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MAMMALS OF THE REXROAD FORMATION FROM
FOX CANYON, KANSAS

BY
CLAUDE W. HIBBARD



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By CLAUDE W. HIBBARD

CONTENTS

Introduction and acknowledgments	114
Rexroad formation	115
Fox Canyon section	120
Fox Canyon vertebrate faunule	121
Pisces	121
Amphibia	121
Reptilia	121
Aves	121
Mammalia	121
<i>Paracryptotis</i> , gen. nov.	121
<i>Paracryptotis rex</i> , sp. nov.	122
<i>Megasorex</i> , gen. nov.	127
<i>Notiosorex</i>	129
<i>Notiosorex jacksoni</i> , sp. nov.	129
<i>Hesperoscalops rexroadi</i> Hibbard	134
<i>Lasiurus fossilis</i> , sp. nov.	134
<i>Paenemarmota barbouri</i> Hibbard and Schultz	136
<i>Citellus</i> sp.	137
<i>Nerterogeomys</i> cf. <i>minor</i> (Gidley)	138
<i>Perognathus pearlettensis</i> Hibbard	139
<i>Perognathus rexroadensis</i> , sp. nov.	140
<i>Baiomys rexroadi</i> Hibbard	145
<i>Onychomys gidleyi</i> Hibbard	146
<i>Symmetrodontomys simplicidens</i> Hibbard	148
<i>Bensonmys arizonae</i> (Gidley)	148
<i>Parahodomys quadriplicatus</i> Hibbard	149
<i>Pliophenacomys primaevus</i> Hibbard	150
<i>Ogmodontomys poaphagus</i> Hibbard	157
<i>Borophagus diversidens</i> Cope	159
<i>Bassariscus rexroadensis</i> , sp. nov.	161
<i>Mustela rexroadensis</i> , sp. nov.	163
<i>Buisnictis</i> , gen. nov.	164
<i>Buisnictis meadensis</i> , sp. nov.	164
<i>Brachyprotoma breviranus</i> Hibbard	165
<i>Hypolagus regalis</i> Hibbard	166
Discussion	167
Rexroad fauna	168
Locality No. 2	168
Locality No. 2a	169

Locality No. 3.....	173
Locality No. 22.....	174
Locality No. UM-K1-47.....	174
Other localities.....	174
Discussion.....	175
Analysis of the Rexroad fauna.....	175
Age and relationship of the Rexroad fauna to other known faunas.....	179
Blancan as a time term.....	182
Correlation of faunas and deposits.....	183
Literature cited.....	184
Plates.....	(after) 188

INTRODUCTION AND ACKNOWLEDGMENTS

THIS paper is a discussion of the Rexroad formation and a description of the deposits in Meade County, Kansas, from which the Rexroad fauna was taken. The fauna as a whole is discussed in relation to the present knowledge of the stratigraphy and faunas of the High Plains. The faunal assemblage consists of eighty-eight forms, exclusive of passerine birds and invertebrates. Of these, two genera and seven species of mammals are described as new and two species are reported for the first time as part of the Rexroad fauna. In addition, many specimens of previously described species were obtained.

In the summer of 1947 a field party of the Museum of Paleontology of the University of Michigan, opened a new quarry in the Rexroad formation of Meade County, Kansas. The members of the expedition were Dick Rinker, Charles C. Carpenter, Faye Hibbard, and Claude W. Hibbard in charge. The University of Michigan field party was particularly indebted to the Kansas Forestry, Fish and Game Commission for living quarters and for permission to use stream facilities for the recovery of the fossil vertebrates. Mr. Horace Adams, the late Mr. A. W. Adams, Mr. Raymond A. Adams, and Mr. Clarence Rexroad kindly gave us permission to collect fossils on their ranches. Detailed study of the stratigraphy and vertebrate faunas of southwestern Kansas was made possible only through the hospitality and personal help of many friends in the region to whom we are greatly indebted.

This work was aided by the loan of specimens under the care of Dr. Hartley H. T. Jackson, United States Fish and Wildlife Service; Dr. Chester Stock, California Institute of Technology; Dr. E. H. Sellards, Texas Memorial Museum; Dr. Robert W. Wilson, University of Kan-

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REXROAD FORMATION

Treatment of the Rexroad formation by many authors working in different areas of western Kansas has been so varied that it seems desirable to trace the development of the term.

The Rexroad formation was named and described by H. T. U. Smith (1940, pp. 95-99) from exposures along tributaries of Crooked Creek on the Rexroad Ranch in sec. 22, T. 33 S., R. 29 W., Meade County, Kansas. Smith's discussion was good as far as the formation was known at the time. He included the Meade Gravels, the Meade formation of Cragin (1896), at the top of the Rexroad. In regard to the base he stated that "the base of the Rexroad is nowhere known to be exposed in Meade County, and the complete thickness is consequently problematical. The formation is especially distinguished and characterized by an assemblage of vertebrate fossils of late Pliocene age, described by Hibbard (1938, 1939) . . ."

Frye and Hibbard (1941, p. 407) excluded from the Rexroad the Meade Gravels (the Meade formation of Cragin), which is separated by an unconformity from the rest of the Rexroad formation of Smith. They designated that part of Smith's Rexroad formation which lies below this unconformity, the Rexroad member of the Ogallala formation and said:

(1) on the basis of both surface and subsurface data, it seems evident that in part of the basin there was continuous sedimentation from middle Pliocene through upper Pliocene time, and in these localities no break is distinguishable; (2) the deposits were trapped in a local basin, and although there are deposits of equivalent age outside this general area, they are not stratigraphically continuous with the

deposits of the Rexroad type locality, and are not genetically related to them; and (3) as Smith (1940, pp. 95-97) has pointed out, the lithology of the Rexroad beds for the most part is indistinguishable from the middle Pliocene part of the Ogallala formation. For these reasons the Rexroad beds do not constitute a mappable unit, except partially in the vicinity of the type locality, where the upper contact, but not the lower, can be mapped. . . . The lower and thicker part of the Rexroad member does not crop out at the surface in the Meade basin area, so that the thickness and character of the member are known only from test-hole samples and well logs.

Frye and Hibbard had actually seen the base of the Rexroad formation at a number of localities in Meade and Seward counties but had failed to recognize it. The base is well exposed in the Wolf Canyon area of southwestern Meade County and westward in Seward County in the outcrop areas of the Laverne formation. Frye and Hibbard (1941, p. 406, Pl. I, Fig. B) figured a cross-bedded sandstone of the Rexroad formation as a sandstone in the lower part of the Ogallala formation. This sandstone has an entirely different lithologic character from the Ogallala sand and gravel in the gravel pit in sec. 20, T. 33 S., R. 28 W., Meade County, and from the basal Meade sand and gravel figured by Frye and Hibbard (p. 413, Pl. II, Fig. A).

Frye (1942, p. 99) recognized the Rexroad member of the Ogallala formation and stated that "the Rexroad member of the Ogallala formation is overlain unconformably by the basal sand or gravel of the Meade formation of Pleistocene age," but he did not recognize that the base of the member was exposed. Under the heading "Ogallala formation" (p. 97) he gave a measured section which he considered to be a part of the Ogallala formation along Wolf Canyon in sec. 7, T. 35 S., R. 30 W. The measured exposures consist of the Rexroad and Meade formations which overlie the Laverne formation (see Bryne and McLaughlin, 1948, p. 74) at this location.

McLaughlin (1946, pp. 33, 113-22) reviewed the study of the Rexroad deposits. McLaughlin and Hibbard did much additional work on the beds of the Rexroad in the summers of 1943 and 1944. They concluded from these studies (McLaughlin, 1946, p. 114) that "sedimentation seemingly was discontinuous from middle Pliocene through upper Pliocene time inasmuch as the Rexroad is nowhere known to lie on Ogallala. Where the base of the Rexroad appears, it is underlain by the Laverne formation. The lower part of the Rexroad formation comprises sand and gravel channeled deeply into the underlying beds. It

was also concluded that the deposits are widespread inasmuch as typical Rexroad beds crop out in the Cimarron Valley of Meade County and occur westward to Morton County, and all these have distinctive lithology. For these reasons, the Rexroad is judged to be a mappable unit and will be classed as a formation."

The fossils from the Rexroad formation in southwestern Kansas, when considered as a unit, are distinct from faunas of the other recognized formations in that area. The single rhinoceros tooth taken by Smith (1940, p. 74) has caused considerable study of the region. No other fossils have been taken from the deposit that yielded this specimen. It was found in stream sand and gravel apparently belonging to the Rexroad formation. Whether the tooth was reworked from older deposits, or whether rhinoceroses lived at the time the deposit was being laid down is not known.

On July 21, 1947, McLaughlin and Hibbard located an invertebrate horizon in the Rexroad formation in the head of Wolf Canyon fifteen to twenty feet below the base of the Meade Gravels. These invertebrates were studied by A. B. Leonard who determined their close relationship with invertebrates of the Rexroad formation at its type locality. As these were the first fossils to be found in the beds south of the Cimarron River in southwestern Meade County, they were of great importance in the correlation of the deposits of the rest of Meade and Seward counties. Therefore a field conference was held the first part of September, 1947, for the purpose of reviewing the Pliocene and Pleistocene stratigraphy of Meade and Seward counties. Special attention was given to the Rexroad formation and the locality in Wolf Canyon from which the invertebrates had been collected by McLaughlin and Hibbard. The conference was attended by Raymond C. Moore and John C. Frye of the State Geological Survey of Kansas; A. Byron Leonard of the University of Kansas; Thad G. McLaughlin of the United States Geological Survey, Ground-water Division of Colorado; and Claude W. Hibbard of the University of Michigan. It was pointed out and demonstrated that the Meade formation of Cragin (1896) [the basal sand and gravel of Frye and Hibbard (1941), of Frye (1942), of Hibbard (1944a), of McLaughlin (1946), and of Byrne and McLaughlin (1948)], which contains the remains of *Equus (Hippotigris) simplicidens* Cope, *Nannippus phlegon* (Hay), and *Stegomastodon mirificus*

(Leidy), unconformably overlies the Rexroad formation. This basal sand and gravel was shown to occupy a lower stratigraphic position than the "sand and gravel" in the new type section of the Meade formation designated by Frye and Hibbard (1941, p. 411) along Crooked Creek.

Byrne and McLaughlin (1948, pp. 73-77) in their report upon Seward County, Kansas, gave a good discussion and included measured sections of the Rexroad formation in southwestern Meade County and Seward County, Kansas.

Hibbard (1948, pp. 592-97) presented evidence to show that the Meade gravels of Cragin were not equivalent to the sand and gravel in the type section proposed by Frye and Hibbard (1941), and that the lower part of the Meade formation, as considered by Frye and Hibbard, consisted of two cycles of Pleistocene sedimentation.

Frye, Swineford, and Leonard (1948, pp. 519-21) without presentation of evidence proposed to restrict the Meade formation, as redefined by Frye and Hibbard (1941), to sediments at the type section in the NW. $\frac{1}{4}$ sec. 21, T. 33 S., R. 28 W., Meade County, Kansas, designated by Frye and Hibbard (1941) but not by Cragin (1896). In following this proposal they confused two cycles of Pleistocene sedimentation, the Meade formation and the overlying Crooked Creek formation (see Hibbard, 1949). They considered the type Rexroad formation as equivalent to the Nebraskan and Aftonian stages (see Frye, Swineford, and Leonard, Fig. 3).

Hibbard (1949a) described the XI member of the Rexroad formation which contains the Saw Rock fauna from Seward County, Kansas. The Saw Rock fauna helps to bridge the gap between the Hemphillian and the Blancan. The Rexroad formation was therefore deposited during a time interval sufficiently long to account for the difference between the Saw Rock and the Rexroad faunas.

Hibbard and Riggs (1949) reported on the mammals recovered from the Rexroad formation in Keefe Canyon, southwestern Meade County, and on the Rexroad vertebrates recovered from southeastern Seward County.

The enclosed chart (Fig. 1) furnishes a summary of the studies of the Rexroad formation and its relationship to the overlying Pleistocene deposits. The diagrammatic section at the left is based on out-

CHART SHOWING RELATIONSHIP OF STRATIGRAPHIC TERMS USED IN VARIOUS REPORTS ON CLARK MEADE AND SEWARD COUNTIES KANSAS

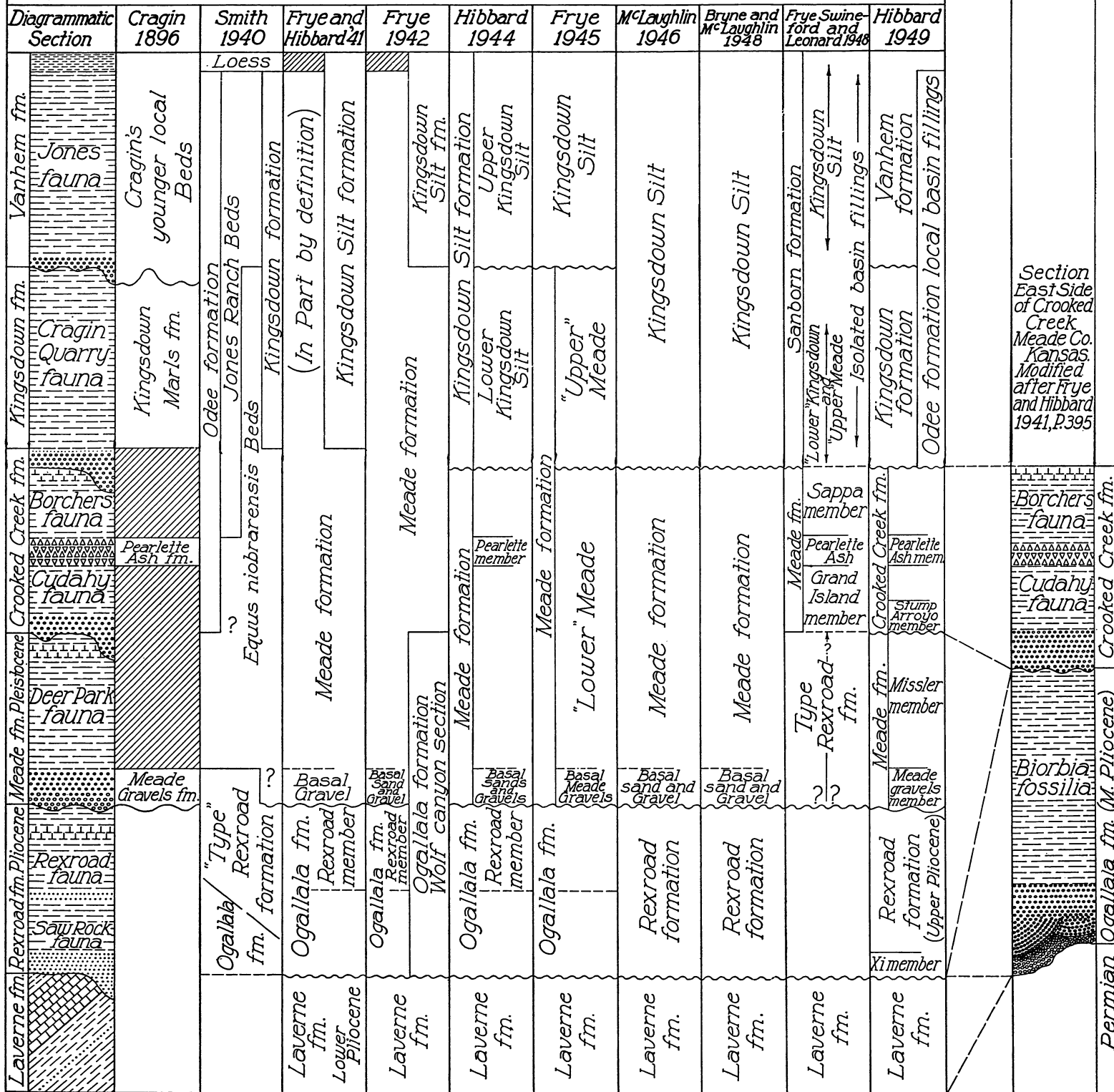


FIG. 1

crops along the Cimarron River, where the Laverne formation rests unconformably on the Permian. On the east side of Crooked Creek, at the type locality of the Crooked Creek formation (Hibbard, 1949) in secs. 15, 16, 21, and 22, T. 33 S., R. 28 W., Meade County, Kansas, the Laverne formation is missing and the Ogallala formation (Middle Pliocene) rests unconformably upon the Permian. Large pieces of sandy silt of the Laverne formation have been recovered here from the stream-deposited sands and gravels of the Ogallala formation in the Borchers gravel pit. At the top of the Ogallala formation the Rexroad and the Meade are missing at this locality and the Crooked Creek formation rests unconformably on the Ogallala.

The Rexroad formation consists of deposits younger than typical Ogallala, as it exists in Meade and Clark counties, Kansas, and older than the Meade Gravels. At the beginning of the deposition of the Rexroad formation, the topography of Seward County and of part of Meade County was very irregular. This irregularity accounts for differences in the thickness of the Rexroad formation from place to place and for variations in the lithologic character of its basal beds. Some of the relief on the pre-Rexroad surface was due to faulting or sink-hole development or both which affected the Laverne formation but not the Rexroad (Byrne and McLaughlin, 1948, p. 73). At the time of the faulting and collapse of the Laverne formation numerous depressions were developed. The initial deposits in these depressions were derived from the Laverne beds. Much of the area was undergoing dissection by a stream (and its local tributaries) flowing from the Rocky Mountain region which carried sands and finer gravels into the area. The stream shifted laterally across its flood plain filling its basin with stream-deposited sediments and built up the following sequence: (1) sand and finer gravels; (2) sandy silt with layers of lignite or bog deposits and soils, which locally contain remains of invertebrates; (3) clay, followed by a massive bed of caliche which is overlain by (4) sandy silt.

The oldest known deposits are the XI member from which the Saw Rock fauna (Hibbard, 1949*a*) was taken. Near the top of the formation below the massive caliche a second fauna known as the Rexroad fauna occurs. The best geological sections of the formation as now understood occur in the Wolf Canyon and Keefe Canyon areas of Meade

County. If it is later demonstrated that the rhinoceros tooth (Smith, 1940, p. 74) taken in Seward County came from a form that lived at the time the deposits were laid down, there will be two possible explanations: (1) that rhinoceros extended past Hemphillian time in the High Plains or (2) that some of the basal beds of the Rexroad formation are equivalent in part to the Ogallala (Middle Pliocene) of that region.

Fox Canyon Section

The Rexroad deposits are exposed along the sides of Fox Canyon in sec. 35, T. 34 S., R. 30 W., Meade County, Kansas. The beds dip toward the Cimarron River and pass under the edge of the valley floor. Because of the dipping of the beds and the great amount of rubble along the sides of the canyon it was not possible to measure the section in detail.

The deposits vary from "channel" sand to sandy silt, clay (apparently of slack-water or flood-plain origin), caliche, and sandy silt containing nodules and stringers of caliche. There is some evidence that there was lateral shifting of the stream across its flood plain at the time the deposits were laid down.

The vertebrate remains described in this report were taken from a pocket of stream-deposited sandy silt, rusty gray to reddish tan in color, which grades laterally and within a few feet into channel sands. This deposit is 17 feet below a massive caliche zone 3 to 5 feet thick near the top of the Rexroad formation. The Meade Gravels begin 22 feet above the massive caliche and are from 12 to 15 feet in thickness. The upland surface is capped by another caliche layer which occurs within the Meade formation.

In the canyon wall stratigraphically above the vertebrate-bearing deposit and 10 feet below the massive caliche is a pocket of blue-gray clay from 4 inches to 3 feet in thickness which contains abundant gastropod remains.

The deposit containing the vertebrate remains at this locality appears slightly lower stratigraphically than the deposit at locality 22 in the SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 34, T. 34 S., R. 30 W. (Hibbard and Riggs, 1949), as is suggested by the difference in interval between it and the massive caliche zone.

The vertebrates from the Fox Canyon deposit, University of Michigan locality UM-K1-47, were recovered from forty-one sacks of sandy silt removed from the deposit and washed in a nearby stream. For the techniques used in the recovery of these small vertebrates, see Hibbard, 1949c, and Plate II, Figure 2 of this paper.

FOX CANYON VERTEBRATE FAUNULE

CLASS PISCES

Family Ameiuridae

Three well-preserved pectoral spines of a small catfish.

CLASS AMPHIBIA

A number of vertebrae and limb bones of salamanders, frogs, and toads.

CLASS REPTILIA

A few vertebrae of snakes and lizards in association with the other vertebrates.

CLASS AVES

Numerous bird bones.

CLASS MAMMALIA

ORDER INSECTIVORA

Family Soricidae

Paracryptotis, gen. nov.

Genotype.—*Paracryptotis rex*, sp. nov., No. 25172, University of Michigan Museum of Paleontology; anterior part of skull with dentition, and an incomplete left ramus bearing M_1 – M_3 .

Diagnosis.—A large shrew with a dental formula of $I_1^3, C_1^1, P_1^2, M_3^3 = 30$. Unicuspid four; the second larger than the first; the third small and approximately one-half the size of the first; and the fourth greatly

reduced, shifted lingually and barely visible from the labial side. The upper fourth premolar and molars are full and not excavated posteriorly. *Paracryptotis* is distinguished from *Cryptotis* by the presence of a relatively broad rostrum which is enlarged in the region of the infraorbital foramen. The heel of M_3 is not greatly reduced.

***Paracryptotis rex*, sp. nov.**

(Figs. 2A; 3A, B)

Holotype.—No. 25172, University of Michigan Museum of Paleontology; anterior part of skull with complete upper dentition and part of the left ramus bearing M_1 – M_3 . Paratypes: No. 25173, left ramus, with complete dentition; No. 25174, incomplete right ramus, with M_1 – M_3 ; and No. 25175, an incomplete right ramus, bearing M_1 . All collected in the summer of 1947 by the University of Michigan Museum of Paleontology field party.

Horizon and type locality.—Upper Pliocene, Rexroad formation, Rexroad fauna. Locality UM-K1-47; Fox Canyon, XI Ranch, Meade County, Kansas.

Description of holotype.—The anterior part of the skull of a large shrew with complete dentition. The rostrum is enlarged in the region dorsal to the contact of P^4 with M^1 . This is in contrast with the even-tapering rostrum of *Cryptotis magna* (Merriam). The rostrum of the fossil specimen approaches in shape the rostrum observed in *Blarina b. brevicauda* (Say), although it is distinguished by a more pronounced indentation of the rostrum just posterior to the junction of M^1 and M^2 . The premaxillae are swollen in the region of the external narial opening, but not as much so as in *Blarina*. The nasals end in a sharp anterior point in the mid-line of the skull. The infraorbital foramina are large. The anterior border of the foramen is approximately on a line with the metacone of P^4 and the posterior border of the foramen is on a line with the parastyle and mesostyle of M^1 . In *Cryptotis magna* the posterior border of the foramen is in line with the posterior edge of the mesostyle of M^1 , whereas in *Blarina b. brevicauda* the position of the infraorbital foramen is approximately the same as in *Paracryptotis*. In *P. rex* the width of the rostrum between the infraorbital foramina is 3.65 mm., whereas in a specimen of *B. b. brevicauda*, No.

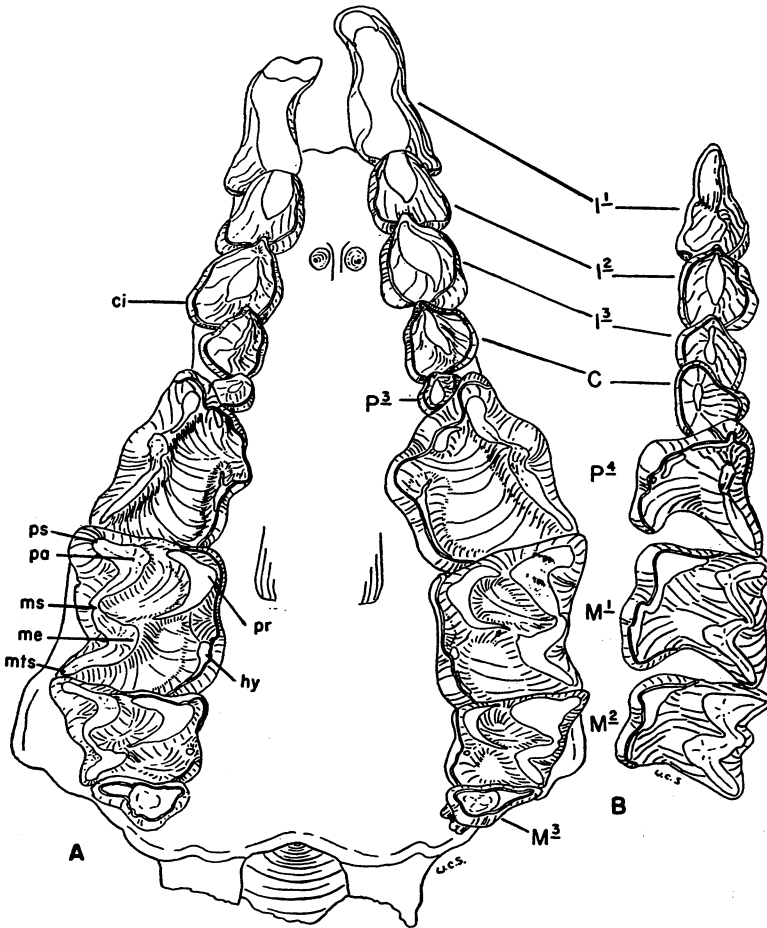


Figure 2

- (A) *Paracryptotis rex*, gen. et sp. nov., holotype, U.M.M.P. No. 25172. Ventral view of rostral region of skull. $\times 10$. Abbreviations: ci, cingulum; hy, hypocone; me, metacone; ms, mesostyle; mts, metastyle; pa, paracone; pr, protocone; ps, parastyle. Drawing by W. C. Sherman.
- (B) *Notiosorex jacksoni*, sp. nov., holotype U.M.M.P. No. 24347. Left I^1 - M^3 . Occlusal view. $\times 10$. Drawing by W. C. Sherman.

56604 U.M.M.Z., from Sioux County, Iowa, the width of the rostrum in this region is 4.0 mm.; and in a specimen of *Cryptotis magna*, No. 68565, Biological Survey collection, from Mt. Zempoaltepec, Oaxaca, Mexico, it is 4.1 mm.

I¹ is large and has a rectangular heel. The external cingulum is strongly developed.

The four unicuspidis are not specialized. The first three possess well-developed external and internal cingula. There are no inner cusplets or indications of them on the unicuspidis.

I³, the second unicuspid, is larger than the first unicuspid. The third unicuspid (canine) is approximately one-half the size of the first. The fourth unicuspid (P³) is greatly reduced, oval in outline, with a very small cingulum. The tooth is shifted lingually and is barely visible from the labial side. The distance between the lingual edges of the fourth unicuspidis is 1.9 mm.

P⁴ is molariform and possesses a well-developed anterointernal angle. The distance between the anterointernal angles (the lingual edges of protocones) of the fourth premolars is 1.65 mm. There is a well-developed projecting shelf between the protocone and the hypocone, in contrast to the notched condition observed between the protocone and hypocone in *Blarina* and *Cryptotis*.

M¹ possesses a cutting ridge running from the posterior part of the protocone to the apex of the metacone, thus producing a well-developed basin between the protocone, paracone, mesostyle, and metacone. This condition is approached in the genus *Blarina* but is poorly developed in *Cryptotis magna*.

M² is distinct in that the transverse width across the parastyle and protocone, 2.0 mm., is considerably greater than the transverse width across the metastyle and hypocone which is 1.3 mm.

M³ possesses a well-developed padlike heel with a reduced protocone. The greatest transverse width is 1.3 mm.

P⁴, M¹, and M² are fully developed, the posterior border of each tooth is in close contact with the anterior border of the next tooth. There is no indication of posterior excavation in these teeth.

The anterior palatine foramina are large. Their posterior borders are situated approximately on a line with the posterior edge of the second unicuspidis. The distance from the posterior border of the

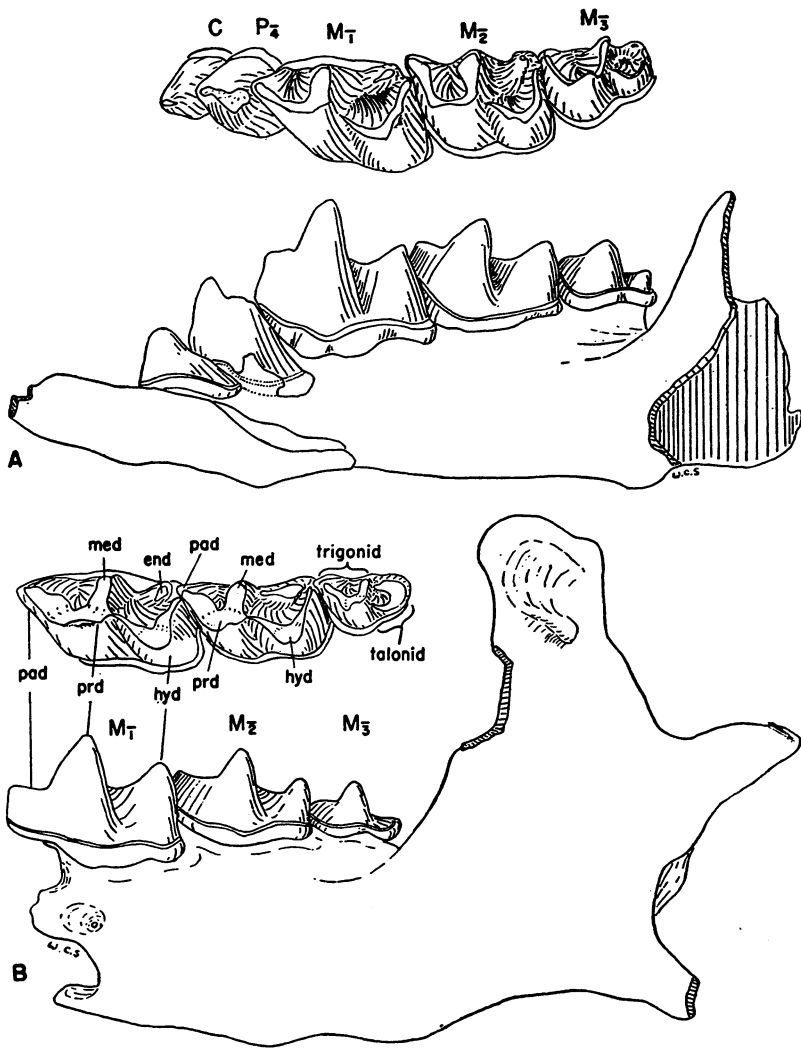


Figure 3

Paracryptotis rex, gen. et sp. nov.

(A) Paratype, U.M.M.P., No. 25173, part of left ramus, I-M₃. Lateral and occlusal views. × 10. Drawing by W. C. Sherman.

(B) Holotype, U.M.M.P., No. 25172, part of left ramus, M₁-M₃. Lateral and occlusal views. × 10. Abbreviations: end., entoconid; hyd., hypoconid; med. metaconid; pad., paraconid; prd., protoconid. Drawing by W. C. Sherman.

anterior palatine foramen to the anterior border of the posterior nares (postpalatal notch) is 7.7 mm.

The posterior border of the downward projecting process of the maxillary is opposite the indentation between the mesostyle and the metastyle of M_2 .

In the holotype specimen, No. 25172, the anterior part of the left ramus is missing. The maximum length of M_1 - M_3 is 5.35 mm. M_1 differs from the M_1 in *Blarina* in that the hypoconid joins the trigonid at the depression (valley) between the protoconid and metaconid; in *Blarina* the junction is shifted labially. The heel (talonid) of M_1 approaches more nearly the development observed in *Cryptotis magna*. The talonid of M_2 has a greater anteroposterior length than the talonid of *Blarina b. brevicauda*. The metaconid of M_3 is more dis-

TABLE I
COMPARATIVE MEASUREMENTS IN MILLIMETERS

Dimension	Holotype <i>Paracryptotis</i> <i>rex</i> No. 25172 U.M.M.P.	<i>Blarina b.</i> <i>brevicauda</i> No. 56604 U.M.M.Z.	<i>Cryptotis</i> <i>magna</i> No. 68565 U.S.N.M.
Palatal length.....	9.4	10.2	10.1
Maxillary breadth.....	7.3	8.1	7.7
Maxillary tooth row.....	8.5	9.0	9.0

tinctly developed than in either *Cryptotis* or *Blarina*. The heel of M_3 is broad and larger than the heel of *Cryptotis magna*, even though the tooth is smaller than the M_3 of *C. magna*. The condyle is more like the condyle of *Blarina* than like the condyle of *Cryptotis*. The internal temporal fossa is normal. The mandibular foramen is smaller than that of *Cryptotis magna*.

Description of paratypes.—No. 25173, a left ramus, has all of the teeth present, though the anterior part of the incisor is missing. The molars agree in all characters with those of the holotype. The ramus is that of a younger individual and the heel of M_3 is not worn as in the holotype. The maximum length of the C- M_3 is 6.7 mm. Specimen No. 25174 is a fragmentary ramus with M_1 - M_3 . The maximum length of the teeth is 5.7 mm.

Discussion.—A left I_1 , No. 3913. University of Kansas, which was

referred by Hibbard (1938, p. 243) to ?*Blarina* is in all probability an incisor of *Paracryptotis rex*. In comparison with *Blarina gidleyi* Gazin from the Upper Pliocene of Hagerman, Idaho, *P. rex* is distinguished by the larger size, larger teeth, and especially by the larger heel on M_3 . The large heel also distinguishes it from *Blarina simplicidens* Cope, which possesses an M_3 with a small heel. The only fossil form to which it may be closely related is *Blarina gidleyi*, which perhaps belongs to the genus *Paracryptotis*. This cannot be certainly determined until the upper dentition of the Hagerman form is known.

Paracryptotis has been compared with *Blarina b. brevicauda* and *Cryptotis magna* because of the large size of all three forms (see Table I). Some characters possessed by *Paracryptotis* are common to one or both of the two genera. The swollen premaxillaries and general shape of the anterior part of the rostrum are like those of *Blarina*. The dental formula of 30 teeth and the nonexcavated P^4-M^2 are also characters of *Cryptotis magna*. Many other characters point to a closer relationship with *Cryptotis magna* than to *Blarina*, although *Paracryptotis* is distinct from all other known genera. Regardless of the characters in common with *Cryptotis*, *Paracryptotis* is so specialized that it cannot be considered as ancestral to any known form of *Cryptotis*.

A comparison of recent North American shrews and the fossil shrews recovered from the Rexroad formation necessitates the naming of a new living genus which may be known as *Megasorex*.

Megasorex, gen. nov.

Genotype.—*Notiosorex gigas* Merriam, 1897, *Proc. Biol. Soc. Wash.*, Vol. 11, p. 227–28. Specimen No. 88012, female, United States National Museum, Biological Survey collection.

Type locality.—Mountains at Milpillas, near San Sebastian, Jalisco, Mexico.

Generic diagnosis.—A large short-tailed shrew; dental formula I_2^2 , C_1^1 , P_1^1 , $M_3^3 = 28$. Teeth white, without trace of color? on tips. Unicuspid well-developed, lacking cusplet or trench on inner side; molars broad, quadrate, not excavated posteriorly; brain case arched and approximately the size of *Cryptotis magna* (Merriam); downward projecting process of maxillary in region of the second and third upper molars lacking.

Discussion.—*Notiosorex gigas* is removed from the genus *Notiosorex* on the basis of the heavy rostrum, arched skull, white? teeth, and non-excavated upper molars. *Megasorex gigas*, like *Notiosorex crawfordi* Baird, possesses a dental formula of 28 teeth, has three well-developed unicusps, and lacks a downward projecting process of maxillary in the region of M^2 - M^3 .

A specimen of *Megasorex gigas*, No. 125896, Biological Survey, a male from Los Reyes, Michoacán, Mexico, has a slight trace of stain on the tip of the right incisor and a very faint trace on the extreme tip of the left incisor. Specimens of *Megasorex*, *Blarina*, *Cryptotis*, and the

TABLE II
COMPARATIVE MEASUREMENTS IN MILLIMETERS OF *Megasorex gigas* AND *Notiosorex crawfordi*

Specimens No. 125896, from Los Reyes, Michoacán; No. 88010 from San Sebastian, Jalisco, Mexico; and No. 120087, from Corpus Christi, Texas, are all from the Biological Survey collection. No. 64012, from Cochise County, Arizona, is from the University of Michigan collection.

Dimension	<i>M. gigas</i> (Male) No. 125896	<i>M. gigas</i> (Female) No. 88010	<i>N. craw-</i> <i>fordi</i> (Maie) No. 120087	<i>N. craw-</i> <i>fordi</i> No. 64012
Condylbasal length.....	23.0	.....	16.55	15.9
Palatal length.....	10.6	10.25	6.9	6.9
Cranial breadth.....	10.3	.....	8.0	7.6
Interorbital breadth.....	5.75	5.4	3.9	3.6
Maxillary breadth.....	6.6	6.7	5.0	4.5
Maxillary tooth row.....	8.8	8.5	6.3	5.75
Maximum length of I-M ₁	9.8	9.5	6.95	6.6
Maximum length of C-M ₃	7.1	6.85	4.75	4.7

many fossil specimens of *Paracryptotis*, *Sorex*, and *Notiosorex* when placed under ultraviolet light gave negative results in regard to the presence of pigmentation. Teeth of recent rodents react positively or negatively under ultraviolet light, and the fluorescence or nonfluorescence is apparently due to the kind of food which has been consumed. If this is the cause, different types of fossilization of a given form should give different results under ultraviolet light.

Notiosorex crawfordi appears to possess more characters in common with *Soriculus* (*Chodsigoa*) of the Chinese Highlands than with *Megasorex gigas*.

The subfamilies Soricinae and Crocidurinae have been separated on the basis of tooth color. The Soricinae possess reddish-tipped teeth and the Crocidurinae possess white teeth. Various degrees of pigmentation of the teeth is seen in the Soricinae. In *Notiosorex* the pigmentation is poorly developed in comparison to that of the teeth of *Cryptotis*. Allen (1938, p. 83) pointed out that the subfamily Soricinae is mainly of northern distribution and occurs throughout most of the holarctic region, while the subfamily Crocidurinae is confined to the eastern hemisphere and is most abundantly represented in the tropical and subtropical areas of that region. Allen also discussed the parallel modifications of the two groups. Bates (1945, p. 759-61), who discussed the presence of pigment in the teeth of *Chimarrogale* (*Crossogale*) and *Necotogale*, stated that "In consequence of this fact [possession of pigmentation] these shrews must be included in the *Soricinae* with coloured teeth, and excluded from the white-toothed *Crocidurinae*." As it appears that tooth color alone can no longer be considered an important character by which the shrews may be divided into subfamilies, it is proposed that the subfamily Crocidurinae be united with the subfamily Soricinae.

Notiosorex Baird

Notiosorex Baird in Coues, 1877, *U. S. Geol. and Geogr. Surv., Bull.*, Vol. 3, pp. 646-47.

Genotype.—The genotype of *Notiosorex* is *Notiosorex crawfordi* Baird. The P⁴, M¹ and M² are strongly excavated posteriorly. There are three upper unicuspid which form a uniform series. The third unicuspid is more than one-half as large as the second unicuspid. In *Notiosorex crawfordi* Baird the tips of the incisors, canines, and premolars are slightly tipped with pigment. The molars are white (for external characters, see Merriam, 1895, pp. 31-34).

***Notiosorex jacksoni*, sp. nov.**

(Figs. 2B; 4A, B)

Holotype.—No. 24347, University of Michigan Museum of Paleontology, left maxillary bearing incisor, three unicuspid, P⁴-M². Paratypes; left maxillary, No. 24348, bearing three unicuspid and P⁴;

left maxillary, No. 24349, bearing last unicuspid, P^4-M^2 ; right maxillary, No. 24350, bearing P^4-M^3 ; complete right ramus, No. 24352, bearing I, C, P_4-M_3 ; right ramus, No. 24354 with complete dentition; left ramus, No. 24358 with complete dentition; left ramus, No. 24359 with complete dentition. Collected in the summer of 1947 by the University of Michigan Museum of Paleontology field party.

Horizon and type locality.—Upper Pliocene, Rexroad formation, Rexroad fauna. Locality UM-K1-47, Fox Canyon, XI Ranch, Meade County, Kansas.

Diagnosis.—A shrew larger than *Notiosorex crawfordi* and smaller than *Megasorex gigas* (Merriam), with a total of 28 teeth; P^4 , M^1 , and M^2 strongly excavated posteriorly.

Description of holotype.—The holotype is the left maxillary of an adult shrew bearing the incisor, three unicuspid, and P^4-M^2 ; M^3 is lacking. The upper incisor is a heavy tooth, with a well-developed posterior lobe and a cingulum. It is notched posteriorly for the reception of the first unicuspid which is large. The first unicuspid is the largest of the three. The second and third are approximately the same size. The three unicuspid are larger than those teeth of *Notiosorex crawfordi*. The teeth do not possess inner cusplets nor do they possess a valley on the lingual side of the tooth between the principal cusp and cingulum as observed in *Notiosorex crawfordi*. The unicuspid are not basined, lingually or labially, posterior to the principal cusp as in *Megasorex gigas*. They are uniform teeth with well-developed internal and external cingula. Where one unicuspid joins the other, they have a shingled appearance and do not join as in *N. crawfordi*, in which the anterior parts of the third and second unicuspid fit into a groove on the posterior edge of the anterior tooth. The groove is produced by an upward growth of the lingual part of the cingulum. There is a distinct difference between P^4 , M^1 , M^2 , and M^3 of this fossil shrew and the corresponding teeth of *N. crawfordi* and *M. gigas*, in that there is no cingulum along the posterior border in the fossil form as there is in the recent forms.

The P^4 is deeply excavated posteriorly. This tooth differs from P^4 in *N. crawfordi* in having the paracone distinct and not continuous with the anteriorly projecting blade of the metacone. In this respect the tooth is similar to the P^4 of *M. gigas*. The protocone in the fossil form

is developed as in *N. crawfordi*, being a part of the lingual border of the tooth. In *Megasorex gigas* the P⁴ is more molariform; the protocone is more distinct, being elevated above the lingual cingulum and not a continuous part of it. The P⁴ of *M. gigas* is but slightly excavated posteriorly.

The M¹ in *Notiosorex jacksoni* does not possess the slight bulge on its anterior face, where the protocone joins the parastyle, which is observed in recent forms. The tooth is excavated as deeply posteriorly as the M¹ in *N. crawfordi*, while in *M. gigas* the M¹ is full and only slightly notched.

The M² is noticeably smaller than the M¹; this is due to the smallness of the hypocone and the lack of a pronounced cingulum. M² is excavated posteriorly though not as deep as in *N. crawfordi*. The posterior indentation in the tooth is larger than in *N. crawfordi*, because the lingual edge of the hypocone joins the lingual edge of the protocone of M³. The hypocone is not deflected labially as in *N. crawfordi*. M¹ and M² of *Megasorex gigas* are approximately the same size and are not excavated posteriorly.

The maximum length of I¹-M² of the holotype is 8.0 mm.; the maximum length of I²-M² is 6.5 mm.; the maximum length of P⁴-M³, of specimen No. 24350, is 4.7 mm.; the maximum length of M¹-M³ is 3.2 mm.; and the transverse width of M³ is 1.2 mm.

Description of paratypes.—M³ is a small tooth. It is not basined between the protocone and metacone as in *N. crawfordi*. The protocone is as high as the paracone, the metacone is lower than the paracone and the mesostyle is poorly developed. No downward projecting process of the maxillary is present in the region of M² and M³.

The ramus is larger and more heavily developed than the ramus of *Notiosorex crawfordi*. The mental foramen is situated beneath the posterior half of M₁; in a few cases the area surrounding the foramen is depressed (see Fig. 4A). The location of the mental foramen is as observed in *N. crawfordi*.

The teeth possess a much more heavily developed cingulum than in *N. crawfordi*. The elongated incisor has two lobes on its dorsal edge; the posterior is larger than the reduced anterior lobe. This is in contrast to the single lobe developed on the elongated lower incisor of *N. crawfordi* and *M. gigas* and three lobes on the incisor of *Sorex taylori*

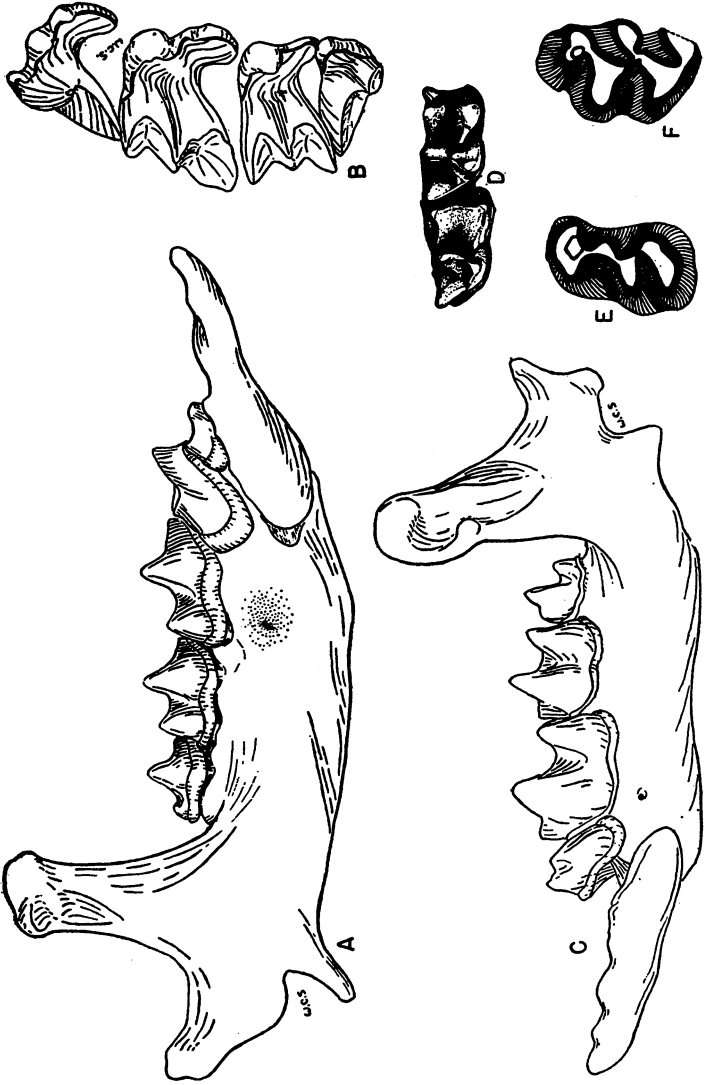


Figure 4

Hibbard (Fig. 4C). The heel of M_3 is greatly reduced and is nearly as small as the heel in *N. crawfordi*, but it is in proportion to the undeveloped M^3 . The heel of M_3 is blade-shaped to pointed in unworn teeth, becoming slightly broader with wear. In twelve specimens the range in maximum length of M_1 - M_3 , was 3.82 to 4.0 mm., average 3.9 mm. The maximum length of M_1 - M_3 of the holotype of *Sorex taylori* is 3.4 mm.

Posterior to M_3 the dorsal surface of the ramus is flattened. The inferior dental foramen in most cases is situated as in the recent form of *Notiosorex*. In a few specimens the foramen has shifted slightly ventrally to lie closer to the base of the ramus. The pterygoid fossa is nearly twice as large as that in *N. crawfordi* and extends upward onto the coronoid process. The angular process is much heavier than that of *N. crawfordi* and more nearly approaches the development of the process in *M. gigas*.

Two rami, Nos. 7011 and 7012, University of Kansas, Museum of Natural History, from Keefe Canyon, locality 22, Meade County, Kansas, (Hibbard and Riggs, 1949, p. 837, Fig. 1J) agree in dental characters with the paratypes.

Discussion.—The teeth of *Notiosorex jacksoni* are more generalized and not as highly specialized as those of *N. crawfordi*. No characters, with the exception of size, have been observed in the material which would exclude *N. jacksoni* from the ancestral stock of *N. crawfordi*. It is interesting to note the close relationship of some of the mammals in the Rexroad fauna to those living at the present time in southwestern North America and Central America.

Figure 4.

- (A) *Notiosorex jacksoni*, sp. nov., paratype, U.M.M.P. No. 24352, right ramus, I- M_3 . $\times 10$. Drawing by W. C. Sherman.
- (B) *Notiosorex jacksoni*, sp. nov., paratype, U.M.M.P. No. 24350, right P^4 - M^3 . Occlusal view. $\times 10$. Drawing by W. C. Sherman.
- (C) *Sorex taylori* Hibbard, Kansas University No. 4615, left ramus, I, canine missing, P_4 - M_3 . $\times 10$. Drawing by W. C. Sherman.
- (D) *Lasiurus* cf. *fossilis*, sp. nov., Kansas University No. 4606, left M_1 - M_2 . Occlusal view. $\times 10$. Drawing by William L. Brudon.
- (E) *Parahodomy's quadruplicatus* Hibbard, U.M.M.P. No. 25772, right M_1 . Occlusal view. $\times 6$. Drawing by Janet E. Roemhild.
- (F) *Parahodomy's quadruplicatus* Hibbard, U.M.M.P. No. 25772a, left M^1 . Occlusal view. $\times 6$. Drawing by Janet E. Roemhild.

Family Talpidae

Hesperoscalops rexroadi Hibbard

Hesperoscalops rexroadi Hibbard, 1941, *Amer. Midl. Nat.*, Vol. 26, No. 2, pp. 337-39, fig. 1.

Two isolated molars, No. 25764, U.M.M.P., of this extinct mole were recovered.

ORDER CHIROPTERA

Family Vespertilionidae

Lasiurus fossilis, sp. nov.

(Fig. 5)

Holotype.—No. 25763, University of Michigan Museum of Paleontology, left ramus with P_4-M_2 . Posterior part of ramus lacking. Collected in the summer of 1947 by University of Michigan Museum of Paleontology field party. Referred specimen, No. 4606, University of Kansas Museum of Natural History, part of a left ramus bearing M_1-M_2 .

Horizon and type locality.—Upper Pliocene, Rexroad formation, Rexroad fauna. Locality UM-K1-47, Fox Canyon, XI Ranch, Meade County, Kansas.

Diagnosis.—A bat larger than *Lasiurus borealis* (Müller) and smaller than *L. cinereus* (Beauvois). The lower dentition consists of 3-1-2-3.

Description of holotype.—The holotype is a left ramus of a mature individual. The mandibular symphysis is present, though the posterior part of the ramus posterior to the alveolus of M_3 is missing.

The three incisors are missing though the alveoli are present. These show that I_1 is the largest, that I_2 is smaller than I_1 , and that I_3 is reduced and crowded close to the canine. The alveolus of I_3 is approximately one-half as wide anteroposteriorly as the alveolus of I_2 . The transverse width of the alveolus of I_3 is as large as the transverse width of the alveolus of I_2 .

The canine is missing; its alveolus, however, is large. P_3 is missing, but its alveolus shows it to have been greatly reduced. The size of the alveolus of the first premolar is approximately the size of the alveolus of the second premolar.

The P_4 possesses a well-developed cingulum. There is a well-developed projection on the anterointernal border of the cingulum, which projects forward along the lingual side of P_3 . There is a projection or cusplet developed from the posterointernal edge of the cingulum which fits against the anterolingual border of M_1 . The antero-posterior width (the greatest) of P_4 , measured across the inner projections of the cingulum, is 0.88 mm. The cusp of P_4 is as high as the protoconid of M_1 . P_4 is basined along its posterior border for the reception of the anterior end of M_1 .

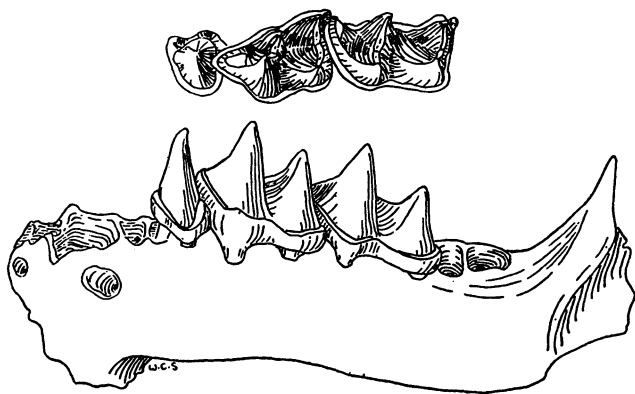


FIG. 5. *Lasiurus fossilis*, sp. nov., holotype, U.M.M.P., No. 25763, part of left ramus, P_4 - M_2 . Lateral and occlusal views. $\times 10$. Drawing by W. C. Sherman.

M_1 does not possess as great a transverse width for its length as is observed in the recent forms of *Lasiurus*. The tip of the paraconid is missing. A slightly deeper notch separates the metaconid and protoconid than is found in recent forms of *Lasiurus* possessing comparable stages of wear. The anterior part of M_1 is more like that of *L. cinereus* than like that of *L. borealis*, because the paraconid is separated from the metaconid by a broad valley. The entoconid is well developed but does not appear as distinct from the hypoconid as in *L. cinereus* or *Dasypterus floridanus* Miller. M_1 is slightly larger than M_2 .

M_2 possesses a well-developed cingulum. The tip of the paraconid is missing. The tooth is shaped more like the M_2 of *borealis* than like the M_2 of *cinereus* because of the upward slope of the trigonid.

The anteroposterior length of P_4 , M_1 , and M_2 , measured at the cingulum, is 3.6 mm. The distance from the anterior border of the canine alveolus to the posterior border of the alveolus of M_3 is 5.9 mm.

The dorsal surface of the ramus posterior to the alveolus of M_3 is broader than in *L. cinereus* or *Dasypterus floridanus*. The molar series is not as large as that of *L. cinereus*. The mental foramen is larger than that in recent forms of *Lasiurus*, and is slightly closer to the alveolus of the canine than it is in *L. cinereus*.

Lasiurus fossilis is smaller than *Simonycteris stocki* Stirton of the Curtis Ranch fauna from the San Pedro Valley, Arizona. The characters of the lower jaw and dentition of *L. fossilis* indicate that it may be considered ancestral to *L. cinereus*.

This is the second bat to be recovered from the Rexroad formation of Meade County. The first specimen (Fig. 4D) was a fragmentary left ramus bearing M_1 and M_2 (Hibbard, 1941a, p. 268, Pl. I, Fig. 4) taken at locality 3. This specimen is slightly smaller than the holotype. The characters of the teeth agree with those of the holotype, and the slight difference in size is considered as individual variation. The specimen is referred to *Lasiurus fossilis*. The teeth show a greater amount of wear. The anteroposterior maximum length of M_1 - M_2 is 2.9 mm.

ORDER RODENTIA

Family Sciuridae

Paenemarmota barbouri Hibbard and Schultz

(Fig. 6A, B)

Paenemarmota barbouri Hibbard and Schultz, 1948, *Univ. Nebr. Mus. Bull.*, Vol. 3, No. 3, pp. 19-29.

An LP³ and an LM₃, No. 25773, from an immature marmot-like rodent, *Paenemarmota barbouri*, were taken from the Fox Canyon deposit. The teeth show no signs of wear. M_3 consists only of the unworn crown, the roots of the tooth had not started to develop.

This is the second occurrence of this large sciurid in the Rexroad formation. The holotype was recovered in Meade County, Kansas, from University of Kansas locality 22, Keefe Canyon, sec. 34, T. 34 S., R. 30 W.

Permission to report on the two specimens from the Blanco beds of

Crosby County, Texas, was kindly extended by Grayson Meade of the Texas Memorial Museum. Specimen No. 31179-52, University of Texas, is a fragmentary right ramus bearing part of M_2 and M_3 (Fig. 6A). The greatest anteroposterior length of M_3 is 11.05 mm., and the greatest transverse width is 9.35 mm. The anteroposterior length of the occlusal surface of M_3 is 9.25 mm. The specimen is that of a young adult. Specimen No. 31176-65, is the anterior part of a right lower incisor. The greatest depth of the incisor is 8.7 mm. and the greatest

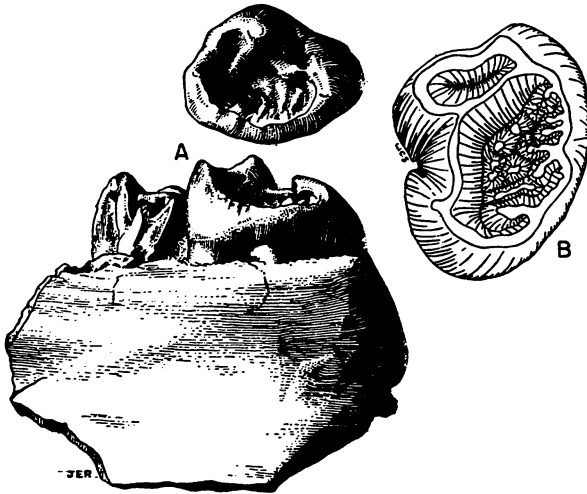


FIG. 6. *Paenemarmota barbouri* Hibbard and Schultz.

- (A) Part of right ramus, bearing part of M_2 and M_3 , University of Texas No. 31179-52. Lingual and occlusal views. $\times 2$. Drawing by Janet E. Roemhild.
 (B) Isolated, immature left M_3 , U.M.M.P. No. 25773. Occusial view. $\times 4$. Drawing by W. C. Sherman.

transverse width is 5.8 mm. There are five longitudinal grooves along the base (underside) of the tooth. The specimens agree with those from the Rexroad and Broadwater faunas.

Citellus sp.

Forty-five isolated upper and lower premolars and molars of ground squirrels were recovered. The material does not permit specific identification.

Family Geomyidae

Nerterogeomys cf. *minor* (Gidley)

(Fig. 7A-F)

Geomys minor Gidley, 1922, *U. S. Geol. Surv., Prof. Paper*, 131-E, p. 123.*Nerterogeomys? minor* (Gidley) Gazin, 1942, *Proc. U. S. Nat. Mus.*, Vol. 92, No. 3155, p. 487.

Fifteen lower jaws, parts of maxillaries, and isolated teeth apparently belonging to this species were recovered from locality UM-K1-47. The lower jaws are of immature, adult, and old specimens. There is considerable variation in the dental pattern of P⁴. The differences in these specimens are considered as age and individual variations.

The alveolar length of P₄-M₃, of a left ramus, No. 25090, is 6.0 mm.; the occlusal length of the teeth is 4.6 mm. The P₄-M₃ of specimen No. 25091 has an alveolar length of 5.85 mm. and an occlusal length of 5.1 mm. The P₄-M₃ of specimen No. 25092 has an alveolar length of 6.5 mm. and an occlusal length of 5.46 mm. Specimen No. 25095 is that of an old adult with P₄-M₂. The occlusal length of P₄-M₂ is 4.85 mm. The re-entrant angles of P₄ vary from acute to rectangular in shape. Both *Nerterogeomys? minor* and *Nerterogeomys persimilis* (Hay) have the mental foramen situated below the anterior extremity of the crest of the masseteric ridge. Only one of the lower jaws, specimen No. 25095, possesses a mental foramen that is situated as in these two forms. In the other fourteen specimens the mental foramen is anterior to the masseteric crest. There is a slight depression posterior to and labial to M₃. The depression or pit is best developed in the old specimen, No. 25095.

The enamel pattern of P⁴ is variable (see Fig. 7B-F). The majority of the teeth have an enamel band on the posterolingual edge of the posterior loph. The width of the posterior enamel band varies and appears to decrease in size with age. In one specimen it is very narrow and centrally located on the posterior surface of the loph. The enamel band is completely lacking on a few of the isolated upper fourth premolars.

M¹ is present in one of the maxillaries and has a typical *Geomys* pattern. The isolated upper incisors recovered are bisulcate.

Discussion.—No remains of the large gopher, *Geomys quinni* Mc-

Grew, were recovered from this deposit. Large and small gophers were recovered from locality 3 (see Franzen, 1947, pp. 55-59). The above specimens of *Nerterogeomys* cf. *minor* (Gidley) were compared with the specimens of *Nerterogeomys*? *minor* and *Nerterogeomys persimilis* in the collection of the United States National Museum. The Rexroad material appears to be more closely related to *N. minor* than to *N. persimilis*. The enamel pattern of P⁴ associated with the bisulcate upper incisors definitely places the gophers in the genus *Nerterogeomys*. More material is needed, especially associated lower and upper denti-

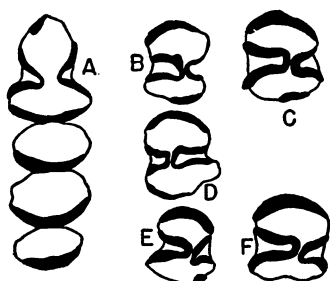


FIG. 7. *Nerterogeomys* cf. *minor* (Gidley).

- (A) U.M.M.P. No. 25092, RP₄-M₃. (B) U.M.M.P. No. 25097, RP⁴.
 (C) U.M.M.P. No. 25098, RP⁴. (D) U.M.M.P. No. 25097, LP⁴.
 (E) U.M.M.P. No. 25096, RP⁴. (F) U.M.M.P. No. 25098a, RP⁴. Occlusal views. All × 6. Drawing by Janet E. Roemhild.

tions, to understand fully the variation that has been observed in the specimens from Fox Canyon.

Family Heteromyidae

Perognathus pearlettensis Hibbard

(Fig. 8B-E)

Perognathus pearlettensis Hibbard, 1941, *Geol. Surv. Kans. Bull.*, 38, Pt. 7, pp. 207-8, Pl. 1, figs. 9; 12, Pl. 2, figs. 10, 14.

This small pocket mouse was common in the deposit. This is the first recorded occurrence of this species in the Rexroad fauna. This species was previously reported from the interglacial Borchers fauna.

Six lower jaws with complete dentitions, parts of thirteen left lower

jaws, nine right lower jaws with partial dentitions, and parts of four maxillaries were recovered from locality UM-K1-47. These specimens agree with the holotype and paratypes.

Specimen, No. 24818, (Fig. 8B) is a left maxillary of an adult animal. The alveolar length of P^4-M^3 is 3.3 mm., the anteroposterior occlusal length is 2.8 mm.

The characters of the lower jaws and dentitions of *P. pearlettensis* indicate that this form is probably more closely related to the *Perognathus intermedius* group than to any other recent group of *Perognathus*.

TABLE III
MEASUREMENTS (IN MILLIMETERS) OF LOWER DENTITIONS IN *Perognathus pearlettensis* HIBBARD, UNIVERSITY OF MICHIGAN, MUSEUM OF PALEONTOLOGY

Dimension	No. 24812	No. 24813	No. 24814	No. 24815	No. 24816
Alveolar length of P_4-M_3	3.1	3.11	3.1	3.1	3.15
Occlusal length of P_4-M_2	2.8	3.0	3.0	2.9	2.85
Greatest transverse width of P_4 ...	0.6	0.7	0.6	0.65	0.67
Greatest transverse width of M_1 ...	0.98	0.98	1.0	0.99	0.99
Greatest transverse width of M_2 ...	0.9	0.91	0.95	0.9	0.91
Greatest transverse width of M_3 ...	0.76	0.72	0.74	0.7	0.75
Depth of jaw (lingual side) below P_4	2.2	2.1	2.1	.....	2.1
Depth of jaw (lingual side) below M_2	1.78	1.7	1.82	.....	1.7
Depth of jaw (labial side) below P_4	2.8	2.5	2.68	.....	2.6
Depth of jaw (labial side) below M_2	2.4	2.25	2.4	.....	2.23

***Perognathus rexroadensis*, sp. nov.**

(Figs. 8A, F; 9, 10A-E)

Holotype.—No. 24793, University of Michigan Museum of Paleontology, a nearly complete left ramus with P_4-M_3 . Paratypes: No. 24792, a left ramus with P_4-M_3 ; No. 24794, a left ramus with P_4-M_3 ; No. 24795, a left ramus with P_4-M_3 ; No. 24796, a left ramus with P_4-M_3 ; No. 24797, a left ramus with P_4-M_3 ; No. 24798, a right ramus with P_4-M_3 ; No. 24799, a right ramus with P_4-M_3 ; No. 24800, a right ramus with P_4-M_3 ; No. 24804, a right maxillary with P^4-M^3 ; No.

24805, a right maxillary with P⁴-M³; No. 24806, a left maxillary with P⁴-M²; maxillaries Nos. 24802, 24803, 24808, and 24809 with both upper premolars. Collected in the summer of 1947 by the University of Michigan Museum of Paleontology field party.

Horizon and type locality.—Upper Pliocene, Rexroad formation, Rexroad fauna. Locality UM-K1-47, Fox Canyon, XI Ranch, Meade County, Kansas.

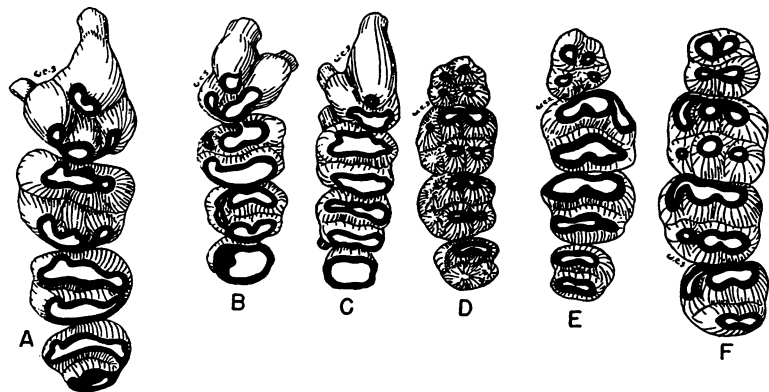


Figure 8

- (A) *Perognathus rexroadensis*, sp. nov., paratype, U.M.M.P. No. 24805, RP⁴-M³.
 (B) *Perognathus pearlettensis* Hibbard, U.M.M.P. No. 24818, LP⁴-M³.
 (C) *Perognathus pearlettensis* Hibbard, U.M.M.P. No. 24817, RP⁴-M³.
 (D) *Perognathus pearlettensis* Hibbard, U.M.M.P. No. 24816, LP⁴-M³.
 (E) *Perognathus pearlettensis* Hibbard, U.M.M.P. No. 24814, RP⁴-M³.
 (F) *Perognathus rexroadensis*, sp. nov., paratype, U.M.M.P. No. 24796, LP⁴-M³.
 Occlusal views. All $\times 10$. Drawings by W. C. Sherman.

Diagnosis.—A pocket mouse which is larger than *Perognathus gidleyi* Hibbard or *Perognathus mclaughlini* Hibbard. The mouse shows a closer relationship to *P. mclaughlini* than to *P. gidleyi*. *Perognathus rexroadensis* approaches forms of *Perognathus hispidus* Baird in size and characters of dentitions.

Description of holotype.—Specimen No. 24793 is a nearly perfect left lower jaw of an adult animal (see Fig. 9). The tips of both the coronoid process and angle are missing. The diastemal region is broad. The masseteric ridge is well developed. The basal capsular process of the incisor is not as inflated as in *Perognathus hispidus*.

P_4 is similar to the P_4 of *P. mclaughlini* of the Saw Rock fauna though larger. There is only a trace of an anterior groove on the front of the tooth separating the two cusps of the anterior loph. The labial re-entrant groove between the anterior loph and the posterior loph is poorly developed and is in contrast to the deeply developed lingual groove. This character distinguishes *Perognathus rexroadensis* from *P. gidleyi*. The labial cusp of the posterior loph is smaller than the lingual cusp of that loph. The lingual cusp is slightly posterior to the labial cusp. P_4 is equal to or smaller than M_3 .

M_1 has three cusps on the anterior and posterior loph. There is a small cingulum extending posteriorly from the labial cusp of the

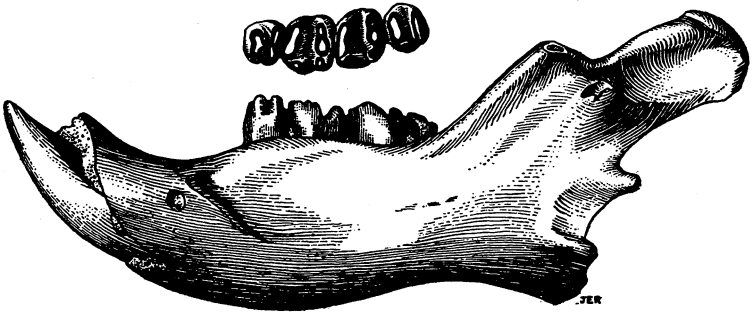


FIG. 9. *Perognathus rexroadensis*, sp. nov., holotype, U.M.M.P. No. 24793, left ramus, P_4 - M_3 . $\times 6$. Drawing by Janet E. Roemhild.

anterior loph (see Fig. 9). M_1 and M_2 are nearly equal in size. M_1 has a greater anteroposterior length than M_2 . M_2 has a greater transverse width than M_1 .

The distance from the anterior border of the alveolus of P_4 to the center of the alveolus of the incisor is 3.4 mm. The greatest diastemal width is 1.4 mm. The distance from the posterior alveolar border of M_3 to the center of the condyle is 6.71 mm. The dental foramen is not as large as it is in *Perognathus hispidus spilotus* Merriam. The depth of the ramus below P_4 on the lingual side is 3.2 mm. The depth of the ramus below M_3 on the lingual side is 2.5 mm. For comparative measurements of the holotype and certain of the paratypes, see Table IV.

Description of paratypes.—The dentitions of the lower jaws range in

TABLE IV
COMPARATIVE MEASUREMENTS (IN MILLIMETERS) OF HOLOTYPE (No. 24793) AND PARATYPES OF *Perognathus rexroadensis*
SP. NOV.

Dimension	No. 24792	No. 24793	No. 24794	No. 24795	No. 24796	No. 24797	No. 24798	No. 24799	No. 24800
Alveolar length of P ₄ -M ₃	3.9	3.9	4.2	4.1	4.08	4.1	4.1	4.1	4.2
Occlusal length of P ₄ -M ₃	3.89	3.9	4.1	4.1	3.85	3.9	4.1	4.05	3.81
Greatest transverse width of P ₄	0.8	0.89	0.9	0.9	0.86	0.91	0.85	1.0	0.9
Greatest transverse width of M ₁	1.15	1.2	1.0	1.25	1.2	1.2	1.25	1.3	1.22
Greatest transverse width of M ₂	1.1	1.3	1.25	1.2	1.2	1.3	1.3	1.3	1.2
Greatest transverse width of M ₃	0.9	1.0	1.25	0.8	0.9	1.05	1.0	1.0	0.88
Depth of ramus (lingual side) below P ₄	3.1	3.1	3.1	3.15	.....	.....	.....	3.15	.....
Depth of ramus (lingual side) below M ₃	2.1	2.5	2.3	2.15	.....	.....	2.85	2.3	.....

age from a young adult specimen, No. 24799, in which the cusps are but slightly worn, to that of an old adult specimen, No. 24800 (Fig. 10E), in which the cusps and re-entrant grooves have been completely worn away. P_4 is consistent in its development. P_4 is equal to or larger than M_3 . M_1 is equal to or larger than M_2 . In the well-worn dentitions M_1 is larger than M_2 . In the old worn specimen, No. 24800, P_4 is larger than M_3 . The capsular process for the base of the incisor is present in specimen No. 24794, and is developed as in the holotype. The coronoid process is also present in specimen No. 24794, and it is not separated

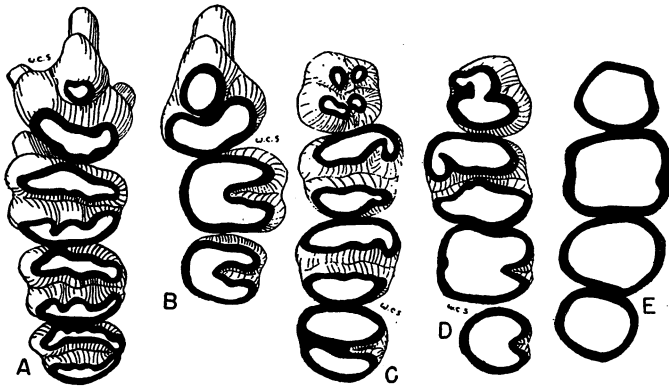


FIG. 10. *Perognathus rexroadensis*, sp. nov., paratypes. (A) U.M.M.P. No. 24804, RP_4-M_3 . (B) U.M.M.P. No. 24806, LP_4-M_2 . (C) U.M.M.P. No. 24798, RP_4-M_3 . (D) U.M.M.P. No. 24795, LP_4-M_3 . (E) U.M.M.P. No. 24800, old adult, RP_4-M_3 .

Occlusal views. All $\times 10$. Drawings by W. C. Sherman.

from the condyle by as broad a notch as in *Perognathus h. spilotus*. In the collection there are ten each of right and left fragmentary rami with partial dentitions. These agree with the holotype.

The anterior part of P^4 has a single cusp. The posterior loph has three cusps and is not as inflated posteriorly as in *Perognathus hispidus spilotus*. The anterior and posterior lophs of M^1 are separated by a deeper groove than the lophs of M^2 in young specimens. Both teeth possess deeper transverse grooves between the lophs than exist in *P. hispidus*. The grooves are not as deep on the lingual side as on the labial side, though they open onto the lingual side.

The transverse groove does not separate the anterior and posterior lophs of M^3 . The lophs are connected on the lingual side.

The alveolar length of P^4-M^3 of the right maxillary, No. 24804, is 4.6 mm. and the occlusal length is 3.7 mm. The alveolar length of P^4-M^3 of the right maxillary, No. 24805, is 4.6 mm. and the occlusal length is 3.8 mm. The maximum width across LP^4 and RP^4 of three maxillaries is as follows: 5.12 mm., 5.15 mm., and 5.35 mm.

Discussion.—*Perognathus rexroadensis* is closely related to *Perognathus mclaughlini*. *P. rexroadensis* is larger and the M_3 possesses a larger posterior loph for the size of the tooth than in the M_3 of *P. mclaughlini*. The M_3 of *mclaughlini* has a deeper transverse groove between the lophs. The two forms seem to represent an evolutionary sequence. No characters were observed in the series of *P. rexroadensis* that would exclude the form from being ancestral to *Perognathus hispidus*. *Perognathus rexroadensis* is distinguished from *P. gidleyi* from the Rexroad fauna by its larger size and by the development of P_4 .

Family Cricetidae

Baiomys rexroadi Hibbard

(Fig. 11)

Baiomys rexroadi Hibbard, 1941, *Amer. Midl. Nat.*, Vol. 26, No. 2, pp. 351–52, fig. 10.

Fifteen lower jaws and two fragmentary maxillaries of this small mouse were recovered. The specimens are slightly larger than the holotype from the Rexroad formation. The anteroposterior length of M_1-M_3 of the type is 2.6 mm. The range in the anteroposterior length of M_1-M_3 of five specimens is 2.85 to 2.95 mm., average, 2.9 mm. The maximum length of M_1-M_2 of five specimens, ranges from 2.0 to 2.35 mm., average, 2.23 mm.

Specimen No. 24846 (Fig. 11) is a nearly complete right ramus. The distance from the tip of the incisor to the center of the articular surface of the condyle is 10.5 mm. The depth of the ramus below M_3 (lingual side) is 1.6 mm. The tooth pattern of the above series agrees with the pattern of the holotype.

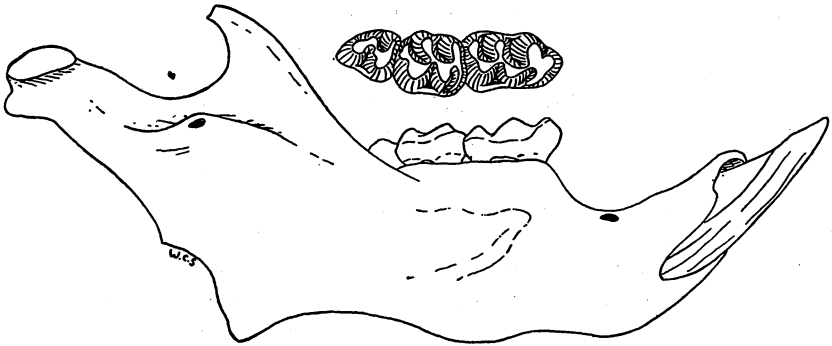


FIG. 11. *Baiomys rexroadi* Hibbard, U.M.M.P. No. 24846, right ramus, M_1 - M_3 . Lateral and occlusal views. $\times 10$. Drawing by W. C. Sherman.

Onychomys gidleyi Hibbard

(Fig. 12)

Onychomys gidleyi Hibbard, 1941, *Trans. Kans. Acad. Sci.*, Vol. 44, p. 281.

Three right and four left lower jaws of this grasshopper mouse were recovered. All of the jaws are broken and the dentitions are incomplete. The alveolar length of M_1 - M_3 in four jaws is 4.35 mm., 4.3 mm., 4.4 mm., and 4.4 mm. The maximum lengths of M_1 - M_2 in two specimens are 3.3 mm. and 3.31 mm. The anteroposterior length of M_1 - M_3 of the holotype is 4.0 mm. The holotype is figured on Plate II, Fig. 8 (Hibbard, 1942, p. 264). The characters of the jaws and teeth are like those of the holotype.

McGrew (1948, p. 550) listed the following rodents as Old World immigrants into North America at the beginning of Blancan time: *Onychomys* [= *Onychomys*], *Synaptomys*, *Ondatra*, *Sigmodon*, *Neotoma*, *Castor*, and *Mimomys*.

A form belonging to the genus *Onychomys* is known from the Middle Pliocene of North America. It was described by Hibbard (1937) as *Peromyscus martinii* from the Edson Quarry (see Hoffmeister, 1945, p. 191). The right lower jaw, No. 6201, Museum of Comparative Zoology, Harvard University, reported by Hibbard (1939a, p. 459) as *Peromyscus martinii* has been restudied as well as the holotype and

these specimens belong in the genus *Onychomys* rather than in the genus *Peromyscus* as previously reported.

There is no evidence to support the idea that *Onychomys*, *Sigmodon*, and *Neotoma* are Old World forms. All evidence from the fossil record points to a derivation from native North American stocks. The fossil record also supports the view that the genus *Ondatra* was derived from the North American *Pliopotamys*. There is no evidence from the fossil record to support the contention that *Pliopotamys* is an Old World immigrant or that the genus *Synaptomys* originated in Asia or Europe. The recovery of *Cosomys* from the Saw Rock Canyon deposits (Hibbard, 1949a, p. 103) makes questionable, in part, the origin of *Mimomys*. The fossil record points as strongly to the origin of the

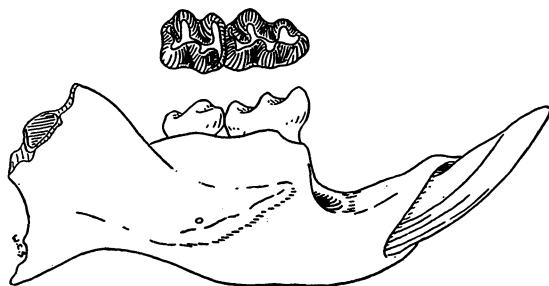


FIG. 12. *Onychomys gidleyi* Hibbard, U.M.M.P. No. 24859, part of right ramus, M_1 - M_2 . Lateral and occlusal views. $\times 6$. Drawing by W. C. Sherman.

Microtinae in North America as in Asia and Europe. The earliest forms, such as *Poamys* and *Goniodontomys*, occur in North America. Until the early and Middle Pliocene faunas of Canada are known, many assumptions in regard to origin and dispersal of Upper Pliocene forms will remain speculative.

Simpson (1947, pp. 641, 643) in his study of holarctic mammalian faunas of the Cenozoic has indicated that the microtines perhaps migrated from North America to Eurasia during the Middle Pliocene. The genus *Castor* appears to be as well known from the fossil records of the New World as from the Old World, but here again the facts concerning the definite origin of the genus awaits future discoveries. Simpson (1947, p. 642) considered that *Castor* may have migrated from North America to Eurasia in the late Pliocene.

Symmetrodontomys simplicidens Hibbard

(Fig. 13)

Symmetrodontomys simplicidens Hibbard, 1941, *Amer. Midl. Nat.*, Vol. 26, No. 2, pp. 354-55, fig. 12.

Seven right and two left lower jaws were recovered of this mouse. None of the lower jaws are complete. The best specimen is No. 24856 (Fig. 13) a right jaw bearing M_1 - M_3 . There is a distance of 10.28 mm. from the anterior border of M_1 to the center of the articular surface of the condyle. The range of the maximum measurements in milli-

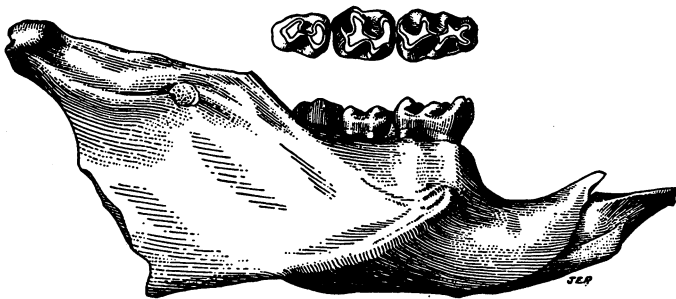


FIG. 13. *Symmetrodontomys simplicidens* Hibbard, U.M.M.P. No. 24856, right ramus, M_1 - M_3 . Lateral and occlusal views. $\times 6$. Drawing by Janet E. Roemhild.

meters of M_1 - M_3 , in a series of seven specimens is 4.1 to 4.4 mm., average 4.28 mm.

The enamel patterns of the teeth agree with those of the holotype. A number of maxillaries were recovered of the different cricetine rodents. Since none of the maxillaries were associated with lower dentitions, they have not been assigned with certainty to the species under discussion.

Bensonmys arizonae (Gidley)

(Pl. I, Figs. 1-10)

Eligmodontia arizonae Gidley, 1922, *U. S. Geol. Surv., Prof. Paper*, 131-E, pp. 124-25, Pl. 35, fig. 3.

Peromyscus eliasi Hibbard, 1937, *Trans. Kans. Acad. Sci.*, Vol. 40, p. 246, Pl. 1, fig. 4.

Eligmodontia? arizonae Gidley, Hibbard, 1941, *Trans. Kans. Acad. Sci.*, Vol. 44, pp. 283-84, Pl. 2, fig. 6.

Bensonomys arizonae (Gidley) Gazin, 1942, *Proc. U. S. Nat. Mus.*, Vol. 92, No. 3155, pp. 489-90.

In the collection there are parts of twenty-seven lower jaws of *Bensonomys* bearing M_1 - M_3 . There are a few fragmentary rami with one or two teeth. The range in measurement of fifteen right and twelve left lower molar series in the greatest anteroposterior length of M_1 - M_3 is from 3.7 to 4.2 mm., average 3.93.

The series of jaws has been compared with the holotype of *Bensonomys arizonae*. The dentitional series is slightly larger in all specimens than in the holotype. M_3 especially is wider and slightly longer than M_3 in the holotype. The jaws have also been compared with the holotype of *Peromyscus eliasi*. Specimen No. 24868, (Pl. I, Fig. 7) agrees with specimen No. 4547, University of Kansas, (Pl. I, Fig. 10) from locality 3. University of Kansas specimen No. 4549, (Pl. I, Fig. 1) is the ramus of an immature specimen. The pattern of M_3 is different from that in any specimen from Fox Canyon.

The size range of the anteroposterior length of M_1 - M_3 is no greater than exists in other forms of cricetines known from the Rexroad fauna. When a better series of *Bensonomys arizonae* is obtained, it may be that the size difference between the specimens from Arizona and Kansas will show that two distinct forms exist and that the name *eliasi* should be assigned to the specimens from Kansas.

The jaws which were recovered perhaps represent a heterogeneous group as there is considerable variation in the enamel pattern of the different molar series (Pl. I, Figs. 1-10). This variation, together with the great range in size which is not correlated with age, suggests that there may be two forms of *Bensonomys* represented in this material.

Parahodomys quadriplicatus Hibbard

(Fig. 4E, F)

Parahodomys quadriplicatus Hibbard, 1941, *Amer. Midl. Nat.*, Vol. 26, pp. 356-62, Pls. 1 and 2.

Two isolated immature teeth of this pack rat, No. 25772, a right M_1 and a left M^1 were recovered from locality UM-K1-47. The dental patterns of the teeth agree with those of the holotype and paratypes.

Pliophenacomys primaevus Hibbard

(Figs. 14A-N; 15A-F, H-J)

Pliophenacomys primaevus Hibbard, 1938, *Trans. Kans. Acad. Sci.*, Vol. 40, pp. 248-49, Pl. 1, fig. 5 (1937).

The holotype, No. 3905, University of Kansas Museum of Natural History, is a fragmentary right ramus of an extinct vole bearing M_1 and M_2 , with the alveolus of M_3 . The specimen was taken in the summer of 1936 at locality 2, Meade County, Kansas. No other specimen of *P. primaevus* was found in that region until the summer of 1947, when some were taken approximately ten miles southwest of the type locality at locality UM-K1-47. There were collected 28 right lower dentitions and 13 left lower dentitions, 94 partial lower left dentitions and 81 partial lower right dentitions, and numerous fragmentary maxillaries and many isolated teeth. Among the isolated teeth recovered were 120 left M_1 and 150 right M_1 . On the basis of the character of the lower first molar, parts of at least 259 individuals were recovered. The remains of this species constituted the dominant element of a local pocket of vertebrate fossils in the Rexroad formation.

The following description of *Pliophenacomys primaevus* is based on the above material which agrees with the holotype (see Fig. 16, for terminology used in discussion of microtine teeth).

Upper dentition and palatal region.— M^1 and M^2 possess typical microtine patterns. M^1 consists of an anterior loop and four alternating triangles (see Fig. 15A-E). The anterior loop is closed. The first and second alternating triangles vary from a closed to a nearly closed condition. The third triangle opens narrowly into the posterior triangle. M^2 consists of an anterior loop and three alternating triangles which are generally closed. In M^3 there is an anterior loop, an alternating triangle and a posterior loop. The tooth has two outer re-entrant angles, the first is weakly developed along the outer side of the anterior loop (see Fig. 15A-D). This incipient re-entrant enamel fold and the presence of the single alternating triangle between the anterior and posterior loop distinguishes *Pliophenacomys* from *Ogmodontomys*, which possesses an M^3 with an anterior loop, two alternating triangles, and a posterior loop. M^1 has three well-developed roots.

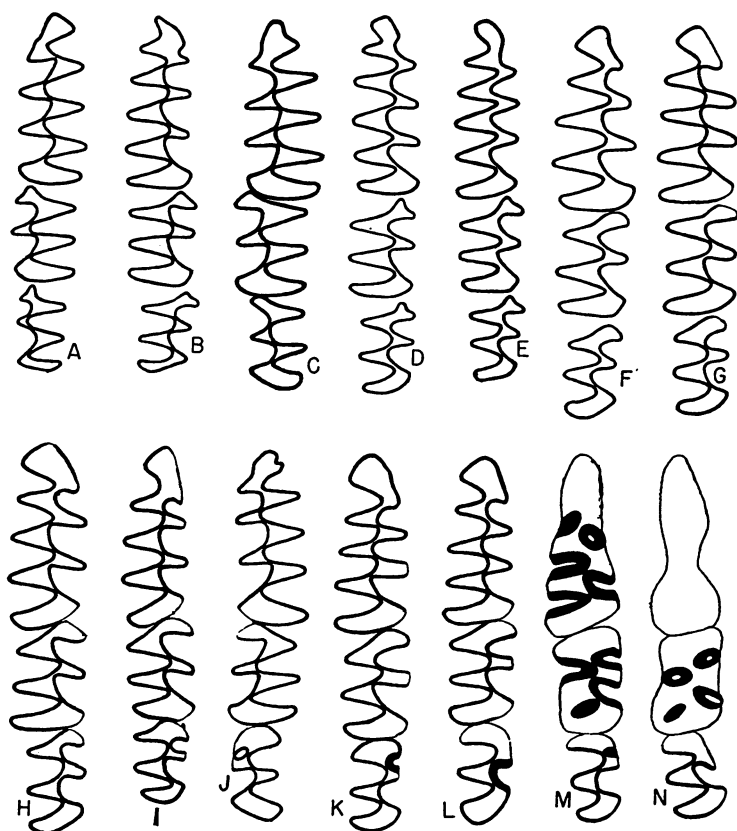


FIG. 14. *Pliophenacomys primaevus* Hibbard. Occlusal views of lower dentition patterns showing individual and age variations. All $\times 8$. Drawings by Betty Brooks.

- | | |
|---|---|
| (A) U.M.M.P. No. 25100, LM ₁ -M ₃ . | (B) U.M.M.P. No. 25101, RM ₁ -M ₃ . |
| (C) U.M.M.P. No. 25102, LM ₁ -M ₃ . | (D) U.M.M.P. No. 25103, RM ₁ -M ₃ . |
| (E) U.M.M.P. No. 25104, RM ₁ -M ₃ . | (F) U.M.M.P. No. 25105, RM ₁ -M ₃ . |
| (G) U.M.M.P. No. 25106, RM ₁ -M ₃ . | (H) U.M.M.P. No. 25107, RM ₁ -M ₃ . |
| (I) U.M.M.P. No. 25108, RM ₁ -M ₃ . | (J) U.M.M.P. No. 25109, LM ₁ -M ₃ . |
| (K) U.M.M.P. No. 25110, RM ₁ -M ₃ . | (L) U.M.M.P. No. 25111, RM ₁ -M ₃ . |
| (M) U.M.M.P. No. 25112, RM ₁ -M ₃ . | (N) U.M.M.P. No. 25113, RM ₁ -M ₃ . |

The large anterior root supports the anterior loop. The posterior root supports the fourth alternating triangle and part of the third alternating triangle. The middle root is situated on the lingual side of the

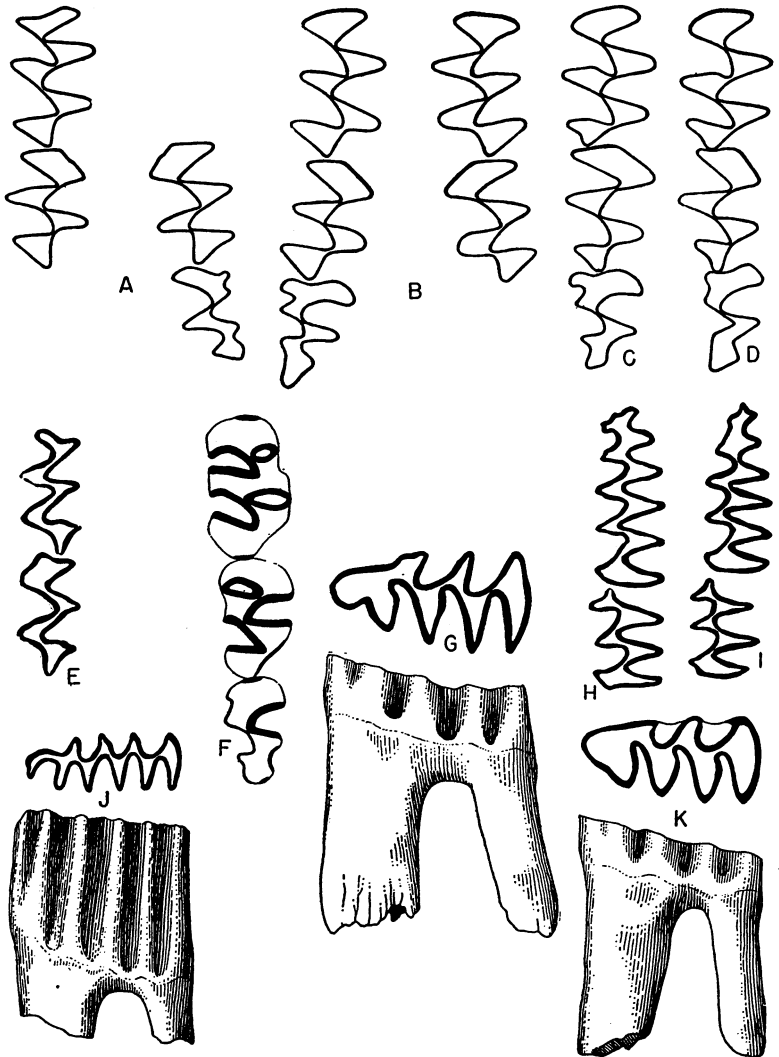


FIG. 15

tooth and supports the first alternating triangle and part of the third alternating triangle.

M² has three well-developed roots. There are two roots supporting the anterior loop and part of the first alternating triangle. The lingual root is larger than the labial root. The posterior root supports the second and third alternating triangles. It is the largest of the three roots.

M³ has two well-developed roots. The anterior root supports the anterior loop. The posterior root supports the alternating triangle and the posterior loop. The alternating triangle, with wear, opens widely into the posterior loop (see Fig. 15 C, D, and F). There is no cement in the re-entrant folds.

The anteroposterior occlusal length of M¹-M³ in No. 25130 is 6.25 mm.; in No. 25131, 6.2 mm.; in No. 25132, 6.3 mm.; in No. 25133, 5.95 mm.; and in No. 25128, 6.1 mm.

The maxillary tooth row is intermediate in size between that of *Phenacomys i. intermedius* Merriam and *Clethrionomys gapperi gaeli* Merriam.

The upper incisors are unknown.

The palate resembles that of *Clethrionomys* more than it does the

FIG. 15. *Pliophenacomys primaevus* Hibbard and *Ogmodontomys poaphagus* Hibbard. Occlusal and lateral views of upper and lower dentition patterns showing individual and age variations. All $\times 8$. Drawings by Betty Brooks and Janet E. Roemhild.

A-F. *Pliophenacomys primaevus*.

- (A) U.M.M.P. No. 25129, RM¹-M² and LM²-M³.
- (B) U.M.M.P. No. 25130, RM¹-M³ and LM¹-M².
- (C) U.M.M.P. No. 25131, RM¹-M³.
- (D) U.M.M.P. No. 25132, RM¹-M³.
- (E) U.M.M.P. No. 26306, immature, LM¹-M².
- (F) U.M.M.P. No. 25128, old adult, RM¹-M³.

G. *Ogmodontomys poaphagus*, U.M.M.P. No. 26305, RM₁. Lingual and occlusal views.

H-J. *Pliophenacomys primaevus*.

- (H) U.M.M.P. No. 26302, young adult, LM₁-M₂.
- (I) U.M.M.P. No. 26308, young adult, LM₁-M₂.
- (J) U.M.M.P. No. 26303, immature, RM₁. Lingual and occlusal views.

K. *Ogmodontomys poaphagus*, U.M.M.P. No. 26309, old adult, RM₁. Lingual and occlusal views.

palate of *Phenacomys*. The posterior borders of the incisive foramina (the anterior palatine foramina) are just anterior to the first molars. In specimen No. 25130 the distance between the posterior borders of the incisive foramina and the posterior border of the palate (measured to indentation) is 5.1 mm. The palate terminates approximately at the posterior border of M^2 . The lateral palatal grooves are well developed. The posterior part of the palate is developed as in *Clethrionomys* with the exception of a small posterior horizontal median process. The posterolateral pits are lateral to the median process. The pits are approximately the size of those of *Clethrionomys* and are developed in the same manner.

Lower jaw.—The lower jaw is heavily constructed in proportion to its size, especially the diastemal region which is broad in comparison to that region in *Phenacomys i. intermedius*. The mental foramen is situated dorsally on the diastemal region instead of on the labial side of the ramus. The incisor crosses from the lingual side of the ramus to the labial side under the posterior root of M_2 . The base of the incisor is well developed and extends farther up the ascending ramus than in either *Phenacomys* or *Clethrionomys*. Therefore the dental foramen is situated higher on the side of the ramus, a distance of 3.2 mm. from the posterior alveolar border of M_3 . There is no pit or indication of a pit labial to M_3 . The broad open groove between the tooth row and the ascending ramus is slightly obstructed posteriorly by the large, well-developed base of the incisor in old adult specimens. The alveolus for M_3 projects slightly linguad. It is intermediate in development between the alveolus of M_3 of *Phenacomys* and *Clethrionomys*. The ridges for the attachment of the masseter muscles are well developed.

Each of the lower molars possesses two roots which are well developed. The bases of the teeth are closed off and roots have started to develop in the youngest specimens studied. There is no cement in the re-entrant angles of the molars (Fig. 14A–N and Fig. 15H, I, and J show stages of wear and variations in dental pattern).

M_1 consists of a posterior loop, five alternating triangles, and an anterior loop. The first and second alternating triangles are nearly always closed. The third and fourth alternating triangles range from closed, or nearly closed, to open. The fifth triangle varies from a closed

triangle to an open triangle. In some young specimens shallow eighth and ninth re-entrant folds are developed on the anterior loop (Fig. 15H). These folds usually disappear with wear. The extreme condition in which the folds are retained in old age is shown in Figure 14J. M_1 is consistent in its retention, during wear, of the three external re-entrant angles and of the fourth internal re-entrant angle which distinguishes that tooth from the M_1 of *Cosomys* and *Ogmodontomys*.

M_2 consists of a posterior loop, and four alternating triangles. The first and second triangles are generally closed and the third and fourth are confluent.

M_3 consists of a posterior loop, and four alternating triangles. The first and second triangles are generally closed. The third and fourth alternating triangles are confluent. With wear the third and fourth triangles usually take on the appearance of an anterior loop. The second alternating triangle is greatly reduced in comparison to the first alternating triangle.

The range of measurements of 40 complete lower dentitions of all ages are as follows: anteroposterior crown (occlusal) length of M_1 - M_3 is 5.8 to 6.8 mm., average 6.32 mm.; anteroposterior alveolar length of M_1 - M_3 , is 6.1 to 7.1 mm., average 6.55 mm. Of forty-six specimens the anteroposterior crown length of M_1 - M_2 was 4.2 to 5.1 mm., average 4.7 mm. Of twenty-six teeth the range in the anteroposterior crown length of M_1 was 2.5 to 3.0 mm., average 2.88 mm. Of ten teeth the range in the anteroposterior crown length of M_2 was 1.5 to 1.8 mm., average 1.66 mm.

Relationship of Pliophenacomys primaevus to other forms.—The genus *Pliophenacomys* is distinct from *Cosomys* Wilson and *Ogmodontomys* Hibbard. It is distinguished from both forms by the characteristic development of M_1 and M^3 . It is more specialized than the above two genera in that it has developed the fourth and fifth alternating triangles of M_1 . It shows a closer relationship to *Mimomys?* *parvus* Wilson from Grand View, Idaho, than to any other known fossil form from America. The structure of M_1 of *Mimomys?* *parvus* Wilson separates it from *Cosomys* and *Mimomys* Forsyth Major.

On the basis of the pattern of M_1 and the absence of cement, although the pattern of M^3 of the paratype of *Mimomys?* *parvus* Wilson

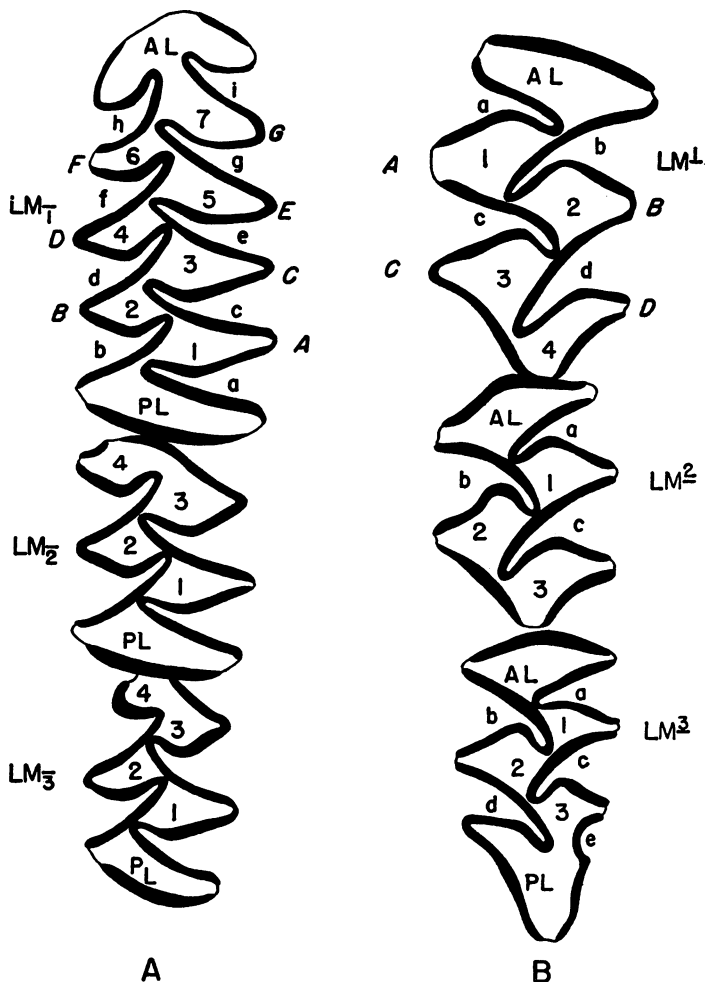


FIG. 16. Dental nomenclature of microtine teeth (after Hinton, 1926).

- (A) Left lower M_1 - M_3 of *Ondatra z. zibethicus*, (Linnaeus) U.M.M.Z. No. 89733. Occlusal view. $\times 8$.
- (B) Left upper M^1 - M^3 of *Ondatra z. zibethicus*, U.M.M.Z. No. 89733. $\times 8$.
- Abbreviations: al, anterior loop. pl, posterior loop or posterior transverse loop. 1, 2, 3, 4, 5, 6, 7; first, second, third, fourth, etc. alternating triangles, which may be closed or open. a, b, c, d, e, f, g, h, i; re-entrant angles. b, d, f, h; labial re-entrant angles. A, B, C, D, E, F, G; salient angles. e of LM^3 ; incipient angle, (see anterior loop of M_1 in Fig. 15H). 3 of LM^3 ; third alternating triangle, part of posterior loop. Lower teeth are described by beginning with posterior loop (pl) and upper teeth are described by beginning with the anterior loop (al).

differs from the known pattern of M^3 of *Pliophenacomys primaevus*, the form is considered to belong to the genus *Pliophenacomys*. The species *parvus* is distinct from *primaevus* due to its larger size and its more open alternating triangles. *Pliophenacomys* shows a close relationship to the genera *Cosomys* and *Ogmodontomys* due to the generalized characters of the early voles. It is probably closer to the genus *Dolomys* Nehring than it is to the genus *Mimomys*. The genus *Mimomys* appears to include two distinct groups of microtines. One group consists of the forms with an M_1 which possesses a posterior loop, three alternating triangles, and an anterior loop. The other group consists of the forms in which the M_1 possesses a posterior loop, five alternating triangles, and an anterior loop. *Pliophenacomys* has many characters in common with *Phenacomys* and *Clethrionomys*.

Ogmodontomys poaphagus Hibbard

(Figs. 15G, and K; 17A-J and L-P)

Ogmodontomys poaphagus Hibbard, 1941, *Amer. Midl. Nat.*, Vol. 26, No. 2, pp. 362-68, Pl. 3.

Parts of nineteen individuals of this extinct vole were recovered. This count is based on the left M_1 . Some of the specimens were young adults though only two of them possessed the enamel islet (Fig. 17B, I) present on the anterior loop of M_1 in the young specimens of *Cosomys* which were recovered with the Saw Rock fauna. The dental pattern agrees with the pattern of the paratypes. Five lower jaws containing M_1 - M_3 were recovered. The range of measurement of the maximum crown length of M_1 - M_3 in these specimens is 7.0 to 7.52 mm., average 7.17 mm. The alveolar length of M_1 - M_3 of four specimens is 7.3 mm., 7.4 mm., 7.5 mm., and 7.8 mm.

Ogmodontomys is slightly larger than the specimens referred to *Cosomys* (Fig. 17K) from the Saw Rock fauna. The forms from Fox Canyon are distinguished also by the character of the anterior loop of M_1 and by the position of the mental foramen which is situated more dorsally on the ramus. There is a close relationship between *Ogmodontomys* and the vole, *Cosomys*, from the Saw Rock fauna. When a better series of the Saw Rock form is known, it may be possible to show that it is ancestral to *Ogmodontomys*.

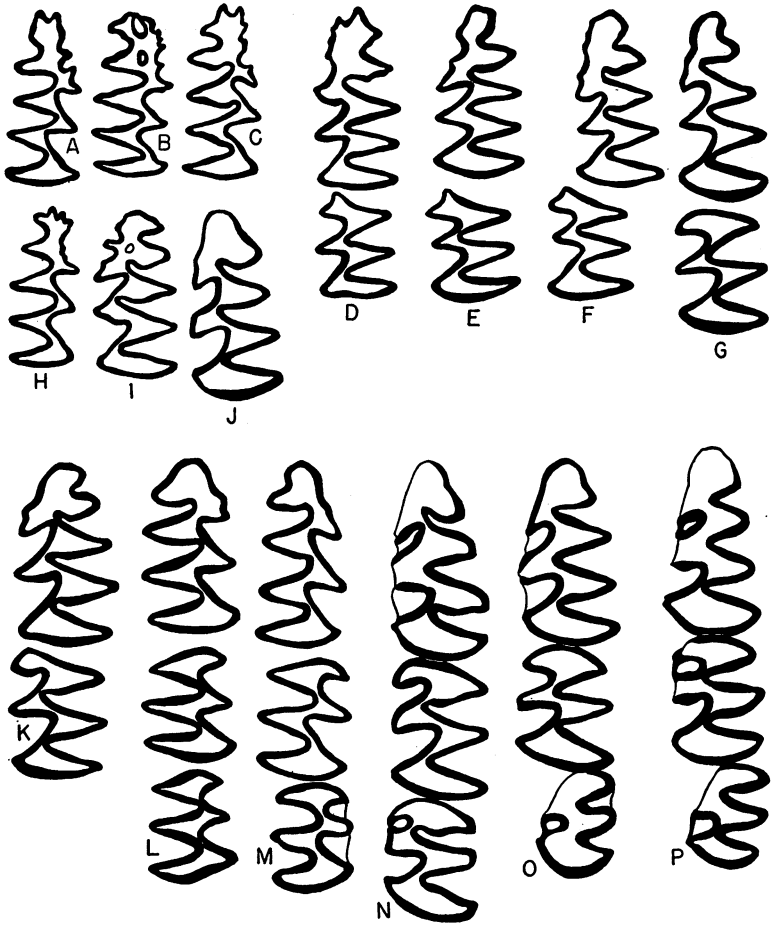


FIG. 17. *Ogmodontomys poaphagus* Hibbard and *Cosomys* cf. *primus* Wilson. Occlusal views of lower dentition patterns showing individual and age variations. All $\times 8$. Drawings by Janet E. Roemhild.

A-J. *Ogmodontomys poaphagus*.

- (A) U.M.M.P. No. 26304, immature, RM_1 .
- (B) U.M.M.P. No. 26307, immature, RM_1 .
- (C) U.M.M.P. No. 26310, immature, RM_1 .
- (D) U.M.M.P. No. 25140a, young adult, LM_1-M_2 .
- (E) U.M.M.P. No. 25140, young adult, LM_1-M_2 .
- (F) U.M.M.P. No. 26311, young adult, LM_1-M_2 .

ORDER CARNIVORA

Family Canidae

Borophagus diversidens Cope

(Fig. 18)

Borophagus diversidens Cope, 1892, *Amer. Nat.*, Vol. 26, p. 1028.

The only specimen of *Borophagus* in the Rexroad fauna was specimen No. 7266, University of Kansas, from the Keefe Canyon quarry, which was reported by Hibbard and Riggs (1949, Fig. 1H, F, and I).

The type specimen from the Blanco formation of Texas consists of the anterior part of a left ramus bearing the alveolus of P_2 , with P_3 and P_4 present. This specimen was figured by Cope (1893, Pl. 13, Figs. 4, 4a, 4b). The type was refigured and discussed by VanderHoof (1936, p. 415).

Meade (1945) at the time of the restudy of the Blanco fauna had only a part of a right maxillary and a right calcaneum in addition to the material reported by Cope.

In the Carnegie Museum is the anterior part of a left ramus, No. 9495, bearing the alveoli of the incisors, the canine, the alveolus of P_2 , and P_3-M_1 (Fig. 18). The specimen was collected seven miles northeast of Crosbyton, Texas. The writer is grateful to Doctor J. LeRoy Kay of the Carnegie Museum for permission to figure and place on record the second known ramus of *Borophagus diversidens*.

The ramus, No. 9495, was a surface find and shows the effects of considerable weathering. It is broken just posterior to M_1 and part of the ventral surface is missing. The distance between the canine and

(G) U.M.M.P. No. 26312, adult, LM_1-M_2 .

(H) U.M.M.P. No. 26307a, immature, RM_1 .

(I) U.M.M.P. No. 26307b, immature, LM_1 .

(J) U.M.M.P. No. 26313, adult, LM_1 .

K. *Cosomys* cf. *primus* Wilson, U.M.M.P. No. 24344, adult, LM_1-M_2 .

L-P. *Ogmodontomys poaphagus*.

(L) U.M.M.P. No. 25142, adult, RM_1-M_3 .

(M) U.M.M.P. No. 25143, adult, RM_1-M_3 .

(N) U.M.M.P. No. 25144, old adult, LM_1-M_3 .

(O) U.M.M.P. No. 25145, old adult, LM_1-M_3 .

(P) U.M.M.P. No. 25146, old adult, LM_1-M_3 .

symphysis is greatly reduced and the incisors are crowded. The alveolus of I_1 is approximately one-half the size of the alveolus of I_3 . The alveolus of I_1 is situated between the canine and symphysis. The alveolus of I_3 is situated anterior to the alveolus of I_1 and the canine and is developed at the anterior end of the narrow ramus.

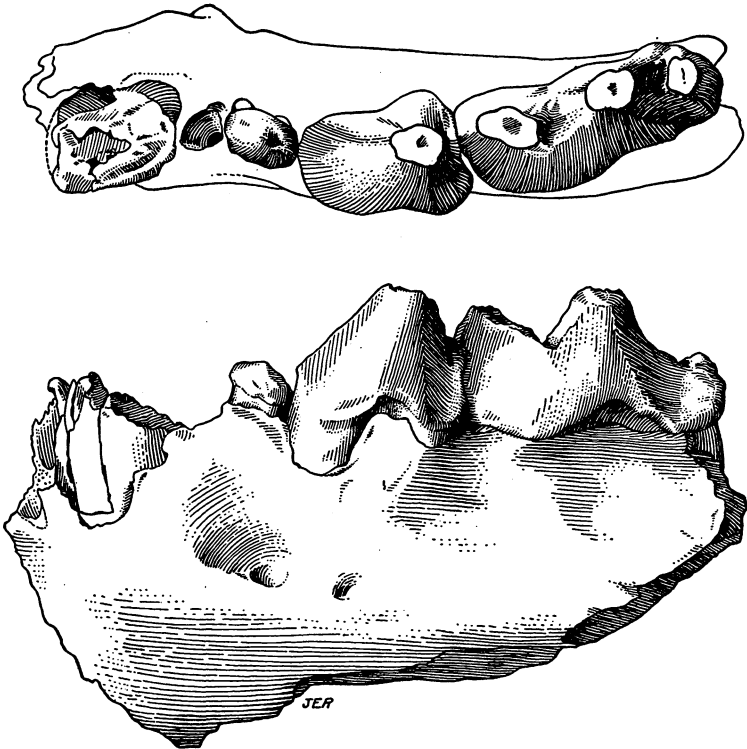


FIG. 18. *Borophagus diversidens* Cope, Carnegie Museum No. 9495, part of left ramus bearing part of canine, P_3 - M_1 . $\times 1$. Drawing by Janet E. Roemhild.

The alveolus of I_2 is greatly reduced and is developed in the posterior mesial border of the alveolus of I_3 . The second incisor was crowded in between I_1 and the canine and is posterior to I_3 . The canine is small in proportion to the massive ramus. Its anteroposterior

length is 16.0 mm., and the transverse width is 13.5 mm. The alveolus of P_2 has an anteroposterior length of 7.0 mm. The tooth was single-rooted and crowded tightly between the canine and P_3 which is two-rooted.

TABLE V

COMPARATIVE MEASUREMENTS (IN MILLIMETERS) OF *Borophagus diversidens*, SPECIMEN NO. 9495, CARNEGIE MUSEUM, AND THE HOLOTYPE OF *Osteoborus progressus* HIBBARD (1944c), SAW ROCK FAUNA, SEWARD COUNTY, KANSAS

Dimension	<i>Borophagus diversidens</i>	<i>Osteoborus progressus</i>
P_3 , anteroposterior length.....	9.3	9.5
P_3 , greatest transverse width.....	6.45	6.5
P_4 , anteroposterior length.....	20.6	17.5
P_4 , greatest transverse width.....	16.1	12.4
M_1 , anteroposterior length.....	35.2	27.8
M_1 , greatest transverse width.....	14.5	11.9
M_1 , transverse width across heel.....	11.65	10.7
Depth of ramus between P_2 and P_3	42.0	.....
Greatest vertical depth of symphysis.....	47.3	.....

Family Procyonidae

***Bassariscus rexroadensis*, sp. nov.**

(Fig. 19)

Holotype.—No. 25766, University of Michigan Museum of Paleontology, left M_1 . Collected in the summer of 1947 by the University of Michigan Museum of Paleontology field party.

Horizon and type locality.—Upper Pliocene, Rexroad formation, Rexroad fauna. Locality UM-K1-47, Fox Canyon, XI Ranch, Meade County, Kansas.

Diagnosis.—A procyonid, larger than any of the known forms of *Bassariscus*. M_1 has a greater transverse width in relation to its anteroposterior length than is known in any other fossil or recent form of *Bassariscus*.

Description of holotype.—The left M_1 has an anteroposterior length of 8.5 mm. The greatest width of the tooth is 4.4 mm. The length of the trigonid is 5.4 mm. The paraconid is nearly as high as the proto-

conid. The paraconid and protoconid are more widely separated than in recent forms of *Bassariscus*, thus producing a broader carnassial notch. The metaconid is well developed and distinct from the protoconid. The metaconid in relation to the protoconid is not as high in *B. rexroadensis* as in *B. astutus nevadensis* Miller. The talonid is short in comparison to the trigonid. The hypoconid is well developed and joins the base of the protoconid at the same angle as in recent forms of *Bassariscus*. There is no swelling or cusplet at the posterior base of the protoconid. The hypoconid and protoconid are separated by a shallow notch. The hypoconulid is not as large as the entoconid. The

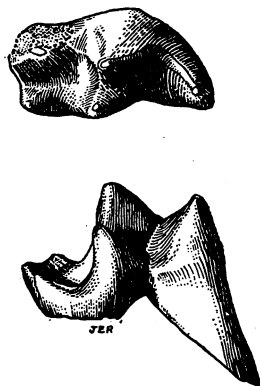


FIG. 19. *Bassariscus rexroadensis*, sp. nov., holotype, U.M.M.P. No. 25766, left M_1 . Lingual and occlusal views. $\times 3$. Drawing by Janet E. Roemhild.

hypoconulid is situated posterior and medial to the hypoconid. The hypoconulid and hypoconid are separated by a slightly greater notch than is observed in recent forms. A broad notch separates the hypoconulid and entoconid. The entoconid is low, which may be due to wear. The greatest transverse width of the talonid is 4.0 mm.

Discussion.—*Bassariscus rexroadensis* is distinguished from other known forms of *Bassariscus* by its broad M_1 and the short talonid in comparison to the length of the trigonid. The open carnassial notch and the open notches between the protoconid and the hypoconid and the hypoconulid and entoconid are distinctive characters.

Family Mustelidae

***Mustela rexroadensis*, sp. nov.**

(Fig. 20)

Holotype.—No. 25767, University of Michigan Museum of Paleontology, part of a right ramus bearing M_1 and the alveoli of P_4 and P_3 . Paratype, No. 25768, a left P^4 . Collected in the summer of 1947 by the University of Michigan Museum of Paleontology field party.

Horizon and type locality.—Upper Pliocene, Rexroad formation, Rexroad fauna. Locality UM-K1-47, Fox Canyon, XI Ranch, Meade County, Kansas.



FIG. 20. *Mustela rexroadensis*, sp. nov., holotype, U.M.M.P. No. 25767, part of right ramus bearing M_1 . Lateral and occlusal views. $\times 3$. Drawing by Janet E. Roemhild.

Diagnosis.—A weasel the size of *Mustela cicognanii* Bonaparte. It is distinguished from recent weasels by the open carnassial notch and the low paraconid blade of M_1 . The paraconid is not as broad as in recent forms. P_4 is larger in proportion to M_1 than P_4 is to M_1 in recent forms.

Description of type.—A fragmentary right ramus bearing M_1 . The anteroposterior length of M_1 is 4.3 mm.; the greatest width is 1.35 mm. The distance from the posterior edge of the alveolus of M_1 to the anterior border of the alveolus of P_3 is 9.9 mm.

The left P^4 is of an adult animal. The paracone does not extend as far anteriorly in relation to the anterior root as does the paracone in recent forms. The anteroposterior length of P^4 is 4.5 mm. The anteroposterior length of the carnassial blade is 3.1 mm.

Buisnictis, gen. nov.

Genotype.—*Buisnictis meadensis*, sp. nov., No. 25769, University of Michigan Museum of Paleontology; left P⁴. Collected in the summer of 1947 by the University of Michigan Museum of Paleontology field party.

Diagnosis.—A mustelid as large as the largest specimens of *Mustela frenata* Lichtenstein. The P⁴ is distinct in that the anterolabial root is not separated from the anterolingual root by a notch as in the genus *Mustela*. The paracone extends anteriorly to the anterior edge of the anterior root of the tooth. There is a small parastyle at the anterior base of the paracone. The protocone (deuterocone) is well developed



FIG. 21. *Buisnictis meadensis*, gen. et. sp. nov., holotype, U.M.M.P. No. 25769, left P⁴. Labial and occlusal views. $\times 3$. Drawing by Janet E. Roemhild.

but slightly pressed to the paracone. The metacone is well developed and separated by a distinct notch from the paracone.

The genus is named in honor of Mr. Brother Buis of Meade, Kansas, who helped during the past twelve years to make each summer's work in southwestern Kansas as successful as possible.

Buisnictis meadensis, sp. nov.

(Fig. 21)

Holotype.—No. 25769, University of Michigan, Museum of Paleontology; a left P⁴. Paratype, No. 25770, a right P⁴.

Horizon and type locality.—Upper Pliocene, Rexroad formation,

Rexroad fauna. Locality UM-K1-47, Fox Canyon, XI Ranch, Meade County, Kansas.

Description of holotype.—A left P^4 of an adult animal. The anteroposterior length of the tooth is 5.55 mm. The anteroposterior length of the carnassial blade (paracone–metacone) is 3.4 mm. The width across the anterior base of tooth is 2.55 mm. The paracone is nearly vertical with the long axis of the anterior root. The parastyle is greatly reduced as a result of the development of the paracone. There is a slight indentation at the anterior border of the tooth. The protocone is well developed and separated by a small groove from the base of the paracone.

Description of paratype.—The paratype has an anteroposterior length of 5.7 mm. The anteroposterior length of the carnassial blade is 4.0 mm. The width across the anterior base of the tooth is 2.65 mm. This tooth is worn more than the type.

Brachyprotoma breviramus Hibbard

(Fig. 22)

Brachyprotoma breviramus Hibbard (1941), *Amer. Midl. Nat.*, Vol. 26, pp. 340–42, fig. 3.

A part of a left ramus, No. 25771, of this small short-jawed skunk, with canine, alveoli of P_2 – P_3 , and P_4 – M_1 , was recovered in association with the above mustelids.

The specimen agrees with the holotype (see Table VI). The anterior part of the ramus is missing. P_2 is crowded labially to the side of P_3 .

TABLE VI
COMPARATIVE MEASUREMENTS (IN MILLIMETERS) OF *Brachyprotoma breviramus*

Dimension	No. 25771 U.M.M.P.	Holotype No. 4609 K.U.
Length from posterior border of canine alveolus to anterior edge of M_1	4.9	5.7
Anteroposterior length of P_4	3.2	.....
Anteroposterior length of M_1	5.85	5.7
Anteroposterior length of trigonid	3.4	3.4
Width of M_1 through base of metaconid- protoconid	2.4	2.8
Width across posterior border of talonid	2.5	2.5

If the tooth possessed two roots, the anterior root was reduced and located in the alveolus with the canine. There are two mental foramina. The anterior opening is located below the posterior alveolus of P_2 . The posterior opening is below the anterior root of P_4 .

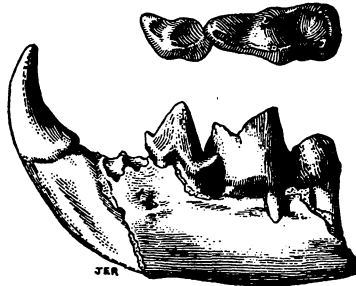


FIG. 22. *Brachyprotoma breviramus* Hibbard, U.M.M.P. No. 25771, part of left ramus bearing canine, P_4 - M_1 . Lateral and occlusal views. $\times 3$. Drawing by Janet E. Roemhild.

ORDER LAGOMORPHA

Family Leporidae

Hypolagus regalis Hibbard

(Figs. 23A, B)

Hypolagus regalis Hibbard, 1939, *Amer. Midl. Nat.*, Vol. 21, No. 2, pp. 510-11, fig. 3.

Two incomplete left rami of *Hypolagus regalis* were recovered from the deposit in Fox Canyon. Specimen No. 24787 (Fig. 23A) is the ramus of a young individual of approximately the same age as the holotype from the Rexroad formation, locality 3, Meade County, Kansas. The specimen lacks M_3 . Specimen No. 24786 (Fig. 23B) is an older individual, the left ramus is more complete and possesses the incisor and P_3 - M_3 . Comparative measurements of these and of the holotype are given in Table VII.

Both of these specimens differ from the holotype in that the enamel in the broad anteroexternal re-entrant angle of P_3 is not crenulated. The enamel of the posteroexternal re-entrant angle of P_3 also lacks the crenulation observed in the holotype.

TABLE VII
COMPARATIVE MEASUREMENTS (IN MILLIMETERS) OF *Hypolagus regalis*

Dimension	Holotype No. 4572 K.U.	No. 24786 U.M.M.P.	No. 24787 U.M.M.P.
Alveolar length (labial) P ₃ -M ₃.....	.....	17.0	.....
Alveolar length (labial) P ₃ -M ₂	12.8	14.0	13.0
Anteroposterior diameter of I.....	2.3	2.6	2.4
Transverse diameter of I.....	2.7	3.2	2.8
Diastema I-P ₃	16.9	19.2	17.6
Depth of ramus (lingual) at posterior edge of M ₂	15.3	15.3	.....

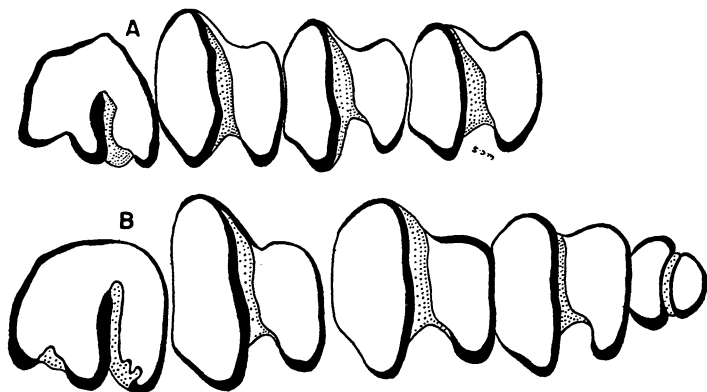


FIG. 23. *Hypolagus regalis* Hibbard. Occlusal views. $\times 6$. Drawings by W. C. Sherman.

(A) U.M.M.P. No. 24787, LP₃-M₂. (B) U.M.M.P. No. 24786, LP₃-M₃.

DISCUSSION

The deposit from which the fossils were taken in Fox Canyon was laid down by a stream that was carrying fine sediments which consisted chiefly of silts and fine sands. The remains of fishes in the deposit indicate that the stream was probably permanent. The size of the fossils recovered shows the effect of stream sorting. The material does not show signs of abrasion and appears to have been transported but a short distance, either from slope wash along the valley or carried by a short tributary that headed in the upland area.

Because of the dominance of rodents, the concentration of small vertebrates is best accounted for as an accumulation of remains from the pellets or castings of owls or hawks that nested nearby.

Notiosorex jacksoni, *Citellus*, *Nerterogeomys minor*, *Perognathus rexroadensis* and *P. pearlettensis*, *Onychomys gidleyi*, and *Pliophenacomys primaevus* are considered as inhabiting upland grassland areas. *Nerterogeomys* is considered as an upland form since it is rare in the deposits where dominant lowland forms have been recovered.

Pliophenacomys appears to be an upland form in contrast to *Ogmodontomys* and *Sigmodon*, which have been taken in deposits that have yielded other lowland forms.

At present it is not possible to assign *Baiomys*, *Bensonomys*, and *Symmetrodontomys* to a definite habitat. *Paenemarmota* may have lived along the valley slopes or on the upland.

REXROAD FAUNA

The first forms of the Rexroad fauna were collected in the summer of 1936, in Meade County, Kansas (Hibbard, 1938).

Many isolated finds of Upper Pliocene vertebrate remains have been made in Meade County, but the great majority were taken from the following five localities: Nos. 2, 2a, 3, and 22, of the University of Kansas, and No. UM-K1-47, of the University of Michigan. These localities are listed and discussed below. The vertebrate assemblage at each of these localities is shown in Table VIII. Forms from the Blanco fauna of Texas which are common to the Rexroad fauna are also noted in the table. For a list of the Blanco fauna, see Meade (1945, p. 515).

Locality No. 2

Locality 2, University of Kansas, is in the SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 22, T. 33 S., R. 29 W. of Meade County, Kansas. The deposit containing the fossils was discovered by members of a CCC Camp, in a tubular pocket of sand on the crest of a small knoll of clay and silty clay of the Rexroad formation. The sand pocket was circular in outline and approximately two feet in diameter (Pl. II, Fig. 1). It contained an abundance of mastodon and horse teeth, which were associated with smaller vertebrate remains and many fragmentary bones. The sand which extended vertically into the clay had been removed to a depth of approximately

four feet, by members of the CCC Camp. This was sifted for vertebrate fossils (see Hibbard, 1949c, Pl. I, Fig. 1) and the sand tube was later excavated to a depth of ten feet.

At the time of the discovery of the deposit and for sometime after its significance was not recognized. Those studying the deposit could not account for the vertical sand tube containing the fine sand and the abundance of the teeth of mastodons and horses.

It was not until locality 2a (described below) had been opened in the Rexroad silt and clay a few yards south of the sand tube across the fence in the NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 22, T. 33 S., R. 29 W., in the pasture of Clarence Rexroad, that it was discovered that the sand tube containing the fossils was part of the remnant of an old artesian spring.

The basin around the extinct spring had been removed by erosion before the fossil locality was discovered. It is not known whether the spring was active prior to the deposition of the Meade formation or after part or all of it had been laid down in that area. Because of the abundance of the teeth of *Nannippus phlegon* recovered from the sand, the nearness of the top of the tube to the present horizon of the Meade Gravels, and the fact that *Nannippus phlegon* had hitherto been rare in typical Rexroad deposits, the fossils were not considered typical of the Rexroad fauna until the same forms were taken from Rexroad deposits which were unquestioned.

Locality 2 was worked in the summer of 1936 and for two days in the summer of 1937. It seems probable that some forms recovered from the sand tube were trapped in the artesian spring basin and others were reworked from the Rexroad clay and silt through which the water passed.

Locality No. 2a

Locality 2a, University of Kansas, is only a few yards south of Locality 2, in the NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 22, T. 33 S., R. 29 W., of Meade County, Kansas. When this locality was excavated, it was considered to be an extension of locality 2, since the outcrop was continuous. The fossils taken from this quarry at that time were reported as from locality 2. The quarry was first worked in the summer of 1938 and the silty clay removed for washing. This locality, which is in the Rexroad pasture, was designated locality 2a because there was: (1)

TABLE VIII
 REXROAD FAUNA OF MEADE COUNTY, KANSAS

Occurrence of forms is listed by localities. Type locality of form is indicated by an asterisk.

Form	No. 2	No. 2a	No. 3	No. 22	UM- K1-47	Blanco
Amphibia						
Family Pelobatidae						
<i>Scaphiopus diversus</i> Taylor			*			
<i>Neoscaphiopus noblei</i> Taylor			*			
Family Bufonidae						
<i>Bufo</i> sp.			*			
Family Ranidae						
<i>Anchylorana moorei</i> Taylor			*			
<i>Anchylorana dubita</i> Taylor			*			
<i>Anchylorana robustocondyla</i> Taylor			*			
<i>Rana fayeae</i> Taylor			*			
<i>Rana meadensis</i> Taylor			*			
<i>Rana ephippium</i> Taylor			*			
<i>Rana rexroadensis</i> Taylor			*			
<i>Rana valida</i> Taylor			*			
<i>Rana parvissima</i> Taylor			*			
Reptilia						
Order Squamata						
Family Teiidae						
<i>Cnemidophorus bilobatus</i> Taylor		*				
Family Scincidae						
<i>Eumeces striatulatus</i> Taylor	*					
<i>Eumecoides hibbardi</i> Taylor	*					
<i>Eumecoides mylocoelus</i> Taylor	*					
Order Testudinata						
Family Testudinidae						
<i>Testudo riggsi</i> Hibbard			?			
Aves						
Order Colymbiformes						
Family Colymbidae						
<i>Colymbus</i> sp.						
Order Ciconiiformes						
Family Threskiornithidae						
Threskiornithid, sp. incert.						
Order Anseriformes						
Family Anatidae						
<i>Neltion bunkerii</i> Wetmore			*			
<i>Charitonetta albeola</i> (Linnaeus)						
Order Falconiformes						
Family Accipitridae						
<i>Buteo</i> sp.						
Order Galliformes						
Family Phasianidae						
<i>Colinus hibbardi</i> Wetmore			*			
Family Meleagrididae						
<i>Meleagris gallopavo</i> Linnaeus						
Meleagrididae, sp.?						

TABLE VIII (Continued)

Form	No. 2	No. 2a	No. 3	No. 22	UM- K1-47	Blanco
Aves—Cont.						
Order Gruiformes						
Family Rallidae						
<i>Rallus prenticei</i> Wetmore	*					
<i>Fulica americana</i> Gmelin						
Order Charadriiformes						
Family Scolopacidae						
Scolopacidae, sp.?						
Family Laridae						
<i>Sterna</i> sp.						
Order Columbiformes						
Family Columbidae						
<i>Zenaidura macroura</i> (Linnaeus)						
Order Psittaciformes						
Family Psittacidae						
Psittacidae, sp.?						
Order Passeriformes						
Passeriformes, not identified						
Mammalia						
Order Insectivora						
Family Soricidae						
<i>Sorex taylori</i> Hibbard	*					
<i>Paracryptotis rex</i> Hibbard	?				*	
<i>Notiosorex jacksoni</i> Hibbard					*	
Family Talpidae						
<i>Hesperoscolops rexroadi</i> Hibbard		*				
<i>Scalopus</i> sp.						
Order Chiroptera						
Family Vespertilionidac						
<i>Lasiurus fossilis</i> Hibbard					*	
Order Edentata						
Family Megalonychidae						
<i>Megalonyx</i> cf. <i>leptostomus</i> Cope						
Order Rodentia						
Family Sciuridae						
<i>Paenemarmota barbouri</i> Hibbard and Schultz						
<i>Citellus howelli</i> Hibbard	?	?	*	*	?	
<i>Citellus rexroadensis</i> Hibbard	?	?	*	?	?	
Family Geomyidae						
<i>Nerterogeomys minor</i> (Gidley)						
<i>Geomys quinni</i> McGrew						
Family Heteromyidae						
<i>Perognathus rexroadensis</i> Hibbard					*	
<i>Perognathus gidleyi</i> Hibbard			*			
<i>Perognathus pearlettensis</i> Hibbard						
<i>Liomys centralis</i> Hibbard			*			

TABLE VIII (Continued)

Form	No. 2	No. 2a	No. 3	No. 22	UM-K1-47	Blanco
Mammalia, Order Rodentia—Cont.						
Family Castoridae						
<i>Dipoides rexroadensis</i> Hibbard and Riggs.....				*		
<i>Procastoroides lanei</i> (Hibbard).....						
Family Cricetidae						
<i>Bensonmys arizonae</i> (Gidley).....						
<i>Peromyscus kansasensis</i> Hibbard.....			*			
<i>Baionmys rexroadi</i> Hibbard.....		*				
<i>Onychomys gidleyi</i> Hibbard.....		*				
<i>Symmetrodontomys simplicidens</i> Hibbard.....			*			
<i>Sigmodon intermedius</i> Hibbard.....	*					
<i>Parahodomys quadriplicatus</i> Hibbard.....			*			
<i>Ogmodontomys pouphagus</i> Hibbard.....			*			
<i>Pliophenacomys primaevus</i> Hibbard.....	*					
<i>Pliopotamys meadensis</i> Hibbard.....	*					
Order Carnivora						
Family Canidae						
<i>Canis</i> sp. (large).....						
<i>Canis lepophagus</i> Johnston.....						
<i>Borophagus diversidens</i> Cope.....						
Family Procyonidae						
<i>Bassariscus rexroadensis</i> Hibbard.....					*	
<i>Procyon rexroadensis</i> Hibbard.....			*			
Family Mustelidae						
<i>Buisnictis meadensis</i> Hibbard.....					*	
<i>Trigonictis kansasensis</i> Hibbard.....			*			
<i>Mustela rexroadensis</i> Hibbard.....					*	
<i>Martes foxi</i> Hibbard and Riggs.....				*		
<i>Taxidea taxus</i> (Schreber).....						
<i>Brachyprotoma breviramis</i> Hibbard.....			*			
<i>Spilogale rexroadi</i> Hibbard.....			*			
Family Felidae						
<i>Felis</i> sp. (large).....						
<i>Felis lacustris</i> Gazin.....						
<i>Machairodus</i> sp. or <i>Chasmaportetes</i> sp.....						
Order Proboscidea						
Family Gomphotheriidae						
<i>Stegomastodon successor</i> (Cope).....						
Family Mammutiidae						
<i>Mammut (Pliomastodon) adamsi</i> Hibbard.....						

TABLE VIII (Concluded)

Form	No. 2	No. 2a	No. 3	No. 22	UM-K1-47	Blanco
Mammalia—Cont.						
Order Perissodactyla						
Family Equidae						
<i>Nannippus phlegon</i> (Hay)	—	—	—	—	—	—
<i>Equus (Hippotigris) simplicidens</i> Cope	—	—	—	—	—	—
Order Lagomorpha						
Family Leporidae						
<i>Pratilepus kansasensis</i> Hibbard	—	—	*	—	—	—
<i>Notolagus lepusculus</i> (Hibbard)	—	—	*	—	—	—
<i>Hypolagus regalis</i> Hibbard	—	—	*	—	—	—
<i>Nekrolagus progressus</i> (Hibbard)	—	—	*	—	—	—
Order Artiodactyla						
Family Tayassuidae						
<i>Platygonus bicalcaratus</i> Cope	—	—	—	—	—	—
Family Camelidae						
<i>Pliauchenia cochranii</i> Hibbard and Riggs	—	—	—	*	—	?
<i>Gigantocamelus spatulus</i> (Cope)	—	—	—	—	—	—
<i>Tanupolama blancoensis</i> Meade	—	—	—	—	—	—
Family Cervidae						
Cervid (genus?)	—	—	—	—	—	—
Family Antilocapridae						
Antilocaprid (genus?)	—	—	—	—	—	—

a difference in the matrix containing the fossils at the two localities; (2) a possibility that some of the fossils removed from the sand tube in the Rexroad clay at locality 2 may have been reworked from deposits younger than the Rexroad; and (3) a chance that the spring may have been active after the deposition of the Rexroad formation and so could have received animals that lived at a later time. The sandy silt and clay at locality 2a seem to be slack-water deposits, probably laid down on a flood plain.

Locality No. 3

Locality 3, University of Kansas, is in the Rexroad pasture at an outcrop in the type section of the Rexroad formation in the W. $\frac{1}{2}$ SW. $\frac{1}{4}$ sec. 22, T. 33 S., R. 29 W. Meade County, Kansas. This quarry (Pl. III, Figs. 1–2) was first worked in the summer of 1937 (Baker, 1938; Hibbard, 1939, 1941, 1941a, 1944; Taylor, 1941, 1942; Wetmore, 1944).

Invertebrates occur in these exposures both below and above the

horizon from which the vertebrate fossils were taken (Baker, 1938). The remains of a number of catfish and a few spines of sunfish have been recovered from this locality but have not been studied. The deposit at locality 3 from which the vertebrates were taken seems to have been laid down in ponded water, either an oxbow lake or back of a beaver dam (Hibbard, 1941*b*).

Locality No. 22

Locality 22, University of Kansas, is in Keefe Canyon, Guy Fox pasture, in the SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 34, T. 34 S., R. 30 W., Meade County, Kansas (Pl. IV, Figs. 1, 2). The fossils were recovered from an old artesian spring in the Rexroad formation approximately fifty feet below the base of the overlying Meade Gravels (Hibbard and Riggs, 1949, Pl. I, Figs. 1-2; Pl. II, Figs. 1-2).

The fossils from this deposit represent small forms which may have lived around the edge of the spring and larger forms that came to the place for water and became mired in the quicksand or in the bog around the edge of the basin.

Locality UM-K1-47

Locality UM-K1-47, University of Michigan is located in Fox Canyon in sec. 35, T. 34 S., R. 30 W., Meade County, Kansas (Pl. V, Figs. 1-2). The vertebrate fossils from this locality are described and discussed in this report.

Other Localities

Other fossil localities in the Rexroad formation of Meade County besides the numbered ones listed above are as follows: (1) near the center of the section line between secs. 17 and 18, T. 32 S., R. 28 W., on the south side of a draw, nine feet above the base of the exposure is a fifteen-inch lens of sandy silt containing abundant remains of invertebrates and some remains of turtle and horse; (2) in the NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 19, T. 32 S., R. 28 W., on the south side of the main branch of Spring Creek, abundant invertebrate fossils occur in an old soil or bog zone at the base of a small exposure of the Rexroad formation.

In Seward County, Kansas, just west of Meade County, in sec. 36, T. 34 S., R. 31 W., the types of *Testudo riggsi* Hibbard (1944*b*) and

Mammot (Pliomastodon) adamsi Hibbard (1944c) were taken from the Rexroad deposits (Hibbard, 1949b; Hibbard and Riggs, 1949).

Discussion

The deposits at the different localities were not laid down at the same time. At present there is no way of demonstrating any great difference in age, nor is there any evidence to prove which is the youngest or the oldest. The overlying Meade Gravels were deposited in channels that were cut deeper into the underlying beds in some places than in others. At localities 2, 2a, and 3 the Meade Gravels and massive caliche are absent.

The difference between the faunules at the various localities appears to reflect to some extent the habitat preference of some forms, those existing in the immediate area, and the accidental preservation of others.

ANALYSIS OF THE REXROAD FAUNA

The absence of *Sigmodon* and *Sorex taylori* from localities UM-K1-47 and 22 is difficult to explain. Most of the forms recovered from the deposit at locality UM-K1-47 are considered upland forms. *Ogmodontomys* is considered to be a lowland form, but its presence in the deposit is rare in comparison with the abundance of *Pliophenacomys* which has been considered as an upland form. There is no evidence that rodent populations in the past did not fluctuate between years of large populations and years of severe decline in numbers, as rodent populations do at the present. It does not follow, however, that when one form is abundant all forms are abundant. It appears that at the time the deposits were being laid down at localities 2a and 3, *Sigmodon* was a common form in the fauna of that area and *Pliophenacomys* was rare; but the reverse relationship existed when the Fox Canyon deposit was laid down.

Observations made at the time the fossil forms were collected demonstrate population fluctuation among living rodents of that area. In the summers of 1936 and 1937 all owl pellets found in Clark, Meade, and Seward counties, Kansas, were examined in order to determine the kinds of small mammals present in that area. The numerous remains of the harvest mouse recovered indicated it to be one of the abundant

forms. No remains of *Sigmodon* or microtines were found but intensive and extensive trapping yielded one specimen of *Sigmodon*. By the summer of 1941 *Sigmodon* had reached nearly a plague stage (Rinker, 1942, p. 377; Hibbard and Rinker, 1942) and by 1944 it was again rare in the region (Hibbard, 1944d, p. 80). The absence of *Sorex* from the Keefe Canyon and Fox Canyon localities is probably accounted for by the type of habitats in that immediate area. Hibbard (1941b, p. 100) stated that the only known vole of the recent fauna of Meade County, is the muskrat. Since 1941 a lemming and another vole (*Microtus*) have been found in isolated habitats in Meade County (Hibbard and Rinker, 1942, 1943). Observations based on one or two years' study of a recent fauna may not reveal all of the forms present, or the changing conditions of that fauna from one year to the next. If this is true in regard to a recent fauna, there is every reason to believe that under the most careful study of a fossil fauna only approximations may be made concerning a group of mammals, and these be open to criticism.

The absence of *Pliopotamys* from the Rexroad deposits is one reason why the age of the artesian-spring deposit at locality 2 has been questioned and the deposit separated from locality 2a. *Pliopotamys* was recovered from the Rexroad formation in the summer of 1936 at locality 2. In the summer of 1944 it was taken from the Meade formation at locality 1 (Hibbard, 1949, p. 68), less than one half mile from locality 2. If *Pliopotamys* is ancestral to *Ondatra* it would presumably have lived in the lowlands, if not along the edge of the water. Its presence, therefore, would be expected in any stream or bog deposit worked in the Rexroad formation, unless it was a very rare member of the fauna.

The Rexroad fauna is one of the better known faunas of the High Plains because the associated invertebrates and vertebrates have been studied. The environmental conditions that existed in that region at the time the fauna lived have been interpreted by various authors. F. C. Baker, after a study and identification of the invertebrates taken at locality 3, wrote in a letter dated January 29, 1940:

The ecology of this deposit appears to have been a river or slough, judged by the character of the fresh-water fauna. The land species lived in well-wooded situations and were probably washed into the fresh-water bodies during rains, from the

hillsides. The great abundance of species indicates that at this time the mollusk fauna was well developed. I would say the climate was warm.

Edward H. Taylor (1942, p. 220), after a study of the fossil toads and frogs, stated in regard to the amphibian fauna and past climatic conditions:

It seems safe to postulate that a very much larger amphibian fauna was present in the Rexroad than is represented by the finds to date. So large a number of ranid frogs warrants the postulation that the climate was such as to supply a much heavier rainfall in order to provide sufficient moisture for these water-loving frogs. It seems strongly probable that with forests, which would be a concomitant of the heavier rainfall, numerous species of the Hylidae, small Leptodactylidae, and Microhylidae would be present. It is likewise probable that there was a population of small salamanders, although not a single species has been so far recovered.

For example, the present climate of North Carolina supports an Anuran population of 26 species and subspecies, representing 5 families and 8 genera. The Caudata are even richer with 40 species and subspecies, representing 6 families and 16 genera. In the case of the caudate fauna the mountainous character of the country is a contributing factor to its diversity. While the two areas are not entirely comparable, the presence in the Rexroad of so large a number of *Rana* in the fauna suggests the possibility that the climates were similar in character, and at least the anuran fauna may eventually prove even richer than the present day fauna of North Carolina.

Alexander Wetmore (1944, p. 91) commented on the Rexroad avian fauna:

Of the identified specimens more than one half belong to aquatic species that live in and around marshes, streams and ponds. Remains of turkeys represent birds of wooded areas, while parrots, pigeons and quail are species of forests, or regions where thickets and groves grow amid plains, prairies or savannas. The passeriform birds may have lived in prairie land, in thickets or in forests.

Hibbard (1941*b*) published on the paleoecology of the Rexroad fauna as indicated by the mammals which had been recovered at that time.

In summary it may be said that the mammalian fauna indicates a varied topography ranging from upland grassland areas to meadow flats and timbered areas at least along parts of the Upper Pliocene stream valleys. There is evidence that the climate in the Upper Pliocene was more equable than at present, without extremely cold winters or severely hot summers, and that there was a greater degree of humidity in the region than there is now.

TABLE IX
STRATIGRAPHIC RANGE OF MAMMALS OF THE REXROAD FAUNA

	Miocene	Lower Pliocene	Middle Pliocene	Upper Pliocene	Pleistocene	Recent
Insectivora						
<i>Sorex</i>	—	—	—	—	—	—
<i>Paracryptotis</i>						
<i>Notiosorex</i>						
<i>Hesperoscalops</i>						
<i>Scalopus</i>		?	—	—	—	—
Chiroptera						
<i>Lasiurus</i>						
Edentata						
<i>Megalcnyx</i>					—	
Rodentia						
<i>Paenemarmota</i>						
<i>Citellus</i>	—	—	—	—	—	—
<i>Nerterogeomys</i>					—	
<i>Geomys</i>						
<i>Perognathus</i>	—	—	—	—	—	—
<i>Liomys</i>						
<i>Dipoides</i>						
<i>Procastoroides</i>					—	
<i>Bensonomys</i>						
<i>Peromyscus</i>						
<i>Baiomys</i>						
<i>Onychomys</i>						
<i>Symmetrodontomys</i>						
<i>Sigmodon</i>						
<i>Parahodomys</i>					—	
<i>Ogmodontomys</i>						
<i>Pliophenacomys</i>						
<i>Pliopotamys</i>				?	—	
Carnivora						
<i>Canis</i>						
<i>Borophagus</i>						
<i>Bassariscus</i>	—	—	—	—	—	—
<i>Procyon</i>						
<i>Buisonictis</i>						
<i>Trigonictis</i>						
<i>Mustela</i>	—	—	—	—	—	—
<i>Martes</i>						
<i>Taxidea</i>						
<i>Brachyprotoma</i>					—	
<i>Spilogale</i>						
<i>Felis</i>						
Proboscidea						
<i>Stegomastodon</i>					—	
<i>Mammut</i>	?	—	—	—	—	—

TABLE IX (Continued)

	Miocene	Lower Pliocene	Middle Pliocene	Upper Pliocene	Pleistocene	Recent
Perissodactyla						
<i>Nannippus</i>		————	————		—	
<i>Hippotigris</i>					—	
Lagomorpha						
<i>Pratilepus</i>				————		
<i>Notolagus</i>			————	————		
<i>Hypolagus</i>	————	————	————	————	————	
<i>Nekrolagus</i>				————	—	
Artiodactyla						
<i>Platygonus</i>				————	————	
<i>Pliauchenia</i>		————	————	————		
<i>Gigantocamelus</i>				————	?	
<i>Tanãpolama</i>				————	————	

That the number of genera known to be common to the Middle and Upper Pliocene is small is believed to be chiefly because the small forms of the Middle Pliocene are unknown, but it may also be partly due to a taxonomic separation of such closely related forms as *Osteoborus*-*Borophagus*, *Martinogale*-*Spilogale*, and *Megatylopus*-*Gigantocamelus* (see Table IX).

The supposedly big break between the faunas of the Hemphillian and Blanco is now partly bridged by the Saw Rock fauna of Seward County, Kansas. This gap will be further closed by the continuing study of this fauna and other intermediate faunas. If the Saw Rock fauna is upper Middle Pliocene and not lower Upper Pliocene, certain of its genera can be extended downward in the Pliocene, but if it is lower Upper Pliocene the genus *Osteoborus* can be extended upward in the Upper Pliocene.

AGE AND RELATIONSHIP OF THE REXROAD FAUNA TO OTHER KNOWN FAUNAS

The Rexroad fauna shows a close relationship to, if it is not identical with, the Blanco fauna of Texas. It is nearly as closely related to the Benson fauna of Arizona. A close relationship also exists with the Tehama, Pittsburgh, Coso Mountains, and San Timoteo faunas of California, and the Hagerman fauna of Idaho.

The geological range of many of the genera and species of mammals

in the Blanco and Rexroad faunas is unknown, but from the few forms that are common to the Blanco, Rexroad, and Broadwater faunas it appears that the three faunas were contemporary. This statement is based on the presence of *Paenemarmota barbouri* Hibbard and Schultz and *Gigantocamelus spatulus* (Cope) in the three faunas.

In Nebraska, Condra, Reed, and Gordon (1947, p. 17) correlated the basal member of the Broadwater formation of Schultz and Stout (1945) with the Holdrege formation and with the Nebraskan glacial stage. They considered the deposits from which the Broadwater fauna (Barbour and Schultz, 1936 and 1937) was recovered to overlie the Holdrege sands and gravels which they tentatively assigned to the Aftonian stage.

McGrew (1944, p. 37) correlated the Sand Draw fauna of Nebraska with the Broadwater fauna and said that "Barbour and Schultz determined the age of the Broadwater as Aftonian on geological observations that have not yet been published." McGrew considered the Rexroad and Blanco as equivalent to the Sand Draw and Broadwater faunas. The Sand Draw fauna of Nebraska is known chiefly from large forms. The Sand Draw fauna may be equivalent to the Deer Park fauna of Kansas, a post-Rexroad-pre-Cudahy fauna. This can perhaps be determined by the recovery and study of small rodents from the Sand Draw deposits.

Meade (1945) followed McGrew (1944) in considering the Blanco as early Pleistocene but he interpreted the Blanco fauna as being of Nebraskan age. He stated (p. 519) that "the upper limit of the Blancan may provisionally be placed at the top of the Aftonian, inasmuch as it is doubtful whether Nebraskan and Aftonian faunas can be differentiated."

Hibbard (1949, 1949b) has demonstrated that faunal shifts have occurred in the High Plains during the Pleistocene and that warm and cool conditions affected the faunas of the region. The Rexroad fauna is a warm fauna of pre-Nebraskan age.

If the Broadwater fauna is equivalent to the Rexroad fauna as stated by McGrew, Meade (1945, p. 517) and Frye, Swineford, and Leonard (1948, p. 521) then the Broadwater formation of Schultz and Stout (1945) in western Nebraska occupies a lower stratigraphic position than the Holdrege (provided the Holdrege sands and gravels

are outwash from the Nebraskan ice or deposited by deflected waters caused by the ice) and the Fullerton formations of central Nebraska with which Condra, Reed, and Gordon correlated it and which they consider equivalent to the Nebraskan and Aftonian stages. This would mean that the Holdrege and Fullerton formations occupy about the same stratigraphic position as the Meade formation of Kansas (Cragin, 1896; Hibbard, 1949, p. 66).

Frye (1942) considered the Meade gravels of Cragin (1896) and the overlying Stump Arroyo sands and gravels of Hibbard (1948, p. 594; 1949, p. 71) as the same stratigraphic unit. The strata along Wolf Canyon which he (Frye, 1942, p. 97) referred to the Ogallala formation have been shown to represent the Rexroad and Meade formations (Byrne and McLaughlin, 1948, p. 74 and Hibbard, 1949a, p. 94). Based on type localities the Meade formation of Cragin (1896) represents an older cycle of deposition of sand and gravel than the sand and gravel in the type locality of the Meade formation as defined by Frye and Hibbard (1941, p. 411) in sec. 21, T. 33 S., R. 28 W. The assignment of the Meade formation at the type locality as designated by Frye and Hibbard (1941) to the Kansan cycle of deposition by Frye, Swineford, and Leonard (1948, p. 521) instead of the assignment of the Meade formation of Cragin (1896) to the Nebraskan cycle to which it apparently belongs, allowed them to correlate the type section of the Rexroad formation with the Aftonian and Nebraskan stages of the Pleistocene instead of with the Upper Pliocene as indicated by the fauna. No explanation is given as to their disposition of the Meade formation of Cragin (1896) and the related overlying silts.

There are few places where the Meade formation or its equivalent can be found to overlies deposits which are equivalent to the Rexroad formation. This has led to confusion in the correlation of deposits because such forms as *Procastoroides*, *Nannippus*, and *Hippoligris* occur in both the Rexroad and Meade formations.

One of the important factors in attempting to date the Rexroad fauna and determine its relationship to other faunas is the time which was necessary to bring about the changes between the Rexroad fauna and the succeeding fauna. Cenozoic mammalian faunas point to a slow gradual change. It must be admitted, however, that the rate of change in some forms has been greater than that in others, and it is impossible,

therefore, to use the evolutionary rate of one group as a basis for a hypothesis in regard to the rate of development in other groups.

If the Rexroad fauna and its contemporaries are assigned to the Aftonian age and the Cudahy fauna to the closing phase of the Kansan (= Pearlette molluscan fauna of Frye, Swineford, and Leonard, 1948, p. 520, considered to be Yarmouthian), then it is evident that there was extremely rapid evolution of a number of forms such as *Pliopotamys* → *Ondatra*; *Cosomys* → *Pedomys* (fide Schultz and Stout, 1948, p. 564) during Kansan time.

There is no evidence of such rapid evolution in these groups during pre-Rexroad time nor from the time of the Cudahy fauna to the present. The evidence seems to point to a hiatus between the Deer Park fauna and the Cudahy fauna of Meade County, Kansas.

BLANCAN AS A TIME TERM

Blancan as a provincial time term was defined by Wood, and others (1941, pp. 12-13). It is based on a local fauna (Blanco) from Crosby County, Texas which was assigned to the late Pliocene. *Plesippus* (*Hippotigris*), one of the index fossils of the Blancan, is now known to extend on into the early Pleistocene. *Nannippus* was reported as becoming extinct with the Blanco fauna, but it is now known to have lived later (Hibbard, 1944a, 1949). When the Aftonian fauna in the central High Plains is known, many of the forms now restricted to the Rexroad fauna may be found to have persisted later.

Elias, and others (1945) agreed that the dating of the Blancan as either late Pliocene or early Pleistocene should be held in abeyance until there is more general agreement among paleontologists as to its age. This agreement has never been fully followed.

The Blancan is the time when the Blanco fauna and its contemporaries lived. McGrew (1948, p. 549) listed three genera as diagnostic of the Blancan: *Plesippus* (*Hippotigris*), *Borophagus*, and *Procastoroides*. Of these three genera only *Borophagus* remains diagnostic of the Blanco fauna, and this is probably because its vertical range is unknown. A logical disposition of the time term Blancan would be to include within it the time from the close of the Hemphillian to the close of the Blanco fauna. It would include the Saw Rock fauna, and other faunas of approximately this age that are post-Hemphillian.

The Saw Rock fauna (Hibbard, 1949a) from the XI member of the Rexroad formation of Seward County, Kansas, reveals that (1) the Saw Rock fauna is distinct from the Rexroad fauna though closely related; (2) the Saw Rock fauna lived at a time in that area when conditions were comparable to the conditions at the time the Rexroad fauna lived; (3) there is no evidence of a climatic change in that region between the time that the Saw Rock fauna and the Rexroad fauna lived; (4) the difference between the two faunas appears to be accounted for chiefly by time; (5) the Saw Rock fauna bridges in part the hiatus between the Hemphillian and Blancan; (6) the present faunal and stratigraphic evidence in regard to the Rexroad and Saw Rock faunas is such that if the Rexroad fauna is to be considered as a Pleistocene fauna so should the Saw Rock fauna. If the Rexroad and Saw Rock faunas are to be considered as Pleistocene faunas, they must be interglacial in age and from all evidence belong to the same interglacial time. Before such an assignment can be made, however, faunal or floral evidence of pre-Saw Rock glaciation must be found in the High Plains region.

CORRELATION OF FAUNAS AND DEPOSITS

From the foregoing account it is evident that agreement does not exist regarding the correlation of deposits in Meade County, Kansas, in which the stratigraphy and vertebrate fossils have been studied in detail. If it is impossible to correlate deposits of equivalent age in Meade County, or to correlate deposits from central Kansas to southwestern Kansas, or from Kansas to Nebraska, or from western Nebraska to eastern Nebraska, and especially to make only tentative correlations between the glacial and interglacial deposits with non-glacial deposits outside of the glacial area in North America, any attempt to correlate late Pliocene or Pleistocene faunas of North America with faunas of Europe is out of the question. At present faunas and faunal relations are not well enough known to attempt long distant correlations. Faunas and especially elements within a fauna are known to lag in certain regions.

One of the best examples of similarity between faunas in Europe and North America is the case of the fauna of the Cromer Forest Bed of Norfolk, England, and the Cudahy fauna of Kansas. The

fauna from the Cromer Forest Bed is considered by Zeuner (1945, p. 260) to belong to the Antepenultimate interglacial (= Aftonian). The Cudahy fauna of Kansas (Hibbard, 1944a, p. 718), which has been fairly well established as belonging to the closing phase of the Kansan though it is considered by Frye, Swineford, and Leonard (1948) to be of Yarmouthian age, shows close relationship to the fauna in England. Are these two faunas on the basis of similarity to be considered as equivalent and the faunal and stratigraphic evidence in regard to their age in the different regions to be disregarded? The relationship of the two faunas appears to reflect, in part, unknown intermediate faunas or a definite faunal lag between Europe and North America in regard to closely related forms. Evidence of earlier Cenozoic forms points to a faunal lag. The Villafranchian fauna could as easily be correlated with the Deer Park fauna as with the Blanco or Rexroad. It will take many more years of constant and detailed work before a satisfactory correlation of the Pliocene and Pleistocene faunas of Europe, Asia, and North America can be made.

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EXPLANATION OF PLATE I

Bensonmys arizonae (Gidley)

- FIG. 1. Kansas University Museum of Paleontology No. 4549, right M_1-M_3 .
FIG. 2. U.M.M.P. No. 24889, left M_1-M_3 .
FIG. 3. U.M.M.P. No. 24879, right M_1-M_3 .
FIG. 4. U.M.M.P. No. 24881, right M_1-M_3 .
FIG. 5. U.M.M.P. No. 24865, right M_1-M_3 .
FIG. 6. U.M.M.P. No. 24888, right M_1-M_3 .
FIG. 7. U.M.M.P. No. 24868, right M_1-M_3 .
FIG. 8. U.M.M.P. No. 24894, left M_1-M_3 .
FIG. 9. U.M.M.P. No. 24872, right M_1-M_3 .
FIG. 10. Kansas University Museum of Paleontology, No. 4547, right M_1-M_3 .
Occlusal views. All $\times 15$. Drawings by William L. Brudon.

PLATE I

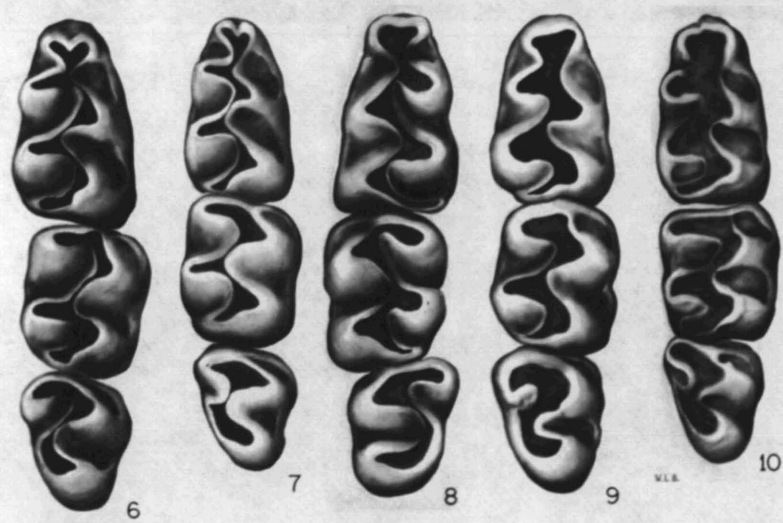
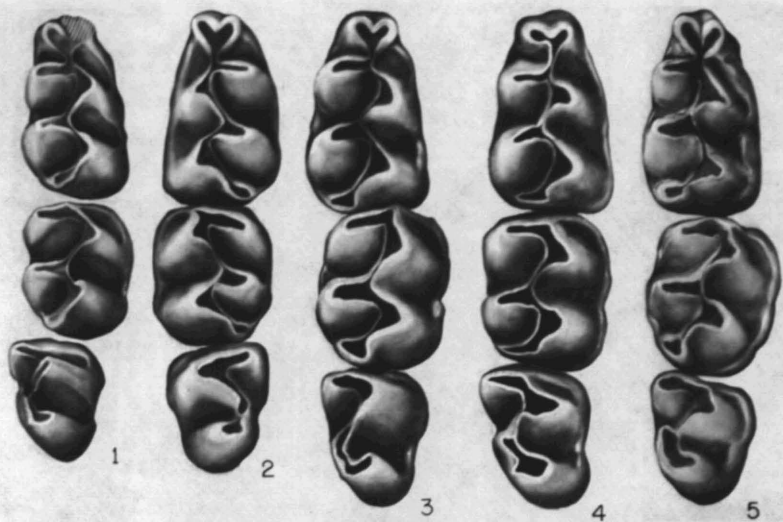


PLATE II



FIG. 1

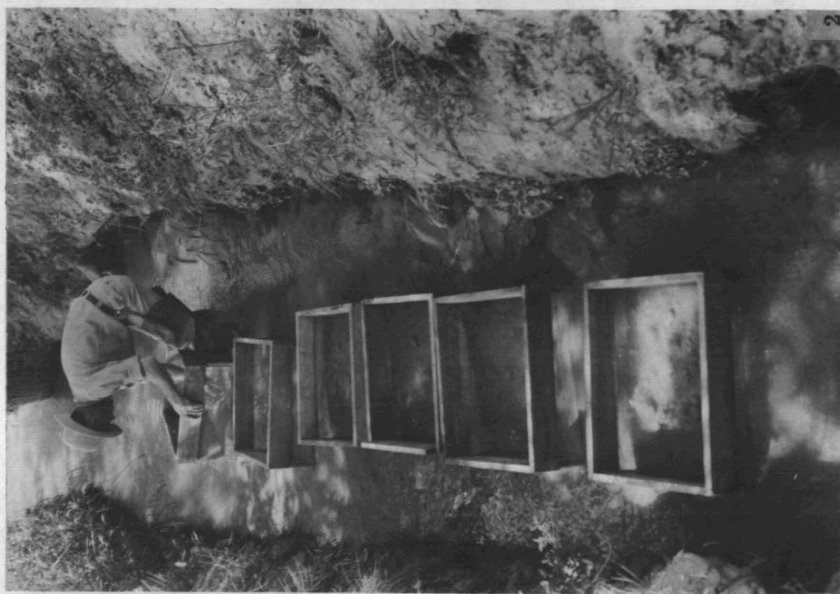


FIG. 2

EXPLANATION OF PLATE II

FIG. 1. Locality 2, Meade County, Kansas, after the removal of the upper part of the sand deposited in the Rexroad silt and clay by an artesian spring.

FIG. 2. The removal of small invertebrates and vertebrates from silt and clay by washing. Photograph by John C. Frye.

EXPLANATION OF PLATE III

FIG. 1. Locality 3, Meade County, Kansas, at the type area of the Rexroad formation. Vertebrates were recovered chiefly at the base of the exposure.

FIG. 2. Close-up view of Rexroad beds, showing lignitic seams. Photographs by H. T. U. Smith.

EXPLANATION OF PLATE IV

FIG. 1. Locality 22, Keefe Canyon, Meade County, Kansas. Photograph by E. S. Riggs.

FIG. 2. Excavation of artesian spring deposit at locality 22.

EXPLANATION OF PLATE V

FIG. 1. Fox Canyon, XI Ranch, Meade County, Kansas. University of Michigan Museum of Paleontology locality UM-K1-47.

FIG. 2. Sandy silt deposits in the Rexroad formation, with the Rexroad caliche showing near the sky line.

PLATE III



FIG. 1



FIG. 2

PLATE IV



FIG. 1

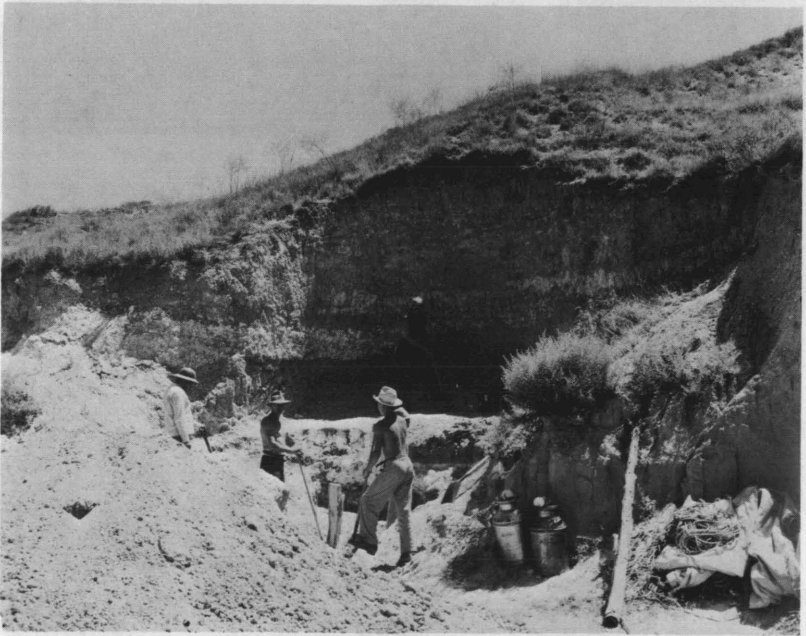


FIG. 2

PLATE V



FIG. 1



FIG. 2

VOLUME VIII

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