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THE MAMMALS OF THE CUDAHY FAUNA

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THE Cudahy fauna may prove to be the best possible index to the effects of Pleistocene glaciation on animal distribution and climatic zonation. This important fauna was recovered from silts lying just below the Pearlette ash—the most significant, widespread time-marker in Pleistocene deposits of nonglaciated areas in the Great Plains and Rocky Mountain regions of North America. This volcanic ash is petrographically distinct and is known to occur in an area extending northward from El Paso, Texas, to southern South Dakota, and westward from western Iowa and Missouri to Colorado, Utah, and possibly Las Vegas, Nevada (Swineford, 1949; Powers et al., 1958; Eardley and Gvosdetsky, 1959). Members of the Cudahy fauna are known from pre-Pearlette ash deposits in Texas, Oklahoma, Kansas, and Nebraska. When these widely separated, contemporaneous deposits are adequately sampled, a relatively precise picture of late Kansan animal distribution and climatic zonation can be constructed.

Several reports have been published on the Cudahy fauna. Smith (1938) first reported the presence of vertebrates from under the ash. Hibbard (1944, 1949b) reported the mammals of the fauna and discussed the climatic conditions which probably existed at the time of their deposition. He concluded that the habitats of the nearest living relatives of certain Cudahy mammals indicated a climate considerably cooler and more humid than presently found in southwestern and central Kansas, and that the fauna was of a late glacial age. Subsequent work (Hibbard, 1949b, 1956; Frye and Leonard, 1952) has substantiated this conclusion. Tihen (1955, p. 240) commented on the ambystomid salamanders from the deposit, and the mollusks were recorded by Franzen (1946), Franzen and Leonard (1947), Frye and Leonard, (1952), Leonard (1946, 1948, and 1950), and Johnston and Savage (1955).

The present study is based on material obtained by a University of Michigan Museum of Paleontology field party in the summer of 1958. The party collected most of the material from below the Pearlette ash at the type locality (University of Kansas Locality 10), Cudahy ash mine, SW¼ Sec. 2, T. 31 S., R. 28 W., Meade County, Kansas. A few specimens were obtained from the Sunbrite ash mine (University of Kansas Locality 17), NW¼, SE¼ Sec. 26, T. 32 S., R. 28 W., in Meade County. Remains of 1,089 individuals representing 28 mammalian species were recovered from a zone within 18 inches of the bottom of the ash bed. Twelve of these mammals are new to the original faunal list of Hibbard (1944). Two forms have been described as new species. The additional material has necessitated some taxonomic changes and has allowed for more detailed descriptions, including an analysis of variation within each species with an adequate sample size. In the following taxonomic accounts, the letters UMMZ stand for the University of Michigan Museum of Zoology. All other numbers are those of the University of Michigan Museum of Paleontology.

CLASS MAMMALIA

ORDER INSECTIVORA

Family Soricidae

Sorex cinereus Kerr

Material.—No. 38436, a complete left lower jaw with I, $P_{\bar{4}}$–$M_{\bar{3}}$; Nos. 38437–38439, 39631, 39632, 69 incomplete, tooth-bearing lower jaws. At least 37 individuals are present.

Description.—The lower jaw and teeth are generally more robust than normal for Recent *Sorex cinereus*, but size overlap does occur. The posterior face of the condylar process is very small and is narrowly constricted by a deep lingual depression between the articular facets. The size and configuration of this process appears to be subject to relatively little individual variation. The height of the ascending ramus is subequal to the length of the molar series. The anteroposterior length from the tip of the incisor to the tip of the condyle is 9.2 mm. (1 specimen).

Sorex (Sorex) cudahyensis Hibbard

(Fig. 1)

Material.—There are 13 lower jaw fragments, 6 of which bear teeth; Nos. 36804, 36805, 39627, 39628, 39634, and 39635. At least 6 individuals are represented.

Description.—*Sorex cudahyensis* is a small shrew with a robust ramus, an elongate molar series, and relatively narrow teeth (Fig. 1). The body of the

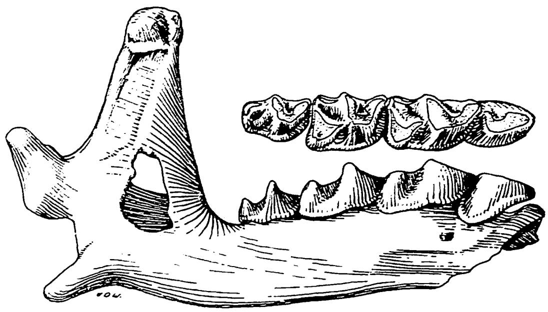

FIG. 1. *Sorex (Sorex) cudahyensis* Hibbard, No. 39627, right lower jaw with $P_{\overline{4}}$–$M_{\overline{3}}$, labial and occlusal views, × 10.

ramus and the length of the tooth row are but slightly smaller than those of small *S. arcticus laricorum* Jackson, but the part of the ramus posterior to $M_{\overline{3}}$ is 20 per cent shorter and the condylar process is about 30 per cent smaller than that of *S. arcticus*. A mandibular and a postmandibular foramen are present. They are subequal in size and are contained in an elongate, diagonal fossa posteriorly. The infracondylar notch is square. The supracondylar notch, labial muscle scars of the coronoid process, and the posterointernal ramal fossa (Gaughran, 1954) are comparable to those of *S. arcticus* and *S. tundrensis* Merriam. The mental foramen is situated below the metaconid of $M_{\overline{1}}$.

The nature of the incisor cusplets is unknown. Labially, the incisor extends just posterior to the canine. The principal cusp of the canine of No. 39634 lacks the well-pronounced posterior (occasionally lingual) depression of Recent species of the genus *Sorex*. The principal cusp of $P_{\overline{4}}$ is robust, and there is no well-developed ridge on its anterior face. Unlike the holotype, there is a lingual depression posterior to the principal cusp, but it is not as broad or deep as in Recent species of *Sorex*. This depression is in a posterior position in the holotype. The posterolabial cusp is not distinctly set off from the principal cusp in the holotype or in the topotypes; it appears to be in a more medial position. The talonid of $M_{\overline{3}}$ is reduced.

Measurements in mm.—Occlusal length of $M_{\overline{1}}$–$M_{\overline{3}}$, 3.5 (3.4–3.6), 3 specimens. Occlusal length of $M_{\overline{1}}$, 1.38 (1.3–1.4); width of $M_{\overline{1}}$, 0.8, 4 specimens each. Height of ascending ramus, 3.8 (3.6–4.0), 7 specimens. Length of ramus posterior to $M_{\overline{3}}$, 3.2, 1 specimen.

Discussion.—The diagnostic characters for *Sorex cudahyensis* are: (1) a relatively large, uncrested canine and $P_{\overline{4}}$; (2) the presence of a postmandibular foramen; (3) an elongate and narrow molar series; (4) a compact ramus posterior to $M_{\overline{3}}$; (5) a small condylar process.

The presence of a postmandibular foramen excludes most species of the genus *Sorex*. *S. trowbridgi* Baird, *S. vagrans* Baird, *S. obscurus* Merriam, and *S. saussurei* Merriam have a wider tooth row, a well-developed talonid on $M_{\overline{3}}$, and a distinct crest on the anterior face of the canine and $P_{\overline{4}}$. The square infracondylar notch, the proportions of the body of the ramus, the nature of the muscle scars, and the general dental features of *S. cudahyensis* strongly suggest affinities with the *S. arcticus* group. However, the small size of the condylar process and the compactness of the ramus posterior to $M_{\bar{3}}$ are distinct from those of *S. arcticus*. I am unable to assign *Sorex cudahyensis* to any Recent species group of shrews.

Sorex (Sorex) lacustris (Hibbard)

(Fig. 2)

Neosorex lacustris Hibbard, 1944, Geol. Soc. Amer. Bull., 55: 721, fig. 5.
Sorex (Neosorex) lacustris (Hibbard), 1959, PMASAL, 43 (1958): 12.

Material.—There are 39 lower jaw fragments, 26 of which have teeth; Nos. 38358–38363, 39633, 39637, and 42342. At least 15 individuals are represented in the collection.

Description.—The size of the ramus and dentition are slightly smaller than those of *Sorex bendirii albiventer* Merriam. The part of the ramus which is posterior to $M_{\bar{3}}$ (dorsal view) is not as abruptly arched laterally as the ramus of *Neosorex*. Two large posterolingual foramina are contained within an elongate, diagonal fossa posteriorly. The anterior foramen enters the mandibular canal and the posterior foramen enters the floor of the posterointernal ramal fossa (Fig. 2*A*). The infracondylar notch is rather square, but in some specimens it is rounded anteriorly. The column connecting the dorsal and ventral articular facets of the condylar process is not concave lingually (Fig. 2*C*). The posterointernal ramal fossa is large; it is often truncated dorsally by a bony ridge, in which case, a shallow fossette is present. The supracondylar notch and the labial muscle scars of the coronoid process are like those of *S. arcticus* Kerr. The body of the ramus is arched dorsally under $M_{\bar{2}}$. The mental foramen is situated below the protoconid of $M_{\bar{1}}$.

The incisor is robust; has 3 heavy, distinct dorsal cusplets; extends labially to a position just posterior to the canine. The canine and $P_{\bar{4}}$ are relatively large and generalized. The lingual (posterior in some cases) depression posterior to the principal cusp is poorly developed; it is barely evident in the canine of No. 38360. The principal cusp of both the canine and $P_{\bar{4}}$ are better developed than those observed in species of Recent *Sorex*. There is no distinct anterior ridge or terminal cusplet present on the canine or $P_{\bar{4}}$ of *S. lacustris*.

The entoconid of $M_{\bar{1}}$ and that of $M_{\bar{2}}$ are well developed and are joined to their respective metaconids by relatively strong lophids. The paraconid generally has an anteriorly bent crest on its anterior face. The paraconid crest extends down the anterior face of the tooth and overhangs or interrupts the strong anterior cingulum. The labial and the lingual cingulum are like those of *S. arcticus*. The length of the tooth row is approximately 15 per cent longer than that of Recent *Sorex* possessing a postmandibular foramen.

Measurements in mm.—Occlusal length of $M_{\bar{1}}$–$M_{\bar{3}}$, 4.3, 2 specimens. Occlusal length of $M_{\bar{1}}$, 1.64 (1.6–1.7); width of talonid of $M_{\bar{1}}$, 0.92 (0.8–1.0), 7 specimens. Height of ascending ramus, 5.0 (4.8–5.1), 7 specimens.

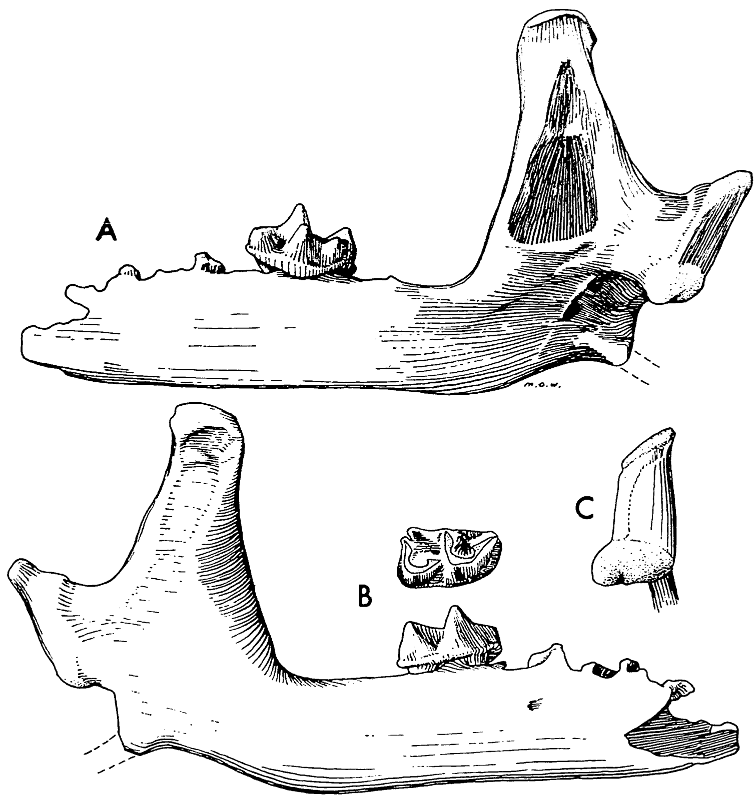

FIG. 2. *Sorex (Sorex) lacustris* (Hibbard), with $M_{\overline{2}}$, No. 38363, *A*, right jaw with $M_{\overline{2}}$, lingual view showing mandibular and postmandibular foramina; *B*, labial and occlusal views; *C*, posterior view of condyle, all × 10.

Discussion.—Stephens (1960, in press) removed this species from the subgenus *Neosorex* because of the presence of a postmandibular foramen. He considered it to be related to the *Sorex arcticus* group. The absence of a distinct anterior crest on the canine and $P_{\overline{4}}$, the well-developed cusplets of the incisor, the relatively strong lophid joining the entoconid and metaconid, and the less-pronounced curvature (dorsal view) of the ramus between $M_{\overline{3}}$ and the dorsal articular facet, further distinguish *S. lacustris* from *Neosorex*. In these characters, as well as in the nature of the condylar process and infracondylar notch, *S. lacustris* closely approaches the *S. arcticus* condition. I agree with Stephens' contention that its affinities are with the *S. arcticus* group.

Sorex lacustris is distinguished from all Recent *Sorex* that have a postmandibular foramen, by its large size and generalized $P_{\overline{4}}$.

Sorex (Neosorex) megapalustris sp. nov.

(Fig. 3)

Material.—Holotype: No. 38357, an incomplete left lower jaw with $M_{\bar{1}}$–$M_{\bar{3}}$ and a complete ascending ramus. The body of the ramus anterior to $M_{\bar{1}}$ is missing and the teeth are heavily worn. Paratypes: No. 36803 includes 5 lower jaw fragments without teeth and 3 fragments with teeth. At least 4 individuals are represented.

Horizon and type locality.—Pleistocene (late Kansan), Crooked Creek formation, Atwater member; University of Kansas Locality 10 (Cudahy ash mine), SW¼ Sec. 2, T.31 S., R.28 W., Meade County, Kansas.

Diagnosis.—A water shrew with a more robust ramus and larger teeth than those of Recent *Neosorex*. Length of tooth row, width of $M_{\bar{1}}$, and height of ascending ramus, are 8 to 15 per cent larger than large Recent individuals of the subgenus. $P_{\bar{4}}$ is more generalized and not as reduced. The supracondylar notch is more broadly rounded.

Description of holotype.—The holotype is similar to *Sorex bendirii palmeri* Merriam in ramus and tooth size, but the salient characters are those of the subgenus *Neosorex*. The ramus posterior to $M_{\bar{3}}$ is markedly arched labially and the vertical axis of the ascending ramus intersects the body axis at a low angle. There is no postmandibular foramen. The dorsal part of the coronoid process is strongly inclined anteriorly and the muscle scars of its dorsolateral side are comparable to those of *Neosorex* (Fig. 3*A*). Although the ventromedial muscle scar of the holotype is in the form of a diagonal ridge, the paratypes indicate that a tubercular scar similar to that in Recent *Neosorex* is the normal con-

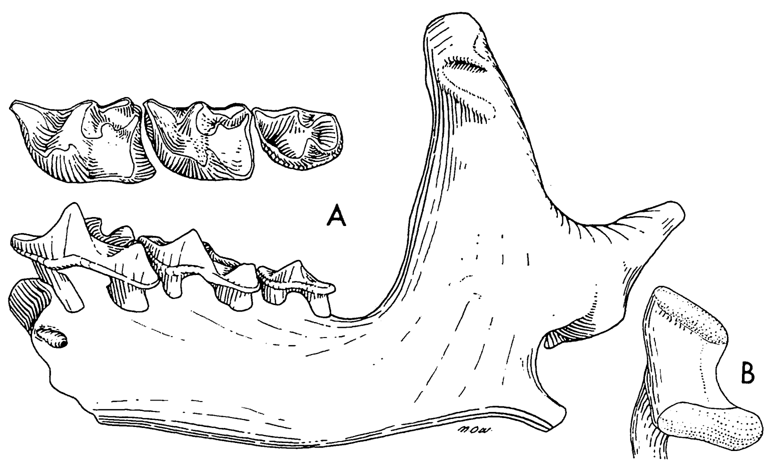

FIG. 3. *Sorex* (*Neosorex*) *megapalustris* sp. nov., holotype, left jaw with $M_{\bar{1}}$–$M_{\bar{3}}$, No. 38357; *A*, labial and occlusal views; *B*, posterior view of condyle, all × 10.

dition. The articular facets of the condylar process are like those of Recent species of *Neosorex*, but the supra- and infracondylar notches are more broadly rounded (Fig. 3*B*). The infracondylar notch of the holotype is 20 per cent wider than that of Recent *Neosorex*. The body of the ramus is arched dorsally below $M_{\bar{2}}$. The mental foramen is placed like that of *Sorex palustris* Richardson but is about twice as large.

The molars of the holotype are extremely large and heavy. $M_{\bar{1}}$ is approximately 15 per cent longer and 20 per cent wider than the largest specimen of *Sorex palustris* observed. The extreme width of $M_{\bar{1}}$ is largely due to the peculiar orientation of the entoconid. This cusp is obliquely inclined beyond the lingual margin of the tooth. The lingual cingulum of $M_{\bar{1}}$ is arched and broadened dorsally just anterior to the metaconid; the labial cingulum is arched dorsally below the protoconid. $M_{\bar{1}}$ is tilted and offset lingually with respect to the position of $M_{\bar{2}}$ and $M_{\bar{3}}$.

Description of paratypes.—The paratype material indicates that the holotype is larger than usual for the species, and that certain characters are a product of old age and heavy wear. The entoconids of the paratypes are not sharply inclined beyond the lingual border of $M_{\bar{1}}$; they are subvertical. The lingual tilt and offset of $M_{\bar{1}}$ in the holotype is a feature of wear. Apparently, as $M_{\bar{1}}$ is worn, new masticatory stresses are introduced and, in response to the new stresses, the tooth is realigned in its alveoli. This interpretation is substantiated by the observation that the identical condition may be observed in old Recent individuals of *S. palustris*.

Like *Sorex palustris*, $P_{\bar{4}}$'s of the paratypes have a strong, narrow crest on their anterior faces. However, the tooth is wider relative to its length than is *S. palustris*. The nature of the canine and incisor is unknown.

Measurements in mm.—Occlusal length of $M_{\bar{1}}$–$M_{\bar{3}}$ in 2 specimens is 4.5. Occlusal length of $M_{\bar{1}}$, 1.82 (1.8–1.85), 4 specimens. Occlusal width of $M_{\bar{1}}$, 1.12 (1.1–1.2), 4 specimens. Height of the ascending ramus, 5.4 (5.3–5.5), 4 specimens.

Discussion.—*Sorex megapalustris* is distinctive in its large size, broadly rounded supracondylar notch, and large $P_{\bar{4}}$. In other characters, however, it is like *S. palustris*. I believe that they are directly related. This is the earliest recorded occurrence of the subgenus *Neosorex*.

Microsorex pratensis Hibbard

Material.—No. 39629, a left lower jaw with I, $M_{\bar{1}}$–$M_{\bar{3}}$; Nos. 39630 and 39636, 10 incomplete lower jaws, 9 of which bear teeth. At least 6 individuals are present.

Description.—The ramus and dentition are very heavy, and the supracondylar notch is broadly rounded. A well-developed depression is present on the axis of the ramus just anterior to the condylar process. The incisor has 2 well-defined tubercles and a suggestion of a third anterior to these. The incisor extends posterolabially to the anterior border of $M_{\bar{1}}$. Ramal body, coronoid and angular processes, infracondylar notch, foramina, dental pattern, and posterointernal ramal fossa are like those of the Recent species (except in size). The posterior face of the articular process is large, but it is overlapped in size by large Recent individuals. A single mandibular foramen is present. Viewed dorsally, the lingual side of the ramus posterior to $M_{\bar{3}}$ is arched abruptly labiad. This feature serves to separate this form from that of the other small shrews (*Sorex cinereus* and *S. cudahyensis*) of the Cudahy fauna. Height of the ascending ramus averages longer than the length of $M_{\bar{1}}$–$M_{\bar{3}}$.

Measurements in mm.—Anteroposterior length from tip of incisor to tip of condyle, 9.2, 1 specimen. Length of $M_{\bar{1}}$–$M_{\bar{3}}$, 3.2, 2 specimens. Height of ascending ramus, 3.36 (3.3–3.4), 7 specimens.

Discussion.—*Microsorex pratensis* is distinguished from the Recent species by its large size and heavy dentition and by its broadly rounded supracondylar notch. This species appears to be in, or very near to, the ancestral stock from which *M. hoyi* was derived. I have not compared this species with *M. minutus* Brown, of the Conard fissure.

Blarina sp.

Material.—No. 36802, a fragment of a left jaw with $M_{\bar{1}}$ and $M_{\bar{2}}$; ascending ramus and body of ramus anterior to $M_{\bar{1}}$ is missing. Teeth are well worn.

Description.—The molars average larger than those of large subspecies of *Blarina brevicauda* Say, but an overlap of size does occur. The mental foramen is surrounded by a pronounced depression and is situated below the paraconid of $M_{\bar{1}}$. The metaconid and entoconid of $M_{\bar{1}}$ and $M_{\bar{2}}$ are not joined by lophids. The above features agree with those of *B. brevicauda*. The lingual cingulum of $M_{\bar{2}}$ is better developed than that of the Recent species. The occlusal length of $M_{\bar{1}}$ to $M_{\bar{2}}$ is 3.8 mm. The greatest width of $M_{\bar{1}}$ is 1.4 mm. The specimen is too fragmentary for specific determination.

ORDER CARNIVORA

The remains of carnivores are rare in the deposit. Those specimens which were recovered are being reported on by Lowell Getz (1960). Parts of *Canis* sp., *Mustela* cf. *erminea* Linnaeus, and *Mustela* cf. *vison* Schreber were identified by Getz.

ORDER RODENTIA

Family Sciuridae

Citellus richardsoni (Sabine)

(Fig. 4*E*)

Material.—No. 36796, 28 isolated teeth. No. 39578, a maxillary fragment with 2 heavily worn teeth. No. 39579, a left jaw with $M_{\bar{1}}$ and $M_{\bar{2}}$ and alveoli for $P_{\bar{4}}$ and $M_{\bar{3}}$. No. 39588, a badly eroded right jaw with $P_{\bar{4}}$ and $M_{\bar{1}}$. At least 3 individuals are represented.

Description.—No. 39579 (Fig. 4*E*) is indistinguishable from the mandible of *Citellus richardsoni*. The anterior vertical prominence of the masseteric scar of *C. armatus* (Kennicott) is distinctive from that of the fossil material. The mental foramen is placed as in Recent *C. richardsoni*, and the muscle scar

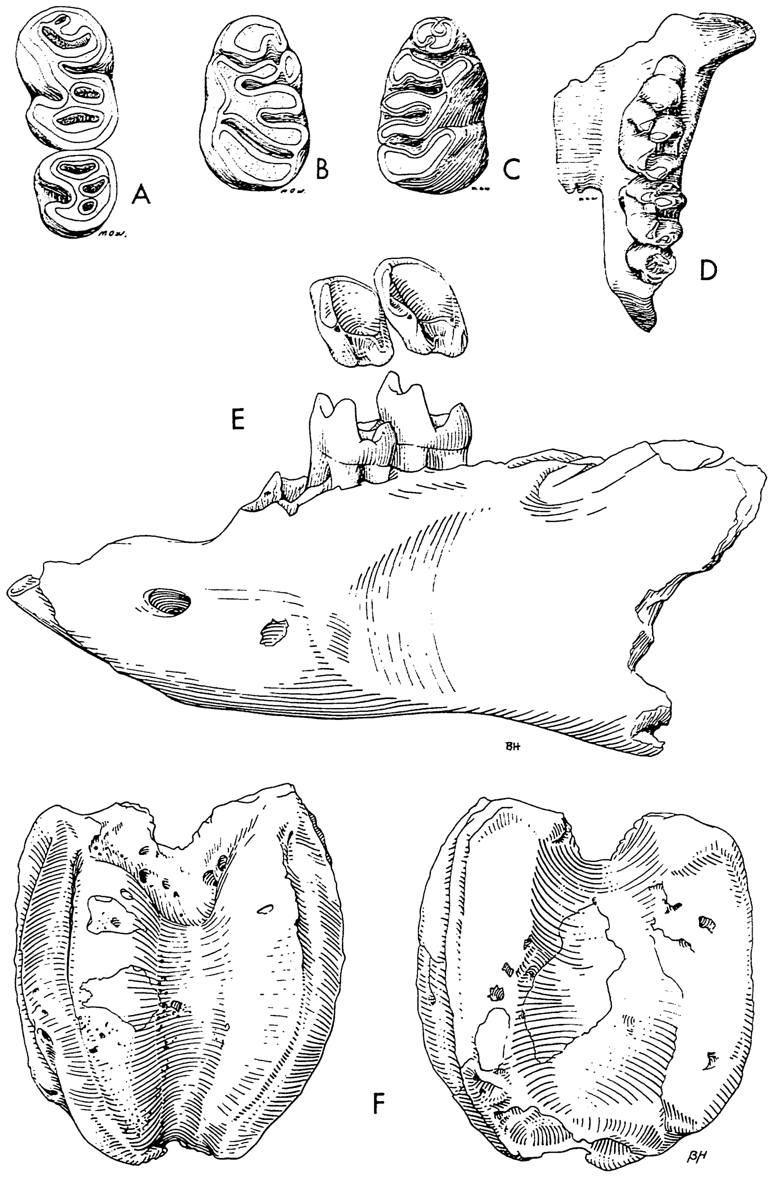

FIG. 4. *A–C*, *Zapus* cf. *sandersi* Hibbard; *A*, No. 38343, left $M_{\overline{2}}$ and $M_{\overline{3}}$, occlusal view; *B*, No. 38342, left $M_{\overline{1}}$, occlusal view; *C*, No. 39518, right $M_{\overline{1}}$, occlusal view, all × 16; *D*, *Reithrodontomys moorei* (Hibbard), No. 39520, left M^1–M^3, occlusal view, × 10; *E*, *Citellus richardsoni* (Sabine), No. 39579, left jaw with $M_{\overline{1}}$ and $M_{\overline{2}}$, labial and occlusal views, × 5; *F*, *Megalonyx* sp., No. 38404, second metacarpal of fourth digit, distal and proximal views, × 1.

on the anterolingual border of $P_{\bar{4}}$ is similar in depth and position. The alveolar length of $P_{\bar{4}}$–$M_{\bar{3}}$ is 9.2 mm.; the depth of jaw below $M_{\bar{1}}$ is 6.5 mm., and the length of $M_{\bar{1}}$–$M_{\bar{2}}$ is 6.5 mm. The upper teeth and the anterior lower teeth are inseparable from those of *C. richardsoni*. One $M_{\bar{3}}$ assigned to this species duplicates the $M_{\bar{3}}$ of smaller individuals of *C. richardsoni*, but all other third molars assigned to this species are smaller and tend to have a less rugose basin and a more narrow talonid. My assignment of these teeth to *C. richardsoni* may be questioned, however.

Citellus cf. *tridecemlineatus* (Mitchill)

Material.—No. 39577, a fragment of a lower jaw with heavily worn $M_{\bar{1}}$ and $M_{\bar{2}}$; No. 42320, 40 isolated teeth. At least 4 individuals are present.

Description.—The size of the teeth corresponds closely with those observed in large individuals of *Citellus tridecemlineatus arenicola* Howell. I was unable to detect any significant differences between the upper cheek teeth of the fossil material and those of Recent specimens. The cone-shaped metaconules of $M^{\underline{1}}$ and $M^{\underline{2}}$ are well developed and separate from the slightly compressed protocones. The parastyle is well developed and its continuation (anterior cingulum) gradually converges posteriorly toward the protocone, where it ends with an abrupt bend. The slight indentations on the outer wall of the well-developed talon of $M^{\underline{3}}$ and the very small, but distinct, elongate enamel fold (metaloph or metacone or both) are common to both fossil and Recent specimens.

Although some of the fossil lower cheek teeth assigned to this species are slightly more compressed anteroposteriorly than in most Recent individuals, there is considerable correspondence in detail. The only difference of possible specific significance is found in the development of the slight groove extending anteriorly from between the hypoconid and entoconid of $M_{\bar{3}}$. This groove is deeper and wider than that of Recent specimens examined. However, the talonid and its basin are subject to such variation in the Recent species, that I am inclined to disregard the difference until more adequate material is obtained.

Citellus nr. *franklini* (Sabine)

Material.—No. 39596, maxillary fragment with R$M^{\underline{1}}$ and $M^{\underline{2}}$; No. 42319, 26 isolated teeth. At least 2 individuals are represented.

Description.—As in the Recent species, the upper molariform teeth possess a well-developed, anteroposteriorly compressed metaconule, united to the metacone by a relatively weak metaloph and connected to the protocone at its base. The mesostyle is variable in size but present in the broadly rounded central valley, which is relatively deep but not so deep as the anterior or posterior valleys. The paracone is better developed than the metacone but is not so high as the anteriorly inclined protocone. The height of crown is equal to that of the Recent species. The characteristic notch just posterior to the protocone of $M^{\underline{3}}$ is present in both forms.

Although the $M_{\bar{3}}$ assigned to this form agrees with that of *Citellus franklini* in most details of dental topography, its general shape is distinct. The posterolingual part is narrow and imparts a triangular appearance to the fossil tooth. The $M_{\bar{3}}$ of *C. franklini* is more squared in appearance. I could not detect any characteristic differences between the anterior lower cheek teeth of the Cudahy material and those of Recent *C. franklini*.

Discussion.—If I am correct in believing that the third lower molars belong with the other dental elements referred to *Citellus* nr. *franklini*, then these specimens probably represent a new species. Such a designation, however, must be held in abeyance until associated material is collected.

Family Geomyidae

Thomomys sp.

Material.—No. 42317, a fragmentary ramus with $P_{\bar{4}}$; an isolated $P^{\underline{4}}$ and 5 molar teeth.

Description.—The generic designation is based on the presence of enamel on the posterior face of $P^{\underline{4}}$ and on the anterior faces of the lower molars. The upper molars are strongly constricted labially and the lowers lingually. Two molars have a third enamel band on the unconstricted side. The dentine tracts of the anterior column of $P^{\underline{4}}$ are situated as those on the $P^{\underline{4}}$ of *T. umbrinus* (Richardson). The lingual dentine tract is wider than the labial. The internal wall of the anterior column of $P_{\bar{4}}$ is concave, and the enamel plate does not extend to the anterior face. The ventral masseteric scar is strongly developed.

Measurements in mm.—Depth of jaw below $P_{\bar{4}}$, 5.7. Occlusal length of $P_{\bar{4}}$, 2.0; width of anterior column, 1.3; width of posterior column, 1.5. Occlusal length of $P^{\underline{4}}$, 1.6; width of anterior column, 1.0; width of posterior column, 1.4.

Discussion.—The material on hand indicates that it is distinct from *T. gidleyi* Wilson, but it is inadequate for specific determination.

Geomys tobinensis (Hibbard)

Parageomys tobinensis Hibbard, 1944, Geol. Soc. Amer. Bull., 55: 735, fig. 16.
Geomys (*Parageomys*) *tobinensis* (Hibbard), Hibbard, 1956, PMASAL, 41 (1955): 183, fig. 11.

Material.—Seven incomplete lower jaws with teeth (Nos. 39582, 39585–39587), 2 maxillary fragments (Nos. 39583 and 42316), and numerous isolated teeth. At least 20 individuals are represented.

Diagnosis.—A small *Geomys* which is near the size of *G. bursarius dutcheri* Davis. The anterior part of the masseteric crest is situated above the horizontal midline of the labial side of the ramus. The infraorbital canal is deep and in a more posteroventral position than in Recent *Geomys*. The area of the anterior palatine foramina is very stout. The ventromedial ridge of the palate is not developed anterior to $P^{\underline{4}}$.

Description.—The lower jaw is comparable to *Geomys bursarius dutcheri* in size, but the diastema is longer (8.7 mm.) and the jaw is less curved anteriorly. These features, however, are well within the range of variability of Recent *G. bursarius* as that species is now conceived. The pit situated between $M_{\bar{3}}$ and the ascending ramus is as deep as Recent *Geomys*, but there are no specimens complete enough to indicate its shape. The mental foramen is medially placed. The anterior part of the masseteric crest is located dorsal to the midline of the labial side. I have observed a similar condition in specimens of *G. b. major* Davis and *G. b. brazensis* Davis, but the usual position of the masseteric crest in Recent *Geomys* is ventral to the midline anteriorly.

The maxillaries in the collection are fragmentary, but No. 39538, an adult, displays some rather important departures from structures found in Recent *Geomys*. The infraorbital canal is situated in a more posteroventral position and is much deeper. The distance from the posterior extremity of the canal to the basal crest of the zygomatic process is 5.5 mm. and the depth of the canal at its posterior extremity is 1.7 mm., or approximately twice that observed in Recent species. The floor of the canal is broadly rounded. The anteroventral part of the maxillary is more robust (not constricted) in *G. tobinensis*. The prominent medial crest which extends along the ventral midline to, or almost to, the anterior palatine foramina in Recent adult *Geomys* is indistinct immediately anterior to P^4 in *G. tobinensis*. I was unable to find a comparable condition in 125 Recent adult specimens.

The enamel folds of $P\frac{4}{4}$ are generally well compressed, but those of young individuals commonly approximate the V-shaped re-entrants of *Thomomys*. The molars are ovate in most adults, but some may have a flat surface on one side (Hibbard, 1944, fig. 7*B*). Both of these occurrences have been observed in the young of *Geomys bursarius*. *G. tobinensis* has an enamel cap on all cheek teeth in youth. With wear, the remnants of these caps appear as continuous, closed, enamel bands on the occlusal surfaces. It is only with continued wear that the charactertistic enamel patterns of the genus appear. This has also been observed in Recent *Geomys* (Merriam, 1895).

Measurements in mm.—P^4: occlusal length, 2.4 (1.9–2.9); width of anterior column, 1.5 (1.2–1.7); width of posterior column, 2.0 (1.7–2.3); 10 specimens each. P_4 : occlusal length, 1.9 (1.6–2.2); width of anterior column, 1.6 (1.3–1.7); width of posterior column, 1.9 (1.6–2.4); 10 specimens each. The depth of jaw below P_4 of 3 specimens are 8.3, 8.5, and 8.7.

Discussion.—*Geomys tobinensis* is distinct from the *Geomys* material reported from the Sanders fauna (Hibbard, 1956). Although the lower jaw of the latter is larger and more robust, it has a diastemal length 14 per cent shorter, due to the extreme anterior curvature of the jaw. Furthermore, in the jaws from the Sanders fauna: (1) the ventral muscle scar of the masseteric crest is in a more ventral position; (2) the mental foramen is in a more posteroventral position; (3) the pit between M_3 and the coronoid process is distinctly shallower; (4) the maxillary is strongly constricted anteriorly and the prominent medial crest on its ventral surface extends to the anterior palatine foramina; (5) the infraorbital canal is shallow.

Geomys quinni McGrew is much larger than *G. tobinensis*. The depth of jaw is 40 per cent greater and the incisor width, the diastemal length, and the size of P_4 average over 20 per cent larger. More significantly, the pit labial to M_3 is not as well developed as in *G. tobinensis*.

An interesting, primitive character persists in approximately 5 per cent of the teeth of *Geomys tobinensis*. A thin enamel band may be present on the posterior face of P^4 and on the anterior face of the lower molars. This band, when present, extends to the base of the tooth and is not, therefore, a character of youth. In a study of 75 specimens of *G. b. dutcheri*, I found but 1 specimen (UMMZ No. 99734) which possessed these atavistic characters. Hibbard (1950, p. 138, fig. 7) reported a similar occurrence on P^4 of *Nerterogeomys* cf. *minor* (Gidley) from the Upper Pliocene Rexroad formation. Although this form cannot be considered to be ancestral to *Geomys*, it is of interest to note that the frequency of occurrence is 43 per cent (75 specimens).

Family Cricetidae

Reithrodontomys moorei (Hibbard)

(Fig. 4*D*)

Cudahyomys moorei Hibbard, 1944, Geol. Soc. Amer. Bull., 55: 725, fig. 9.

Material.—No. 38348, a left lower jaw with I–M_3 ; the coronoid process is missing, and the teeth are slightly worn. No. 39520, a maxillary fragment with M^1–M^3.

Description.—A small harvest mouse with a ramus slightly smaller than average for that of *Reithrodontomys humulus* (Audubon and Bachman). The position and size of the mental foramen is similar to that of *R. humulus*. The tooth row is narrow relative to its length. M_3 is notably reduced in size.

The anteroconid is simple, conical, and without external or internal folds. The anterolophid is well developed and is united to the protoconid in all teeth; a weak extension of this ridge is continuous with the hypoconid in M_1 and M_2 . A small cusplet is developed on the ridge at the labial extreme of the protoconid of M_1 and of M_2 . The protoconid of M_1 is weakly developed, rounded, and strongly inclined lingually. In appearance, it is more a low-lying fold than a cone-shaped cusp. The hypoconid of M_1 and M_2 lie in a lingual position and are broadly rounded rather than cone-shaped. The posterior cingulum is short and is not distinctly set off from the hypoconid. The lingual cusps of all teeth are well developed and conical. The anterolingual valley is very shallow and is anteriorly placed. Its labial extension curves abruptly posteriad between the anterolophid and the protoconid, rather than bisecting the labial wall of the tooth. The medial part, if present, is lost with slight wear. The primary folds are broad and rather U-shaped.

M_3 is reduced, narrow, and elongate (about 20 per cent longer than wide). The protoconid is very small, not bulbous. The first primary fold is much more extensive than the major fold, but the valley between the metaconid and the hypoconid is almost completely closed by a strong lophid. The major fold is a mere indentation. The cuspular pattern is C-shaped (Hooper, 1952, p. 29). The cusps are well fused.

The upper molars are hypsodont and with deep, broad, re-entrant folds. The cusps are alternate in position, inclined posteriorly, compressed anteroposteriorly (except hypocone), and united to the succeeding posterior cusp at their posteromedial border (Fig. 4*D*). Accessory lophs and styles are absent. The anterior cingulum is well developed in M^2 and M^3. The hypocone of M^2

is in a more posterior position than normal for *Reithrodontomys montanus* or *R. humulus*. This imparts a squared appearance to the posterior margin of the tooth. M^3 is reduced in size; it has a C-shaped occlusal pattern and is rounded in shape, but it is wider than long. The first primary fold is much shorter than the second primary fold and does not extend to the midline of M^3. The major fold is absent. A fourth root, narrow and anteriorly inclined, is present below the paraconid of M^1. The other 3 roots are in their normal positions. Three roots are present in M^2.

Measurements in mm.—No. 38348: alveolar length of $M_{\bar{1}}$–$M_{\bar{3}}$, 2.9. Length of $M_{\bar{1}}$, 1.4; width, 0.8. Length of $M_{\bar{2}}$, 1.0; width, 0.8. Length of $M_{\bar{3}}$, 0.65; width, 0.55. No. 39520: alveolar length of M^1–M^3, 3.3.

Discussion.—The trenchant characters separating *Reithrodontomys moorei* from all Recent and fossil species are: (1) the anterior position and shallowness of the anterolabial groove on $M_{\bar{1}}$ (if present medially, soon lost with slight wear); (2) the reduced and recumbent nature of the protoconid and, to a lesser extent, the hypoconid of $M_{\bar{1}}$ and $M_{\bar{2}}$; (3) the reduced condition of $M_{\bar{3}}$ in general, and of its protoconid in particular.

The fused and reduced nature of the cusps and valleys of $M\frac{3}{3}$ clearly place *R. moorei* in the *megalotis* group of the subgenus *Reithrodontomys* (Hooper, 1952). More specifically, the presence of a labial shelf on $M_{\bar{1}}$ and $M_{\bar{2}}$ indicate that its morphological affinities are nearest to those of *R. montanus* (Baird), *R. humulus*, and *R. burti* Benson, the only Recent species possessing the shelf. The recumbent nature of the protoconid and hypoconid, the well-developed anterolophid, and the enclosed condition and posterior trend of the labial extension of the anterolingual fold, are most like those of *R. humulus*. On the other hand, the narrow and reduced condition of $M_{\bar{3}}$, the alternate positioning of the upper molar cusps, and the degree of hypsodonty are more like those of *R. montanus* and, presumably, *R. burti*. It is assumed, however, that the reduced and folded nature of the labial cusps of $M_{\bar{1}}$ and $M_{\bar{2}}$, the shallowness of the anterior groove of $M_{\bar{1}}$, and the pronounced reduction of $M_{\bar{3}}$ are advanced characters. If this view is correct, *R. moorei*, although closely related, is too specialized to have given rise to any known member of the genus.

Subsequent to the original description of *Cudahyomys moorei*, Claude W. Hibbard discovered a third root on $M_{\bar{1}}$ of the holotype. In the course of this study, I have observed several specimens of *R. montanus* (Nos. 66950, 79280, 95871 UMMZ) with 3 roots on $M_{\bar{1}}$. X-rays of the topotype (No. 38348), however, show no third root. *R. montanus* and *R. megalotis* also frequently have a fourth root under the paracone of M^1 . To my knowledge, the presence of extra roots on $M\frac{1}{1}$ has not been previously reported for the genus.

Peromyscus cragini Hibbard

Material.—No. 35919, a left maxillary with M^1 ; No. 38346, a left jaw fragment with I–$M_{\bar{2}}$; No. 38347, a right jaw with an incisor and $M_{\bar{1}}$. Nos. 39521 and 39576, 2 maxillary fragments with heavily worn teeth. Only 1 individual is definitely represented.

Description.—The remains of this small mouse are rare in the fauna. As observed in the holotype, the lower molars of No. 38346 are simple and display no accessory lophids or stylids. A thin cingulum connects the protoconid and hypoconid in $M_{\bar{1}}$ and $M_{\bar{2}}$, but there is no indication of cusplet development. The protolophid is short but stout and is not distinct from the anteroconid. $M_{\bar{3}}$ is wider, but not as elongate as that of the holotype. The occlusal length of $M_{\bar{1}}$–$M_{\bar{2}}$ is 2.6 mm.; the alveolar length of $M_{\bar{1}}$–$M_{\bar{3}}$ is 3.4 mm.; the diastemal length is 2.9 mm.; and the depth of jaw below $M_{\bar{1}}$ is 2.6 mm. $M_{\bar{1}}$ of No. 38347 has a small mesostylid between the metaconid and entoconid, and the anterior part is narrower than that of the holotype. They compare well in other features, however. The greatest length of $M_{\bar{1}}$ is 1.4 mm.

Ondatra annectens (Brown)

(Fig. 5)

Ondatra kansasensis Hibbard, 1944, Geol. Soc. Amer. Bull., 55: 721, fig. 5.
O. kansasensis Hibbard, Hibbard, 1958, PMASAL, 43(1957): 12.
O. annectens (Brown), Stephens, 1960, in press.

Material.—Nos. 38334 and 38335, 2 fragmentary jaws with $M_{\bar{1}}$ and $M_{\bar{2}}$, ascending rami are absent. Nos. 38336 and 38337, 34 isolated teeth. No. 42318, a toothless maxillary. At least 4 individuals are represented.

Description.—Because Hibbard (1944, pp. 732–734, fig. 14) has described and illustrated the teeth of this form in considerable detail, little of significance

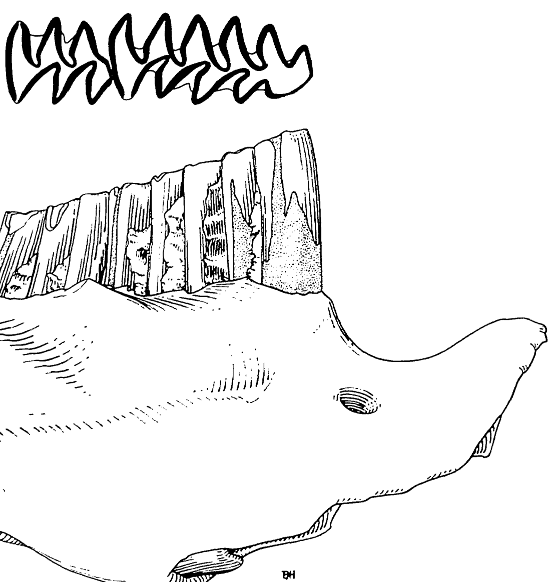

FIG. 5. *Ondatra annectens* (Brown), No. 38335, labial view of right jaw and occlusal view of $M_{\bar{1}}$ and $M_{\bar{2}}$, × 5.

can be added here. The occlusal patterns of $M_{\bar{1}}$ and $M_{\bar{2}}$, as well as the position of the mental foramen and the masseteric crest are illustrated in Fig. 5. The ventral surface of the maxillary displays structures comparable to Recent *Ondatra*. The medial depression is deeper than the lateral palatal grooves. The palatine joins the maxillary at a position similar to that of Recent *Ondatra*.

Measurements in mm.—The occlusal length of $M_{\bar{1}}$ is 5.67 (5.4–6.1), 4 specimens; occlusal width of $M_{\bar{1}}$ is 2.28 (2.1–2.5), 4 specimens.

Discussion.—Stephens, who studied the above material in connection with his study of the Doby Springs local fauna from Oklahoma, compared this material with the holotype of *Ondatra annectens* (Brown). He states: "Better material was recovered in the summer of 1958 of *Ondatra kansasensis* Hibbard, from the Cudahy local fauna of southwestern Kansas. . . . A comparison of this material . . . was made with *Ondatra annectens* (Brown), A.M.N.H. No. 12424 (a left lower jaw and right M^1) from the Conard Fissure, Arkansas. This comparison showed that *O. kansasensis* is the same as *O. annectens*." I have followed Stephens in this assignment.

Synaptomys (Mictomys) meltoni sp. nov.

(Fig. 6)

Material.—Holotype: No. 38327, a left lower jaw with incisor, $M_{\bar{1}}$, and $M_{\bar{2}}$. The posterior part of the ascending ramus is missing. Paratypes: Nos. 38328–38332 include 5 jaw fragments with $M_{\bar{1}}$–$M_{\bar{2}}$, and Nos. 39572 and 39606 include 5 incomplete jaws with $M_{\bar{1}}$. There are 119 isolated teeth in the collection. The minimal number of individuals represented is 39.

Horizon and type locality.—Pleistocene (late Kansan), Crooked Creek formation, Atwater member; Locality 10, Cudahy ash mine, SW¼ Sec. 2, T.31 S., R.28 W., Meade County, Kansas.

Diagnosis.—The size of the ramus is about that of *Synaptomys borealis chapmani* Allen, but the teeth are larger. The enamel of the molars is differentiated into thick and thin portions. In the lower teeth, the enamel of the anterior walls of the triangles is much thicker than that of the posterior walls. In the upper teeth, the enamel of the anterior walls of the triangles is thinner than that of the posterior walls. The first triangle of $M_{\bar{1}}$ has a convex rather than a concave posterior wall, and the base of the second triangle is broad. There is no distinct, cement-filled labial re-entrant on $M_{\bar{3}}$. The basal capsular process for the incisor is situated as in Recent *Mictomys*.

Description of holotype.—The holotype (No. 38327) is a left lower jaw of an adult with incisor, $M_{\bar{1}}$, and $M_{\bar{2}}$ (Fig. 6*C*). $M_{\bar{1}}$ consists of 4 closed prisms; a posterior loop, first and second triangles, and an anterior loop. The posterior wall of the first triangle is convex and the base of the second triangle is broad. The enamel on the posterior walls of the 4 prisms is reduced to a very thin and delicate plate. The enamel of the anterior walls is 2 to 3 times thicker than that of the posterior walls. $M_{\bar{2}}$ consists of 3 closed triangles. The posterior wall of the second triangle is convex. Like $M_{\bar{1}}$, the enamel of the anterior wall is much thicker than the posterior wall. The capsular process for the reception of the base of the incisior is just anterior to $M_{\bar{3}}$.

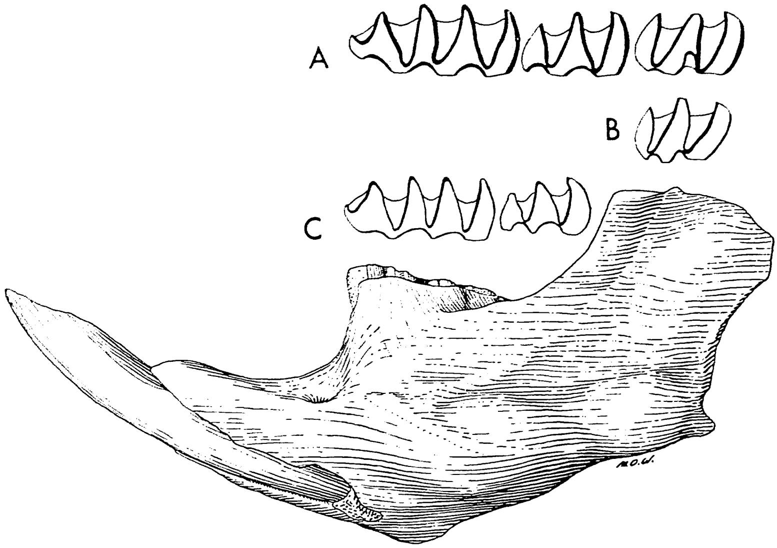

FIG. 6. *Synaptomys* (*Mictomys*);, *A S. borealis* (Richardson), UMMZ No. 97546, occlusal view of $M_{\overline{1}}$–$M_{\overline{3}}$; *B*, *S. meltoni*, sp. nov., $M_{\overline{3}}$, occlusal view; *C*, holotype, *S. meltoni*, sp. nov., $M_{\overline{1}}$ and $M_{\overline{2}}$, labial and occlusal views, all × 8.

Description of paratypes.—The characters of the holotype described above are shared by all paratypes. The rest of this description is based upon isolated teeth.

$M_{\overline{3}}$ is distinctive (Fig. 6*B*). It consists of 3 triangles, 2 lingual re-entrants, and 2 labial crenulations. Unlike Recent *Mictomys*, the second and third triangles have convex posterior walls. The enamel distribution of $M_{\overline{3}}$ is like that of the anterior molars; thick on the anterior walls and thin on the posterior. There is no distinct, cement-filled labial re-entrant. The configuration of the upper molars is the same as in Recent *Mictomys*, but the enamel of the anterior walls of all triangles is reduced.

Measurements in mm.—Holotype: length of diastema is 3.5. Depth of jaw below $M_{\overline{1}}$ is 4.7. Width of incisor is 1.0. Occlusal length of $M_{\overline{1}}$ to $M_{\overline{2}}$ is 4.3. Paratypes: the average and extreme measurements obtained from 13 specimens of $M_{\overline{1}}$ are occlusal length, 2.8 (2.5–3.2); width, 1.1 (1.0–1.2).

Discussion.—*Synaptomys borealis* (Richardson), the only living representative of the subgenus *Mictomys*, is characterized in part by: (1) an equal thickness of enamel on both walls of the prisms (Howell, 1927, p. 8); and (2) deep lingual re-entrants and simple cementless crenulations on the labial side of the lower teeth, with the exception of $M_{\overline{3}}$ in which a distinct, cement-filled re-entrant is developed (Howell, 1927, p. 20). The teeth of *S. meltoni* have an unequal enamel distribution, with no cement-filled, labial re-entrant in $M_{\overline{3}}$ (Fig.

6*B*). In addition, Recent *Mictomys* frequently have a thin, continuous band of enamel around the anterior prisms of $M_{\bar{1}}$, $M_{\bar{2}}$, and $M_{\bar{3}}$, and on the labial side of the posterior prisms of $M_{\bar{2}}$ and $M_{\bar{3}}$. These occurrences are not present in *S. meltoni*. The advanced state of enamel reduction in *Synaptomys meltoni* strongly suggests that it is not ancestral to *S. borealis*.

Synaptomys kansasensis Hibbard is distinct from *S. meltoni* although the similar configuration of the teeth and the comparable state of enamel differentiation establish their close relationship. In *S. kansasensis*, the basal capsular process is situated well posterior to the anterior border of $M_{\bar{3}}$, although it is anterior to $M_{\bar{3}}$ in *S. meltoni*. In addition, the lower jaw of *S. kansasensis* is much larger; $M_{\bar{1}}$ being 11 per cent wider, the incisor 17 per cent wider, and the ramus below $M_{\bar{1}}$ 22 per cent deeper.

This is the earliest recorded occurrence of the subgenus *Mictomys*. It is named for William G. Melton, Preparator at the University of Michigan Museum of Paleontology, who led the field party that recovered the specimens discussed in this report.

Microtus paroperarius Hibbard

(Fig. 7)

Material.—In varying states of completeness, 217 tooth-bearing lower jaws and numerous isolated teeth; Nos. 24715, 38349–38355, 38442, 38443, 39568, 39569, 39574, 39581, 39607–39612, and 42128. A count of lower left $M_{\bar{1}}$'s indicates that at least 723 individuals are represented.

Description.—Normally, $M_{\bar{1}}$ consists of a posterior loop, 4 closed triangles, and a fifth triangle which is open and confluent with the anterior loop. In approximately 20 per cent of the jaws, however, the fourth lingual and the third labial re-entrants converge to close the fifth triangle. The fourth labial re-entrant is normally present and is developed enough to contain cement in more than half of the specimens. I have not observed cement in the fourth labial re-entrants of any of the specimens of *Microtus oeconomus* Pallas—the nearest living relative of *M. paroperarius*—in the collection of the University of Michigan Museum of Zoology. The fifth lingual re-entrant is almost always present and is deeper and better developed than in *M. oeconomus*. In 1 specimen (No. 39569, Fig. 7*G*), a faint suggestion of a sixth lingual re-entrant is present. The variation in the size and depth of the re-entrants mentioned above determines the shape of the anterior loop. Fig. 7*A–G* is designed to demonstrate the gradational nature of the progression from a 4 to a 5 closed-angle condition, as well as to indicate the variable degrees of development of the fourth labial and fifth lingual re-entrants. Fig. 7*C* is the normal condition for $M_{\bar{1}}$ with 4 closed triangles, and Fig. 7*E* is the normal condition for $M_{\bar{1}}$ with 5 closed triangles.

Measurements in mm.—Occlusal length of $M_{\bar{1}}$–$M_{\bar{3}}$, 5.96 (5.4–6.5), 6 specimens. Occlusal length of $M_{\bar{1}}$–$M_{\bar{2}}$, 4.49 (4.1–4.7), 20 specimens. Occlusal length of $M_{\bar{1}}$, 2.96 (2.6–3.4), 20 specimens; width of $M_{\bar{1}}$, 1.07 (1.0–1.2), 20 specimens. Length of diastema, 3.91 (3.3–4.1), 10 specimens. Greatest depth of jaw, 4.87 (4.3–5.5), 10 specimens.

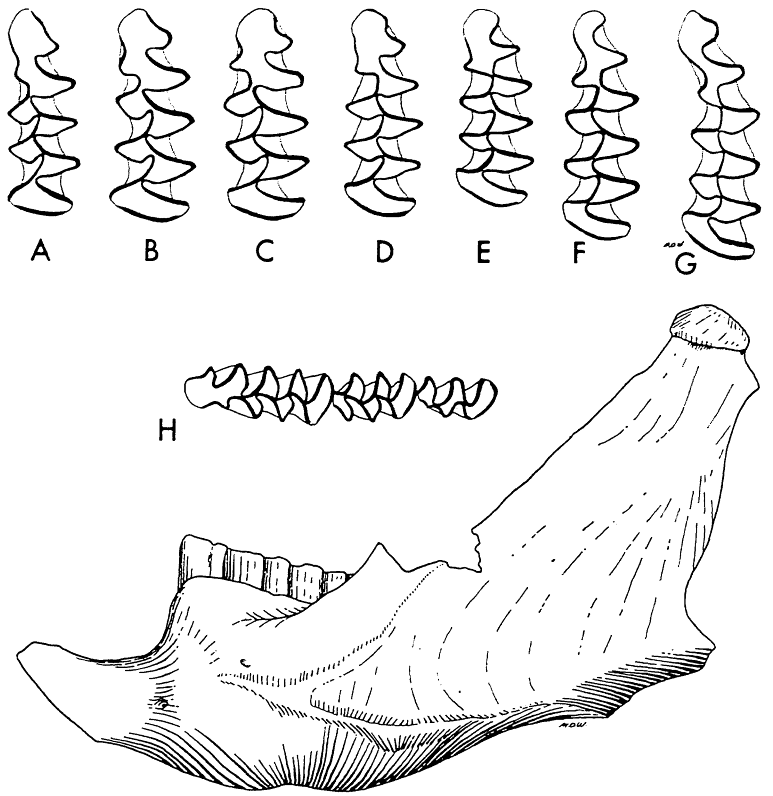

FIG. 7. *Microtus paroperarius* Hibbard, *A–G*, left $M_{\overline{1}}$ variation series, *A* and *B*, No. 36801; *C–F*, No. 36800; *G*, No. 39569; occlusal views, all × 10; *H*, No. 38350, left jaw with $M_{\overline{1}}$–$M_{\overline{3}}$, labial and occlusal views, × 8.

Discussion.—Claude W. Hibbard and I collected a poorly preserved specimen (No. 42128) of *Microtus paroperarius* from a reddish, sandy silt below the Pearlette ash exposure on the ranch of Alfred Shoemaker, SE corner, NW¼, NW¼ Sec. 26, T.19 N., R.13 W., Valley County, Nebraska, in the summer of 1959. In this specimen, the incisor, $M_{\overline{1}}$ and $M_{\overline{2}}$ are present. $M_{\overline{1}}$ consists of a posterior loop, 4 closed angles, and a constricted fifth angle which is confluent with the anterior loop. A broad, fourth labial re-entrant is present. $M_{\overline{2}}$ consists of a posterior loop and 4 closed angles. The occlusal length of $M_{\overline{1}}$ is 2.15 mm., and the width is 0.8 mm. The estimated length of $M_{\overline{1}}$–$M_{\overline{2}}$ is 4.0 mm.

This specimen agrees with the occlusal pattern of *M. paroperarius*, but it is 11 per cent smaller than the average specimen of *M. paroperarius* from the type locality. I believe that its small size is more a result of geographic variation than of age or individual variation, since the specimens from Russell and Lincoln counties, Kansas, as measured by Hibbard (1944, pp. 737 and 740) are intermediate in size.

The dental pattern of $M_{\bar{1}}$ of *Microtus oeconomus* is usually characterized as having". . . only four closed triangles, (the) fifth triangle being open and confluent with (the) short terminal loop. . ." (Hall and Kelson, 1959, p. 735). In a study of 45 Recent specimens of *M. oeconomus*, I found that 18 per cent had 5 closed angles on $M_{\bar{1}}$. I believe that the similar frequency of occurrence of 5 closed angles in *M. oeconomus* and *M. paroperarius* indicates a relationship between the 2 species. Hibbard (1955, p. 90) considers *Microtus speothen* (Cope) to be related to, but distinct from, *M. paroperarius*.

Pitymys meadensis Hibbard

(Fig. 8*A–G*)

Material.—In various degrees of completeness, 68 tooth-bearing lower jaws and numerous isolated teeth. None of the jaws possesses a complete ascending ramus. Nos. 24714, 27174, 36224, 36799, 38356, 38440, 38441, 39570, 39571, 39595, 39602, 39603. A count of right $M_{\bar{1}}$'s indicates that at least 206 individuals are represented in the collection.

Description.—The characters cited in the original diagnosis (Hibbard, 1944, p. 731) of *Pitymys meadensis* are remarkably constant. In $M_{\bar{1}}$, the dentine of the posterior loop and the first 3 alternating triangles are almost always separate from one another (one exception in 150 teeth); that of the confluent fourth and fifth triangles is consistently separate from the dentine of the anterior loop and of the third triangle. The posterior loop and the 4 triangles of $M_{\bar{2}}$ are also normally closed (Fig. 8*G*).

The fourth labial and fifth lingual re-entrants of the anterior loop are highly variable. Generally, these re-entrants are broad and relatively shallow, but in some cases, they may be so well developed that the dentine of the anterior loop is divided into two separate units. Fig. 8*A–F* illustrates this progression. Both of these re-entrants ordinarily contain cement, but it may be absent from the fourth labial re-entrant in exceptional cases. The angular and broad nature of the labial re-entrants—notably the second—are distinct from the oblique, crescent-shaped re-entrants typical of Recent *Pitymys* and *Pedomys*.

Measurements in mm.—Occlusal length of $M_{\bar{1}}$–$M_{\bar{3}}$, 6.0, 1 specimen. Occlusal length of $M_{\bar{1}}$–$M_{\bar{2}}$, 4.4 (4.1–4.7), 15 specimens. Occlusal length of $M_{\bar{1}}$, 3.0 (2.8–3.3) 10 specimens; width of $M_{\bar{1}}$, 1.15 (1.0–1.2), 20 specimens. Length of diastema, 3.4 (3.0–3.9), 5 specimens.

Discussion.—The enamel pattern, the well-developed fourth and fifth lingual re-entrants of $M_{\bar{1}}$, and the angular nature of the labial re-entrants of $M_{\bar{1}}$ suffice to separate *Pitymys meadensis* from all living and fossil North American species. The $M_{\bar{1}}$ of *P. gregaloides* Hinton (4 specimens, No. 39773) from the upper Biharium (= Kansan) of central Bohemia is 13 per cent smaller and lacks a fourth labial re-entrant. The fifth lingual re-entrant is well developed and the configuration of the labial re-entrants are comparable to those of *P. meadensis*. In *P. hintoni* Kretzoi (No. 34914, 2 specimens), from equivalent

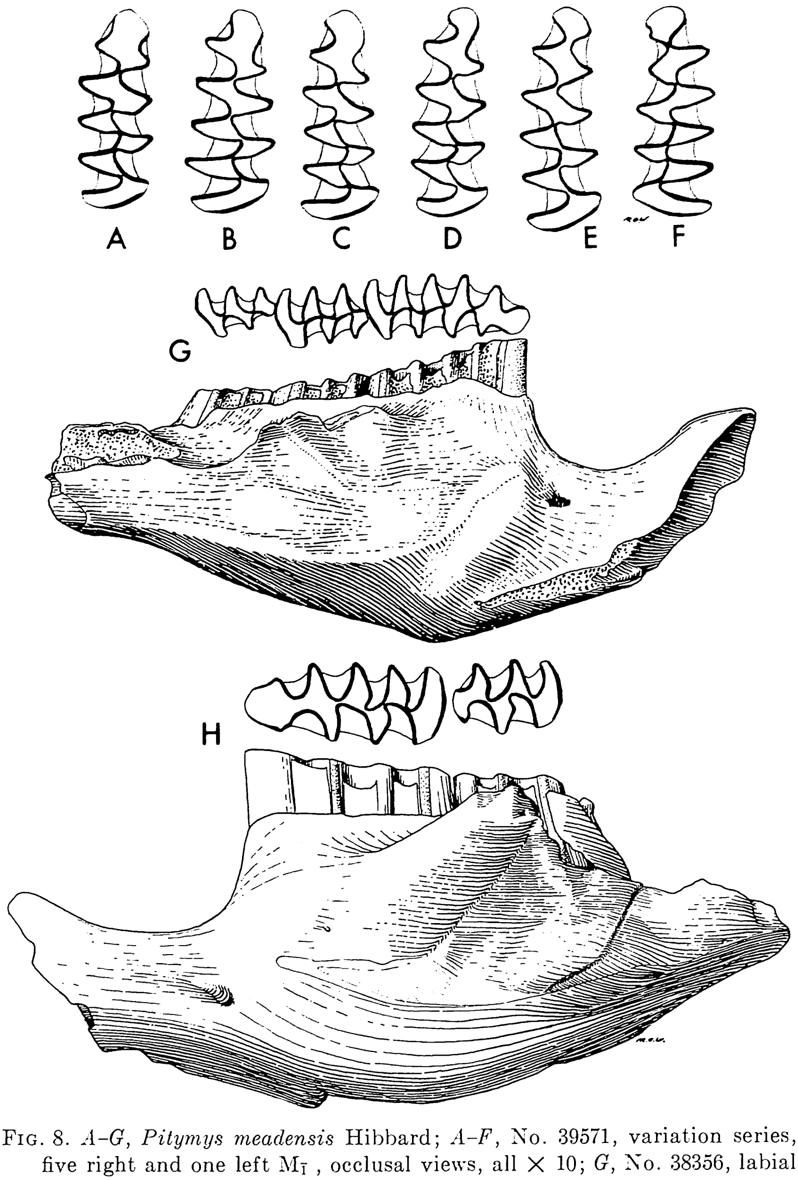

FIG. 8. *A–G*, *Pitymys meadensis* Hibbard; *A–F*, No. 39571, variation series, five right and one left $M_{\bar{1}}$, occlusal views, all × 10; *G*, No. 38356, labial and occlusal views, × 8; *H*, *Pedomys llanensis*, No. 39604, labial and occlusal views, × 10.

deposits in Yugoslavia, the fourth labial and fifth lingual re-entrants are not well developed.

Hibbard (1944) pointed out that *Pitymys meadensis* appeared too late to be considered ancestral to Recent North American *Pitymys* or *Pedomys.*

Pedomys llanensis Hibbard

(Fig. 8*H*)

Material.—No. 24511, a left jaw with $M_{\overline{1}}$–$M_{\overline{3}}$ but without the incisor, coronoid or angular processes. No. 39604, an incomplete left lower jaw with $M_{\overline{1}}$ and $M_{\overline{2}}$; No. 39605, a fragmentary jaw with $M_{\overline{1}}$–$M_{\overline{2}}$; and isolated teeth. At least 4 individuals are present.

Description.—As in the holotype, the topotype material has fourth and fifth triangles which are confluent with the broad anterior loop in $M_{\overline{1}}$, and confluent third and fourth triangles in $M_{\overline{2}}$ (Fig. 8*H*). The third labial and fourth lingual re-entrants of $M_{\overline{1}}$ are better developed in the topotype material. In No. 39605, there is a shallow, fifth lingual re-entrant containing cement, and a slight fourth labial one without cement. These 2 re-entrants are generally better developed in Recent *Pitymys* and *Pedomys.* The confluence of the third and fourth triangles of $M_{\overline{2}}$ is like that of the holotype. The labial re-entrants of $M_{\overline{1}}$, especially the second, are wide and angular medially. In a study of Recent specimens, I was unable to duplicate the configuration of the re-entrants in 91 specimens of *Pitymys pinetorium* LeConte and 146 of *Pedomys ochrogaster* (Wagner). Typically, the re-entrants of the Recent forms are in the form of anteriorly oriented half crescents. Some individuals of *Pedomys* were observed to have a somewhat angular re-entrant, but they are not as wide medially as in *P. llanensis.* The pit between $M_{\overline{3}}$ and the ascending ramus is deep, but this feature is subject to such extreme geographic variation in Recent *Pedomys* and *Pitymys* that I consider it to be of little diagnostic importance.

Measurements in mm.—Occlusal length of $M_{\overline{1}}$–$M_{\overline{3}}$, 5.9, 1 specimen. Occlusal length of $M_{\overline{1}}$–$M_{\overline{2}}$, 4.5 (4.4–4.6), 3 specimens. Occlusal length of $M_{\overline{1}}$, 2.9 (2.8–3.0), 3 specimens; greatest width of $M_{\overline{1}}$, 1.15 (1.1–1.2), 3 specimens.

Discussion.—The similarity in the nature of the labial re-entrants of *Pitymys meadensis* and *Pedomys llanensis*, and the slight development of the fourth labial and fifth lingual re-entrants in the topotypes of the latter led me to suspect that the two forms might be variants of the same species. A subsequent study of 103 $M_{\overline{1}}$'s and 169 $M_{\overline{2}}$'s convinced me that they are distinct species. I consider No. 24511 to be *P. llanensis* rather than a variant of *Pitymys meadensis* (Hibbard, 1949, p. 74, fig. 2). *Pedomys* or *Pitymys dideltus* Cope from the Port Kennedy Cave deposit of Pennsylvania has an enamel configuration which is similar to *Pedomys llanensis* (Hibbard, 1955, p. 97, fig. 2*A*). However, in *P. dideltus*, the confluence of the third and fourth triangles of $M_{\overline{2}}$ is more constricted and the tooth row is larger (10 per cent) than in *P. llanensis.* Hibbard (1955, p. 91) gave the measurement of 3.8 mm. for an $M_{\overline{1}}$ of *P. dideltus* from the collections of the Academy of Natural Sciences of Philadelphia. This figure is 25 per cent larger than the average for $M_{\overline{1}}$ of *P. llanensis.*

The teeth and lower jaws of Recent North American species of *Pedomys* and *Pitymys* are so extremely variable that separating criteria do not exist. In a comparative study of *Pitymys pinetorium* and *Pedomys ochrogaster*, I found that 95 per cent of the latter had the fourth and fifth triangles of $M_{\bar{1}}$ confluent with the anterior loop as well as confluent third and fourth triangles on $M_{\bar{2}}$, as compared to 60 per cent in *Pitymys*. This greater frequency, plus the general observation that the labial re-entrant angles of *Pedomys* more closely approach the nature of those of *P. llanensis*, suggest that the Cudahy specimens are *Pedomys*. However, it is not possible to assign this species to either genus with certainty.

Family Zapodidae

Zapus cf. *sandersi* Hibbard

(Fig. 4*A–C*)

Material.—No. 38342, a left jaw fragment with a well-worn $M_{\bar{1}}$; No. 38343, a fragmentary jaw with $M_{\bar{2}}$ and $M_{\bar{3}}$; No. 38344, a lower jaw of an old adult with incisor and $M_{\bar{1}}$; No. 38345, a lower jaw with $M_{\bar{1}}$; No. 38518, an isolated $M_{\bar{1}}$ and $M^{\underline{2}}$. At least 3 individuals present.

Description.—A small *Zapus* with a ramus size near to that of *Z. hudsonius* (Zimmerman). The size, shape, and occlusal pattern of the 4 recovered $M_{\bar{1}}$'s are remarkably similar. All are rather blunt and broadly rounded anteriorly. This lends an appearance of stoutness when compared with those of Recent species and is due to the wide protoconid (0.8 mm.). This appearance of bluntness is approached by *Z. hudsonius* only after extremely heavy wear, or in the somewhat exceptional case when a deep anteromedial groove interrupts the protoconid—a feature not present in any known fossil species. No. 38345 (Fig. 4*C*) has a very thin, shallow anteromedial groove similar to that observed in some *Z. trinotatus* Rhoads. This feature is lost early in life. No. 38518 (Fig. 4*B*), which is moderately worn, shows no sign of this groove. The external re-entrant valley of the Cudahy specimens is broad. It is most similar to *Zapus sandersi* Hibbard in this respect. The depth of this re-entrant is more shallow than *Z. trinotatus* and *Z. princeps* Allen. It duplicates the depth observed in *Z. sandersi* and *Z. hudsonius*.

$M_{\bar{2}}$ and $M_{\bar{3}}$ (No. 38343, Fig. 4*A*) are distinct from all specimens of *Zapus* observed. $M_{\bar{2}}$ is subquadrate; that is, wider than the $M_{\bar{2}}$ of Recent species with a similar occlusal length. $M_{\bar{3}}$ is oval in shape and is slightly reduced in size. $M_{\bar{2}}$ and $M_{\bar{3}}$ of *Z. hudsonius acadicus* Dawson most closely resemble these teeth in size, but in *Z. h. acadicus*, $M_{\bar{1}}$ and $M_{\bar{2}}$ are more elongate and slender, and $M_{\bar{3}}$ is larger and generally subtriangular in shape rather than round.

Measurements in mm.—Greatest length of $M_{\bar{1}}$, 1.58 (1.55–1.60); greatest width of $M_{\bar{1}}$, 0.95 (0.9–1.0), 4 specimens each. Occlusal length of $M_{\bar{2}}$, 1.3; greatest width, 0.9, 1 specimen. Greatest length of $M_{\bar{3}}$, 0.8; greatest width, 0.75, 1 specimen. Greatest length of $M^{\underline{2}}$, 1.5; greatest width, 1.15, 1 specimen.

Discussion.—I consider the Cudahy material definitely distinct from any living species of *Zapus*. It may be distinguished from *Z. trinotatus* and *Z. princeps* by its small tooth size and by the shallow depth of its external re-entrant fold in $M_{\bar{1}}$. *Z. hudsonius* is easily separated by its elongate and narrow tooth row and, in most cases, by the deep anteroconid groove extending well down the anterior face of M_1 . *Zapus adamsi* Hibbard is larger and has: (1) a more elongate, narrow tooth row; (2) a deeper external re-entrant fold; (3) a larger M_3 than the Cudahy material. *Z. burti* Hibbard is much larger than the Cudahy specimens and the external re-entrant approach is much shorter in both M_1 and M_2 . The nature of this approach is considered to be relatively constant because it does not vary significantly in Recent species. *Z. rinkeri* Hibbard, the largest as well as the oldest known member of the genus, is much too large for consideration.

Z. sandersi of the Aftonian interglacial epoch, is known from a lower jaw fragment with M_1 . This tooth is comparable to those of the Cudahy material in both size and shape. The width and depth of the labial and lingual re-entrants are similar, although a slight anterior projection of the entoconid somewhat constricts the external re-entrant of *Z. sandersi*. The approach of this re-entrant is the same in both forms, however. Because these features are relatively constant in Recent species, they are considered significant here.

ORDER EDENTATA

Family Megalonychidae

Megalonyx sp.

(Fig. 4*F*)

A left upper tooth (No. 38403) and a left, second metacarpal of the fourth digit (No. 38404) represent this ground sloth. It was not previously known in the fauna. In cross section, the tooth is elliptical but with a swelling on the lingual side (Hay, 1914, p. 114, Fig. 6). This establishes that it is the anteriormost tooth in the jaw. The anteroposterior length is 34.5 mm., and its greatest width is 15.2 mm. The left metacarpal (Fig. 4 *F*) compares best with the first phalanx of the fourth digit of *Megalonyx*. I am grateful to John J. Stephens for making this comparison with the mounted skeleton of *Megalonyx* at Ohio State University.

ORDER PROBOSCIDEA

Family Elephantidae

Mammuthus sp.

This family is represented by a single plate of a tooth of *Mammuthus*. This is the first record of mammoth in the Cudahy fauna of Meade County.

ORDER LAGOMORPHA

Family Leporidae

Sylvilagus sp.

This is the first record of a rabbit in the fauna. It is represented by a right, upper, cheek tooth; probably M^1. The anteroposterior occlusal length of No. 39573 is 1.95 mm., and the greatest occlusal length is 3.6 mm.

ORDER ARTIODACTYLA

Family Tayassuidae

Platygonus sp.

This peccary is represented by 3 tooth fragments (No. 42345). This is the first record of the genus in the Cudahy fauna.

Family Antilocapridae

Antilocaprid

Two pronghorn teeth ($LP_{\overline{3}}$ and $LP_{\overline{4}}$) which closely correspond to those of *Antilocapra americana* (Ord) were recovered from locality 17. The teeth are well worn and the roots are fully formed. A remnant of an enamel pit is present on $P_{\overline{4}}$; all other pits have been lost with wear. The anteroposterior length of $P_{\overline{3}}$ is 7.3 mm., and that of $P_{\overline{4}}$ is 9.2 mm. The greatest width of $P_{\overline{3}}$ is 5.2 mm. and the greatest width of $P_{\overline{4}}$ is 5.6 mm. This is the first recorded occurrence of the pronghorn in the Cudahy fauna.

ORDER PERISSODACTYLA

Family Equidae

Equus sp.

A horse hoof (No. 38405) and tooth fragments of this genus were recovered. Hibbard (1944) reported 2 molars which compared best with *Equus niobrarensis* Hay. The additional material is too fragmentary for specific identification.

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