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LATE CENOZOIC MICROTINE RODENTS  
FROM WYOMING AND IDAHO

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Reprinted from  
PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE, ARTS, AND LETTERS  
Vol. XLIV, 1959 (1958 MEETING)  
*Printed in U.S.A.*



## LATE CENOZOIC MICROTINE RODENTS FROM WYOMING AND IDAHO

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THIS paper is one of a series resulting from relatively detailed study of some Pliocene and Pleistocene faunas from the western United States. Co-operative work with Dwight W. Taylor of the United States Geological Survey is aimed at careful stratigraphic collection of associated fossils representing a number of groups of both plants and animals. We believe that such work can significantly advance knowledge of the geologic range and stratigraphic value of many types of fossils. Possibly even more important will be the broader and firmer basis for environmental interpretation of these fossil-bearing deposits. Especially within the Pleistocene epoch and eventually in the Pliocene as well, the development of an inferred climatic sequence may yield information of great value for correlation. The Pleistocene has been shorter than any other epoch and as a consequence the evolutionary changes in faunas are fewer—and of less stratigraphic usefulness—than in the Miocene or Pliocene, for example.

Even the mammals, a relatively rapidly diversifying group, in some instances have not shown clear evidence of evolution within the Pleistocene. Many genera and species have gradually become extinct during the Ice Age, but a large proportion of these may be Pliocene novelties. The microtine rodents, however, stand in striking contrast to such relatively conservative groups as the camels, horses, and pocket-mice. These mice diversified rapidly during the late Cenozoic and developed progressive specializations. These changes, which are of considerable taxonomic value, include several important modifications of teeth and tooth patterns. Some lines of microtines that had rooted cheek teeth gradually lost these roots and developed high-crowned teeth that grew throughout the life of the animal. Other microtines with rooted or ever-growing cheek teeth had cement deposits on their teeth, and some developed an interrupted enamel pattern on the grinding (occlusal) surface.

*List of localities.*—The fossil voles reported in this paper were

taken at the following places. All locality numbers are in the United States Geological Survey Cenozoic series. Field numbers are in parentheses.

19128 (DWT 406). Owyhee Co., Idaho. Hammett quad. (1948) 1:24000. SW.  $\frac{1}{4}$  Sec. 1, T. 6 S., R. 8 E. 1550' E., 650'-1050' N. of SW. corner. 2600' elev. Abundant shells and fewer of other fossils weathering from fine sand. Most if not all fossils are from a sandy coquina about 6" thick.

19129 (DWT 407). Owyhee Co., Idaho. Hammett quad. SW.  $\frac{1}{4}$  Sec. 1, T. 6 S., R. 8 E. 1950' E., 950' N. to 2200' E., 525' N. of SW. corner. 2690' elev. Fossils from a 15'-20' interval of tan, fine, cross-bedded sand immediately above a 2'-3' thick ash bed. This is probably very close to the locality from which Yen (1944) described freshwater mollusks.

19216 (DWT 431). Twin Falls Co., Idaho. Hagerman quad. (1950) 1:24000. NE.  $\frac{1}{4}$  Sec. 20, T. 7 S., R. 13 E. 1100' W., 775' S. to 1150' W., 650' S. of NE. corner. 3295' elev. Hagerman formation, 25' below top. Fossils from fine, micaceous, cross-bedded, gray sand.

19217 (DWT 432). Twin Falls Co., Idaho. Hagerman quad. NE.  $\frac{1}{4}$  Sec. 20, T. 7 S., R. 13 E. 150' W., 800' S. of NE. corner. 3115' elev. Hagerman formation, 205' below top. Fossils from fine sand and silt exposed on bench on ridge.

20764 (T56-39). Owyhee Co., Idaho. Jackass Butte quad. (1948) 1:24000. NE.  $\frac{1}{4}$  Sec. 15, T. 4 S., R. 2 E. 1925' W., 1950' S. of NE. corner. 2515' elev. Fossils from fine sand exposed on minor bench immediately south of gulch heading on east side Jackass Butte. This is believed to be the type locality of the microtines described by Wilson (1933).

20765 (DWT 540). Twin Falls Co., Idaho. Hagerman quad. SW.  $\frac{1}{4}$  Sec. 28, T. 7 S., R. 13 E. 350' E., 2100' N. of SW. corner. 3025' elev. Hagerman formation. Fossils from higher saddle on south spur of square-nosed butte, from 2'-10' above a conspicuous, light gray, 2"-thick, platy weathering, carbonaceous clay shale.

20766 (T56-18). Teton Co., Wyoming. Grand Teton National Park sheet (1948) 1:62500. NW.  $\frac{1}{4}$  Sec. 19, T. 42 N., R. 115 W. 1200' E., 150' S. of NW. corner. Teewinot formation. Exposure on northwest side of road to Kelly, 2.3 miles from junction of Kelly road with U. S. Highway 187, in road cut beneath mantle of terrace gravel.

20767 (T56-120; FPV-123). Elmore Co., Idaho. Twentymile Butte quad. (1949) 1:24000. NE.  $\frac{1}{4}$  Sec. 27, T. 7 S., R. 11 E. 0'-250' W., 1550' S. of NE. corner. 3165' elev. Hagerman formation. Fossils from sand exposed on gentle slopes on north side of tributary to Rosevear Gulch.

This study reviews the microtines of the following four assemblages:

1. Unnamed assemblage, Middle Pliocene. Teewinot formation, Jackson Hole, Wyoming.
2. Sand Point local fauna, late Pliocene. Unnamed formation, Owyhee Co., Idaho.
3. Hagerman local fauna, early Pleistocene. Hagerman formation, Twin Falls Co., Idaho.
4. Grand View local fauna, Middle Pleistocene. Unnamed formation, Owyhee Co., Idaho.

The material has been partly collected by Taylor, who since 1954 has been studying the late Cenozoic stratigraphy and paleontology of southern Idaho and adjacent areas. Another part of the material was collected personally in 1956, when I visited the areas listed above to see the fossil sites and to examine the Pliocene and Pleistocene succession in the Snake River valley. The third part consists of older material from various sources.

The fossils are in the following institutions: California Institute of Technology collection at the Los Angeles County Museum (CIT); United States Geological Survey (USGS); United States National Museum (USNM); University of California Museum of Paleontology (UCMP); and University of Michigan Museum of Paleontology (UMMP).

*List of species.*—The following list summarizes the species discussed in this paper and their stratigraphic occurrence.

*Microscoptes disjunctus* (Wilson)

Described originally from the Middle Pliocene Rome local fauna, southeastern Oregon. Additional specimens are recorded herein from the Teewinot formation, Jackson Hole, Wyoming.

*Mimomys (Cosomys) primus* (Wilson); Hagerman local fauna.

This vole was first reported from the Coso Mountains local fauna of California.

*Nebraskomys? taylori* Hibbard, sp. nov.; Hagerman local fauna.

*Pliophenacomys idahoensis* Hibbard, sp. nov.; Sand Point local fauna.

*Pliophenacomys parvus* (Wilson); Grand View local fauna.

*Pliopotamys* indet.; Sand Point local fauna.

*Pliopotamys minor* (Wilson); Hagerman local fauna.

*Ondatra idahoensis* Wilson; Grand View local fauna.

*Systematic account of the rodents.*—The detailed morphologic descriptions of the fossils follow. In addition to the usual information I have given a list of associated species. The molluscan faunas recovered in association with the vertebrates will be reported upon by Dwight W. Taylor. The large amount of fishbones found with the other specimens are being studied by Carter R. Gilbert, a graduate student at the University of Michigan.

*MicrotoscOPTES disjunctus* (Wilson)

(Figs. 1 A-C)

*Goniodontomys disjunctus* Wilson, Love, 1956, Wyo. Geol. Assoc. Guidebook, 11th Ann. Field Conf.: 91; Amer. Assoc. Petrol. Geol. Bull., 40: 1910.

The Mongolian form *MicrotoscOPTES praetermissus* Schaub is distinguished from *M. disjunctus* by its smaller size.

In the collection from the Middle Pliocene of Jackson Hole (USGS loc. 20766) are parts of three left lower jaws. They are quite fragile. Specimen No. 21383 USNM retains the incisor, M<sub>1</sub> and M<sub>2</sub>. The anteroposterior occlusal length of M<sub>1</sub> and M<sub>2</sub> (Fig. 1B) is 5.25 mm. The ascending ramus is missing. The lower incisor extends posterior to the alveoli of M<sub>3</sub>. The incisor, shape of jaw, position of the mental foramen, and dental pattern agree with that of the holotype (No. 1959 CIT).

Specimen No. 21826 USNM, a young adult individual (Fig. 1C), is the most complete. The lower incisor extends posterior to M<sub>3</sub> and for some distance upward into the ascending ramus. There is no capsular process or swelling on the labial side of the jaw to indicate where the incisor ends. The mental foramen is situated dorsally on the diastema just anterior to the alveoli of M<sub>1</sub>. The greatest height of the crown of M<sub>1</sub> is 1.8 mm. The occlusal length of M<sub>1</sub> and M<sub>2</sub> is 4.5 mm. M<sub>1</sub> consists of a posterior loop which is broadly confluent with the first inner triangle. The second and third triangles are confluent and nearly opposite. They are separated from the first triangle and the anterior loop by a thin connection of enamel that is no thicker than the enamel along the border of the tooth.

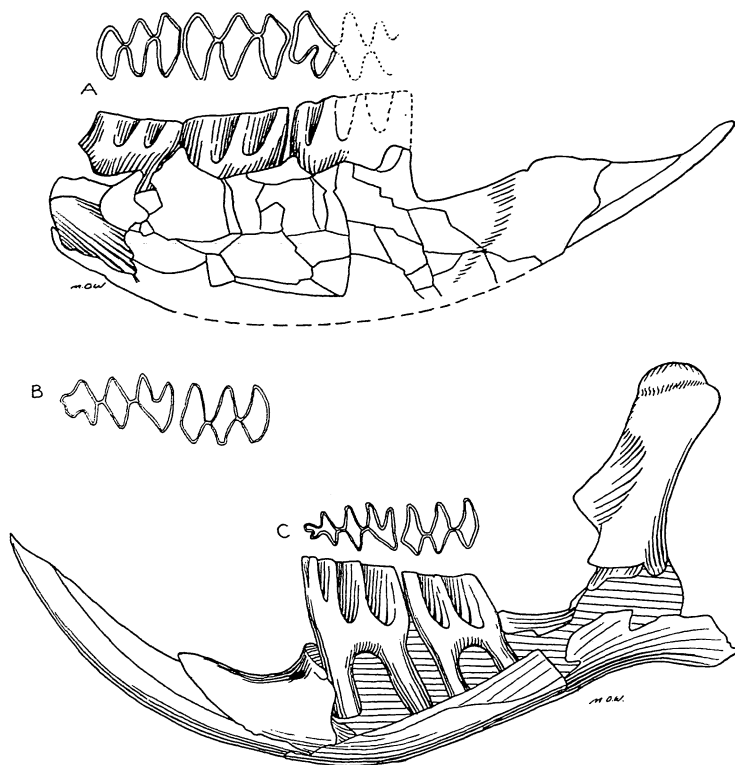


FIG. 1. Lower dentition of *Microtoscopes disjunctus*: A, USNM 21825, part of left lower jaw, lingual and occlusal views,  $\times 6$ ; B, USNM 21383, occlusal view of left  $M_1$  and  $M_2$ ,  $\times 6$ ; C, USNM 21826, part of left lower jaw, labial and occlusal views,  $\times 5$ .

This thin enamel connection extends to the base of the crown and is transparent. The dentine is confined entirely to the loops and confluent triangles in all the lower molars. The anterior loop consists of the fourth and fifth confluent triangles and a grooved anterior part. The anterior groove of the loop would soon disappear with wear.

$M_2$  consists of a posterior loop, two confluent and opposite triangles, and an anterior loop.

The masseteric crest of the mandible is present on part of the specimen. It extends posterior to  $M_2$ , but due to the broken con-

dition of the jaw the entire length is unknown. The position and development of the part of the masseteric crest which is present is like that in later microtines.

Specimen No. 21825 USNM is broken just posterior to  $M_3$ . The anterior part of the crown of  $M_1$  is missing. The incisor passes from the lingual side of the jaw to the labial side just posterior to  $M_2$  and beneath  $M_3$ . The posterior part of the incisor is broken, but it extends a short distance past  $M_3$ .  $M_3$  consists of a posterior loop, two confluent and opposite triangles, and an anterior loop. The posterior loop and the anterior loop are separated from the two confluent and opposite triangles by a very thin enamel connection (Fig. 1A).  $M_1$ ,  $M_2$ , and  $M_3$  have two well-developed roots with the posterior root being larger. The anteroposterior length of  $M_1$ - $M_3$  is 7.0 mm. The occlusal length of  $M_2$  is 2.3 mm. and of  $M_3$ , 2.0 mm. Cement is lacking in the re-entrant angles.

*Discussion.*—A larger series of specimens from both Oregon and Wyoming may show that the Wyoming form is a different species. I consider the difference in the anterior loop between the Oregon and Wyoming specimens as only individual variation, since the anterior loop varies greatly within any given species of microtines. The “Prismenfalte” of Schaub (1940, p. 73; Hinton, 1926, p. 111) as shown by Wilson (1937a, pl. 2, fig. 2) to be present in *M. disjunctus* is absent in the Wyoming specimens. The “prism fold” does not occur in all the young specimens of *Ogmodontomys* but is a variable character.

The genus *Microscoptes* was described from the Pliocene of Mongolia by Schaub, who discussed its relationship with the Microtinae. Wilson, not knowing of Schaub's work, described the genus *Goniodontomys*, based upon specimens from the Middle Pliocene of Oregon (Rome local fauna). He considered the specimens as questionably belonging to the Microtinae. Schaub (1934), Stehlin and Schaub (1951), and Wilson (1937a) discussed the relationship of this genus to other rodents. I agree with Schaub and Wilson that its closest affinity is with the Microtinae. A skull or palate with the upper dentition of this rodent would contribute much to the understanding of this genus. Wilson (1937b, p. 51) stated “*Goniodontomys*, if a vole, is an aberrant member of the group without descendants.”

Professor Schaub kindly loaned excellent figures of the genotype, which aided greatly in the present study.



*Associated forms.*—The shrew, *Hesperosorex lovei* Hibbard (1958b), and the beaver, *Dipoides stirtoni* Wilson (Love, 1956b), were found with the remains of *Microscoptes disjunctus*. The molluscan fauna, consisting of thirteen species, was reported by Taylor (1956).

*Mimomys (Cosomys) primus* (Wilson)

(Figs. 2 A-E)

*Cosomys primus* Wilson, 1932, Jour. Mammal., 13 (2): 150-154, 1 pl.

*Mimomys (Cosomys) primus* (Wilson), Wilson, 1933, Carnegie Inst. Wash. Pub., 440: 126-128, 1 fig.

Wilson (1933) gave an excellent description of the parts of this vole recovered from the type Hagerman formation, near the Hagerman horse quarry (Gazin, 1936). He also discussed the probable relationship of the American form with the European genus *Mimomys*.

Many specimens of this vole were recovered by Dwight W. Taylor in the summer of 1955, and by myself in the summer of 1956, from the following two locations in the type Hagerman formation south of the Hagerman horse quarry (N.  $\frac{1}{2}$  NW.  $\frac{1}{4}$  Sec. 16, T. 7 S., R. 13 E., Twin Falls County, Idaho): (1) USGS Cenozoic Locality 19217; and (2) Locality 20765. Study of this additional material contributes to the understanding of variation in the species due to age and individual differences.

Five complete lower dentitions were found. The occlusal length of  $M_1$ - $M_3$  is 7.0, 7.0, 7.1, 7.2, and 7.3 mm. Forty-four parts of lower jaws containing  $M_1$  to  $M_2$  were studied. The occlusal length of  $M_1$ - $M_2$  varied from 5.0 to 5.8 mm.; the average is 5.29 mm. Seventy-four first lower molars were examined. Twenty-eight had a shallow pit on the anterior loop (Fig. 2D). Two molars were from young specimens that lacked both the pit and "prism fold." The pit soon disappears with wear. An immature  $RM_1$  (Fig. 2C) shows the development of the pit from the third outer re-entrant angle. The "prism fold" of Hinton (1926, p. 111) is retained longer than the pit but it disappears in teeth due to wear (Figs. 2 A-B). The "prism fold" or evidence of it was present on 51 of the first lower molars.

The posterior end of the lower incisor ends above the dental foramen in a well-developed capsular process on the labial side of the jaw. The dorsal surface of the process is separated from the condylar process by a distinct groove (Figs. 2 A-B).

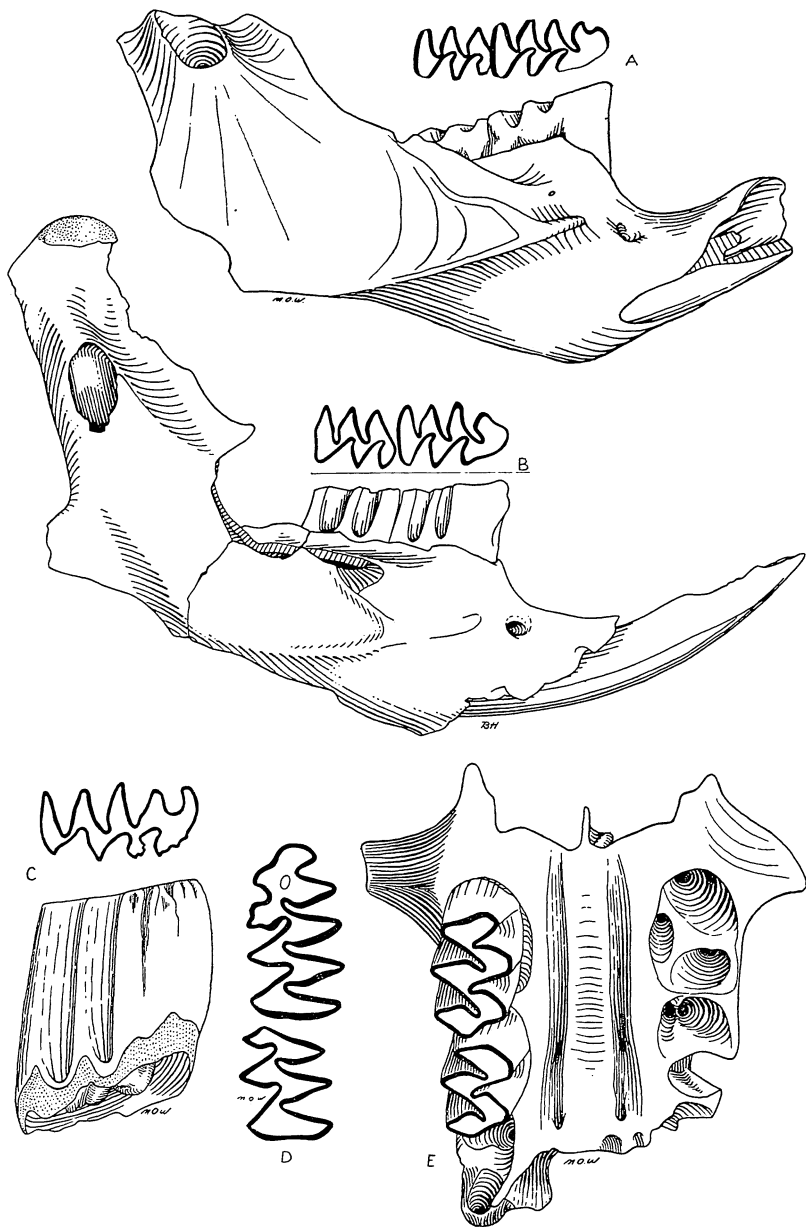


FIG. 2. *Mimomys (Cosomys) primus*: A, UMMP 34438 and B, USNM 21869, right jaws, M<sub>1</sub>-M<sub>2</sub>, labial and occlusal views, × 10; C, UMMP 34204, immature RM<sub>1</sub>, labial and occlusal views, × 8; D, USNM 21870, left M<sub>1</sub>-M<sub>2</sub>, occlusal view, × 8; E, USNM 21868, palatal view, × 6.

Numerous isolated upper molars were examined. All upper first molars have three well-developed roots except one in which the anterior root is very broad and shows evidence of the fusion of two roots.  $M^2$  is three-rooted and  $M^3$  two-rooted. There is no evidence of cement on any of the teeth. Part of a palate, No. 21868 USNM, with  $RM^1$  and  $M^2$  was taken at Locality 20765 (Fig. 2E). The palate terminates more posteriorly than in *Ogmodontomys* and *Pliophenacomys*. It ends opposite the posterior edge of the anterior root of  $M^3$ . In the succeeding genera the palate ends approximately at the posterior border of  $M^2$ . The most posterior palatine foramina open into the posterolateral pits.

Dwight W. Taylor and Harold E. Malde collected a number of isolated teeth of this vole, November 11, 1956, in Elmore County, Idaho, at USGS Cenozoic Locality 20767. The fossils were taken from an olive drab, medium to coarse grained sand resting on a cinder bed at an elevation of 3,165 feet. Taken in association with these vole teeth were fragments of fish, a frog or toad vertebra, a bird vertebra, a fragment of a large shrew jaw, and part of a left lower jaw of *Canimartes?* cf. *cookii* (Gazin) with  $M_1$  (see Gazin, 1934a and 1937).

*Associated forms.*—At Locality 20765 *Mimomys (Cosomys) primus* was found with *Blarina gidleyi* Gazin, *Pliopotamys minor* (Wilson), *Mustela gazini* Hibbard (1958d), *Peromyscus?*, rabbit, gopher, swan, cormorant, *Kinosternon*, *Chrysemys* or *Pseudemys*, catfish, and *Lithoglyphus*. At Locality 19217 *Mimomys primus* occurred with *Blarina gidleyi* Gazin, *Pliopotamys minor* (Wilson), *Chrysemys* or *Pseudemys*, *Gonidea*, *Sphaerium*, *Valvata humeralis* Say, and *Lithoglyphus*. For other members of the Hagerman local fauna see Gazin, 1936.

*Discussion.*—Although *Mimomys (Cosomys) primus* is known from only a few localities, nevertheless there is a suggestion that it did not live in the Hagerman area during all of the time in which the Hagerman formation was being deposited. Two sites in the uppermost Hagerman formation have been reasonably well sampled: the horse quarry (elevation, 3,290–3,300 feet) and Locality 19216 (elevation, 3,295 feet). *Mimomys (C.) primus* has not been found at either of these localities but has been found at several stratigraphically lower. At Locality 19216 a smaller vole, *Nebraskomys?* *taylori* Hibbard, sp. nov., occurs instead of *Mimomys*. In considering

these occurrences one must bear in mind that they are all in one depositional unit, without intervening unconformities or lithologic changes. I have no explanation for the absence of this vole and the occurrence of another in the uppermost Hagerman formation except environmental change or ecologic replacement or both. It may be entirely due to a local environmental condition. For example, after twenty years of collecting of the Rexroad local fauna at Locality 3 in Meade County, Kansas, only the remains of *Ogmodontomys* have been found at this site. At the Fox Canyon site in Meade County, parts of 1,560 individuals of *Pliophenacomys* have been recovered in comparison to 114 of *Ogmodontomys*. This count is based on the number of left  $M_1$ 's recovered. The difference in the Rexroad fauna at these two sites appears to be caused by dissimilar local environmental conditions.

I have followed Wilson in considering *Cosomys* as a subgenus of *Mimomys*. The genus *Mimomys* has been used in Europe in the broadest sense to include numerous medium-sized voles with different stages of root development of the teeth, with presence or absence of cement, and with highly specialized pit development of the teeth. The genus as so used is not comparable to genera of recent microtines. A refinement of the usage of the genus *Mimomys* in Europe would help greatly in the stratigraphic study of faunas in that region and would aid in the correlation of faunas between North America and Europe.

*Nebraskomys? taylori* Hibbard sp. nov.

(Figs. 3 A-C)

*Holotype*.—No. 21832 USNM, part of a right lower jaw with incisor,  $M_1$ – $M_3$ . Collected by Dwight W. Taylor in 1955.

*Paratypes*.—No. 21833 USNM is part of a right lower jaw with incisor,  $M_1$  and  $M_2$ ; No. 21871 USNM is assigned to parts of two left lower jaws containing the incisor and  $M_1$ , and to part of a left lower jaw containing the incisor and  $M_2$ . No. 33903 UMMP is a nearly perfect left lower jaw with incisor,  $M_1$  and  $M_2$ ; and No. 34827 UMMP is part of a right lower jaw with incisor and  $M_2$ . Collected in 1956 by Claude W. Hibbard.

*Horizon and type locality*.—Near the top of the Hagerman formation; Hagerman local fauna, early Pleistocene, tentatively considered as Aftonian. USGS Genozoic Locality 19216, NE.  $\frac{1}{4}$  Sec.

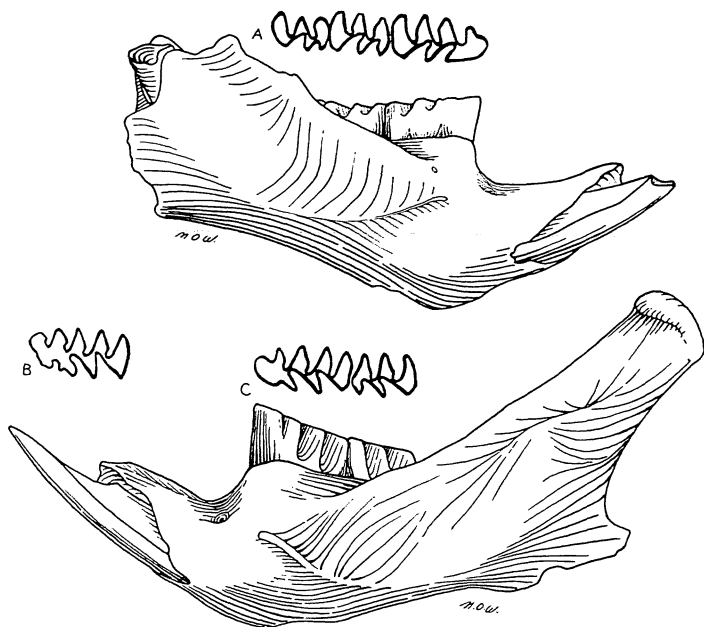


FIG. 3. *Nebraskomys? taylori*, sp. nov.; A, USNM 21832, holotype, right jaw,  $M_1$ - $M_3$ , labial and occlusal views; B, USNM 21871, paratype, left  $M_1$ , occlusal view; C, UMMP 33903, paratype, left jaw,  $M_1$ - $M_2$ , labial and occlusal views. All  $\times 5$ .

20, T. 7 S., R. 13 E., Twin Falls County, Idaho; Hagerman quadrangle; 1,000 feet W. and 700 feet S. of NE. corner. Fossils from micaceous, cross-bedded, gray, fine sand on ridge at elevation 3,295 feet. This species is only known from the type locality.

*Diagnosis.*—*Nebraskomys? taylori* is a vole with rooted molars which lack cement.  $M_1$  consists of a posterior loop, three alternating closed triangles, and a complicated anterior loop. It is larger than *N. mcgrewi* Hibbard and smaller than *Mimomys (Cosomys) primus* (Wilson). The capsular process for the reception of the incisor is poorly developed.

*Description of holotype.*—The right lower jaw is that of an adult. It is broken at the ventral border of the dental foramen. The lower incisor is narrower than that of *Mimomys (Cosomys) primus* and broader than that of *Nebraskomys mcgrewi*. It passes from the lingual side to the labial side of the jaw beneath the posterior root of

M<sub>2</sub>. There is no pit between M<sub>3</sub> and the ascending ramus. The mental foramen is situated high on the side of the jaw (Fig. 3A) but more anteriorly than in *N. mcgrewi*.

M<sub>1</sub> consists of a closed posterior loop, three alternating closed triangles, and a large anterior loop. There is no evidence of a "prism fold." The re-entrant angles are broad, and the apex of each angle is not as constricted or directed as sharply anteriorly as in *Mimomys (C.) primus*. The enamel thins slightly in the apex of the re-entrant angles of M<sub>1</sub> and M<sub>2</sub>.

M<sub>2</sub> has a closed posterior loop and four alternating triangles. The first and second are closed, and the third and fourth are confluent.

M<sub>3</sub> has a closed posterior loop which is more rounded on the lingual side than (observed) in *Mimomys (C.) primus* of a comparable stage of wear. The first and second alternating triangles are connected by a narrow tract of dentine. The second lingual or third alternating triangle is closed off from the anterior loop. The apex of each re-entrant angle of M<sub>3</sub> is not directed as strongly forward as in *M. (C.) primus*. The lower molars are two-rooted. The occlusal length of M<sub>1</sub>-M<sub>3</sub> is 5.75 mm. The occlusal length of M<sub>1</sub> is 2.5 mm., and the greatest width is 1.25 mm. The occlusal length of M<sub>2</sub> is 1.75 mm. and of M<sub>3</sub>, 1.5 mm. The occlusal length of M<sub>1</sub> of the holotype of *Nebraskomys mcgrewi* is 2.25 mm.

This species is named for Dwight W. Taylor.

*Description of paratypes.*—No. 21833 USNM is part of a right lower jaw of an adult specimen but younger than that of the holotype. The pattern of M<sub>1</sub> and M<sub>2</sub> agrees with that of the holotype. The occlusal length of M<sub>1</sub> and M<sub>2</sub> is 4.25 mm. The occlusal length of M<sub>1</sub> is 2.5 mm. No. 21871 USNM consists of parts of three right lower jaws, one containing M<sub>2</sub>, and the others, M<sub>1</sub>. The occlusal pattern of these teeth, except one M<sub>1</sub>, agrees with that of the holotype, and of paratype No. 21833. One M<sub>1</sub> (Fig. 3B) of an adult individual with age wear comparable to paratype No. 21833, has a very shallow "prism fold." The other paratype with only M<sub>1</sub> is that of a young adult. There is no evidence of the "fold" or a pit on the anterior loop of M<sub>1</sub>. Paratype No. 33903 UMMP is that of an adult with a nearly perfect lower jaw (Fig. 3C). Only M<sub>1</sub> and M<sub>2</sub> are present. They are in a young adult stage of wear. The occlusal pattern is like that of specimen No. 21833 USNM. There is no evidence of a "prism fold." In teeth with comparable stage of wear

of *Mimomys (Cosomys) primus* the "prism fold" is present in nearly all specimens.

In specimen No. 33903 UMMP the incisor extends slightly dorsal to the dental foramen but not as high as in *Mimomys (C.) primus*. Furthermore, the capsular process is not as well developed as in *M. (C.) primus* (see Figs. 2A and B). The capsular process is poorly developed as in *Ogmodontomys poaphagus* Hibbard and *Pliophenacomys primaevus* Hibbard. The condyle of the lower jaw of *M. (C.) primus* above the capsular process for the reception of the incisor is more lingually inflected than that of *Nebraskomys? taylora*.

Two isolated upper first molars were found. Both have three roots; the middle or lingual root is not as well developed for the size of the tooth as is the lingual root of  $M_1$  in *Mimomys (Cosomys) primus*.

In the Museum of Paleontology, University of California, is part of a right lower jaw, with the incisor and  $M_2$ , No. 45063, of this rodent from the type locality. The size and pattern of  $M_2$  is like that of the type and paratypes.

*Associated forms.*—The following were associated with *Nebraskomys? taylora*: *Blarina gidleyi* Gazin; *Thomomys gidleyi* Wilson; *Alilepus? vagus* Gazin; and *Pliopotamys minor* (Wilson).

*Discussion.*—I consider *Nebraskomys? taylora* distinct from the genus *Mimomys* for the following reasons: (1) the "prism fold" of  $M_1$  is not a common character; (2) the anterior loop of  $M_1$  lacks the pit or enamel islet; (3) the re-entrant angles of  $M_1$  and  $M_2$  are broad and not directed as strongly forward; (4) the capsular process for the reception of the incisor is poorly developed; and (5) the condyle of the lower jaw is not greatly deflected lingually.

The vole is questionably referred to the genus *Nebraskomys* which occurs in the Sand Draw local fauna of late Nebraskan age (McGrew, 1944; Taylor, 1954; Hibbard, 1957). Skull or palate with teeth, as well as immature dentitions, are needed of both the Hagerman form and *N. mcgrewi* before their true relationship to other Cenozoic voles is known.

*Pliophenacomys idahoensis* Hibbard sp. nov.

(Figs. 4 A-I)

*Holotype.*—No. 21872, USNM a right  $M_1$ . Collected by Dwight W. Taylor in 1956.

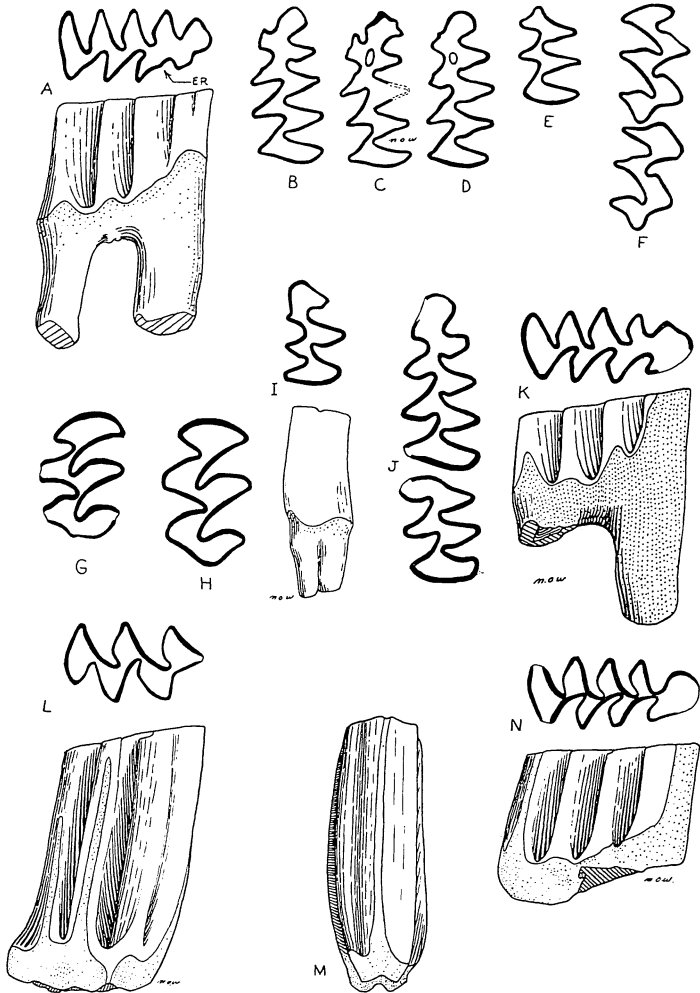


FIG. 4. *Pliophenacomys* and *Pliomys*: A, *Pliophenacomys idahoensis*, sp. nov., holotype, USNM 21872, right  $M_1$ , labial and occlusal views; er = enamel ridge. B-I, *P. idahoensis*, sp. nov., paratypes; B-D, USNM 21873, three left  $M_1$ 's, occlusal views. E, USNM 21874, left  $M_2$ , occlusal view. F, USNM 21876, right  $M_1$  and  $M_2$ , occlusal view. G and H, USNM 21874, left  $M_1$ 's, occlusal view. I, USNM 21875, left  $M_3$ , anterior and occlusal views. J and K, *P. parvus* (Wilson), USNM 21877; J, left  $M_1$  and  $M_2$ , occlusal view. K, right  $M_1$ , labial and occlusal views. L-N, *Pliomys episcopalis bolkayi*, UMMP 34901; L, left  $M_1$ , lingual and occlusal views; M, left  $M_1$ , posterior view. N, right  $M_1$ , labial and occlusal views. All  $\times 8$ .



*Paratypes*.—No. 21873 USNM includes three left  $M_1$ 's of young adult and adult specimens; No. 21874 USNM includes two upper left first molars and a left  $M_2$ ; No. 21875 USNM is two  $M^3$ 's; and 21876 USNM is part of a right maxillary with  $M^1$  and  $M^2$ . Collected in 1956 by Dwight W. Taylor, Harold E. Malde, and Claude W. Hibbard.

*Horizon and type locality*.—Late Pliocene, USGS Cenozoic Locality 19128, S.  $\frac{1}{2}$  SW.  $\frac{1}{4}$  Sec. 1, T. 6 S., R. 8 E., Owyhee County, Idaho; Hammett quadrangle; 1,550 feet E. and 650–1,050 feet N. of the SW. corner of Sec. 1; elevation, 2,600 feet. The formation is unnamed.

*Diagnosis*.—A small vole slightly smaller than *Pliophenacomys primaevus* Hibbard and distinguished from the latter by narrower re-entrant angles of  $M_1$ . The apexes of these angles are slightly constricted and are directed more strongly anteriorly. *Pliophenacomys idahoensis* is smaller than *P. parvus* (Wilson) and *P. meadensis* Hibbard.  $M_1$  of *P. idahoensis* has a small enamel ridge along the anterior face of the second outer (labial) triangle; a vestigial sixth alternating triangle (third labial triangle) forms part of the anterior loop. Its apex (labial edge) is flattened and not pointed as in *P. primaevus*.

*Description of holotype*.—No. 21872 USNM is an isolated right  $M_1$  of an adult individual. The two roots are well developed.  $M_1$  consists of a posterior loop, five alternating triangles, and an anterior loop. A thin tract of dentine connects the posterior loop and the first three alternating triangles. The fourth and fifth triangles are confluent and open widely into the anterior loop (Fig. 4A). A narrow enamel ridge occurs on the anterior face of the second outer triangle. It extends to the base of the re-entrant angle. The flattened apex of the sixth triangle on the labial side of the anterior loop is well developed. The development of the enamel ridge along the anterior face of the second labial triangle has been observed in only one other specimen of *Pliophenacomys* studied. This was on No. 32051d UMMP, an isolated right  $M_1$  of *P. meadensis* from the Dixon local fauna of Kansas. This  $M_1$  also had the flat apex of the sixth triangle (see Hibbard, 1956, fig. 6D).

The lingual re-entrant angles of  $M_1$  are narrower than those of *Pliophenacomys primaevus*. There is a tendency for a slight constriction (narrowing) near the apex. The first lingual re-entrant

angle swings slightly forward. The second and third lingual re-entrant angles swing more sharply forward as in *P. meadensis* and *P. parvus*.

The enamel on the anterior loop of  $M_1$  extends downward on a level with the base of the anterior re-entrant angles as in *Pliophenacomys primaevus* and *P. meadensis*. The enamel on the anterolabial side of the anterior loop in *P. parvus* extends well above the base of the anterior re-entrant angles. In wear the anterior loop of *P. parvus* presents an interrupted enamel pattern before the tooth is worn down to the base of the crown. *Pliophenacomys idahoensis* has shorter crowned molars than *P. parvus* and *P. meadensis*.

The occlusal length of  $M_1$  is 2.5 mm. The greatest occlusal width is 1.25 mm.

*Descriptions of paratypes.*—No. 21873 USNM is a left  $M_1$ , with an occlusal length of 2.5 mm. The tooth is from a slightly younger vole than the holotype although the occlusal pattern is the same (Fig. 4B). The other two left first lower molars are from younger animals. Their occlusal lengths are 2.5 and 2.6 mm. The occlusal pattern is like that of the other two molars except that there is a very shallow enamel pit (Figs. 4 C–D) between the apexes of the fourth lingual and third labial re-entrant angles. Whether this is a common character in young specimens of this species is unknown. It is the first time I have even seen an enamel pit developed in relation to the anterior loop of  $M_1$  in *Pliophenacomys*.

$M_2$ , No. 21874 USNM, is two-rooted and consists of a posterior loop, two alternating triangles, and an anterior loop (Fig. 4E). No isolated lower third molars were found. In the collection is part of a badly eroded left lower jaw. It contains the two roots of  $M_1$ ,  $M_2$ , which is worn down to the base of the crown, and the alveoli of  $M_3$ , which show that it was two-rooted.

Three isolated upper first molars were taken. All have three well-developed roots. The occlusal length of these teeth are 2.2, 2.2, and 2.3 mm. (Figs. G–H). Figure G is the occlusal view of the tooth of an old adult that has worn down to the base of the crown.

Two isolated upper third molars, No. 21875 USNM, are in the collection. The occlusal pattern (Fig. 4I) is more similar to *Pliophenacomys meadensis* than to that of *P. primaevus*. All teeth are without cement.

Part of a right maxillary, 21876 USNM, of an immature individual containing M<sup>1</sup> and M<sup>2</sup> (Fig. 4F) was recovered at USGS Locality 19129, stratigraphically about 100 feet higher than the type locality. In this specimen M<sup>1</sup> is three-rooted, M<sup>2</sup> has the two anterior roots fused. The fusion is well defined by a deep groove along the anterior face of the root. One other isolated M<sup>2</sup> was found. The two most anterior roots were also fused, and a groove is developed along the anterior surface of the root. This is a more advanced character than found in *Pliophenacomys primaevus* where M<sup>2</sup> possesses three well-developed roots.

*Sand Point local fauna.*—The term Sand Point local fauna is applied here to the fossils from USGS Locality 19128, SW. ¼ Sec. 1, T. 6 S., R. 8 E., Owyhee Co., Idaho. The site is southeast of the town of Hammett, on the south side of the Snake River by Wilson Grade. The “promontory” is locally called Sand Point; whence the name.

Fossils from one other locality, USGS 19129, are referred to the Sand Point local fauna at this time. Locality 19129 is on Sand Point also, but 100 feet topographically and stratigraphically higher. Dwight W. Taylor has furnished the partial list of mollusks from the Sand Point local fauna.

Locality 19128 has yielded a number of mammals, as well as many fishes and mollusks:

MAMMALIA

*Hypolaqus*  
*Pliophenacomys idahoensis* Hibbard  
 sp. nov.  
*Pliopotamys*  
*Thomomys*  
*Plesippus*  
*mastodont*

*Fluminicola weaveri* Yen  
*Bithynia campbelli* (Dall)  
*Pyrgulopsis carinata* Yen  
*Ceriphasia taylora* (Gabb)  
*Ceriphasia* n. sp.  
*Lymnaea* cf. *stagnalis* (Linné)  
*Payetia dallii* (White)  
*Anisus pattersoni* (Baker)  
*Gyraulus parvus* (Say)  
*Gyraulus (Idahoella) multicarinatus*  
 (Yen)  
*Promenetus umbilicatellus* (Cockerell)  
*Ancylus*  
*Orygoceras arcuatum* Dall  
*Hawaiiia minuscula* (Binney)

MOLLUSCA

*Sphaerium idahoense* Meek  
*Valvata humeralis* Say  
*Lithoglyphus occidentalis* (Hall)  
*Lithoglyphus superbus* (Yen)  
*Lithoglyphus* n. sp.

Locality 19129 has yielded only one mammal, but a number of mollusks and fishes.

## MAMMALIA

*Pliophenacomys idahoensis* Hibbard,  
sp. nov.

*Lithoglyphus occidentalis* (Hall)

*Lithoglyphus superbus* Yen

*Pliopholyx* n. sp.

*Ceriphasia taylora* (Gabb)

*Payettia dallii* (White)

## MOLLUSCA

*Gonidea coalingensis* Arnold

*Valvata humeralis* Say

*Amnicola bithynoides* Yen

*Fluminicola weaveri* Yen

*Gyraulus (Idahoella) multicarinatus*  
(Yen)

*Vorticifex* n. sp.

*Ancylus*

*Orygoceras arcuatum* Dall

*Age of the Sand Point local fauna.*—The Sand Point local fauna is probably of latest Pliocene age and seems to be younger than the Rexroad local fauna of Kansas, for the following reasons:

1. *Pliophenacomys idahoensis* is more advanced than *P. primaevus* of the Rexroad local fauna, but less advanced than *P. parvus* of the Grand View local fauna. Unfortunately, no *Pliophenacomys* is known from the Hagerman local fauna.

2. *Pliopotamys* is not known from the Rexroad or the Saw Rock Canyon faunas on the Plains, but appears first in early Pleistocene assemblages. This may be entirely a case of faunal lag if *Pliopotamys* is a northern element that did not reach the southern Plains until a southward shift of the northern fauna during the beginning of the Pleistocene. There are other northern elements that did not reach the southern Plains region until the early Pleistocene, such as *Anisus pattersoni* (Baker), which is known from the Middle Pliocene Teewinot formation, Jackson Hole, Wyoming, and from the late Pliocene Sand Point local fauna. The earliest records of its occurrence in Plains faunas are in the early Pleistocene Sand Draw local fauna of Nebraska and the Dixon local fauna of Kansas. In both of these faunas this mollusk is associated with *Pliopotamys*.

3. The mollusks of the Sand Point local fauna include many extinct species and genera not found in the overlying Hagerman formation. The magnitude of the faunal break is most reasonably explained by postulating the extinction of these groups by changes associated with the beginning of widespread glaciation.

4. Although superposition of the containing stratigraphic units shows that the Hagerman local fauna is younger than the Sand

Point local fauna, the argument may be presented that the differences are only in environments affecting the mollusks, and there may be no significant hiatus between the assemblages. There is, however, sufficient overlap between the types of facies represented that Taylor believes such an explanation inadequate. Furthermore, occurrence in the Sand Point local fauna of a distinct *Pliophenacomys* is suggestive of a definite stratigraphic break. More mammals from the older assemblage will probably help resolve the matter.

5. *Plesippus* certainly does not indicate a necessarily Pleistocene age, if that epoch be defined by the beginning of continental glaciation. In southwestern Kansas, where knowledge of Pliocene and Pleistocene faunal and stratigraphic sequence is more detailed than elsewhere in North America, *Plesippus* is found in three superposed stratigraphic units. The oldest unit, the Rexroad formation, contains three fossil assemblages of markedly Pliocene appearance, both by the relationships of many members of the faunas and by the environmental implications of these assemblages. In the overlying Ballard (Hibbard, 1958a) and Crooked Creek formations the fossils compose markedly different assemblages. They show appearance of many new types of animals and lack great numbers of the Rexroad formation forms. Environmental interpretation of these faunas suggests strongly a marked cooling of the climate, most reasonably correlated with continental glaciation. *Plesippus* is found throughout the two older formations and in the Stump Arroyo member of the Crooked Creek formation (Hibbard, 1949), but the associated small mammals, amphibians, reptiles, and mollusks agree in providing evidence of a sharp faunal break (Hibbard, 1958c; Taylor, in press; Tihen, 1955).

Farther south in the High Plains also, there is another occurrence of *Plesippus* probably of late Pliocene age. At a locality southwest of Channing, Texas (described by Taylor, in press), *Plesippus* is associated with a fauna similar to the Rexroad local fauna. The stratigraphic sequence has not been studied as yet, but the fauna as a whole is in marked contrast to known early Pleistocene assemblages in Texas, Oklahoma, and Kansas.

The Benson local fauna of Arizona includes a horse of the genus *Plesippus* (Gazin, 1942, p. 495). Here, too, other mammals in the fauna suggest a Pliocene age. Savage (1955) has indicated the differences found in *Stegomastodon*, where less advanced types are found

in the Rexroad and Benson local faunas and more advanced kinds in known early Pleistocene assemblages. A gopher in the Benson fauna is most closely related to one of the Rexroad local fauna (Hibbard, 1950, p. 138).

There are other localities for *Plesippus* in North America, such as some in California that are considered as late Pliocene (Woodring, 1952). What I want to emphasize is that the Sand Point *Plesippus* is far from being the only occurrence for which the evidence favors a Pliocene age; and that if *Plesippus* is taken as indicating Pleistocene age a good deal of opposing evidence from various sources is subordinated to one "index fossil."

*Pliophenacomys parvus* (Wilson)

(Figs. 4 J-K)

*Mimomys?* *parvus* Wilson, 1933, Carnegie Inst. Wash. pub., No. 440: 128-132, figs. 5 and 6.

*Pliophenacomys parvus* (Wilson); Hibbard, 1950, Univ. Mich. Mus. Pal., Contrib., 8(6): 155-157.

*Pliomys parvus* (Wilson) *non* Hibbard; Kretzoi, 1955, Acta Geol., 3 (4): 354.

A member of the Grand View local fauna, *Pliophenacomys parvus* is so far only known from the type locality (USGS 20764). This locality is in the NE.  $\frac{1}{4}$  Sec. 15, T. 4 S., R. 2 E., on the southeast side of Jackass Butte, Owyhee County, Idaho. This vole seems to be the most common species at this locality, judging by the recent collections made by Taylor and me.

*Pliophenacomys parvus* is distinguished from *P. meadensis* by its smaller size, slightly narrower molars with thinner enamel walls and by narrower re-entrant angles of the molars. The enamel is uniform in thickness. *Pliophenacomys parvus* is more advanced than *P. meadensis*, as shown by the loss of enamel on the anterior loop of  $M_1$ . The dentine on the anterolabial side of the anterior loop extends well above the base of the anterior re-entrant angle. With wear the anterior loop of  $M_1$  in *P. parvus* presents an interrupted enamel pattern before the tooth is worn down to the base of the crown (Figs. 4 J-K). In *P. meadensis* there is no encroachment of the dentine on the anterior loop of  $M_1$ . The enamel extends downward to a level with the bases of the anterior re-entrant angles.

Among the specimens recovered of *Pliophenacomys parvus* is part of a left lower jaw, No. 21877 USNM, with the incisor,  $M_1$  and

M<sub>2</sub> (Fig. 4J). The occlusal length of M<sub>1</sub> and M<sub>2</sub> is 4.75 mm. In the group of isolated teeth there are six first lower molars. They range in occlusal length from 2.5 to 2.8 mm., with an average of 2.6 mm. Root development in the molars is larger on *P. meadensis* than on *P. parvus*. M<sup>1</sup> is three-rooted with the inner root greatly reduced. M<sup>2</sup> and M<sup>3</sup> are two-rooted.

No cement is present on the molars of *Pliophenacomys parvus*. Its absence cannot be due to accidents of preservation, for the associated teeth of *Synaptomys* and *Ondatra* retain cement in the re-entrant angles of the molars.

*Associated forms.*—Directly associated with *Pliophenacomys parvus* were *Synaptomys vetus* Wilson and *Ondatra idahoensis* Wilson. In the immediate vicinity of this site (about fifty feet west and within five feet stratigraphically) I collected two larger mammals. A partial horse dentition represents a large zebra, tentatively identified as *Plesippus idahoensis* (Merriam). Part of a large antler is identified as *Cervus* cf. *lucasi* Hay.

*Discussion.*—I have examined isolated teeth of *Pliomys episcopalis bolkayi* Kormos from Podumci, Dalmatia, Yugoslavia, which were identified as *Dolomys episcopalis bolkayi* Kormos by Dr. Kowalski. The specimens were taken from deposits of Mindel age. The subspecies *bolkayi* is said to differ only from *Pliomys e. episcopalis* in its slightly larger size and higher crowned teeth.

In comparison with *Pliophenacomys parvus* the teeth of *P. e. bolkayi* are much higher crowned; root development occurs only in adult and old adult specimens (Fig. 4N). No cement is present in the re-entrant angles. The alternating triangles of the lower molars are more tightly closed than in *P. parvus* and especially the fifth alternating triangle of M<sub>1</sub>, which is tightly closed off from the anterior loop in young adult specimens and remains so in old adult specimens. The fourth alternating triangle of M<sub>2</sub> is closed off from the third whereas in *Pliophenacomys* the third and fourth triangles of M<sub>2</sub> are confluent. The striking difference is the much higher crowned teeth of *P. e. bolkayi*, which have an advanced interrupted enamel pattern and have the enamel of the lower molars differentiated into thick and thin tracts as in the genus *Microtus*.

In young adult specimens of *P. e. bolkayi* the dentine tract on the anterolabial side of the anterior loop of M<sub>1</sub> extends upward 2.5 mm. above the base of the crown. There is a dentine tract the full length

of the labial edge of the posterior loop of  $M_1$ , but the dentine tract on the lingual edge of the posterior loop of  $M_1$  lacks 1.0 mm. of reaching the occlusal surface.  $M_2$  in young adult specimens has a dentine tract along the anterior face of the fourth alternating triangle where it joins  $M_1$ . This dentine tract in young specimens ends just short of the occlusal surface and with little wear produces an interrupted enamel pattern. There are both labial and lingual dentine tracts on the sides of the posterior loop. The labial tract is approximately three-fourths the crown length, and the lingual tract of dentine is two-thirds the crown length in young adult teeth.  $M_3$  possesses the same dentine tracts as  $M_2$ . In these teeth the base of the crown has started to close, but roots have not developed.  $M_2$  is decidedly curved labially as in *Microtus*, a marked contrast to the straight crowned  $M_2$  of *Pliophenacomys parvus*.

An  $LM^1$  of a young adult, specimen No. 34901 UMMP (Fig. 4 *L-M*), lacking roots and with a crown height of 4.0 mm., has a dentine tract along both the labial and lingual edges of the anterior loop which lacks 1.0 mm. of reaching the occlusal surface. The first lingual triangle has a longer dentine tract, which reaches within 0.5 mm. of the occlusal surface. A dentine tract extends the full length of the fourth or posterior triangle where it joins the anterior surface of  $M^2$ .

I consider *Pliomys episcopalis balkayi* Kormos generically distinct from *Pliophenacomys parvus* because the teeth are much higher crowned, the roots of the teeth are greatly reduced, the occlusal pattern of the teeth have an advanced interrupted enamel pattern with differentiated enamel along the faces of the alternating triangles, and  $M_2$  is strongly curved. *Pliomys episcopalis balkayi* is the first of the rooted microtines I have studied that possesses characters that show some relationship to the genus *Microtus*. It is too young to be considered the ancestral stock, but it is probably closely related to the line that gave rise to the genus *Microtus*.

On account of the absence of cement in the re-entrant angles, I agree with Kretzoi that it is distinct from the recent *Dolomys bogdanovi* Martino, which possesses both an interrupted enamel pattern and cement in the re-entrant angles of the teeth. Kretzoi has placed the recent forms in the genus *Dinaromys*. I have examined teeth of *Dolomys dalmatinus* Kormos from Podumci, Dalmatia, Yugoslavia, of Mindel age, which were identified by Dr. Kowalski.



These specimens possess better developed roots than *Pliomys e. bolkayi*, but the teeth have an interrupted enamel pattern which is as advanced. Cement is present in the re-entrant angles of old adult teeth. I consider this form generically distinct from *Pliomys* and also from *Dolomys milleri* (Nehring), which lacks cement on the teeth. There is one question: does *D. milleri* possess an interrupted enamel pattern in adult and old adult specimens?

Since its true relationship to Eurasian forms is unknown, I have retained *Pliophenacomys parvus* Wilson tentatively in the genus *Pliophenacomys*, to which it is closely related.

*Pliopotamys* sp.

(Figs. 5 A-B)

A palate and isolated teeth of *Pliopotamys* were taken in association with the remains of *Pliophenacomys idahoensis* and other forms from USGS Locality 19128, Owyhee County, Idaho. They are the earliest record of *Pliopotamys* in North America.

*Description of specimens recovered.*—Four lower first molars show a posterior loop and five alternating triangles. The fifth triangle opens broadly into the anterior loop. Specimen No. 21827 USNM

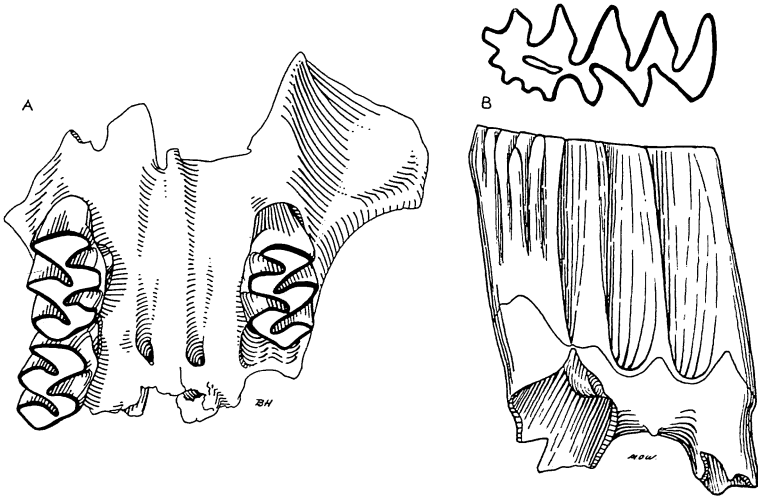


FIG. 5. *Pliopotamys* sp. A, USNM 21831, palatal view,  $\times 4$ ; B, USNM 21827, LM<sub>1</sub>, labial and occlusal views,  $\times 8$ .

(Fig. 5B) is a left  $M_1$  of a young animal. Its occlusal length is 4.0 mm. In size it corresponds to *Pliopotamys minor*, but the re-entrant angles are broader. The isolated first lower molars have longer roots than those of *P. minor*, with the same stage of wear. An  $M_1$  of an old adult has an anteroposterior occlusal length of 4.15 mm.

Five upper first molars were found. Those of old adults possess larger roots than occur on  $M^1$  of *Pliopotamys minor* from the Hagerman local fauna. The largest  $M^1$  has an anteroposterior occlusal length of 3.2 mm. and a transverse width of 2.5 mm.

A single  $M^3$  was found. It consists of an anterior loop, three alternating triangles, and a posterior loop, which is broken. The two anterior roots are fused, a condition not observed in *Pliopotamys minor* or *P. meadensis*.

The palate, No. 21831 USNM, is broken just posterior to  $M^2$  (Fig. 5A). It contains the right and left upper first molars and  $RM^2$ . The occlusal length of  $M^1$  and  $M^2$  is 6.75 mm. The occlusal length of  $M^1$  is 3.5 mm. and the width is 2.5 mm. The occlusal patterns of  $M^1$  and  $M^2$  are like those of *Pliopotamys minor*. The lingual side of the first alternating triangle of  $M^1$  is flat. Better material is needed for definite specific assignment of the specimens.

*Pliopotamys minor* (Wilson)

(Figs. 6 A-F)

*Ondatra idahoensis minor* Wilson, 1933, Carnegie Inst. Wash. Publ., No. 440: 135.

*Dolomys minor* (Wilson) non Hibbard; Kretzoi, 1955, Acta Geol., 3(4): 348-355.

*Pliopotamys idahoensis* (Wilson), Hibbard, 1956, Pap. Mich. Acad. Sci., Arts, and Letters, 41 (1956): 176.

*Pliopotamys idahoensis* (Wilson) Hibbard, in Flint, 1957. Glacial and Pleistocene Geology, Wiley and Sons, p. 461.

The holotype of *Pliopotamys minor* is from the Hagerman formation and was recovered in the vicinity of the horse quarry (N.  $\frac{1}{2}$  NW.  $\frac{1}{4}$  Sec. 16, T. 7 S., R. 13 E., Twin Falls County, Idaho).

Specimens of this vole were recovered by Dwight W. Taylor and myself in the summers of 1955, 1956, and 1957 from the following three localities south of the horse quarry: USGS Cenozoic Localities 19216, 19217, and 20765. At these three localities parts of at least sixteen individuals were found, as shown by the number of left first lower molars recovered. Most of these teeth are in fragmentary

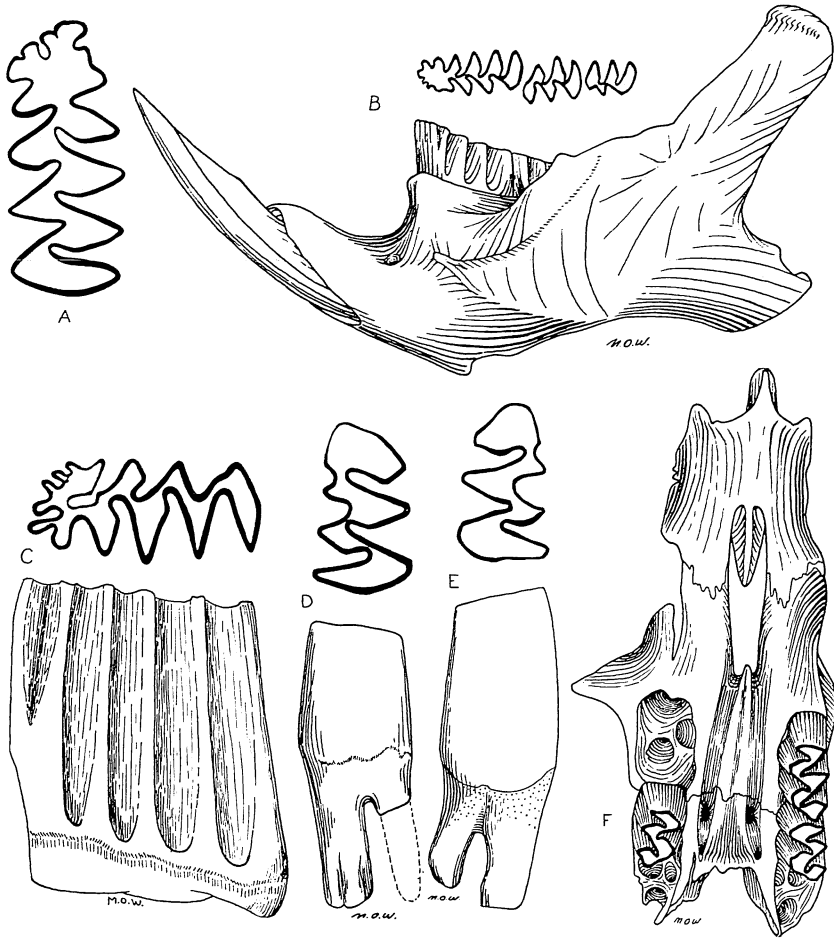


FIG. 6. *Pliopotamys minor*; A, USNM 21830, LM<sub>1</sub>, occlusal view,  $\times 8$ ; B, UMMP 33895, left jaw, labial and occlusal views,  $\times 3$ ; C, UMMP 31421, right immature M<sub>1</sub>, lingual and occlusal views,  $\times 8$ ; D and E, USNM 21829, left and right M<sub>3</sub>, anterior and occlusal views,  $\times 8$ ; F, UMMP 33896, palatal view, RM<sub>2</sub>, LM<sub>1</sub> and M<sub>2</sub>,  $\times 3$ .

jaws. Fragments of maxillaries were also found. No size differences were noted in the individuals from the different localities.

M<sub>1</sub> consists of a posterior loop and five alternating triangles, the fifth opening broadly into the anterior loop. The anterior loop is

decidedly crenulate in young specimens (Figs. 6 *A* and *C*).  $M_2$  consists of a posterior loop and four alternating triangles, the third and fourth confluent.  $M_3$  consists of a posterior loop, two alternating triangles, and an anterior loop. The second triangle is considerably smaller than the first. In *Ondatra* the labial triangles are not so small in comparison with the lingual triangles as they are in *Pliopotamys*. The lower molars are two-rooted. In old adult specimens a slight depression occurs labial to  $M_3$ , although it is not so pronounced as in adult specimens of *Ondatra*. A deep, broad groove separates the base of  $M_3$  from the angle of the jaw. The condyle of the lower jaw curves slightly lingually but is not so pronounced as in *Ondatra*. There is a slight swelling on the labial side of the jaw which indicates the posterior position of the incisor. The incisor ends just above the upper edge of the dental foramen. Two nearly complete lower jaws found represent young adult individuals. The anteroposterior occlusal length of  $M_1$ - $M_3$  of specimen No. 33895, UMMP, is 9.8 mm. (Fig. 6*B*). The greatest occlusal lengths of  $M_1$ ,  $M_2$ , and  $M_3$  are 4.5, 2.7, and 2.5 mm. The anteroposterior occlusal length of  $M_1$ - $M_3$  of specimen No. 21829 USNM is 9.1 mm. The greatest occlusal lengths of  $M_1$ ,  $M_2$ , and  $M_3$  are 4.1, 2.5, and 2.5 mm. The anteroposterior occlusal length of eighteen other lower first molars measured varies from 4.0 to 4.8 mm., with an average length of 4.21 mm.; molars of four young individuals measured 4.0 mm. The greatest occlusal length of  $M_1$  was 4.8 mm. in an old adult. The narrowest occlusal width of  $M_1$  was 1.8 mm. and the greatest 2.0 mm.

A number of isolated teeth were recovered. All upper molars had three well-developed roots (Figs. 6 *D-E*). Cement is lacking on lower and upper molars.

A nearly complete palate and diastemal region of an adult (No. 33896 UMMP) contains a right  $M^2$ , left  $M^1$  and  $M^2$ , and alveoli of the other missing teeth (Fig. 6*F*). The length from the posterior border of the alveolus of the incisor to the posterior border of the alveoli of  $M_3$  is 22.4 mm. The diastemal length is 12.3 mm. The anterior palatine foramina are 7.4 mm. long. The lateral palatal grooves extend posteriorly from each of the foramen and end in a posterior palatal foramen opposite the anterior loop of  $M^2$ . The posterior edge of the palatine is nearly square and lacks a median posterior process. Posterior palatal pits are lacking. Posterior foramina are present. The lingual border of the maxillary forming

the labial border of the palatal groove is not deflected labially until it passes the anterior roots of  $M^3$  (Fig. 6F).

*Remarks.*—*Pliopotamys minor* (Wilson) is distinguished from *P. meadensis* by the occlusal pattern of  $M_1$ . All occlusal patterns of  $M_1$  in *P. minor* except that of one tooth have the fifth alternating triangle opening broadly into the anterior loop (see fig. 8a, Wilson, 1933). In the occlusal pattern of *P. meadensis* the apex of the third labial re-entrant angle is opposite or nearly opposite the apex of the fourth inner re-entrant angle (see fig. 5A, Hibbard, 1956). In all of the young and adult specimens of *P. meadensis* only one pattern was found like that of *P. minor* (see pl. I, fig. 6, Hibbard, 1938). Considerable variation occurs in the occlusal patterns of old adult specimens as the tooth is worn to the base of the crown.

The genus *Pliopotamys* is distinguished from the genus *Dolomys* Nehring (genotype, *Dolomys milleri* Nehring), by the presence of three well-developed roots on  $M^1$ ,  $M^2$ , and  $M^3$ . *Dolomys milleri* has the third root of  $M^1$  more reduced than in *Pliopotamys*, and  $M^2$  and  $M^3$  are two-rooted (Nehring, 1898; Méhely, 1914; and Hinton, 1926).

Kretzoi (1955) considered *Ondatra idahoensis idahoensis* Wilson and *Ondatra idahoensis minor* Wilson as belonging to the genus *Dolomys*. Kretzoi assumed, as I did (Hibbard, 1956, p. 176), that the two microtines described by Wilson from the Pleistocene of Idaho belong to the same genus. Although *Ondatra idahoensis idahoensis* Wilson is a true muskrat (*Ondatra*), I believe Wilson's other form is generically distinct, i.e., *Pliopotamys minor* (Wilson).

*Ondatra idahoensis* Wilson

(Figs. 7 C–D, F–G)

*Ondatra idahoensis idahoensis* Wilson, 1933, Carnegie Inst. Wash. Publ., No. 440, p. 132.

Only one isolated tooth of this species was found at the rodent site of the Grand View local fauna, Jackass Butte, USGS Cenozoic Locality 20764, Idaho. The following discussion is based principally on the original material in the California Institute of Technology collections.

A good description of this muskrat is given by Wilson (1933). The following comments concern the development of the dentine tracts along the sides of the teeth and the development of the inter-

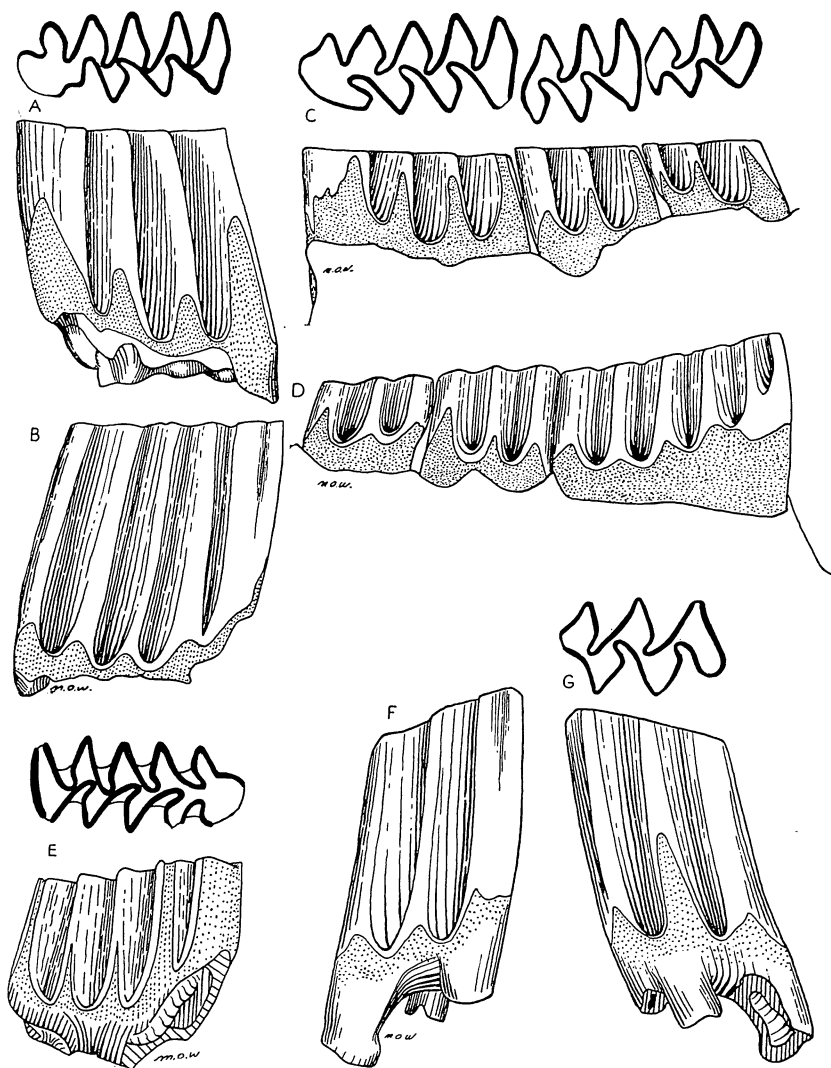


FIG. 7. *Ondatra*; A and B, *Ondatra* sp.; UMMP 32046, LM<sub>1</sub>; A, labial and occlusal views; B, lingual view. C and D, CIT 1376, holotype, *Ondatra idahoensis*; C, left M<sub>1</sub>-M<sub>3</sub>, labial and occlusal views; D, left M<sub>1</sub>-M<sub>3</sub>, lingual view. E, *Ondatra kansasensis*, KUMNH 6662, RM<sub>1</sub>, labial and occlusal views. F and G, *Ondatra idahoensis*, CIT 1377, RM<sub>1</sub>; F, labial view; G, lingual and occlusal views. A-D, F and G,  $\times 6$ ; E,  $\times 5$ .

rupted enamel pattern. The holotype, No. 1376, CIT is part of a left lower jaw of an adult muskrat bearing  $M_1$ - $M_3$ . The antero-posterior occlusal length of the molar series is 10.1 mm. Interstitial cement is poorly developed in the re-entrant angles and occurs in the base of the labial anterior re-entrant angles of  $M_1$ . It is better developed in the lingual re-entrant angles of this tooth, especially at the base and along the sides of the angles, but not so well developed in the deep apex. Cement has not been deposited on the teeth of young specimens, but the dentine tracts are present along the sides of the teeth. Cement occurs on teeth of adult and old adult specimens. The dentine tracts are best developed on the labial side of the lower molars and the lingual side of the upper molars (Figs. 7 C and G). In the holotype the occlusal surface has worn down so that there is an interrupted enamel pattern on the labial side of the posterior loop of  $M_1$  (Fig. 7C). With further wear the anterior loop would have had the enamel interrupted by the dentine. The enamel of  $M_2$  and  $M_3$  would have been first interrupted by the dentine tracts on the labial side of the posterior loops.

*Discussion.*—The dentine tracts on the sides of the teeth of *Ondatra idahoensis* do not appear to be as well developed as those of *O. hiaticidens* (Cope) (see Hibbard, 1955) or of *O. kansasensis* Hibbard (Fig. 7E). There is evidence, however, that some individuals or species of *Ondatra* did not have as well-developed dentine tracts as others. I (1956, p. 177) referred a left lower molar, No. 32046 UMMP, of a young individual from the Borchers local fauna to *Pliopotamys* because of its lack of cement. After comparison of this tooth (Figs. 7 A-B) with the series from the Grand View local fauna, I find that the tooth is that of an immature *Ondatra*, in which the roots or cement were not developed. As is visible in Figure 7B, the dentine tracts are developed on the lingual side as they are in *O. idahoensis*. This may be due to the lack of a well-defined crown and roots. No tooth of comparable age wear is known from the Grand View local fauna which can be used for comparison. The dentine tracts are not as well developed as in *O. kansasensis* of the Kansan age Cudahy fauna of the High Plains. It may well be that some of the early species of *Ondatra* were more progressive in the development of higher dentine tracts along the sides of the teeth than were others. The deposition of cement may also be an age character that varies in early *Ondatra* species.

## MAMMALIA

*Hypolagus furlongi* Gazin, 1934*Castor* cf. *accessor* Hay, 1927*Synaptomys vetus* Wilson, 1933*Ondatra idahoensis* Wilson, 1933*Pliophenacomys parvus* (Wilson) 1933*Erethizon bathygnathum* Wilson, 1935*Felis* cf. *lacustris* Gazin, 1933*Lutra* (*Satherium*) *ingens* Gazin, 1934*Plesippus idahoensis* (Merriam), 1918*Cervus* cf. *lucasi* Hay, 1927

*Grand View local fauna.*—In this discussion I have summarized the Grand View local fauna and reconsidered its age and environmental interpretation. This section is based partly on newly available material and partly on re-evaluation of older information.

The location indicated by Wilson (1933, p. 120) is identifiable as Jackass Butte, Jackass Butte quadrangle, in spite of the lack of precise locality description. N. R. Anderson, College of Puget Sound, Tacoma, Washington, corresponded with Wilson and also attempted to examine the field notebooks of the California Institute of Technology party which originally collected at the Grand View site. The field data could not be found, but Wilson sent what information he recalled to Anderson. The CIT material came primarily from the southern and eastern sides of Jackass Butte, but some is from beds directly across the river. All of the rodent specimens came from a single bed.

This information was the basis for field examination of the area by Anderson and Taylor, and later by Taylor and Hibbard. At least at Jackass Butte, only one sedimentary unit is involved—a series of olive clay interbedded with lighter silt and fine sand. The fine grain size and lenticular bedding suggest deposition by a slow-moving stream aggrading its flood plain. In grain size, color, and bedding, this sequence is strikingly similar to the type Hagerman formation. Certainly most, and probably all, of the original CIT material came from this unit. The later collection of *Ondatra*, *Pliophenacomys*, and *Synaptomys* at USGS Locality 20764 strongly suggests that this is the type locality for the three species described by Wilson. The horse material described by Schultz (1936) apparently came from both Jackass Butte (CIT Locality 119) and north of the Snake River opposite Jackass Butte (CIT Locality 118).

The inferences from the fauna as a whole can be divided into the



types of evidence that suggest the Grand View local fauna is (a) younger than the Hagerman local fauna; (b) of interglacial rather than glacial age; and (c) most probably of Yarmouth age. The detailed consideration of each species follows the more general discussion.

1. Relationship of the Hagerman and Grand View local faunas. All of the paleontologists who have considered the relative age of the Hagerman and Grand View local faunas have concluded that the Grand View local fauna is younger (Wilson, 1937b; Gazin, 1934b, p. 119; 1936, p. 286). This belief, further maintained here, is based on the small percentage of mammals common to the two faunas, on the inferred structural progressiveness of related species in the Grand View local fauna, and on correlation of these two faunas with assemblages in the Great Plains where an age difference is demonstrable.

The mammals of the Hagerman local fauna were listed by Gazin (1936). Comparison of that Hagerman list with the summary of the Grand View assemblage given above shows there are only two species which may be common to both faunas: *Felis lacustris* Gazin and *Castor* cf. *accessor* Hay. The former is a puma-like cat of relatively long geologic range. It is not significant for discrimination of the small time segments concerned here. The beaver *Castor* from the Hagerman local fauna has never been studied in detail, and the necessary careful comparisons between the Hagerman and Grand View material are not available. It is therefore not at all certain that the same species of beaver occurs in both assemblages. Stirton (1935, p. 446) referred to the Hagerman species as *Castor* cf. *californicus* but did not discuss the relationship of *C. accessor* Hay.

A second line of reasoning that suggests that the Grand View local fauna is younger than the Hagerman local fauna is the inferred structural progressiveness of Grand View species over their Hagerman relatives. The following pairs of related species have the more advanced form in the Grand View local fauna, the less advanced one in the Hagerman local fauna.

HAGERMAN	GRAND VIEW
<i>Pliopotamys minor</i> (Wilson)	<i>Ondatra idahoensis</i> Wilson
<i>Plesippus shoshonensis</i> Gidley	<i>Plesippus idahoensis</i> (Merriam)
<i>Lutra piscinaria</i> Leidy?	<i>Lutra ingens</i> Gazin

A third kind of evidence for the younger age of the Grand View local fauna is the younger age of its correlatives compared to the Hagerman correlatives. The early Pleistocene age of the Hagerman local fauna is now rather generally accepted by vertebrate paleontologists. I (Hibbard in Flint, 1957; Hibbard, 1958c) have referred it to the Aftonian, but it may possibly be of Nebraskan age. Correlatives of the Hagerman local fauna which are of early Pleistocene date, but not necessarily from the same glacial or interglacial interval, are the Blanco local fauna of Texas; the Dixon, Deer Park, and Sanders local faunas of Kansas; and the Sand Draw local fauna of Nebraska. Evidence of the fossil mammals suggests that the Grand View local fauna is related not to these, but to distinctly younger assemblages. Relationships of three Grand View species are summarized below.

*Synaptomys vetus* Wilson: Nearest relative is in the Borchers local fauna, Kansas.

*Ondatra idahoensis* Wilson: Stage of development of this species is most like that of *Ondatra* of the Borchers local fauna.

*Pliophenacomys parvus* (Wilson): Nearest relative is in the Sanders local fauna, Kansas, but it is definitely more advanced than that species.

The Borchers local fauna is in a formation unconformably overlying that which has yielded the Deer Park and Sanders local faunas. These three assemblages are all in Meade County, Kansas, and their stratigraphic relations have been demonstrated (Hibbard 1949, 1956, 1958a).

2. Interglacial age of Grand View local fauna. Evidence of the glacial or interglacial age of the Grand View local fauna must come at this time from comparison with the known assemblages of the Great Plains. Southern Idaho is the only area west of the Rocky Mountains where even the beginning of a varied sequence of Pleistocene nonglacial deposits is known. As such, it holds considerable promise for translating detailed late Cenozoic correlations toward the Pacific Coast.

Unfortunately the basis for believing the Grand View local fauna to be of interglacial age is largely negative evidence. It consists of the absence of such small mammals as *Synaptomys* (*Mictomys*) *borealis* (Richardson), *Microtus*, and *Sorex*. These are forms of northern distribution in the United States today that characterize post-Nebraskan glacial faunas of the southern High Plains, in south-

western Kansas and western Oklahoma. If the Grand View fauna were of glacial age, one might expect such boreal elements.

A variety of mollusks is not yet known from the Grand View local fauna. When obtained, this will be of considerable help in interpreting the environment of the fauna.

3. Yarmouth age of Grand View local fauna. The evidence presented so far indicates that the Grand View local fauna is younger than the early Pleistocene Hagerman local fauna and is more probably of interglacial than glacial age. The weight of present evidence favors a Yarmouth age. The stage of evolution and the nearest relatives of *Synaptomys vetus*, *Ondatra idahoensis*, and *Pliophenacomys parvus* suggest correlation with the Borchers local fauna of southwestern Kansas. This assemblage is definitely interglacial, and if there were but three interglacial ages it is of Yarmouth age (Hibbard, 1949).

*Age relationships of Grand View local fauna.*—This section summarizes the age significance of each mammal in the fauna, on which the preceding discussion was based.

1. *Hypolagus furlongi* Gazin. Gazin (1934b) concluded that *H. furlongi* is closely related to the Hagerman species *H. limnetus*: “. . . probably the deposits in which remains of the two were found are of slightly different age as indicated by the specific differences observed between the otters and some of the rodents. In these cases the Grand View stage appears somewhat more advanced.”

2. *Castor* cf. *accessor* Hay. Hay (1927, p. 266) described this beaver from material collected by N. F. Drake (see Lindgren, 1900, p. 99; Lindgren and Drake, 1904, pp. 2–3). The locality was given originally as “Two and one-half miles NNW. of ferry where Caldwell-Rockville road crosses Snake River; elevation 2,500 feet; collector, N. F. Drake; soft lake beds forming bluffs facing Snake River.” The map published by Lindgren and Drake indicates this location is in or close to the N.  $\frac{1}{2}$  Sec. 7, T. 3 N., R. 4 W.; now in Canyon Co., Idaho.

Inadequacy of both the Grand View material and the type of *Castor accessor* prevents definite identification of the Grand View material (Wilson, 1933, pp. 123–124). Beaver material from the Hagerman local fauna has been listed as *Castor accessor?* Hay (Gazin, 1936, p. 285), and as *Castor* cf. *californicus* (Stirton, 1935, p. 446). Until the Hagerman material has been studied in detail, however,

the relationships of the Grand View and Hagerman beavers will remain uncertain. At this time the Grand View *Castor* has no precise age significance.

3. *Synaptomys vetus* Wilson. The closest relative of this species is *S. landesi* Hibbard, from the Borchers local fauna of Kansas.

4. *Ondatra idahoensis* Wilson. The earliest known occurrence of this genus is in the late Kansan Cudahy fauna of the Great Plains. It is not known from the Hagerman local fauna; nor from the late Nebraskan age, Sand Draw local fauna, Nebraska; nor from the transitional Nebraskan-Aftonian Dixon local fauna, Kansas; nor from the Aftonian Deer Park and Sanders local faunas of Kansas. All these assemblages have been reasonably well sampled, especially those in Kansas, so that these negative occurrences do carry some weight. The absence of this muskrat in the Hagerman local fauna is especially striking, for the type of sediments comprising the Hagerman formation and the general aspect of the fauna (Gazin, 1936, p. 285) strongly indicate that it would have found a congenial if not ideal habitat. The related *Pliopotamys* in the Hagerman fauna further supports such an inference. The suggestion is strong that *Ondatra* is absent from the Hagerman local fauna because it had not yet evolved, or had not yet immigrated into the Snake River Valley.

Compared to other Pleistocene muskrats, *Ondatra idahoensis* is closest in its stage of development to that from the Borchers local fauna of Kansas.

5. *Pliophenacmys parvus* (Wilson). This vole is most closely related to *P. meudensis* Hibbard, of the Aftonian Sanders local fauna, Kansas. It is, however, definitely more advanced than that species.

6. *Erethizon bathygnathum* Wilson. Porcupines are rare fossils, and hence it is not surprising this species lacks stratigraphic value. It may be the earliest record of the genus.

7. *Felis cf. lacustris* Gazin. This species was described from the Hagerman local fauna, and two specimens from the Grand View site referred to it. It does not possess great stratigraphic significance, partly because rather adaptable large cats of this type seem to be fairly long ranging.

8. *Lutra (Satherium) ingens* Gazin. The Grand View otter is distinct from the Hagerman species by the greater size and massiveness of its jaw. It may well be descended from the latter. Whether

*L. ingens* was a larger animal, or differed mostly in proportions, is uncertain.

*Lutra piscinaria* Leidy (1873, p. 316) is of uncertain relation to the Grand View and Hagerman species. It is based on a tibia from the indefinite locality Sinker Creek, Idaho, and comparable material from the Grand View local fauna is unknown. As indicated by Gazin (1934, p. 149) *L. piscinaria* may be the Grand View rather than the Hagerman form.

9. *Plesippus idahoensis* (Merriam). This species was described on the basis of material from two localities (Merriam, 1918, p. 527):

a) "near Froman Ferry on the Snake River, eight miles southwest of Caldwell, Idaho." The locality record at the University of California Museum of Paleontology lists Locality 3036 as two miles plus northwest of Froman Ferry, 7-8 miles southwest of Caldwell, Idaho, T. 3 N., R. 4 W., Sec. 7. Evidently two specimens (including the holotype) of this horse come from very close to, if not indeed from, the type locality of *Castor accessor* Hay.

b) "north bank of the Payette River, about four and one-half miles southeast of the town of Payette." UCMP Locality 3039. The locality record at the University of California Museum of Paleontology adds the information that this site is on Horn's ranch.

There is no independent evidence of the age of these two localities. The principal significance of this horse in the Grand View local fauna is that it is distinct from the Hagerman *Plesippus shoshonensis*. *P. idahoensis* is the youngest known species of the genus in North America. Schultz (1936) referred this species to *Plesippus*, although he recognized that there were *Equus*-like features in it.

10. *Cervus* cf. *lucasi* Hay. This elk was described from Sand Hollow, Ada County, Idaho, from an astragalus and phalanx (Hay, 1927, pp. 110-111). The two Grand View specimens are parts of antlers, and hence cannot be referred with any certainty to Hay's form. There is no independent evidence for the age of the original specimens of *C. lucasi*.

*Correlative occurrences in Idaho.*—So far, the Grand View local fauna is the only middle Pleistocene assemblage recognized in Idaho. There are several scattered occurrences (such as those in the Payette River valley) which may be correlative, but are indeterminate. The site near Froman Ferry is quite possibly of middle Pleistocene age

and correlative with the Grand View fauna, however. The evidence of *Plesippus idahoensis* and *Castor accessor* is suggestive, but not definitive.

#### ACKNOWLEDGMENTS

I wish to thank the following for permission to study specimens under their care: William Otto, California Institute of Technology; Theodore Downs, Los Angeles County Museum; Preston E. Cloud, Jr., United States Geological Survey; C. Lewis Gazin, United States National Museum; Donald E. Savage, Museum of Paleontology, University of California; and Robert W. Wilson, Museum of Natural History, University of Kansas. I also wish to express my gratitude to Dwight W. Taylor, United States Geological Survey, for reading the manuscript and for furnishing the data on the field localities and the lists of associated mollusks. I am indebted to Louis Thaler of France for his discussions concerning various European microtines and their associated faunas.

The drawings were made by Bonnie Hall (BH), Museums artist of the University of Michigan, and Michael O. Woodburne (M. O. W.).

Financial support for the artist, Michael O. Woodburne, and for Allen S. Hunt, research assistant, was provided by the Board of Governors of the Horace H. Rackham School of Graduate Studies of the University of Michigan.

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