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A RODENT FAUNA FROM LATER CENOZOIC BEDS OF SOUTHWESTERN IDAHO

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With two plates and eight text-figures

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A RODENT FAUNA FROM LATER CENOZOIC BEDS OF SOUTHWESTERN IDAHO

INTRODUCTION

The late Pliocene or early Pleistocene continental deposits occurring in southwestern Idaho have yielded scattered fossil mammalian remains during the past forty years or more. However, with the exception of beaver material described as *Castor accessor* by O. P. Hay nothing has been recorded concerning the rodents from these beds. That a diversified assemblage of types occurs in these later Cenozoic sediments is clearly shown by collections procured in recent years in the course of palæontological explorations along the Snake River near Grand View and Hagerman, Idaho.

The westerly of the two principal localities in this region of Idaho is situated on the west side of the Snake River approximately thirteen miles northwest of the town of Grand View. This site was investigated by the California Institute of Technology. The Hagerman locality, where extensive excavations were conducted by the United States National Museum, is situated on the Snake River across from the town of Hagerman. In an airline, the distance between the localities at Grand View and Hagerman is approximately sixty miles.

The United States National Museum has generously permitted me to borrow the rodent collections obtained by that institution at the Hagerman locality. The beaver remains were not included, since important studies of this group are being conducted elsewhere. The present paper embraces therefore a study of the rodent types now known from the Hagerman and Grand View localities, with the exception of the material noted above, and grateful acknowledgment is made here for opportunity to study the National Museum collections. Recent comparative material was loaned by the Division of Vertebrate Zoology, California Institute. The illustrations of the rodent material were prepared from photographic enlargements by John L. Ridgway. The author also wishes to thank Dr. Chester Stock for opportunity to study the California Institute collections and for supervision of the work, as well as for a critical reading of the manuscript.

AGE RELATIONSHIPS OF FAUNA

The following rodents are now known from the Grand View and Hagerman localities:

† Citellus? species.
† Thomomys gidleyi n. sp.
*, ? † Castor cf. accessor Hay.
* Synaptomys vetus n. sp.
† Mimomys (Cosomys) primus (Wilson).
* Mimomys? parvus n. sp.
* Ondatra idahoensis idahoensis n. sp., n. subsp.
† Ondatra idahoensis minor n. subsp.

* Grand View locality.
† Hagerman locality.

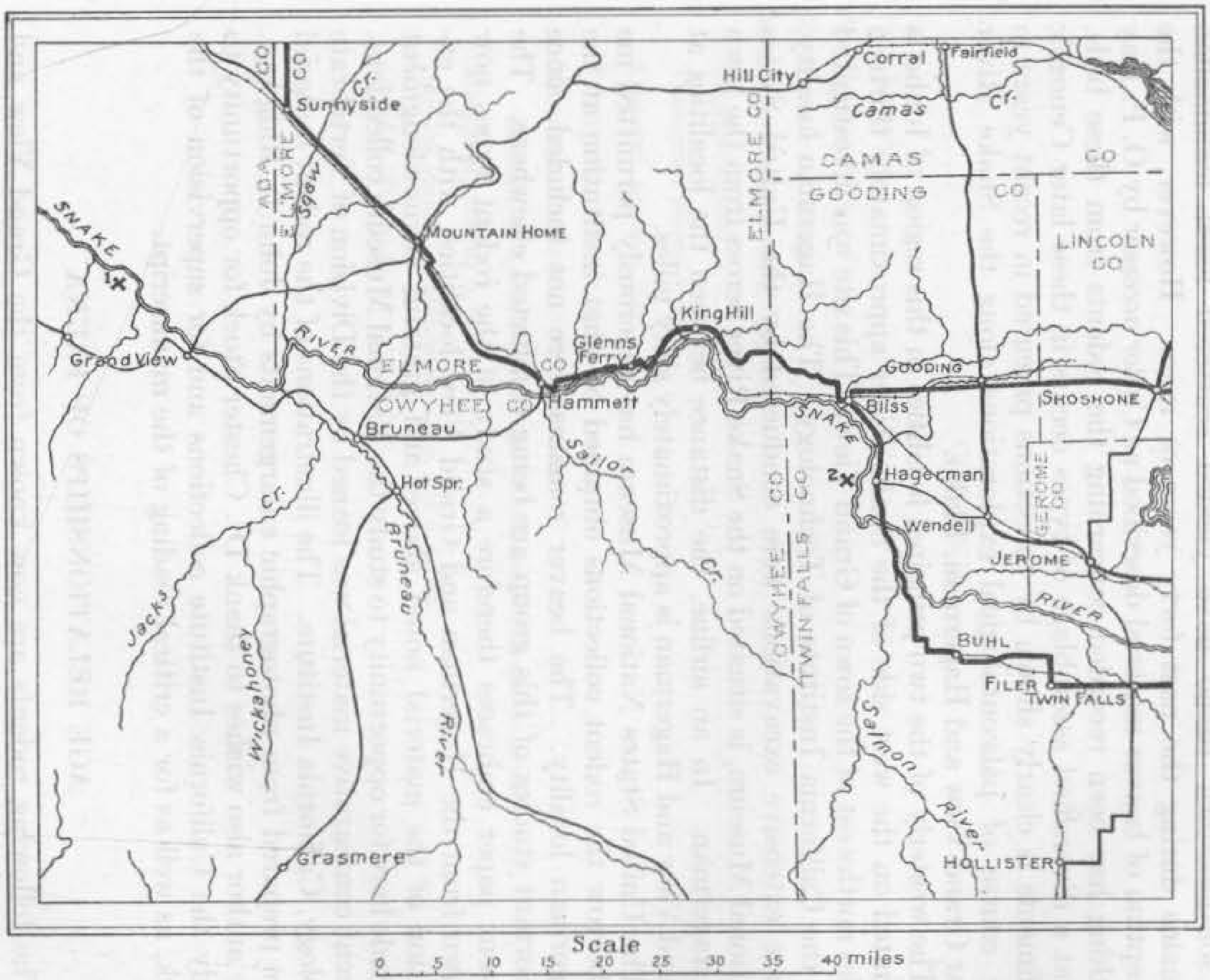


FIG. 1—Index map of a portion of southwestern Idaho, showing location of fossil vertebrate occurrences near Grand View ([1]X), and Hagerman ([2]X). From road map of Automobile Club of Southern California.

Only a limited number of comparisons with related faunas can be made, since rodent assemblages from the uppermost Pliocene or lowermost Pleistocene in North America are at present very imperfectly known.

The type of *Mimomys primus*[1] occurs in upper Pliocene beds of the Coso Mountains, California. Since the known history of the vole group appears to indicate a rather rapid change in certain structural details of the dentition in these types during the upper Pliocene and lower Pleistocene, the presence of the same species at localities in California and Idaho may be of some importance in assisting to establish a correlation between the two deposits. Unfortunately, no other rodents are known from the locality in the Coso Mountains.

A rodent collection described by Gidley[2] from later Cenozoic deposits in San Pedro Valley, Arizona, and referred to a late stage of the Pliocene, includes an incomplete upper second molar assigned by that author to the genus *Neofiber*. This tooth is characterized by the presence of small roots, in which respect it differs from teeth in Recent specimens of the genus. In this character and in that of size, the San Pedro Valley specimen agrees apparently with *Ondatra idahoensis* from the Idaho beds. No other rodents common to both localities have been discovered.

Mimomys pliocænicus from the upper Pliocene of Europe presents a stage of evolution closely comparable to that of *Mimomys primus*. In England this species ranges from the Norwich Crag to the shelly crag of lower Cromerian or Weybourne Crag age, at East Runton.

In the present state of our knowledge, an exact determination of age based on the relationships of the Idaho rodent fauna can not be made. However, available evidence indicates a stage of development not earlier than upper Pliocene or later than middle Pleistocene. Presence of *Mimomys primus* in the Hagerman fauna points to an upper Pliocene or lower Pleistocene age, more probably to the former.

The faunas from the Grand View and Hagerman localities may not represent exact equivalents in time, but there can hardly be any considerable hiatus between them.

ENVIRONMENT OF FAUNA

The rodent assemblage appears to offer evidence of value in an interpretation of the ecologic conditions prevailing during the accumulation of the later Cenozoic beds in southwestern Idaho. Presence of beavers and muskrats suggests the close proximity of fresh water, perhaps an ancient lake or a predecessor of the present Snake River. The occurrence of a lemming and of several species of voles also points

[1] R. W. Wilson, Jour. Mamm., vol. 13, 150-154, 1932.
[2] J. W. Gidley, U. S. Geol. Surv. Prof. Paper 131, 119-128, 1922.

to the prevalence of rather moist conditions and to the presence of abundant grasses. Remaining elements in the fauna, namely a sciurid and a gopher, do not offer any noteworthy suggestions as to the ecologic conditions that prevailed.

SYSTEMATIC DESCRIPTION OF SPECIES

Citellus? species

Included in the material from Hagerman is a right lower fourth premolar of a sciurid type (Pl. 1, fig. 6), No. 12963 U. S. Nat. Mus. This specimen probably represents a species of *Citellus* in the broader sense and as included in such doubtful genera as *Callospermophilus* and *Otospermophilus*. No. 12963 resembles the comparable tooth in the latter genera decidedly more so than it does that in typical *Citellus*.

The Idaho citellid differs from specimens of *Otospermophilus beecheyi beecheyi*, the Recent California ground-squirrel, in slightly more marginal position of the cusps, in presence of a U-shaped rather than a V-shaped notch between paraconid and internal rim of talonid, in greater definitiveness of paraconid and protoconid, and in smaller size. No. 12963 differs somewhat from specimens of Recent *Callospermophilus lateralis certus* in the more U-shaped notch between paraconid and internal rim of talonid, and in the slightly greater separation of paraconid and protoconid. No. 12963 is slightly larger than $P\overline{4}$ in Recent specimens of *Callospermophilus*.

The Idaho specimen is distinctly smaller than either of the two fossil citellids described by Gidley[1] from the San Pedro Valley beds. *Citellus cochesii* apparently possesses somewhat broader teeth, while *Citellus bensoni*, agreeing with *Otospermophilus beecheyi* except for slightly better defined valleys and cusps, differs probably in one or more of the characters stated above in a comparison of the form from southwestern Idaho with the modern species.

Measurements (in millimeters)

$P\overline{4}$, anteroposterior length	1.7
$P\overline{4}$, transverse width	2.0

Thomomys gidleyi n. sp.

Locality—Hagerman, Idaho.

Type—No. 12651, U. S. National Museum, an incomplete left ramus bearing $P\overline{4}$ and $M\overline{1}$ (Pl. 1, figs. 4, 4a).

Specific characters—First lower molar narrowing gradually toward internal side instead of being rather abruptly constricted as in living species of *Thomomys*. Size small, approximately that in Recent *Thomomys quadratus quadratus*.

Remarks—Apparently but two well-established extinct species of the genus are known from the Pleistocene of North America, namely, *Thomomys orientalis* of Florida and *T. microdon* of California, both from cave deposits. Unfortunately these types are represented only by skull fragments. Since rami are unknown, a comparison with the Idaho specimen is limited to the character of size. *Thomomys orientalis* is a larger form than the Idaho species, while *T. microdon* apparently resembles *Thomomys gidleyi* in size.

[1] J. W. Gidley, *ibid.*, 121-122, 1922.

The lower premolar of *Thomomys gidleyi* corresponds to that in examined specimens of Recent *T. quadratus quadratus*, *T. monticola mazama* and *T. fuscus fuscus* in the somewhat elliptical shape of the anterior lobe and in the size of angle made by the intersection of the principal axis of the lobe and the major axis of this tooth. In disposition of the anterior enamel band on $P\bar{4}$, the Idaho specimen differs somewhat from normal specimens of the several species mentioned above. In *T. gidleyi* this band is confined to the anterior face of the tooth, whereas, in the Recent species referred to, the anterior enamel band usually extends to the internal face of the lobe. However, a ramus of *T. monticola mazama* shows a $P\bar{4}$ in which the enamel is confined to the anterior face. Furthermore, the internal wall of the anterior lobe is commonly slightly concave in Recent forms instead of straight as in the Idaho specimen. This character also appears to be subject to variation. Evidently in shape of $M\bar{1}$, the Idaho type presents a character distinguishing it from known species of *Thomomys*. The first lower molar of *T. gidleyi* narrows gradually toward the inner side, in which respect it differs from the comparable tooth in all other specimens of *Thomomys* examined, where the inner side of the tooth is abruptly constricted.

Measurements (in millimeters)

	Anteroposterior diameter	Transverse diameter
$P\bar{4}$	1.9	1.6
$M\bar{1}$	1.2	1.8

Castor cf. accessor Hay

Locality—Grand View, Idaho.

Material—A fragment of ramus with $M\bar{1}$, No. 1360 Calif. Inst. Tech. Coll. Vert. Pale. (Pl. 1, figs. 3, 3a); several isolated cheek-teeth (Pl. 1, figs. 1, 1a, 2, and 5); and two distal fragments of humeri.

Remarks—The beaver material from the locality at Grand View is referred to the genus *Castor* because of close resemblance in tooth pattern between the Idaho form and the modern genus. However, the material certainly represents a type distinct from any living species of *Castor* in the less persistent hypsodonty exhibited by the cheek-teeth. The pulp cavities of the cheek-teeth are closed and roots have formed in a number of the fossil specimens. In Recent *Castor*, roots are developed rather late in life, apparently somewhat later than in the Idaho form. Moreover, the external lateral grooves in the upper cheek-teeth and the internal lateral grooves in the lower cheek-teeth are closed at the base and have retreated from the base of the crowns for varying distances, except in very young specimens. Closing of the lateral grooves is apparently to be considered as a first step in the cessation of growth of crown and in the formation of roots in these teeth. Hence, the presence of closed grooves in all but the youngest specimens suggests a less hypsodont crown in teeth of the Idaho form than in those of Recent *Castor*. In the latter the lateral grooves apparently are not closed until a late stage has been reached in the life of the animal.

Castor accessor,[1] described by O. P. Hay, was found in beds of later Cenozoic age near Caldwell, Idaho. The type and apparently only described specimen is a $P\bar{4}$. Unfortunately this particular tooth is not represented in the Grand

[1] O. P. Hay, Carnegie Inst. Wash. Pub. No. 322B, 266-267, 1927.

View collections. However, the beaver from the latter locality possesses teeth nearly comparable in size to the type of *C. accessor*, although considerable variation in this character is exhibited by the available material from the region of Grand View. The type of *Castor accessor* is little worn and the internal lateral grooves extend to the base of the tooth. A similar feature exists in a specimen from Grand View, No. 1386 Calif. Inst. Tech. Coll., in which the crown is unworn. Whether or not the stage of hypsodonty seen in Recent *Castor* is more closely approached by the type of *C. accessor* than by the specimens from Grand View can not be satisfactorily determined.

The description and illustrations of *Castor californicus*[1] from the Etchegoin formation of the Kettleman Hills, California, do not suffice for full comparisons with the Idaho material. If the Californian type represents $M\underline{2}$, as determined by Miss Kellogg, it can be distinguished from the Idaho specimens by greater elongation of crown. However, the recognition of this tooth as a second upper molar may not be correct. *Castor californicus* appears to represent a somewhat smaller species than *C. accessor*, although the variation in size exhibited by both forms is not known.

Beaver material has been recorded also from the Hagerman locality.

Measurements (in millimeters)

	Anteroposterior diameter*	Transverse diameter*
$M\underline{1}$	9.5	10.2
$M\underline{2}$	7.7	10.0
$M\underline{3}$	7.6	8.2
$M\overline{1}$	8.0	7.9

* Measured at occlusal surface.

Synaptomys vetus n. sp.

Locality—Grand View, Idaho.

Type—No. 1364 Calif. Inst. Tech. Coll. Vert. Pale., a fragment of jaw with right $M\overline{1}$.

Paratypes—No. 1365, a right $M\underline{1}$; No. 1366, a right $M\underline{2}$; and No. 1367, a right $M\underline{3}$.

Referred material—No. 1368, a fragmentary right ramus without incisor or cheek-teeth; a number of isolated cheek-teeth and incisors.

Specific characters—Closed triangle absent on external side of $M\overline{1}$. A rather deep, second external re-entrant angle[2] present on $M\overline{1}$. Size resembles that of Recent *S. borealis wrangeli*.

Description—The referred upper incisors are grooved near their outer borders. Behind the convex chisel edge, when unbroken, is frequently developed a deep excavation due to the rapid wearing away of the soft dentine. It is to be noted that the genus *Synaptomys* is the only lemming possessing distinctly grooved upper incisors, although traces of grooves are sometimes

[1] Louise Kellogg, Univ. Calif. Pub., Bull. Dept. Geol., vol. 6, No. 17, 401-402, 1911.

[2] In describing the cheek-teeth of this and of the microtine species which follow, the system used by M. A. C. Hinton for enumeration of the re-entrant and salient angles has been adopted. See Hinton, *Monograph of the voles and lemmings (Microtinæ) living and extinct*, vol. 1, 22, 1926. To quote from Hinton: "In describing the teeth it is customary to enumerate the salient angles and re-entrant folds from before backwards in upper molars, and from behind forwards in lower molars, the first salient angles on each side being formed by the transverse loop."

present in the upper incisors of *Lemmus*. The lower incisor is wholly lingual in position and apparently terminates at a point situated slightly in back of the anterior margin of $M\overline{3}$. The cheek-teeth possess cement but are without roots.

The pattern of $M\underline{1}$ (fig. 2c) consists of an anterior loop and four alternating triangles. The external re-entrant angles are much deeper than the internal re-entrants as is the case in all of the superior cheek-teeth with the exception of the second internal re-entrant angle of $M\underline{3}$. The pattern is essentially the same as in the corresponding tooth of Recent *Synaptomys borealis*. $M\underline{2}$ (fig. 2b) possesses an anterior loop and three alternating triangles. This tooth cor-

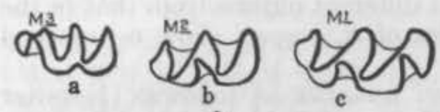


FIG. 2—*Synaptomys vetus* n. sp. a, right $M\underline{3}$, No. 1367 C. I. T.; b, right $M\underline{2}$, No. 1366 C. I. T.; c, right $M\underline{1}$, No. 1365 C. I. T. x 6. Grand View, Idaho.

FIG. 3—*Synaptomys vetus* n. sp. Right $M\overline{1}$, No. 1364 C. I. T. x 6. Grand View, Idaho.

responds in pattern to the second upper molar of *S. borealis*. $M\underline{3}$ (fig. 2a) may be described as having four simple transverse loops. The major transverse axis of the third transverse loop in contrast to those for the first and second loops intersects the anteroposterior axis of the tooth to form a large angle. The fourth transverse loop is reduced. The commissure between the third and fourth loops is situated on the internal side of the tooth. In contrast, the commissures separating the first three loops have an external position. $M\underline{3}$ differs from a comparable tooth in *Synaptomys borealis* in the less transverse position of the third loop, in shallower external re-entrant angles, and in the more nearly opposite position of the first external and internal re-entrant angles. In individuals of the Recent species the tooth is subject to considerable variation.

The pattern of $M\overline{1}$ (fig. 3) consists of a posterior loop, three alternating triangles, of which the external one is small and broadly confluent with the first internal one, and an anterior loop. The second external re-entrant angle is rather deep and more or less opposed to the third internal re-entrant.

The genus *Synaptomys* is divided into two subgenera, *Synaptomys* represented by the single Recent species *cooperi* and *Mictomys* represented by the single Recent species *borealis*.[1] The tooth pattern of the former is essentially as in the genus *Lemmus*. The latter subgenus is, on the other hand, distinguished from all other members of the *Lemmi* by the absence of external closed triangles in the inferior dentition, the buccal border being crenulated instead of possessing distinct salients and re-entrants. Absence of closed triangles on the external side of $M\overline{1}$ in *Synaptomys vetus* indicates a resemblance to *Mictomys*, but the first external re-entrant angle in this tooth is perhaps more prominent in *S. vetus* than in the latter subgenus, and the second external re-entrant angle is deep and seems to correspond more closely to the equivalent angle in the subgenus *Synaptomys*.

Comparisons—*Synaptomys vetus* apparently represents a form intermediate between the two Recent subgenera, *Synaptomys* and *Mictomys*, with perhaps closer relationship to *Mictomys* in so far as the tooth-pattern of the molars is concerned. In position of the grooves on the upper incisors, however, *S. vetus* may make a closer approach to individuals of the subgenus *Synaptomys*.

[1] A. Brazier Howell, U. S. Dept. Agric., North American Fauna No. 50, 9, 1927.

The grooves in both subgenera are close to the outer borders of the teeth but the grooves in *Mictomys* are situated slightly nearer the median line. In *S. vetus* the grooves are situated close to the outer borders, a position more like that in *Synaptomys* than like that in *Mictomys*.

Only one fossil form of *Synaptomys* is close enough to *S. vetus* to warrant comparison, namely *S. cooperi annexus*[1] from the Frankstown Cave deposits. Although *S. c. annexus* was regarded as subspecifically distinct from the modern form, it appears to be entitled to full specific rank in the light of the characters shown in the figure of the type. None of the external triangles appears to be fully closed. In $M\overline{1}$ the dentine is confluent throughout the tooth and the anterior loop has a somewhat different outline from that in the Recent *S. cooperi*. The modern subspecies of *S. cooperi* show no marked differences in tooth-pattern.

Synaptomys vetus differs from *S. cooperi annexus* as follows: (1) outer triangle of $M\overline{1}$ much less definitely marked, especially in type of *S. vetus;* (2) anterior loop of $M\overline{1}$ shorter and with different outline; (3) salient angles sharper and re-entrant angles more alternating; and (4) considerably larger size (about 20 per cent). Recognition of the species *Synaptomys vetus* in the later Cenozoic emphasizes the fact that the immediate predecessor of *Synaptomys* should be sought for in the Tertiary rather than in the Quaternary.

Comparative measurements (in millimeters)

	Synaptomys vetus Calif. Inst. Tech. Coll. Grand View				*Synaptomys borealis wrangeli* Dickey Coll. Recent No. 9311
	No. 1365	No. 1366	No. 1367	No. 1364	
$M\underline{1}$, anteroposterior diameter	2.7	...	...	...	2.7
$M\underline{1}$, transverse diameter	1.3	...	...	...	1.2
$M\underline{2}$, anteroposterior diameter	...	2.0	...	...	2.0
$M\underline{2}$, transverse diameter	...	1.1	...	...	1.1
$M\underline{3}$, anteroposterior diameter	...	...	2.0	...	2.1
$M\underline{3}$, transverse diameter	...	...	1.0	...	1.0
$M\overline{1}$, anteroposterior diameter	...	...	...	3.0	2.9
$M\overline{1}$, transverse diameter	...	...	...	1.3	1.2

Mimomys (Cosomys) primus (Wilson)

Locality—Hagerman, Idaho.

Material—A right maxillary fragment with well worn $M\underline{1}$–$M\underline{3}$ in place, No. 12644 U. S. National Museum; a right ramus with $M\overline{1}$–$M\overline{3}$ also rather worn, No. 12633 U. S. Nat. Mus. (fig. 4b); a right ramus with $M\overline{1}$ and $M\overline{2}$, No. 12645 U. S. Nat. Mus. (fig. 4a); numerous fragments of rami with and without cheek-teeth; and isolated teeth comprising $M\underline{1}$–$M\underline{3}$ and $M\overline{1}$–$M\overline{3}$.

[1] O. A. Peterson, Ann. Carnegie Mus., vol. 16, 277, fig. 4, 1926.

Relationships—This species was described originally from late Pliocene beds of the Coso Mountains, California. The new genus *Cosomys* was proposed to accommodate it. However, it was recognized that the form had many structural features in common with the extinct European genus *Mimomys*. The two genera were separated principally on the basis of fusion of the temporal ridges in the American form, a character not known to occur

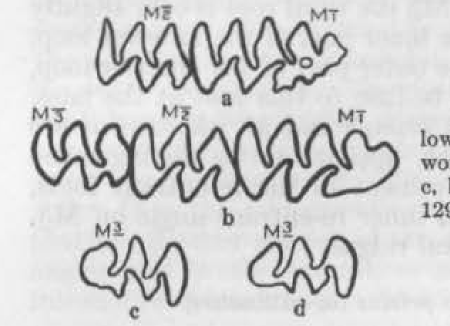


FIG. 4.—*Mimomys primus* (Wilson). a, incomplete lower right dentition No. 12645 U. S. Nat. Mus.; b, rather worn lower right dentition, No. 12633 U. S. Nat. Mus.; c, left $M\underline{3}$, No. 12964 U. S. Nat. Mus.; d, left $M\underline{3}$, No. 12965 U. S. Nat. Mus. x 6. Hagerman, Idaho.

in *Mimomys*. Several structural features of minor importance, as well as the wide geographic separation of the two forms, were regarded as further evidence for recognition of the Californian form as a distinctive generic type. M. A. C. Hinton has objected to this generic separation, presenting cogent facts in support of his view.[1]

Additional but likewise incomplete material of *Cosomys primus* from the later Cenozoic beds along the Snake River has served chiefly to increase the similarity between *Mimomys* and *Cosomys*, leaving only the fusion of the temporal ridges and the geographic separation as characters distinguishing the two genera. It is proposed therefore to refer *C. primus* to the European genus *Mimomys*, but to retain for the present *Cosomys* as a subgenus in view of the differences exhibited, particularly in development of the temporal ridges.

REVISION OF SPECIFIC CHARACTERS OF MIMOMYS (COSOMYS) PRIMUS

Specific characters—Teeth without cement. Third outer fold in $M\bar{1}$ reduced to form a pit surrounded by enamel as in *Mimomys pliocænicus*. Persistent "prism fold" in $M\bar{1}$. Second inner fold of $M\bar{3}$ not reduced by isolation of tip of this fold as in *M. pliocænicus*. $M\underline{1}$ and $M\underline{2}$ with three roots; remaining superior and inferior cheek-teeth with two roots each. Size approximately that of *M. pliocænicus*.

There can be little doubt that the Idaho species is identical with that described from the Coso Mountains. Selected individuals possess practically identical characters. Taking into account the individual variation shown by the Idaho material, no characters present themselves which might serve to distinguish specifically the forms known from the two localities.

The Idaho material furnishes added information regarding particular characters in *Mimomys primus*. No teeth were found with visible traces of cement, the Idaho specimens thus agreeing with the material from the Coso Mountains. Formation of the enamel islet in $M\bar{1}$ by an isolation of the tip of the third inner re-entrant angle and not by the third outer re-entrant was suggested in the original paper on *Cosomys*. Certain specimens in the Idaho

[1] M. A. C. Hinton, Jour. Mamm., vol. 13, 280-281, 1932.

collection clearly show the tip of the third outer re-entrant angle in process of isolation to form the islet. Thus the Idaho form agrees with the European species. Of the several available specimens of third upper molars (figs. 4c, 4d), none shows a tendency to isolate the tip of the second inner re-entrant. In *M. pliocænicus,* the species resembling *M. primus* most closely in general characteristics, the tip is isolated. $M\underline{1}$ and $M\underline{2}$ are three-rooted, the remaining teeth being two-rooted. In $M\underline{1}$ the third small inner root supports the first closed triangle as in *M. pliocænicus* In $M\underline{2}$ the third root is only slightly smaller than the other two. It supports the inner part of the anterior loop. This root is distinct from that supporting the outer part of the anterior loop, but in some specimens it shows a tendency to fuse to this root at the base.

Mr. Hinton has suggested that *Mimomys primus* and *M. pliocænicus* are conspecific. The American species, however, appears to be distinguished from the European form by (1) absence of cement in the re-entrant folds, (2) lack of reduction of the tip of the second inner re-entrant angle on $M\underline{3}$, and possibly by (3) the union of the temporal ridges.

Comparative measurements of Mimomys primus (*in millimeters*)

	C. I. T. No. 500 Coso Mts.	U. S. Nat. Mus No. 12644 Hagerman	U. S. Nat. Mus. No. 12645 Hagerman	U. S. Nat. Mus. No. 12633 Hagerman
$M\underline{1}$, anteroposterior diameter	2.7	2.7	...	...
$M\underline{1}$, transverse diameter	1.7	1.9	...	...
$M\underline{2}$, anteroposterior diameter	2.1	2.1	...	...
$M\underline{2}$, transverse diameter	1.6	1.7	...	...
$M\underline{3}$, anteroposterior diameter	2.1	2.2	...	...
$M\underline{3}$, transverse diameter	1.3	1.4	...	...
$M\overline{1}$, anteroposterior diameter	3.2	...	3.1	3.2
$M\overline{1}$, transverse diameter	1.5	...	1.5	1.7
$M\overline{2}$, anteroposterior diameter	2.0	...	2.0	2.2
$M\overline{2}$, transverse diameter	1.5?	...	1.5	1.5
$M\overline{3}$, anteroposterior diameter	1.9	...	...	1.9
$M\overline{3}$, transverse diameter	1.1	...	...	1.4
Length of lower tooth row (crown)	7.1	...	...	7.1

Mimomys? parvus n. sp.

Locality—Grand View, Idaho.

Type—No. 1369 Calif. Inst. Tech. Coll. Vert. Pale., an incomplete left ramus with $M\overline{1}$ and $M\overline{2}$ (fig. 6a).

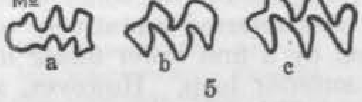
Paratypes—No. 1370, a left $M\underline{1}$; No. 1371, a left $M\underline{2}$; and No. 1372, a left $M\underline{3}$.

Referred material—Abundant but fragmentary material representing various lower jaws, with and without teeth, and numerous isolated cheek-teeth and incisors (Pl. 2, figs. 3, 4).

Specific characters—Anterior loop of $M\overline{1}$ cut by re-entrant angles isolating a fourth and fifth triangle, these triangles being more or less confluent with each other and with the anterior loop. First external triangle of $M\underline{3}$ reduced, external re-entrant angles shallow, and dentinal spaces of entire tooth broadly confluent. Dentinal spaces of remaining cheek-teeth somewhat confluent. Cheek-teeth without cement. Enamel not noticeably differentiated into thick and thin tracts. $M\underline{1}$ with three roots. Size small, but slightly larger than *Mimomys newtoni*.

Description—The description of the superior dentition is based entirely upon isolated teeth as no maxillary fragments bearing cheek-teeth have been obtained.

$M\underline{1}$ (fig. 5c) and $M\underline{2}$ (fig. 5b) possess a characteristic pattern. The first upper molar consists of an anterior transverse loop followed by four alternating and essentially closed triangles. The second upper molar has a transverse loop followed by three closed and alternating triangles. The single $M\underline{3}$ (fig. 5a) available shows an anterior loop, two alternating triangles and a posterior loop. The dentinal spaces of the tooth are rather broadly confluent. The anterior loop is rectangular, the alternating triangles broadly confluent, the outer one reduced. The posterior loop is rather broad and possesses two small basal salient angles suggesting two additional triangles. The second inner re-entrant angle is directed transversely across the tooth-axis with no tendency to curve backward. The outer re-entrant angles are rather shallow. $M\underline{3}$ differs from the corresponding tooth of *Mimomys primus* and probably from that in all other species of the genus in shallowness of the outer re-entrant angles and in the transverse rather than backward direction of the first internal re-entrant angle. In so far as can be determined from the specimen



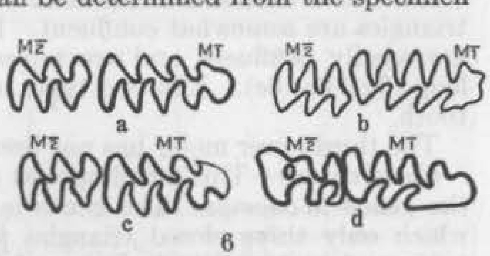


FIG. 5—*Mimomys? parvus* n. sp. a, left $M\underline{3}$, No. 1372 C. I. T.; b, left $M\underline{2}$, No. 1371 C. I. T.; c, left $M\underline{1}$, No. 1370 C. I. T. x 6. Grand View, Idaho.

FIG. 6—*Mimomys? parvus* n. sp. a, incomplete left lower dentition, No. 1369 C. I. T.; b, incomplete young right lower dentition, No. 1374 C. I. T.; c, worn left lower dentition, No. 1373 C. I. T.; d, very worn incomplete right lower dentition, No. 1375 C. I. T. x 6. Grand View, Idaho.

at hand, which represents the tooth of a young individual, reduction of the angle by isolation of the tip has not taken place as is the case in *M. pliocænicus*. Further differences of minor character may be noted, but they lie possibly within the range of individual variation. $M\underline{3}$ next to $M\overline{1}$ is the most variable of the cheek-teeth. Since but a single specimen of $M\underline{3}$ is available, the characters noted in this tooth may be subject to individual variation and may not always be especially diagnostic of this form. This tooth is similar to the corresponding tooth in certain species of *Alticola* and allied genera in the small size of the external triangle and in the confluency of that element with the anterior loop. However, in *Alticola* the first and second alternating triangles are shut off from each other. The first inner re-entrant angle is generally directed backward and the posterior part of the tooth is considerably narrower.

$M\underline{1}$ possesses three roots, while the remaining cheek-teeth both above and below possess each but two roots. The third root of $M\underline{1}$ is small and supports the first outer triangle.

The mandibular incisor passes from the lingual to the buccal side of the ramus apparently between $M\overline{2}$ and $M\overline{3}$. The incisor terminates proximally at a point situated slightly above the dental foramen.

$M\overline{1}$ consists of a posterior loop, three alternating and closed triangles, and an anterior loop which is deeply cut on each side by re-entrant angles isolating a fourth and a fifth triangle. These triangles are more or less confluent with each other and with the anterior loop. In some specimens belonging to young individuals the anterior portion of the anterior loop is further complicated by several shallow re-entrant angles. The first lower molar is subject to noteworthy individual variation, clearly shown by the additional material available. The principal variations, apparently not particularly associated with age, are the greater or less confluency of the fourth and fifth triangles (figs. 6a, 6b), and the width of the dentinal commissure between the fifth triangle and the anterior portion of the loop. This portion of the loop also varies considerably but is usually sub-circular except for a distinct backwardly directed, basal angle on the buccal side which constitutes the fourth outer salient angle. In very worn specimens in which the lateral grooves are on the point of disappearance, only three triangles are present, the fourth internal re-entrant is shallow and the third external re-entrant has disappeared (fig. 6d).

$M\overline{2}$ consists of a posterior loop and four essentially alternating triangles with the third and fourth more or less confluent. This tooth also shows considerable individual variation. In some specimens the first and second triangles are somewhat confluent. In other specimens the last two triangles are wholly confluent and are replaced by what is essentially a transverse loop (figs. 6a, 6c). The two types of variation may be present in a single tooth.

The third lower molar has not been definitely recognized in the collections.

Comparisons—This small species of vole has been referred tentatively to the genus *Mimomys*. The genus is characterized by a first lower molar in which only three closed triangles precede the anterior loop. However, a more or less complete isolation of the fourth and fifth triangles occurs in *Mimomys? parvus*. In addition, the Idaho species possesses a rather distinctive $M\underline{3}$. Hence it seems possible that *M.? parvus* represents a distinct generic type. On the other hand the species is apparently closer to *Mimomys* than to any other genus, and although the characters separating *M.? parvus* and *M. primus* may appear at first sight to be of some magnitude, study of the European species of the genus reveals characters which to a certain extent bridge the gap between these two forms. Furthermore, it seems desirable when working with fossil forms to draw the generic lines somewhat more broadly than with Recent types. Additional material, especially of the superior and inferior third molars, doubtless will help to clarify the systematic position of this vole.

The genus *Mimomys* is divided into two groups, one characterized by reduction of the third outer re-entrant angle in $M\overline{1}$ (*pliocænicus* group), the other by retention of this angle as a deep re-entrant (*newtoni* group). *Mimomys? parvus*, if actually a member of that genus, falls within the second or *newtoni* group, and in tooth-pattern most closely resembles *M. majori* Hinton.[1] It is to be separated from the latter form by absence of cement in the lateral grooves of the cheek-teeth, the invariable absence of the "prism fold,"[2] presence of three roots on $M\underline{1}$, an earlier appearance of roots on the cheek-teeth, presence of a basal angle on the anterior portion of the anterior loop (fourth outer salient angle), and more particularly by the greater depth of the third outer and fourth inner re-entrant angles, thus causing a more or less complete isolation of the fourth and fifth triangles. $M\underline{3}$ differs apparently from the comparable tooth of *M. majori* in the characters enumerated under

[1] M. A. C. Hinton, Proc. Geol. Assoc., 21, 491, 1910; *Monograph of the voles and lemmings (Microtinæ) living and extinct*, vol. 1, 378-383, 1926.

[2] M. A. C. Hinton, *op. cit.*, 111, 1926.

the detailed description of that tooth. No figures of the third upper molar of *M. majori* are available for comparison. *M. majori* is a rather advanced member of the genus while *M? parvus* possesses several primitive characters, namely, well-developed roots on the cheek-teeth, presence of three roots on $M\underline{1}$, and lack of cement in the re-entrant folds of the cheek-teeth. Absence of a "prism fold" on $M\overline{1}$, a progressive character in the genus *Mimomys*, has been noted, however, in *M.? parvus*.

In tooth-pattern of $M\overline{1}$, *Mimomys? parvus* makes a close approach to certain specimens of *Microtus* (*Pedomys*) *haydeni*, *Neodon*, *Pitymys*, and allied genera. In these forms the first lower molar develops as characteristic features a posterior loop, five alternating triangles, the last two of which are more or less confluent, and an anterior loop. This loop is somewhat longer than the corresponding element in *M.? parvus*. In all of the above mentioned genera the cheek-teeth are without roots. However, the Idaho type can hardly be regarded as ancestral to the North American species *Microtus* (*Pedomys*) *haydeni* and to species of *Pitymys*, for representatives of *Microtus*

Measurements (in millimeters)

	No. 1370	No. 1371	No. 1372	No. 1369
$M\underline{1}$, anteroposterior diameter	2.1	...	...	...
$M\underline{1}$, transverse diameter	1.3	...	...	...
$M\underline{2}$, anteroposterior diameter	...	1.8	...	...
$M\underline{2}$, transverse diameter	...	1.1	...	...
$M\underline{3}$, anteroposterior diameter	...	...	1.7	...
$M\underline{3}$, transverse diameter	...	...	0.9	...
$M\overline{1}$, anteroposterior diameter	...	...	...	2.7
$M\overline{1}$, transverse diameter	...	...	...	1.3
$M\overline{2}$, anteroposterior diameter	...	...	...	1.6
$M\overline{2}$, transverse diameter	...	...	...	1.1
$M\overline{1}$-$M\overline{3}$, alveolar length	...	...	...	6.3?
$M\overline{1}$-$M\overline{3}$, alveolar length (average of 5 specimens)			6.1	

and *Pitymys* are found in the upper Pliocene of England. These forms, like their modern representatives, possess teeth without roots. If, however, *Pedomys* is generically distinct from *Microtus*, as Hinton maintains, then *M.? parvus* may be regarded as ancestral to the former genus.

Species of *Dolomys* Nehring[1] are to be distinguished from *Mimomys? parvus* by presence of five substantially closed and alternating triangles. Apparently no tendency toward confluency of the fourth and fifth triangles is evident in this genus as in *M.? parvus*. Moreover, the mandibular incisor extends slightly less backward than in our forms. The position of the posterior end of the incisor in *Dolomys* is on a level with or is slightly below the dental foramen, whereas in *M.? parvus* the posterior termination is slightly above the dental foramen. The third upper molar of *M.? parvus* differs distinctly from the comparable molar in *Dolomys bogdanovi* in shallowness of the second inner re-entrant angle and in absence of a second outer triangle. The only available figures of *Dolomys* were those of the Recent *D. bogdanovi* given by Hinton[2] and no detailed comparisons were made with the European fossil forms.

[1] A. Nehring, Zool. Anz., 21, 13, 1898; M. A. C. Hinton, *op. cit.*, 339-348, 1926.

[2] M. A. C. Hinton, *op. cit.*, 347, fig. 98, 1926.

No figures of *Apistomys* Mehely are available for comparison, but according to Hinton[1] this extinct European genus is hardly to be distinguished generically from *Dolomys*.

Mimomys? parvus may be readily distinguished from *Clethrionomys* by the higher position of the proximal end of the mandibular incisor. In the Idaho type, as already stated, the tip of the incisor terminates above the level of the dental foramen, while in *Clethrionomys* it terminates below this opening. This difference likewise exists between *M.? parvus* and members of the genus *Phenacomys*. Moreover, the latter genus is characterized by lower molars in which the inner salients and re-entrants are considerably better developed than those of the buccal side. *Dolomys, Apistomys, Clethrionomys,* and *Phenacomys* agree with one another and with *M.? parvus* in the presence of roots on the cheek-teeth.

Ondatra idahoensis idahoensis n. sp. and n. subsp.

Locality—Grand View, Idaho.

Type—No. 1376 Calif. Inst. Tech. Coll. Vert. Pale.; an incomplete left ramus with $M\bar{1}$-$M\bar{3}$ (Pl. 2, figs. 1, 2; fig. 8c).

Paratypes—No. 1377, a right $M\underline{1}$; No. 1378, a right $M\underline{2}$; and No. 1379, a right $M\underline{3}$.

Additional material—No. 1380, a right ramus with $M\bar{2}$ and $M\bar{1}$ (fig. 8b); several fragments of rami with and without teeth; and numerous isolated teeth belonging to both inferior and superior dentitions.

Specific characters—$M\bar{1}$ with a posterior loop, five alternating triangles, and an interior loop of somewhat complicated pattern in the early stages of wear. No tendency of re-entrant angles to cut the anterior loop of $M\bar{1}$, isolating a sixth and seventh triangle as in Recent species of the genus. Dentinal spaces of teeth confluent. $M\underline{3}$ with a rather shortened posterior loop. Teeth without cement. $M\underline{1}$ possesses three roots. Roots of cheek-teeth developing somewhat earlier than in Recent species. Size small, somewhat smaller than *Ondatra annectens* and about as in *Neofiber alleni*.

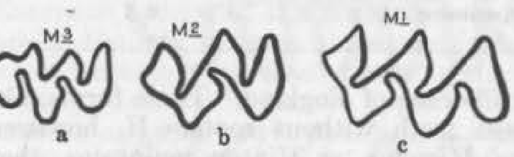


FIG. 7—*Ondatra idahoensis idahoensis* n. sp. and n. subsp. a, right $m\underline{3}$, No. 1379 C. I. T.; b, right $M\underline{2}$, No. 1378 C. I. T.; c, right $M\underline{1}$ No. 1377 C. I. T. x 6. Grand View, Idaho.

Subspecific characters—Size slightly larger than *Ondatra idahoensis minor*. Average length of $M\bar{1}$ 10 per cent greater. Anterior wall of third outer re-entrant angle with distinct backward curvature.

Description—*Ondatra idahoensis idahoensis* is somewhat smaller than the extinct species *O. annectens*, heretofore the smallest known species of the genus. Among Recent voles, our form compares favorably in size with *Neofiber alleni*.

The first upper molar (fig. 7c) exhibits on the occlusal surface an anterior loop and four alternating triangles. The tooth has a characteristic pattern and does not differ essentially from that in Recent *Ondatra*. $M\underline{1}$ possesses, however, three roots instead of two, the small third root supporting the first closed triangle. In addition, the dentinal spaces of the tooth are confluent. Moreover, confluency of the dentinal spaces is a distinctive character for all of the cheek-teeth of *Ondatra idahoensis*. In Recent *Ondatra* the alternating triangles are very tightly closed. $M\underline{2}$ (fig. 7b) presents an anterior loop and three alternating triangles. This tooth is also of normal pattern and agrees

[1] M. A. C. Hinton, *op. cit.*, 349, 1926.

closely in structure with the corresponding tooth in Recent *Ondatra*. $M\underline{3}$ (fig. 7a) possesses a transverse loop, two alternating triangles and a posterior loop. It differs from the corresponding tooth in Recent species of *Ondatra* in the anteroposterior shortening of the posterior loop.

The mandibular incisor crosses from the lingual to the buccal side, apparently between $M\overline{2}$ and $M\overline{3}$, and terminates above the dental foramen. Its termination is indicated by a pronounced hump developed on the external surface of the ascending ramus. $M\overline{3}$ is not noticeably displaced by the incisor. A slight displacement of $M\overline{2}$ appears to take place in some specimens.

The occlusal surface of $M\overline{1}$ is composed of a posterior loop, five alternating triangles, and an anterior loop possessing complications (fig. 8b) in an early stage of wear. The first lower molar of *Ondatra idahoensis* differs from the corresponding tooth in known species of *Ondatra* in the reduction of the re-entrant angles cutting the anterior loop. Even in very young specimens the re-entrant angles cutting the anterior loop of this tooth are present as rather shallow infolds. The latter are probably no better developed than the early complications present in some individuals of *Neofiber*. Usually in Recent

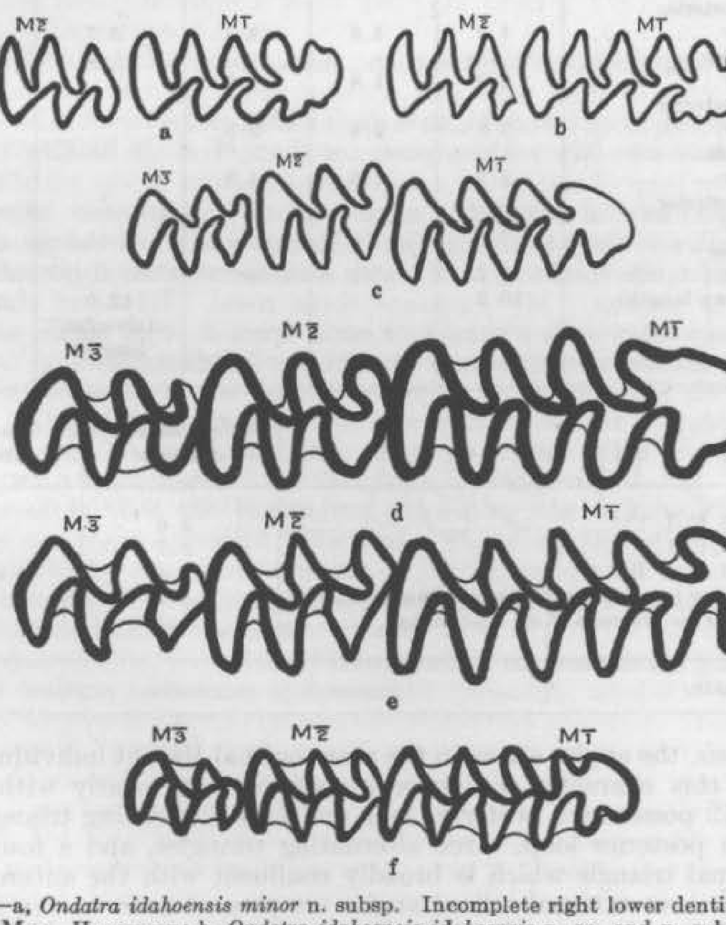


FIG. 8.—a, *Ondatra idahoensis minor* n. subsp. Incomplete right lower dentition, No. 12624 U. S. Nat. Mus., Hagerman; b, *Ondatra idahoensis idahoensis* n. sp. and n. subsp., incomplete right lower dentition, No. 1380 C. I. T., Grand View; c, *Ondatra idahoensis idahoensis* n. sp. and n. subsp., left lower dentition, No. 1376 C. I. T., Grand View; d, *Ondatra zibethica osoyoosensis* (Lord), left lower dentition, No. 8463 Dickey Coll., Recent, Idaho; e, *Ondatra zibethica osoyoosensis* (Lord), left lower dentition, No. 17875 Dickey Coll., Recent, British Columbia; f, *Neofiber alleni* True, left lower dentition, No. 9742 Dickey Coll., Recent, Florida. x 6.

specimens of the genus, the fourth external and the fifth internal re-entrant angles cut the anterior loop deeply enough to isolate a sixth and seventh triangle (fig. 8c). However, some specimens, apparently after considerable wear, present a pattern comparable to that in O. *idahoensis* (cf. figs. 8c and 8d). In the latter form the absence of the sixth and seventh triangles is constant in the material available. Reduction of the fourth external and fifth internal re-entrant angles is not shown in other fossil species of *Ondatra*. In the first lower molar of *O. oregona* and *O. annectens* these angles are deeper than in any existing species, and in the case of the only other known fossil species,

Comparative measurements (in millimeters)

	O. i. idahoensis Calif. Inst. Tech. Grand View No. 1376	*O. i. idahoensis* Calif. Inst. Tech. Grand View No. 1380	*O. i. minor* U. S. N. M. Hagerman No. 12624	*O. annectens* A. M. N. H. Conard Fissure No. 12424	*O. zibethica osoyoosensis* Dickey Coll. Recent No. 17875
$M\overline{1}$, anteroposterior diameter	4.9	4.6	4.3	5.7	7.4
$M\overline{1}$, transverse diameter	2.2	1.8	1.9	....	3.1
$M\overline{2}$, anteroposterior diameter	2.8	2.4	2.6	....	3.7
$M\overline{2}$, transverse diameter	2.1	1.6	1.8	....	2.7
$M\overline{3}$, anteroposterior diameter	2.5	...	...	....	3.6
$M\overline{3}$, transverse diameter	1.7	...	...	....	2.4
$M\overline{1}$-$M\overline{3}$, (crown length)	10.2	...	...	12.0 (alveolar length)	14.6

	Anteroposterior diameter	Transverse diameter
$M\underline{1}$, No. 1377, C. I. T.	3.6	2.1
$M\underline{2}$, No. 1378, C. I. T.	2.7	1.9
$M\underline{3}$, No. 1379, C. I. T.	*a*2.4	*a*1.5
$M\overline{1}$, Grand View loc. average of six specimens	4.7	2.1
$M\overline{1}$, Hagerman loc. average of six specimens	4.2	1.9

a, Approximate.

O. nebrascensis, the angles are as in the more normal Recent individuals of the genus.[1] In this character *O. idahoensis* agrees more nearly with *Neofiber* (fig. 8f). $M\overline{2}$ possesses a posterior loop and four alternating triangles. $M\overline{3}$ consists of a posterior loop, three alternating triangles, and a fourth small antero-external triangle which is broadly confluent with the antero-internal one. In $M\overline{3}$ three external salient angles are present as in known species of *Ondatra*, while two only are found in *Neofiber* (cf. figs. 8c, 8d, and 8f). Some Recent specimens of *Ondatra* apparently possess only two salients,[2] but so far as is known two is the maximum number found in *Neofiber*.

[1] N. Hollister, U. S. Dept. Agric., North American Fauna No. 32, 32-34, 1911.
[2] N. Hollister, *op. cit.*, 34, 1911.

In addition to the characters discussed above, *Ondatra idahoensis* differs from all other described species of *Ondatra* in the absence of cement on the cheek-teeth. It differs from Recent species of *Ondatra*, and perhaps from described fossil species as well, in an earlier development of roots in the cheek-teeth. In a jaw of the Idaho form where the transitory complications of the anterior loop of $\overline{M1}$ are still present, the pulp cavities of $\overline{M3}$ are closed. In Recent *Ondatra* this tooth, in contrast to the remaining cheek-teeth, shows the smallest development of roots.

In the pattern of the cheek-teeth and especially in that of the first lower molar, *Ondatra idahoensis* approaches *Neofiber*. However, the Idaho type is quite distinct generically from this form. The cheek-teeth of *Neofiber* grow with a persistent pulp-cavity present in contrast to the rather early development of roots in the cheek-teeth of *O. idahoensis*. Differences of less importance which distinguish *O. idahoensis* from *Neofiber* are: (1) $\overline{M3}$ with three outer salients instead of two, (2) teeth lacking cement, and (3) dental foramen of ramus situated somewhat above the posterior notch as in Recent *Ondatra* and not nearly opposite this notch as in a compared specimen of *Neofiber*.

Ondatra idahoensis minor n. subsp.

Locality—Hagerman, Idaho.

Type—No. 12624 U. S. Nat. Mus., an incomplete right ramus with $\overline{M1}$-$\overline{M2}$ (fig. 8a).

Additional material—No. 12623 U. S. Nat. Mus., a left ramus with $\overline{M1}$-$\overline{M3}$; Nos. 12625-12627 U. S. Nat. Mus., incomplete rami; and various isolated cheek-teeth.

Subspecific characters—Size averaging slightly smaller than *Ondatra idahoensis idahoensis*. Average length of $\overline{M1}$ 10 per cent smaller. Anterior wall of the third outer re-entrant angle nearly transverse with respect to tooth-axis.

Remarks—This form is very close to *Ondatra idahoensis idahoensis*, but appears to be distinguished from it by the characters cited above. Further differences are to be noted but do not seem to be constant throughout the material. Thus, the fourth and fifth triangles of $\overline{M1}$ are rounded, especially the fourth, and the fourth and fifth triangles of this tooth are slightly more confluent with the anterior loop than in *O. i. idahoensis*.

It is possible that the characters separating the subspecies *minor* and *idahoensis* are more apparent than real. However, the available material, which is relatively abundant, appears to justify subspecific separation of the Hagerman type. The geographic separation of the two forms likewise may suggest the presence of two distinct races.

For measurements, see table of comparative measurements under the discussion of *Ondatra idahoensis idahoensis*.

PLATE 1

Castor cf. *accessor* Hay

FIGS. 1, 1a.—Right $M\underline{1}$, No. 1361 C. I. T., Grand View, Idaho; x 2. Fig. 1, occlusal view; fig. 1a, external view.

FIG. 2.—Left $M\underline{3}$ No. 1362 C. I. T., Grand View, Idaho; x 2.

FIGS. 3, 3a.—Fragmentary right ramus with $M\overline{1}$, No. 1360 C. I. T., Grand View, Idaho; x 2. Fig. 3, external lateral view; fig. 3a, occlusal view.

FIG. 5.—Left $M\underline{2}$, No. 1363 C. I. T., Grand View, Idaho; x 2.

Thomomys gidleyi n. sp.

FIGS. 4, 4a.—Left ramus of mandible, No. 12651 U. S. Nat. Mus., Hagerman, Idaho; x 6. Fig. 4, external view; fig. 4a, occlusal view.

Citellus? species

FIG. 6.—Right $P\overline{4}$, No. 12963 U. S. Nat. Mus., Hagerman, Idaho; x 6.

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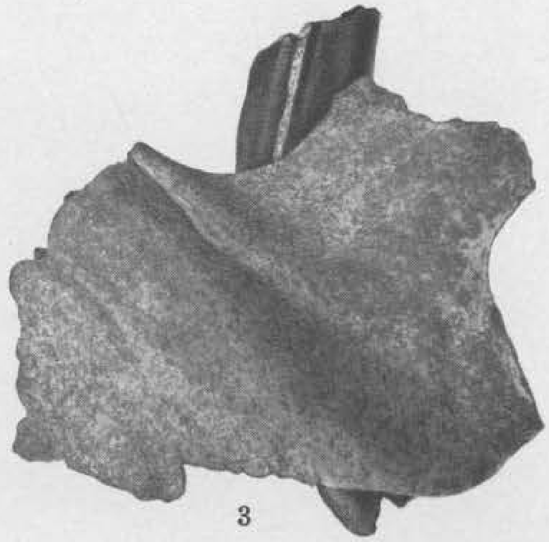

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1[a]

4

3[a]

5

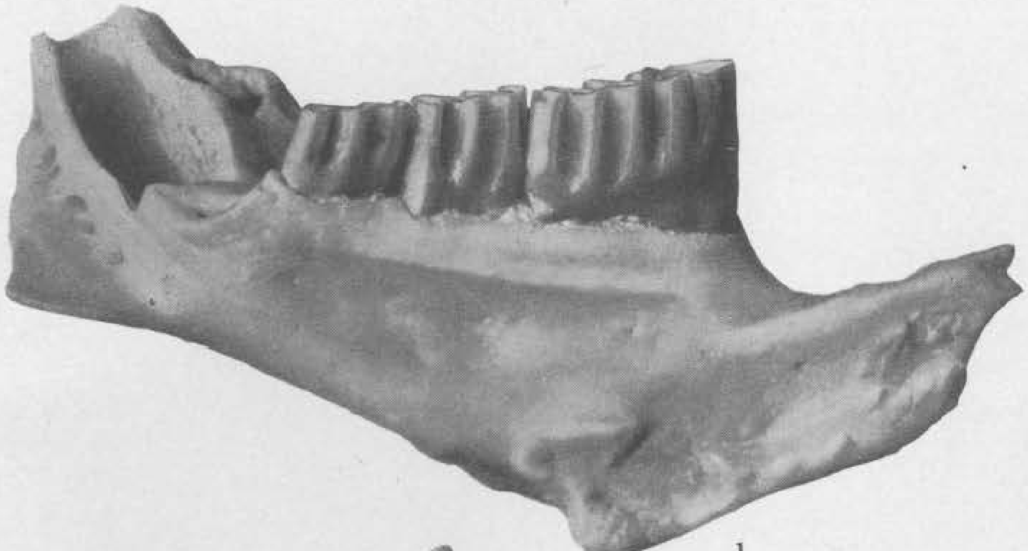
4[a]

6

PLATE 2

FIGS. 1, 2.—*Ondatra idahoensis idahoensis* n. sp. and n. subsp. Left ramus of mandible, No. 1376 C. I. T., Grand View, Idaho; x 5. Fig. 1, internal view; fig. 2, external view.

FIGS. 3, 4.—*Mimomys? parvus* n. sp. Right ramus of mandible, No. 1375 C. I. T., Grand View, Idaho; x 5. Fig. 3, external view; fig. 4, internal view.



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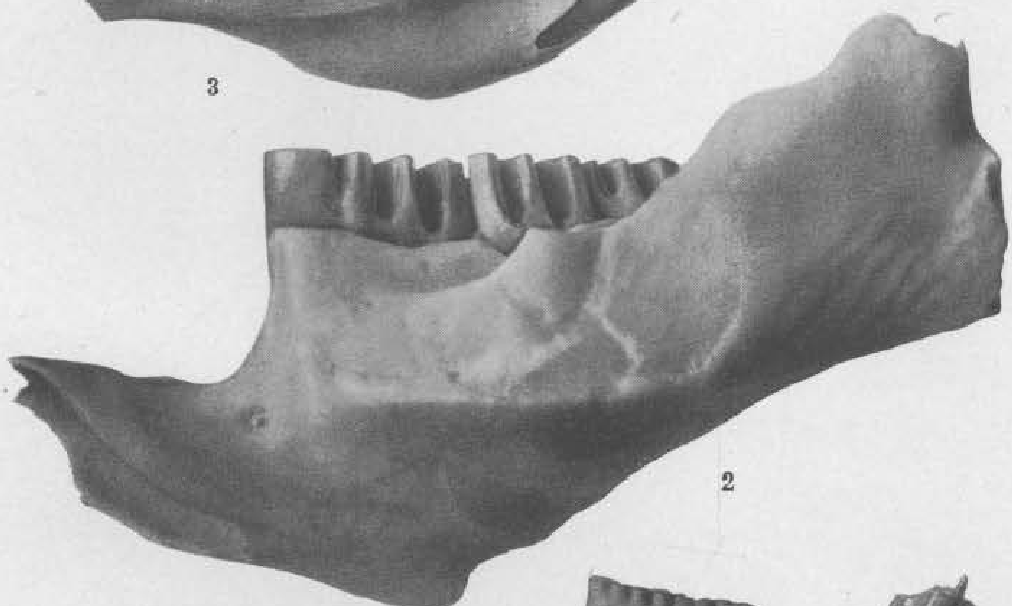

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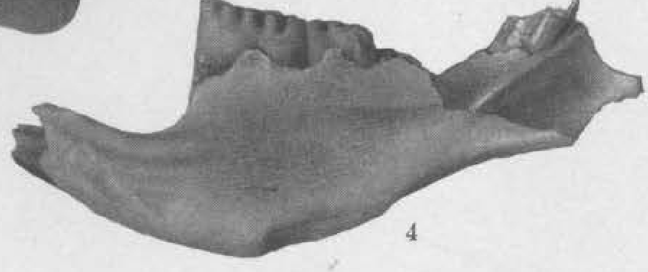

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