). Extinct *E.* (*Quagga*), *E.* (*Amerhippus*), *E.* (*Hesperohippus*), and *E.* (*Tomolabis*). In comparison to these, *E.* (*Dolichohippus*) is longer headed has a wider, heavier, more posteriorly extended occipital region, and a longer, slenderer rostral region, a nasal notch that is more completely formed within the nasal bone, and canines that show a stronger degree of sexual dimorphism (i.e. very large in males and very small in females).

The presence or lack of cups in I_3, although a useful character for specific separation, is not applicable for subgeneric separation of equids. The mountain zebra, *E.* (*Hippotigris*) *zebra*, has cups in all lower incisors in contrast to the plains zebra, *E.* (*Pseudoquagga*) *burchelli antiquorum*, which resembles *E.* (*Amerhippus*) *andium* in having no cups in the lower incisors. Hoffstetter (1950) used this character (no cups in lower incisors) to distinguish his genus *Amerhippus* and his subgenus *E.* (*Pseudoquagga*). Lower incisors one and two of *E.* (*Dolichohippus*) have deep cups, but I_3 may have a cup or a deep lingual V-shaped notch, a combination that is also present in *E.* (*Hemionus*) and *E.* (*Asinus*).

LIMBS: The ulna of living *E.* (*Dolichohippus*) remains a distinct entity for the entire length of the radius, a condition not observed in other subgenera of *Equus*. One example (AMNH(M) 82037) has a complete fibula, but this may be an anomaly. Metapodials of *E.* (*Dolichohippus*) are heavy and have longer, less reduced laterals than other subgeneric groups of *Equus*. Such characters suggest primitive limb development.

Equus (Dolichohippus) simplicidens
(Cope, 1892), new combination
Figure 57

Equus simplicidens COPE, 1892b (February), p. 124.

Plesippus simplicidens (Cope): MATTHEW, 1924, p. 12.

Plesippus proversus (Merriam, 1916): MATTHEW, 1924, p. 12.

Plesippus shoshonensis GIDLEY, 1930, p. 301.

Hippotigris simplicidens (Cope): McGREW, 1944, p. 55.

Equus (*Plesippus*) *simplicidens* Cope: HOWE, 1970, p. 959.

TYPE: TMM 40282–6, left M^1 collected by W. T. Cummins from "a white siliceous friable chalk . . . highly diatomaceous" (Cope, 1892b, p. 123), Blanco Formation, Crosby County, Texas. For illustration, see Cope, 1892, figure 1.

DISTRIBUTION: Late Pliocene, Glenns Ferry Formation, Twin Falls County, Idaho. Early Pleistocene: Blanco Formation, Crosby County, Texas; Keim Formation, pre-Nebraskan glaciation; Long Pine Formation, Nebraskan glacial outwash and Duffy Formation, interstadial; Brown County, Nebraska; Broadwater Formation, Lisco Member, Morrill and Garden counties, Nebraska; Ballard Formation, Meade County, Kansas.

The similarities between skulls and dentitions of the extinct North American *Equus* (*Dolichohippus*) *simplicidens* and living *E.* (*D*). *grevyi* are so marked that I consider *Plesippus* a junior synonym of *E.* (*Dolichohippus*). Such differences as exist are mainly those of the skull, but when temporal and geographic separation are considered, these differences seem slight, barely of specific value. In superficial characteristics *E.* (*D.*) *grevyi* resembles a mule with a very long head and ears, but divested of the soft parts and hide, the skull, teeth, and postcranial elements indicate that it was a direct descendant of the extinct equids found in the North American Pleistocene.

ADDITIONAL DIAGNOSIS: The occipital region of *E.* (*D.*) *grevyi* is more expanded posteriorly and broader transversely than *E.* (*D.*) *simplicidens* and permits a larger area for muscular attachments. A distinct but shallow naso-maxillary fossa is present in all examples of *E.* (*D.*) *simplicidens*; in *E.* (*D.*) *grevyi* this is a barely discernible preorbital depression. The position of the nasal notch of *E.* (*D.*) *grevyi* is above the suture of the nasal and premaxillary bones, whereas in *E.* (*D.*) *simplicidens* (e.g. AMNH 32551, 20077), the nasal notch is at the suture. Cranial elongation, nasal retraction, skull size, and placement of orbits in relation to dentition, are similar in both species.

With the exception of the occipital region, skull measurements of referred *E.* (*D.*) *simplicidens* are within the observed range of eight *E.* (*D.*) *grevyi* specimens. This is a small sample for a living population and is probably biased by "hunter's selection." A statistical population study based on a large sample of both taxa would probably show minor differences as well as many similarities.

Dental Nomenclature

A brief discussion is inserted here to clarify my nomenclature of the lower dentition of *Equus* (*Dolichohippus*) sp. and *E.* (*Hemionus*) sp. It by no means covers the subject. Many authors have applied names to the myriad parts of equid teeth, yet these are only a few of the names still needed to explain the intricacies of equid dental evolution.

In the present paper figures 57A and B and 58B illustrate the various parts of the lower dentition of *Dolichohippus* and *Hemionus*. Figure 57A shows the components of the teeth and the order of their development as follows: (1) Enamel (may be considered analagous to the skeleton) is the first part of the tooth to take shape within the dental sac. (2) Dentine is the internal filling of the enamel skeleton. (3) Cement (also known as cementum) is the bony covering that reinforces the outside of the tooth. It is deposited on the teeth just before and after eruption.

I separate lower dental parts (conids, stylids, commissures, and plicids) from dental folds, which are infoldings of enamel surfaces resulting from change in shape and size of dental parts. These infoldings are usually filled with cement in later forms of horses (fig. 57A).

I further separate lower dental parts into two categories: primary and secondary. Primary parts are conids and stylids. Secondary parts are commissures and plications (plicids in lower teeth). Commissures appear on the occlusal pattern as enamel-bordered isthmuses (fig. 57B) that link conids and stylids. Isthmuses reflect the basic arrangement by which the primary parts are united.

Following are the isthmuses represented in this report: (1) A plain isthmus (fig. 57B, P_4) is formed whenever the protoconid is united to the metaconid and the hypoconid is united to the posterior part of the protoconid. (2) Antro-isthmus unites the protoconid to the metaconid (e.g. M_1, fig. 57B) and only when the hypoconid is united to the metastylid. (3) Postisthmus unites the hypoconid to the metastylid (e.g. M_1, fig. 57B) only when the protoconid is united to the metaconid as in (2) above. (4) Meta-isthmus is the enamel bar that unites the metaconid to the metastylid (e.g. M_1, fig. 57B) after these have separated and become distinct entities.

Plications (plicids in lower teeth) are outfoldings of enamel that originate on the surface of any part of either upper or lower dentition. Plications add greatly to the complexity of the dental pattern. The most persistent of these has been named "plicaballinid" in the lower dentition (P_3, fig. 58B).

Fossetids seldom occur in the lower dentition of equids, although the fossettes in the upper teeth are part of the standard pattern of most post-Miocene horses. I have illustrated a fossetid (fig. 58F) on the crown pattern of DP_2. Here the cement-filled preflexid has been enclosed by the junction of the metaconid and paraconid.

Upper Dentition: A comparison of upper cheek teeth of *E.* (*Dolichohippus*) *simplicidens* and *E.* (*D.*) *grevyi* shows only minor differences. Some examples of *E.* (*D.*) *grevyi* teeth have slightly longer protocones with more distinct lingual folds than those of *E.* (*D.*) *simplicidens*. On the other hand some examples of *E.* (*D.*) *grevyi* teeth have small protocones that match those of *E.* (*D.*) *simplicidens*.

The hypoconal groove of the extinct *E.* (*D.*) *simplicidens* does not extend so far down the tooth as in *E.* (*D.*) *grevyi*, and as a result the hypoconal fossettes are more frequently observed on the crown pattern of the premolars in *E.* (*D.*) *simplicidens*. Closure of the hypoconal groove below the crown, however, is not sufficient reason for specific or even varietal categories. In

TABLE 19

MEASUREMENTS (IN MILLIMETERS) OF SKULLS OF *Equus* (*Dolichohippus*) *simplicidens* AND *Equus* (*Dolichohippus*) *grevyi*

	E. (*D.*) *simplicidens* AMNH 20077♀[b]	AMNH 32551♀[c]	*E.* (*D.*) *grevyi*[a] Minimum	Average	Maximum
Median, foramen magnum to incisive border (basilar)	(532.0)[d]	538.0	537.5	550.0	570.0
Median, occiput to anterior incisive border (over all)	(614.0)	604.0	591.0	610.0	634.0
Postorbital process to anterior incisive border (facial)	(421.0)	409.0	401.0	415.0	425.0
Postorbital process to occiput (cranial)	(193.0)	196.0	187.0	197.0	208.0
Median, occiput to nasal notch	441.0	432.0	436.0	445.0	467.0
Median, foramen magnum to vomer	102.0	—	120.0	130.0	137.0
Median, foramen magnum to postpalatine border	237.0	256.0	255.0	264.0	273.0
Median, anterior P^2 to incisive border (muzzle)	(140.0)	145.0	139.0	149.0	153.0
Narrowest part of muzzle on palatal side	(66.0)	38.0	41.0	42.5	50.0
Widest part across postorbital rims	—	208.0	201.0	212.0	218.0
Width across temporal condyles	—	200.0	195.0	206.0	217.0
Widest part across zygoma	—	199.0	206.0	212.0	220.0
Narrowest part across zygoma	—	183.0	176.0	185.0	190.0
Width across occipital condyles	80.0	83.0	77.0	80.1	82.0
Depth, top of occiput to bottom of condyles	116.0	92.0	108.0	112.0	116.0
Depth, plane of nasals to alveolar border P^2	(107.0)	110.0	96.0	101.0	107.0
Depth, plane of frontals to alveolar border M^3	(135.0)	131.0	140.0	142.5	149.0
Width at mastoid-occiput suture	62.0	64.0	75.0	83.8	89.0
Top of foramen magnum to top of nuchal crest	71.0	64.0	72.0	74.2	77.0
Width at posterior process squamosal on temporal	—	111.0	112.0	116.5	126.0
Postpalatine border to postpalatine fissure	(165.0)	153.0	137.0	147.0	154.0
Incisive border to posterior border palatine fissure	(141.0)	132.0	134.0	140.5	144.0
Nasal notch to posterior angle zygoma	(347.0)	328.0	330.0	340.0	357.0
Incisive border to anterior facial crest	(254.0)	240.0	240.0	263.0	259.0
Incisive border to posterior angle zygomatic arch	(519.0)	501.0	489.0	508.0	524.0

[a]Eight mature examples of *E.* (*D*) *grevyi* were measured: AMNH(M) 82036 ♂, 82037 ♂, 82038 ♀, 54247 ♂, 54286 ♂, and 54285 ♀; CM 213 ♀, 184♂.

[b]Skull from Mt. Blanco, Crosby County, Texas, that Matthew, 1924 used to establish the genus *Plesippus*.

[c]Skull from the Hagerman, Idaho horse quarry referred by Gazin, 1936, to *Plesippus shoshonensis*.

[d]Parentheses around a measurement indicates approximation.

the sample of *E.* (*D.*) *simplicidens* the dP^1 is larger and persists into older age than that of *E.* (*D*). *grevyi*, a character also observed in other earlier equids.

LOWER DENTITION: The characters of the lower cheek teeth of *E.* (*D.*) *grevyi* and *E.* (*D.*) *simplicidens* show no differences that separate them into two subgeneric populations. The characters of the lower molars of *Dolichohippus* species, however, readily separate it from all the *Hemionus* species and asslike equids. The lower premolars of these groups are very similar.

In figure 57 showing the occlusal pattern of *Dolichohippus*, note that the protoconid is united to the metaconid by an antero-isthmus, the hypoconid to the metastylid by a post-isthmus, and the metaconid to the metastylid by a meta-isthmus. In the facing figure 58 of *Hemionus*, M_1–M_2 and usually M_3 have the protoconid united to the metastylid by a plain isthmus the hypoconid to the posterior part of the protoconid-isthmus complex, and the metastylid, remaining free from the hypoconid, united only to the metaconid. Occasionally M_3 of *Hemionus* (particularly *E.* (*H.*) *conversidens*) assumes the caballid type of junction (fig. 57, i.e. hypoconid-metastylid union).

The arrangement of the isthmuses on the lower molars readily separate the hemionid and asinid groups from the zebrid and caballid horses. *Hemionus* and *Asinus* usually carry

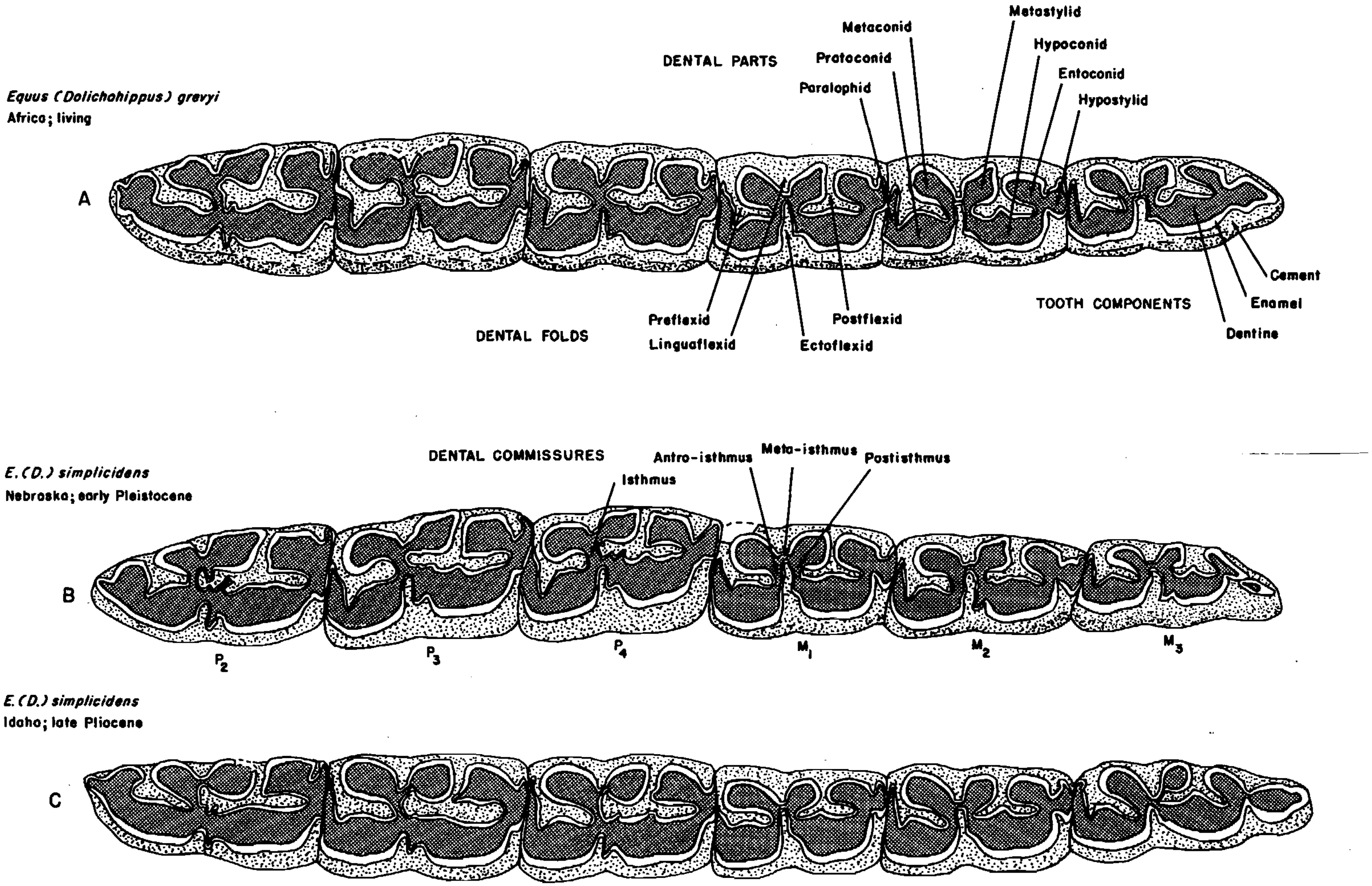


FIG. 57. A. *Equus* (*Dolichohippus*) *grevyi*, left P_2–M_3, AMNH(M) 54247. Occlusal view, showing dental parts and dental folds. B, C. *Equus* (*Dolichohippus*) *simplicidens*. B. Left P_2–M_3, F:AM 87440. Occlusal view showing dental commissures. C. Left P_2–M_3, AMNH 32551. Occlusal view. All × 1. See page 120 for explanation.

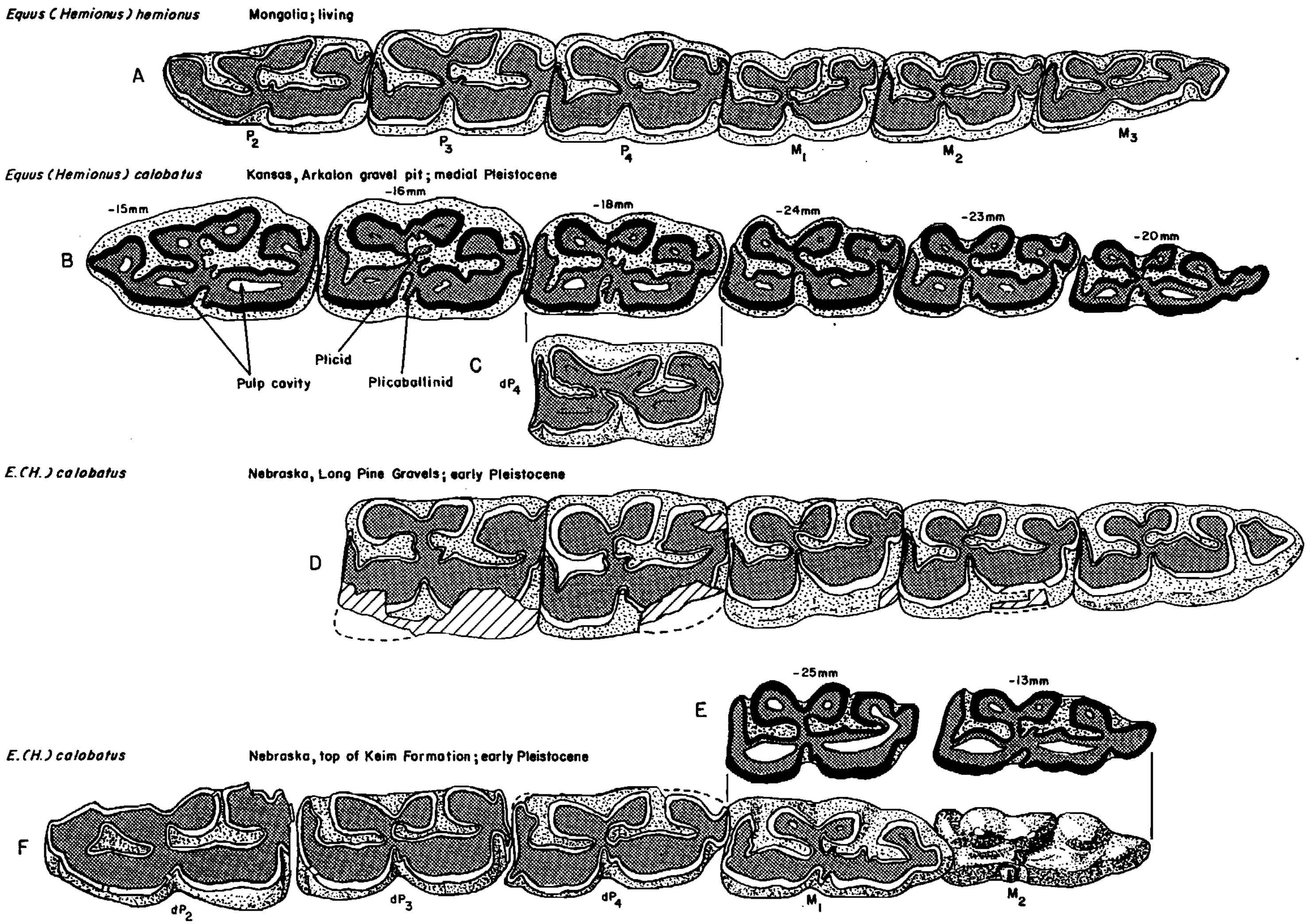


FIG. 58. A. *Equus* (*Hemionus*) *hemionus*, left P_2–M_3, AMNH(M) 57213. Occlusal view. B–F. *Equus* (*Hemionus*) *calobatus*. B. Left P_2–M_3, F:AM 87459, sectioned to show mature pattern. Occlusal view. C. Left dP_4, F:AM 87459. Occlusal view. D. Left P_3–M_3, F:AM 87433. Occlusal view. E. M_1 and M_2, F:AM 87441, sectioned to show mature pattern. Occlusal view. F. dP_2–M_2, F:AM 87441. Occlusal view. All $\times 1$. See page 120 for explanation.

isthmuses throughout P_2–M_3 (note exception above), whereas *Dolichohippus*, all other zebras (*sensu lato*), and caballid horses carry antero-isthmuses and post-isthmuses on M_1–M_3, the exception being *E. przewalskii* which usually has an isthmus on M_3. Some groups of North American Pleistocene equids have asslike patterns (e.g. *Amerhippus*) but differ from the ass in having no cups in the lower incisors.

Referred Material Used in this Report: Blanco Formation, Crosby County, Texas: AMNH 20077, a skull, partly restored (used by Matthew, 1924, as his example of *Plesippus simplicidens*).

Glenns Ferry Formation, Horse Quarry, Twin Falls County, Idaho: F:AM 32551, skull and mandible. An example from a large population sample used by Gazin, 1936.

Keim Formation, Brown County, Nebraska: Sand Draw: FM P14973, left P^2–M^3; FM P26163, left P_2–M_3, upper part of formation (McGrew, 1944, fig. 19); F:AM 87428, partial skull and mandible, 2 feet below the contact of the Keim Formation with the Long Pine Gravel; F:AM 87443, partial palate, 5 feet below the Long Pine Gravel; F:AM 87449, associated upper and lower teeth. Sand Draw Quarry: F:AM 87447, an immature partial mandible. *Stegomastodon* Quarry: F:AM 87450, immature left ramus; F:AM 87454, left metatarsal; F:AM 87451, right metacarpal. Vicinity of *Stegomastodon* Quarry, base of Keim Formation: F:AM 87448, partial mandible. Lee Magill ranch: F:AM 87438, partial skull associated with *Stegomastodon primitivus* (F:AM 25725B), from a limy calcareous clay or marl; F:AM 87434, right partial ramus from 20 feet above the marl; F:AM 87444, right maxillary dentition; F:AM 87440, mandible from a tributary canyon of Willow Creek just below the Long Pine Gravel and above the marl. West Fork of Deep Creek, base of formation: F:AM 87429, palate and premaxilla with closely associated left metatarsal. Head of West Fork of Deep Creek, lower part of Keim Formation; F:AM 87437, partial femur, right patella, left metatarsal, first and second phalanges, and carpals.

Long Pine Formation, Lee Magill ranch: F:AM 87432, fragment of a right ramus; F:AM 87435, an upper molar.

Duffy Formation, Sand Draw, at a road cut above the Long Pine Formation: F:AM 87430, partial right ramus.

SUBGENUS *EQUUS (HEMIONUS)* STEHLIN AND GRAZIOSI, 1935[1]

Type Species: *Equus hemionus* Pallas, 1775. (Living kiang.)

Distribution: Pleistocene, North American. Living in Asia.

Additional Diagnosis: Very small, light occipital region; lower cheek teeth with single distinct isthmus uniting metaconid-metastylid column with protoconid and hypoconid. See figure 58A.

Discussion: The Mongolian kiang was widely distributed on the high plains of North America during the Pleistocene and still survives in parts of Asia. Skull and lower dental characteristics and proportions of the long slender limbs, separate them distinctly from other equid subgenera. In North American Pleistocene collections examples of the kiang have been described as *Equus conversidens*, *E. conversidens leoni*, *E. francisi*, and *E.* (*Asinus*) *calobatus*. Undescribed specimens in the Frick Collection assignable to the subgenus *Hemionus* have been found in deposits from near Hay Springs, Nebraska; Arkalon, Kansas; Red Knolls near Safford, Arizona; Laguna Indian Reservation, Valencia County, New Mexico; Dallam County, Texas; and Fairbanks, Alaska.

Specimens from the early Pleistocene deposits in Brown County, Nebraska, show that *E.* (*Hemionus*) was contemporaneous with *E.* (*Dolichohippus*). In the present paper, figure 58A–F illustrates the similarities between the lower dental series of *E.* (*Hemionus*) *calobatus* (extinct) and *E.* (*H.*) *hemionus* (living). Figure 57A–C on the opposite page, shows how these dentitions differ from extinct and living examples of *E.* (*Dolichohippus*). These figures also show the similarity between the premolars and the difference between the molars of both subgeneric groups. Sectioned molars illustrate the modes in which the metaconid-metastylid column joined

[1] Simpson, 1945, p. 137, attributed the generic use of *Hemionus* to F. Cuvier, 1823, but gave no reference in the bibliography. In the Dictionnaire des Sciences Naturelles (Cuvier, 1821, p. 555) is a reference to "HEMIONUS" [*sic*] with a specific definition: "The name of a species of horse. See horse. (F.C.)" In all volumes of this dictionary, words to be defined were written in capital letters, which does not constitute generic usage.

the protoconid and hypoconid and remained constant from crown to near the root.

Equus (*Hemionus*) *calobatus* Troxell, 1915
Figure 58B–F

Equus (*Asinus*) *calobatus* TROXELL, 1915, p. 619.

LECTOTYPE: Troxell based his species, *E.* (*H.*) *calobatus*, on a syntypic series of a left tibia, metatarsal, astragalus, a right metacarpal, several phalanges, and vertebrae all under YPM 13470. As first revisor, Hibbard (1953, legend for fig. 2) selected the "right" metatarsal (but as figured, a left metatarsal) as the lectotype, YPM 13470 (field and accession numbers, 208, 3196) to stand for the type of *E.* (*Hemionus*) *calobatus*. See Troxell, 1915, figure 4, number 1.

TYPE LOCALITY: Quarry 1 near the *Equus scotti* Quarry of Gidley, 1900, at the head of Rock Creek, NE. ¼, sect. 208, Blocks G–M and A, Briscoe County, Texas, *fide* Troxell, 1915, figure 1.

DISTRIBUTION: Early Pleistocene, Brown County, Nebraska; medial Pleistocene, Seward County, Kansas and Briscoe County, Texas; and early Sangamon (interglacial), Meade County, Kansas.

DIAGNOSIS: Same as for genus.

REFERRED MATERIAL: Brown County, Nebraska, Lee Magill ranch, upper part of Keim Formation, 20 feet above marl: F:AM 87441, left ramus with dP_2–dP_4, M_1–M_2 sectioned; Sand Draw, Long Pine Formation: F:AM 87431, partial mandible, lacking symphysis, left P_2 (alveolus)–P_4 with detached lower molar; F:AM 87433, left ramus with P_3–M_3. Seward County, Kansas, from medial Pleistocene site lying north and within junction of road to Arkalon and U.S. Highway 54, north of the Chicago, Rock Island and Pacific railroad tracks in sect. 35, T. 33 S., R. 32 W., from a silty ash above the gravels: F:AM 87459, left ramus with P_2–M_3 (dP_4 not shed), right P_2–M_3 sectioned, detached incisors and postcranial elements that include right humerus, radius and ulna, carpals, metacarpal, proximal phalanx and second phalanx, right femur, tibia, astragalus, calcaneum, tarsals, metatarsal, proximal phalanx and left astragalus, calcaneum, and tarsals, all of one individual. This specimen was collected by George Sternberg and George Pearce in the spring of 1934, in the head of a short canyon tributary to the Cimarron River. The site is the same as that reported by Hibbard (1953) who collected specimens from the vicinity of a large abandoned gravel pit in the W. ½, sect. 35, T. 33 S., R. 32 W., Seward County, Kansas. Hibbard (1953, p. 114) in reference to specimens from the site, wrote: "These vertebrates and invertebrates associated with the Pearlette ash member can be tentatively assigned to the latest Kansan, provided there were only four major continental glaciations during the Pleistocene."

DESCRIPTION: In the immature left ramus (F:AM 87441, fig. 58F) a strong ectoparastylid extends to the base of dP_4; a weak plihypoconid is present on dP_{3-4} and is also present on M_{1-2} but is rapidly reduced with wear; at 25.0 mm. below the crown of M_1 the plihypoconid is lost and disappears 30.0 mm. below the crown of M_2; ectoflexids on the deciduous premolars are shallow and do not separate the metaconid-metastylid column, which is united to the protoconid and hypoconid by a single isthmus; the metaconid-metastylid column on M_{1-2} is also united to the protoconid and hypoconid by a single isthmus.

An adult individual of *E.* (*H.*) *calobatus* (F:AM 87433, fig. 58D) has a metastylid similar to a living kiang (AMNH(M) 117569) but is much less similar in this same character to another living kiang (AMNH(M) 57213). Apparently the shape of the metastylid is subject to some variation and is not a distinct character that warrants specific or even varietal separation.

DISCUSSION: Unfortunately the dentition of the stilt-legged *Equus* (*Hemionus*) *calobatus* was not recognized in the type locality at Rock Creek, Texas. The lower dentition and articulated fore and hind limbs of one individual (F:AM 87459) that came from the Arkalon, Kansas site of Hibbard's (1953) three metatarsals, represents one of the two known (or reported) associations of dental and limb characters of this taxon. The first report was by Schultz (1969, pp. 65–66, fig. 8A, D) who recorded the youngest known Pleistocene occurrence of *E.* (*H.*) *calobatus* from the early Sangamon Kingsdown Formation, Big Springs Ranch, Meade County, Kansas. This specimen is a constituent of the Cragin Quarry local fauna and consists of a first and questionably a second phalange and a right lower jaw that Schultz (1969, fig. 8D) referred only to the subgenus *E.* (*Hemionus*), but which I would refer tentatively, at least, to *E.* (*H.*) *calobatus*.

Equus (*Hemionus*) cf. *conversidens* Owen, 1869
Equus conversidens Owen, 1869, p. 563, pl. 61, fig. 1.

Referred Material: F:AM 87480, single water-worn metacarpal, from the talus of the Sand Draw, Brown County, Nebraska (fig. 7). A firm geological assignment cannot be made, except to state that the metacarpal is from the early Pleistocene deposits in the area.

Measurements (in Mm.): F:AM 87480, metacarpal: length 240; medial width 30; estimated distal width 39.8; proximal width 40.

Discussion: The specimen is too slender to be assigned to *Equus* (*Dolichohippus*) *simplicidens* and too short to be assigned to *E.* (*Hemionus*) *calobatus*; both are in the Pleistocene deposits in the area. The metacarpal is, however, easily matched by specimens from a population sample (over 50) of *E.* (*Hemionus*) *conversidens* from Dallam County, Texas. Skull, mandible, and other limb elements of *E.* (*Hemionus*) *conversidens* are also present at the Dallam County site. The upper dentitions of specimens found there are specifically assignable to *E. conversidens*, comparing well with Owen's holotype. The lower dentition of the Dallam County collection compares better with living *Hemionus* than with *Asinus*.

In 1942 I figured a complete *E.* (*Hemionus*) *conversidens* skull from the late Pleistocene Papago Springs Cave fauna, near Sonoita, Arizona, and erroneously assigned some heavy metapodials to *E. conversidens*. I also assigned a slender phalanx in the fauna to *Equus tau*. Later studies of living and extinct *Equus* in the American Museum of Natural History Mammal and Frick collections have convinced me that the Papago Springs Cave phalanx should be assigned to *E. conversidens* and that the heavy limbs represent another form of *Equus* for which we found no dentition.

TABLE 20
Occurrence of Mammals in Blancan Faunas in the Great Plains Province and Idaho

	Pleistocene							Pliocene	
	Nebr. 2317–2480 ft. Sand Draw	Nebr. 3900–3950 ft. Broadwater	Kans. 2510 ft. Deer Park	Kans. 2580 ft. Sanders	Kans. 1570 ft. Dixon	Texas 3400 ft. Cita Canyon	Texas 3200 ft. Blanco	Kans. 2480 ft. Rexroad	Idaho 2900–3400 ft. Hagerman
Class Mammalia									
Order Insectivora									
Family Soricidae									
Sorex taylori Hibbard[a]	—	—	—	—	—	—	—	*	—
Sorex leahyi Hibbard[a]	—	—	—	—	*	—	—	—	—
Sorex sandersi Hibbard[a]	X	—	—	*	—	—	—	—	—
Sorex hagermanensis Hibbard and Bjork[a]	—	—	—	—	—	—	—	—	*
Sorex meltoni Hibbard and Bjork[a]	—	—	—	—	—	—	—	—	*
Sorex powersi Hibbard and Bjork[a]	—	—	—	—	—	—	—	—	*
Sorex cf. *S. rexroadensis* Hibbard[a]	—	—	—	—	—	—	—	—	X
Sorex sp.	X	X	—	—	X	—	—	—	—
Planisorex dixonensis (Hibbard), new genus[b]	X	—	—	—	*	—	—	—	—
Paracryptotis gidleyi (Gazin)[b]	—	—	—	—	—	—	—	—	*
Blarina sp.	—	—	—	—	X	—	—	—	—
Family Talpidae									
Hesperoscalops rexroadi Hibbard[b]	—	—	—	—	—	—	—	*	—
Scalopus aquaticus (Linnaeus)	X	—	—	—	—	—	—	—	—
Scapanus sp.	—	—	—	—	—	—	—	—	X
Talpid sp.	—	—	—	—	—	X	—	—	X
Order Chiroptera									
Family Vespertilionidae									
Lasiurus fossilis Hibbard[a]	—	—	—	—	—	—	—	*	—

TABLE 20-*(Continued)*

	Pleistocene Nebr. 2317–2480 ft. Sand Draw	Pleistocene Nebr. 3900–3950 ft. Broad-water	Pleistocene Kans. 2510 ft. Deer Park	Pleistocene Kans. 2580 ft. San-ders	Pleistocene Kans. 1570 ft Dixon	Pleistocene Texas 3400 ft Cita Canyon	Pleistocene Texas 3200 ft Blanco	Pliocene Kans. 2480 ft. Rex-road	Pliocene Idaho 2900–3400 ft. Hager-man
Order Lagomorpha									
Family Leporidae									
Hypolagus limnetus Gazin[b]	—	—	—	—	—	—	—	—	*
Hypolagus regalis Hibbard[b]	—	—	—	—	—	—	—	*	—
Hypolagus cf. *H. vetus* (Kellogg)[b]	—	—	—	—	—	—	—	—	X
Hypolagus sp. (large)[b]	—	X	—	—	—	X	X	—	—
Hypolagus sp. (small)[b]	—	—	X	—	—	—	—	—	—
Pratilepus kansasensis Hibbard[b]	—	—	—	—	—	—	—	*	—
Pratilepus vagus (Gazin)[b]	—	—	—	—	—	—	—	—	*
Hypolagus or *Pratilepus*[b]	X	—	—	—	—	—	—	—	—
Notolagus lepusculus (Hibbard)[b]	—	—	—	—	—	—	—	*	—
Nekrolagus progressus (Hibbard)[b]	—	—	—	—	—	—	—	*	—
Sylvilagus sp.	—	X	—	—	—	—	—	—	—
Order Rodentia									
Family Sciuridae									
Paenemarmota barbouri Hibbard & Schultz[b]	—	X	—	—	—	—	X	—	X
Cynomys meadensis Hibbard[a]	—	—	*	—	—	—	—	—	—
Cynomys sp.	—	X	—	—	—	—	—	—	—
Spermophilus howelli (Hibbard)[a]	—	—	—	—	—	—	—	*	—
Spermophilus cf. *S. howelli* (Hibbard)[a]	—	—	—	—	—	—	—	—	X
Spermophilus rexroadensis (Hibbard)[a]	—	—	—	—	—	—	—	*	—
Spermophilus boothi, new species[a]	*	—	—	—	—	—	—	—	—
Spermophilus johnsoni, new species[a]	*	—	—	—	—	—	—	—	—
Spermophilus meltoni, new species[a]	*	—	—	—	—	—	—	—	—
Spermophilus sp.[a]	—	X	X	—	X	—	—	—	X
Ammospermophilus or *Spermophilus* sp.	—	—	—	—	—	—	—	—	X
Family Geomyidae									
Thomomys gidleyi Wilson[a]	—	—	—	—	—	—	—	—	*
Pliogeomys parvus Zakrzewski[b]	—	—	—	—	—	—	—	—	*
Geomys (*N.*) *minor* Gidley[a]	—	—	—	—	—	—	—	X	—
Geomys (*G.*) *jacobi* Hibbard[a]	—	—	—	—	—	—	—	*	—
Geomys tobinensis Hibbard[a]	—	—	—	X	—	—	—	—	—
Geomys quinni McGrew[a]	*	X	X	—	—	—	—	—	—
Geomys sp.	—	X	—	—	X	X	—	—	—
Family Heteromyidae									
Perognathus gidleyi Hibbard[a]	—	—	—	—	—	—	—	*	—
Perognathus magnus Zakrzewski[a]	—	—	—	—	—	—	—	—	*
Perognathus maldei Zakrzewski[a]	—	—	—	—	—	—	—	—	*
Perognathus cf. *P. pearlettensis* Hibbard[a]	—	—	—	X	—	—	—	—	—
Prodipodomys centralis (Hibbard)[b]	X	—	—	X	—	—	—	*	—
Prodipodomys idahoensis Hibbard[b]	—	—	—	—	—	—	—	—	X
Dipodomys sp.	—	X	—	—	—	—	—	—	—
Family Castoridae									
Castor cf. *C. californicus* Kellogg	—	—	—	—	—	—	—	—	X
Dipoides rexroadensis Hibbard & Riggs[b]	X	—	—	—	—	—	—	X	—
Dipoides intermedius Zakrzewski[b]	—	—	—	—	—	—	—	—	*

TABLE 20-*(Continued)*

	Pleistocene							Pliocene	
	Nebr. 2317–2480 ft. Sand Draw	Nebr. 3900–3950 ft. Broad-water	Kans. 2510 ft. Deer Park	Kans. 2580 ft. San-ders	Kans. 1570 ft Dixon	Texas 3400 ft Cita Canyon	Texas 3200 ft Blanco	Kans. 2480 ft. Rex-road	Idaho 2900–3400 ft. Hager-man
Procastoroides sweeti Barbour & Schultz [b]	X	*	X	—	—	—	—	X	—
?*Procastoroides*	—	—	—	—	X	—	—	—	—
Family Cricetidae									
Sigmodon medius Gidley [a]	X	—	—	X	—	—	—	X	—
Onychomys gidleyi Hibbard [a]	—	—	—	—	—	—	—	*	—
Onychomys sp.	X	—	—	—	—	—	—	—	—
Symmetrodontomys simplicidens Hibbard [b]	—	—	—	—	—	—	—	*	—
Bensonomys eliasi (Hibbard) [b]	—	—	—	—	—	—	—	*	—
Bensonomys meadensis Hibbard [b]	X	—	—	*	—	—	—	—	—
Baiomys rexroadi Hibbard [a]	—	—	—	—	—	—	—	*	—
Baiomys aquilonius Zakrzewski [a]	—	—	—	—	—	—	—	—	*
Baiomys sp.[a]	—	—	—	—	—	—	—	—	X
Peromyscus baumgartneri Hibbard [a]	—	—	—	—	—	—	—	*	—
Peromyscus kansasensis Hibbard [a]	—	—	—	—	—	—	—	*	—
Peromyscus cf. *P. kansasensis* Hibbard [a]	X	—	—	—	—	—	—	—	—
Peromyscus hagermanensis Hibbard [a]	—	—	—	—	—	—	—	—	*
Peromyscus sp. [a]	—	X	—	—	X	—	—	—	—
Neotoma quadriplicatus (Hibbard) [a]	—	—	—	—	—	—	—	*	—
Neotoma cf. *N. quadriplicatus* (Hibbard) [a]	—	—	—	—	—	—	—	—	X
Neotoma sp. [a]	X	X	—	—	—	—	—	—	—
Ogmodontomys p. poaphagus Hibbard [b]	X	—	X	—	—	—	—	*	—
Ogmodontomys magilli, new species [b]	*	—	—	—	—	—	—	—	—
Nebraskomys rexroadensis Hibbard [b]	—	—	—	—	—	—	—	*	—
Nebraskomys mcgrewi Hibbard [b]	*	—	—	—	X	—	—	—	—
Cosomys primus Wilson [b]	—	—	—	—	—	—	—	—	*
Ophiomys taylori (Hibbard) [b]	—	—	—	—	—	—	—	—	*
Ophiomys meadensis (Hibbard) [b]	—	—	—	*	X	—	—	—	—
Ophiomys fricki, new species [b]	*	—	—	—	—	—	—	—	—
Pliophenacomys primaevus Hibbard [b]	X	—	—	—	—	—	—	—	—
Pliophenacomys sp. [b]	—	X	—	—	—	—	—	—	—
Pliopotamys minor (Wilson) [b]	—	—	—	—	—	—	—	—	*
Pliopotamys meadensis Hibbard [b]	X	—	*	—	X	—	—	—	—
Pliopotamys sp. [b]	—	X	—	—	—	—	—	—	—
Pliolemmus antiquus Hibbard [b]	X	—	*	X	X	—	—	—	—
Synaptomys (S.) rinkeri Hibbard [a]	—	—	—	—	*	—	—	—	—
Family Dipodidae									
Zapus s. sandersi Hibbard [a]	—	—	—	*	—	—	—	—	—
Pliozapus? sp. [b]	—	X	—	—	—	—	—	—	—
Order Edentata									
Family Megalonychidae									
Megalonyx leptostomus Cope [b]	—	—	—	—	—	X	*	—	—
Megalonyx sp. [b]	—	X	—	—	—	—	—	X	X
Family Mylodontidae									
Glossotherium sp. [b]	—	X	—	—	—	X	—	—	—
Family Glyptodontidae									
Glyptotherium texanum Osborn [b]	—	—	—	—	—	—	*	—	—
Glyptotherium cf. *G. texanum* Osborn [b]	—	—	—	—	—	X	—	—	—

TABLE 20-*(Continued)*

	Pleistocene							Pliocene	
	Nebr. 2317–2480 ft. Sand Draw	Nebr. 3900–3950 ft. Broad-water	Kans. 2510 ft. Deer Park	Kans. 2580 ft. San-ders	Kans. 1570 ft. Dixon	Texas 3400 ft. Cita Canyon	Texas 3200 ft. Blanco	Kans. 2480 ft. Rex-road	Idaho 2900–3400 ft. Hager-man
Order Carnivora									
Family Canidae									
Canis lepophagus Johnston[a]	X	—	—	—	—	*	—	X	X
Canis sp.	—	X	X	—	—	—	—	X	—
Urocyon progressus Stevens[a]	—	—	—	—	—	—	—	*	—
?*Urocyon* sp.	—	X	—	—	—	—	—	—	—
Borophagus diversidens Cope[b]	X	—	—	—	—	—	*	—	—
Borophagus sp.[b]	—	X	—	—	—	X	—	X	X
Family Ursidae									
Ursus abstrusus Bjork[a]	—	—	—	—	—	—	—	—	*
?*Ursus* sp.	—	—	—	—	—	X	—	—	—
Tremarctine sp.[a]	—	—	—	—	—	—	—	—	X
Family Procyonidae									
Bassariscus casei Hibbard[a]	—	—	—	—	—	—	—	*	—
Procyon rexroadensis Hibbard[a]	—	—	—	—	—	—	—	*	—
Procyon sp.	—	—	—	—	—	X	—	—	—
Family Mustelidae									
Mustela rexroadensis Hibbard[a]	—	—	—	—	—	—	—	—	X
Canimartes cumminsi Cope[b]	—	—	—	—	—	—	*	—	—
Ferinestrix vorax Bjork[b]	—	—	—	—	—	—	—	—	*
Trigonictis idahoensis (Gazin)[b]	X	X	X	—	—	—	—	X	*
Trigonictis cooki (Gazin)	X	—	—	—	—	—	—	—	*
Sminthosinis bowleri Bjork[b]	—	—	—	—	—	—	—	—	*
Taxidea cf. *T. taxus* (Schreber)	X	—	X	—	—	—	—	X	—
Taxidea sp.	—	X	—	—	—	X	—	—	X
Buisnictis breviramus (Hibbard)[b]	—	—	—	—	—	—	—	*	X
Buisnictis burrowsi, new species[b]	*	—	—	—	—	—	—	—	—
Buisnictis sp.[b]	—	—	X	—	—	—	—	—	—
Spilogale rexroadi Hibbard[a]	—	—	—	—	—	—	—	*	—
Mephitis sp.	—	X	—	—	—	—	—	—	—
Mustelid sp.	—	—	—	X	X	X	—	—	X
Satherium priscinaria (Leidy)[b]	X	—	—	—	—	—	—	X	X
Satherium p. middleswarti Barbour & Schultz[b]	—	*	—	—	—	—	—	—	—
Satherium sp. (large)[b]	—	—	—	—	—	—	—	X	—
Family Hyaenidae									
Chasmaporthetes johnstoni (Stirton & Christian)[b]	—	—	—	—	—	*	—	—	—
?*Hyaenid* sp.	—	—	—	—	—	—	—	—	X
Family Felidae									
Felis rexroadensis Stephens[a]	—	—	—	—	—	—	—	*	—
Felis lacustris Gazin[a]	—	—	—	—	—	—	—	X	*
Felis aff. *F.* (*Lynx*) *issiodorensis* (Croizet & Jobert)[a]	—	—	—	—	—	X	—	—	—
Felis studeri Savage[a]	—	—	—	—	—	*	—	—	—
Panthera palaeoonca Meade[a]	—	—	—	—	—	—	*	—	—
Lynx cf. *L. rufus* (Schreber)	—	—	—	—	—	X	—	—	—

TABLE 20-*(Continued)*

	Pleistocene							Pliocene	
	Nebr. 2317–2480 ft. Sand Draw	Nebr. 3900–3950 ft. Broad-water	Kans. 2510 ft. Deer Park	Kans. 2580 ft. San-ders	Kans. 1570 ft Dixon	Texas 3400 ft Cita Canyon	Texas 3200 ft Blanco	Kans. 2480 ft. Rex-road	Idaho 2900–3400 ft. Hager-man
?*Machairodus hesperus* Gazin [b]	—	X	—	—	—	—	—	—	*
Ischyrosmilus johnstoni Mawby [b]	—	—	—	—	—	*	—	—	—
Ischyrosmilus crusafonti Schultz and Martin [b]	—	*	—	—	—	—	—	—	—
Homotheriini gen. and sp. indet. [b]	—	—	—	—	—	—	—	X	X
Ischyrosmilus sp. or *Dinobastis* sp. [b]	X	—	—	—	—	—	—	—	—
Order Proboscidea									
Family Gomphotheriidae									
Stegomastodon rexroadensis Woodburne [b]	—	—	—	—	—	—	—	*	—
Stegomastodon primitivus Osborn [b]	*	—	—	—	—	—	—	—	—
Stegomastodon mirificus primitivus Osborn [b]	—	X	—	—	—	—	—	—	—
Stegomastodon mirificus (Leidy) [b]	—	X	X	—	—	X	X	—	—
Rhynchotherium falconeri Osborn [b]	—	—	—	—	—	—	*	—	—
Rhynchotherium sp. [b]	—	—	X	—	—	—	—	—	—
Serbelodon(?) *praecursor* Cope [b]	—	—	—	—	—	—	*	—	—
Mammut sp. [b]	—	X	—	—	—	—	X	—	X
Order Perissodactyla									
Family Equidae									
Nannippus phlegon (Hay) [b]	—	—	X	X	—	X	*	X	—
Nannipus sp. [b]	—	X	—	—	—	—	—	—	—
Equus (*Dolichohippus*) *simplicidens* (Cope) [a]	X	X	X	X	—	X	*	X	X
Equus (*Hemionus*) *calobatus* (Troxell) [a]	X	—	—	—	—	—	—	—	—
Equus (*Asinus*) *cumminsii* Cope [a]	—	—	X	—	—	—	*	—	—
Equus cf. *E.* ?*occidentalis* Leidy	—	—	—	—	—	X	—	—	—
Pliohippus (*Astrohippus*) or very small *Equus* [b]	—	—	—	—	—	X	—	—	—
Order Artiodactyla									
Family Tayassuidae									
Platygonus pearcei Gazin [b]	—	—	—	—	—	—	—	—	*
Platygonus bicalcaratus Cope [b]	—	—	X	—	—	X	*	X	—
Platygonus sp. [b]	X	X	—	—	—	—	—	—	—
Family Camelidae									
Gigantocamelus spatulus (Cope) [b]	X	X	—	—	—	—	*	—	—
Megatylopus sp. [b]	—	—	—	—	—	X	—	—	X
Camelops sp. (large) [b]	X	X	X	—	—	X	X	—	X
Camelops sp. (small) [b]	—	—	X	—	—	X	—	—	—
Tanupolama blancoensis Meade [b]	—	—	—	—	—	—	*	X	—
Tanupolama sp. [b]	X	X	—	—	—	X	—	—	X
Pliauchenia sp. [b]	—	—	—	—	—	X	—	—	—
Family Cervidae									
Cervid sp.	X	—	—	—	—	—	—	—	X
Odocoileus brachyodontus Oelrich [a]	—	—	—	—	—	—	—	X	—
Odocoileus sp. (large) [a]	—	—	—	—	—	X	—	X	—
Family Antilocapridae									
Ceratomeryx prenticei Gazin [b]	—	—	—	—	—	—	—	—	*

TABLE 20-*(Continued)*

	Pleistocene							Pliocene	
	Nebr. 2317–2480 ft. Sand Draw	Nebr. 3900–3950 ft. Broad-water	Kans. 2510 ft. Deer Park	Kans. 2580 ft. Sanders	Kans. 1570 ft. Dixon	Texas 3400 ft. Cita Canyon	Texas 3200 ft. Blanco	Kans. 2480 ft. Rex-road	Idaho 2900–3400 ft. Hager-man
Capromeryx arizonensis schultzi Skinner[b]	—	*	—	—	—	—	—	—	—
Capromeryx sp.[b]	—	—	—	—	—	X	—	—	—
Tetrameryx sp.[b]	—	—	—	—	—	X	—	—	—
Breameryx sp.[b]	—	—	—	—	—	X	—	—	—
Antilocaprid sp.	X	—	X	—	—	—	—	—	—

[a]Extinct species.
[b]Extinct genus.
Symbols; *, holotype; X, occurrence in fauna.

TABLE 21
FAUNAL SIMILARITIES

(Calculated from Table 20 by $\frac{100C}{N^1}$ where C equals Number of Species Common to Two Faunas and N^1 equals Number in Smaller Fauna)

	Sand Draw	Broad-water	Deer Park	Sanders	Dixon	Cita Canyon	Blanco	Rex-road	Hager-man
Sand Draw (N=31)	—	64	62	54	57	15	20	35	10
Broadwater (N=11)	64	—	45	10	0	18	36	36	36
Deer Park (N=13)	62	45	—	27	29	31	38	46	8
Sanders (N=11)	54	10	27	—	29	18	18	36	0
Dixon (N=7)	57	0	29	29	—	0	0	0	0
Cita Canyon (N=13)	15	18	31	18	0	—	38	23	8
Blanco (N=15)	20	36	38	18	0	38	—	27	7
Rexroad (N=42)	35	36	46	36	0	23	27	—	15
Hagerman (N=37)	10	36	8	0	0	8	7	15	—

SAND DRAW LOCAL FAUNA CORRELATION, AGE, AND PALEOECOLOGY

BY CLAUDE W. HIBBARD

Figures 59, 60. Tables 20, 21

SOME LOCAL FAUNAS of the Great Plains assigned to the Nebraskan, and especially those assigned to the Aftonian (Hibbard, 1970b), do not fit into conventional North American Pleistocene correlation charts. I have previously been at a loss to explain why certain mammalian taxa survived the Nebraskan glaciation and the Aftonian interglacial only to become extinct during the early part of the Kansan. How does one explain the dispersal northward of the large land tortoise (*Geochelone*) after the withdrawal of Nebraskan ice only to have it occur as a fossil early in the supposed Aftonian Sand Draw local fauna? Why did a large *Gopherus* (UMMP V32455) and a large *Geochelone* (UMMP V60019) occur in the lower part of the Ballard Formation in southwestern Kansas (fig. 60) if this formation represented the time of Nebraskan glaciation retreat? The presence of these turtles is evidence of a much warmer climate than would be expected at the closing phase of Nebraskan glaciation.

The discovery of the Spring Creek local molluscan fauna in Meade County, southwestern Kansas, prompted Taylor (1966) to assign the warm faunas containing mollusca to a probably pre-Nebraskan age; before this they were thought to be Aftonian. But it was not until the Keim Formation carrying the Sand Draw local fauna and the overlying outwash gravels and sands had been studied, that it became clear that these late Blancan warm faunas in the Great Plains lived before the Nebraskan glaciation. It should be clearly understood that these faunas lived during a considerable time interval prior to Nebraskan glaciation, but all were not contemporaneous.

I consider faunas that contain *Borophagus diversidens*, *Nannippus phlegon*, and *Equus* (*Dolichohippus*) *simplicidens* to represent late Blancan time. The occurrence of the following small rodents is thought to indicate climatic deterioration and the beginning of the Pleistocene: *Nebraskomys mcgrewi*, *Ophiomys meadensis*, *O. magilli*, *O. fricki*, *Pliopotamys meadensis*, *Pliolemmus antiquus*, and *Synaptomys rinkeri*. So far as known all these mammals are indigenous to North America.

The following are the late Blancan warm local faunas believed to be pre-Nebraskan in age: Sand Draw, Broadwater, Spring Creek, Deer Park, Sanders, Cita Canyon, and Blanco. Of these the Sand Draw local fauna is the most diverse and most northerly known. In tables 20 and 21 mammalian taxa of the Sand Draw local fauna are compared with mammalian taxa from other late Blancan, pre-Nebraskan warm local faunas of the Great Plains. Included for comparison are three other local faunas: Kansas Rexroad localities 3 and 2A[1] and Idaho Hagerman, both early Blancan, and the Dixon (Nebraskan) from Kansas. The complex relationships of the local faunas and geology are shown in figure 60.

The Sand Draw local fauna shows a closer relationship to the Broadwater of southwestern Nebraska than to the other late Blancan faunas (tables 20, 21). When the entire Broadwater fauna is studied, an even greater relationship will probably be shown between these two faunas. The Blanco and Cita Canyon local faunas of West Texas, from deposits about 570 miles to the south, show the least relationship to the Sand Draw local fauna. The microfauna is not known for the Blanco and Cita Canyon local faunas, but if it were, I would expect only a few species in common with those of the Sand Draw 570 miles to the north.

The Sand Draw and Blanco local faunas have

[1] Evernden et al. (1964) gave the first radiometric dates that related to North American mammalian ages. In the Great Plains the oldest K–Ar date from the lower Pearlette-like volcanic ash (type S) is 1.2 m.y. (Richmond, 1970, p. 9; Izett et al. 1970, p. 123).

Hibbard and Zakrzewski (1967), Zakrzewski (1969), and Bjork (1970) considered the Rexroad local fauna to be older than the Hagerman local fauna which contains more advanced mammalian taxa. If the date of $3.48 \pm 0.27 \times 10^6$ years (KA-1173, Evernden et al. 1964) is accepted for the Hagerman local fauna, it can be assumed that the Rexroad local fauna is at least 3.6×10^6 years. Both the Hagerman and Rexroad local faunas indicate a warm climate.

FIG. 59. Map showing location of the following local faunas. Nebraska: Sand Draw (1), Brown County; Broadwater (2), Morrill and Garden counties. Kansas: Dixon (3), Kingman County; Rexroad Locality 3, Spring Creek, Deer Park and Sanders (4). Texas: Cita Canyon (5), Randall County; Blanco (6), Crosby County. Idaho: Hagerman (7), Twin Falls County; Grandview (8), Owyhee County.

the following common taxa: *Geochelone* sp. (large), *Borophagus diversidens*, *Stegomastodon mirificus* (*fide* Savage, 1955), *Equus* (*Dolichohippus*) *simplicidens*, and *Gigantocamelus spatulus*. A combination of these taxa and *Nannippus phlegon* occur in other late Blancan warm faunas (table 20).

The Sand Draw local fauna probably lived about the same time as the Deer Park and the later Sanders local faunas (350 miles to the south) as they have these mammals in common: *Sorex sandersi*, *Geomys quinni*, *Prodipodomys centralis*, *Procastoroides sweeti*, *Sigmodon medius*, *Bensonomys meadensis*, *Ogmodontomys p. poaphagus*, *Pliopotamys meadensis*, *Pliolemmus antiquus*, *Trigonictis idahoensis*, *Taxidea* cf. *taxus*, and *Equus* (*Dolichohippus*) *simplicidens*.

The Broadwater Formation (Schultz and

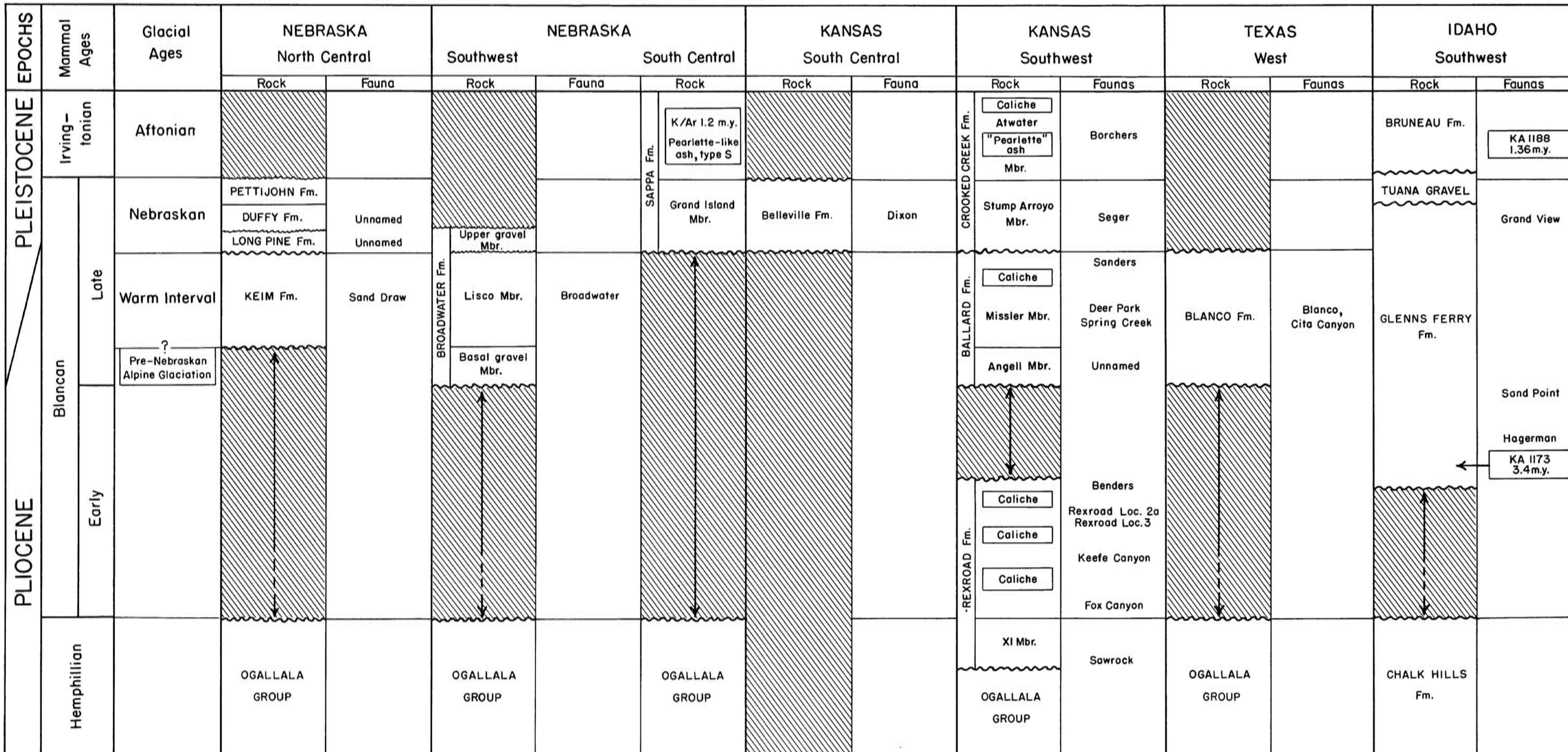


FIG. 60. Correlation of Blancan deposits and faunas in the Great Plains region and Idaho.

Stout, 1945) in Morrill and Garden counties in southwestern Nebraska, contains the Broadwater local fauna listed in Schlutz, Lueninghoener and Frankforter, (1951, table 1) which these authors considered as Aftonian.[1] The Broadwater Formation consists of a basal gravel member, a middle member (Lisco), from which the Broadwater local fauna was taken, and an overlying gravel member. Condra and Reed (1950, pp. 17, 21) correlate the lower member of the Broadwater Formation with the Holdrege Formation (sand and gravel, Nebraskan in age), and the overlying upper gravel with the Grand Island Formation (sand and gravel, Kansan in age). These terms have been slightly revised by Reed and Dreeszen (1965). Stout (1965, p. 67) concurred in part with these authors in an Aftonian age for the diatomite and peat bed, which is the lower part of the Lisco Member, but believed that the upper part of the Lisco was deposited during a cold period (Kansan). I contend that the lower sand and gravel of the Broadwater Formation are pre-Nebraskan and represent the effect of alpine glaciation in the Rocky Mountains.

The Ballard Formation (Hibbard, 1958) in Meade County, southwestern Kansas, contains four local faunas (fig. 60). The oldest, an unnamed local fauna (Hibbard, 1956, p. 157), comes from the basal sand and gravel, the Angell Member. Hibbard (1944, pl. 1, fig. 21) reported a striated pebble from this member and at the time considered it to be of Nebraskan age. The Angell Member is now considered to have been deposited during, or after, alpine glaciation but before the Nebraskan glaciation, as suggested also by Taylor (1966, p. 10). A cool fauna has never been recovered from the Ballard Formation.

The Spring Creek molluscan local fauna occurs in the Missler Member of the Ballard Formation just above its contact with the Angell Member. Taylor (1966, pp. 9, 103) stated, "The Spring Creek local fauna Berry and Miller (1966), includes one of the most significant fossil occurrences in southwestern Kansas. The fauna is from the Ballard Formation, previously correlated as Nebraskan and Aftonian, and contains the extinct freshwater snail, *Biomphalaria kansasensis* Berry . . . *Biomphalaria* is a tropical and subtropical group now found sparsely in the United States only along the southernmost Coastal Plains. *B. kansasensis* is not closely related to any living form, but has affinities with an early Pliocene species from nearby Oklahoma. Hence, most likely *Biomphalaria* lived in the southern Great Plains province through the Pliocene and became extinct in that region in the early Pleistocene."

The Deer Park local fauna (Hibbard, 1956, p. 169) occurs in the Missler Member of the Ballard Formation below a well-developed caliche. This local fauna was first reported as Nebraskan (Hibbard, 1949, p. 1421), but after the recovery of part of a large *Geochelone*, it was thought to be a warm Aftonian fauna (Hibbard, 1956, 1960). In regard to Deer Park, Taylor (1966, p. 103) stated, "the fauna seems to be older than the first major continental glaciation of North America during which the Nebraska till was deposited, but younger than an episode of climatic cooling associated with alpine or limited continental glaciation."

The fourth and youngest of the local faunas in the Ballard Formation is the Sanders (Hibbard, 1956, p. 179) that occurs above the caliche in the Missler Member (fig. 60).

The Blanco local fauna is from the Blanco Formation in Crosby County, Texas. Meade (1945, p. 519) concluded that, "The paleontological evidence indicates an early or earliest Pleistocene age." I, however, took too literally the use of the term Nebraskan (Hibbard, 1957b, p. 467), again in 1958 (Hibbard, 1958, p. 11), and 1970b, I assigned the Blanco local fauna to the Aftonian on the evidence of its large *Gopherus* and *Geochelone* tortoises, indicators of a warm fauna.

The Cita Canyon local fauna (Johnston and Savage, 1955) was recovered from lake or playa sediments in Randall County, Texas, and compared with the Blanco local fauna. There is general agreement that all these late Blancan local faunas are warm, particularly because of the presence of the large land tortoise (*Geochelone*) in the Sand Draw, Deer Park, and Blanco. Based on the evidence of the large vertebrates, the Blanco and Cita Canyon local faunas show a close relationship to the Sand

[1] The faunal list of Schultz, Lueninghoener, and Frankforter (1951, table 1) certainly indicates a pre-Nebraskan age, except for one form, *Microtus* sp. Dr. C. B. Schultz (in letter, October 26, 1970) and Larry Martin (oral commun., October, 1970) say that they have not seen a *Microtus* in the fauna and think its listing was a misidentification.

Draw, Broadwater, Deer Park, and Sanders local faunas.

The Dixon local fauna is from the Belleville Formation in Kingman County, Kansas, and is here considered Nebraskan in age. The fauna (Hibbard, 1956, p. 160) is restricted to the Dixon farm in the SW. ¼, sect. 12, T. 29 S., R. 8 W., the locality 1 of Taylor (1960, p. 36). Taylor (1966, p. 104) stated that, "The previous age assignment of latest Nebraskan or earliest Aftonian is probably wrong; the fauna more likely came from shortly after a time of Alpine or minor continental glaciation that preceded the first major continental glaciation."

The Dixon local fauna is the earliest cool fauna recognized from Kansas. The first appearance of *Synaptomys* (*Synaptomys*) *rinkeri*, which is associated with *Planisorex dixonensis*, *Nebraskomys mcgrewi*, *Pliopotamys meadensis*, and *Pliolemmus antiquus* from the more northern Sand Draw local fauna, indicates that the fauna moved southward at the time of the Nebraskan glaciation.

At the time the Sand Draw local fauna lived, the climate in what is now Brown County, Nebraska, was probably subhumid. There is no evidence of the present annual temperature fluctuation. Precipitation slightly exceeded evaporation, as shown by the presence of oxbow lake sediments and its included molluscan and fish faunas (see Smith and Lundberg, p. 53, present paper). The mammals suggest the following communities:

STREAM-BANK AND LAKE-BANK COMMUNITIES: Only four mammals have been closely associated with these communities: *Dipoides rexroadensis*, *Procastoroides sweeti*, *Pliopotamys meadensis*, and *Satherium priscinaria*. The larger mammals, *Stegomastodon primitivus*, *Equus* (*Dolichohippus*) *simplicidens*, *Equus* (*Hemionus*) *calobatus*, *Gigantocamelus spatulus*, *Tanupolama*, and carnivores from other "communities" would come to these watering places.

MARSH AND SEMIAQUATIC COMMUNITIES: The sediments of the Keim Formation not only indicate a braided stream but the presence of ox-bow lakes and marshes. *Planisorex dixonensis*, *Ogmodontomys p. poaphagus*, *O. magilli*, and *Pliolemmus antiquus* probably preferred a marsh habitat.

SAVANNA VALLEY COMMUNITIES: This community extended from the dry stream-bank and marsh to the valley slope and included the dry meadows with tall grasses, some trees, and shrubs. The large mammals that lived chiefly in this community are the semi-browsers and semi-grazers, *Stegomastodon primitivus* and *Gigantocamelus spatulus*. I would expect *Platygonus* to have been found in this community as well as in the Upland Community. The most abundant small mammals recovered are *Geomys quinni*, *Scalopus aquaticus*, *Sorex sandersi*, and *Hypolagus* or *Pratilepus*, *Spermophilus meltoni*, *Pliophenacomys primaevus*, and the rare *Nebraskomys mcgrewi*.

VALLEY SLOPE COMMUNITIES: *Peromyscus* and *Neotoma*, the wood rat, probably lived in this area. *Sigmodon medius* may have lived along the juncture of the Savanna Valley and Valley Slope communities.

UPLAND COMMUNITIES: The upland region or dry plains contributed only a few small mammals to the fauna, such as *Prodipodomys centralis*, *Onychomys*, and *Bensonomys meadensis*. The carnivores, *Canis lepophagus*, *Taxidea* cf. *taxus* and *Ischyrosmilus* or *Dinobastis*, as well as the horses, *Equus* (*Dolichohippus*) *simplicidens* and *Equus* (*Hemionus*) *calobatus*, *Tanupolama* sp., and antilocaprid species are considered to be members of this community.

CONCLUSIONS

MORRIS F. SKINNER AND CLAUDE W. HIBBARD

FOUR MAIN EVENTS are recorded in the pre-glacial early Pleistocene rocks of Brown County, Nebraska: (1) A slow-moving trunk river filled a broad, shallow, southeasterly trending paleo-valley with deposits (Keim Formation) that carried a large and diverse fauna. Lakes and ponds surrounded by abundant vegetation amply sustained aquatic and non-aquatic life. Martin (present paper, p. 36) points out that the flora is "not notably different" from the post-glacial fauna from Hackberry Lake some 40 miles west, and further states that the flora is "certainly not a glacial-type record." (2) The Long Pine Gravel, an outwash of the first continental glaciation (Nebraskan) covered the Keim Formation and the bordering Pliocene uplands. Some large land forms (e.g. *Stegomastodon*) presumably found adequate sustenance along the streams. Invertebrate-bearing chert pebbles (Batten, present paper, p. 25) show that the source of the fluvial outwash, Long Pine Gravel, is from the north, northeast, near Lake Winnipegosis, Canada, not from the Rocky Mountains or the Black Hills as previously postulated. (3) An interstadial sand and silt (Duffy Formation) was deposited over the Long Pine Gravel. Fossils of only a few large land forms (horse, camel, mastodont) and *Geomys* have been found in the Duffy sediments. (4) The last event was a second gravel outwash, the Pettijohn Formation. Fossils have not been recovered from this gravel sheet and the source can only be postulated as the same as the Long Pine Gravel. These early Pleistocene rocks have no intervening tills or soils, suggesting a short temporal interval for deposition, in an area peripheral to the glaciated area to the east and northeast.

The geomorphology shows that the severe degradation cycle now in progress started after these early Pleistocene events. Entrenchment of the Niobrara River system can be attributed to regional uplift and the increased development of the Missouri and Mississippi river systems.

The study of the faunas from three of the formations (Keim, Long Pine, and Duffy) made independently from the geology, bear out the data on rock sequence and time. No morphological changes were noted in the fauna. The presence as well as the disappearance of some forms tallied with the climatic deterioration of an area peripheral to a glacier.

Gutentag (present paper, p. 39) concludes that the "ostracodes in the Sand Draw sites contain elements representing both late Pliocene and late Kansan and could be considered as post-late Pliocene and pre-late Kansan . . . [and] represent, for the most part a permanent pond assemblage." Gutentag interprets some of the localities (i.e. UM-Nebr. 1–68 and 3–68) to be representatives of deeper ponds or deeper parts of large shallow ponds because of the absence of associated cyprids. The presence of cyprids, on the other hand (i.e. UM-Nebr. 2–68 and 4–68) indicate shallow water.

Smith and Lundberg (present paper, p. 52) find that, "The Sand Draw fish fauna includes two ecological associations: (1) large-river and lake fishes restricted to lower elevations and more permanent aquatic habitats than occur in Brown County, Nebraska presently, and (2) prairie and plains species characteristic of small streams and lakes."

Holman observes (present paper, p. 71) that the Sand Draw "herpetofauna is not one that would be typical of the area today, for with the exception of the two tortoises and the fox snake, *Elaphe vulpina*, the herpetofauna is one that is typical of Kansas rather than Nebraska, with the nearest area where all these Sand Draw amphibians and reptiles can be found living together today is north-central Kansas."

A study of avian remains by Feduccia and Rich shows that water birds (grebe, swan, goose, duck), ranging into Brown County today, make up most of the avifauna in the Keim Formation and evidence the presence of lakes and ponds during filling of the Keim paleovalley. Occurrence of Burrowing Owl suggests the near proximity of prairies or open plains and a climate no more rigorous than that of southern Canada today. The only species no longer represented in Nebraska that was found in the Keim sediments is the extinct Asphalt Stork, *Ciconia maltha*.

Hibbard's study of the mammals led him to conclude that the Sand Draw local fauna is the most diverse and northern of the other late Blancan warm local faunas known from the Great Plains. Most of the fossil sites represent marsh deposits or slack water deposition as indicated by the mollusca and fishes.

No other Blancan fauna has so many taxa of microtine rodents, seven in number, as the Sand Draw local fauna. The appearance of *Equus* (*Hemionus*) *calobatus* in the Sand Draw fauna is the earliest record of this horse in North America. Representatives of the subgenus *Equus* (*Hemionus*) and *Equus* (*Dolichohippus*) are present in North American early Pleistocene sediments and are living in Asia and Africa today.

The boundary of the Blancan-Irvingtonian mammal age is placed at the close of the Nebraskan and not in mid-Kansas as previously considered by Hibbard et al., 1965, and Hibbard, 1970b.

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ERRATA

AMNH BULLETIN 148 : ARTICLE 1   NEW YORK : 1972

Figure 51 on page 110 is upside down.
The legend should read: *Taxidea* cf. *T. taxus*, left P^4-M^1, F:AM62915. Occlusal view. X2.