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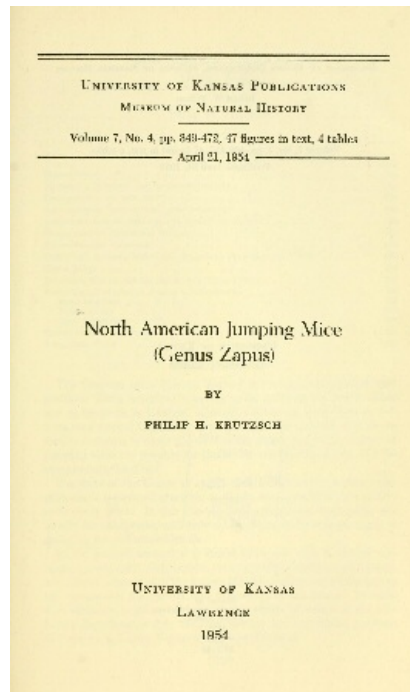
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**North American Jumping Mice
(Genus Zapus)**

BY

PHILIP H. KRUTZSCH

UNIVERSITY OF KANSAS
LAWRENCE
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Philip H. Krutzsch

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INTRODUCTION

The jumping mice (Genus *Zapus*) are widely distributed over northern North America, occurring as far north as the Arctic Circle and as far south as Georgia, Missouri, Oklahoma, New Mexico, Arizona, and central California. In some years these small rodents are locally common in moist places that are either grassy or weedy; the jumping mice are notable for the much enlarged hind legs and the exceptionally long tail.

Members of the Genus as a whole have received no serious comprehensive taxonomic attention in the 54 years since Preble's (1899) revisionary work. In this time 15 new names have been proposed, mostly for subspecies, and only a few attempts have been made at grouping related named kinds.

In the present account it is aimed to record what is known concerning geographic distribution, taxonomically significant characters, and interrelationships of the known kinds as well as to provide means for recognizing the species and subspecies in the genus. In addition, attention is given to the probable center of origin of the subfamily Zapodinae and to the relationships and taxonomic positions of the genera *Zapus*, *Napaeozapus*, and *Eozapus*.

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MATERIALS, METHODS, AND ACKNOWLEDGMENTS

The present report is based on a study of approximately 3,600 specimens that were assembled at the Museum of Natural History of the University of Kansas or that were examined at other institutions. Most of these specimens are stuffed skins with skulls separate. Skulls without skins, skins without skulls, entire skeletons, and separately preserved bacula are included as a part of the total. Almost every specimen is accompanied by an attached label, which bears place and date of capture, name of collector, external measurements, and sex.

Specimens used in the study of geographic variation were arranged by season of capture and according to geographic location; then they were segregated as to sex, and, under each sex, by age. Next, individual variation was measured in comparable samples of like age, sex, season, and geographic origin. Finally, comparable materials were arranged geographically in order to determine variations of systematic significance.

The only external measurements used were total length, length of tail, and length of hind foot; these measurements were recorded by the collectors on the labels attached to the skins. Height of the ear was not used since it was not recorded by many of the collectors.

In order to determine which cranial structures showed the least individual variation but at the same time showed substantial geographic variation, a statistical analysis was made of the 30 measurements, of cranial structures, heretofore used in taxonomic work on *Zapus*. The following measurements of the skull showed the least individual variation but showed some geographic variation and therefore, were used in this study. See [figs. 1-3](#) which show points between which measurements were taken:

Occipitonasal length.—From anteriormost projection of nasal bones to posteriormost projection of supraoccipital bone. *a* to *a'*

Condylbasal length.—Least distance from a line connecting posteriormost parts of exoccipital condyles to a line connecting anteriormost projections of premaxillary bones. *b* to *n*

Palatal length.—From anterior border of upper incisors to anteriormost point of postpalatal notch. *b* to *b'*

Incisive foramina, length.—From anteriormost point to posteriormost point of incisive foramina. *c* to *c'*

Incisive foramina, breadth.—Greatest distance across incisive foramina perpendicular to long axis of skull. *f* to *f'*

Zygomatic length.—From anteriormost point of zygomatic process of maxillary to posteriormost point of zygomatic process of squamosal. *d* to *d'*

Zygomatic breadth.—Greatest distance across zygomatic arches of cranium at right angles to long axis of skull. *j* to *j'*

Breadth of inferior ramus of zygomatic process of maxillary.—Greatest distance across inferior ramus of zygomatic process of maxillary taken parallel to long axis of skull. *d* to *e*

Palatal breadth at M3.—Greatest distance from inside margin of alveolus of right M3 to its opposite. *g* to *g'*

Palatal breadth at P4.—Same as above except taken at P4. *g* to *g'*

Mastoid breadth.—Greatest distance across mastoid bones perpendicular to long axis of skull. *h* to *h'*

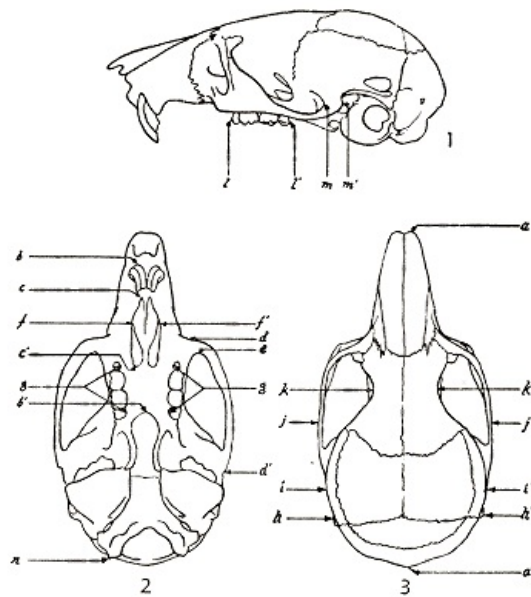
Breadth of braincase.—Greatest distance across braincase taken perpendicular to long axis of skull. *i* to *i'*

Interorbital breadth.—Least distance across top of skull between orbits. *k* to *k'*

Length of maxillary tooth-row.—From anterior border of P4 to posterior border of M3. *l* to *l'*

Breadth of base zygomatic process of squamosal.—Greatest distance across base of zygomatic process of squamosal taken parallel to long axis of skull. *m* to *m'*

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FIGS. 1-3. Three views of the skull to show points between which measurements of the skull were taken. Based on *Z. t. montanus*, adult, female, No. 22165 KU, Cascade Divide, 6400 ft., Crater Lake Nat'l Park, Klamath County, Oregon. $\times 4$.

The baculum has a characteristic size and shape according to the species, and the following significant measurements of the structure were taken:

Greatest length.—From posteriormost border of base to anteriormost point on tip.

Greatest breadth at base.—Greatest distance across base taken parallel to long axis of bone.

Greatest breadth at tip.—Greatest distance across tip taken parallel to long axis of bone.

In the descriptions of color the capitalized color terms refer to those in Ridgway (1912). Any color term that does not have the initial letter capitalized does not refer to any one standard.

In the description of the subspecies the two sexes are treated as one because no significant secondary sexual variation was found. Only fully adult specimens of age groups 3 to 5, as defined on pages 377 and 388, have been considered.

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Unless otherwise indicated, specimens are in the University of Kansas Museum of Natural History. Those in other collections are identified by the following abbreviations:

- AMNH. American Museum of Natural History.
- CAS. California Academy of Science.
- CM. Carnegie Museum.
- Chic. AS. Chicago Academy of Science.
- Clev. MNH. Cleveland Museum of Natural History.
- LMH. Collection of Lawrence M. Huey.
- JKJ. Collection of J. Knox Jones, Jr.
- CMNH. Colorado Museum of Natural History.
- FM. Chicago Museum of Natural History.
- HM. Hastings Museum, Hastings, Nebraska.
- ISC. Iowa State College.
- MCZ. Museum of Comparative Zoology.
- MO. University of Missouri Museum of Zoology.
- MVZ. Museum of Vertebrate Zoology, Berkeley, Calif.
- NMC. National Museum of Canada.
- NGFP. Nebraska Game, Forestation, and Parks Commission.
- NCS. North Carolina State College.
- OHIO. Ohio Wildlife Research Unit, Ohio State University.
- OKLA. Oklahoma Agricultural and Mechanical College.
- PM. Provincial Museum of British Columbia.
- ROM. Royal Ontario Museum of Zoology.
- SDM. San Diego Natural History Museum.
- SITC. Southern Illinois Teachers College.
- USBS. United States Biological Surveys Collection.
- USNM. United States National Museum.
- UCM. University of Colorado Museum.
- UIM. University of Illinois Museum of Natural History.
- UM. University of Michigan Museum of Zoology.

The species are arranged from least to most progressive, and the subspecies are arranged alphabetically.

The synonymy for each subspecies includes first a citation to the earliest available name then one citation to each name combination that has been applied to the subspecies and, finally, any other especially important references.

Marginal records of occurrence for each subspecies are shown on the maps by means of hollow circles and these localities are listed in clockwise order beginning with the northernmost locality. If more than one of these localities lies on the line of latitude that is northernmost for a given subspecies the western-most of these is recorded first. Marginal localities have been cited in a separate paragraph at the end of the section on specimens examined in the account of a subspecies. Localities that are not marginal are shown on the maps by solid black circles. Localities that could not be represented on the distribution map because of undue crowding or overlapping of symbols are italicized in the lists of specimens examined and in the lists of marginal records.

The localities of capture of specimens examined are recorded alphabetically by state or province, and then by county in each state or province. Within a county the specimens are recorded geographically from north to south. The word "County" is written out in full when the name of the county is written on the label of each specimen listed for that county, but the abbreviation "Co." is used when one specimen or more here assigned to a given county lacks the name of the county on the label. [355]

The following account has been made possible only by the kindness and cooperation of those persons in charge of the collections listed above. For the privilege of using the specimens in their care I am deeply grateful, as I am also to Prof. A. Byron Leonard for assistance with [figures 35-37](#), to Dr. Rufus Thompson for [figures 16-21](#), and to Mr. Victor Hogg who made all of the other illustrations. My wife, Dorothy Krutzsch, helped untiringly in assembling data, in typing the manuscript, and gave me continued encouragement. Finally, I am grateful to Professor E. Raymond Hall for guidance in the study and critical assistance in the preparation of the manuscript and to Professors Rollin H. Baker, Robert W. Wilson, and Robert E. Beer for valued suggestions.

PALEONTOLOGY OF THE GENUS

The fossil record of the genus *Zapus* is scanty. All of the known fossils of it are lower jaws of Pleistocene Age. The Recent species *Z. hudsonius* was recorded by Cope (1871:86) in the Port Kennedy Cave fauna (pre-Wisconsinian) of Pennsylvania. Gidley and Gazin (1938:67) reported a single mandibular ramus bearing m1-m3 recovered from the Cumberland Cave (pre-Wisconsinian) of Maryland. The teeth are not typical of modern *Zapus* in that m1 and m2 are shorter crowned and m1 has a longer anterior lobe. Gidley and Gazin, nevertheless, considered their material insufficient for establishing a new species.

Two extinct species have been described: *Zapus burti* Hibbard (1941:215) from the Crooked Creek formation (= Meade formation of the State Geological Survey of Kansas) mid-Pleistocene of Kansas and *Zapus rinkerii* Hibbard (1951:351) from the Rexroad formation (= Blanco formation of the State Geological Survey of Kansas) of Blancan Age of Kansas. Both species resemble *Zapus hudsonius*, but differ from it in broader crowned more brachydont cheek-teeth. *Z. rinkerii* differs from *Z. burti* and *Z. hudsonius* by a more robust ramus, broader molars, and three instead of two internal re-entrant valleys posterior to the anterior loop on m1. The three species *Z. rinkerii*, *Z. burti*, and *Z. hudsonius* are in a structurally, as well as a geologically, progressive series. The trend in dentition is from broad, brachydont cheek-teeth to narrow, semi-hypsodont cheek-teeth. [356]

RELATIONSHIPS, DISTRIBUTION, AND SPECIATION

Relationships in the Subfamily Zapodinae

The subfamily Zapodinae is known from Pliocene and Pleistocene deposits of North America and now occurs over much of northern North America and in Szechuan and Kansu, China. The living species occur among grasses and low herbs in damp or marshy places both in forested areas and in plains areas.

The early Pliocene *Macrognathomys nanus* Hall (1930:305), originally described as a Cricetid, is actually a Zapodid as shown by the structure of the mandibular ramus, shape of the incisors, and occlusal pattern of the cheek-teeth.

If *Macrognathomys* can be considered a member of the subfamily Zapodinae (possibly it is a sicistine) then it represents the oldest known member of this subfamily. Judging from the published illustrations, *Macrognathomys* seems to be structurally ancestral to the Mid Pliocene *Pliozapus solus* Wilson; the labial re-entrant folds are wider and shorter and on m2 and m3 fewer. The difference in stage of wear of the teeth in *Macrognathomys* and *Pliozapus* is a handicap in comparing the two genera but they are distinct. Wilson (1936:32) points out that *Pliozapus*

clearly falls in the Zapodinae and stands in an ancestral position with respect to the structurally progressive series *Eozapus*, *Zapus*, and *Napaeozapus*. Nevertheless, *Pliozapus* cannot be considered as directly ancestral to *Eozapus* because of the progressive features in the dentition of *Pliozapus*. Wilson (1937:52) remarked that if *Pliozapus* is ancestral to *Zapus* and *Napaeozapus*, considerable evolution must have taken place in the height of crown and in the development of the complexity of the tooth pattern. In contrast to Wilson's opinion, Stehlin and Schaub (1951:313) placed *Pliozapus* and *Eozapus* in the subfamily Sicistinae because certain elements in the occlusal pattern of the cheek-teeth are similar. I disagree with those authors and hold with Wilson; I consider *Pliozapus* and *Eozapus* in the subfamily Zapodinae. In dental pattern *Pliozapus*, as Wilson (1936:32) pointed out, resembles the Recent Eurasiatic sicistid, *Sicista* more than do *Zapus* or *Napaeozapus*. Nevertheless, from *Sicista* Wilson distinguishes *Pliozapus* and relates it to the subfamily Zapodinae by: "more oblique direction of protoconid-hypoconid ridge, anterior termination of this ridge at buccal portion of protoconid rather than between protoconid and metaconid as in *Sicista*; cusps more compressed into lophs; cheek-teeth somewhat broader; greater development of metastylid; greater development of hypoconulid ridge, ... absence of anteroconid...."

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Eozapus is more closely related to *Pliozapus* than to either *Zapus* or *Napaeozapus* (Wilson, 1936:32) but all four genera are in the subfamily Zapodinae. Stehlin and Schaub (op. cit.:158 and 311) relate *Eozapus* to the subfamily Sicistinae on the basis of similarity in the occlusal pattern of the cheek-teeth of *Eozapus* and various sicistines. Stehlin and Schaub do not consider other structures such as the elongate hind limbs, the shape of malleus and incus, and the shape of the baculum, in which there is close resemblance to the Zapodinae. It is these structural similarities as well as those, pointed out by Wilson (*loc. cit.*), in dentition that leads me to place *Eozapus* in the subfamily Zapodinae. The early Pleistocene *Zapus rinkeri* Hibbard shows that the *Zapus* stage of development had already been achieved perhaps as early as the late Pliocene. Hibbard (1951:352) thought that *Zapus rinkeri* was not structurally intermediate between *Pliozapus* and any Recent species of *Zapus*; although the teeth of *Z. rinkeri* have the broader, shallower, re-entrant folds of *Pliozapus*, these teeth are higher crowned and have an occlusal pattern resembling that of the Recent species of *Zapus*. The middle Pleistocene species, *Zapus burti* Hibbard, progressed essentially to the structural level of the Recent *Zapus hudsonius*, but the molars were more brachydont, broader crowned, and their enamel folds less crowded. Pleistocene material of pre-Wisconsin age obtained from cave deposits in Pennsylvania and Maryland is most nearly like *Zapus hudsonius*. One such cave deposit in Maryland contained an example of the Recent genus *Napaeozapus*, indicating that its history dates from at least middle Pleistocene time.

The Asiatic Recent Genus, *Eozapus*, has not progressed much beyond the Pliocene stage in zapidine evolution if *Pliozapus* be taken as a standard; the North American Recent Genus *Zapus* essentially achieved its present form by early Pleistocene times, and the Recent Genus *Napaeozapus* achieved its more progressive structure by middle Pleistocene times.

Perhaps *Pliozapus* and *Eozapus* represent one phyletic line and *Zapus* and *Napaeozapus* a second line, both of which lines evolved from a pre-zapidine stock in the Miocene. As mentioned earlier, Wilson (1936) thinks that *Pliozapus* is not directly ancestral to *Eozapus*. Possibly these two genera diverged at an early date; nevertheless, they are closely related primitive forms.

Zapus and *Napaeozapus* closely resemble each other and both are structurally advanced; *Napaeozapus* seems to have differentiated at a more rapid rate.

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According to Simpson (1947), the occurrence of the same group of mammals on two different land masses is to be taken as prima facie evidence that migration has occurred. Keeping in mind then the present geographic distribution, unspecialized condition of the dentition of *Eozapus*, and its resemblance to the extinct *Pliozapus* known from North America but not from Asia, it may be that *Eozapus* descended from primitive stock of a North American jumping mouse that was forced to the periphery (across the Asiatic North American land bridge) by the more specialized zapidine stock.

Subsequently or perhaps during the migration of the pre-*Eozapus* stock the zapidine stock may have dispersed transcontinentally, occupying most of northern North America. The unprogressive *Macrognothomys* and *Pliozapus* line which remained in North America may have become extinct. Any such period of dispersal and climatic equilibrium ended when glaciers came to cover most of the northern part of the continent and the mammals living there were forced southward by the ice or remained in ice-free refugia within the glaciated area. Later, with melting and retreat of the ice, the jumping mice could have again spread enough to occupy the northern part of the continent. Such glaciation isolated segments of the population and aided their evolution into distinct species.

If it be assumed, as Matthew (1915) did and as Hooper (1952:200) later on the generic level did, that the region of origin and center of dispersal for a given group of animals is characterized by the presence of the most progressive forms, then southeastern Canada and the northeastern United States make up the area of origin and center of dispersal in relatively late time of the subfamily Zapodinae. This area is inhabited by *Zapus hudsonius* and *Napaeozapus*, the most progressive members of the subfamily.

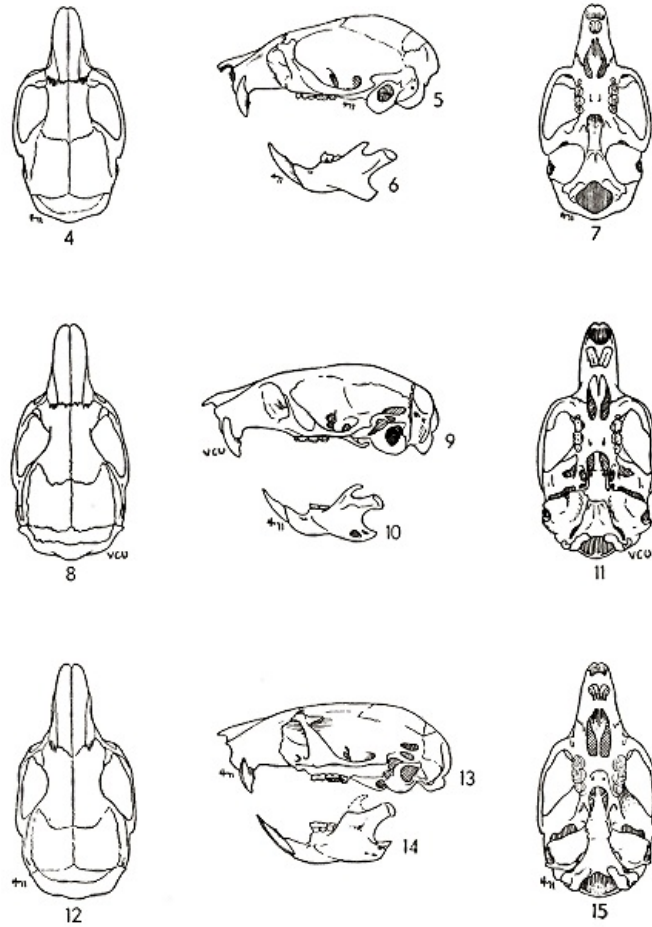
As I visualize it, the evolution of the Zapodinae occurred in two stages: the first stage involved the movement of the primitive pre-*Eozapus* stock to Asia and the second stage involved the dispersal, isolation, and specialization in North America of the more progressive basic

zapidine stock into the present genera *Zapus* and *Napaeozapus*.

Status of the genera *Eozapus*, *Zapus*, and *Napaeozapus*

The genus *Zapus* is one of three living genera in the subfamily Zapodinae. These genera *Zapus* and *Napaeozapus* from North America and *Eozapus* from China have been variously considered as subgenera of the genus *Zapus* (Preble, 1899) or as three separate genera (Ellerman, 1940).

[359]



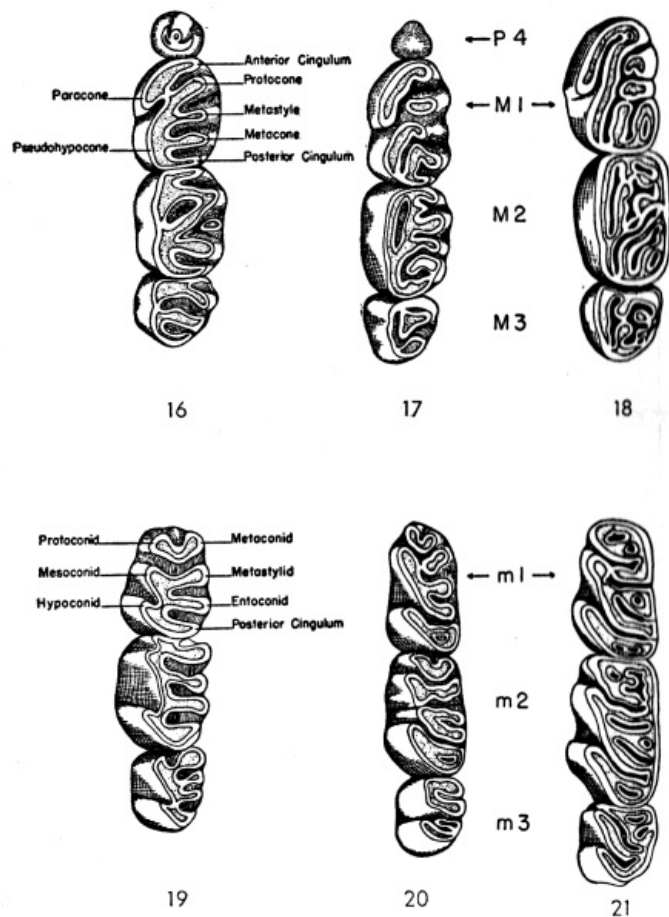
FIGS. 4-15. Three views of the skull and a lateral view of the left lower jaw of each of the Recent genera of the subfamily Zapodinae. $\times 1.5$.

FIGS. 4-7. *Eozapus s. vicinus*, adult, male, No. 240762 USNM, Lanchow, Kansu, China.

FIGS. 8-11. *Zapus h. pallidus*, adult, male, No. 240762 KU, 5 1/2 mi. N, 1 3/4 mi. E Lawrence, Douglas County, Kansas.

FIGS. 12-15. *Napaeozapus i. insignis*, adult, male, No. 41109 KU, Shutsburg Rd., at Roaring Creek, 600 ft., Franklin County, Massachusetts.

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FIGS. 16-21. Occlusal views of upper and lower right cheek-teeth, of the three Recent genera of the subfamily Zapodinae. $\times 12\frac{1}{2}$.

FIGS. 16 AND 19. *Eozapus s. vicinus*, adult (age group 3), male, No. 240762 USNM, Lanchow, Kansu, China.

FIGS. 17 AND 20. *Zapus h. alascensis*, adult (age group 2), female, No. 29073 KU, E side Chilkat River, 9 mi. W and 4 mi. N Haines, Alaska.

FIGS. 18 AND 21. *Napaeozapus i. insignis*, adult (age group 3), male, No. 41109 KU, Shutsburg Rd., at Roaring Creek, 600 ft., Franklin County, Massachusetts.

Note especially the variation in complexity of occlusal pattern, width of re-entrant folds, and degree of tubercularity.

The remarkable similarity of the body form, post-cranial skeleton, mandibular rami, and general structure of the cranium of *Zapus*, *Napaeozapus*, and *Eozapus* indicate their relationship (see [figs. 4-15](#)); however, dissimilarity between the groups in the dentition (tooth number and occlusal pattern), bacula, and ear ossicles provides basis for considering them distinct genera. As pointed out earlier, *Zapus* and *Napaeozapus* appear to be more closely related and progressive and the Asiatic *Eozapus* somewhat removed and less progressive.

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Teeth.—According to the complexity in dental pattern and in number and size of the cheek-teeth, these genera can be arranged in a structurally progressive series with *Eozapus* showing the least complexity and *Napaeozapus* the most (see [figs. 16-21](#)). There are three distinct molar patterns; one is simple (*Eozapus*) and the others (*Zapus* and *Napaeozapus*) are more complex. The complexity is greatest in *Napaeozapus*, which is characterized by numerous additional flexures in the enamel and dentine. The simplicity of the molars of *Eozapus* is evident in the tuberculate rather than flat-crowned occlusal surface; the wide, simple, re-entrant bays; the small (or sometimes absent) anteroconid; and the essentially quadrilateral nature of the teeth. The molars of *Zapus* and *Napaeozapus* are flat crowned; however, *Zapus* has wider and fewer re-entrant bays, a smaller anteroconid, and less complexity in the occlusal pattern. The characteristics of the molar teeth would tend to indicate a close relationship between *Zapus* and *Napaeozapus* and to place *Eozapus* as primitive.

The absence of P4 in *Napaeozapus* would lead one to suspect that this genus has evolved at a more rapid rate than the historically older *Zapus* and *Eozapus* which still retain this structure. The small size of P4, even in the primitive *Eozapus*, indicates that it has long been of little use to the mouse. An even greater reduction of P4 in the more complex dentition of *Zapus* argues for complete loss of this tooth as the next step in specialization, such as is seen in the more

progressive *Napaeozapus*. The following parallel columns show selected differences between the occlusal patterns of the cheek-teeth of the three genera:

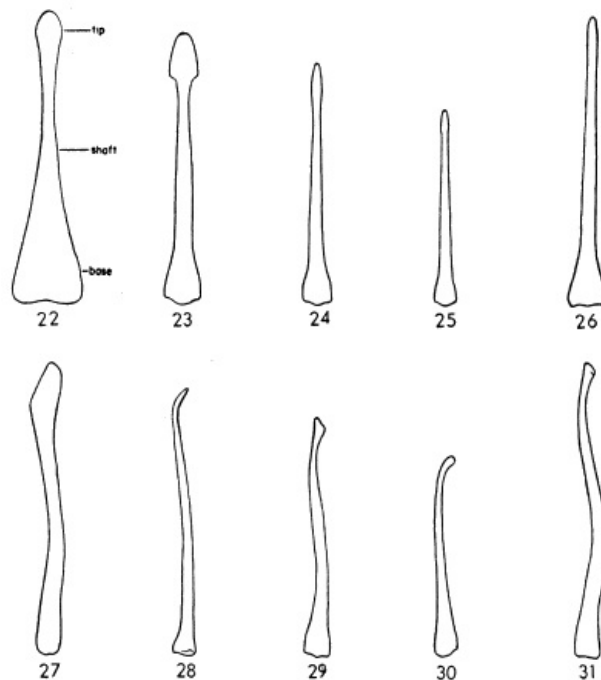
BACULUM.—The baculum (os penis) of *Eozapus* is known to me only from Vinogradov's (1925) figures of the dorsal and lateral aspects. The proximal end (base) is laterally expanded, and the shaft tapers gradually toward the distal end where it expands abruptly into the spade-shaped tip. In lateral aspect the bone is relatively thick; it is curved downward slightly from the proximal end to the base of the tip where it curves upward to a rounded point.

The baculum of *Zapus* differs from that of *Eozapus* as follows: base less expanded horizontally; shaft slenderer; distal end less spade-shaped except in *Z. trinotatus*. The tip is less expanded in *Z. princeps* and is still less so in *Z. hudsonius*. In *Napaeozapus* the tip is lanceolate, the base is narrow, and in lateral view the shaft is slender and curved (see [figs. 22-31](#)).

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<i>Eozapus</i>	<i>Zapus</i>	<i>Napaeozapus</i>
P4 Small —	Smaller	Absent
M1 Four wide labial re-entrant folds of equal length; paracone and metacone largest cusps; anterior cingulum large.	Four moderately narrow labial re-entrant folds of unequal length; 1st and 3d longer than 2d, 4th shortest; paracone smaller than in <i>Eozapus</i> ; metacone largest cusp; anterior cingulum small.	Three narrow labial re-entrant folds of unequal length, 1st long, 2d and 3d shorter; paracone and metacone larger than in <i>Zapus</i> and <i>Eozapus</i> ; anterior cingulum absent.
M2 Four wide labial re-entrant folds; 2d short, others of equal length but longer than 2d; anterior and posterior cingula large; occlusal pattern simple.	Four moderately narrow labial re-entrant folds of unequal length, 1st and 3d long, 2d and 4th short; anterior and posterior cingula moderately large; occlusal pattern moderately complex.	Narrow labial re-entrant folds, variable in number, often as many as 6; anterior and posterior cingula small; occlusal pattern complex.
M3 Three wide labial re-entrant folds of unequal length, 1st short, 2d and 3d long; anterior and posterior cingula low, small; occlusal pattern simple.	Two moderately narrow labial re-entrant folds of equal length; anterior and posterior cingula moderately large; occlusal pattern moderately complex.	Three narrow labial re-entrant folds of unequal length, 1st long, 2d and 3d short; anterior and posterior cingula large; occlusal pattern complex.
m1 Anterior oblique re-entrant fold separating equal sized protoconid and metaconid cusps; 3 wide lingual re-entrant folds of equal length; anteroconid absent; occlusal pattern simple; mesoconid present.	No anterior re-entrant fold; 4 moderately narrow lingual re-entrant folds of equal length, 1st joining 1st labial re-entrant fold, 4th joining 2d labial re-entrant fold; anteroconid well developed, encloses small lake; occlusal pattern moderately complex; mesoconid absent.	No anterior re-entrant fold; narrow lingual re-entrant folds variable in number, often as many as 4; anteroconid well developed, encloses 1 or 2 small lakes; occlusal pattern complex; mesoconid absent.
m2 Four wide lingual re-entrant folds of unequal length, 1st short, other 3 equal and long; anteroconid moderately large; occlusal pattern simple.	Four moderately narrow lingual re-entrant folds, 1st and 2d long, 3d and 4th short, 1st joins 1st labial re-entrant fold and 4th joins 2d labial re-entrant fold; anteroconid large; occlusal pattern moderately complex.	Narrow lingual re-entrant folds, variable in number, may be as many as 5; anteroconid large, encloses complex folds from 1st labial re-entrant fold; occlusal pattern complex.
m3 Three wide lingual re-entrant folds of near equal length; anteroconid absent; occlusal pattern simple; 1 labial re-entrant fold.	Narrow lingual re-entrant folds variable in number, as many as 3; anteroconid present; occlusal pattern complex; 2 labial re-entrant folds.	Three moderately narrow lingual re-entrant folds of unequal length, 1st and 2d long, 3d short; anteroconid absent; occlusal pattern moderately complex; 1 labial re-entrant fold.

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FIGS. 22-31. Dorsal and lateral views of the bacula of the Recent genera (and species of the genus *Zapus*) of the subfamily Zapodinae. $\times 10$.

FIGS. 22 and 27. *Eozapus setchuanus* (after Vinogradov, 1925:585).

FIGS. 23 and 28. *Zapus t. trinotatus*, adult, No. 94596 MVZ, $1\frac{1}{4}$ mi. ENE Amboy, 350 ft., Clark County, Washington.

FIGS. 24 and 29. *Zapus p. princeps*, adult, No. 20870 KU, 3 mi. S Ward, Boulder County, Colorado.

FIGS. 25 and 30. *Zapus h. pallidus*, adult, No. 22954 KU, 4 mi. N, $1\frac{3}{4}$ mi. E Lawrence, Douglas County, Kansas.

FIGS. 26 and 31. *Napaeozapus i. insignis*, adult, No. 41110 KU, Shutsburg Rd., at Roaring Creek, 600 ft., Franklin County, Massachusetts.

EAR OSSICLES.—The auditory ossicles are of three types which differ only slightly. These ossicles possibly are more conservative than some other structures because the ossicles are not so much affected by the molding influence of the environment.

Instances of variation in the auditory region in mammals in general are small, even at the family level; therefore, these differences in the subfamily Zapodinae are offered as additional support for recognizing *Eozapus*, *Zapus*, and *Napaeozapus* as distinct genera. The distinctive features are chiefly in the malleus and incus; the stapes, however, differs slightly and, therefore, it too is described (see [figs. 32-34](#)).

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In *Eozapus* the head of the malleus is narrow, oblong, and rounded dorsally and attaches to the body by a long, slender, abruptly recurved neck. The body is weakly pointed ventrally and rounded dorsally. A beaklike manubrium malleus composed of anterior projecting external and internal spines extends from the body to the tympanum. The incus has a dorsally rounded body with an anterior downward snoutlike projection with which the malleus articulates. The short limb of the incus is broad basally and narrows somewhat distally. The long limb is narrow and its articulating lenticular process is a flat circular structure. The limbs of the stapes are wide-spread and heavy. The neck is short and wide with a large circular articulating surface.

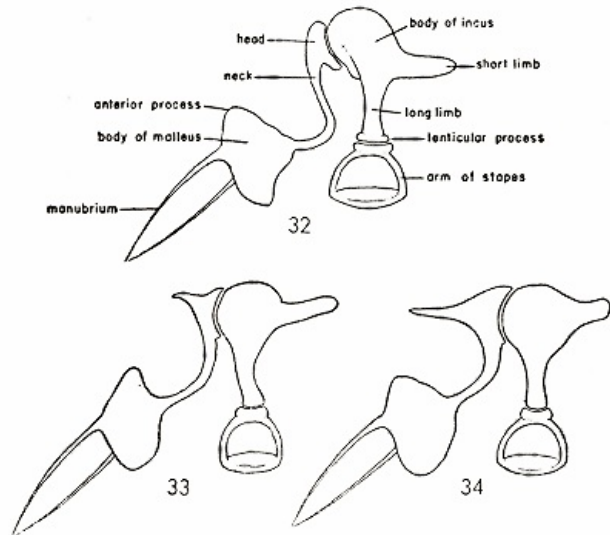
In *Zapus* the head of the malleus is angular with an anterior projecting point and is flattened in dorsal aspect. The neck is slender, elongate, and gently curved away from the long limb of the incus. The body is pointed dorsally and rounded ventrally, the reverse of the condition in *Eozapus*. There is a beaklike manubrium malleus composed of internal and external anteriorly projecting spines extending from the body to the tympanum as in *Eozapus*. The incus has a rounded body with a long angular limb articulating via a small lenticular process with the stapes. The short limb is narrow but does not taper distally as in *Eozapus*. The limbs of the stapes are relatively narrow, weak, and gently curved. The neck is longer and more slender than that of *Eozapus*.

In *Napaeozapus* the head and neck of the malleus resemble those of *Zapus* but are less

robust. The body is more rounded dorsally, having the curved dorsal surface directed anteriorly rather than posteriorly (as in *Zapus*) and the lateral surface is nearly flat instead of curved as in the other genera. The manubrium resembles that of *Eozapus* and *Zapus*. The body of the incus is flattened dorsally but otherwise rounded. The long limb of the incus is angular and longer than that of *Zapus*. The short limb of the incus is broad at the base and tapers distally. The limbs of the stapes are narrow, weak, and abruptly curved. The neck is more slender and elongate than in *Zapus*.

In summary: Only the head and body of the malleus and the short and long limbs and body of the incus are sufficiently consistent within a given group to be of taxonomic importance. The similarity in the morphology of these ossicles indicates a close relationship between all three genera. *Zapus* and *Napaeozapus* resemble one another more than either resembles *Eozapus*. The differences recorded are constant between the described groups and, therefore, are considered to be of taxonomic significance. The differences give basis for dividing the subfamily Zapodinae into the three genera *Eozapus*, *Zapus*, and *Napaeozapus*.

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FIGS. 32-34. Lateral views of the left ear ossicles (articulated) of the Recent genera of the subfamily Zapodinae. $\times 20$.

FIG. 32. *Eozapus s. vicinus*, adult, male, No. 240762 USNM, Lanchow, Kansu, China.

FIG. 33. *Zapus p. princeps*, adult, male, No. 32858 KU, Medicine Wheel Ranch, 28 mi. E Lovell, Big Horn County, Wyoming.

FIG. 34. *Napaeozapus i. insignis*, adult, male, No. 9544 KU, 3 mi. W Base Station, Coos County, New Hampshire.

Distribution of and Speciation in the Genus *Zapus*

Many of the described kinds of the genus *Zapus* were initially named as distinct species (see Preble, 1899). Subsequently (see Hall, 1931), some of the nominal species were reduced to the rank of subspecies. Only three species in the genus *Zapus* are recognized in the following account. The concept of species adopted here is, in Mayr's (1942:120) words, this: "Species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups." The three species are *Z. trinotatus*, *Z. princeps*, and *Z. hudsonius*. No hybridization is known where two occur together or where their ranges are adjacent. Each of these species has several geographically contiguous subspecies.

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The three species of *Zapus* are closely related but are not equally progressive. If eastern North America is considered to be the region of origin and center of dispersal of *Zapus* (see pp. 368-369) the geographically distant species would be expected to be the least progressive, and such seems to be the case. *Zapus trinotatus* is geographically farthest removed and structurally least progressive. *Zapus hudsonius* occurs at the center of dispersal and is the most progressive structurally whereas *Z. princeps* is geographically and structurally intermediate. Structural progressiveness is postulated for the species that has the simplest (in this instance specialized) baculum and smallest fourth upper premolar. The phyletic branches of the genus *Zapus* possibly developed from geographic segments of a population radiating from the centrally located progressive group. On continental areas where a species with a wide and continuous range gives rise to several daughter species, geographic isolation is thought to be important in bringing about the formation of species. The unspecialized populations conceivably occupied an area west of the present Rocky Mountains and south of latitude 50° . From later Miocene times on, climatic and geological differentiation occurred in this area, and with the growth of geological barriers and differentiation of habitat these unspecialized populations may have been separated into two ecological groups, one inhabiting the more arid area between the present Rocky Mountains and

the present Cascade Range and Sierra Nevada and the other group inhabiting the Pacific coastal region. Isolation of each of these groups probably was not complete. How far differentiation might have proceeded with incomplete isolation can only be guessed, but at least incipient differences probably were present and possibly the animals approached in character those found in these areas today in that the ecology of the region was much the same as now.

In the region between the Rocky Mountains and the present Cascade Range and the Sierra Nevada, the flora (in late Pliocene) became semidesert, which presumably made most of this region uninhabitable for jumping mice. The aridity probably induced local concentration into boreal montane islands, thus possibly displacing the populations of the two species that were in contact.

In Pleistocene times continental glaciation must have interrupted the contacts between the coastal, intermontane (the area between the present Rocky Mountains and the present Cascade Range and the Sierra Nevada), and northern and eastern groups of *Zapus* or mammals of any genus that occurred over all of this vast region. The advance of the ice southward would have increased opportunity for evolution by interposing barriers that isolated some populations. The populations possibly were re-established in interglacial periods and then were isolated again by another descent of glacial ice.

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If a population occupied the unglaciated coastal region of Oregon and Washington it may have been separated from other populations to the north and east by an ice cap which covered most of the Cascade Range. The population occupying the intermountain region probably was isolated from the population to the north and west. The formation of glaciers presumably reduced the size of areas available to the populations occupying eastern North America, Alaska, and Canada with the result that they persisted only in areas south of the ice or in ice-free refugia (central and western Alaska) within the glaciated area. According to Axelrod (1948), the flora in the eastern United States during the Pleistocene furnished most of the stock for the revegetation of southern and subarctic Canada east of the Rocky Mountains. Eastern populations of *Z. hudsonius* (or its progenitors) probably followed the spread of this vegetation and, thus, extended their range into Canada where they crossbred with populations advancing south and east from the refugia in Alaska. Western montane floras, which extended north along the Rocky Mountains and the Cascade and Coast ranges, probably paved the path for a northward migration of populations of the intermountain *Z. princeps* (or its progenitors). Populations of *Z. princeps* moved eastward from the present Rocky Mountains, inhabiting the high plains of southern Canada and the north-central United States. In general, *Zapus hudsonius* occupies the region to the north and to the east of that inhabited by *Zapus princeps*; however, the ranges of the two meet and overlap in central and northern British Columbia and in the high plains area of southern Alberta, Saskatchewan, eastern Manitoba, eastern Montana, North Dakota, and northern South Dakota. In these places of overlap, owing to range expansion following the retreat of the ice, there is no sign of interbreeding, indicating that the populations have attained specific rank.

Populations of both *Z. hudsonius* and *Z. princeps* occur together at Indianpoint Lake, British Columbia. Specimens taken there are readily sorted into two groups; none is intermediate. The difference in size between these species there is especially marked; *Z. p. saltator* there is a large derivative of *Z. princeps* and *Z. h. tenellus* is a medium-sized *Z. hudsonius*.

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Z. princeps minor and *Z. hudsonius intermedius* have been taken at several neighboring localities in North Dakota. Although these geographic races are more nearly of the same size (*minor* is a small subspecies of *princeps* and *intermedius* is a moderately large subspecies of *hudsonius*) they do not interbreed. Specimens of *Z. p. minor* and *Z. h. intermedius* have been obtained from an ecologically homogeneous area in the vicinity of Fort Totten and Devils Lake, North Dakota. Values obtained from several measurements of the skull and baculum allow for ready recognition of the two species. The populations from North Dakota are, however, not so widely divergent as are those populations from the area of contact in British Columbia. Perhaps the difference in the degree of distinction between the species at the two areas of contact is indicative of the length and completeness of geographic isolation between neighboring populations.

The ranges of *Z. trinotatus* and *Z. hudsonius* are not at present in contact, but the two species differ more strongly than do *hudsonius* and *princeps* or *princeps* and *trinotatus*. Therefore, *trinotatus* and *hudsonius* are here considered to be two distinct species.

As pointed out earlier in this discussion, the separation between the progenitors of *Z. trinotatus* and *Z. princeps* probably occurred when the present Cascade Range and the Sierra Nevada were being formed. From this time until Pleistocene glaciation an incomplete geographic isolation was in effect between the populations of the Pacific coast and the intermountain populations. Perhaps in the region north of the present Cascade Range there was moderate interbreeding between these populations and the transcontinental form. There may have been a similar zone of interbreeding along the crest of the present Cascades where the intermountain and coastal populations conceivably could have met. At least incipient characters probably were present when in Pleistocene time, continental glaciation further isolated the two populations. Since the retreat of the last ice (Wisconsin) the unprogressive coastal *Z. trinotatus* has expanded its range only slightly, reaching as far as southwestern British Columbia. It seems that ecological difference rather than the barrier formed by the higher elevations is responsible for the limited expansion of range. The population of *princeps* has extended its range northward to the southern

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part of the Yukon Territory but does not occur in coastal southern British Columbia because that area already was occupied by *Zapus trinotatus*. The ranges of the two species meet and overlap in southwestern British Columbia. The species occur sympatrically in Manning Park where, according to Carl *et al.* (1952:77), they occupy the same range in the region of Allison Pass, Pinewoods, and Timberline Valley. These workers remark that no intergradation was apparent between individuals of the two species obtained in the same trap line.

I have examined material of both species from Allison Pass. There the species differ in color, in the shape of the skull, and in the size and shape of the baculum. Material from Timberline Valley, an area in which Carl *et al.* (*loc. cit.*) reported both species, here is assigned to *Z. princeps*. Where bacula have been preserved the identity of the species is instantly possible.

In summary: First, a population of jumping mice, possibly a monotypic genus, occurred over most of North America; then this population partly divided into Pacific northwest, intermountain (from the east slopes of the present Rocky Mountains to the east slopes of the present Cascade Range and the Sierra Nevada), and transcontinental (eastern and northern) groups with the least progressive groups peripheral; a further reduction or possibly a complete isolation of these populations followed owing to Pleistocene glaciation (especially in the Wisconsin period); and, finally, the present day contacts were established between these populations which by now have differentiated into species. Conceivably, *Z. burti* (Blancan age) and *Z. rinkerii* (mid Pleistocene) may represent stages in the development of *Z. hudsonius*.

ANNOTATED LIST OF SPECIFIC AND SUBSPECIFIC NAMES

(Applied to the genus *Zapus* since 1899)

Edward A. Preble's (1899) early revisionary account of the genus *Zapus* provides an annotated list of the names which had been proposed for American jumping mice to that date. The present account supplies in chronological order the names proposed (including the new kinds described by Preble) in the 54 years since Preble's revision. Detailed synonymies are given for each kind under the accounts of the subspecies.

- 1899 *campestris* (*Zapus hudsonius*) Preble, N. Amer. Fauna, 15:20, August 8, 1899, applies to the jumping mouse of southeastern Montana, and the Black Hills region of Wyoming and South Dakota. [370]
- 1899 *minor* (*Zapus princeps*) Preble, N. Amer. Fauna, 15:23, August 8, 1899, originally applied to the jumping mouse of the prairies of Saskatchewan, but now includes populations of this species from the plains of Canada (southern Manitoba to Canadian Rockies) and northern United States (Montana, North and South Dakota).
- 1899 *oregonus* (*Zapus princeps*) Preble, N. Amer. Fauna, 15:24, August 8, 1899, originally applied to the jumping mouse of eastern Oregon, but now applies also to populations from southeastern Idaho, eastern and central Nevada, and extreme northeastern California.
- 1899 *major* (*Zapus*) Preble [= *Zapus princeps oregonus*], N. Amer. Fauna, 15:25, August 8, 1899, arranged as a subspecies of *Zapus princeps* by Hall, Univ. California Publ. Zool., 37:10, April 10, 1931; here considered a synonym of *Zapus princeps oregonus*.
- 1899 *nevadensis* (*Zapus*) Preble [= *Zapus princeps oregonus*], N. Amer. Fauna, 15:25, August 8, 1899, arranged as a subspecies of *Zapus princeps* by Hall, Univ. California Publ. Zool., 37:10, April 10, 1931; here considered a synonym of *Zapus princeps oregonus*.
- 1899 *orarius* (*Zapus*) Preble [= *Zapus trinotatus orarius*], N. Amer. Fauna, 15:29, August 8, 1899, applies to the animals from southwestern Marin County, California.
- 1911 *luteus* (*Zapus*) Miller [= *Zapus princeps luteus*], Proc. Biol. Soc. Washington, 24:253, December 23, 1911, applies to the jumping mouse in north-central and southern New Mexico and eastern Arizona.
- 1913 *australis* (*Zapus luteus*) Bailey [= *Zapus princeps luteus*], Proc. Biol. Soc. Washington, 26:129, May 21, 1913, was applied to the jumping mouse of southern New Mexico, but is here regarded as a synonym of *luteus*.
- 1920 *eureka* (*Zapus trinotatus*) Howell, Univ. California Publ. Zool., 21:229, May 20, 1920, applies to the jumping mouse of the humid coastal district of northern California.
- 1931 *cinereus* (*Zapus princeps*) Hall, Univ. California Publ. Zool., 37:7, April 10, 1931, applies to the jumping mouse of extreme northwest Utah and south-central Idaho.
- 1931 *curtatus* (*Zapus princeps*) Hall, Univ. California Publ. Zool., 37:7, April 10, 1931, applies to the jumping mouse of the Pine Forest Mountains, Humboldt County, Nevada.
- 1931 *palatinus* (*Zapus princeps*) Hall [= *Zapus princeps oregonus*], Univ. California Publ. Zool., 37:8, April 10, 1931, was applied to the jumping mouse of Lander and Nye counties, Nevada, but is here regarded as a synonym of *oregonus*.
- 1932 *kootenayensis* (*Zapus princeps*) Anderson, Ann. Rept. Nat. Mus. Canada for 1931:108, November 24, 1932, applies to the jumping mouse of southeastern and central British Columbia, northern Idaho, and eastern Washington.
- 1934 *idahoensis* (*Zapus princeps*) Davis, Jour. Mamm., 15:221, August 10, 1931, applies to populations in parts of British Columbia, Alberta, Idaho, Montana, and Wyoming.
- 1939 *utahensis* (*Zapus princeps*) Hall, Occas. papers Mus. Zool. Univ. Michigan, 296:3, November 2, 1934, applies to the jumping mouse of southeastern Idaho, western Wyoming, and eastern Utah. [371]
- 1941 *burti* (*Zapus*) Hibbard, Univ. Kansas Publ., Bull. State Geol. Surv. Kansas, 38:214, July 14, 1941, refers to two

- fragmentary right rami of Pleistocene age (Borchers fauna) from Loc. No. 9, Meade County, Kansas.
- 1942 *brevipes* (*Zapus hudsonius*) Bole and Moulthrop [= *Zapus hudsonius americanus*], Sci. Publ. Cleveland Mus. Nat. Hist., 5:168, September 11, 1942, based on specimens from Bettsville, Seneca County, Ohio, which are inseparable from *americanus* that has priority.
- 1942 *rafinesquei* (*Zapus hudsonius*) Bole and Moulthrop [= *Zapus hudsonius americanus*], Sci. Publ. Cleveland Mus. Nat. Hist., 5:169, September 11, 1942, was applied to jumping mouse of southeastern Ohio but is here regarded as a synonym of *americanus*.
- 1943 *ontarioensis* (*Zapus hudsonius*) Anderson [= *Zapus hudsonius canadensis*], Ann. Rept. Provancher Soc. Nat. Hist., Quebec, 1942:52, September 7, 1943, was applied to animals from eastern Ontario but is here regarded as a synonym of *canadensis*.
- 1950 *pallidus* (*Zapus hudsonius*) Cockrum and Baker, Proc. Biol. Soc. Washington, 63:1, April 26, 1950, refers to the jumping mouse from Kansas, Missouri, Oklahoma, Nebraska, and south-central South Dakota.
- 1951 *rinkeri* (*Zapus*) Hibbard, Jour. Mamm., 32:351, August, 1951, refers to single incomplete right ramus of upper Pliocene age, Rexroad formation and fauna, from Loc. UM-UK-47, Fox Canyon, sec. 25, T. 34S, R. 30W, XI Ranch, Meade County, Kansas.
- 1953 *intermedius* (*Zapus hudsonius*) described as new on [page 447](#) of this paper.
- 1953 *preblei* (*Zapus hudsonius*) described as new on [page 452](#) of this paper.

CHARACTERS OF TAXONOMIC WORTH

EXTERNAL PARTS.—The total length, the length of the tail, and the length of the hind foot are useful to some extent in distinguishing species and subspecies. Geographic variation in these measurements is clinal in some species. For example, *Zapus trinotatus*, which inhabits the western coast of North America, decreases in size from the northern to the southern part of its range. There is considerable overlap in external measurements, in specimens of the same age, between the species *Z. trinotatus* and *Z. princeps*, but only slight overlap between *Z. princeps* and *Z. hudsonius* and between *Z. trinotatus* and *Z. hudsonius*. If all collectors measured external parts in the same way the measurements would be more useful for differentiating one species from another.

PELAGE.—The pelage, both in its entirety and as individual hairs, provides taxonomic characters as has been pointed out by Moojen (1948:324) for the genus *Proechimys*, by Williams (1938:239) for the Insectivora, and by Hausman (1920:496) for several groups of mammals. In addition to the sensory hairs, facial vibrissae, nasal hairs, and carpal vibrissae, there are three kinds of hairs in the normal coat of *Zapus*: guard hairs, overhairs, and underfur. The guard hairs and underfur differ in different species (see [figs. 35-37](#)). [372]

The guard hairs taper at both ends, are elliptical in cross section, and are wider and longer than the other two kinds of hair. The bases of the guard hairs are grayish, and the amount of pigment gradually increases distally to a dark brownish or blackish shade. The guard hairs vary in greatest diameter from 96 microns to 168 microns, depending upon the species, and variation in diameter provides characters of taxonomic worth. No clinal variation in diameter of the guard hairs was detected. In *Z. hudsonius* the guard hairs average 115 microns (96-140) and are significantly narrower than those of *Z. princeps* and *Z. trinotatus*, which average 142 microns (130-168) and 141 microns (133-154), respectively. Pigmentation of the guard hairs contributes little information useful in separating the species of *Zapus*. All of the species have a prominent compounded medulla in which the pigment cells anastomose to form a labyrinthine column.

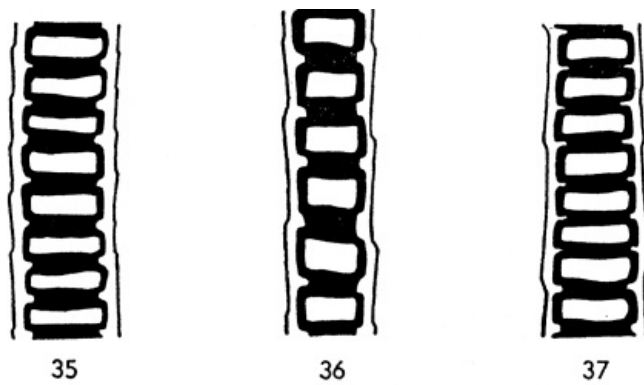
The individual hair of the underfur is cylindrical and tapers abruptly at each end; it is short, thin, flexible, and usually is bicolored on the back and sides of the mouse. The apical zone is yellow-brown (for example, Ochraceous-Buff) and the proximal part is whitish or grayish, which gradually darkens to near black subapically.

The width of a hair in the underfur is of no taxonomic significance, in that individual variation exceeds that between species.

The pattern of the pigment in the medulla of the hair, however, does vary specifically. Comparable samples from *Z. trinotatus*, *Z. princeps*, and *Z. hudsonius* of the same age, sex, and season reveal a pattern characteristic for each species (see [figs. 35-37](#)).

All species of *Zapus* agree closely in color pattern. A broad longitudinal dorsal band of some shade of yellow-brown flecked with black hairs is bordered by a lateral band of a lighter color usually containing fewer black hairs than on the dorsum. The underparts are usually white but are sometimes suffused with color resembling that on the sides. Between the white underparts and the darker color of the sides there is often a narrow, clear ochraceous stripe. Dorsal and lateral hairs are uniformly grayish-white at their bases; only the distal parts of the hairs are responsible for the external color of the animal.

The pelage of juveniles is usually finer and softer than the pelage of adults. The lateral and dorsal bands are not so conspicuously marked in young animals, and individual hairs are not so long or so wide as in adult animals. [373]



FIGS. 35-37. Photomicrographs of underhairs (middle third) from each of the species of the genus *Zapus*. $\times 500$.

FIG. 35. *Zapus t. orarius*, adult, female, No. 20293 MVZ, 3 mi. W Inverness, 300 ft., Marin County, California.

FIG. 36. *Zapus p. oregonus*, adult, male, No. 47856 KU, Harrison Pass R. S., Ruby Mt's, Elko County, Nevada.

FIG. 37. *Zapus h. pallidus*, adult, male, No. 22954 KU, 4 mi. N, $1\frac{3}{4}$ mi. E Lawrence, Douglas County, Kansas.

Preble (1899:7) and Howell (1920:226) remark as to the noticeable difference between pelages of spring and early fall. The pelage in spring is described as bright and fresh whereas that in fall is dull and worn. Actually both bright and worn pelages can occur in any one population at any one time. Some newly molted individuals are in fresh unworn pelage; some individuals, which are molting, are in ragged, worn pelage; and other individuals perhaps could be found to represent intermediate stages.

Variations from the normal color of the pelage are rare. Among more than 3,000 specimens of *Zapus* examined there were only 12 individuals (five *Z. princeps*, 6 *Z. hudsonius*, and 1 *Z. trinotatus*) that were abnormally colored. A single white spot was noted on each of 10 (5 *Z. princeps*, 4 *Z. hudsonius*, and 1 *Z. trinotatus*) of these individuals; the spots were on the dorsal, anterior half of the body. The skin beneath the patch of white hair was in each animal like that beneath the neighboring normally-pigmented hair. One specimen of *Z. hudsonius* (NMC No. 6669) is everywhere black, excepting the dorsal surface of the toes of the forefeet. Most of the individual hairs from various areas of the body are black for their entire length; some, however, have non-pigmented silvery tips. One specimen of *Z. hudsonius* (KU No. 645) lacks any black; dorsally the pelage is nearest to Ochraceous-Buff and it is white on the venter. Individual hairs of the dorsal area are white for the basal two-thirds of their length (as compared to gray and brown in the animals with normal pigmentation) and near Ochraceous-Buff on the distal third (as compared to hairs which are dark brown tipped with Ochraceous-Buff). The feet and tail are white.

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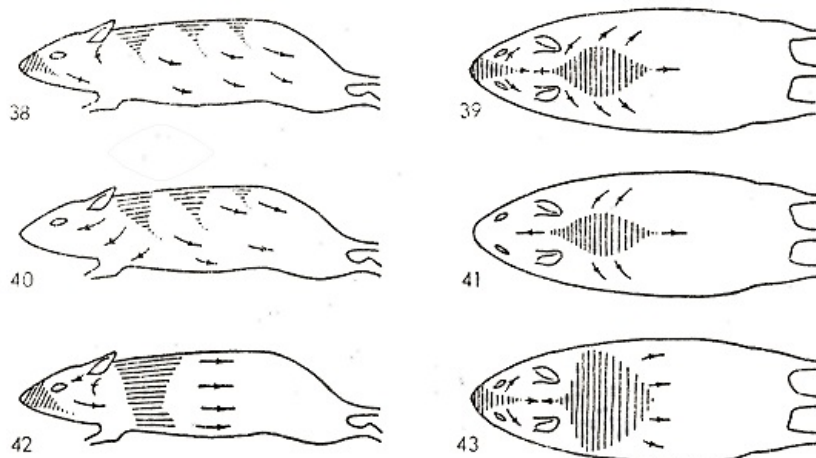
MOLT.—The sequence of molt for *Zapus* has been ascertained from examination of the study skins. In all species of this genus there seems to be only one annual molt in adults. In the young of the year this molt occurs after August first and before hibernation. All individuals of a single population do not molt at any one time; females continue to molt later in the autumn than do the males; some individuals begin the molt as early as mid-June and others show molt as late as the end of October; approximately three weeks are required for an individual to complete its molt (Quimby, 1951:74); readiness for molt and early stages in molt can be detected (in museum specimens) by the greater thickness of the skin. Hairs lost accidentally are quickly replaced, regardless of the condition of the molt.

In *Zapus hudsonius*, new hair appears simultaneously on the anterior dorsal surface of the nose and on the mid-dorsal surface between the scapulae. The molt proceeds anteriorly from the shoulders and posteriorly from the nose. At the same time that the head is covered, new hair appears on the sides of the body from the forelegs to the cheeks. New pelage then appears posteriorly, and molt continues as a wave from these points over the sides and back with the rump receiving new hair last (see [figs. 42 and 43](#)).

In *Zapus princeps* new hair appears first on the mid-dorsal surface between the scapulae. From this starting point molt progresses anteriorly, laterally, and posteriorly. Progress over the head is rapid; the head receives its new hair sooner than the caudal region. Molt moves progressively nearer to the base of the tail and progressively nearer to the mid-ventral surface. The rump is the last area to complete its molt (see [figs. 40 and 41](#)).

The progress of molt in *Z. princeps* might be likened to the flow of a drop of paint on the curved surface of a ball where the paint flows in all directions but is speeded at one point and slowed at the opposite by a slight tilting of the ball from the horizontal.

In the species *Zapus trinotatus* new hair appears simultaneously on the anterior, dorsal surface of the nose and on the mid-dorsal surface between the scapulae. In this respect the progress of molt of *Z. trinotatus* resembles that of *Z. hudsonius*. From these starting points molt progresses rapidly over the head, the molt moving anteriorly from the shoulders and posteriorly from the nose with the result that it covers the dorsal surface of the head; hair then appears on the cheeks and sides of the neck. The progress of molt on the remaining areas of the body is comparable to that of *Z. princeps*; molt progresses toward the tail and toward the mid-ventral line. The rump, as in *Z. princeps*, is the last area to complete its molt (see [figs. 38 and 39](#)).



FIGS. 38-43. Diagrams showing differences in progress of molt in the three species of the genus *Zapus*. All approximately $\frac{1}{2}$ natural size. Figs. 38, 40 and 42 lateral view. Figs. 39, 41 and 43 dorsal view.

FIGS. 38 AND 39. *Zapus trinotatus*.

FIGS. 40 AND 41. *Zapus princeps*.

FIGS. 42 AND 43. *Zapus hudsonius*.

BACULUM.—The general shape and dimensions of the baculum (os penis) provide characters of taxonomic value for the species of *Zapus* (see [figs. 23-25](#) and [figs. 28-30](#)).

Three measurements—length, transverse diameter at the base, and transverse diameter at the tip—are easily obtained and are diagnostic. The bacula of all species are somewhat curved. The measurement of length used by me does not represent the actual length of the bone, but instead the chords of the arcs involved.

SKULL.—Some of the structures useful for separating taxonomic entities may have little or no biological significance to the animals in nature. Characters mentioned by me are chosen simply for their significance taxonomically. The zygomata vary in degree of lateral bowing, being widely bowed in *Z. princeps* and *Z. trinotatus*, and less so in *Z. hudsonius*. Differences in zygomatic breadth owing to the degree of bowing are an aid in differentiating subspecies. The length of the skull from the occipital condyles to the tip of the longest nasal bone is useful in separating *Z. hudsonius* from *Z. trinotatus* and *Z. princeps*. The narrowness of the base of the zygomatic process of the squamosal is useful in distinguishing between *Z. hudsonius* and *Z. princeps*, but shows no variation of subspecific worth. The shape and dimensions of the incisive foramina provide specific and subspecific characters. The position of the anterior margin of the postpalatal notch, in relation to the last molars, provides subspecific characters in *Z. princeps*. In the species *Z. princeps* the median projection on the inferior ramus of the zygomatic process of the maxillary is absent in some subspecies, small in others, and large in some. Shape and inflation of the auditory bullae, shape of the pterygoid fossae, and shape of the nasals are useful in determining specific and subspecific relationships.

TEETH.—The alveolar length of the upper maxillary tooth-rows aids in distinguishing *Z. hudsonius* from *Z. princeps* and *Z. trinotatus*. Nearly parallel versus anteriorly divergent upper tooth-rows is a subspecific difference in *Z. princeps*. Variations in the dimensions of P4 and M1 aid in estimating the relationships of species. The occlusal pattern shows little variation and was of no use in separating species.

NONGEOGRAPHIC VARIATION

A knowledge of variation resulting from age, individual, or secondary sexual differences, as opposed to geographic variation between two or more populations of a single species is important in determining the reliability of taxonomic characters.

The largest population-sample of *Zapus* available to me for the study of nongeographic variation was 63 individuals from various localities in Keweenaw and Menominee counties, Michigan. Thirty-nine were females and 24 were males. It is on these specimens that this

discussion is based.

Age Variation

TEETH.—The teeth provide a valuable standard for age determination in that they wear at a measurable rate. The molars erupt in sequence from front to back, and wear shows first on M1 and last on M3. The peglike permanent P4, of which I have not seen the deciduous precursor, receives wear at the same time that the molars are being worn. Wear proceeds at approximately the same rate in the teeth of both the upper jaws and lower jaws.

In order to be more nearly certain that specimens used in making racial comparisons were comparable as to age, six age-groups were established, from youngest to oldest. These groups were based on the degree of wear on the occlusal surface of the upper cheek-teeth, and are as follows: group 1, in which M1 and M2 have not reached full and equal height and show no occlusal wear, and M3 has not erupted or is just breaking through the alveolus; group 2, in which M1 and M2 have reached full and equal height and show slight wear, and M3 may be almost or quite equal in height to M1 and M2 and, when equal, sometimes shows slight wear; group 3, in which M1 and M2 show wear on all cusps but cusps are visible, and M3 shows slight wear; group 4, in which P4 shows slight wear, M1 has cusps and re-entrant folds between cusps mostly gone, M2 shows considerable wear but re-entrant folds are visible, and M3 has most re-entrant folds and cusps gone; group 5, in which P4 shows considerable wear, M1 has cusps completely worn away, M2 has re-entrant folds and cusps worn away, and M3 lacks occlusal pattern except for one or two lakes; group 6, in which all upper cheek-teeth are without occlusal pattern.

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These groupings are based on continuously variable features, and, therefore, when the teeth are at certain stages of wear a specimen is difficult to place in one of two groups.

Age group 1 and 2 include juvenal and subadult animals. Animals of age groups 3 through 6 are considered adult. Individuals of age groups 3 through 5, including as they do the great majority of the adult population, were the only age classes used in measuring geographic variation.

Quimby's (1951:69) data indicate that some mice produce litters at the age of approximately 2 months, when four-fifths grown. Therefore, sexual maturity is not always synonymous with morphological maturity.

MEASUREMENTS OF EXTERNAL PARTS.—Data presented here on *Z. hudsonius* are those recorded by Quimby (1951) on specimens from Anoka County, Minnesota, and those obtained by me from museum specimens from Menominee and Keweenaw counties, Michigan.

According to Quimby (1951:65-66) the mean length [= body length] for three newly born *Z. hudsonius* is 24.8 mm (24.0-25.5); at the end of the fourth week of growth the mean length averaged 64.4 mm and at the 13th week 77.6 mm. Rapid growth occurs during the first four weeks, with the mean length increasing approximately 2.6 times the size at birth. After the fourth week of development, growth proceeds at a slower rate; the mean length at 13 weeks is only 3.1 times greater than the mean length at birth.

In specimens assigned to age groups 1 and 2 the length of the body averaged 70 and 74.8 mm, respectively. The individuals of both groups are less than 13 weeks old if we assume that growth proceeds at the same rate in Michigan as it does in Minnesota.

In the specimens from Michigan of age groups 3, 4, 5, and 6 the average length of the body is 80.9, 83.7, 89.0, and 83.6, respectively.

According to Quimby (*loc. cit.*), the average length of the tail for three *Z. hudsonius* at birth was 9.2 mm. (8.5-10.0). During the first four weeks of development the tail grew rapidly and reached an average length of 92.0 mm, which was 10 times the length at birth. By the end of 13 weeks of development the average length of the tail for these three individuals was 119.6 mm or 12 times the average length at birth. The most rapid growth was early in development: 80 per cent of the growth of the tail occurred during the first month, after which growth proceeded at a much slower rate.

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Quimby (*loc. cit.*) records an average dimension of 4.7 mm (4.5-5.0) for the length of the hind foot in three newly born *Z. hudsonius*. The hind foot grew rapidly in length and by the fourth week had increased 5.6 times in its length and averaged 26.3 mm. Growth was much less rapid from the fourth to the thirteenth week when the hind foot averaged 27.7 mm, only five per cent more than in mice four weeks old. Assuming the average length of the hind foot of the adults to be 29.0 mm, the hind foot in individuals 13 weeks old is 96 per cent of the adult size.

According to Quimby (*loc. cit.*), the pinna of the ear at birth is small and folded over the external auditory meatus. The length of the ear increases proportionately more (29 per cent) than any other external dimension after the first four weeks of growth.

If the average length of the ear (measured from the crown) of adults is 14.7 mm, the animals from Michigan in age groups 1 and 2 are 91.8 per cent and 96.5 per cent as large as adults.

Table 1.—Average Dimensions (in Millimeters) for Specimens of *Z. h. hudsonius* of Various Ages (Specimens from Michigan).

Age	1	2	3	4	5	6
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groups						
No. examined	4	13	33	12	3	3
Body	70.0	74.8	80.9	83.7	89.0	83.6
Tail	113.8	118.5	122.9	125.0	125.0	118.3
Hind foot	28.8	28.6	28.9	29.1	28.9	29.3
Ear	13.5	14.2	14.7	14.8	15.0	14.3

From these data, concerning growth of external parts, it seems that: growth is most rapid during the four weeks following parturition; specimens from Michigan, assigned to age groups 1 and 2 on the basis of tooth wear, are less fully developed and probably younger than mice from Minnesota, with a known age of 13 weeks; individuals with sufficient wear on the teeth to be placed in age group 3, if they were obtained in the late fall, may be young from the first litters of the year or, if they were obtained in early spring, may be at least one year old; individuals in age groups 4, 5, and 6 are at least one year old.

SKULL.—The post-embryonic development of the skull is rapid. Animals in age groups 1 and 2 have skulls which average more than 80 per cent of the size that is here considered adult (an average size obtained from age groups 3, 4, and 5). The actual increase in size of certain cranial elements for various age groups is given in [table 2](#).

In age group 1 the rostrum is relatively short as it is in *Neotoma micropus* (J. A. Allen, 1894:235) and juveniles of *Peromyscus truei* (Hoffmeister, 1951:7). The rostrum lengthens rapidly and there is a general increase in actual and relative size of the entire preorbital region; the increase after age group 3 is slower and of lesser magnitude. Changes with age in the size of the braincase are slight. In age group 1 the average depth of the braincase is 99.6 per cent of the adult size; the average breadth of the braincase is 98 per cent of the adult size, and the average width across the mastoid region is 96.4 per cent of the adult size. These dimensions indicate that the braincase reaches full size early. The zygomatic arch, however, undergoes change with age; there is a gradual increase in breadth owing to lateral bowing and a gradual lengthening which is in keeping with a general elongation of the skull anterior to the braincase.

The incisive foramina in age group 1 are short (4.0 mm), broad (2.2 mm in the middle), and taper to a point at each end. In age group 2 the foramina have elongated (4.2 mm) and are less pointed posteriorly, but there is no change in breadth. In age groups 3, 4, 5, and 6 the foramina become progressively longer (4.5 mm in age group 6), have a relatively constant breadth (2.2 mm), and become more nearly truncate anteriorly.

Table 2.—Average and Extreme Measurements (in Millimeters) of Skulls of Six Age-groups in Specimens of *Zapus hudsonius* from Michigan.

Age groups	1	2	3	4	5	6
Number examined	4	13	33	14	3	3
Occipitonasal length	20.5 20.0 21.2	21.2 20.8 21.8	22.0 21.5 23.2	22.7 21.8 23.4	22.9 22.7 23.3	23.0 22.4 23.7
Mastoid breadth	9.8 9.7 10.0	10.04 9.6 10.4	10.12 9.5 10.5	10.12 9.6 10.7	10.3 10.0 10.8	10.36 10.1 10.8
Length of zygomatic arch	8.07 8.0 8.2	9.02 8.5 9.3	9.07 8.5 9.4	9.25 9.2 9.4	9.5 9.5 9.5	9.35 9.1 9.6
Breadth of palate at P4	3.36 3.3 3.5	3.33 3.1 3.4	3.37 3.1 3.8	3.44 3.1 3.7	3.66 3.6 3.7	3.45 3.4 3.5
Breadth of palate at M3	2.4 2.3 2.6	2.55 2.3 2.7	2.66 2.3 3.2	2.74 2.5 3.0	3.11 3.0 3.2	2.77 2.6 2.9
Palatal length	8.67 8.4 9.1	8.98 8.8 9.2	9.38 9.3 9.8	9.59 9.0 10.0	9.73 9.5 9.9	9.8 9.6 10.1
Distance from incisors to postpalatal notch	8.53 8.4 8.7	8.98 8.5 8.5	9.08 9.0 9.8	9.68 9.2 10.0	9.73 9.5 9.9	9.80 9.6 10.1
Interorbital breadth	4.25 4.2 4.3	4.19 4.0 4.4	4.2 4.0 4.4	4.2 4.0 4.4	4.23 4.1 4.4	4.2 4.2 4.2
Average length of upper molar series	3.2 3.2 3.4	3.2 3.2 3.4	3.21 2.9 3.5	3.22 2.9 3.5	3.2 3.2 3.2	3.16 3.1 3.2
Breadth of braincase	9.5 9.3 9.7	9.58 9.2 9.7	9.61 9.1 10.0	9.68 9.3 10.0	9.83 9.5 10.2	9.63 9.3 9.9
Zygomatic breadth	10.33 10.0 10.7	10.49 10.4 10.9	10.55 10.1 11.2	10.80 10.7 11.2	11.0 10.5 11.5	11.25 11.2 11.3
Condylbasal length	16.9 16.6 17.1	18.33 17.4 19.2	18.80 18.2 19.5	19.33 18.5 19.9	19.6 19.4 19.8	19.9 19.5 20.3

Individual Variation

Measurements of external parts in *Zapus* are more variable than are measurements of most

parts of the skull. As Hoffmeister (1951:16) points out for *Peromyscus truei*, this variation in external features results in part from “the difficulties in accurately measuring soft parts of the anatomy” and also from inconsistencies on the part of collectors in making these measurements.

A comparison of coefficients of variation (see [table 3](#)) for cranial measurements between populations of like age and sex for the species *Z. hudsonius*, *Z. princeps*, and *Z. trinotatus* shows that variation of approximately the same degree is recorded in corresponding elements in all species; that is to say, structures which are most variable individually in *Z. princeps* are also most variable in *Z. trinotatus* and *Z. hudsonius*.

Individual variation in the occlusal pattern of the molariform teeth is slight. In several specimens, however, the re-entrant fold is absent from the lingual surface of M1. Teeth in addition to the normal number were recorded for five specimens. In all instances they are in the upper dentition and usually at the posterior end of the maxillary tooth-row. In each of four specimens (KU No. 34852, KU No. 32852, MVZ No. 52105, all *Z. princeps*, and USBS No. 22921, *Z. hudsonius*), there is only a single additional tooth. One individual (USBS No. 264388, *Z. princeps*) possessed two extra molars, one in each maxillary tooth-row. The extra teeth vary in size from those which are only slightly smaller than the adjacent normal molars to those which are simple, peglike structures. In four of the five animals the extra teeth are posterior to the normal M3; in the fifth (MVZ No. 52105) the added tooth is anteriomedial to M3.

Table 3.—Coefficients of Variation for Dimensions of Corresponding Parts of the Skull of Three Species of *Zapus*. The Specimens of *Zapus hudsonius* are from Menominee and Keweenaw counties, Michigan, the *Zapus princeps* are from the Vicinity of Encampment, Wyoming, and the *Zapus trinotatus* from Huntingdon, British Columbia.

Species	<i>Z. h. hudsonius</i>	<i>Z. p. princeps</i>	<i>Z. t. trinotatus</i>
No. examined	52	46	19
Mastoid width	2.85	1.98	2.21
Occipitonasal length	2.64	1.37	1.20
Incisors to postpalatal notch	3.02	2.56	2.56
Interorbital constriction	2.75	3.66	3.22
Zygomatic breadth	2.74	2.54	1.94
Maxillary tooth-row	4.50	4.44	3.82

The size and shape of certain cranial elements vary individually even between right and left sides of the same animal. The paired parietal bones in some animals are nearly square and identical. In other animals these bones are approximately equal and straight on three sides with the fourth side forming an anterolateral projection; this projection may be slightly or greatly produced, and opposite elements in a single individual differ in this respect.

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The interparietal also is variable; the lateral arms may be blunted and not included in the fusion of the squamosal, parietal, and occipital elements, or the interparietals may be elongated and fused with these elements. Posterior and anterior borders of the interparietal may be straight, produced anteriorly, produced posteriorly, or produced anteriorly and posteriorly.

There is frequently variation in the degree of taper of the nasals. They may be parallel sided, narrowed distally, or narrowed proximally. There is some variation in the degree of inflation, in the size, and in the shape of the frontal bones. The anterior surface of the postpalatal notch varies individually and may be truncate, anteriorly convex, or anteriorly concave.

Individual variation in the color of the pelage of animals that are in the same stage of molt or non-molt is by my observation slight. The presence of oil in the hair results in a false impression of sleekness and seemingly darker pigmentation. Abnormal white-spotting dorsally occurs as does yellow and melanistic coat color. These mutations are considered in the discussion concerning pelage.

Secondary Sexual Variation

In specimens of the two sexes from similar age groups of *hudsonius* from Michigan, the mean values for each measurement for the two sexes differ only slightly or are essentially the same (see [table 4](#)). In no species has secondary sexual variation been found to be greater than individual variation.

Table 4.—Mean Measurements for Adult Male and Female *Z. hudsonius* of Age Group 2 and Per Cent Difference of Females to Males (Specimens from Michigan).

Sex	Male	Female	Per cent difference, females to males
No. examined	18	15	
Total length	202.85	202.88	0.02% larger
Hind foot	122.85	122.10	0.60% smaller
Mastoid width	10.10	10.28	1.50% larger
Occipitonasal length	22.15	22.03	0.55% smaller
Incisors to postpalatal notch	9.39	9.33	0.64% smaller

Zygomatic breadth	10.47	10.57	0.95% larger
Maxillary tooth-row length	3.52	3.60	0.23% larger

CHECK-LIST OF THE SPECIES AND SUBSPECIES OF THE GENUS *ZAPUS*

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<i>Zapus trinitatus</i>	385
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<i>Zapus trinitatus montanus</i> Merriam	390
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<i>Zapus hudsonius preblei</i> Krutzsch	452
<i>Zapus hudsonius tenellus</i> Merriam	453

Genus *Zapus* Coues

***Genotype.*—*Dipus hudsonius* Zimmerman.**

EXTERNAL CHARACTERS.—Muriform in general appearance; forelimbs small, short; hind limbs greatly developed; hind feet long and narrow; tail tapering, attenuate, subcylindrical; head long and mouse-shaped; eyes small and situated midway between nose and ear; external ear somewhat longer than surrounding hair and provided with antitragal flap which can cover external auditory meatus, and in company with tragus completely close opening; upper lip without median groove; internal cheek-pouches well developed and opening at corners of mouth; mystacial vibrissae conspicuous; superciliary vibrissae few; genal tuft absent; teats normally eight and arranged in pairs (one pectoral, two abdominal, and one inguinal); anterior and posterior pairs frequently undeveloped; general pelage coarse; color of pelage varies somewhat in different species but always follows single basic pattern of broad dorsal band of some shade of brown or brownish-yellow darkened with brownish-black, sides of a lighter tone and slightly streaked with brownish-black, underparts snow-white, sometimes suffused with color of the sides and usually separated from color of sides by sharp line of clear brownish-yellow; backs of forefeet and hind feet grayish-white; tail distinctly bicolor, dark brown above and yellowish-white below; ears dark and narrowly edged with light color.

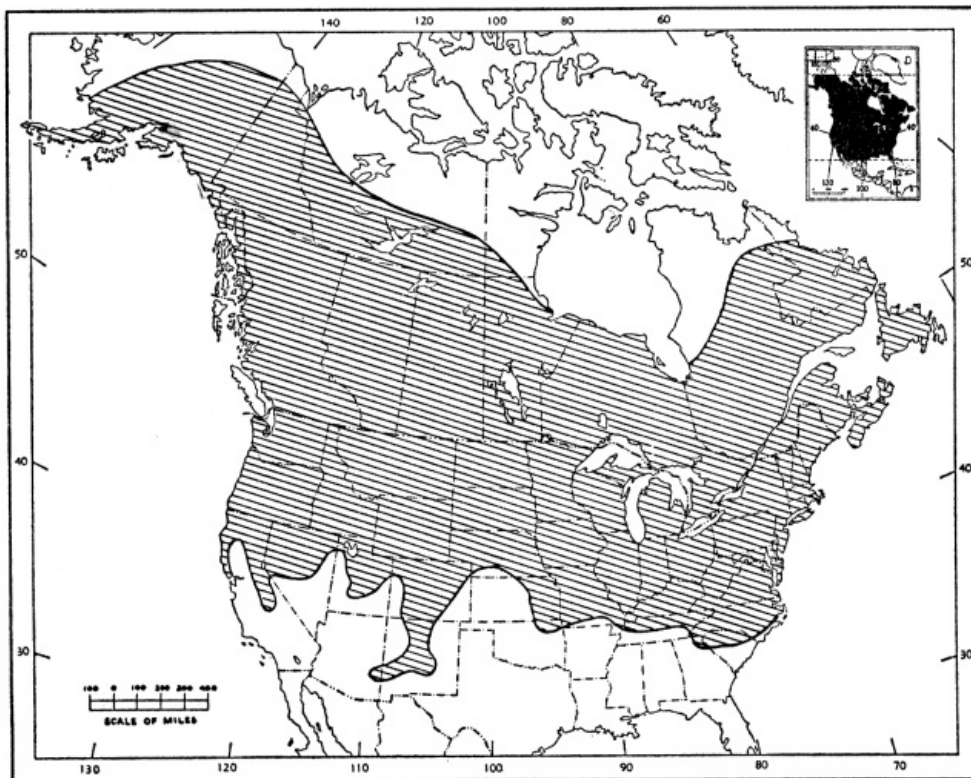


FIG. 44. Map showing distribution of the genus *Zapus*.

CRANIAL CHARACTERS.—Skull short in relation to width, deep relative to other dimensions, somewhat convex; delicate, papery, without strong angularity; braincase relatively unexpanded; antorbital foramen obliquely oval and transmits masseter muscle of great size; foramen in inferior ramus of zygomatic process of maxillary for passage of superior maxillary branch of trigeminal nerve small; zygomata not wide-spreading; underside of zygoma nearly horizontal, upper edge anteriorly rises prominently owing to extension of jugal upward along maxillary; jugal and lachrymal in contact; one ramus of zygomatic process of maxilla arises directly above other; rostrum thick basally and relatively attenuate distally; ends of nasals project noticeably beyond incisors; premaxillaries develop strong alveolar plate separating superior incisors for half their length; palatal bones shortened posteriorly, free edge often concave; incisive foramina long, broad, and separated by bulbose (except at posterior end) bony septum; mastoid bullae absent; auditory bullae short and transversely placed; postorbital process never present; parietals nearly square, sometimes emarginate in front; angle of mandible flattened and bent inward; coronoid process weak, acute, and slopes strongly upward.

DENTAL CHARACTERS.—Dental formula

$$\frac{I \ 1 \quad C \ 0 \quad P \ 1 \quad M \ 3}{i \ 1 \quad c \ 0 \quad p \ 0 \quad mv \ 3} = 18;$$

upper incisors short, compressed, curved backward, and strongly grooved; lower incisors slender, curved backward, and ungrooved; both upper and lower incisors deep orange or yellow; four upper cheek-teeth present; premolar small, single rooted and, sometimes, non-functional; upper molars tri-rooted, sub-hypsodont, and with occlusal surface non-cuspidate (flat); enamel pattern, much complicated, consisting of one main re-entrant fold lingually and four re-entrant folds labially; three lower molars, bi-rooted, sub-hypsodont, flat crowned, with two outer and four inner re-entrant folds.

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POSTCRANIAL CHARACTERS.—Neck short and weak; atlas large; axis separate from atlas; remaining (5) cervical vertebrae also free; thoracic (12) and lumbar (7) vertebrae strongly built; posterior lumbar with enlarged neural and anteriorly directed transverse processes; sacral vertebrae (7) as in murids; caudal vertebrae variable in number (average 36); clavicle long, slender, uniformly curved, convex outwardly; scapula with supraspinous and infraspinous fossae of equal size; forelimbs short, approximately half as long as hind limbs; hind limbs elongate, slender; femur with third trochanter; tibia and fibula fused slightly distal to middle of former; five elongate, separate metatarsals (first and fifth subequal, shorter than others).

ARTIFICIAL KEY TO THE SPECIES OF THE GENUS ZAPUS

- A. Baculum with tip spade-shaped and tip wider than 0.43 mm; underfur with medullary pattern rectangular, cuticular scales small; coronoid process of mandible long and slender, angle of divergence from condyle broad; angle of mandible turned in and wide; pterygoid fossae wide; skull broad in relation to length; premolars with crescentine fold on occlusal

surface.

Zapus trinotatus p. 385

A'. Baculum with tip lanceolate (not spade-shaped) and tip less than 0.43 mm wide; underfur with medullary pattern square or rectangular; but, if rectangular, cuticular scales large; coronoid process short and broad, angle of divergence from condyle narrow; angle of mandible turned inward and small to medium; pterygoid fossae usually narrow; skull not broad in relation to length; premolars without crescentine fold on occlusal surface.

B (A Baculum less than 5.1 mm in total length; guard hair averaging 115 micra in diameter; underfur with rectangular medullary pattern, cuticular scales large; skull small; incisive foramina shorter than 4.6 mm; condylobasal length averaging less than 20 mm; length of maxillary tooth-row averaging less than 3.7 mm; palatal breadth at M3 less than 4.2 mm.

Zapus hudsonius p. 420

B'. Baculum more than 5.1 mm in total length; guard hair averaging more than 140 micra in diameter; underfur with square medullary pattern, cuticular scales moderately large; skull large; incisive foramina longer than 4.7 mm; condylobasal length more than 21 mm; maxillary tooth-row averaging more than 3.8 mm; palatal breadth at M3 more than 4.4 mm.

Zapus princeps p. 394

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SYSTEMATIC ACCOUNTS OF SPECIES AND SUBSPECIES

Zapus trinotatus Rhoads

(Synonymy under subspecies)

Range.—From southwestern British Columbia southward through western Washington and Oregon and in the humid coastal district of California almost to the Golden Gate (see [fig. 45](#)).

Characters of the species: External.—Size medium to large (total length 221 mm to 238 mm); tail longer than head and body (131 mm to 149 mm) and bicolored, brown above, white to yellowish-white below; hind feet long (31 mm to 34 mm), grayish-white above; back various hues and tones of ochraceous and tawny; sides paler than back; lateral line separating sides from ventral surface usually distinct and bright; ventral coloration white, usually with suffusion of ochraceous; ears usually dark, sometimes flecked, and usually narrowly edged with color of sides; guard hairs average 141 microns (133u to 155u) in diameter; underhair with medullary pigment in narrow, hollow rectangles; cuticular scales of underhair smaller and more numerous than in other species.

Baculum.—Size large (total length 6.7 mm to 7.4 mm); base broad (0.7 mm to 0.9 mm); tip broad (0.44 mm to 0.57 mm); spade-shaped in dorsal aspect and tilted upward, gradually tapering to thin-edged tip; shaft rounded, straight.

Skull.—Large, broad and deep in relation to length; pterygoid fossa broad; anterior ramus of zygomatic process of maxillary relatively narrow; nasofrontal juncture relatively broad; coronoid process of mandible elongate. Upper premolars relatively large (averaging .70 mm in length and .75 mm in width), usually functional, occlusal surface with labial re-entrant fold forming crescentine loop incompletely enclosing single central cusp; m3 relatively large, elongated; m1 elongated, broadly rounded anteriorly.

GEOGRAPHIC VARIATION

There are four subspecies currently recognized, all of which are confined to the Pacific coastal region of North America (See [fig. 45](#)). The features that vary geographically are external size, color of pelage (shade and tone of upper parts and tint of lower parts), and dimensions of certain cranial structures (zygomata, braincase, incisive foramina, palatal bridge, auditory bullae, and pterygoid fossae).

External size is smallest in the southernmost geographic race (*Z. t. orarius*) and largest in the northernmost geographic race (*Z. t. trinotatus*). This decrease in size from north to south is clinal and is in keeping with Bergman's Rule which postulates that within one species the smallest individuals occur in the warmer parts of its geographic range.

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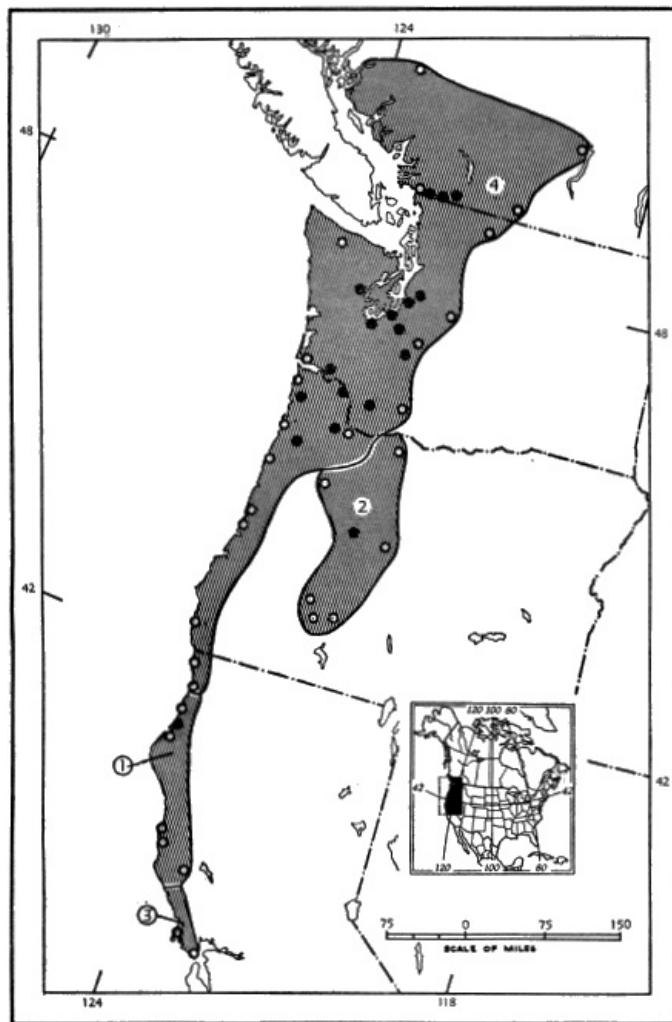


FIG. 45. Map showing distribution of *Zapus trinotatus*.

1. *Z. t. eureka*
2. *Z. t. montanus*
3. *Z. t. orarius*
4. *Z. t. trinotatus*

Coloration of pelage is geographically variable. There is a gradual change in the color of the pelage from north to south. Animals obtained in the northern part of the geographic range of *Z. trinotatus* are generally darker dorsally (more tawny) with the ventral pelage usually pure white. Those individuals from the southern part of the geographic range of *Z. trinotatus* have the dorsal pelage lighter (more reddish and yellow-brown) and ventrally the pelage is usually heavily suffused with reddish-brown. The crania also vary geographically; they are largest in the northernmost part of the range of the species and smallest in the southernmost part.

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NATURAL HISTORY

Habitat.—On the Olympic Peninsula, Washington, in 1931 Svihla and Svihla (1933:132) found this species equally abundant in alpine meadows near timberline, in open grassy areas, and in tall meadow grass and low blueberry bushes. All of the mice were in wet marshy places. Bailey (1936:232) reported that in Oregon, these mice live in meadows, marshes, under ferns and weeds in the woods, or near mountain brooks and streams. Taylor (1922:221) found *Zapus* in moderately moist meadows in the Hudsonian Life-zone at Mt. Rainier, Washington, and Dice (1932:49) found them in deciduous forest and in open, grassy, or sphagnum bogs. Dice records it as common also among the alders and willows in high, open, grassy parks. Merriam (1897b:223) found *Z. trinotatus* abundantly in moist places grown-over with grass or weeds. Grass cuttings two to three inches long were left in small heaps at feeding sites and indicate the presence of these mice.

Behavior.—Svihla and Svihla (1933:131) write that the long tail of *Z. trinotatus* is used as a balancing organ when the mouse is in motion. A tailless mouse, attempting to escape, turned somersaults in the air and invariably landed on its back; the loss of its tail seemed to leave the mouse without compensation for the vigorous push of the hind legs. Dalquest (1948:371) noted that the jumping mouse sometimes walks on all fours, but ordinarily moves by means of short hops on the hind feet alone. When startled, jumping mice travel in bounds of six feet or more at a jump.

Zapus trinotatus, according to Bailey (1936:232) and Elliot (1899:261), is mainly nocturnal but occasionally is active in daylight.

Svihla and Svihla (*op. cit.*:132) heard captive animals make squeaking noises when fighting. On several occasions captive animals made a drumming noise by rapidly beating the tail against a resonant body such as the bottom of a tin can.

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Concerning hibernation, Bailey (*loc. cit.*) remarks that animals of this species in Oregon, become fat in early autumn and lay down excess adipose tissue under the skin, over the muscles, and in the abdominal cavity. Svihla and Svihla (*op. cit.*:133) noted that captives from the Olympic Peninsula, Washington, gained weight in September and October and became extremely fat. With the additional weight they were more listless and drowsy, often spending days curled up in the hibernating position with the head between the hind legs and the long tail curled completely over the head and body. Warmth aroused the animals to activity, but when the temperature dropped they again hibernated. Flahaut (1939:17) reported the discovery on February 23, 1939, at Henderson Inlet, South Bay, Thurston County, Washington, of two nest cavities inhabited by jumping mice that were hibernating. The nests, four inches apart and 30 inches below the surface of the ground, were approximately five inches in diameter and made of shredded paper. Both mice were dormant, covered by nesting materials and curled up in the aforementioned hibernating posture. Dalquest (1948: 371) writes that in the lowlands of Washington this species disappears by late July but that in the mountains it remains active until the middle of September. Edson (1932:56) records an individual taken on April 20 from its place of hibernation beneath the roots of a decaying stump. This animal quickly roused in the warm mid-afternoon sun but became dormant again when the temperature dropped to 45° F. It seems that animals near the end of hibernation become active on warm days and return to the torpid state on cold ones.

Enemies.—Little is recorded concerning enemies of *Z. trinotatus*, but Bailey (1936:233) lists owls and other nocturnal birds, weasels, skunks, and badgers as preying on this mouse. Smith and Hopkins (1937:191) found *Z. t. orarius* in barn owl pellets obtained in Elk Valley, Marin County, California.

Food.—Bailey (*loc. cit.*) remarks that in Oregon, these mice feed mainly on small seeds of grasses, small grains (wheat, barley, oats, and rye), and other plants. These seeds are obtained by cutting the stems, drawing the stems down and biting off lower sections until the seed-laden heads are reached. Bailey (*op. cit.*:234) found that *trinotatus* utilized also the seeds of the western skunk cabbage.

Near Seattle, Washington, according to Dalquest (*loc. cit.*), the principal food of *Z. trinotatus* was velvet grass (*Holchus lanatus*), broad-leaved dock, and the seeds of other grasses. Dalquest reports also that the fruit of the blackberry (*Rubus macropelatus*) is eaten and that an occasional jumping mouse has its chin stained a deep purple by juice from these berries.

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Reproduction.—There is normally a single litter of from four to eight young per year according to Bailey (*loc. cit.*). Newly born young have been described by Svihla and Svihla (1933:132) as follows: slightly smaller than newly born harvest mice (*Reithrodontomys m. megalotis*), average weight .8 grams, hairless (without even vibrissae visible), pink, eyes closed, ears folded, heads short and stubby, tails long (longer than those of newly born *Peromyscus*), and bodies surprisingly small (when compared with newly born *Peromyscus maniculatus*).

Zapus trinotatus eureka A. B. Howell

Zapus trinotatus eureka A. B. Howell, Univ. California Publ., Zool. 21:229, May 20, 1920.

Zapus trinotatus trinotatus, Preble, N. Amer. Fauna, 15:26, August 8, 1899 (part—the part from Crescent City and Carsons Camp, Mad River, California).

Zapus orarius Preble, N. Amer. Fauna, 15:29, August 8, 1899 (part—the part from Eureka and Carsons Camp, Mad River, California).

Type.—Female, adult, skin and skull, No. 11703, Mus. Vert. Zool.; Fair Oaks, Humboldt County, California; obtained on August 27, 1910, by Joseph S. Dixon, original No. 1743.

Range.—Northwestern coastal region of California, from Russian Gulch State Park, Mendocino County north to Trinidad, Humboldt County. Zonal range: humid Transition.

Description.—Size medium; color dull; back near Ochraceous-Buff with heavy admixture of black hairs, forming broad dorsal band; sides from near Ochraceous-Buff to near Ochraceous-Salmon, sometimes with heavy admixture of black hairs; lateral line usually distinct, sometimes blending with color of belly and side; ventral surface usually suffused with color of sides; tail bicolored, dark brown above, white to yellowish-white below; feet grayish-white above; ears dark, edged with color of sides; auditory bullae large; pterygoid fossae broad; incisive foramina relatively short; palatal bridge short; maxillary tooth-rows relatively short; narrow across zygomata; braincase narrow; interorbital region narrow; zygomatic arch relatively short.

Comparisons.—From *Zapus trinotatus trinotatus*, *Z. t. eureka* differs in: Size smaller; ventral surface with much greater suffusion of ochraceous; auditory bullae larger; pterygoid fossae relatively broader; frontal region less inflated; palatal bridge shorter; braincase narrower; narrow across zygomata; upper tooth-rows shorter.

For comparison with *Zapus trinotatus orarius* see account of that subspecies.

Remarks.—Howell (1920:230), without having examined the material, provisionally referred specimens from Requa and Crescent City, Del Norte County, California, to *Z. t. eureka*. I have studied this material and find the specimens to be intermediate between *Z. t. trinotatus* and *Z. t. eureka* in cranial characters (zygomatic breadth, interorbital width, and breadth of braincase), but nearer *Z. t. trinotatus* in coloration (absence of ochraceous suffusion ventrally). They are here referred to *Z. t. trinotatus*. The zone of intergradation between *Z. t. trinotatus* and *Z. t. eureka* seems to extend from Requa, California, north to Gold Beach, Oregon, where other specimens

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intermediate between these two subspecies, have been obtained. These individuals are also referred to *Z. t. trinotatus* on the basis of cranial features and color.

Specimens examined.—Total, 42, all from California, distributed as follows: *Humboldt Co.*: Trinidad, 4 (SDM); Carsons Camp, Mad River, 3 (USBS); 3 mi. W Arcata, 5 (MVZ); $7\frac{3}{10}$ mi. E Bayside, 1 (MVZ); 12 mi. S Korbek, on Maple Creek, 2 (MVZ); Falk, 1 (MVZ); Carlotta, 1 (MVZ); *F. B. Summer Redwoods, S Eureka*, 1 (MVZ); *Maple Creek, 1 mi. W junction Mad River*, 12 (MVZ). *Mendocino County*: Mendocino City, 1 (MVZ); Albion River, $\frac{1}{2}$ mi. E MacDonalds Ranch, 1 (MVZ); Russian Gulch State Park, 10 (MVZ).

Marginal records.—California: Trinidad; Russian Gulch State Park; Albion River, $\frac{1}{2}$ mi. E MacDonalds Ranch; Mendocino City; Carlotta.

***Zapus trinotatus montanus* Merriam**

Zapus trinotatus montanus Merriam, Proc. Biol. Soc. Washington, 11:104, April 26, 1897; Bailey, N. Amer. Fauna, 55:234, August 29, 1936.

Zapus montanus, Preble, N. Amer. Fauna, 15:28, August 8, 1899.

Type.—Female, adult, skin and skull; No. 79863, U. S. Nat. Mus., Biol. Surv. Coll.; Crater Lake, Klamath County, Oregon; obtained on August 19, 1896, by Edward A. Preble, original No. 1388.

Range.—From Crater Lake, Klamath County, Oregon, northward along the Cascade Range into Hood River County, Oregon. Zonal range: Transition and Canadian.

Description.—Size medium; back near Ochraceous-Buff with admixture of black hair, resulting in a grizzled, broad, dorsal band; sides lighter than back, from near Ochraceous-Buff to near Pinkish-Cinnamon, and lined with black hair; lateral line distinct; underparts usually pure white, sometimes with slight suffusion of ochraceous on lower throat and upper chest; tail bicolored, brown above and yellowish-white below; ears dark, sometimes flecked with ochraceous, edged with yellowish-white; feet grayish-white above; braincase relatively narrow; zygomatic arch relatively short; condylobasal length short; mastoid region relatively narrow; palatal bridge short; auditory bullae large; frontal region inflated; pterygoid fossae relatively narrow.

Comparison.—From *Zapus trinotatus trinotatus*, *Z. t. montanus* differs as follows: Size averaging smaller; sides more ochraceous, fewer black hairs; upper parts duller; skull smaller; zygomatic arch shorter, braincase relatively narrower; frontal region more inflated; pterygoid fossae relatively narrower; zygomatic arch narrower.

Remarks.—The systematic status of *Z. t. montanus* has been in doubt. Several workers, for example, Howell (1920:227) and Preble (1899:28), considered it to be a species, and others (Merriam, 1897a:104, Bailey, 1936:234) considered it to be a subspecies of *Z. trinotatus*. *Z. t. montanus* is here considered to be a subspecies of *Z. trinotatus*, because of the agreement of the two in size and shape of the baculum, diameter and pigment pattern of the hair, and the over-all proportions of the skull. In addition, animals from intermediate geographic areas are available and show actual intergradation.

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Intergradation has been noted in specimens from North Santiam River, 3400 ft., Oregon. In color, in length of incisive foramina, in breadth of braincase, and in width of zygomatic arch these specimens are intermediate between *Zapus trinotatus montanus* and *Z. t. trinotatus*, but in the sum-total of characters they are referable to the former. Specimens from Lost Creek R. S., 10 mi. SE McKenzie Bridge, are intermediate in color between *Z. t. trinotatus* and *Z. t. montanus*; they are referable to *Z. t. montanus*. The animals available from Brooks Meadow, 4300 ft., 9 mi. ENE Mt. Hood and the one from Mt. Hood, in color, in length of incisive foramina, and in mastoid width, closely approach *Z. t. trinotatus* from Skamania County, Washington, but in the sum-total of characters are nearest *Z. t. montanus* and are here referred to *montanus*.

Specimens examined.—Total, 35, all from Oregon, distributed as follows: *Deschutes County*: Tumalo Creek, 15 mi. W Bend, 6100 ft., 3 (MVZ). *Douglas Co.*: Diamond Lake, 1 (USBS). *Hood River Co.*: Brooks Meadow, 4300 ft., 9 mi. ENE Mt. Hood, 10 (MVZ); *Mt. Hood*, 1 (USBS). *Klamath Co.*: *Crater Lake*, 3 (MVZ); $\frac{1}{2}$ mi. N Government Camp, 6700 ft., *Munson Valley, Crater Lake Nat'l Park*, 2 (MVZ); east slope Cascade Divide, 6400 ft., *Crater Lake Nat'l Park*, 2; *Anna Creek, Mt. Mazama*, 6000 ft., 2 (USBS). *Lane Co.*: *Lost Creek R. S.*, 10 mi. SE McKenzie Bridge, 6 (USBS); *Three Sisters, Alder Springs*, 4300 ft., 2 (USBS). *Linn County*: *North Santiam River*, 3400 ft., 3 (MVZ).

Marginal records.—Oregon: Brooks Meadow, 4300 ft., 9 mi. ENE Mt. Hood; Tumalo Creek, 15 mi. W Bend, 6100 ft.; *Anna Creek, Mt. Mazama*, 6000 ft.; east slope Cascade Divide, 6400 ft., *Crater Lake Nat'l Park*; *Diamond Lake*; *North Santiam River*, 3400 ft.

***Zapus trinotatus orarius* Preble**

Zapus orarius Preble, N. Amer. Fauna, 15:29, August 8, 1899.

Zapus pacificus Merriam, Proc. Biol. Soc. Washington, 11:104, April 26, 1897 (part—the part from Point Reyes, Marin County, California).

Zapus trinotatus orarius, Hooper, Misc. Publ. Mus. Zool. Univ. Michigan, 59:67, January 12, 1944.

Type.—Male, adult, skin and skull, No. 250, collection of E. A. and O. Bangs (now in Mus. Comp. Zool.); Point Reyes, Marin County, California; obtained on May 14, 1893, by C. A. Allen, original No. 618.

Range.—Southern and western Marin County, California. Zonal range: Upper Sonoran areas that are moist yet safe from continuous inundation.

Description.—Size small; back dark ochraceous, usually overlaid with black hairs forming broad dorsal band; side lighter than back with admixture of black hairs; lateral line distinct, usually bright, near Ochraceous-Buff; under parts strongly suffused with ochraceous; tail bicolored, white to yellowish-white below and dark brown above; feet grayish-white above; ears dark, edged with yellowish-white or tan; skull small; zygomatic arch narrow; braincase narrow; maxillary tooth-rows short; interorbital region narrow; incisive foramina short; palatal bridge relatively long; mastoid region relatively broad; occipitonasal length short.

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Comparison.—From *Zapus trinotatus eureka*, *Z. t. orarius* differs in: Size smaller; color, dorsally and laterally,

brighter, more ochraceous; skull averaging smaller in all measurements taken except length of palatal bridge, where it averages longer; auditory bullae smaller, less inflated; pterygoid fossae narrower.

Remarks.—Preble (1899:30) named this jumping mouse as a full species. Included in the specimens examined were animals from Eureka and Mad River, Humboldt County, California. Howell (1920:231) retained *Z. orarius* as a full species but restricted its range to Marin County, California, and referred material from northern California, including the animals from Eureka and Mad River, to a new subspecies (*eureka*) of the species *Z. trinotatus*. Howell (*loc. cit.*) suggested that *Z. orarius* had its closest affinity with *Z. t. eureka* but remarked that intergrading material was not available. Hooper (1944:68) arranged *Z. orarius* as a subspecies of *Z. trinotatus* and suggested that intergrades could be expected from geographically intermediate areas, for example, northern Sonoma County, California.

Although animals from intermediate geographic areas still are not available to show actual intergradation, I concur with Hooper (*loc. cit.*) and arrange *Z. orarius* as a subspecies of *Z. trinotatus*. The close relationship of *Z. orarius* to *Z. trinotatus* is evident; certain diagnostic characters, held in common, are the shape and size of the os penis, the diameter and pigment pattern of the hair, and the general configuration of the skull.

Interbreeding in the wild between *Z. t. orarius* and *Z. t. eureka* probably does not take place, because these subspecies are separated by terrain unsuited to jumping mice.

Specimens examined.—Total, 29, all from California, distributed as follows: *Marin County* (MVZ): 3 mi. W Inverness, 300 ft., 14; *5 mi. NNE Point Reyes Lighthouse*, 12; *W end Elk Valley*, 10 ft., 1; West Portal, Fort Barry, 2.

Marginal records.—California: 3 mi. W Inverness, 300 ft.; West Portal, Fort Barry.

Zapus trinotatus trinotatus Rhoads

Zapus trinotatus Rhoads, Proc. Acad. Nat. Sci. Philadelphia, 1894:42, January 15, 1895.

Jaculus hudsonius, Baird, Repts. Expl. and Surv. 111, 8 (pt. 1): 433, July 14, 1858 (part—the part from Washington).

Zapus hudsonius, Coues, Bull. U. S. Geol. and Geog. Surv. of the Territories, 2nd ser., No. 5:260, 1877 (part—the part from Steilacoom [Pierce County], Washington). [393]

Zapus imperator Elliot, Field Columbian Mus., publ. 30, zool. ser., 1:228, February 1, 1899, type from Siegs Ranch, Elwah River, Clallam County, Washington.

Zapus princeps trinotatus, Dalquest, Univ. Kansas Publ. Mus. Nat. Hist., 2:371, April 9, 1948.

Type.—Male, adult, skin and skull, No. 360, S. N. Rhoads Coll.; Lulu Island, mouth of Frazer River, British Columbia; obtained on May 31, 1892, by S. N. Rhoads (type in Philadelphia Acad. Nat. Sci.).

Range.—Pacific coastal region from Requa, Del Norte County, California, north in Oregon west of the Cascades, and in Washington including the Cascades; to southwestern British Columbia.

Description.—Size large; back from near Ochraceous-Buff to near Tawny with admixture of black hair forming broad dorsal band; sides lighter than back from near Ochraceous-Buff to near Tawny; lateral line usually distinct; belly white, sometimes with faint suffusion of ochraceous on lower throat and upper chest; tail bicolored, brown above, white to yellowish-white below; ears dark, sometimes flecked with color of sides, edged with ochraceous; feet grayish-white above; palatal bridge relatively short; incisive foramina relatively long; condylobasal region long; zygomatic width great; braincase relatively broad; distance from incisors to postpalatal notch relatively great.

Comparisons.—For comparisons with *Zapus trinotatus montanus* and *Zapus trinotatus eureka* see accounts of those subspecies.

Remarks.—This subspecies retains most of its diagnostic characters throughout nearly all parts of its geographic range. Intergradation occurs between *Z. t. eureka* and *Z. t. trinotatus* in extreme southwestern Oregon and northwestern California (see account of *Z. t. eureka*). Intergrades between *Z. t. montanus* and *Z. t. trinotatus* have been commented on in the account of *Z. t. montanus*. Specimens from Eugene, Oregon, according to Bailey (1936:232), show affinity to *Z. t. montanus* but are considered by him to be *Z. t. trinotatus*.

Specimens examined.—Total, 238, distributed as follows:

BRITISH COLUMBIA: Alta Lake, on Pac. Gt. Eastern Ry., 2600 ft., 5 (MVZ); Okanagan, 1 (FM); *Vedder Crossing*, 4 (1 MVZ, 3 PM); *Chilliwack Valley*, 2 (NMC); 18 mi. S Chilliwack, 1 (MVZ); Cultus Lake, 2 (NMC); *Lihumpton Park, 4500-4800 ft.*, 12 (NMC); *Seymour Mtn., 4000 ft.*, 8 (1 MVZ, 7 PM); *Cariboo*, 2 (FM); *Sumas*, 8 (1 MVZ, 7 FM); Huntingdon, 40 (NMC); *Parnassus Creek, Black Tusk Meadow, 5200 ft.*, 1 (PM); *Howe Sound, Brackendale*, 2 (NMC); Stanley Park, Vancouver, 1 (PM); *Allison Pass, Manning Park*, 1 (PM); Manning Park, 2 (PM).

CALIFORNIA: *Del Norte Co.*: Crescent City, 11 (6 FM, 5 USBS); Requa, 4 (FM).

OREGON: *Benton County*: 3 mi. N Corvallis, 2. *Clatsop County*: Old Fort Clatsop, 100 ft., 11 (MVZ); 7½ mi. S Cannon Beach, 50 ft., 1 (MVZ). *Columbia County*: 7 mi. SE Rainier, 100 ft., 11 (MVZ). *Curry County*: Gold Beach, 3 (FM). *Douglas County*: Gardiner, 7 (5 MVZ, 2 FM). *Lane County*: Sutton Lake, 6 mi. N Florence, 1 (MVZ). *Lincoln County*: *Delake*, 3 (2 MVZ); Newport, 2 (MVZ). *Multnomah County*: Portland, Council Crest, 950 ft., 1 (MVZ). *Tillamook Co.*: *Tillamook*, 1 (MVZ); 9 mi. S *Tillamook*, 1 (MVZ); Netarts, 3 (SDM); Blaine, 3 (MVZ). *Washington County*: 18½ mi. NW Portland, 1300 ft., 5 (MVZ). [394]

WASHINGTON: *Clallam County*: Deer Lake, 3800 ft., 3. *Clarke County*: 3½ mi. E and 1½ N *Amboy*, 3500 ft., 3 (MVZ); 1½ mi. *ENE Amboy*, 3500 ft., 13 (MVZ); 3½ mi. E and 5 mi. N *Yacolt*, 500 ft., 1 (MVZ); 1½ mi. *W Yacolt*, 800 ft., 11 (MVZ). *Cowlitz County*: 6 mi. *NE Kelso*, 4 (MVZ); 4 mi. *E mouth Kalama River*, 5 (MVZ). *King County*: Lakeridge Tract, S end Forest Ave., Lake Washington, 2 (MVZ); Seattle 2 (MVZ); Snoqualmie Pass, 5 (MVZ). *Mason County*: Potlatch, 2 (MVZ). *Pacific County*: 1½ mi. N *Chinook*, 10 ft., 1 (MVZ); 3½ mi. SE *Chinook*, 10 ft., 5 (MVZ). *Pierce Co.*: 5 mi. E Tacoma, 4 (MVZ); Puyallup, 3 (1 MVZ, 2 FM); Mt. Rainier, 1 (MVZ); 3 mi. E *Ashford*, 1 (LMH). *Skamania County*: Ice Caves, 2800 ft., 5 mi. WSW *Guler*, 1 (MVZ). *Thurston County*: Boston Harbor, 5 (CAS). *Wahkiakum County*: 4 mi. E

Marginal records.—British Columbia: Okanagan; Manning Park. Washington: Baker Lake; Snoqualmie Pass; Mt. Rainier; Ice Caves, 2800 ft., 5 mi. WSW Gulch. Oregon: Portland, Council Crest, 950 ft. California: Requa; Crescent City. Oregon: Gold Beach; Gardiner; Sutton Lake, 6 mi. N Florence; Newport; Netarts; Old Fort Clatsop, 100 ft. Washington: 3 1/2 mi. SE Chinook, 10 ft.; Deer Lake, 3800 ft. British Columbia: Stanley Park, Vancouver; Alta Lake, 2600 ft.

Zapus princeps Allen (Synonymy under subspecies)

Range.—The Rocky Mountains region from Yukon south into Arizona and New Mexico; westward through eastern Oregon and through the Cascades and Sierra Nevada of California; eastward in the northern Great Plains to extreme eastern parts of the Dakotas (see [fig. 46](#)).

Characters of the species: External.—Size medium to large (total length 216 mm to 247 mm); tail longer than head and body (129 mm to 148 mm) and bicolored, pale brown to grayish-brown above, white to yellowish-white below; hind feet long (31 mm to 34 mm), grayish-white above; back variable from yellowish-gray to salmon-brown and ochraceous; sides paler than back; lateral line usually present but sometimes indistinct or entirely absent (when present usually clear Ochraceous-Buff); ventral coloration white, usually suffused with ochraceous; ears usually dark, sometimes flecked and usually narrowly edged with light color; guard hairs average 142 microns (130u to 168u) in diameter; underhair with medullary pigment in form of hollow squares; cuticular scales of underhair larger and fewer than in other species.

Baculum.—Size medium (total length 5.6 mm to 6.6 mm); base moderately broad (0.7 mm to 0.8 mm); tip narrow (0.26 mm to 0.31 mm) rounded and dished out in dorsal aspect, blunted; shaft rounded, slightly sinusoidal, recurved at tip.

Skull.—Large, not exceptionally broad and deep in relation to length; rostrum broad but tapering; pterygoid fossa moderately narrow; anterior ramus of zygomatic process usually broad; incisive foramina usually broadly rounded and elongate; auditory bullae usually moderately inflated; coronoid process of mandible relatively short. Upper premolars of medium size (averaging .55 mm in length and .50 mm in breadth), sometimes functional, with occlusal surface normally divided by single shallow re-entrant fold; m1 relatively short, narrow anteriorly.

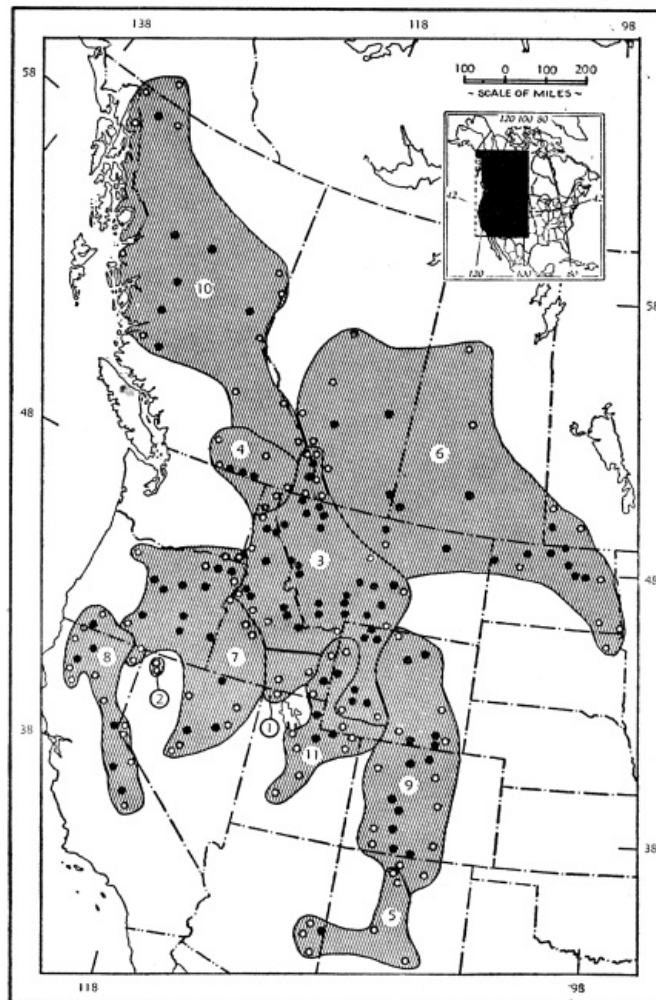


FIG. 46. Distribution of *Zapus princeps*.

Guide to subspecies

- | | |
|-------------------------------|----------------------------|
| 1. <i>Z. p. cinereus</i> | 7. <i>Z. p. oregonus</i> |
| 2. <i>Z. p. curtatus</i> | 8. <i>Z. p. pacificus</i> |
| 3. <i>Z. p. idahoensis</i> | 9. <i>Z. p. princeps</i> |
| 4. <i>Z. p. kootenayensis</i> | 10. <i>Z. p. saltator</i> |
| 5. <i>Z. p. luteus</i> | 11. <i>Z. p. utahensis</i> |
| 6. <i>Z. p. minor</i> | |

GEOGRAPHIC VARIATION

There are 11 subspecies recognized, most of which are in the mountains of the western United States and southwestern Canada. There is geographic variation in color, relative proportions of external parts (tail, hind feet, head, and body), and shape and size of the skull.

Three basic types of coloration occur in *Z. princeps*, as pointed out by Hall (1931:9). Yellow-sided dark-backed jumping mice exemplified by *kootenayensis*, *idahoensis*, and *utahensis* are found to the eastward in the Rocky Mountains. Reddishbrown-sided, brown-backed jumping mice typified by *luteus* and *pacificus* are found to the westward in the Sierra Nevada and in New Mexico and Arizona; mice with yellowish-buff or pinkish-buff-sides and light backs are the subspecies, *cinereus*, *curtatus*, and *oregonus*, that occur in the intervening Great Basin.

External dimension as a whole decreases from north to south, although not uniformly. For example, the smallest individuals are of the southernmost geographic subspecies (*Z. p. luteus*), but the largest are of the subspecies (*Z. p. utahensis*) that is near the geographic center of the range for the species. In the skull there is geographic variation in the length and shape of the zygomata, size and shape of the incisive foramina, alignment of maxillary tooth-rows, size and shape of auditory bullae, position of the postpalatal notch in relation to M3, and the presence or absence and size of the medial projection on the inferior ramus of the zygomatic process of the maxillary.

NATURAL HISTORY

Habitat.—*Zapus princeps* occurs most commonly adjacent to streams where grasses and herbs are in lush growth. It frequents mountain meadows neighboring small streams and is often taken from alder, aspen, or stands of willow, where the moist ground supports a heavy undergrowth of herbs. Davis (1939:330) found these mice in heavy herbage along a small stream bordered by quaking aspen near Victor, Teton County, Idaho. They were found along streams bordered by willow, rose, alder, huckleberry, sedges, and herbs of various kinds at Alturas Lake, Mill Creek, and at the head of the Pahsimeroi River. Linsdale (1938:195) found jumping mice in the Toyabe Mountains, Nevada, near the streamsides or in seepy areas close to the streams where associated vegetation included rose, willow, wild peach, sage, grasses, and herbs. In the Uinta Mountains, Utah, R. D. Svihla (1931:264) obtained them from willows along streams in mountain parks. Borell and Ellis (1934:37) in the Ruby Mountains, Nevada, found jumping mice to be common in heavy vegetation along streams. Louise Kellogg (1916:369) obtained jumping mice in northern California; all were near water, in grassy meadows, or under alders where vegetation was dense.

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Zapus princeps is locally abundant, but its numbers seem to vary considerably from year to year as well as seasonally. Early autumn, when young of the year are abroad, seems to be the period of greatest abundance. Moore (1928:154) remarks that runways were plainly marked and well strewn with four-inch pieces of brome-grass. Davis (1939:334) notes that *Z. princeps* has runways, and found that sections, four inches long, of cut grass piled in runways was good evidence of the presence of the mouse.

Behavior.—In reference to locomotion of *Z. princeps*, Davis (*loc. cit.*) writes, "In rapid progression jumping mice move by a series of zigzag hops. One young of the year found in tall grass near Victor made horizontal leaps of approximately three feet. The zigzag course was difficult for me to follow, and I was led to wonder if this mode of locomotion were not advantageous to the mice in eluding animals that would do them harm." Hollister (1912:26) remarked that *princeps*, when startled, sometimes jumps five to six feet at a bound. Concerning the swimming ability of *Z. princeps*, Bailey (1936:233) quotes from Hollister's notes, "While I was walking around the grassy border of a small pond one jumped out at my feet and struck in the water like a frog, which at first it was thought to be, until it was seen swimming across the pond on the surface of the water ... he certainly handled himself as if perfectly at home and swam with little effort and great speed over the still surface of the pond." Davis (1939:334) obtained two individuals at Mill Creek, Idaho, in traps placed on artificial islands of stones in the middle of the creek where the water was about six inches deep. He speculated that the only way the mice could have reached the traps was by swimming. Grinnell, Dixon, and Linsdale (1930:531) record an individual which was seen hopping in the inch-deep water of a small stream at Lake Helen, California.

According to Hollister (1912:26) and Davis (1939:335), jumping mice are for the most part nocturnal, but occasionally they are seen by day in tall grass.

Little is recorded concerning the hibernation of *Z. princeps*. What data are available suggest that, starting in July, these animals accumulate a heavy layer of fat on the inside of the skin with especially large amounts in the inguinal region. By August or early September, animals are excessively fat, and the start of hibernation is dependent then upon the arrival of a heavy cold snap. Grinnell, Dixon, and Linsdale (1930:531), in their study of the vertebrates of the Lassen Peak region of California noted that the latest activity by these mice was September 13. As regards the time of onset of hibernation in Idaho, Davis (1939:336) states that, "I know of no records of capture later than September and infer that hibernation begins in that month or the next." Bailey (1932:227) writes that in New Mexico, animals obtained on September 20 were very fat, probably were ready to hibernate at the first cold wave, and had winter nests in burrows well underground.

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Enemies.—Bailey (*loc. cit.*) lists hawks, owls, and weasels as natural predators on *Z. princeps*. Stanford (1931:362) records the garter snake (*Thamnophis*) as a predator of jumping mice. A large snake of this genus obtained by him regurgitated two jumping mice a few hours after its capture. Grinnell, Dixon, and Linsdale (1937:232) report that on Parker Creek, in California, H. C. Bryant frightened a weasel that dropped a freshly killed jumping mouse. Crowe (1943:407) reported *Cuterebra* fly larvae in the inguinal region of a *Z. princeps* obtained at Invermere, British Columbia. Several mice of this species taken at Moccasin Lake, 19 mi. W and 4 mi. N of Lander, 10,000 ft., Fremont County, Wyoming, were heavily infested with mites of the family Laelaptidae.

Food.—In early September in central Utah, Moore (1928:154) found only a white, starchy, glutinous paste in stomachs of six *Z. princeps* and only traces of a brown seed coat in a seventh. The main seeds eaten seemed to be from an introduced brome-grass which was abundant in the vicinity of capture. Bailey (1932:226) wrote of *Z. princeps* in New Mexico, that "In feeding they cut down the tall grass, beginning at the bottom and cutting the stem at intervals as high as they can reach until the seed part of the grass is brought down." He (*op. cit.*:227) remarked that the food was almost entirely seeds of grass and grasslike plants and that the stomach contents almost always were perfectly clean white dough from the shelled kernels of small seeds.

Reproduction.—Females with embryos have been collected from late May to mid-July and lactating individuals until late August. Possibly there is only one litter per season as Davis (1939:336) suggests is the case in Idaho.

Embryos in 25 pregnant females averaged 5 (2-7). The mammae of the female are arranged in four pairs (two abdominal, one pectoral, and one inguinal).

Z. princeps builds a grass nest on the ground which is placed under cover of vegetation or surface litter. Bailey (1932:227) writes that in New Mexico jumping mice of this species use fibers of grass to construct a ball-shaped nest. The nest usually has one opening but sometimes there are two. In the Ruby Mountains, of Nevada, Borell and Ellis (1934:37) found the globular nests of this mouse on the ground in tall grass.

Zapus princeps cinereus Hall

Zapus princeps cinereus Hall, Univ. California Publ. Zool., 37:7, April 10, 1931.

Type.—Female, adult, skin and skull; No. 45422, Mus. Vert. Zool.; Pine Canyon, 6600 feet altitude, Raft River Mountains, 17 mi. northwest Kelton, Boxelder County, Utah; obtained on July 14, 1930, by Annie M. Alexander; original No. 689.

Range.—Raft River Mt's in northwestern Utah and in isolated mountains in southern Idaho. See [fig. 46](#). Zonal range: Transition and Canadian.

Description.—Size, medium; back with broad mid-dorsal band, varying from pale brown mixed with Pinkish-Buff to dark brown mixed with Warm-Buff or Ochraceous-Buff; sides varying from near Pinkish-Buff to near Ochraceous-Buff; ventral surface white to base of hairs, not suffused with other color; tail bicolored, pale brown above and white to yellowish-white below; ears dark, edged with white or yellowish-white; upper teeth divergent anteriorly; auditory bullae small; skull relatively long; zygomata relatively weak and not widely bowed; nasals wide posteriorly; pterygoid fossae relatively narrow.

Comparisons.—From *Zapus princeps nevadensis*, *Z. p. cinereus* differs as follows: Size averaging smaller; entire coloration lighter; zygomata not so widely bowed; incisive foramina not so wide posteriorly; auditory bullae smaller; nasals wider posteriorly; pterygoid fossae narrower.

From *Zapus princeps idahoensis*, *Z. p. cinereus* can be distinguished by: generally paler color; smaller auditory bullae; broader interorbital region; anteriorly diverging tooth-rows; narrower pterygoid fossae.

For comparison with *Zapus princeps utahensis* see account of that subspecies.

Remarks.—Davis (1939:343) writes that "since *cinereus* was described from nine specimens, only two of which are near adult, one cannot place much value on the coloration ascribed to it by Hall (1931:7)." I examined the type series and found, as did Davis (*loc. cit.*), that the type is much lighter and grayer than is a near adult paratype, which was obtained the same day; however, I do not concur with Davis (*loc. cit.*) that specimens from Mt. Harrison, 10 mi. S Albion, Idaho, which are darker and much more ochraceous than the paratype, necessarily are more nearly typically colored. These individuals, judged by cranial characters, are more nearly typical of *cinereus* but show intergradation with *Z. p. idahoensis* in their darker and more ochraceous pelage.

Durrant (1952:387) found that the gray color of *Z. p. cinereus* was not diagnostic in separating *Z. p. cinereus* from *Z. p. utahensis*, because gray animals are also found in *Z. p. utahensis*. Specimens from Camp Tendoy, Pocatello, Idaho, are intermediate in color and in cranial characters as between *Z. p. idahoensis* and *Z. p. cinereus*, but here are referred to *Z. p. cinereus*. Whitlow and Hall (1933:268) compared these individuals with specimens of *Z. p. princeps* and *Z. p. cinereus*, finding them intermediate but in the aggregate of several differential characters better referred to the latter.

Specimens examined.—Total, 35, distributed as follows:

IDAHO: *Bannock County*: Camp Tendoy, Pocatello, 2 (MVZ). *Cassia County*: Mt. Harrison, 10 mi. S Albion, 16 (MVZ).

UTAH: *Boxelder Co.*: south fork of George Creek, 5 mi. SE Yost, Raft River Mts., 6700 ft., 1 (UU); *George Creek*, 7 mi. SE Yost, Raft River Mts., 6500 ft., 6 (UU); *Pine Canyon*, 6600 ft., 17 mi. NW Kelton, Raft River Mts., 8 (MVZ); *Pine Creek*, 3 mi. N Rosette, Raft River Mts., 6100 ft., 2 (UU).

Marginal records.—Idaho: Camp Tendoy, Pocatello. Utah: Pine Creek, 3 mi. N Rosette, Raft River Mts., 6100 ft.

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Zapus princeps curtatus Hall

Zapus princeps curtatus Hall, Univ. California Publ. Zool., 37:7, April 10, 1931.

Zapus princeps oregonus, Taylor, Univ. California Publ. Zool., 7:281, June 24, 1911.

Type.—Female, adult, skin and skull, No. 7991, Mus. Vert. Zool.; head of Big Creek, 8000 feet altitude, Pine Forest Mountains, Humboldt County, Nevada; obtained on June 30, 1909, by Walter P. Taylor and C. H. Richardson, original No. 777 of W. P. T.

Range.—Pine Forest Mt's, Humboldt County, Nevada. See [fig. 46](#). Zonal range: Transition and Canadian.

Description.—Size medium; back pale near Light Ochraceous-Buff with admixture of black hair forming dark dorsal band; sides lighter than back; lateral line faintly indicated; ventral surface white; tail bicolored, grayish-white to yellowish-white below and pale brown above; ears dark, edged with yellowish-white; feet grayish-white above; palatal bridge short; tooth-rows almost parallel; mastoid region of skull relatively narrow; incisive foramina wide posteriorly; narrow across zygomata; nasals relatively narrow posteriorly.

Comparisons.—For comparison with *Zapus princeps oregonus* see account of that subspecies.

Remarks.—This jumping mouse, which was described from the Pine Forest Mountains, closely resembles *Zapus princeps oregonus* but differs in lighter color, slightly smaller body, less divergent tooth-rows, shorter palate, and narrower skull across the mastoid region. [401]

The Pine Forest Mountains are isolated from neighboring boreal regions by a belt of the Upper Sonoran Life-zone, which is inhospitable to *Zapus*; therefore, intergrades between *Z. p. oregonus* and *Z. p. curtatus* are not known and probably do not exist. Nevertheless, *Z. p. curtatus* shows close affinity with *Z. p. oregonus*, as indicated by Taylor (1911:281), and I agree with Hall (1931:7) that the relationships of *Z. p. curtatus* are best expressed by arranging it as a subspecies of *Zapus princeps*.

Specimens examined.—Total, 18, all from Nevada, distributed as follows: *Humboldt County*: Pine Forest Mts.; Alder Creek, 6000 ft., 2 (MVZ); head of Big Creek, 8000 ft., 14 (MVZ); *Leonard Creek, 6500 ft.*, 2 (MVZ); Meadow, 1 (MVZ).

Marginal records.—Nevada: Pine Forest Mts., Alder Creek; Meadow.

Zapus princeps idahoensis Davis

Zapus princeps idahoensis Davis, Jour. Mamm., 15:221, August 10, 1931.

Jaculus hudsonius, Allen, Bull. Essex Inst., 6:61, April, 1874 (part—the part in Carbon County, Wyoming).

Zapus hudsonius, Merriam, N. Amer. Fauna, 5:72-73, July 30, 1891.

Zapus princeps princeps, Preble, N. Amer. Fauna, 15:22-23, August 8, 1899 (part).

Type.—Male, adult, skin and skull; No. 54845, Mus. Vert. Zool.; 5 mi. E Warm Lake, 7000 ft., Valley County, Idaho; obtained on July 9, 1932, by Robert T. Orr; original No. 660.

Range.—From Banff, Alberta, southward through extreme southwestern Alberta and extreme southwestern British Columbia, most of the panhandle of Idaho, Kamiak Butte in eastern Washington, western Montana, and western Wyoming (Green, Wind River and Absoroka ranges of the Rocky Mt's). See [fig. 46](#).

Description.—Size, medium; back from near Clay Color to near Warm Buff, usually overlaid with black hairs forming broad dorsal band; sides lighter than back; lateral line indistinct or wanting; belly pure white, occasionally faintly tinged with Ochraceous-Buff; tail indistinctly bicolored, tan to grayish-white below and pale brown above; hind feet grayish-white above; ears dark, edged with white or yellowish-white; postpalatal notch anterior to posterior border of last molars; proximal part of inferior ramus of zygomatic process of maxillary relatively narrow and usually without enlarged median projection; auditory bullae well inflated; incisive foramina relatively narrow.

Comparisons.—From *Zapus princeps kootenayensis*, *Z. p. idahoensis* differs as follows: Size averaging larger; upper parts with greater suffusion of ochraceous, not grayish or dusty; skull larger; incisive foramina longer and relatively wider; zygomatic breadth averaging greater; nasals broader at tips; auditory bullae more inflated.

From *Zapus princeps oregonus*, *Z. p. idahoensis* differs in: Size averaging smaller; upper parts generally more suffused with black hairs, on the average more yellowish with less ochraceous; skull smaller; incisive foramina narrower (breadth less, instead of more, than 52 per cent of length); palatal bridge shorter; zygomatic arch shorter; pterygoid fossae narrower. [402]

From *Zapus princeps utahensis*, *Z. p. idahoensis* can be distinguished by: Size less; color slightly darker; skull averaging smaller in zygomatic breadth, least interorbital constriction, and occipitonasal length; palate narrower; upper tooth-rows nearly parallel as opposed to diverging anteriorly.

From *Zapus princeps minor*, *Z. p. idahoensis* differs in: Size larger; color of underparts less ochraceous; lateral line indistinct or wanting; skull averaging larger in all measurements taken except that the two subspecies are approximately same in least interorbital constriction, length of zygomatic arch, and distance from anterior face of incisors to postpalatal notch; nasals, in profile, straight instead of with proximal third depressed; postpalatal notch anterior to posterior face of last molar, instead of even with, or usually posterior to, same.

From *Zapus princeps saltator*, *Z. p. idahoensis* differs as follows: Size averaging slightly larger; color darker, being less ochraceous and more yellow dorsally and laterally; auditory bullae more inflated; zygomatic arches less bowed laterally; incisive foramina narrower.

For comparison with *Zapus princeps princeps* and *Zapus princeps cinereus* see accounts of those subspecies.

Remarks.—Intergradation occurs at almost all of the places where the range of *Z. p. idahoensis* is known to touch that of any other geographic race. Nevertheless, each of the populations studied has characters which make this subspecies recognizable as a taxonomic unit, although its characters are not yet stabilized even in the central part of its range.

Among named subspecies of *Zapus princeps*, *Zapus p. idahoensis* most closely resembles *Zapus princeps kootenayensis*, its nearest geographic neighbor to the north. Three specimens from 2 mi. NE Weippe, 3000 ft., Idaho, are best referred to *Z. p. idahoensis* but show relationship to *Z. p. kootenayensis* in size and shape of the tympanic bullae. The relationship of individuals from Idaho, here referred to *Z. p. idahoensis*, from Glidden Lakes, Enaville, Cascade Creek, and 13 mi. E and 5 mi. N Coeur d'Alene, is discussed in the account of *Z. p. kootenayensis*. British Columbian specimens from Newgate and Crows Nest Pass, 4450 ft., as well as Albertan specimens from Crows Nest Pass and various places in Waterton Lake Park, resemble *Z. p. kootenayensis* in color but cranially are more nearly like *Z. p. idahoensis*.

Intergradation with *Zapus princeps oregonus* was noted by Davis (1939:340) in a specimen from Cedar Mountain in Idaho. I have not seen this individual which he referred to *Z. p. idahoensis* but have seen a specimen from the N Fork of Potlatch River (15 mi. SE Cedar Mt.), which, in color, closely resembles *Z. p. oregonus* but cranially (shape of incisive foramina, size, and inflation of auditory bullae) is more nearly like *Z. p. idahoensis* to which it is referred. Davis (*loc. cit.*) indicates that specimens from summit of Smith Mt., from 1 mi. N Bear Creek R. S., from ½ mi. E Black Lake, and from 3 mi. W Payette Lake, Idaho, are in an area of intergradation between *Z. p. oregonus* and *Z. p. idahoensis*, but he referred them to *Z. p. idahoensis* on the basis of cranial characters and length of hind foot. Seven specimens from Alturas Lake, 7000 ft., Idaho, were likewise so allocated by Davis (*loc. cit.*). I concur with him and in addition refer the following intermediate individuals from Idaho to *Z. p. idahoensis*: New Meadow, 1; Warren, 1; Perkins Lake, 7000 ft., Sawtooth Nat'l Forest, 1; Prairie Creek, 12 mi. W Ketchum, 2400 ft., 3. All are more nearly like *Z. p. oregonus* in color but cranially they show more resemblance to *Z. p. idahoensis*.

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In the eastern part of the range of *Z. p. idahoensis*, intergradation occurs with *Zapus princeps minor*, as at 15 mi. S Heath, N Fork Flat Willow Creek, Big Snowy Mt's, Montana. Specimens from there have the lateral line enlarged and the maximum seen in this species of Ochraceous color ventrally. The pterygoid fossae are large and the bullae are reduced as in *Z. p. minor*, but in the sum total of the characters the mice more closely resemble *Z. p. idahoensis*. At Lewistown, 7 mi. NE Judith Mt's, Lime Kiln Gulch, Montana, the animals are colored as are *Z. p. minor* but cranially are like *Z. p. idahoensis* to which they are referred. Specimens from the Highwood Mt's, Montana, also are intergrades; they have a relatively distinct lateral line as in *Z. p. minor* but show no ventral suffusion of Ochraceous; they have large bullae, nasals that are straight in lateral profile and other cranial characters of *Z. p. idahoensis* to which they are here referred.

A single specimen from Kamiak Butte, Whitman County, Washington, has been referred to *Z. p. idahoensis* by Dalquest (1948:373). I have not seen this individual, but, on geographic grounds, it is likely to be of this subspecies.

Specimens examined.—Total, 342, distributed as follows:

ALBERTA: Boom Creek, 5600 ft., 27 mi. W Banff, 2 (NMC); *Banff, Cascade Basin*, 2 (NMC); *Bryant Creek, Banff Park*, 1 (NMC); *Spray River, 7 mi. Cabin, Banff Park*, 3 (NMC); Crows Nest Pass, 2 (NMC); Waterton Lakes Park, 16 (NMC); *Linnets Pond, Waterton Lakes Park*, 4 (NMC); *Bertha Creek, Waterton Lakes Park*, 8 (NMC).

BRITISH COLUMBIA: Vermilion Crossing, Kootenay, 1 (ROM); Paradise Mine, 3 (PM); Crows Nest Pass, 4450 ft., 3 (NMC); Newgate, 10 (NMC).

IDAHO: *Adam Co.*: ½ mi. E Black Lake, 6800 ft., 8; *summit of Smith Mtn.*, 7500 ft., 9 (3 MVZ); 1 mi. N Bear Creek R. S., SW Slope Smith Mtn., 5400 ft., 13; New Meadows, 1 (USBS); 3 mi. W Payette, 5400 ft., 4 (MVZ). *Blaine County*: *Perkins Lake, 7000 ft., Sawtooth Nat'l Forest*, 1; *Alturas Lake, 7000 ft.*, 3 (MVZ); *Prairie Creek, 12 mi. NW Ketchum, 2400 ft.*, 3. *Clearwater County*: 2 mi. NE Weippe, 3000 ft., 3 (MVZ). *Custer County*: *Loon Creek R. S., 6000 ft., Challis Nat'l Forest, 2; Head Pahsimeroi River, 2 (MVZ); Mill Creek, 14 mi. WSW Challis, 8370 ft., 1 (MVZ). Fremont County*: 7 mi. W West Yellowstone, 7000 ft., 3; 17 mi. E and 4 mi. N of Ashton, 6275 ft., 9 (MVZ). *Idaho Co.*: *Packers Meadow, near state line, South Lobo Hot Springs, 5150 ft., 7 (USBS); Warren, 1 (USBS). Kootenai Co.*: 13 mi. E and 5 mi. N Coeur d'Alene, 5; *Cascade Creek, 36 mi. E Coeur d'Alene, Coeur d'Alene Nat'l Forest, 1 (USBS). Latah Co.*: *N Fork Potlatch River, 1 (USBS). Lemhi County*: *Salmon River Mts., 3 (USBS). Shoshone Co.*: *Enaville 1 (USBS); Glidden Lakes, 5700 ft., 4 (MVZ). Valley County*: 5 mi. E Warm Lake, 7000 ft., 6 (MVZ); 5 mi. W Cape Horn, 7000 ft., *Sawtooth Range, 1 (MVZ).*

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MONTANA: *Beaverhead County*: *Birch Creek, 18 mi. NE Dillon, 7100 ft., 14 (MVZ). Carbon Co.*: *Pryor Mts., 1 (USBS); 2 mi. E Shriver, 6500 ft., 6 (MVZ). Cascade Co.*: *Neihart, 1 (USBS). Chouteau Co.*: *Upper Muddy, 1 (USBS); Highwood Mts., 2 (USBS). Fergus Co.*: *Lime Kiln Gulch, 7 mi. NE Judith Mts., 3 (USBS); 15 mi. S Heath, N Fork Flat Willow Creek, 8 (USBS); 10 mi. W Tyler, N Fork Flat Willow Creek, 1 (USBS); Crystal Lake, 6000 ft., Big Snowy Mts., 3 (UM). Flathead Co.*: *Waterton Lake, 1 (USBS); Crosley Lake, Glacier Nat'l Park, 1 (USBS); Paola, 1 (USBS); Summit, 2 (USBS); 1 mi. W and 2 mi. S Summit, 5000 ft., 12. Gallatin Co.*: 4 mi S Logan, Camas Creek, Big Belt Mts., 5 (USBS); *Gallatin Gateway, 5 (SDM); west fork West Gallatin River, 6500 ft., 6 (USBS). Glacier Co.*: *Babb, 1 (LMH); 2½ mi. W and 1½ mi. S Babb, 4700 ft., 1; Many Glaciers, 4900 ft., Glacier Nat'l Park, 5 (MVZ); 6 mi. S St. Marys, 6500 ft., 1; St. Marys Lake, 7 (USBS); McDermit Lake, 1 (USBS); Blackfoot Agency, 1 (USBS). Golden Valley County*: *Swimming Woman Canyon, ¾ mi. S Fergus County line, Big Snowy Mts., 4 (UM). Judith Basin Co.*: *Little Belt Mts., Dry Wolf Creek, 20 mi. SW Stanford, 4 (USBS); 13 mi. W Buffalo, 1 (USBS). Madison Co.*: 12 mi. SW Alder, Hinch Creek, Ruby Mts., 2 (USBS). *Meagher Co.*: 16 mi. N White Sulphur Springs, Little Belt Mts., 7 (USBS). *Park County*: *West Boulder Creek, 18 mi. SE Livingston, 1 (USBS); Emigrant Gulch, 3 mi. SE Chico, 6500 ft., 4 (USBS); 2 mi. NE Cooke, 8000 ft., 22 (MVZ). Ravalli County*: 3 mi. SW Florence, 3700 ft., 1; 6 mi. E Hamilton, 3700 ft., 1. *Sanders Co.*: *Prospect Creek, near Thompson, 1 (USBS). Sweet Grass Co.*: *near head of Big Timber Creek, 5200 ft., Crazy Mts., 11 (USBS); Brannin Ranch, Sweet Grass Creek Canyon, 6 (UM); Big Timber, 1 (USBS). Teton County*: 17½ mi. W and 6½ mi. N Augusta, 5100 ft., 2.

WYOMING: *Fremont County*: *Moccasin Lake, 19 mi. W and 4 mi. N of Lander, 10,000 ft., 1; 23½ mi. S and 5 mi. W Lander, 8600 ft., 4. Park County*: 31½ mi. N and 36 mi. W Cody, 6900 ft., 7; 28 mi. N and 30 mi. W Cody, 7200 ft., 1; 16¼ mi. N and 17 mi. W Cody, 5625 ft., 14; 2 mi. S and 42 mi. W Cody, 6400 ft., 5; 12 mi. W Wapiti, 6 (LMH); 25 mi. S

and 28 mi. W Cody, 6350 ft., 5. Sublette County: E end Island Lake, 10,600 ft., 3 mi. S Fremont Park, 1; N side Halfmoon Lake, 7900 ft., 3; W end Halfmoon Lake, 7900 ft., 2; 10 mi. NE Pinedale, 8000 ft., 1; 5 mi. E and 8 mi. N Pinedale, 7500 ft., 1; 3 mi. E and 5 mi. N Pinedale, 7500 ft., 4; 19 mi. W and 2 mi. S Big Piney, 7700 ft., 3.

Marginal records.—Alberta: Boom Creek, 5600 ft., 27 mi. W Banff; Crows Nest Pass; Waterton Lakes Park. Montana: Highwood Mts.; 15 mi. S Heath, N Fork Flat Willow Creek; 2 mi. E Shriver, 6500 ft. Wyoming: 23½ mi. S and 5½ mi. W Lander, 8600 ft.; 10 mi. W and 2 mi. S Big Piney, 7700 ft. Idaho: 7 mi. W West Yellowstone, 7000 ft.; Prairie Creek, 12 mi. NW Ketchum, 2400 ft.; 5 mi. W Warm Lake, 7000 ft.; 1 mi. N Bear Creek R. S., SW slope Smith Mtn., 5400 ft.; N Fork Potlatch River; 13 mi. E and 5 mi. N Coeur d'Alene. British Columbia: Newgate; Vermilion Crossing, Kootenay.

Zapus princeps kootenayensis Anderson

Zapus princeps kootenayensis Anderson, Ann. Rept. Nat. Mus. Canada for 1931:108, November 24, 1932.

Zapus princeps princeps, Preble, N. Amer. Fauna, 15:23, August 8, 1899 (part).

Type.—Adult female, skin and skull, No. 10,020, Nat. Mus. Canada; near summit of Green Mountain, head of Murphy Creek, about 10 miles north of Rossland, West Kootenay district, British Columbia, at about, 6000 ft.; latitude 49° 13' north, longitude 117° 52' west; obtained on July 18, 1929, by R. M. Anderson, original No. 24. [405]

Range.—From Glacier in the Selkirk Range, British Columbia, south to 5 mi. W Cocolalla, Bonner County, Idaho, west and north to Sullivan Lake, Pend Oreille County, Washington; and northwestward to Manning Park on the eastern summit of the Cascade Range in British Columbia. See [fig. 46](#).

Description.—Size, medium; color moderately dark; upper parts noticeably dull and dusty; broad dorsal band of dull Ochraceous-Buff to near Warm Buff sprinkled with black hair to a varying degree, resulting in two color phases (dark has more black hair; Ochraceous phase or Warm Buff phase has more brown hair); sides paler than back owing to fewer black hairs; lateral line, when present, narrow and dull; ventral surface pure white; tail bicolored, pale brown above, yellowish-white to dull white below; ears dark with narrow white or yellowish-white edgings; feet white above; skull narrow across zygomata; incisive foramina narrow; bullae moderately inflated; nasals narrow at tips; postpalatal notch anterior to posterior face of last molars; braincase moderately narrow; zygomatic arch short.

Comparisons.—From *Zapus princeps saltator*, *Z. p. kootenayensis* differs as follows: Upper parts generally dull with less ochraceous; sides with more yellow, less ochraceous; lateral line wanting or not bright; skull averaging slightly smaller; incisive foramina smaller and narrower posteriorly; small medium projection on inferior ramus of the zygomatic process of maxillary frequently present instead of absent; pterygoid fossae shorter and narrower.

For comparison with *Zapus princeps idahoensis* see account of that subspecies.

Remarks.—This subspecies is paler and averages smaller than either of the subspecies with adjoining geographic ranges. There is intergradation with *Zapus princeps idahoensis* in color, shape and size of incisive foramina, and in the shape of the nasals in Idaho-taken specimens from Glidden Lakes and Enaville. These individuals are thought to be *Z. p. idahoensis*. Specimens from the same state taken at Cascade Creek and 13 mi. E and 5 mi. N Coeur d'Alene show intergradation in color, size and inflation of bullae, configuration of nasals, and shape of the vomer between *Zapus princeps idahoensis* and *Z. p. kootenayensis*. The majority of characters studied show these animals to be referable to *Z. p. idahoensis*.

Specimens from Monashee Pass, 4000 ft., British Columbia, show relationship to *Zapus princeps saltator* in the posteriorly wide incisive foramina, in the narrow vomer, and, in some individuals, in the increased amount of ochraceous, dorsally and laterally. The majority of characters studied show these animals to be referable to *Z. p. kootenayensis*.

The animals available from Glacier, British Columbia, are in color more nearly like *Z. p. saltator* and cranially combine the characters of *Z. p. idahoensis*, *Z. p. saltator*, and *Z. p. kootenayensis*. The sum total of their characters places them with *Z. p. saltator*. Anderson (1932:108) remarks on the disparity of size between the two sexes of *Z. p. kootenayensis*, stating that females are considerably larger than males. I have examined most of the material used in the original description and find that animals of like age in the two sexes show no significant size difference. Anderson (*loc. cit.*) seems to have compared young males with adult females. [406]

Specimens examined.—Total, 68, distributed as follows:

BRITISH COLUMBIA: Manning Park, 3 (PM); *Good Fellow Creek, Manning Park*, 1 (PM); *Mt. Beaver Valley, 6300 ft., Manning Park*, 1 (PM); *Timberline Valley, 6500 ft.*, 3 (PM); *Allison Pass, 1 mi. E Manning Park*, 1 (PM); Monashee Pass, 4000 ft., 13 (PM); Hope-Princeton Summit, 5500 ft., 1 (NMC); *Hedley, Stirling Creek*, 1 (NMC); Anarchist Mts., 1 (PM); Fairview-Keremeos Summit, 5 (NMC); *Westbridge*, 2 (NMC); *Midway*, 2 (NMC); Green Mtn., near Rossland, 6000 ft., 12 (11 NMC, 1 MVZ); *Mt. Old Glory, 7000 ft., Rossland*, 5 (4 NMC, 1 MVZ); *Rossland, 5800 ft.*, 12 (11 NMC, 1 MVZ); Camp 6, Meadow Creek, 7 mi. SE of Yahk, 1 (NMC).

IDAHO: *Bonner County*: 5 mi. W Cocolalla, 3500 ft., 2 (MVZ). *Boundary County*: 4 mi. W Meadow Creek, 3000 ft., 2 (MVZ).

Marginal records.—British Columbia: Monashee Pass, 4000 ft.; Camp 6, Meadow Creek, 7 mi. SE Yahk. Idaho: 4 mi. W Meadow Creek, 3000 ft.; 5 mi. W Cocolalla, 3500 ft. British Columbia: Hope-Princeton Summit, 5500 ft.; Manning Park.

Zapus princeps luteus Miller

Zapus luteus, Miller, Proc. Biol. Soc. Washington, 24:253, December 23, 1911.

Zapus luteus australis, Bailey, Proc. Biol. Soc. Washington, 26:132, May 21, 1913. Type from Socorro, Socorro County, New Mexico.

Type.—Female, adult, skin and skull, No. 133601, U. S. Nat. Mus. Biol. Surv. Coll., Espanola, 5000 ft., Rio Arriba Co., New Mexico; obtained on June 24, 1904, by McClure Surber, original No. 162.

Range.—White Mt's of southern Apache County and northern Greenlee County, Arizona; in New Mexico, from the

Sacramento Mt's, Otero County, northward to the San Juan Mt's, Rio Arriba County. See [fig. 46](#). Zonal range: Lower Sonoran (1 individual), Upper Sonoran, Transition, and Canadian.

Description.—Size, small; back near Ochraceous-Buff, having black hair interspersed; mid-dorsal band not always well marked; sides Ochraceous-Buff with fine admixture of black hair; lateral line blending with Ochraceous-Buff of sides, not distinct; ventral surface white to base of hairs, in some cases lightly suffused with color of sides; tail indistinctly bicolored, tan to grayish-white below and brown above; hind feet grayish-white above; ears brownish, narrowly edged with Ochraceous-Buff; skull small; antorbital foramina relatively large; interorbital region broad; inferior ramus of the zygomatic process of the maxillary broad, often with medial projection; incisive foramina narrow posteriorly becoming broadly rounded anteriorly; palatal bridge relatively long; pterygoid fossae narrow; zygomatic arches relatively robust; nasals tapering at each end.

Comparisons.—From *Zapus princeps princeps*, *Z. p. luteus* differs as follows: Size, smaller; color lighter, more Ochraceous-Buff; ears lighter, edged with Ochraceous-Buff as compared with white or yellowish-white; lateral line indistinct or wanting as opposed to distinct; dorsal stripe not well defined; interorbital region broader; antorbital foramina relatively larger; zygomatic arches more robust; nasals tapering at each end as opposed to parallel sided; auditory bullae smaller, less inflated.

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Remarks.—The characters of this subspecies are relatively stable throughout most of its geographic range. Hall and Davis (1934:56) remarked that their material from the White Mountains of Arizona answered precisely to Miller's original description (1911:253) of the species, and my examination of these and other specimens from that area indicates the same thing except that the specimens average slightly darker mid-dorsally than those from New Mexico.

Zapus luteus australis, based on a single individual taken in a riparian thicket along the Rio Grande at Socorro, New Mexico, is referable to *Z. p. luteus*. The diagnostic characters, referred to in the original description, are as follows: Small, slender, and very narrow skull; especially narrow braincase; slender rostrum; and light dentition. These are expressions of age, rather than of geographic variation, in that the individual is a subadult (young of the year). The color, which is paler than in adults of *Z. p. luteus*, is almost identical with that of a subadult (No. 205585 USBS) from Alpine, Arizona. I can see no basis for recognition of *Z. p. australis* and the name, therefore, is placed as a synonym of *Z. p. luteus*.

Four specimens from 4 mi. NE El Rito, 7000 ft., New Mexico, show intergradation, in the shape of the nasals and incisive foramina, in the robustness of the zygomatic arch, and in the breadth of the braincase with a specimen of *Zapus princeps princeps* from Tierra Amarilla, New Mexico. In color and in external measurements as well as in other cranial characters they closely agree with typical *Z. p. luteus* and are here referred to the latter.

Specimens examined.—Total, 49, distributed as follows:

ARIZONA: *Apache Co.*: North Fork White River, White Mts., 24 (SDM); Alpine, 8500 ft., 6 (USBS); West Fork Black River, 7700 ft., 8 (MVZ); *Greenlee County*: Hannagan Creek, 8200 ft., 2 (MVZ).

NEW MEXICO: *Otero Co.*: 12 mi. E Cloudcroft, 7500 ft., 2 (USBS). *Rio Arriba Co.*: 4 mi. NE of El Rito, 7000 ft., 4; Espanola, 5000 ft., 2 (USBS). *Socorro Co.*: Socorro, 1 (USBS).

Marginal records.—New Mexico: 4 mi. N El Rito, 7000 ft.; Espanola, 5000 ft.; 12 mi. E Cloudcroft, 7500 ft. Arizona: Hannagan Creek, 8200 ft.; W. Fork Black River, 7700 ft.; N. Fork White River, White Mts. New Mexico: Socorro.

Zapus princeps minor Preble

Zapus princeps minor Preble, N. Amer. Fauna, 15:23, August 8, 1899.

Zapus hudsonius campestris, Bailey, N. Amer. Fauna, 49:117, January 8, 1927 (part).

Type.—Adult female, skin and skull, No. 73673, U. S. Nat. Mus. Biol. Surv. Coll., Wingard, near Carlton House, Saskatchewan; obtained on July 23, 1895, by J. Alden Loring, original No. 3123.

Range.—Most of southern half of Saskatchewan and Alberta, northeastern Montana southeastward to Aweme, Manitoba, and Webster, South Dakota. See [fig. 46](#). Zonal range: Transition, Hudsonian, and Canadian.

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Description.—Size, small; back dark, usually with a distinct mid-dorsal band of black mixed with Warm Buff; sides lighter, more yellowish, but always with an admixture of black hairs; lateral line distinct, near Ochraceous-Buff, ventral surface characteristically suffused with Ochraceous-Buff; tail bicolored, grayish-white to yellowish-white below and pale brown above; hind feet grayish-white above; ears dark, edged with white or yellowish-white; skull small; postpalatal notch often anterior to posterior part of molars; inferior ramus of zygomatic process of maxillary often with well developed medial projection; auditory bullae flattened; nasals narrower anteriorly and proximal third depressed; base of zygomatic process of squamosal broad.

Comparisons.—From *Zapus princeps princeps*, *Z. p. minor* differs as follows: Size averaging smaller in all measurements taken, except least interorbital constriction which is approximately the same; color dorsally and laterally more yellowish, less Ochraceous-Buff; ventrally greater suffusion of Ochraceous-Buff.

For comparison with *Zapus princeps idahoensis* see account of that subspecies.

Remarks.—This geographic race is notably stable and retains most of its diagnostic characters throughout nearly all parts of its range. Intergradation occurs with *Zapus princeps idahoensis* at various localities in Montana, as is described in more detail in the account of *idahoensis*. Crowe (1943:406) gives evidence of intergradation between *Zapus princeps idahoensis* and *Z. p. minor* in specimens from Entrance in western Alberta. Crowe (*loc. cit.*) described these individuals as intermediate in color (lateral line present, under parts washed with buff, sides and dorsal stripe rich in ochraceous), and in cranial characters (smaller skulls, anteriorly narrower nasals, shorter more deflected rostrum, and higher cranium); but he considered them closer to *Z. p. minor*.

A skin without skull from Kananaskis Valley, Alberta, shows intergradation between *Z. p. idahoensis* and *Z. p. minor*. This individual is like *Z. p. idahoensis* in dorsal and lateral coloring, but is nearer *Z. p. minor* in ventral coloring and in the presence of a distinct lateral line. External measurements provide basis for tentatively assigning the skin to *Z. p. minor*.

Specimens examined.—Total, 118, distributed as follows:

ALBERTA: 4 mi. N Marinville, 2; Blindman River, 1 (USBS); Camrose, 1 (ROM); Red Deer River, 1 (USBS); Didsbury, Little Red Deer River, 1 (ROM); Kananaskis Valley, 7000 ft., 1 (ROM); High River, 2 (ROM); Lodge Creek, 2 (NMC).

MANITOBA: Shoal Lake, 6 (NMC); Oak Lake, 4 (NMC); Aweme, 7 (6 ROM; 1 USBS).

MONTANA: *Chouteau County*: Eagle Creek, 25 mi. SE Big Sandy, 3 (UM). *Hill Co.*: Fort Assiniboine, 1 (USBS); *Bear Paw Mt's*, 20 mi. SE Fort Assiniboine, 4 (USBS); *head Eagle Creek, Bear Paw Mt's*, 7 (UM). *Valley Co.*: Glasgow, 1 (USBS). [409]

NORTH DAKOTA: *Benson Co.*: 4 mi. W Leeds, 1400 ft., 2; 2 mi. W Fort Totten, 1400 ft., 13; Fort Totten, 4 (USBS). *Bottineau Co.*: 4 $\frac{1}{10}$ mi. N Bottineau, 2100 ft., 2; 3 $\frac{1}{2}$ mi. N Bottineau, 1920 ft., 2; 2 $\frac{1}{10}$ mi. N Bottineau, 1800 ft., 3; Bottineau, 1 (USBS). *Dickey Co.*: Oakes, 3 (USBS). *Grand Forks Co.*: Larimore, 3 (USBS). *Montrail Co.*: 6 mi. N Lostwood, 2 (USBS). *Nelson Co.*: Stump Lake, 1 (USBS). *Richland Co.*: Lidgerwood, 1 (USBS); 4 mi. S Blackner, (USBS). *Rolette Co.*: St. John, 1 (USBS). *Sargent County*: 7 $\frac{1}{2}$ mi. E and 1 $\frac{1}{2}$ mi. S Oakes, 1200 ft., 6; 3 mi. W Cayuga, 1000 ft., 2. *Walsh Co.*: Grafton, 2. *Ward Co.*: Minot, 3 (CMNH). *Williams Co.*: Grinnell, 2 (USBS); Buford, 2 (USBS).

SASKATCHEWAN: Wingard, near Carlton House, 2 (USBS); Fort Carlton, 1 (MVZ); Indian Head, 2 (USBS); Cypress Hills, N Maple Creek, 18 (NMC); *Battle Creek*, 1 (NMC).

SOUTH DAKOTA: *Day Co.*: Webster, 1 (Chic. AS).

Marginal records.—Saskatchewan: Wingard, near Carlton House; Fort Carlton. Manitoba: Shoal Lake; Aweme. North Dakota: Larimore; 4 mi. S Blackner. South Dakota: Webster. North Dakota: Oakes; Grinnell. Montana: Eagle Creek, 25 mi. SE Big Sandy. Alberta: High River; Kananaskis Valley, 2000 ft.; Red Deer River; Blindman River; 4 mi. N Marinville.

***Zapus princeps oregonus* Preble**

Zapus princeps oregonus Preble, N. Amer. Fauna, 15:24, August 8, 1899.

Zapus major Preble, N. Amer. Fauna, 15:24, August 8, 1899, type from Warner Mt's, Lake County, Oregon.

Zapus princeps major, Hall, Univ. California Publ. Zool., 37:10, April 10, 1931.

Zapus nevadensis Preble, N. Amer. Fauna, 15:25, August 8, 1899, type from Ruby Mt's, Elko County, Nevada.

Zapus princeps nevadensis, Hall, Univ. California Publ. Zool., 37:10, April 10, 1931.

Zapus princeps palatinus Hall, Univ. California Publ. Zool., 37:8, April 10, 1931, type from Wisconsin Creek, 7800 ft., Toyabe Mt's, Nye County, Nevada.

Zapus princeps princeps, Anthony, Bull. Amer. Mus. Nat. Hist., 33:17, March 17, 1913.

Type.—Male, adult, skin and skull; No. 78156, U. S. Nat. Mus. Biol. Surv. Coll.; Elgin, Blue Mountains, Union Co., Oregon; obtained on May 29, 1896, by Edward A. Preble, original No. 959.

Range.—Southeastern Washington, eastern Oregon east of Cascades, northeastern California, central and northeastern Nevada, and southwestern Idaho. See [fig. 46](#). Zonal range: Transition and Canadian.

Description.—Size large; back from near Light Ochraceous-Buff to near Cinnamon-Buff, usually overlaid with black hairs forming broad dorsal band, which in some individuals is almost black; sides lighter than back, from near Light Pinkish-Cinnamon to near Cinnamon-Buff and Ochraceous-Buff, often with black hairs interspersed; lateral line faintly marked or wanting; belly pure white; tail bicolored, grayish-brown above and grayish-white to yellowish-white below; ears dark, edged with color of sides; palatal bridge long; interorbital region broad; inferior ramus of zygomatic process of maxillary usually with median projection; auditory bullae relatively small; incisive foramina greatly enlarged posteriorly; tooth-rows divergent anteriorly; nasals narrow posteriorly.

Comparisons.—From *Zapus princeps curtatus*, *Z. p. oregonus* differs as follows: Size averaging larger; upper parts darker; tooth-rows more divergent anteriorly; palatal bridge longer; mastoid region broader; incisive foramina relatively wider posteriorly. [410]

For comparisons with *Zapus princeps cinereus*, *Zapus princeps pacificus* and *Zapus princeps idahoensis* see accounts of those subspecies.

Remarks.—The coloration in *Z. p. oregonus* varies somewhat from north to south. In the northern part of the range the average coloration of the upper parts is darker with more ochraceous on the sides. To the southward the upper parts are progressively paler and the sides are near Light Pinkish-Cinnamon. Because of this variation of color, and because of the small samples available to workers in the past, three populations of this subspecies have been named as distinct. However, with the large amount of additional material now available, the supposed diagnostic characters of these "forms" prove to be within the range of individual variations of each of several populations of which large samples are available.

Zapus major Preble (1899:24) was described as having zygomata short, palate broad and long, incisive foramina large and elliptical, and color dark. Some specimens of *Z. p. oregonus*, from nearly all parts of its geographic range, show these same characters. Resemblances in anteriorly divergent tooth-rows, broad interorbital region, small auditory bullae, and posteriorly narrow nasals, are additional reasons for placing *Z. major* as a synonym of *Z. p. oregonus*.

Zapus nevadensis Preble (1899:25), here considered a synonym of *Z. p. oregonus*, was described as having: auditory bullae small, posterior border of the palate usually convex anteriorly, palatal bridge long, and color pale. These characters, however, are within the range of individual variation of *Zapus p. oregonus*. Similarities such as tooth-rows diverging anteriorly,

nasals narrow posteriorly, interorbital region broad, and incisive foramina enlarged posteriorly are added reasons for placing *Z. nevadensis* as a synonym of *Z. p. oregonus*.

Zapus princeps palatinus Hall (1931:8) was described as having: palatal bridge long, incisive foramina wide posteriorly, posterior border of palate straight or convex posteriorly, and color pale. These characteristics are to be found in some individuals in most populations of *Z. p. oregonus*. Additional well marked cranial similarities, such as small auditory bullae, broad interorbital region, and nasals narrow posteriorly offer additional evidence as to the close relationship of *Z. p. palatinus* and *Z. p. oregonus*. Hall (*loc. cit.*), with a small sample available to him for comparative purposes (14 specimens of *Z. p. palatinus* and 12 specimens of *Z. p. nevadensis*), was impressed by the condition of the palate in *Z. p. palatinus* and wrote: "the generally straight, or even posteriorly convex, posterior border of the palate seems to be unique among described forms of *Zapus*. The name *palatinus* is given in allusion to this structural feature." With more than 300 specimens of *Z. p. oregonus* available for study I find that a straight or posteriorly convex posterior border of the palate occurs in more than 50 per cent of the individuals examined. Specimens displaying this described palatal condition are known from all parts of the range of *Z. p. oregonus*, but do occur in a higher percentage of specimens in the area ascribed by Hall (*loc. cit.*) to the range of *Z. p. palatinus*.

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Intergradation with *Zapus princeps idahoensis* and *Zapus princeps cinereus* is discussed in the accounts of those subspecies.

Specimens examined.—Total, 340, distributed as follows:

CALIFORNIA: *Modoc Co.*: Buck Creek R. S., 1 (CAS); *Willow Ranch*, 4 (CAS); *Sugar Hill, 5000 ft.*, 1 (MVZ); *Goose Lake Meadows, near Sugar Hill*, 4 (MVZ); *Parker Creek, Warner Mts., 5500 ft.*, 18 (MVZ); *Dry Creek, Warner Mts., 4800 ft.*, 3 (MVZ) *east face Warner Peak, Warner Mts., 8700 ft.*, 1 (MVZ); *5 mi. NW Eagle Peak, 7000 ft.*, 5 (MVZ); *Lassen Creek*, 1 (SDM); *Happy Camp*, 1 (CAS).

IDAHO: *Boise Co.*: Bald Mtn. R. S., Boise Nat'l Forest, 10 mi. S. Idaho City, 7400 ft., 2 (USBS). *Elmore Co.*: Trail Creek, Boise Nat'l Forest, 2 (USBS). *Washington County*: 1 mi. NE Heath, SW Slope Cuddy Mtn., 4000 ft., 20 (5 MVZ).

NEVADA: *Elko County*: 6 mi. SW Mountain City, Cobb Creek, 6500-6550 ft., 44 (MVZ); *summit between heads of Copper and Coon creeks, Jarbidge Mts.*, 18 (9 MVZ); *head of Ackler Creek, 6800 ft.*, 2; *Steel Creek, 7000 ft.*, 11 (4 MVZ); *summit of Secret Pass, 6200 ft.*, 8; *south fork Long Creek, 7830 ft.*, 4; *Harrison Pass R. S., Green Mtn., Canyon, 6050 ft.*, 12. *Eureka County*: 4 mi. S Tonkin, Denay Creek, Roberts Mt's, 1 (MVZ). *Humboldt County*: *Martin Creek R. S.*, 1 (MVZ); 13 mi. N Paradise Valley, 6700 ft., 19 (MVZ). *Lander County*: *Kingston R. S.*, 7500 ft., 4 (MVZ). *Nye County*: *Wisconsin Creek, 7000 ft.*, 12 (MVZ). *White Pine County*: *Willow Creek, 2 mi. S Elko County line, Ruby Mts., 6500 ft.*, 24 (2 MVZ).

OREGON: *Baker Co.*: *East Pine Creek, 2 1/2 mi. NE Cornucopia*, 6 (USBS); *McEwen*, 2 (USBS); *Bourne*, 7 (USBS). *Clackamas County*: *Marks Creek, 12 mi. N of Howard*, 2 (USBS); *Howard*, 2 (USBS). *Crook County*: *Ochoco R. S., 4000 ft.*, 4 (MVZ). *Grant Co.*: *Austin*, 2 (USBS); *Cold Spring, 4900 ft., 8 mi. E Austin*, 4 (MVZ); *Beech Creek*, 1 (USBS); *Strawberry Mts.*, 6 (USBS); *north fork Malheur River, 21 mi. SE Prairie City, 5000 ft.*, 21 (MVZ). *Harney Co.*: 10 mi. N. *Harney*, 1 (USBS); *Steen Mts., Keiger Gorge, 6900 ft.*, 6 (USBS); *Diamond, 4300 ft.*, 2 (USBS). *Jefferson Co.*: *Foley Creek, 12 mi. E Hay Creek*, 1 (USBS). *Klamath Co.*: *Fort Klamath*, 1 (USBS). *Lake Co.*: *Silver Creek, 7000 ft., Yamsey Mts.*, 1 (USBS); *2 mi. E Lakeview, 5200 ft.*, 3 (MVZ). *Malheur Co.*: *Jordan Valley, 4200 ft.*, 1 (USBS). *Umatilla Co.*: *Meacham*, 1 (USBS). *Union County*: *Elgin*, 2 (USBS). *Wallowa Co.*: *Paradise, 10 mi. N Horse Creek, 7000 ft.*, 1 (USBS); *Minam Lake*, 1 (USBS); *16 mi. S and 3 mi. E Lostine, 5500 ft.*, 9 (MVZ); *west fork Wallowa River, 5000 ft., 2 1/2 mi. above Wallowa Lake*, 1 (FM); *near Wallowa Lake, 4500 ft.*, 3 (FM). *Wheeler County*: 11 mi. W and 7 mi. S Mitchell, 4850 ft., 20 (MVZ).

WASHINGTON: *Asotin Co.*: *Anatone, 3300 ft.*, 1 (USBS). *Columbia County*: *Twin Buttes, 25 mi. SE Dayton, Blue Mts.*, 2 (MVZ); *Stayawhile Spring, 5150 ft.*, 4 (MVZ).

Marginal records.—Washington: *Anatone, 3300 ft.* Oregon: *East Pine Creek, 2 1/2 mi. NE Cornucopia.* Idaho: 1 mi. NE Heath, SW slope Cuddy Mtn., 4000 ft.; *Bald Mtn., R. S., Boise Nat'l Forest, 10 mi. S. Idaho City, 7400 ft.*; *Trail Creek, Boise Nat'l Forest.* Nevada: *Harrison Pass R. S., Ruby Mts.; Steel Creek, 7000 ft.*; *Wisconsin Creek, 7000 ft.*; 13 mi. N Paradise Valley, 6700 ft. California: *Lassen Creek; Buck Creek R. S.* Oregon: *Fort Klamath; Howard; Meacham.* Washington: *Twin Buttes, 25 mi. SE Dayton, Blue Mts.*

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***Zapus princeps pacificus* Merriam**

Zapus pacificus Merriam, Proc. Biol. Soc. Washington, 11:104, April 26, 1897; Preble, N. Amer. Fauna, 15:30, August 8, 1899.

Jaculus hudsonius, Baird, Repts. Expl. and Surv. 111 8 (pt. 1):433, July 14, 1858 (part—the part from Canoe Creek, California).

Zapus alleni Elliot, Field Columbian Mus., publ. 27, zool. ser., 1:212, April 19, 1898, type from Pyramid Peak, Lake Tahoe, El Dorado County, California.

Zapus trinotatus alleni, Elliot, Field Columbian Mus. Publ. 91, zool. ser., 3:315, July 5, 1904; Preble, N. Amer. Fauna, 15:27, August 8, 1899.

Zapus pacificus alleni, Howell, Univ. California Publ. Zool., 21:232, May 20, 1920.

Zapus trinotatus pacificus, Bailey, N. Amer. Fauna, 55:233, August 29, 1936.

Zapus princeps alleni, Hall, Mammals of Nevada; Univ. California Press, Berkeley, California, 579, July 1, 1946.

Type.—Male, subadult, skin and skull, No. 80445, U. S. Nat. Mus. Biol. Surv. Coll.; Prospect, Rogue River Valley, Jackson Co., Oregon; obtained on August 29, 1896, by Edward A. Preble, original No. 1454.

Range.—Sierra Nevada Mt's, from Kern Peak, Tulare County, California, northeastward to Mt. Rose, Washoe County, Nevada, then northwestward through the Trinity and Salmon mountains, California, to the upper Rogue River Valley, Oregon, thence southwestward to South Yolla Bolly Mt'n, Tehama County, California. See [fig. 46](#). Zonal range: Transition, Canadian, and Hudsonian.

Description.—Size medium; color bright; back near Ochraceous-Buff with admixture of black hair forming dark dorsal band; sides bright Ochraceous-Buff with fine admixture of black hair; lateral line blending with color of sides or wanting or indistinct; ventral surface white; tail bicolored, grayish-brown above, yellowish-white below, in some specimens with white tip; feet grayish-white above; ears dark, edged with Ochraceous Buff; braincase relatively narrow; incisive foramina relatively short; pterygoid fossae usually broad; proximal part of inferior ramus of zygomatic process of maxillary broad; postpalatal notch usually broadly rounded; auditory bullae relatively small and flattened; nasals parallel sided; maxillary tooth-row short; interorbital region moderately broad.

Comparison.—From *Zapus princeps oregonus*, *Z. p. pacificus* differs in being brighter in all pigmented areas; more ochraceous and less yellow laterally; dorsally more ochraceous and less black; size averaging smaller; maxillary tooth-rows shorter; auditory bullae less inflated and smaller; interorbital region averaging narrower; palatal bridge averaging shorter; incisive foramina shorter and posteriorly narrower; nasals parallel rather than narrowed posteriorly.

Remarks.—Original describers considered both *Z. pacificus* and *Z. alleni* as specifically distinct from *Z. trinotatus*. Merriam (1897a:104) named *Z. pacificus* and gave the following diagnostic characters: short rostrum and nasals; small auditory bullae; basioccipital broad between bullae. Elliot (1898:212) named *Z. alleni* and ascribed to it the following diagnostic characters: cranium long and narrow; nasals same breadth for entire length; palate wide; pterygoid fossae wide posteriorly; auditory bullae small; basisphenoid and basioccipital wide; upper tooth-rows short. Preble (1899:27) considered *Z. alleni* to be a subspecies of the species *Z. trinotatus*, remarking that the skulls are similar to those of *Z. trinotatus* but smaller with much smaller bullae; in coloration the animals are lighter above and without fulvous below. Preble remarked that the skull of *Z. alleni* differs so greatly from that of *Z. montanus* that comparison was not required. Preble (*op. cit.*:30) treated *Z. pacificus* as a full species. Howell (1920:233) considered *Z. pacificus* and *Z. alleni* to be subspecies of *Z. pacificus*. Howell (*loc. cit.*) pointed out size, cranial, and color similarities between the two, and remarked that *pacificus* is clearly distinct from *Z. montanus*, its nearest geographic neighbor. Hall (1946:578) arranged *Z. alleni* as a subspecies of *Z. princeps*, although not on grounds wholly satisfactory to him because actual intergrades between *alleni* and neighboring races of *princeps* were not available.

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I here consider *Z. alleni* to be synonymous with *Z. pacificus*; the latter is a subspecies of *Z. princeps*. Certain diagnostic characters, such as the shape and size of the os penis, the diameter and pigment pattern of the hair, the over-all proportions of the skull, and the size and shape of the teeth indicate that *alleni* and *princeps* belong to the same species, even though animals from intermediate geographic areas are not available to show actual intergradation.

The diagnostic characters referred to in the original description of *Z. alleni*, as given earlier in this account, agree with characters of specimens of *Z. p. pacificus*. Howell (1920:233) remarks that, in coloration and length of foot, typical *alleni* differs but slightly from *pacificus*. Howell (*loc. cit.*) noted, as I also have, that there are slight cranial differences in specimens from various parts of the range of *Z. p. pacificus*; these variations are somewhat clinal in nature, cranial dimensions showing a slight increase from south to north. The largest animals occur in western Tehama, Trinity, and Siskiyou counties, California. Samples from various localities in Jackson County, Oregon, are slightly smaller than these, but are larger than specimens from the southern Sierra Nevada.

Specimens examined.—Total, 264, distributed as follows:

CALIFORNIA: *Alpine County*: Carson River, $\frac{1}{4}$ mi. SW Woodfords, 5700 ft., 3 (MVZ); *Diamond Valley*, 5500 ft., 1 mi. SE Woodfords, 6 (MVZ); *Faith Valley*, 1 (MVZ). *El Dorado County*: *Glen Alpine Creek*, near *Fallen Leaf Lake*, 6600 ft., 8 (MVZ); 1 mi. W *Fyffe*, 1 (MVZ); *Fresno County*: *Hume*, 1 (MVZ). *Mariposa County*: *Chinquapin*, 6700 ft., *Yosemite Nat'l Park*, 12 (MVZ); *E fork Indian Canyon*, 7300 ft., 8 (MVZ); *Merced Grove*, *Big Trees*, 7 (MVZ); 1 mi. E *Merced Lake*, 5 (MVZ); near *Mono Meadow*, *Yosemite Nat'l Park*, 4 (MVZ); near *Mt. Hoffman*, 8100 ft., *Yosemite Nat'l Park*, 5 (MVZ); *Porcupine Flat*, 8100 ft., *Yosemite Nat'l Park*, 9 (MVZ); *Yosemite Creek*, *Yosemite Valley*, 7 (MVZ); foot *Yosemite Falls*, *Yosemite Nat'l Park*, 8 (MVZ). *Mono County*: *Walker Lake*, 8000 ft., 5 (MVZ); *Swager Canyon*, 7800 ft., 3; *Mono Lake P. O.* 6500 ft., 4 (MVZ). *Placer Co.*: *Truckee River*, *Squaw Creek*, 1 (SDM); *W bank Truckee River*, 1 (MVZ). *Plumas County*: *Rich Gulch*, 3850 ft., 11 mi. W and 8 mi. N *Quincy*, 2 (MVZ). *Shasta County*: *Warner Creek*, 8000 ft., *Lassen Peak*, 6 (MVZ). *Siskiyou Co.*: *Donomore Meadow*, 5800 ft., 15 mi. W *Hilt*, 7 (MVZ); *Poker Flat*, 5000 ft., 12 mi. NW *Happy Camp*, 7 (MVZ); *Little Shasta*, 1 (USBS); *Siskiyou Mts.*, 6000 ft., 2 (USBS); *Sisson*, 1 (SDM); *Mt. Shasta*, 6500 ft., 6 (MVZ). *Salmon River Divide*, 2 (MVZ); *S fork Salmon River*, 5000 ft., 7 (MVZ). *Tehama County*: 2 mi. W *Black Butte*, on *Lassen Rd.*, 6800 ft., 5 (MVZ); 2 mi. E *Mineral*, 5200 ft., 2 (MVZ); 2 mi. S *Yolla Bolly Mtn.*, 11 (MVZ). *Trinity Co.*: *N fork Coffee Creek*, 4500 ft., 34 (MVZ); *Canyon Creek*, 4 (USBS); 8 mi. NE *Hyampon*, 2900 ft., 1 (MVZ); 3 mi. NNW *Mad River Bridge*, 2900 ft., *South Fork Mtn.*, 5 (MVZ); 1 $\frac{1}{2}$ mi. N *Mad River Bridge*, 3000 ft., *South Fork Mtn.*, 6 (MVZ); 1 mi. SW *North Yolla Bolly Mtn.*, 14 (11 MVZ); $\frac{1}{2}$ mi. S *South Yolla Bolly Mtn.*, 3 (MVZ). *Tulare County*: *Jordan Hot Springs*, *Sierra Nevada Mts.*, 6700 ft., 9 (MVZ); *Sherman Creek*, *Sequoia Nat'l Park*, 1 (MVZ); *Tokopah Valley*, 7000 ft., *Sequoia Nat'l Park*, 1 (MVZ); 2 mi. E *Kern Peak*, 9300 ft., *Sierra Nevada Mts.*, 1 (MVZ). *Tuolumne County*: head *Lyle Canyon*, *Yosemite Nat'l Park*, 10,000 ft., 9 (MVZ); *Tuolumne Meadows*, 8600 ft., *Yosemite Nat'l Park*, 1 (MVZ).

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NEVADA: *Douglas County*: $\frac{1}{2}$ mi. E *Zephyr Cove*, *Lake Tahoe*, 6400 ft., 1 (MVZ). *Ormsby County*: *S end Marlette Lake*, 8000 ft., 2 (MVZ); $\frac{1}{2}$ mi. S *Marlette Lake*, 8150 ft., 3 (MVZ). *Washoe County*: $\frac{1}{2}$ mi. S *Mt. Rose*, 9500 ft., 3 (2 MVZ); 3 mi. S *Mt. Rose*, 8500 ft., 3 (MVZ).

OREGON: *Jackson Co.*: *Prospect*, 3 (2 USBS, 1 MVZ); *W slope Grizzly Peak*, 4600 ft., 1 (USBS); *Siskiyou*, 1 (USBS); *Longs Camp*, N base *Ashland Peak*, 3300 ft., 1 (USBS).

Marginal records.—Oregon: *Prospect*. Nevada: 3 mi. S *Mt. Rose*, 8500 ft.; $\frac{1}{2}$ mi. E *Zephyr Cove*, *Lake Tahoe*, 6400 ft. California: *Mono Lake P. O.*, 6500 ft.; 2 mi. E *Kern Peak*, 9300 ft., *Sierra Nevada Mts.*; *Rich Gulch*, 3850 ft., 11 mi. W and 8 mi. N *Quincy*; *Warner Creek*, 8000 ft., *Lassen Peak*; 2 mi. S *Yolla Bolly Mtn.*; 8 mi. NE *Hyampon*, 2900 ft.; *Siskiyou Mts.*, 6000 ft.; *Poker Flat*, 5000 ft., 12 mi. NW *Happy Camp*.

Zapus princeps princeps J. A. Allen

Zapus princeps J. A. Allen, Bull. Amer. Mus. Nat. Hist., 5:71-72, April 28, 1893; Preble, N. Amer. Fauna, 15:23,

Type.—Female, adult, skin and skull; No. 5260/4140, Amer. Mus. Nat. Hist.; Florida, La Plata County, Colorado; obtained on June 27, 1892, by Charles P. Rowley.

Range.—Sierra Madre, Medicine Bow, Laramie, and Big Horn mountains of Wyoming southward through Colorado into the Taos and San Juan mountains in northern New Mexico. See [fig. 46](#). Zonal range: Transition, Canadian and Hudsonian.

Description.—Size, medium; back dark usually with broad mid-dorsal band of black mixed with Warm Buff or Ochraceous-Buff; sides light (Warm Buff) but varying to Ochraceous-Buff, always with admixture of black hair; lateral line distinct and broad, varying from Light Ochraceous-Buff to Ochraceous-Buff; ventral surface white to base of hairs, frequently suffused with Ochraceous-Buff; tail indistinctly bicolored, tan to grayish-white below and pale brown above; hind feet grayish-white above; ears edged with white or yellowish-white; skull medium; large medial projection on inferior ramus of zygomatic process of maxillary; palate moderately long; postpalatal notch usually broadly rounded and posterior to posterior part of last molar; proximal part of inferior ramus of zygomatic process of maxillary broad; pterygoid fossae broad; auditory bullae moderately inflated.

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Comparisons.—From *Zapus princeps luteus*, *Z. p. princeps* differs as follows: Total length, tail and hind foot longer; color darker, being less ochraceous; ears darker, edged with white or yellowish-white instead of Ochraceous-Buff; lateral line more distinct; skull larger, except least interorbital breadth which is smaller; auditory bullae larger, more inflated; pterygoid fossae larger; incisive foramina broader, longer, and posteriorly more truncate; nasals broader, tapering less distally.

From *Zapus princeps idahoensis*, *Z. p. princeps* differs in: Size larger; darker with more Ochraceous-Buff; lateral line much more distinct; underparts frequently suffused with Ochraceous-Buff rather than seldom so; skull larger as regards length of palatal bridge, length of zygomatic arch, and width of proximal part of inferior ramus of zygomatic process of maxillary; pterygoid fossae broader; medial projection on inferior ramus of zygomatic process of maxillary large instead of reduced or absent; postpalatal notch usually anterior to, or on a plane with, posterior face of last molars rather than posterior to same.

Remarks.—This subspecies retains most of its diagnostic characters in all parts of its geographic range. An individual from the type locality, Florida, Colorado, resembles *Zapus princeps luteus* in color, but cranially is most nearly like *Z. p. princeps*. A specimen from Tierra Amarilla, New Mexico, a locality 25 miles north of, and in homogeneous habitat with, El Rito, New Mexico, from which specimens of *Z. p. luteus* are known, shows resemblance to the latter in some cranial characters (see account of *Zapus princeps luteus*) but is most nearly like *Z. p. princeps* to which it is referred.

Animals from Medicine Wheel Ranch, 9000 ft., 28 mi. E Lovell, Wyoming, which are here referred to *Z. p. princeps*, show intergradation with *Zapus princeps idahoensis*, being similar in size of pterygoid fossae, breadth of postpalatal notch, and in size and degree of inflation of the auditory bullae, but differ in color and in other cranial characters. Specimens from 2 mi. E Shriver, 6500 ft., Montana, which lack the distinct lateral line and ventral suffusion of Ochraceous-Buff, are here referred to *Z. p. idahoensis*.

Specimens examined.—Total, 344, distributed as follows:

COLORADO: *Archuleta County*: upper Navajo River, 5 (CMNH); Navajo River, 6 (CMNH). *Boulder Co.*: 12½ mi. S Estes Park, 2; 3 mi. S Ward, 3; Gold Hill, 1 (USBS); 7 mi. NW Nederland's, 2 (UM); 3 mi. E Pine Cliff, 3 (CMNH). *Chaffee County*: 1½ mi. S Monarch, 10,500 ft., 2 (OKLA). *Conejos Co.*: Antonito, 1 (USBS); 5 mi. S and 24 mi. W Antonito, 9600 ft., 2. *Costilla Co.*: 7 mi. SE Russell, 9200 ft., 1 (MVZ); Fort Garland, 6 (USBS). *El Paso County*: Minnehaha, Half Way, 5 (UM). *Grand Co.*: Rocky Mtn. Nat'l Park, 5 (UM). *Gunnison County*: Gothic, 10 (8 OKLA; 2 USBS); Major Creek, foot of Monarch Pass, 1 (OKLA). *Jackson Co.*: Arapahoe Pass, Rabbit Ear Mts., 1 (USBS). *La Plata Co.*: 7 mi. N Florida, Florida River, 7146 ft., 8 (MVZ); Florida, 6500 ft., 11 (1 FM; 9 AMNH). *Larimer Co.*: Elkhorn, 7000 ft., 1 (USBS); 19½ mi. W and 2½ mi. S Loveland, 7300 ft., 3. *Mineral Co.*: Wasson Ranch, Creede, 1; 3 mi. E Creede, 1; 23 mi. S and 11 mi. E Creede, 9300 ft., 5. *Rio Blanco Co.*: 9½ mi. SW Pagoda Peak, 7700 ft., 5; Meeker, 1 (USBS). *Rio Grande County*: Rock Creek Camping Area, 1 (OKLA). *Saguache Co.*: Saguache Park, Cochetopa Forest, 1 (USBS); 22 mi. W Saguache, 1 (MVZ); 20 mi. S Saguache, Cochetopa Pass, 1 (USBS). *San Juan County*: 6½ mi. SW Silverton, 4.

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NEW MEXICO: *Rio Arriba Co.*: Tierra Amarilla, 1 (USBS). *Taos Co.*: Hondo Canyon, 8200 ft., west slope Taos Mts., 1 (USBS); east slope Taos Mts., 8800 ft., 1 (USBS).

WYOMING: *Albany County*: 32 mi. N and 12½ mi. E Laramie, 6080 ft., 1; 30 mi. N and 10 mi. E Laramie, 6760 ft., 1; 29 mi. N and 8¾ mi. E Laramie, 6420 ft., 6; 2 mi. S Browns Peak, 10,600 ft., 2; 3 mi. ESE Browns Peak, 10,000 ft., 8; 8 mi. E and 4 mi. S Laramie, 8600 ft., 2; 8 mi. E and 6 mi. S Laramie, 8500 ft., 1; 1 mi. ESE Pole Mtn., 8350 ft., 2; 1½ mi. ESE Pole Mtn., 8200 ft., 1; 2 mi. SE Pole Mtn., 8300 ft., 3; Centennial, 8120 ft., 1. *Big Horn County*: Medicine Wheel Ranch, 9000 ft., 28 mi. E Lovell, 36; 12 mi. E and 2 mi. N Shell, 7500 ft., 13; 17 mi. E and 3 mi. S Shell, 9000 ft., 1; 17½ mi. E and 4½ mi. S Shell, 9100 ft., 6. *Carbon County*: Bridgers Pass, 18 mi. SW Rawlins, 7500 ft., 6; Lake Marie, Medicine Bow Nat'l Forest, 10,400 ft., 6; 14 mi. E and 6 mi. S Saratoga, 5; 10 mi. N and 10 mi. E Encampment, 8000 ft., 1; 10 mi. N and 12 mi. E Encampment, 7200 ft., 2; 10 mi. N and 14 mi. E Encampment, 8000 ft., 28; 9 mi. N and 3 mi. E Encampment, 2; 8 mi. N and 8 mi. E Encampment, 8900 ft., 1; 8 mi. N and 14 mi. E Encampment, 8400 ft., 5; 8 mi. N and 14½ mi. E Encampment, 8100 ft., 12; 8 mi. N and 16 mi. E Encampment, 8400 ft., 6; 8 mi. N and 22 mi. E Encampment, 10,000 ft., 1; 8 mi. N and 19½ mi. E Savery, 8800 ft., 12; 8 mi. N and 20 mi. E Savery, 8800 ft., 1; 7½ mi. N and 18 mi. E Savery, 8400 ft., 2; 7½ mi. N and 18½ mi. E Savery, 8400 ft., 1; 7 mi. N and 18 mi. E Savery, 8400 ft., 2; 6 mi. N and 13½ mi. E Savery, 8400 ft., 6; 6 mi. N and 14 mi. E Savery, 8350 ft., 6; 4 mi. N and 8 mi. E Savery, 7300 ft., 1. *Converse County*: 21 mi. S and 24 mi. W Douglas, 7400 ft., 6; 21 mi. S and 24½ mi. W Douglas, 7400 ft., 3; 21½ mi. S and 24½ mi. W Douglas, 7600 ft., 15; 22½ mi. S and 24½ mi. W Douglas, 7600 ft., 1; 23 mi. S and 25 mi. W Douglas, 7800 ft., 7. *Johnson County*: 6½ mi. W and 2 mi. S Buffalo, 5700 ft., 4; 5½ mi. W and 1½ mi. S Buffalo, 5520 ft., 3; 5½ mi. W and 1 mi. S Buffalo, 4800 ft., 1; 1 mi. W and ¾ mi. S Buffalo, 4800 ft., 1. *Laramie County*: 5 mi. W and 1 mi. N Horse Creek P. O., 3. *Natrona County*: 2 mi. W and 7 mi. S Casper, 6370 ft., 2. *Washakie County*: 9 mi. E and 5 mi. N Tensleep, 7400 ft., 2; 9 mi. E and 4 mi. N Tensleep, 7000 ft., 5.

Marginal records.—Wyoming: Medicine Wheel Ranch, 9000 ft., 28 mi. E Lovell; 21 mi. S and 24 mi. W Douglas, 7400 ft.; 5 mi. W and 1 mi. N Horse Creek P. O. Colorado: Gold Hill; Minnehaha. New Mexico: E slope Taos Mts.; Tierra

Zapus princeps saltator J. A. Allen

Zapus saltator J. A. Allen, Bull. Amer. Mus. Nat. Hist., 12:3-4, March 4, 1899; Preble, N. Amer. Fauna, 15:31, August 8, 1899.

Zapus princeps, Preble, N. Amer. Fauna, 15:23, August 8, 1899 (part—the part from Glacier, British Columbia).

Zapus hudsonius, Kermode and Anderson, Rep. Prov. Mus. Nat. Hist. for 1913:21, 1914.

Zapus princeps saltator, Hall, Univ. California Publ. Zool., 37:10, April 10, 1931.

Type.—Female, subadult, skin and skull, No. 14408, Amer. Mus. Nat. Hist.; Telegraph Creek, British Columbia; obtained on August 23, 1897, by A. J. Stone.

Range.—Southern Yukon and southeastern Alaska south in British Columbia, to Bella Coola Inlet and Glacier. See [fig. 46](#). Zonal range: Canadian and Hudsonian. [417]

Description.—Size medium; back near Ochraceous-Buff, overlaid with black hairs forming dark dorsal band thickly flecked with ochraceous; sides lighter than back; lateral line usually distinct; belly pure white, sometimes faintly suffused with Ochraceous-Buff; tail bicolored, dark above and grayish-white below; hind feet grayish-white above; ears dark, edged with yellowish-white or Ochraceous-Buff; incisive foramina long, broad posteriorly; palatal bridge relatively short; postpalatal notch anterior to posterior border of last molars; proximal part of inferior ramus of zygomatic process of maxillary without enlarged median projection; zygomatic arch short.

Comparisons.—For comparison with *Zapus princeps kootenayensis* and *Zapus princeps idahoensis* see accounts of those subspecies.

Remarks.—The geographic range of *Z. p. saltator*, as here understood, includes several localities heretofore considered to be within the geographic ranges of neighboring subspecies. Specimens from Indianpoint Lake, 15 mi. N of Barkerville, British Columbia, for example, which Hall (1934:379) considered nearer *Z. p. princeps*, are here referred to *Z. p. saltator*, with which they closely agree in cranial measurements and color of pelage. One individual from Glacier, British Columbia, thought to be *Z. p. princeps* by Preble (1899:32), is here considered to show intergradation between *Z. p. kootenayensis* and *Z. p. saltator* but is more nearly like *Z. p. saltator* to which it is here referred. Intergradation between *Zapus princeps idahoensis* and *Z. p. saltator* is noted, in color and in shape and size of the incisive foramina, in a specimen from Vermilion Crossing, Kootenay, British Columbia. The majority of cranial characters show these animals to be referable to *Z. p. idahoensis*. Specimens from Mt. Revelstoke, 3400 ft., British Columbia, show intergradation in shape of auditory bullae, in breadth of pterygoid fossae, and in shape and size of antorbital foramina between *Z. p. idahoensis* and *Z. p. saltator*. Resemblance in pelage and in the majority of cranial characters indicates that these specimens are best referred to *Z. p. saltator*.

Specimens examined.—Total, 187, distributed as follows:

ALASKA: Taku River, 1 (MVZ).

BRITISH COLUMBIA: Atlin, 7 (6 CAS; 1 PM); *Deep Creek, 60 mi. above Telegraph Creek*, 1 (USBS); *Sawmill Lake, near Telegraph Creek*, 6 (MVZ); junction 4 mi. N Telegraph Creek, 1 (ROM); McDame Post, Dease River, 1 (USBS); *Stikine River, at Glenora*, 28 (MVZ); *Kispiox Valley, 23 mi. N Hazelton*, 3 (MVZ); *9-mi. Mtn., 4500 ft., NE Hazelton*, 1 (MVZ); Hazelton, 959 ft., 20 (MVZ); Bear River, 7 mi. N Bear Lake, 1 (USBS); Charlie Lake, Fort St. John, 1 (PM); *Moose River*, 2 (PM); Tupper Creek, 7 (PM); *Babine*, 2 (USBS); *Port Simpson*, 3 (USBS); 12 mi. N Summit Lake, Alaska Highway, 3300 ft., 3 (NMC); *Giscome*, 1 (USBS); *Ootsa Lake*, 3 (PM); Inverness, mouth Skeena River, 1 (USBS); W end Eutsuk Lake, 1 (PM); Wapiti, head of Middle Branches River, 1 (USBS); Hagensborg, 15 (NMC); *Stuie, Cariboo Mtn., 4700 ft.*, 2 (NMC); Rainbow Mts., Mt. Brilliant, 5000 ft., 10 (NMC); N 7 Wistaria P. O., 13 (NMC); *Mt. McLean, Lillooet*, 1 (PM); Mt. Robson P. O., Mt. Robson Park, 1 (MVZ); *Indianpoint Lake, 15 mi. NE Barkerville*, 42 (29 MVZ; 18 PM); Cottonwood P. O., 2 (MVZ); Mt. Revelstoke, 3400 ft., 6 (PM); Glacier, 1 (ROM). [418]

YUKON: Rose River, mile 95 on Canol Road, 1 (NMC).

Marginal records.—Yukon: Rose River, mile 95 on Canol Road, British Columbia; McDame Post, Dease River; Charlie Lake, Fort St. John; Tupper Creek; Wapiti, head of Middle Branches River; Mt. Robson P. O., Mt. Robson Park; Mt. Revelstoke, 3400 ft.; Cottonwood P. O.; Rainbow Mts., Mt. Brilliant, 5000 ft.; Inverness, mouth Skeena River. Alaska: Taku River. British Columbia: Atlin.

Zapus princeps utahensis Hall

Zapus princeps utahensis Hall, Occ. papers, Mus. Zool., Univ. Michigan, 296:3, November 2, 1934.

Jaculus Hudsonius, J. A. Allen, Bull. Essex Inst., 6:65, April, 1874 (part—the part concerning Great Salt Lake Valley, Utah).

Zapus princeps princeps, Wolfe, Jour. Mamm., 91:154, May 9, 1928.

Zapus princeps idahoensis, Davis, Recent Mammals of Idaho, Caxton Printers, Caldwell, Idaho, p. 341, April 5, 1939 (part—the part from southeast Idaho).

Type.—Female, adult, skin and skull; No. 59153, Museum of Zoology, University of Michigan; Beaver Creek, 19 mi. S Manila, Daggett County, Utah; obtained on July 16, 1928, by A. and R. D. Svihla, original No. 176.

Range.—Southeastern Idaho and extreme western Wyoming (Teton, Snake, and Uinta Mt's) southward through Uinta, Wasatch, Oquirrh, and Beaver Mt's of Utah. See [fig. 46](#). Zonal range: Transition, Canadian, and Hudsonian.

Description.—Size, large; back from Cinnamon-Buff to Warm Buff overlaid with black hairs; sides lighter with less admixture of black hairs; lateral line indistinct, sometimes wanting; tail bicolored, brownish-black above, white to yellowish-white beneath; feet grayish-white above; ventral surface white to base of hairs; ears dark, edged with white to yellowish-white; skull large; palatal bridge relatively short; upper tooth-rows diverging anteriorly; occipitonasal length great; interorbital region broad; zygomata widely bowed; postpalatal notch anterior to posterior face of last molars;

mastoid width great.

Comparisons.—From *Zapus princeps princeps*, *Z. p. utahensis* differs in: color dorsally and laterally less ochraceous, lacking broad lateral line; skull larger in every part measured, excepting length of palatal bridge and breadth of palate at M3; zygomata more bowed; upper tooth-rows more divergent anteriorly; postpalatal notch anterior to posterior border of last molars.

Compared with *Zapus princeps cinereus*, *Z. p. utahensis* differs as follows: Size averaging larger; upper parts darker, Cinnamon-Buff not Pinkish-Buff; incisive foramina wider posteriorly; palate wider; zygomata more robust.

For comparison with *Zapus princeps idahoensis* see account of that subspecies.

Remarks.—*Zapus princeps utahensis* most closely resembles the several subspecies in the Great Basin in its large size, widely bowed zygomata, and posteriorly broadened incisive foramina. Intergradation between *Z. p. utahensis* and *Zapus princeps cinereus*, geographically the nearest of the Great Basin subspecies, is not known. Intergradation in color and cranial characters occurs between *Zapus princeps idahoensis* and *Z. p. utahensis* in specimens from 17 mi. E and 4 mi. N of Ashton, Idaho. All these specimens are, however, referable to *Z. p. idahoensis*. Animals from 9 mi. SE Irwin and from 3 mi. SW Victor, Idaho, resemble *Z. p. utahensis* in most differential characters (dorsally ochraceous, lateral line more distinct, incisive foramina large, palate broad anteriorly, auditory bullae less inflated), and are here referred to *Z. p. utahensis*. A series of specimens from the head of Crow Creek, Idaho, were considered by Davis (1939:340) to be intergrades between *Z. p. idahoensis* and *Z. p. utahensis*; he thought that the specimens were more nearly like *Z. p. utahensis* in color, but cranially (80 per cent in average ratio of anterior width of palate to posterior width of palate), more nearly like *Z. p. idahoensis*, to which subspecies he referred them. I have examined these specimens and find them to be more nearly like *Z. p. utahensis* not only in color but in cranial characters as well. For example, the average ratio obtained by me for anterior width of palate to posterior width of palate is 72 per cent, rather than 80 per cent as given by Davis (*loc. cit.*). Other cranial characters, size of the incisive foramina, shape of the foramen magnum, and shape of the auditory bullae, indicate relationship with *Z. p. utahensis* to which they are here referred. Two immature individuals from Strawberry Creek, 20 mi. E Preston, Idaho, considered to be *Z. p. idahoensis* by Davis (*op. cit.*:341), also are here referred to *Z. p. utahensis*.

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Specimens examined.—Total, 178, distributed as follows:

IDAHO: *Bonnerville County*: 9 mi. SE Irwin, 6400 ft., 3. *Caribou Co.*: Head Crow Creek, Preuss Mts., 7500 ft., 6 (USBS). *Franklin County*: Strawberry Creek, 20 mi. NE Preston, 6700 ft., 2 (MVZ). *Teton County*: 3 mi. SE Victor, 6 (MVZ).

UTAH: *Beaver County*: Puffer Lake, 1 (UU). *Daggett County*: junction Deep Creek and Carter Creek, 7900 ft., 2 (UU). *Duchesne Co.*: Carrant Creek, Uinta Forest, 2 (USBS). *Morgan Co.*: exact locality not given, 1 (UU). *Rich County*: 12 mi. SW Woodruff, 1 (MVZ). *Salt Lake County*: Lambs Canyon, 2 mi. above Parleys Canyon, 7000 ft., 1 (UU); head Lambs Canyon, 9000 ft., 3 (UU); Salamander Lake and Lambs Canyon, 9000 ft., 11 (UU); "The Firs," Mill Creek Canyon, 2 (UU); Brighton, Silver Lake P. O., 8700 ft., Cottonwood Canyon, 1 (UU); Brighton, Big Cottonwood Canyon, 8000 ft., 1 (UU); 1 mi. above Alta, 4 (UU); Butterfield Canyon, approximately 5 mi. above Butterfield Tunnel, 3 (UU). *Sanpete Co.*: 8 mi. E Fairview and 5 mi. S Mammoth R. S., Manti Nat'l Forest, 9000 ft., 1 (USBS); Baldy R. S., Manti Nat'l Forest, 1 (UU); Ephraim, 8850 ft., 1 (USBS). *Summit County*: Henrys Fork, Uinta Mts., 8000 ft., 4 (UU); 14 mi. S and 2 mi. E Robertson, 9300 ft., 3. *Uintah County*: 21 mi. W and 15 mi. N Vernal, 10,050 ft., 1. *Utah County*: Payson Lake, 8300 ft., 12 mi. SE Payson, Mt. Nebo, 12 (UU); 1 mi. E Payson Lake, 8300 ft., Mt. Nebo, 3 (UU). *Wasatch County*: Provo River, 3 mi. N Soapstone R. S., Wasatch Nat'l Forest, 1 (UU).

WYOMING: *Lincoln County*: 3 mi. N and 11 mi. E Alpine, 5650 ft., 37. *Teton County*: ¼ mi. E Moran, 6700 ft., 4; Bar B. G. Ranch, 6500 ft., 2½ mi. NE Moose, 11; Moose, 6225 ft., 1. *Uinta County*: 2 mi. E Robertson, 7200 ft., 1; 9 mi. S Robertson, 8000 ft., 21; 9 mi. S and 2½ mi. E Robertson, 8000 ft., 1; 9½ mi. S and 1 mi. W Robertson, 8600 ft., 2; 10 mi. S and 1 mi. W Robertson, 8700 ft., 18; 10½ mi. S and 2 mi. E Robertson, 8900 ft., 1; 13 mi. S and 1 mi. E Robertson, 9000 ft., 4; 5 mi. E Lonetree, 1 (ROM).

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Marginal records.—Wyoming: ¼ mi. E Moran, 6700 ft.; 2 mi. E Robertson, 7200 ft. Utah: junction Deep Creek and Carter Creek, 7900 ft.; Paradise Park, 21 mi. W and 15 mi. N Vernal, 10,500 ft.; Ephraim, 8500 ft.; Puffer Lake; Payson Lake, 8300 ft., 12 mi. SE Payson, Mt. Nebo; Butterfield Canyon, approximately 5 mi. above Butterfield Tunnel. Idaho: Strawberry Creek, 20 mi. NE Preston, 6700 ft.; 3 mi. SW Victor.

Zapus hudsonius (Zimmerman) (Synonymy under subspecies)

Range.—From Pacific Coast of Alaska eastward to Atlantic Coast; from northern limit of tree-growth south into central Colorado and northeastern parts of Oklahoma and Georgia. See [fig. 47](#).

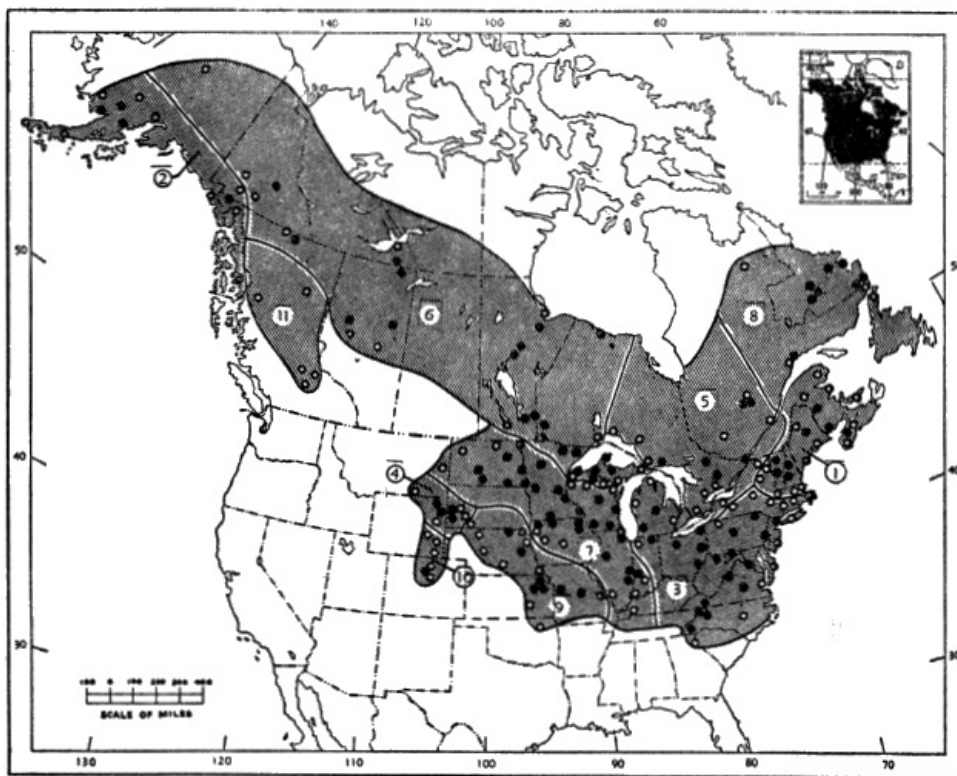


FIG. 47. Distribution of *Zapus hudsonius*.

Guide to subspecies

- | | |
|----------------------------|-----------------------------|
| 1. <i>Z. h. acadicus</i> | 7. <i>Z. h. intermedius</i> |
| 2. <i>Z. h. alascensis</i> | 8. <i>Z. h. ladas</i> |
| 3. <i>Z. h. americanus</i> | 9. <i>Z. h. pallidus</i> |
| 4. <i>Z. h. campestris</i> | 10. <i>Z. h. preblei</i> |
| 5. <i>Z. h. canadensis</i> | 11. <i>Z. h. tenellus</i> |
| 6. <i>Z. h. hudsonius</i> | |

Externals.—Size small to medium (total length 188 mm to 216 mm); tail longer than head and body (112 mm to 134 mm) and bicolored, pale brown to brownish-black above, white to yellowish-white below; hind feet long (28 mm to 31 mm), grayish-white above; back ochraceous to dark brown; sides paler than back with dark hair interspersed; lateral line usually present but sometimes indistinct or entirely absent (when present usually clear Ochraceous-Buff); ventral coloration white, sometimes with suffusion of ochraceous; guard hairs average 115 microns (96u to 140u) in diameter; underhair with pigment pattern in form of hollow, narrow rectangles; cuticular scales of underhair large and fewer than those of the underfur of *Z. trinotatus*, but underhair of *Z. hudsonius* otherwise resembles that of *Z. trinotatus*.

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Baculum.—Size small (total length 4.5 mm to 4.9 mm); base medium in width (0.64 mm to 0.72 mm); tip narrow (0.24 mm to 0.26 mm) and dished out in dorsal aspect, blunted; shaft rounded, curving gently upward at tip.

Skull.—Small to medium and relatively narrow in relation to length; rostrum pointed and short; mastoid region relatively narrow; incisive foramina short; base of zygomatic process of squamosal narrow; coronoid process of mandible short, relatively weak. Upper premolar usually small (averaging .30 mm in length and .35 mm in breadth) sometimes functional (most often so in old adults), occlusal surface divided by single shallow re-entrant fold, which in worn teeth forms centrally located lake; tooth-row short as compared to that of other species; individual cheek-teeth usually smaller than those of other species; lower cheek-teeth shorter and narrower than those of other species; angle of mandible strongly inflected.

GEOGRAPHIC VARIATION

The species *Z. hudsonius* is divisible into 11 subspecies based on differences in color, relative proportions of the tail, hind feet, body, and size and shape of parts of the skull (zygomata, braincase, incisive foramina, auditory bullae, pterygoid fossae, rostrum, and interorbital breadth).

Color of the pelage varies, as a general rule, from dark-backed, dull-sided individuals in the northern parts of the geographic range of the species to light-backed, bright-sided individuals in the southern parts of the range.

Individuals from the southernmost geographic races (*Z. h. americanus* and *Z. h. pallidus*) are the smallest for the species and those from the northernmost subspecies (*Z. h. alascensis*) are the largest. One subspecies, *Z. h. campestris*, from the central part of the range of the species, however, seems to be out of the cline. This form inhabits the eastern foothills of the Rocky Mountains and is a robust animal approaching *Z. princeps* in size.

Seemingly there is no clinal variation in the several qualitative features of the cranium, for instance in the shape of the auditory bullae, shape of the incisive foramina, and shape of the postpalatal notch. On the other hand, the dimensions of the entire skull show that the larger crania are of the northernmost subspecies and the smaller of the southernmost subspecies.

Habitat.—*Zapus hudsonius* occurs in low undergrowth usually of grasses or forbs or both, in open coniferous forests, deciduous hardwood groves, or in stands of tall shrubs and low trees, but most frequently in open, moist areas.

Quimby (1951:75) notes that jumping mice were more common in the moist lowlands than in the drier uplands. More were in the open type lowlands than in the forested type, and these mice favored habitats normally bordered by small streams affording moist to semi-aquatic living conditions. The reports of Goodwin (1924:255), Christian (1936:416), G. S. Miller (1899:329), Cory (1912:249), Lyon (1936:277), Stoner (1918:123), and others, although concerning widely different parts of North America, indicate that *Z. hudsonius* selects habitats in vegetation of like form, even though different assemblages of plant species may be involved.

An average of 11.91 mice per acre was recorded by Quimby (1951:91) from a study plot at Itasca Park, Clearwater County, Minnesota. He gives the monthly population densities per acre for *Z. hudsonius* at Centerville, Anoka County, Minnesota, as follows: June 2.78, July 3.57, August 3.10, and September 1.81. Blair's (1940:248) data on bi-monthly population density per acre for *Z. hudsonius* on the Edwin S. George Reserve, Livingston County, Michigan, are remarkably similar, when adjusted on a monthly basis, to those obtained by Quimby (*loc. cit.*). Blair's (*loc. cit.*) monthly population densities per acre are as follows: June 3.90, July 3.85, August 3.10, and September 2.00. Townsend (1935:90) estimated population densities per acre for *Z. hudsonius* in central New York state, at 11 to 72 individuals. As Quimby (1951:92) points out, Townsend's figures are probably too high, as commonly is the case when the moving quadrat technique is used because animals from neighboring areas enter the trapped area to take over the niches made available by their predecessors' removal.

The population of *Z. hudsonius* may vary considerably from year to year as well as seasonally. Blair (1940:249) found notably fewer jumping mice on the George Reserve in 1938 than in 1939. Quimby (1951:94) found the numbers of *Zapus* to be highly variable and thought that there was a rapid turnover. Young animals were not caught until July when 25 per cent were either juveniles, young, or subadults; from this time on these age classes increased to a high of sixty-one per cent in September. Quimby (*loc. cit.*) found that separating the individuals into their proper age classes was more difficult in September, since the young from early litters are adultlike in appearance. His data indicate as he remarked, "That the over-wintering adults are, for the most part, gradually replaced by the young of the year as the summer progresses." [423]

The sexes in *Z. hudsonius* vary only slightly from a one to one ratio. Quimby (1951:63) found a sex ratio of 110 females to 100 males and Blair (1940:245) records a sex ratio of 113 males to 100 females. Townsend (1935:42) records a sex ratio in central New York of 155 males to 100 females. Such a wide variation from a one to one ratio suggest that the moving quadrat technique, which Townsend (1935:90) employed in obtaining his data, may be, in some way unknown to me, more selective for the males.

Behavior.—The saltatorial powers of *Z. hudsonius* are well developed and often have been described in the literature. Stoner (1918:123) remarks that, "When disturbed *hudsonius* moves away by a series of leaps ... the distance traversed in one of these leaps is from six to eight feet."; Cory (1912:249) observed these mice to make surprisingly long leaps, and, according to him, a distance of 10 feet is by no means unusual; Handley and Patton (1947:49) credit these animals with jumping eight to ten feet at a single bound; Hamilton (1935:190) remarked that he noted an average of not more than four to six feet per jump; Townsend (1935:91) observed one individual make jumps of about two feet; and Harper (1932:29) records a jumping mouse leaping for distances of two to three feet. Quimby (1951:72) notes that he had never seen one jump farther than three feet. He found that the greatest jumps occurred initially and normally covered a distance of two to three feet; subsequent leaps were shorter but more rapid. A jumping mouse in full retreat progressed by jumps of about one foot.

Statements concerning the gait of *Z. hudsonius* are not in agreement but the consensus of opinion is that these animals when unfrightened progress by a series of hops of one to six inches, or, occasionally, with a slow creeping motion while the animal is on all fours. When frightened, however, their progress is by long bounds; the mice make a series of two or three such leaps to the nearest protective cover, and then sit motionless until pursued.

Concerning the use of the tail as a balancing organ, G. S. Miller (1899:330) describes the behavior of a jumping mouse from which the tail had been severed by the sickle of a mowing machine. "When I approached, it made violent efforts to escape, but the moment it was launched in the air, its body, deprived of its balancing power, turned end over end so that it was as likely as not to strike the ground facing the direction from which it had come." [424]

Riparian animals such as *Z. hudsonius* need enter the water to escape from enemies or perhaps in search of food. *Zapus hudsonius* can and does swim. Hamilton (1935:190) found it to be a strong swimmer capable of remaining in the water for from four to five minutes. According to Hamilton (*loc. cit.*), when the mouse is swimming the head is held high, the tail is arched near its middle, and only the hind limbs are employed in propulsion. According to Sheldon (1938:327), Philip Allan, in northern Minnesota, saw many *Z. hudsonius* swimming three or four inches under the surface of the water. The mice swam upstream and only the hind legs were employed in the swimming movements. N. A. Preble (1944:200), at Archer's Pond, 3 miles southeast of Center, Ossipee County, New Hampshire, observed a jumping mouse swimming rapidly under water

toward another portion of the shore 30 or 40 feet away. The mouse, swimming less than a foot beneath the surface, was vigorously using both forefeet and hind feet, but the long tail trailing limply behind, contributed in no way to the animal's movements. Quimby (1951:72) released five of the mice, one at a time, in the open water of a lake. He followed alongside in a boat and observed that, "In all instances the animals proved to be excellent swimmers both on and underneath the surface. The methods of progression were similar to land movements; i. e., the limbs were employed differently at various times depending upon the speed. When first placed in water they moved rapidly by lunges produced by sweeping strokes of the hind limbs employed simultaneously. This movement was accomplished similarly to the long jumps made on land ... Following the first excited lunges, they settled down to a steadier and slower gait using all four limbs one at a time. The anterior part of the body was held high in the water ... When approached too closely, they attempted to escape by diving. The maximum distance noted was about four feet ... One was able to swim vigorously for approximately three minutes after which it tired greatly and was in danger of drowning."

As concerns digging ability, Goodwin (1935:148) reports that *Z. hudsonius* makes its own burrows; these are short and close to the surface in the summer but longer, deeper, and below the frost-line in winter. Two captives used their forefeet and nails in digging a tunnel in the foot of soil that Goodwin (*loc. cit.*) had placed in their cage. Quimby (1951:72) remarks that captives excavate soil by means of the front feet and throw the soil out behind; as the burrow deepened the hind feet were also utilized to throw the loose soil out of the burrow.

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Zapus hudsonius climbs; Sheldon (1934:293) observed captive animals to climb over small evergreen trees in their cages. They moved with surprising sureness and agility, chasing each other among the branches or sitting for several minutes at a time on one of the limbs. Hamilton (1935:190) found that the mice ran over limbs and brush which were placed in their outdoor enclosure.

Ordinarily *Z. hudsonius* is nocturnal, appearing in the early dusk and remaining active until pre-dawn. Occasional individuals are abroad in daylight hours. Sheldon (1934:293) found in Nova Scotia that *Z. hudsonius* is most active from early dusk through the night, but that it may be abroad in daylight as well. Her statements are based on trapping results, field observations, and observations made on captive individuals. Quimby (1951:73) found that *Z. hudsonius* in Michigan is mostly nocturnal; however, he saw mice on a few occasions in the daytime. Diurnal activity seems to be increased in cloudy or damp weather; Quimby (*loc. cit.*) almost invariably trapped more of these mice on cloudy, damp days than on other days.

This jumping mouse usually is silent but does utter various sounds. Sheldon (1934:295) records squeaking and clucking noises. Quimby (1951:73) records the clucking noise described by Sheldon (*loc. cit.*) and mentions also the squeaking and suckling sounds produced by the small young. This mouse is most vociferous when young or when about to go into hibernation. Sheldon (1938:327) writes that *Z. hudsonius* makes a drumming noise by vibrating the tail against dry leaves.

Many data are available concerning the hibernation of *Z. hudsonius*. In general it seems necessary for the mice to put on a certain amount of fat preparatory to hibernation. This fat is deposited in a thin layer over the inside of the skin, over the back, and in the body cavities. The thickest deposits are in and about the inguinal region.

Quimby (1951:83) noted that gain in weight was accelerated in a brief period prior to entrance into hibernation. This relationship of rapid gain in weight to hibernation allows a person to estimate the date of hibernation. Cold weather seems to hasten hibernation, but less so than the correct physiologic condition which is foreshadowed by a rapid gain in weight. For example, Quimby's (1951:84) data reveal that mice that were moved to a heated room gained weight and hibernated in a fashion similar to those in unheated surroundings. Hamilton (1935:193) states that, "It seems necessary for the mouse to lay on a certain amount of fat before it is capable of hibernation." Hamilton (*loc. cit.*) reported that 18 specimens of *Z. hudsonius* taken [presumably in an active state] near Ithaca, New York, on November 13, were without a trace of fat.

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Data that are available concerning the hibernation sites of *Z. hudsonius* show that almost invariably these mice seek shelter in burrows beneath the surface of the ground and there construct nests of grass, leaves, or some other vegetation. Nicholson (1937:103) found a hibernating *Z. hudsonius* on the George Reserve, Livingston County, Michigan, on October 20. The mouse was in a nest, composed of 10 to 12 damp elm leaves, in a sand bank two feet three inches vertically and three feet nine inches horizontally from the surface. On April 11, 1948, Schwartz (1951:228) found five nests (three with occupants) of *Z. hudsonius* at Jefferson City, Cole County, Missouri. All nests were one foot beneath the surface of a pile of coal-ash, which was about three and one-half feet high and five feet in diameter. The nests were spherical, approximately four inches in diameter and consisted of dried oak leaves and bits of dried grass. Grizzell (1949:74) found two hibernating jumping mice at the Patuxent Research Refuge, Laurel, Maryland, in January, 1948. The mice were in separate woodchuck dens; one mouse was 40 inches below the surface and the other was 26 inches below the surface. The mice were curled up in the center of masses of dead leaves, and thus, were well insulated against the cold. On April 29, 1944, at Ithaca, New York, Eadie (1949:307) uncovered a hibernating jumping mouse. The nest, about the size of a baseball, was compactly made of fine grasses and was 10 inches below the surface of the ground in a mound of earth that was approximately six by four feet at the base and three feet high.

From the foregoing reports on hibernation sites it is evident that well drained areas are utilized. Sheldon (1934:300) remarks that the burrows used for hibernating are dug in a bank or some place from which the rain water and melted snow probably drains off.

Eadie (1949:307), Grizzell (1949:75), Sheldon (1934:299), Schwartz (1951:228), and Sheldon (1938:331) all agree that the hibernating mouse rolls up into a ball-like shape (resting on its head and pelvis) with the head between the hind legs, the nose against the lower belly, the forefeet curled on the chest, and the tail curled around the head and body.

A marked loss of weight occurs immediately after hibernation begins, and then reduction in weight is slow and regular. (See Hamilton, 1935:194 and Quimby, 1951:84.) [427]

Sheldon (1934:297) cites a letter from Vernon Bailey in which he remarks on the necessity of abundant moisture and saturate air for hibernating jumping mice. Bailey writes "... they will awaken at times famished for water and will drink and drink before going back to sleep."

Hamilton (1935:195) thinks that in the Ithaca area of New York these mice probably leave their winter quarters in the second half of April and that in southern New York and Long Island they emerge considerably earlier. Quimby (1951:82) and Bernard Bailey (1929:163) report that males appear earlier in the spring than do the females. Quimby (*loc. cit.*), by recording the sequence and dates of phenological events and appearance of *Zapus* in several years, was able to predict fairly accurately the time of emergence of *Zapus* in a succeeding year. In Minnesota, jumping mice emerged late compared to other hibernating rodents.

Enemies.—V. Bailey (1927:119) reports that A. K. Fisher found 50 skulls of *Zapus* in barn owl pellets taken from the towers of the Smithsonian Institution, Washington, D. C. Dearborn (1932:32) reported mink as having fed on jumping mice. Surface (1906:197) records taking a *Zapus* from the stomach of a rattlesnake. Pearson and Pearson (1947:138) found remains of *Z. hudsonius* in pellets of barn owls. Quimby (1951:74) reports two cases of predation on *Z. hudsonius*; one was by a northern pike, *Esox lucius* Linnaeus and the other was by a weasel, *Mustela* sp. Vergeer (1948:91) collected a green frog, *Rana clamitans* Latreille, which had eaten a jumping mouse.

Quimby (1951:74) frequently found the fleas, *Megabothris quirini* Rothschild, and *Megabothris wagneri* (Baker), and occasionally a larval tick, *Dermocenter variabilis* (Say), on *Z. hudsonius*. Sheldon (1934:296) remarks that captive animals are burdened with numerous fleas. Hamilton (1935:191) removed a louse from a jumping mouse. One mouse had a hole in the throat and three others had holes in the inguinal region; presumably bot-flies had emerged from these holes. Test (1943:507) found a single *Cuterebra* larva in the inguinal region of a *Z. hudsonius*, and Sheldon (1938:328) found *Z. hudsonius* infested by larvae of *Cuterebra fontinella* Clark. Here, as in other cases, these larvae were found immediately below the skin. Erickson (1938:252) examined 18 *Z. hudsonius* obtained in Minnesota, and found that three were parasitized. He found a bot-fly larva, *Cuterebra* sp., nematodes of the genera *Subulura* and *Spirocerca*, and a fluke of the genus *Notocotylus*. [428]

Food.—Quimby (1951:85-86) studied the food preferences, by presenting to caged *Z. hudsonius* the plants and invertebrate animals normally available to these mice in nature, and indicates that in general, the starchy fruits of the Gramineae and the less fleshy fruits of various groups of plants are more heavily utilized than other plant materials. His observations indicate that these rodents are highly insectivorous and that they consume many insects under natural conditions. Goodwin (1935:148) reports that the stomach contents of several individuals obtained at South Woodstock, Connecticut, consisted exclusively of blackberries, and that others had subsisted principally on cranberries. Hamilton (1935:197) remarks that seeds are the favored food but that berries, nuts, fruits of various kinds, roots, and insects are also utilized. Stoner (1918:123) writes that the food in cultivated areas of Iowa is various grains as well as grass and weed seeds; in wooded places the mice feed on seeds and nuts of trees. Vernon Bailey (1927:118) states that the examination of a great many stomachs of these jumping mice [in North Dakota] revealed nothing "but the fine white pulp of carefully shelled, well-masticated seeds. Generally these are from grasses, although grain and a variety of other plant seeds are eaten." Schmidt (1931:116) examined the stomach contents of several *Z. hudsonius* taken in Clark County, Wisconsin, and in most stomachs found the remains of finely chewed roots; however, two from Hewett had eaten several geometrid caterpillars.

Lyon (1938:279), Stoner (1918:123), and J. W. Bailey (1946:263) present information which indicates that *Z. hudsonius* stores food in its nests or burrows. Possibly these mice awaken at intervals from hibernation and eat.

"These rodents characteristically seize the material to be eaten with the front feet and devour it while reclining on their haunches. The following observation of a caged animal is typical of their feeding habits. The mouse selected a head of yellow foxtail, *Setaria glauca* (Weig.) Stuntz, from several in the cage, separated it by gnawing through the supporting stem, seized it with the front feet, held it up to the mouth and began to gnaw at one end, stripping all parts from the rachis. The grass head was slowly rotated and shifted sideways until nothing remained but the rachis which was discarded. Actually the seeds were the only parts eaten ..." (Quimby, 1951:73). Sheldon (1934:294) remarks that *Z. hudsonius* eats from a squatting position and holds the piece of food in the forepaws. The mouse seems to bite off a seed, and then, holding it in the forepaws, transfers it to the mouth. [429]

According to Sheldon (*op. cit.*:295) and Quimby (*loc. cit.*), caged jumping mice drink water. When drinking, the mouths of the mice are in contact with the water, but neither observer determined whether the mice lapped or sucked the water. Sheldon (*loc. cit.*) observed these mice passing stems of long grass through their mouths as though to squeeze out moisture, and thought that the mice obtain most of their required moisture from green plants.

Reproduction.—The breeding season begins shortly after the jumping mice emerge from hibernation in the spring, and reproduction continues until a few weeks before they hibernate in the autumn. The extent of the breeding period probably varies geographically and possibly seasonally. For example, Quimby's (*op. cit.*:70) information suggests that the 1947 period of parturition occurred between June 15 and August 30 in the area of Centerville, Minnesota. In Michigan, Blair (1940:246) found a peak of breeding activity in spring and another in late summer with little activity in the intervening midsummer. Brimley (1923:263) records a female in North Carolina, with eight embryos on June 13, 1895, and another with seven embryos on September 17, 1891, indicating a strong possibility of two litters per year there. Vernon Bailey (1927:118) records young born in May or June in North Dakota and thinks that there is time for only one litter per year. Petrides (1948:76) captured a female on September 22, 1944, at Athens, Georgia, that gave birth to six young on September 29. This late parturition date indicates a longer breeding season in the southeastern part of the range of *Z. hudsonius*.

The gestation period of nonlactating, caged *Z. hudsonius*, Quimby (1951:63) thinks, "is approximately 18 days ... [but] gestation is prolonged in lactating females."

Data from museum labels indicate that embryos in 62 pregnant females averaged 5.4 (2-8) per female. Quimby (1951:67) found the average number of embryos per female for 14 females taken in Minnesota, to be 5.3 and that litters of young found in nests averaged 5.8. Sheldon (1938:330) reports two litters of seven young each and one of four young for *Z. hudsonius* in Vermont. Petrides (1948:76) records a litter of six young for *Z. hudsonius* in Georgia. Brimley (1923:263) records one lot of seven and one lot of eight embryos for *Z. hudsonius* in North Carolina. Vernon Bailey (1923:120) reports six embryos for a female of *Z. hudsonius* taken in Washington, D. C. Ivor (1934:8) obtained a litter of five young *Z. hudsonius* from Erindale, Peel County, Ontario. Hamilton (1935:195) records litters of two, four, and five young and embryo counts of four, two, four, and four for *Z. hudsonius* in New York.

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There seems to be two litters per year. According to Quimby (1951:69), "most adult females breed soon after emergence from hibernation and produce the first litters within a month. The remaining females do not breed immediately but produce the first litter," he says, "in the second month after emergence." Both early-breeding females and late-breeding females produce at least 2 litters per year. Those that breed early may have 3 litters.

The appearance and development of growing young of *Z. hudsonius* in successive weeks is described by Quimby (1951:65). Newborn young are pink and hairless except for microscopic vibrissae. The eyes and external auditory meatus are closed, and the pinnae are folded. The toes are fleshy and clawless; the tail is short in relation to the length of the body. The average weight was .78 grams. The average measurements of three from different litters are: total length, 34 mm; tail, 9.2 mm; hind foot, 4.7 mm. The young are helpless but capable of emitting a high pitched squeaking sound which is audible for several feet.

In the first week of growth the vibrissae become visible to the naked eye, the body changes to flesh color, the dorsal parts become dark gray, the pinna unfolds and is black tipped, and the claws appear. The young now are able to crawl and make a suckling noise, but they are not yet able to support themselves on their legs.

In the second week of development, tawny yellow hair appears on the back and spreads onto the sides. Sparse hair of a lighter color appears on the belly, backs of the feet, and outer surfaces of the legs. Vibrissae are now prominent. The eyes are still closed, but a crack down the center of each is visible by the 13th day. Claws have grown, the longest measuring 1.5 mm. The incisors erupt on approximately the 13th day, those in the lower jaw appearing slightly before those in the upper jaw, and all are white. Activity is increased; nevertheless the young still crawl, make suckling notes, and squeak.

In the third week of development the mice are covered with hair; darker hair appears dorsally; and vibrissae continue rapid growth. The external auditory meatus begins to open on about the 19th day and young react to sound on the 20th. The incisors now are 1 mm long and the claws 1.5 mm long. Young are able to support themselves on their legs, walk, and make one inch hops.

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In the fourth week the juvenal pelage is replaced by adult pelage. The eyes open between the 22nd and 25th days. The color of the incisors changes from white to yellowish-orange as in the adults. P⁴, M¹, M², m¹ and m² have emerged from the maxillary and dentary bones; M³ and m³ have not yet erupted. A mouse 33 days old had all teeth well developed. By the end of the 4th week the young, except for size, are adultlike and capable of independent existence.

The greatest increase in dimensions of the body is in the first four weeks. A slowing down of growth is simultaneous with weaning.

Other workers, Sheldon (1938:330), Petrides (1948:76), and Ivor (1934:8) also describe the appearance of the young.

Summer nesting sites are usually on the surface of the ground. Jumping mice characteristically construct a globular nest of grass but will utilize other vegetation if grasses are not available. Nests are usually concealed under rocks, logs, bushes, or grass and can be entered by a hole at one side.

Sheldon (1938:328) described a nest of *Z. hudsonius* found on the ground near the edge of a small hay field. The nest was globular, not more than four inches in outside diameter and two inches in inside diameter; it was closely woven of fine, dry grass and bits of moss. Another nest found in the same field measured 11.5 inches in circumference at the base and six inches in circumference over the top. The inside width and length each was three inches, and the inside height was 3.5 inches. Vernon Bailey (1927:118) remarks that summer nests are placed on the surface of the ground well concealed under grass or other vegetation. He describes the nest as "neat little balls of fine grass with a tiny opening at one side and a soft lining in the central chamber." Cory (1912:249) reports that summer nests are concealed behind rocks or under bushes and thick grass. The nests are round and four or five inches in diameter with an entrance hole at one side. Goodwin (1935:148) examined a nest made entirely of straight, narrow leaves of grass. Ivor (1934:8) found one made of finely shredded jute sacking. Quimby (1951:80) describes several nests: one in the center of a rotten willow log was lined with small pieces of pulpy wood; another was in the rotted wood and debris, at ground level, inside a large, red oak (this globular nest composed of grasses, plant fibers, and rootlets measured six inches in diameter). Another nest was composed of a pile of wood pulp, leaves of oaks, and grasses; this nest was in a hollow root detached from a willow tree.

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The mean home range of males, of *Z. hudsonius* in Minnesota, according to Quimby (1951:86), was 2.70 plus or minus .50 acres; this was significantly larger than the mean home range of females, 1.57 plus or minus .27 acres. According to Quimby (*loc. cit.*), the size and shape of the home range is influenced by the general features of the terrain, density and type of cover, and land use in the immediate area. Quimby (1951:94) remarked that the home range of the jumping mouse is relatively unstable and Blair (1940:247) stated that the home ranges of both sexes generally overlapped the ranges of other members of the same species and sex. The average size of the home range for *Z. hudsonius* in Michigan was .89 plus or minus .11 acres for males and .92 plus or minus .11 acres for females.

***Zapus hudsonius acadicus* (Dawson)**

Meriones acadicus Dawson, Edinburgh New Philos. Jour., new ser., 3:2, 1856.

Meriones labradorius, Dawson, Edinburgh New Philos. Jour., new ser., 3:2, 1856.

Jaculus hudsonius, Baird, Rept. Expl. and Surv...., 8 (pt. 1):433, July 14, 1858 (part—the part from Nova Scotia, Vermont, and New York).

Zapus hudsonius, Coues, Bull. U. S. Geol. and Geog. Surv. of the Territories, 2nd ser., No. 5:260, 1877 (part—the part from Nova Scotia, Vermont, and New York); Preble, N. Amer. Fauna, 15:17, August 8, 1899 (part—the part from New Brunswick, Nova Scotia, Maine, New Hampshire, Vermont, Massachusetts, and northeastern New York).

Zapus hudsonius canadensis, Batchelder, Proc. New England Zool. Club, 1:5, February 8, 1899 (part—the part from Keene Valley in Essex County of New York, and Orivell in Vermont); Anderson, Ann. Rept. Provancher Soc. Nat. Hist., Quebec, 1941:35-37, July 14, 1942 (part—the part from the tip of the Gaspé Peninsula in Quebec, New Brunswick, Maine, New Hampshire, Vermont, and New York).

Zapus hudsonius hardyi, Batchelder, Proc. New England Zool. Club, 1:6, February 8, 1899, type from Mt. Desert Island, Hancock County, Maine; Bole and Moulthrop, Sci. Publ. Cleveland Mus. Nat. Hist., 5:165, September 11, 1947 (part—but excluding Pennsylvania and Ohio).

Zapus hudsonius acadicus, Anderson, Ann. Rept. Provancher Soc. Nat. Hist., Quebec, 1941:38, July 14, 1942.

Type.—No type specimen designated. Subspecies characterized from specimens obtained in Nova Scotia.

Range.—Gaspé Peninsula of Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Maine, New Hampshire, Vermont, Massachusetts, northern Connecticut and northeastern New York. See [fig. 47](#). Zonal range: Transition and Canadian.

Description.—Size medium; back from near Ochraceous-Tawny to near Yellow-Ocher with heavy admixture of black-tipped hair, the dorsal band distinct against color of sides; sides lighter than back and from near Cinnamon-Buff to near Ochraceous-Buff lined with black-tipped hair; lateral line usually faintly marked but sometimes distinct and clear Warm-Buff; underparts white, sometimes suffused with color of sides; tail distinctly bicolored, brownish-black above and yellowish-white to grayish-white below; ears dark, edged with color of sides; feet grayish-white above; pterygoid fossae relatively narrow; zygomata relatively long and broad; auditory bullae relatively narrow, usually with depression on anterior surface; mastoid region relatively narrow; inferior arm of zygomatic process of maxillary relatively narrow.

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Comparisons.—From *Zapus hudsonius canadensis*, *Z. h. acadicus* differs in: Size averaging larger; upper parts usually less brownish and more ochraceous, sides and flanks being more ochraceous and less yellowish; zygomata relatively longer; pterygoid fossae relatively narrower; auditory bullae relatively narrower and usually with depression on anterior surface.

From *Zapus hudsonius americanus*, *Z. h. acadicus* differs as follows: Size larger; color darker on upper parts, flanks duller (less ochraceous); underparts white, much less frequently suffused with color of sides; ears dark, usually without flecks of ochraceous; general appearance of pelage not so brightly colored; zygomata longer; condylobasal length greater; mastoid region relatively broader; bullae larger, more inflated and usually with depression on anterior surface; maxillary tooth-row relatively longer.

For comparison with *Zapus hudsonius ladas* see account of that subspecies.

Remarks.—Specimens from various localities in Nova Scotia, Prince Edward Island and New

Brunswick are essentially similar. Anderson (1942:38) revived the name *Z. h. acadicus* for jumping mice from these areas, correctly considering them to be distinct from *Z. h. canadensis*, the geographic race immediately to the west.

In the size and shape of the auditory bullae, length of the zygomata, breadth of the pterygoid fossae, and general color of the pelage the populations from Nova Scotia and New Brunswick are essentially indistinguishable from material of *Zapus hudsonius hardyi* from Maine. Thus, *Z. h. hardyi* must fall as a synonym of the earlier proposed name *Z. h. acadicus*.

Bole and Moulthrop (1942:165) applied the name *Z. h. hardyi* (= *acadicus*) to the mice inhabiting a large area from coastal Maine and central New Hampshire through southern New England, New York, northwestern Pennsylvania, and northeastern Ohio. I agree with Bole and Moulthrop (*loc. cit.*) that the population of *Zapus hudsonius* from Maine, New Hampshire, west-central and northern New England are different from neighboring subspecies and are referable to *Z. h. acadicus*, but find that material from extreme southern Massachusetts, Connecticut, southern New York, northwestern Pennsylvania, and northeastern Ohio is best referred to *Zapus hudsonius americanus* (see account of that subspecies).

Intergradation between *Z. h. americanus* and *Z. h. acadicus* is indicated by specimens from Berlin, Rensselaer County, New York. In color of ears, length of zygomata, and size and shape of the incisive foramina these specimens are more nearly like *Z. h. americanus* but in size and shape of the auditory bullae, breadth of the mastoid region, and general appearance of the pelage they are more nearly like *Z. h. acadicus* and are here referred to *acadicus*. Specimens from Glenville, Schenectady County, New York, are intermediate in cranial characters between *Z. h. americanus* and *Z. h. acadicus* but in color are best referred to the latter. Specimens from 1 mi. S Ayer, Worcester County, Massachusetts, are like *Z. h. americanus* in their short zygomata, narrow mastoid region and suffusion of the underparts; nevertheless, in the shape of the auditory bullae, breadth of the pterygoid fossae, and greater condylobasal length the specimens are more nearly like *Z. h. acadicus* which they are here considered to be. Animals from Essex and Wilmington, Essex County, Massachusetts, are like *Z. h. americanus* in external size and in the size and shape of the auditory bullae; but they are more nearly like *Z. h. acadicus* in most cranial characters and in the general color of the pelage and are here assigned to *Z. h. acadicus*.

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Specimens from Keene Valley, Essex County, New York, considered by Batchelder (1899:4) to be *Z. h. canadensis*, are in color, length of the zygomata, and size and shape of the auditory bullae more nearly like *Z. h. acadicus* to which subspecies they are here assigned. A specimen from Orwell, Addison County, Vermont, that Batchelder (*op. cit.*:5) referred to *Z. h. canadensis* is more nearly like *Z. h. acadicus* in the shape of the auditory bullae, length of the zygomata, and color of the pelage, and is here referred to *Z. h. acadicus*. Specimens from western New Brunswick, referred to *Z. h. canadensis* by Anderson (1942:37), are more nearly like *Z. h. acadicus*. Specimens from Ste. Anne des Monts, Gaspé Peninsula, Quebec, are intermediate between *Z. h. canadensis* and *Z. h. acadicus* in color and size and also in the shape of the auditory bullae but are best referred to *Z. h. acadicus*.

Zapus hudsonius acadicus as here understood is a relatively wide-ranging subspecies. Populations at the southern periphery of its range are difficult to separate from populations at the northern periphery of the range of *Z. h. americanus*. These two geographic races represent opposite extremes of a clinal gradient and, as would be expected, geographic intermediates are morphologically similar.

Specimens examined.—Total, 156, distributed as follows:

MAINE: *Aroostock County*: Madawaska, 6 (MCZ). *Hancock County*: Mount Desert Island, 9 (6 MCZ, 3 UM). *Piscataquis County*: Mount Katahdin, 1 (USNM); Sebec Lake, 4 (USBS); *Katahdin Lake*, 1 (USBS). *Sagadahoc Co.*: Small Point Beach, 1 (Clev. MNH). *Somerset County*: east branch Penobscot River, 2 (USBS). *Washington County*: Columbia Falls, 1 (USBS).

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MASSACHUSETTS: *Essex County*: Essex, 4 (Clev. MNH); Wilmington, 4 (3 USBS, 1 USNM). *Worcester County*: Lunenburg, 2 (USBS); 1 mi. S Ayer, 2 (MVZ); 2 mi. N Gilbertville, 1.

NEW BRUNSWICK: *Charlotte County*: 6 mi. N St. Andrews, 2 (NMC); 5 mi. N St. Andrews, 4 (NMC). *Carleton County*: Debec, 1 (MVZ). *Gloucester County*: Dalhousie, 2 (MVZ); *Miramichi Road*, 15 mi. from Bathurst, 4 (NMC); *Youghall*, 3 (NMC). *Madawaska County*: Baker Lake, 2 (NMC); 9 mi. NE Edmundston, 4 (NMC); 5 mi. N St. Leonard, 5 (NMC). *Victoria Co.*: Tobique Point, 1 (AMNH). *York County*: Queensbury, 1 (USBS).

NEW HAMPSHIRE: *Carroll County*: Intervale, 1 (UM); Ossipee, 4 (3 USBS); 2 mi. S Ossipee, 12 (2 USNM). *Coos County*: Nathan Pond, 1 (UM); Fabyans-Bretton Woods, Dartmouth Brook, 2 (UM); Fabyans, 1 (USNM); 3 mi. W Base Station, 1; Mt. Washington, 1 (MVZ); Pinkham Notch, 1900 ft., 1 (USNM). *Grafton County*: Franconia Notch, Profile Lake, 1 (UM); Lebanon, 3 (UM). *Strafford Co.*: 1 mi. E Durham, 1 (UM).

NEW YORK: *Essex Co.*: Keene Valley, 5 (MCZ); Keene Heights, 5 (MCZ); Minerva, 1700 ft., 1 (AMNH). *Herkimer County*: Northwood, 7 (AMNH). *Rensselaer Co.*: Berlin, 8 (AMNH). *Schenectady County*: Glenville, 1 (USBS). *Warren County*: Lake George, 5 (USBS). *Washington County*: Patterns Mills, 1 (USBS).

NOVA SCOTIA: *Annapolis Co.*: Bear River, 7 (NMC); Lake Kedgemakooge, 5 (UM); 2 mi. S Milford, 1 (AMNH). *Kings Co.*: Black River Dist., 1 (NMC); no exact locality, 1 (NMC). *Shelburne County*: Doctors Cove, N Barrington Passage, 1 (NMC); Barrington Passage, 4 (NMC).

PRINCE EDWARD ISLAND: no exact locality, 1 (USBS).

QUEBEC: Ste. Anne des Monts, 1 (AMNH).

VERMONT: *Addison County*: Orwell, 1 (MCZ); *Lamville County*: Mt. Mansfield, 2 (USBS). *Windham County*: Whitingham, 2 (AMNH).

Marginal records.—Quebec: Ste. Anne des Monts. New Brunswick: Dalhousie. Prince Edward Island. Nova Scotia: Black River District; Doctors Cove, N Barrington Passage. Maine: Columbia Falls; Small Point Beach. Massachusetts: Wilmington; 2 mi. N Gilbertville. New York: Berlin; North Wood; Keene Valley. Maine: E branch Penobscot River. New Brunswick: Baker Lake.

Zapus hudsonius alascensis Merriam

Zapus hudsonius alascensis Merriam, Proc. Biol. Soc. Washington, 2:223, July 15, 1897.

Zapus hudsonius hudsonius, Osgood, N. Amer. Fauna, 24:37, November 23, 1904.

Type.—Male, adult, skin and skull, No. 73584, U. S. Nat. Mus., Biol. Surv. Coll.; Yakutat Bay, Alaska; obtained on July 5, 1895, by Clark P. Streater, original No. 4660.

Range.—Alaska Peninsula, coastal section of mainland of southern and southeastern Alaska including Revillagigedo Island; also southwestern Yukon. See [fig. 47](#). Zonal range: Canadian and Hudsonian.

Description.—Size large; back from near Ochraceous-Tawny to near Dresden Brown, sometimes darkened with black tipped hair usually with darker mid-dorsal area forming a band; sides lighter than back and from near Ochraceous-Tawny to near Clay Color; lateral line usually distinct, of clear Ochraceous-Buffer; belly white, frequently with a slight suffusion of Ochraceous-Buffer; tail bicolored, brownish to brownish-black above, white to yellowish-white below; ears dark, edged and flecked on the inner surface with color of sides; feet grayish-white above; auditory bullae broad and moderately inflated; pterygoid fossae relatively broad; incisive foramina relatively long, zygomata relatively long and broadly bowed; mastoid region relatively broad; distance from incisors to postpalatal notch relatively great; occipitonasal length relatively great.

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Comparisons.—From *Zapus hudsonius tenellus*, *Z. h. alascensis* differs as follows: Size larger; upper parts darker, less ochraceous; sides duller, less ochraceous more tawny; incisive foramina averaging longer; mastoid region broader; occipitonasal length greater; zygomata wider-spreading and longer; condylobasal length averaging greater; auditory bullae less broadly rounded; and distance from incisors to postpalatal notch averaging greater.

For comparison with *Zapus hudsonius hudsonius* see account of that subspecies.

Remarks.—*Zapus hudsonius alascensis* is a fairly well marked subspecies retaining most of its characters throughout its range. Variation is noted in specimens from the southwest end of Dezadeash Lake, 2400 ft., Yukon Territory, and seems to be the result of intergradation between *Zapus hudsonius hudsonius* and *Z. h. alascensis*. These animals are like *Z. h. hudsonius* in the shape of the auditory bullae but are otherwise more nearly like *Z. h. alascensis* to which they are here assigned. Alaskan specimens from 7 mi. SSE Haines, and from a point 9 mi. W and 4 mi. N Haines average slightly larger than *Z. h. alascensis* in most measurements taken; however, in coloration they more nearly agree with *Z. h. alascensis* than with *Z. h. hudsonius* or *Z. h. tenellus* the geographic ranges of which adjoin that of *Z. h. alascensis*.

Specimens examined.—Total, 56, distributed as follows:

ALASKA: Cook Inlet, Tyonek, 1 (USBS); head Chalitna River, 2 (USBS); Lake Clark, 4 (USBS); east side Chilkat River, 100 ft., 9 mi. W and 4 mi. N Haines, 8; Yakutat, 3 (USBS); Lake Iliamna, 1 (USBS); Lake Aleknagik, 1 (USBS); *Kokwok*, 1 (USBS); *Nushagak River*, 3 (USBS); *Chilkat Peninsula*, 10 ft., 7 mi. SSE Haines, 18; Nushagak, 3 (USBS); Chignik Bay, 1 (USBS); Portage Cove, Revillagigedo, 1 (MVZ); *Izembek Bay*, 1 (USBS); Frosty Peak, 1 (USBS).

BRITISH COLUMBIA: *west end Kelsall Lake*, 2900 ft., 1; Stonehouse Creek, 5½ mi. W junction Stonehouse Creek and Kelsall River, 4.

YUKON: SW end Dezadeash Lake, 2400 ft., 2.

Marginal records.—Alaska: Lake Aleknagik; head Chalitna River. Yukon: SW end Dezadeash Lake, 2400 ft. Alaska: E side Chilkat River, 100 ft., 9 mi. W and 4 mi. N Haines; Portage Cove, Revillagigedo Island; Yakutat; Cook Inlet, Tyonek; Chignik Bay; Frosty Peak.

Zapus hudsonius americanus (Barton)

Dipus americanus Barton, Trans. Amer. Philos. Soc., 4:115, 1799.

Jaculus americanus Wagler, Nat. Syst. Amphibien, 23, 1830.

Meriones microcephalus Harlan, Proc. Zool. Soc. London, p. 1, 1839, based on two specimens from "the farm of Mr. Beck, in Philadelphia County, a few miles northeast of the city [= Philadelphia, Pennsylvania]."

Jaculus hudsonius, Baird, Repts. Expl. and Surv. 111, 8 (pt. 1): 433, July 14, 1858 (part—the part from Massachusetts, Connecticut, New York, New Jersey, and Pennsylvania).

Zapus hudsonius, Coues, Bull. U. S. Geol. and Geog. Surv. of the territories, 2nd ser. No. 5:260, 1877 (part—the part from Massachusetts, Connecticut, New York, and Pennsylvania); Preble, N. Amer. Fauna, 15:17, August 8, 1899 (part—the part from Peterboro and Waterville, New York, southeastern Massachusetts, Connecticut, New Jersey, Pennsylvania, West Virginia, Maryland, North Carolina, and Ohio).

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Zapus hudsonius americanus, Batchelder, Proc. New England Zool. Club, 1:6, February 8, 1899; Preble, N. Amer. Fauna, 15:19, August 8, 1899.

Zapus hudsonius hardyi, Bole and Moulthrop, Sci. Publ. Cleveland Mus. Nat. Hist., 5:165, September 11, 1942 (part—the part from New York, Ohio, and Pennsylvania).

Zapus hudsonius brevipes Bole and Moulthrop, Sci. Publ. Cleveland Mus. Nat. Hist., 5:168, September 11, 1942, type from Bettsville, Seneca County, Ohio.

Zapus hudsonius rafinesquei Bole and Moulthrop, Sci. Publ. Cleveland Mus. Nat. Hist., 5:169, September 11, 1942 (part—the part from southeastern Ohio), type from Cat Run, extreme southeastern Belmont County, Ohio.

Type.—No type specimen designated. *Dipus americanus* was characterized from jumping mice obtained by Barton near the Schuylkill River, a few miles from Philadelphia, Pennsylvania.

Range.—Southeastern United States and lower peninsula of Michigan; east of central Indiana; from central New

York and Massachusetts southward to northern Georgia. See [fig. 47](#). Zonal range: Austroriparian (Lower Austral), Carolinian (Upper Austral), Alleghanian (Transition), and Canadian.

Description.—Size small; back from near Light Ochraceous-Buff to near Ochraceous-Buff with admixture of black-tipped hair forming distinct dorsal band; sides bright, lighter than back from near Light Ochraceous-Buff to near Ochraceous-Buff; lateral line usually distinct and of color of sides; underparts white, sometimes with slight suffusion of color of sides; tail bicolored, brown to brownish-black above, yellowish-white to grayish-white below; ears narrowly edged and heavily flecked with color of sides; feet white to grayish-white above; skull short; braincase relatively narrow; incisive foramina relatively broad; skull relatively narrow across zygomata; interorbital region relatively broad; distance from incisors to postpalatal notch relatively short; auditory bullae relatively small.

Comparisons.—Compared with *Zapus hudsonius canadensis*, *Z. h. americanus* differs as follows: Smaller; paler (in a sense brighter because more ochraceous and less tawny); skull smaller; auditory bullae narrower, less inflated; incisive foramina relatively more bowed; condylobasal length averaging less.

From *Zapus hudsonius intermedius*, *Z. h. americanus* differs as follows: Smaller; color brighter, more ochraceous, less yellow; braincase relatively narrower; auditory bullae usually smaller; incisive foramina broader; inferior ramus of zygomatic process of maxillary usually with median projection; interorbital region averaging broader.

For comparison with *Zapus hudsonius acadicus* see account of that subspecies.

Remarks.—Intergradation with *Zapus hudsonius acadicus* occurs in southeastern New York as indicated by a series of 25 specimens from Peterboro. They resemble *Z. h. acadicus* in width of the mastoid region and relatively longer tooth-row, but in the size and shape of the auditory bullae, width of the pterygoid fossae, and lighter, brighter, color of the sides they are more nearly like *Z. h. americanus* to which they are here referred. [438]

Intergradation between *Z. h. americanus* and *Z. h. acadicus* is indicated also by specimens from Lawyersville and Schoharie, New York. In animals from both localities the length of the zygomata and the breadth of the mastoid region are more nearly as in *Z. h. acadicus*, but in size and shape of the auditory bullae, over-all length of the skull, color of the ears, and general color of the pelage they are more nearly like *Z. h. americanus* to which they are here referred.

Specimens from western Pennsylvania, judged to be *Z. h. hudsonius* by Preble (1899:17), and those from northwestern Pennsylvania and northeastern Ohio, allocated to *Z. h. hardyi* (= *acadicus*) by Bole and Moulthrop (1942:165), are more nearly like *Z. h. americanus* in size and shape of the auditory bullae, short zygomata, relatively narrow mastoid region, and color of pelage.

Specimens from the lower peninsula of Michigan, northeastern Indiana, and northwestern Ohio, described by Bole and Moulthrop (*op. cit.*:168) as belonging to a new subspecies (*Zapus hudsonius brevipes*), are to me indistinguishable from most specimens of *Z. h. americanus*. The characters which Bole and Moulthrop (*loc. cit.*) ascribe to *Z. h. brevipes*—color bright Ochraceous-Buff, tail and hind feet short, and skull narrow—are also those of *Z. h. americanus*.

Specimens from various localities in southeastern Ohio, all within the range ascribed by Bole and Moulthrop (*op. cit.*:169) to *Zapus hudsonius rafinesquei*, are indistinguishable from specimens of *Z. h. americanus* from eastern Tennessee, West Virginia, North Carolina, and Maryland. *Zapus hudsonius rafinesquei* (at least that part from southeastern Ohio) is indistinguishable from *Z. h. americanus* and therefore is synonymized under *Z. h. americanus*.

Specimens from Lagrange County, Indiana, show intergradation between *Zapus hudsonius intermedius* and *Z. h. americanus* in the color of the pelage but are more nearly like *Z. h. americanus* to which they are here referred. One from Porter County, Indiana, is more nearly like *Z. h. intermedius* in size and shape of the bullae and in breadth of the pterygoid fossae but in color and degree of lateral bowing of the zygomata is better placed with *Z. h. americanus*.

Z. h. americanus is a wide ranging subspecies. Animals at the northern periphery of the range (lower peninsula of Michigan to the west and southeastern Massachusetts to the east) are largest and darkest; to the southward there is a progressive reduction in size and a change to a lighter, brighter color. Animals from Maryland, Virginia, and North Carolina are more nearly average representatives of the subspecies than are those from the region of the type locality. [439]

A jumping mouse allegedly of this subspecies has been recorded by Coleman (1941:91) from Caesars Head, 300 ft., South Carolina. This specimen and one from Athens, Georgia, provide the southeasternmost record-stations of occurrence for the species *Z. hudsonius*.

Specimens examined.—Total, 318, distributed as follows:

CONNECTICUT: *Hartford County*: Windsor, 1 (USBS); *East Hartford*, 2 (MCZ). *Litchfield County*: Sharon, 3 (AMNH); *Macedonia Park*, 2 (AMNH). *Middlesex County*: Clinton, 1 (AMNH). *Windham County*: South Woodstock, 10 (AMNH); *Pomfret*, near Hampton line, 1.

GEORGIA: *Clarke Co.*: Athens, 1 (USBS).

INDIANA: *Lagrange Co.*: no exact locality, 2 (UM). *Porter Co.*: Mineral Springs, 1 (FM); *no exact locality*, 1 (FM).

MARYLAND: *Anne Arundel County*: *Patuxent Research Refuge*, 1 (USBS). *Charles County*: *no exact locality*, 1 (USBS). *Garrett Co.*: Finzel, 6 mi. N Frostburg, 1 (USBS). *Montgomery County*: *Sandy Springs*, 2 (USBS); *Kensington*, 1 (USNM); *Cabin John Bridge*, 2 (1 USBS; 1 USNM). *Prince Georges County*: *Laurel*, 8 (USNM); *Branchville*, 1 (USBS); *College Park*, 1. *Worcester County*: *Assateague*, 5 mi. S Ocean City, 1 (USBS).

MASSACHUSETTS: *Barnstable County*: *West Falmouth*, 1 (USBS). *Bristol County*: *Raynham*, 1 (Clev. MNH). *Dukes County*: *Martha's Vineyard*, 1 (USBS); *West Chop*, *Martha's Vineyard*, 1 (Clev. MNH). *Nantucket County*: *Nantucket Island*, 1 (USNM). *Plymouth County*: *Middleboro*, 1 (USNM); *Plymouth*, 1 (UM); *Marshfield*, 6 (USBS); *Wareham*, 3 (1

MICHIGAN: *Alcona Co.*: 2 mi. S Harrisville, 2 (UM). *Allegan Co.*: near junction Swan Creek and Kalamazoo River, 3 (UM). *Berrien Co.*: Warren Woods, 2 (UM); Three Oaks, 1 (UM). *Charlevoix Co.*: Thumb Lake, 1 (UM); Section 1 Norwood Township, 1 (UM); Boyne Falls, 12 (UM); 2 mi. S Boyne Falls, 2 (UM). *Cheboygan Co.*: Douglas Lake, 2 (UM). *Clinton Co.*: 2 mi. SE DeWitt, 1 (UM). *Emmet Co.*: Maple River, near Douglas Lake, 1 (UM). *Huron Co.*: Rush Lake, 1 (UM). *Kalamazoo Co.*: no exact locality, 1 (UM). *Lake Co.*: 1 mi. NW Chase, 1 (UM). *Livingston Co.*: George Reserve, Pinckney, 2 (UM); Upper Whitewood Lake, 1 (UM); Whitmore Lake, 1 (UM); Portage Lake, 3 (UM). *Mason Co.*: 9 mi. N Ludington, 1 (UM). *Midland Co.*: Sanford, 1 (UM). *Montmorency Co.*: T. 32N, R. 1E, Sec. 30, 1 (UM). *Muskegon Co.*: 4 mi. NW North Muskegon, 2 (UM). *Oakland Co.*: Bloomfield, 1 (UM); no exact locality, 1 (UM). *Otsego Co.*: Pigeon River, 1 (UM); T. 32N, R. 1W, Sec. 25, 1 (UM); Waters, 1. *Roscommon Co.*: T. 24N, R. 2W, Sec. 2, 1 (UM). *Shiawassee Co.*: ½ mi. NE Byron, 5 (UM); ¼ mi. S Byron, 2 (UM); 2 mi. SE Byron, 1 (UM); 3 mi. SW Byron, 1 (UM). *Van Buren Co.*: Van Auken Lake, 1 (UM). *Washtenaw County*: Whitmore Lake, 1 (UM); 2 mi. W Cherry Hill, 1 (UM); Ann Arbor, 7 (UM); 2 mi. E Ann Arbor, 2 (UM); Willow Run Village, 1 (UM).

NEW JERSEY: *Bergen County*: Harrington Park, 1 (AMNH); Englewood, 1 (USNM). *Cape May County*: Mays Landing, 3 (Clev. MNH). *Morris County*: Mendham, 1 (AMNH). *Ocean County*: Tuckerton, 3 (USBS). [440]

NEW YORK: *Broome Co.*: 5 mi. N Binghamton, 2 (USNM). *Cayuga County*: E Aurora, 1 (USBS). *Greene County*: Catskills, 4 (USNM); Kaaterskill Junction, 1 (USNM). *Madison County*: Peterboro, 25 (2 MCZ; 19 USNM; 4 Clev. MNH). *Nassau County*: Locust Grove, 3 (USNM). *Orange Co.*: Cranberry Pond, 840 ft., Highland, 2 (USNM). *Otsego County*: Lake Charlotte, 1 (AMNH). *Queens County*: Woodside, Long Island, 1 (USNM); near Forest Hills, Long Island, 1 (AMNH); Ray Nu Beach, Long Island, 1 (USNM). *Rockland County*: Tappan, 1 (AMNH). *Schoharie County*: Lawyersville, 1 (AMNH); Schoharie, 1 (AMNH). *Suffolk County*: Montauk Point, Long Island, 8 (USBS). *Tioga County*: Owego, 1 (USBS). *Westchester Co.*: Bedford, 1 (AMNH).

NORTH CAROLINA: *Buncombe County*: Weaverville, 1 (AMNH). *Cherokee Co.*: Martin Creek, 2 (UM). *Mitchell County*: Roan Mountain, 2 (USBS). *Wake County*: Raleigh, 5 (3 USNM; 1 UM; 1 NCS).

OHIO: *Carroll Co.*: Carrollton, 2 (UM). *Cuyahoga County*: Big Creek, Brookside Park, 1 (Clev. MNH); Dover, 1 (Clev. MNH); Rocky River Metr. Park, 3 (Clev. MNH); North Olmstead, 1 (Clev. MNH). *Erie Co.*: Milan, 1 (Clev. MNH); Mill Hollow, Vermilion River, 1 (Clev. MNH). *Lake Co.*: Holden Arboretum, 3 (Clev. MNH). *Meigs Co.*: Portland Station, 1 (Clev. MNH). *Seneca Co.*: Bettsville, 4 (Clev. MNH); Old Fort Seneca, 4 (Clev. MNH); Corners, 1 (Clev. MNH). *Wayne Co.*: Wooster, 1 (UM); Craighton, 1 (UM).

PENNSYLVANIA: *Beaver Co.*: 1 mi. NE Darlington, 1 (CM); 2 mi. E Industry, 1 (CM); 4 mi. E Frankfort, 2 (CM). *Bedford Co.*: 1 mi. NE Osterburg, 1 (CM). *Berks Co.*: 2 mi. W Strausstown, 1 (USNM). *Bradford Co.*: 2½ mi. NNW Wyalusing, 2 (CM). *Bucks Co.*: 2 mi. N New Britain, 1 (CM). *Butler Co.*: Thorn Creek, 4 mi. S Butler, 4 (CM); 2 mi. E Middle Lancaster, 1 (CM); Orphans Home, 2 mi. E Mars, 2 (CM). *Cambria Co.*: 2½ mi. S Patton, 1750 ft., 1 (CM); 5½ mi. NE Ebensburg, 1 (CM). *Centre Co.*: 2, mi. E Snowshoe, 2 (CM). *Chester Co.*: 2 mi. S West Chester, 1 (CM). *Clinton Co.*: Tamarack, 9 mi. NNW Renovo, 1 (CM). *Crawford Co.*: Pymatuning Lake, 3 (Clev. MNH). *Erie Co.*: 4½ mi. SW [town of] North East, 2 (CM); East Springfield, 1 (CM). *Fulton Co.*: 1½ mi. NE Warfordsburg, 580 ft., 1 (CM). *Huntington Co.*: 6½ mi. S Shade Gap, 2 (CM). *Indiana Co.*: ½ mi. E Indiana, 1320 ft., 2 (CM). *Lebanon Co.*: 1½ mi. SE Cornwall, 800 ft., 1 (CM). *Mercer Co.*: 2½ mi. W Mercer, 2 (CM); 5 mi. S Mercer, 1 (CM). *Monroe Co.*: Pocene Lake, 1 (CM). *Pike Co.*: Bruce Lake, 1 (CM). *Potter Co.*: Woodcock Run, 7½ mi. WSW Ulysses, 2 (CM). *Sommerset County*: 4 mi. SW Somerset, 2100 ft., 2 (CM); New Lexington, 1 (USBS). *Susquehanna Co.*: 10 mi. NNW Montrose, 1 (CM). *Union Co.*: Glen Iron, 2 (CM). *Warren Co.*: Bensons Swamp, 5 mi. E Columbus, 1 (USNM); Miles Run, 5 mi. NW Pittsfield, 1 (CM); 1½ mi. N Pittsfield, 1 (CM); 2½ mi. N Kinzua, 2 (CM); 2 mi. N Kinzua, 1 (CM).

TENNESSEE: *Carter Co.*: 3 mi. SSW Roan Mountain (town), 2900 ft., 1 (UM).

VIRGINIA: *Amelia Co.*: Amelia, 1 (UM). *Elizabeth City County*: Near Hampton, 2 (UM). *Fairfax County*: Fall Church, 4 (2 USNM; 2 USBS); opposite Plummers Island, Maryland, 1 (USNM). *Highland Co.*: Laurel Park, 9 mi. NNW Monterey, 3100 ft., 4 (UM). *Nelson Co.*: no exact locality, 5 (USNM). *Norfolk County*: Deep Creek, 1 (USBS). *Page Co.*: no exact locality, 1 (USNM). *Smyth Co.*: Sugar Grove, 1 (UM); ½ mi. E Konnarock, 2800 ft., 1 (UM). *Washington Co.*: Konnarock, 2900 ft., 1 (UM).

WASHINGTON D. C.: *Chevy Chase*, 1 (USBS); no exact locality, 4 (3 USNM; 1 USBS).

WEST VIRGINIA: *Monongalia Co.*: Morgantown, 6.

Marginal records.—Michigan: Douglas Lake; Bloomfield. New York: E Aurora; Peterboro; Catskills. Connecticut: Sharon; South Woodstock. Massachusetts: Middleboro. New Jersey: Tuckerton. Maryland: Assateague, 5 mi. S Ocean City. North Carolina: Raleigh. Georgia: Athens. Indiana: Mineral Springs. Michigan: 9 mi. N Ludington. [441]

Zapus hudsonius campestris Preble

Zapus hudsonius campestris Preble, N. Amer. Fauna, 15:20, August 8, 1899.

Type.—Male, adult, No. 65872 U. S. Nat. Mus., Biol. Surv. Coll.; Bear Lodge Mt's [Crook County], Wyoming; obtained on June 21, 1894, by B. H. Dutcher, original No. 600.

Range.—Southeastern Montana, southwestern South Dakota, and northeastern Wyoming. See [fig. 47](#). Zonal range: Transition.

Description.—Size large; back from near Ochraceous-Tawny to near Ochraceous-Buff with admixture of black tipped hair forming distinct dorsal band; sides lighter than back, from near Ochraceous-Buff to near Yellow Ocher with black hair interspersed; lateral line usually distinct, of clear Ochraceous-Buff; belly white, usually with moderate suffusion of Ochraceous-Buff; tail bicolored, brownish to brownish-black above, grayish-white to yellowish-white below; ears dark, edged with Ochraceous-Buff; feet grayish-white above; auditory bullae large, well inflated; incisive foramina long and usually truncate at posterior border; pterygoid fossae broad; zygomatics relatively wide-spread and long; large medial projection on inferior ramus of zygomatic process of maxillary; condylobasal length and occipitonasal length relatively great; mastoid region and palatal region relatively broad; interparietal bone usually broad.

Comparisons.—From *Zapus hudsonius pallidus*, *Z. h. campestris* differs as follows: Coloration darker (more black and yellow but less orange); averaging larger in all measurements taken except in least interorbital constriction and distance from incisors to postpalatal notch which are slightly larger and breadth across zygomatic arches which is same; zygomatic arch heavier; incisive foramina larger; interparietal bone broader.

Compared with *Zapus hudsonius intermedius*, *Z. h. campestris* differs as follows: Coloration more tawny and

ochraceous, less yellow; auditory bullae averaging larger, more inflated; condylobasal length averaging greater; zygomata averaging more wide-spread and longer; distance from incisors to postpalatal notch averaging longer; mastoid region broader; incisive foramina longer and more truncate posteriorly.

From *Zapus hudsonius hudsonius*, *Z. h. campestris* differs as follows: Size larger; color lighter, more ochraceous, less tawny; occipitonasal length averaging greater; mastoid region broader; zygomata averaging longer; zygomatic arch more widely bowed; distance from incisors to postpalatal notch averaging longer; incisive foramina longer; auditory bullae broader, more inflated.

For comparison with *Zapus hudsonius preblei* see account of that subspecies.

Remarks.—Animals from the Black Hills of South Dakota and Wyoming are thought of as most characteristic of this geographic race. Intergradation is noted with *Zapus hudsonius pallidus* and is discussed in the account of that subspecies.

Specimens examined.—Total, 66, distributed as follows:

MONTANA: *Big Horn County*: Rotten Grass Creek, north base Big Horn Mts., 2 (USBS); *Little Big Horn River*, 2 mi. from Wyoming line, 1 (USBS).

SOUTH DAKOTA: *Custer County*: *Custer*, 3 (USNM); Bull Springs, 6 (Clev. MNH); *Beaver Creek*, *Wind Cave Nat'l Park*, 1 (UM); *Wind Cave Nat'l Park Game Ranch*, Cold Spring Creek, *Wind Cave Nat'l Park*, 2 (UM); *Pennington County*: *Rapid Creek*, 2 mi. *W Pactola*, 4800 ft., 3 (UM); *Castle Creek*, R. 2E, T. 1N, 6500 ft., 3 (UM); *Nelsons Place*, 3 mi. SE Hill City, 6 (UM); *Palmer Gulch*, 4 mi. SE Hill City, 3 (UM); *Palmer Gulch*, 9 (FM); *no definite locality*, 4 (UM). [442]

WYOMING: *Crook County*: Devils Tower, flood plain Belle Fourche River, 3350 ft., 1 (USBS); Bear Lodge Mts., 4 (USBS); 15 mi. N Sundance, *Black Hills Nat'l Forest*, 5500 ft., 2; 3 mi. NW Sundance, 5900 ft., 17; *Sundance*, 2 (USBS). *Weston Co.*: 1 ½ mi. E Buckhorn, 6150 ft., 5.

Marginal records.—Montana: Rotten Grass Creek, N base Big Horn Mts. South Dakota: Nelsons Place, 3 mi. SE Hill City; *Wind Cave Nat'l Park Game Ranch*, Cold Spring Creek. Wyoming: 1 ½ mi. E Buckhorn, 6150 ft.

Zapus hudsonius canadensis (Davies)

Dipus canadensis Davies, Trans. Linn. Soc. London, 4:157, 1798.

Zapus hudsonius hudsonius, Preble, N. Amer. Fauna, 15:17, August 8, 1899 (part—the part from Ontario).

Zapus hudsonius canadensis, Batchelder, Proc. New England Zool. Club, 1:5, February 8, 1899 (part—the part from Quebec); Anderson, Rept. Provancher Soc. Nat. Hist., Quebec, 1941:35-37, July 14, 1942 (part—the part from Quebec excepting the Gaspé Peninsula).

Zapus hudsonius ontarioensis Anderson, Ann. Rept. Provancher Soc. Nat. Hist., Quebec, 1942:59, September 7, 1943, type from Pancake Bay (Batchawana Bay) southeast end of Lake Superior, Algoma District, about 40 miles northeast of Sault Ste-Marie, Ontario.

Type.—No type specimen designated, subspecies characterized on the basis of two specimens obtained by Major General Thomas Davies within a few miles of the city of Quebec.

Range.—Eastern Ontario and western Quebec from Hudson Bay southward to the Great Lakes and into northwestern New York. See fig. 47. Zonal range: Transition and Canadian.

Description.—Size medium; back from near Clay Color to near Cinnamon-Buff with admixture of black hair usually forming a dorsal band; sides from near Clay Color to near Cinnamon-Buff and lighter than back; lateral line usually distinct, and clear Cinnamon-Buff; belly white, sometimes with slight suffusion of Cinnamon-Buff mid-ventrally; tail bicolored, brownish to brownish-black above, grayish-white to yellowish-white below; ears dark, sometimes flecked with color of the sides, edged with Cinnamon-Buff; feet grayish-white above; auditory bullae large, relatively broad and flat; incisive foramina relatively short and narrow, widest posteriorly; zygomata not widely bowed outward; mastoid region relatively wide; frontal region well inflated; nasals relatively narrow, short, and parallel sided.

Comparisons.—From *Zapus hudsonius hudsonius*, *Z. h. canadensis* differs as follows: Upper parts generally dull averaging lighter, less black tipped hair; sides also lighter with less suffusion of dark hair; frontal region more inflated; mastoid region averaging broader; auditory bullae broader; distance from incisors to postpalatal notch averaging slightly longer.

For comparison with *Zapus hudsonius acadicus*, *Zapus hudsonius ladas*, and *Zapus hudsonius americanus* see accounts of those subspecies.

Remarks.—Bole and Moulthrop (1942:165) refer 2 specimens from Elba, New York, to *Z. h. hardyi* (= *acadicus*); they are more nearly like *Z. h. canadensis* in size and shape of the auditory bullae and general color of the pelage. A specimen from Spectacle Pond, New York, has the narrow pterygoid fossae and relatively narrow auditory bullae of *Z. h. acadicus* and the relatively short, narrow incisive foramina, inflated frontal region, and color of *Z. h. canadensis* to which the specimen is here referred. Intergradation is noted also in animals from Schreiber, Ontario. They resemble *Zapus hudsonius hudsonius* in their darker coloration and shape of auditory bullae but in the remainder of the characters studied resemble *Z. h. canadensis* to which they are referred. Specimens from Notre Dame de la Dore and ½ mi. N Mistassini Post, Quebec, in size and shape of the auditory bullae and in width of the pterygoid fossae, closely approach *Z. h. ladas* but in color, distinct dorsal band, and in narrower zygomata are all nearest *Z. h. canadensis* to which subspecies they are here referred. [443]

Zapus hudsonius ontarioensis Anderson (1942:59) from eastern Ontario was based chiefly, in comparison with *Z. h. canadensis*, upon, "dorsal stripe less distinct and sides somewhat duller yellowish with more admixture of blackish hairs." Examination of 68 of the 69 specimens from the type locality shows that 58 are subadult and in subadult pelage. Individuals which are adult are indistinguishable in color of pelage and in cranial features from comparable material from southern Quebec. *Z. h. ontarioensis* is, therefore, considered to be a synonym of *Z. h. canadensis*.

Specimens examined.—Total, 123, distributed as follows:

NEW YORK: *Franklin Co.*: Spectacle Pond, Brighton Township, 2 (AMNH). *Genesee Co.*: Elba, 2 (Clev. MNH).

ONTARIO: Schreiber, 2 (NMC); Franz, 5 (MVZ); Pancake Bay, Algoma District, 68 (NMC); Maclennan, Algoma District, 3 (ROM); Cache Lake, Algonquin Park, 1 (MVZ); *Experimental Farm, Ottawa*, 1 (NMC); *Dows Swamp, Ottawa*, 1 (NMC); Apple Hill, 1 (NMC); Clear Lake, Arden, 1 (NMC); *Athens*, 1 (NMC); *Aurora*, 4 (Clev. MNH); Pattageville, Toronto, 1; *Lorne Park, Toronto*, 1 (NMC); *Credit*, 2 (NMC); Pickering, 1 (MVZ); *Preston*, 1 (NMC); St. Thomas, 1 (NMC).

QUEBEC: *Notre Dame de la Dore*, 3 (NMC); ½ mi. N Mistassini Post, 1 (NMC); Lake Albanel, 1 (NMC); St. Felicien, 3 (NMC); Valcartier, 8 (NMC); Kiamika Lake, 4 (NMC); *Ste. Veronique*, 2 (NMC); *Val Jalbert*, 2 (NMC); *St. Methode*, 1 (NMC).

Marginal records.—Quebec: ½ mi. N Mistassini Post; Valcartier. New York: Spectacle Pond, Brighton Township; Elba. Ontario: St. Thomas; Pancake Bay, Algoma Dist.; Franz; Schreiber. Quebec: Kiamika Lake.

Zapus hudsonius hudsonius (Zimmerman)

Dipus hudsonius Zimmerman, Geog. Geschichte d Menschen u. vierfussigen Thiere, 2:358, 1780.

Dipus labradorius Kerr, Animal Kingdom:276 (based on the Labrador Jerbooid Rat of Pennant, 1781—but Preble, N. Amer. Fauna, 15:11, August 8, 1899, states that the specimen came from Hudson Bay), 1792.

Gerbillus canadensis, Desmarest, Mammalogie, 2:321, 1822.

Gerbillus labradorius, Harlan, Fauna Amer., p. 157, 1825.

Meriones labradorius, Richardson, Fauna Boreali-Americana, 1:144, 1829.

Jaculus labradorius Wagner, Suppl. Schreber's Saugthiere, 3:294, 1843.

Zapus hudsonius hudsonius, Preble, N. Amer. Fauna, 15:15, August 8, 1899 (part—the part from Northwest Territory, Ontario, Michigan, northern Wisconsin and northern Minnesota).

Zapus hudsonius alascensis, Osgood, N. Amer. Fauna, 19:38, October 6, 1900.

Type.—Type specimen not known to be in existence; from Hudson Bay, locality now considered to be Fort Severn, Ontario (see Anderson, 1942:37).

Range.—Central Alaska southeastward to central Ontario, northern Minnesota, northern Wisconsin, and upper peninsula of Michigan. See [fig. 47](#). Zonal range: Hudsonian, Canadian, and into Transition.

Description.—Size medium; back dark, from near Tawny-Olive to near Cinnamon with heavy admixture of black hair forming dorsal band; sides lighter than back and from near Tawny-Olive to near Cinnamon, sometimes with admixture of black hair giving sides streaked appearance; lateral line usually distinct, clear Ochraceous-Buff; underparts white, sometimes with slight suffusion of Ochraceous-Buff; tail bicolored, brown to brownish-black above, grayish-white to yellowish-white below; ears dark, usually edged with ochraceous; feet grayish-white above; incisive foramina relatively short and broadly rounded; zygomatic arches relatively short; braincase relatively broad; auditory bullae flat, long, and relatively broad; pterygoid fossae relatively narrow; nasals relatively broad and short.

Comparisons.—From *Zapus hudsonius alascensis*, *Z. h. hudsonius* differs as follows: upper parts generally darker, more black tipped hair; sides darker with greater suffusion of dark hair; lateral line brighter, more distinct; size averaging smaller; zygomatic arches less bowed outward; distance from incisors to postpalatal notch shorter; zygomatic shorter; occipitonasal length less; mastoid region narrower.

From *Zapus hudsonius intermedius*, *Z. h. hudsonius* differs in: color darker, more tawny dorsally; sides averaging darker, more black-tipped hairs; size averaging larger; braincase averaging broader; distance from incisors to postpalatal notch averaging slightly shorter; zygomatic averaging longer; mastoid region averaging broader; incisive foramina averaging shorter.

From *Zapus hudsonius tenellus*, *Z. h. hudsonius* differs as follows: upper parts averaging darker; tail averaging shorter; condylobasal length averaging more; braincase averaging broader; auditory bullae broader and less inflated; interparietal averaging broader; incisive foramina more broadly rounded and averaging longer.

For comparison with *Zapus hudsonius canadensis* and *Zapus hudsonius campestris* see accounts of those subspecies.

Remarks.—Preble (1899:16) had available for study five specimens of *Zapus hudsonius hudsonius* from Hudson Bay. Four were preserved in alcohol and one as an incomplete skin (prepared from an alcoholic specimen). All were unreliable for comparative purposes owing to the effects of the preservative. Preble, therefore, (*loc. cit.*) selected as a fairly typical sample a series of specimens from Tower, St. Louis County, Minnesota; these formed the basis of comparison between *Z. h. hudsonius* and other subspecies of *Zapus hudsonius*. Now that additional material (well prepared skins and skulls) is available from the Hudson Bay region and from other localities in northern and western Canada it is evident that the specimens from Tower, although here considered to be *Z. h. hudsonius*, are not typical *Z. h. hudsonius* but are intergrades between *hudsonius* and specimens of *Zapus hudsonius intermedius*. Comparisons made in the present account are based on specimens from the vicinity of Hudson Bay (Fort Severn, Ontario, York Factory, Shamatawa River, and Robinson Portage, Manitoba). These individuals are considered typical of this subspecies. With these new data available the range of *Z. h. hudsonius* is now understood to include all of the region from eastern Alaska to the northern parts of Minnesota, Wisconsin, and Michigan.

Intergradation between *Zapus hudsonius canadensis* and *Z. h. hudsonius* is noted in specimens from 30 mi. NE Port Arthur and also in those from Silver Islet, Thunder Cape, Ontario. These individuals resemble *Z. h. canadensis* in size and shape of the auditory bullae and in the shape of the nasals, but in their darker coloration, broadly rounded incisive foramina, and relatively narrow pterygoid fossae they are more nearly like *Z. h. hudsonius* to which they are here referred.

Specimens from Minaki, Ontario, are tending toward *Zapus hudsonius intermedius* in lighter

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coloration but in the size and shape of the auditory bulla, size and shape of the incisive foramina, and in the width of the pterygoid fossae they are more nearly like *Z. h. hudsonius* to which they are here referred. Specimens from various localities in Menominee County, Michigan, are like *Z. h. intermedius* in shape of the incisive foramina and shape of the postpalatal notch, but in color of pelage, size and shape of the auditory bullae, and breadth of the pterygoid fossae they closely resemble *Z. h. hudsonius*.

In Wisconsin, intergradation occurs in color and in cranial characters in specimens from Mercer, Solon Spring, and in a single individual from Basswood Lake. All these specimens, however, are best referable to *Z. h. hudsonius*.

Specimens from one mile southwest of Fairbanks and from Fairbanks, Alaska, show intergradation with *Zapus hudsonius alascensis* in coloration (more brown, less black), but in small size, short, broadly rounded incisive foramina, and in size and shape of the auditory bullae are nearest to *Z. h. hudsonius* to which they are here assigned.

Intergradation with *Zapus hudsonius alascensis* is noted also in specimens from McIntyre Creek, Yukon. They are like *Z. h. alascensis* in the size and shape of the auditory bullae and in the more elongate incisive foramina, but in the coloration, size of the pterygoid fossae, and breadth of the braincase are more nearly like *Z. h. hudsonius* and are here referred to this geographic race. [446]

In British Columbia, in specimens from 1 mi. NW junction of Irons Creek and Laird River as well as in those from Hot Springs, 3 mi. WNW junction of Trout River and Laird River, and in those from $\frac{1}{4}$ mi. S of the junction of the same rivers, three way intergradation occurs. These animals are like *Zapus hudsonius alascensis* in color and in length of tail. They agree with *Zapus hudsonius tenellus* in shape of nasals. In degree of inflation of auditory bullae, in length and width of incisive foramina, and in shape of pterygoid fossae they are as in *Z. h. hudsonius* to which they are here assigned.

Specimens examined.—Total, 230, distributed as follows:

ALASKA: Fairbanks, 1 (USNM); 1 mi. SW Fairbanks, 440 ft., 1.

ALBERTA: Conibear Lake, Wood Buffalo Park, 1 (NMC); Assineau River, 1920 ft., 10 mi. E and 1 mi. N Kinuso, 1; Mountain Rapid, Athabasca River, 1 (USBS); *Brule Rapid, Athabasca River*, 1 (USBS); 25 mi. above Pelican Rapid, Athabasca River, 1 (USBS); Lac la Nonne, 7 (NMC); *Swift Current, Athabasca River*, 1 (USBS); *junction Lac la Biche River and Athabasca River*, 1 (USBS); 30 mi. above Athabasca Landing, Athabasca River, 1 (USBS).

BRITISH COLUMBIA: 1 mi. NW junction Irons Creek and Laird River, 3; Hot Springs, 3 mi. WNW junction Trout River and Laird River, 1; $\frac{1}{4}$ mi. S junction Trout River and Laird River, 1.

MANITOBA: York Factory, 2 (USBS); Shamatawa River, 1 (USBS); Oxford House, 15 (USBS); *Robinson Portage*, 4 (USBS); *Echamamish*, 1 (USBS); Norway House, 1 (USBS); *Swan River*, 1 (NMC); Bird, 1 (NMC); *Aimie Lake*, 2 (NMC); Albert's Lake, Flin Flon, 2 (NMC); Portage La Prairie Prov., Delta, 1 (UM).

MACKENZIE DISTRICT: Fort Resolution, 3 (USBS); Fort Smith, 3 (USBS).

MICHIGAN: *Chippewa Co.*: Marquette Nat'l Forest, 4; *no exact locality*, 2. *Gogebic Co.*: Mud Lake, $\frac{1}{4}$ mi. SE Thousand Island Lake, 2. *Keweenaw Co.*: Lake Manganese, 1 mi. SSE Copper Harbor, 5 (UM); $2\frac{1}{2}$ mi. SE Copper Harbor, 8 (UM); 5 mi. E Eagle Harbor, 6 (UM); *E end Lake Upson*, 3 (UM); *Bete Grise*, 5 (UM). *Marquette County*: Michigamme, 3 (2 USBS). *Menominee Co.*: 8 mi. N Hermansville, 6 (UM); 6 mi. NW Banat, 8 (UM); 5 mi. SW Banat, 8 (UM); 8 mi. SW Banat, 2 (UM); 7 mi. E Stephenson, 3 (UM); 8 mi. WSW Stephenson, 2 (UM); 10 mi. W Stephenson, 2 (UM); 13 mi. WSW Stephenson, 2 (UM); 5 mi. N Menominee, 2 (UM).

MINNESOTA: *Lake Co.*: Splitrock River, 2 (UM); *St. Louis County*: Tower, 27 (USBS).

ONTARIO: Fort Severn, Kenora District, 6 (ROM); Minaki, 7 (MVZ); 30 mi. NE Port Arthur, 6 (UM); Silver Islet, Thunder Bay District, 4 (NMC); 20 mi. SW Fort Williams, 3 (UM); 20 mi. SE Fort Williams, 1 (UM).

SASKATCHEWAN: Emma Lake, 3 (ROM).

WISCONSIN: *Bayfield County*: *Herbster*, 4 (USBS); Brinks Camp, Washburn, 1 (AMNH); *Basswood Lake*, 10 mi. SE Iron River, 1 (USBS). *Douglas County*: Solon Springs, 9 (USBS). *Forest County*: Crandon, 1 (USBS). *Iron County*: Mercer, 2 (USBS). *Oneida County*: *Crescent Lake*, 2 (USBS). *Vilas County*: *Mamie Lake*, 2 (USBS); *Lake St. Germain*, 9 (USBS).

YUKON: Lake Lebarge, 3 (USBS); Forks of MacMillian River, 1 (USBS); McIntyre Creek, 2250 ft., 3 mi. NW Whitehorse, 4. [447]

Marginal records.—Alaska: Fairbanks. MacKenzie: Ft. Resolution. Manitoba: York Factory. Ontario: Fort Severn, Kenora District; Silver Islet, Thunder Bay Dist. Michigan: Marquette Nat'l Forest; 5 mi. N Menominee. Wisconsin: Crandon; Solon Springs. Minnesota: Tower. Manitoba: Portage la Prairie Prov., Delta. Saskatchewan: Emma Lake. Alberta: 30 mi. above Athabasca Landing, Athabasca River; Lac la Nonne. British Columbia: 1 mi. NW junction Irons Creek and Laird River. Yukon: McIntyre Creek, 2250 ft., 3 mi. NW Whitehorse; Lake Lebarge.

***Zapus hudsonius intermedius* new subspecies**

Type.—Male, adult, No. 83400, Univ. Michigan Mus. Zool.; Ridgeway, Winneshiek County, Iowa; obtained on July 22, 1939, by S. A. Hoslett, original No. 517.

Range.—Eastern Montana, North Dakota, probably northern South Dakota, all but northern parts of Minnesota and Wisconsin, Iowa, Illinois, southwestern Indiana, and western Kentucky. See [fig. 47](#). Zonal range: Upper Austral (Upper Sonoran and Carolinian) and Transition (Alleghanian and Transition).

Description.—Size medium; back from near Warm Buff to near Ochraceous-Buff with admixture of hair tipped with black or dark brown usually forming distinct, broad, dorsal band; sides lighter, from near Warm Buff to near Ochraceous-Buff with sparse mixture of dark-tipped hairs; lateral line often poorly marked but when present of clear

Ochraceous-Buff; belly white, sometimes with slight suffusion of color of sides; tail bicolored, grayish-brown to brownish-black above, white to grayish-white or yellowish-white below; ears dark, narrowly edged with color of sides; feet white to grayish-white above; tail relatively short; lateral margins of nasals parallel; auditory bullae relatively short, broadly rounded, and moderately inflated; incisive foramina relatively long and narrow; pterygoid fossae relatively narrow; zygomata relatively long; inferior ramus of zygomatic process of maxillary frequently lacking a median projection.

Comparisons.—From *Zapus hudsonius pallidus*, *Z. h. intermedius* differs as follows: Coloration duller, not so bright, more yellow or buff and less bright Ochraceous-Buff; interorbital region averaging narrower; incisive foramina averaging longer and narrower; condylobasal length averaging greater; braincase averaging broader; mastoid region averaging broader.

For comparisons with *Zapus hudsonius hudsonius*, *Zapus hudsonius campestris*, and *Zapus hudsonius americanus* see accounts of those subspecies.

Remarks.—*Zapus hudsonius intermedius* has a large geographic range. There is some variation detectable when individuals from widely separate localities are compared, but where there is much variation it is obviously the result of intergradation. All characters differentiating *Z. h. intermedius* from any contiguous subspecies are not present in every specimen even in the type series. Nevertheless, a certain series of cranial characters (narrow incisive foramina, short rounded auditory bullae, parallel lateral margins of nasals and narrow pterygoid fossae) is diagnostic.

Animals obtained from extreme southwestern Indiana and from eastern Illinois approach *Z. h. americanus* in color and in shape of the incisive foramina, but in the shape of the nasals, width of the pterygoid fossae and breadth of the zygomata are most nearly like *Z. h. intermedius* to which they are here referred. Specimens from Lake and Kane counties, Illinois, also show affinity with *Z. h. americanus* in color, but cranially are most nearly like *Z. h. intermedius* and are assigned to that subspecies.

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Two specimens from southern Illinois (Perry County) are intergrades between *Z. h. pallidus* and *Z. h. intermedius*. Cockrum and Baker (1950:3) mentioned that these individuals showed evidence of intergradation with *Z. h. pallidus* in color of the pelage and the breadth of the least interorbital constriction. In other characters the specimens are most nearly like *Z. h. intermedius* to which they are here referred. Animals from Lyon County, Iowa, also show intergradation between *Z. h. pallidus* and *Z. h. intermedius*. These individuals are most nearly like *Z. h. pallidus* in interorbital breadth of the skull but in other characters agree with *Z. h. intermedius* and, therefore, are referred to that subspecies.

Intergradation between *Z. h. campestris* and *Z. h. intermedius* is noted in a specimen from 7 mi. NE Glendive, Montana. This individual has the larger, broader, auditory bullae and more widely bowed incisive foramina of *Z. h. campestris*, but in color, in smaller external size, and in the majority of cranial characters it is best referred to *Z. h. intermedius*.

Specimens from the north-central periphery of the geographic range of *Z. h. intermedius* (northern Minnesota and Wisconsin) on the average are darker, have longer auditory bullae, wider bowed incisive foramina, and (some specimens) a slightly wider pterygoid fossa than is normal in more southern populations. This deviation from the norm is interpreted as intergradation between *Z. h. hudsonius* and *Z. h. intermedius*. Individuals from Burnett, Price, and Oconto counties, Wisconsin, and those from Cass and southern Clearwater counties, Minnesota, show such intergradation but are here considered to be *Z. h. intermedius*.

Specimens examined.—Total, 199, distributed as follows:

ILLINOIS: *Coles Co.*: Fox Ridge State Park, 1 (UIM). *Fulton Co.*: ½ mi. N Norris, 2 (UIM); 3 mi. N Canton, 1 (UIM); 2½ mi. N Canton, 2 (UIM); 2 mi. NW Canton, 3 (UIM); 2 mi. W Canton, 1 (UIM); 3 mi. SW Monterey, 1 (UIM). *Jo Daviess Co.*: near Galen, 3 (FM). *Kane Co.*: Sugar Grove, 1 (Chic. AS). *Lake Co.*: Fox Lake, 4 (FM); Pistakee Bay, 1 (FM). *Perry Co.*: 6 mi. S Pinckneyville (near Pyatt), 2 (SITC). *Vermilion Co.*: Kickapoo State Park, 2 (UIM); Jordan Creek, 3 mi. NE Fairmont, 5 (UIM).

INDIANA: *Owen Co.*: La Fayette, 1 (USNM). *Parks Co.*: Turkey Run State Park, 2 (1 UM; 1 UIM). *Posey Co.*: Hovey Lake, 1 (UM); New Harmony, 2 (Clev. MNH); no exact locality, 2 (UM). *Sullivan Co.*: no exact locality, 1 (UM).

IOWA: *Dickinson Co.*: Camp Forester, E Okeboji Lake, 3 (ISC). *Emmet Co.*: Fort Defiance State Park, 1 (ISC). *Hamilton Co.*: Little Wall Lake, Jewell, 6 (ISC). *Ida Co.*: Arthur, 1 (ISC). *Lyon Co.*: Elgin Township, Sec. 35, 2 (ISC); Riverside Township, Sec. 28, 1 (ISC). *Palo Alto Co.*: Ruthven, 1 (ISC). *Sioux Co.*: Ireton, 1 (UM). *Story Co.*: Ames, 1 (ISC). *Winneshiek Co.*: Decorah, 3 (UM); Ridgeway, 11 (UM); Conover, 3 (UM).

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KENTUCKY: *Lyon Co.*: no exact locality, 1 (USNM).

MONTANA: *Dawson Co.*: Yellowstone River, 7 mi. NE Glendive, 2000 ft., 1 (MVZ).

MINNESOTA: *Cass County*: Cass Lake, 7 (USBS). *Clearwater Co.*: Itasca Park, Biological Station, 5 (UM). *Grant Co.*: 3 mi. NW Barrett, 1 (UM). *Jackson Co.*: 4 mi. E Heron Lake, 1 (UM). *Ottertail Co.*: 5 mi. NW Vergas, 8 (UM); 4 mi. NW Ashley, 1430 ft., 2. *Ramsey Co.*: St. Paul, 1 (UM). *Sherburne County*: Elk River, 23 (2 UM; 6 MVZ; 3 USBS). *Winona County*: La Crescent, 3 (USBS).

NORTH DAKOTA: *Cass County*: Fargo, 1 (USBS). *Dickey County*: Ludden, 1 (USBS); Ellendale, 1 (USBS). *Kidder County*: Pettibone, 3 (Chic. AS). *La Moure County*: La Moure, 1 (USBS). *Oliver County*: Fort Clark, 3 (USBS). *Pembina County*: Pembina, 2 (USNM). *Ramsey County*: Devils Lake, 3 (USBS). *Ramson County*: Lisbon, 1 (USBS). *Richland County*: Wahpeton, 2 (USBS); 5 mi. NE Fairmont, Sioux River, 5 (USBS); Blackner, 2 (USBS). *Rolette County*: Fish Lake, 2 (USBS). *Sioux County*: Cannon Ball, 4 (USBS). *Williams Co.*: Grinnell, 2 (USBS).

WISCONSIN: *Burnett County*: Danbury, 1 (USBS). *Chippewa County*: Holcombe, 3 (USBS). *Clark County*: Withee, 4 (USBS); Worden Township, 2 (USBS). *Crawford County*: Lynxville, 1 (USBS). *Dane Co.*: Madison, 2 (OHIO). *Dodge Co.*: Horicon Refuge, 2 (USBS). *Juneau County*: Mather, 1 (USBS). *Marathon Co.*: Rib Hill, 8 (USBS). *Oconto County*:

Lakewood, 1 (USBS). *Portage County*: Stevens Point, 3 (USBS). *Price County*: Ogema, 2 (USBS). *Rock County*: Milton, 1 (USBS). *Sauk County*: Devils Lake, 1 (USBS). *Sheboygan County*: 8 mi. SW Mellen, 1 (USBS); *Elkhart Lake*, 1 (USBS). *Walworth County*: Delavan, *Fosters Bridge*, 1 (USBS); *Turtle Lake*, 1 (USBS). *Wood Co.*: *Thorp Township*, 2 (AMNH); *Hewett Township*, 4 (AMNH).

Marginal records.—North Dakota: Fish Lake; Pembina. Wisconsin: Danbury; Ogema; Lakewood. Illinois: Fox Lake. Indiana: La Fayette; New Harmony. Illinois: 6 mi. S Pinckneyville (near Pyatt). Iowa: Ames; Arthur; Ireton. Montana: Yellowstone River, 7 mi. NE Glendive, 2000 ft. North Dakota: Grinnell.

***Zapus hudsonius ladas* Bangs**

Zapus hudsonius ladas Bangs, Proc. New England Zool. Club, 1:10, February 28, 1899.

Type.—Female, adult, skin and skull, No. 4169, E. A. and O. Bangs Coll. (now in Mus. Comp. Zool.); Rigoulette, Hamilton Inlet, Labrador; obtained on July 18, 1895, by C. H. Goldthwaite.

Range.—Eastern Quebec north of Gulf of St. Lawrence, Labrador, and Newfoundland. See [fig. 47](#). Zonal range: Canadian and Hudsonian.

Description.—Size medium; back relatively dark, near Ochraceous-Tawny with admixture of black-tipped hair; dorsal band relatively wide but not sharply defined against color of sides; side lighter than back, from near Ochraceous-Tawny to near Cinnamon and lined with black-tipped hair; lateral line distinct of clear Cinnamon-Buff or Light Ochraceous-Buff; underparts white, often suffused with Ochraceous-Buff; tail distinctly bicolored, dark brown to black above and yellowish-white to grayish-white below; ears dark, usually flecked with Tawny Ochraceous and edged with ochraceous; feet grayish-white above; incisive foramina relatively short and broad; pterygoid fossae relatively broad; auditory bullae broad and well inflated; mastoid region relatively broad; zygomata relatively short; inferior arm of zygomatic process of maxillary relatively broad. [450]

Comparison.—From *Zapus hudsonius acadicus*, which *Z. h. ladas* closely resembles, it differs in: Color darker, dorsal band much less distinct, underparts more frequently suffused with Ochraceous-Buff; auditory bullae relatively broader and more inflated; pterygoid fossae broader; zygomata averaging shorter; incisive foramina relatively shorter; inferior arm of zygomatic process of maxillary relatively broader.

From *Zapus hudsonius canadensis*, *Z. h. ladas* differs as follows: Color darker, more richly tawny, dorsal band less distinct; auditory bullae relatively shorter, more inflated; pterygoid fossae averaging broader; zygomata averaging broader; incisive foramina averaging longer.

Remarks.—This subspecies retains all of its diagnostic characters throughout nearly all parts of its geographic range. Specimens from Nova Scotia are like *Z. h. ladas* in their darker color and less distinct dorsal band, but in the remainder of their characters they are distinct and best referable to *Z. h. acadicus*.

Zapus h. ladas, with its relatively large size, poorly defined dorsal band, and broad, well inflated auditory bullae, is one of the better marked subspecies of the species *Zapus hudsonius*.

Specimens examined.—Total, 41, distributed as follows:

LABRADOR: Mahkovik, 1 (USNM); Etagaulet Bay, Lake Melvikl, 2 (USNM); 3 mi. above mouth of Naskaupi River, 1 (USNM); *Northwest River*, 6, (USNM); Cartwright, 1 (USBS); Muskrat Falls, Hamilton River, 1 (USNM); Hamilton River, Flour Lake, 3 (USNM); Hawke Harbor, 4 (USNM); Goose Bay, 3 (USNM); *Niger Sound*, *Islet Bay*, 1 (USNM); Red Bay, 5 (USNM); *Mecklenburg Harbor*, 2 (USNM); *Mary Harbor*, 1 (USNM).

NEWFOUNDLAND: Hare Harbor, 3 (USNM).

Quebec: northwest Ungava, 1 (NMC); Moise Bay, 5 (NMC); Trout Lake, near Moise Bay, 1 (NMC).

Marginal records.—Labrador: Mahkovik; Red Bay. Newfoundland: Hare Harbor. Quebec: Trout Lake, near Moise Bay; northwest Ungava.

***Zapus hudsonius pallidus* Cockrum and Baker**

Zapus hudsonius pallidus Cockrum and Baker, Proc. Biol. Soc. Washington, 63:1, April 26, 1950.

Jaculus hudsonius, Baird, Repts. Expl. and Surv. 111, 8 (pt. 1):433, July 14, 1858 (part—the part from Platte River, Nebraska, and Cass County, Missouri).

Zapus hudsonius, Coues, Bull. U. S. Geol. and Geog. Surv. of the Territories, 2nd ser. No. 5:260, 1877 (part—the part from Platte River, Nebraska).

Zapus hudsonius campestris Preble, N. Amer. Fauna, 15:20, August 8, 1899 (part—the part from Columbus in Nebraska and Jackson County in Missouri).

Type.—Male, adult, No. 22953, Univ. Kansas Mus. Nat. Hist.; NW corner sec. 4, T. 12S, R. 20E, 5 ½ mi. N, 1 ¼ mi. E Lawrence, Douglas County, Kansas; obtained on May 4, 1948, by E. Lendell Cockrum and Rollin H. Baker, original No. 916 of Cockrum.

Range.—Southern South Dakota, Nebraska, Kansas, Missouri, and northeastern Oklahoma. See [fig. 47](#). Zonal range: Upper Austral (Upper Sonoran and Carolinian). [451]

Description.—Size small; back near Cinnamon-Buff with admixture of dark-tipped hair forming distinct, broad, dorsal band; sides bright Cinnamon-Buff with sparse mixture of dark-tipped hair; lateral line usually distinct, of clear Cinnamon-Buff; belly white, sometimes with suffusion of color of sides, tail bicolored, brownish to brownish-black above, grayish-white to yellowish-white below; ears dark, narrowly edged with color of sides; feet white to grayish-white above; mastoid region relatively narrow; maxillary tooth-row relatively short; zygomata relatively short; zygomatic arch relatively broad; interorbital region relatively broad; auditory bullae relatively small and narrow; lateral margins of nasals not constricted posteriorly.

Comparisons.—From *Zapus hudsonius preblei*, *Z. h. pallidus* differs as follows: Coloration brighter and richer, more buff, less black; zygomatic arch more broadly bowed; condylobasal length averaging less; braincase narrower; interorbital region broader; incisive foramina shorter.

For comparisons with *Zapus hudsonius pallidus* and *Zapus hudsonius intermedius* see accounts of those subspecies.

Remarks.—The characters that distinguish this jumping mouse from neighboring kinds are relatively stable throughout most of its geographic range. *Zapus hudsonius pallidus* is one of the best defined subspecies of *Z. hudsonius*.

One specimen from Batesland, South Dakota, is referred to *Z. h. pallidus* but shows evidence of intergradation with *Zapus hudsonius campestris* in the shape of the nasals, incisive foramina, and in breadth of the zygomatic arch. An animal from 3 mi. NE Ponca, Nebraska, is intermediate between *Z. h. pallidus* and *Zapus hudsonius intermedius* in size and shape of the auditory bullae and in the breadth of the pterygoid fossae, but since this individual shows more resemblance to *Z. h. pallidus* in coloration and in the majority of cranial characters it is here referred to *Z. h. pallidus*. Specimens from Beemer, Nebraska, show an intergrading tendency toward *Zapus hudsonius intermedius* in the reduced lateral bowing of the zygomatic arch and in shorter zygomata. Since these individuals resemble *Z. h. pallidus* in the majority of characters they are referred to that race. An individual of *Z. h. pallidus* from Pevely, Missouri, is to some extent an intergrade with *Z. h. intermedius* of neighboring southern Illinois. Two individuals of *Z. h. pallidus* from Mohawk Park, Oklahoma, are darker dorsally than, but otherwise similar to, specimens from the type locality.

Zapus hudsonius pallidus seems to be the terminus of a cline; this is a southward trend toward smaller size and lighter, brighter color. There is a similar clinal tendency in the jumping mice in eastern North America, and *Z. h. americanus* from North Carolina, pronouncedly resembles *Z. h. pallidus* from Kansas.

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Specimens examined.—Total, 44, distributed as follows:

KANSAS: *Brown Co.*: Horton, 1. *Douglas Co.*: Sec. 8, T. 123, R. 20E, 5 ½ mi. N, 1 ¾ mi. E Lawrence, 10; 5 mi. N and 1 ½ mi. E Lawrence, 3; *Robinson Farm*, 5 mi. N and 3 mi. E Lawrence, 2; 4 mi. N, 2 ½ mi. E Lawrence, 1; Lakeview, 2; 7 ½ mi. SW Lawrence, 1. *Greenwood Co.*: ½ mi. S Hamilton, 1.

MISSOURI: *Cole Co.*: Jefferson City, 2 (MO). *Jackson Co.*: no exact locality, 1 (USBS). *Jefferson County*: Pevely, 1 (USBS).

NEBRASKA: *Blaine Co.*: *Dismal River, at Thomas-Blaine County line*, 1 (NGFP). *Boyd Co.*: 2 mi. E and 15 mi. S Spencer, 1. *Buffalo Co.*: Platte Meadows, Kearney, 1 (HM). *Butler Co.*: 5 mi E Rising City, 1. *Cherry Co.*: Niobrara River, 18 mi. NW Kennedy, 1; Ballard Marsh, 20 mi. S Valentine, 1 (JKJ); *Pony Lake Headquarters, Valentine Nat'l Wildlife Refuge*, 1 (JKJ). *Colfax Co.*: 2 mi. S Schuyler, 1 (JKJ). *Cuming County*: Beemer, 4 (USBS). *Dixon Co.*: 3 mi. NE Ponca, 1. *Platte County*: Columbus, 1 (USBS). *Richardson Co.*: 5 mi. SE Rulo, 1 (NGFP).

OKLAHOMA: *Tulsa Co.*: Mohawk Park, 2 (UM).

SOUTH DAKOTA: *Bennett Co.*: Batesland, 1 (FM).

Marginal records.—South Dakota: Batesland. Nebraska: 3 mi. NE Ponca; Beemer; 5 mi. SE Rulo. Missouri: Pevely. Oklahoma: Mohawk Park. Kansas: ½ mi. S Hamilton. Nebraska: Platte Meadows, Kearney; Ballard Marsh, 20 mi. S Valentine; Niobrara River, 18 mi. NW Kennedy.

***Zapus hudsonius preblei* new subspecies**

Type.—Male, adult, No. 73085, U. S. Nat. Mus., Biol. Surv. Coll.; Loveland, Larimer County, Colorado; obtained on July 23, 1895, by E. A. Preble, original No. 435.

Range.—Southeastern Wyoming and north-central Colorado. See [fig. 47](#). Zonal range: Transition.

Description.—Size medium; color dull, back from near Clay Color to near Tawny-Olive with admixture of black hair forming poorly defined dorsal band; sides lighter than back from near Clay Color to near Cinnamon-Buff; lateral line distinct and clear Ochraceous-Buff; belly white, sometimes with faint wash of clear Ochraceous-Buff; tail bicolored, brownish to light brownish-black above, grayish-white to yellowish-white below; ears dark, narrowly edged with color of sides; feet grayish-white above; incisive foramina relatively narrow and elongate; auditory bullae moderately inflated; pterygoid fossae relatively broad; postpalatal notch broadly rounded; interorbital region relatively narrow; zygomatic arch not widely bowed; frontal region well inflated; distance from incisors to postpalatal notch relatively short.

Comparisons.—Among named subspecies, *Zapus hudsonius preblei* most closely resembles *Z. h. campestris*. From topotypes of *Z. h. campestris*, *Z. h. preblei* differs as follows: Upper parts generally dull, averaging lighter, less black-tipped hair; dorsal band less distinct; sides duller; averaging smaller in most cranial measurements taken; least interorbital constriction narrower; auditory bullae smaller, less well inflated; incisive foramina narrower, not truncate posteriorly; frontal region usually more inflated.

From *Zapus hudsonius pallidus*, *Z. h. preblei* differs as follows: Upper parts generally duller (less ochraceous); dorsal band less distinct; sides paler (not bright Ochraceous-Buff); zygomatic arch less widely bowed; least interorbital constriction narrower; occipitonasal length averaging greater; distance from incisors to postpalatal notch averaging less; incisive foramina longer, proportionally less widely bowed; auditory bullae longer; pterygoid fossae averaging broader.

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Remarks.—No evidence of intergradation with any other geographic race was noted. To the east the range of *Z. h. preblei* is separated from that of *Z. h. pallidus* (western Kansas and southwestern Nebraska), by several hundred miles of mixed and short grass prairie. Much of this area is unsuitable to jumping mice but local marshy places might be inhabited. Much territory inhospitable to *Zapus* intervenes also between the ranges of *Z. h. preblei* and *Z. h. campestris*. This area (northern Platte, Goshen, eastern Converse, Niobrara, and southern Weston counties, Wyoming) is chiefly rolling hills and short grass prairie and, like that to the east, is only locally suitable for *Zapus*. If jumping mice do occur in suitable places in these intervening areas it is to be expected that they will show intergradation between the subspecies concerned.

Zapus hudsonius preblei, on the basis of 11 specimens, agrees most closely in size and color with *Z. h. campestris*; there is much less resemblance between *Z. h. preblei* and *Z. h. pallidus*.

An adult from Springhill, 12 mi. N Laramie Peak, is typically *Z. h. preblei* as is one from Cheyenne.

Although specimens of *Z. h. preblei* are few (4 adult, 7 non-adults), the differences between this and neighboring named kinds is considerable.

Specimens examined: Total, 11, distributed as follows:

COLORADO: *Boulder County:* 3 mi. E Boulder, 1 (UCM); *5 mi. E Boulder,* 1 (UCM); *south of Boulder* (no exact locality), 1 (UCM). *Jefferson County:* Semper, 1. *Larimer County:* Loveland, 2 (USBS).

WYOMING: *Albany County:* Springhill, 12 mi. N Laramie Peak, 6300 ft., 3 (USBS). *Laramie County:* Cheyenne, 1 (USNM). *Platte County:* Chugwater, 1 (Clev. MNH).

Marginal records.—Wyoming: Springhill, 12 mi. N Laramie Peak, 6300 ft.; Chugwater; Cheyenne. Colorado: Loveland; Semper.

Zapus hudsonius tenellus Merriam

Zapus tenellus Merriam, Proc. Biol. Soc. Washington, 11:103, April 26, 1897.

Zapus hudsonius tenellus, Hall, Univ. California Publ. Zool., 40:377, November 5, 1934.

Zapus hudsonius hudsonius, Baker, Univ. Kansas Publ., Mus. Nat. Hist., 5:111, November 28, 1951 (part—the part from E side Minaker River, 1 mi. W Trutch and 3 mi. N Fort St. John, British Columbia).

Type.—Female, young adult, skin and skull, No. 66932 U. S. Nat. Mus., Biol. Surv. Coll.; Kamloops, British Columbia; obtained on August 25, 1894, by Clark P. Streater, original No. 4196.

Range.—British Columbia. See fig. 47. Zonal range: Canadian and Hudsonian.

Description.—Size medium; back from near Clay Color (brighter) to near Cinnamon-Buff with admixture of black tipped hairs forming a weakly defined dorsal band; sides lighter than back from near dull Ochraceous-Buff to near Cinnamon-Buff frequently with admixture of dark-tipped hairs; lateral line usually distinct, of clear Ochraceous-Buff; belly white sometimes with slight suffusion of Ochraceous-Buff; tail bicolored, brownish to brownish-black above, white or grayish-white to yellowish-white below; ears dark, edged and flecked on inner surface with color of sides; feet grayish-white above; auditory bullae relatively narrow, moderately inflated, elongate when viewed from below, anterior edge slightly concave; incisive foramina relatively short; braincase relatively narrow; vertical depth of skull at junction of frontals and nasals relatively great; nasals relatively narrow; pterygoid fossae moderately broad; zygomata relatively short.

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Comparisons.—For comparisons with *Zapus hudsonius hudsonius* and *Zapus hudsonius alascensis* see accounts of those subspecies.

Remarks.—Merriam (1897a:103) named this jumping mouse as a full species, mentioning that the skull is similar in size and characters to that of *Zapus hudsonius* but that externally these animals differed in coloration and length of the tail. Hall (1934:377) treated *Z. tenellus* as a subspecies of *Z. hudsonius*. He observed that the difference between *Z. tenellus*, *Z. h. alascensis*, and *Z. h. hudsonius* was of the same degree, and, even though intergrading material was not known to him, he considered *tenellus* only subspecifically distinct from *Z. hudsonius*. Hall (*loc. cit.*) tentatively referred to *Z. h. tenellus* specimens from Indianpoint Lake, 15 mi. NE Barkerville, Cottonwood P. O., and Hazelton, British Columbia. I have seen and compared with the type of *Z. tenellus* all specimens examined by Hall and agree with him that they are best referred to *Z. h. tenellus*. Since 1934, several additional localities in British Columbia have yielded specimens. Those from Minaker River and Fort St. John are intermediate in dorsal coloration and in size and shape of the auditory bullae between *Zapus hudsonius hudsonius* and *Z. h. tenellus* but in all other characters are most nearly like *Z. h. tenellus* to which they are here assigned. These intergrades constitute additional evidence that *Z. tenellus* and *Z. hudsonius* are only subspecies of a single species.

Specimens examined.—Total, 17, all from British Columbia, distributed as follows: east side Minaker River, 1 mi. W Trutch, 1; Hazelton, 959 ft., 2 (MVZ); 5 mi. W and 3 mi. N Fort St. John, 1; *Indianpoint Lake, 15 mi. NE Barkerville,* 5 (MVZ); Cottonwood P. O., 3 (MVZ); S end Swan Lake, Vernon, 1200 ft., 2 (MVZ); Kamloops, 3 (USBS).

Marginal records.—British Columbia.—E side Minaker River, 1 mi. W Trutch; 5 mi. W and 3 mi. N Fort St. John; S end Swan Lake, Vernon, 1200 ft.; Kamloops; Hazelton, 959 ft.

Table 5.—Cranial Measurements (in Millimeters) of *Zapus*.

[455]

Number examined, ♂♂ plus ♀♀	Breadth of braincase	Condylbasal length	Interorbital breadth	Mastoidal breadth	Length of maxillary tooth-row	Occipitonasal length	Palatal length	Zygomatic breadth	Zygomatic length
<i>Zapus trinotatus eureka</i> , Big Lagoon, California.									
13 mean	10.3	21.4	4.2	10.9	3.9	24.5	10.4	12.5	9.5
max	10.6	22.1	4.4	11.1	4.0	25.5	11.5	13.2	10.0
min	10.0	20.7	3.9	10.0	3.7	24.0	10.5	12.1	9.0
<i>Zapus trinotatus montanus</i> , Crater Lake, Oregon.									
10 mean	10.3	20.7	4.5	10.6	4.0	24.3	10.5	12.1	9.5
max	10.5	21.5	4.7	11.1	4.1	24.8	10.8	12.6	9.8
min	10.2	20.3	4.2	10.2	3.7	23.5	10.1	11.8	9.0

	Lost Cr. R. S., 10 mi. SE McKenzie Bridge, Oregon.									
5 mean	10.3	20.9	4.5	10.7	3.9	24.2	10.4	12.1	9.0	
max	10.5	21.3	4.6	10.9	4.1	24.6	10.7	12.2	9.0	
min	10.2	20.4	4.4	10.5	3.8	23.5	10.0	12.0	9.1	
	<i>Zapus trinotatus orarius</i> , 3 mi. W Inverness, 800 ft., California.									
12 mean	9.9	20.4	3.8	10.8	3.7	22.6	10.0	12.1	9.3	
max	10.2	20.9	4.1	11.0	3.8	23.5	10.6	12.5	9.8	
min	9.6	19.9	3.7	10.4	3.6	21.7	9.8	11.9	8.5	
	<i>Zapus trinotatus trinotatus</i> , Old Fort Clatsop, 100 ft., Oregon.									
8 mean	10.3	21.1	4.4	10.7	3.8	24.3	10.6	12.3	9.0	
max	10.6	21.8	4.8	11.0	3.9	25.0	11.0	12.7	10.0	
min	10.0	20.2	4.0	10.4	3.7	23.6	10.0	11.9	9.2	
	Cayuse Meadow, 3800 ft., 3 ½ mi. SW Steamboat Mt'n, Wash.									
10 mean	10.4	21.5	4.5	11.1	3.9	24.6	10.7	12.6	9.7	
max	10.6	22.2	4.8	11.4	4.1	25.4	11.1	12.8	10.0	
min	10.2	20.6	3.8	10.8	3.8	23.7	10.2	12.2	9.3	
	Snoqualmie Pass, Washington.									
5 mean	10.6	21.6	4.6	11.1	4.0	24.8	10.9	12.8	9.0	
max	10.7	22.2	4.8	11.5	4.2	25.6	11.2	13.2	10.0	
min	10.4	21.2	4.4	10.9	3.8	24.0	10.5	12.5	9.5	
	Alta Lake, 2200 ft., British Columbia.									
5 mean	10.6	21.6	4.3	11.3	4.1	24.7	10.8	12.7	9.0	
max	10.9	21.9	4.6	11.5	4.3	25.0	10.9	13.1	9.0	
min	10.5	21.2	4.2	11.0	3.9	24.4	10.7	12.3	9.6	
	<i>Zapus princeps cinereus</i> , Raft River Mt's, Utah.									
4 mean	10.5	21.5	5.0	11.1	4.1	24.5	10.9	12.6	[459]10	
max	11.0	22.5	5.1	11.4	4.3	25.0	11.6	12.9	10.0	
min	10.3	21.0	4.6	10.7	3.9	24.0	10.4	12.3	9.4	
	Mt. Harrison, 10 mi. S Albion, Idaho.									
13 mean	10.5	21.4	4.8	10.9	4.1	24.9	10.9	12.4	10.1	
max	10.7	22.0	5.1	11.4	4.2	25.5	11.4	12.8	10.8	
min	10.2	20.9	4.5	10.5	3.9	24.3	10.2	11.7	9.8	
	<i>Zapus princeps curtatus</i> , Pine Forest Mt's, Nevada.									
11 mean	10.5	21.1	4.7	10.7	4.2	24.6	10.9	12.2	9.7	
max	10.6	21.8	5.0	11.0	4.4	25.3	11.4	12.5	10.0	
min	10.2	20.5	4.2	10.5	3.9	24.0	10.5	11.9	9.4	
	<i>Zapus princeps idahoensis</i> , several localities near Cody, Wyoming.									
24 mean	10.5	21.4	4.6	11.0	4.0	24.7	10.9	12.6	9.6	
max	11.2	22.6	5.2	11.4	4.2	25.6	11.5	13.3	10.2	
min	9.9	20.6	4.3	10.5	3.9	24.1	10.2	12.0	9.3	
	5 mi. E Warm Lake, 7000 ft., Idaho.									
4 mean	10.2	21.2	4.3	11.0	4.1	24.4	10.7	12.3	9.0	
max	10.3	21.8	4.4	11.1	4.2	24.8	11.0	12.6	9.0	
min	10.0	20.7	4.2	10.8	4.0	23.9	10.3	12.0	9.1	
	Summit Smith Mt'n, 7500 ft., Idaho.									
9 mean	10.2	21.3	4.4	10.9	4.1	24.5	10.7	12.1	9.0	
max	10.5	22.5	4.6	11.3	4.3	25.2	11.2	12.6	10.0	
min	10.0	20.8	4.0	10.5	3.9	23.9	10.3	11.8	9.1	
	2 mi. NE Cooke, 8500 ft., Montana.									
6 mean	10.4	21.1	4.4	10.9	4.0	24.3	10.5	12.5	9.0	
max	10.6	21.8	4.5	11.5	4.1	25.4	11.1	12.9	10.0	
min	10.2	20.3	4.3	10.7	3.8	23.5	9.9	12.0	9.0	
	Birch Cr., 18 mi. NE Dillon, 7100 ft., Montana.									
11 mean	10.3	21.3	4.3	11.0	4.0	24.5	10.8	12.6	9.6	

max	10.6	22.2	4.6	11.6	4.3	25.5	11.5	13.0	9.9
min	9.7	20.7	4.0	10.6	3.8	23.7	10.3	12.4	9.2
<i>Zapus princeps idahoensis</i> , Waterton Lakes Park, Alberta.									
5 mean	10.6	21.4	4.6	10.7	4.1	24.5	10.8	12.2	[45]10
max	10.9	22.1	4.7	11.0	4.2	25.2	11.0	12.3	10.0
min	10.3	21.0	4.4	10.4	4.0	24.2	10.6	11.8	9.3
<i>Zapus princeps kootenayensis</i> , near Rossland, British Columbia.									
10 mean	10.2	20.5	4.4	10.6	4.0	23.7	10.4	11.9	9.2
max	10.8	21.0	4.8	10.9	4.2	24.4	10.7	12.2	9.5
min	9.7	20.0	4.1	10.0	3.8	23.2	9.9	11.4	9.0
<i>Zapus princeps luteus</i> , White Mt's, Arizona.									
20 mean	10.1	20.3	4.9	10.7	3.9	23.8	10.4	11.9	9.7
max	10.4	21.1	5.1	11.2	4.0	24.8	10.9	12.6	10.2
min	9.6	19.1	4.3	10.2	3.6	22.5	9.5	11.1	8.9
Espanola, 5000 ft., New Mexico.									
3 mean	9.8	19.8	4.7	10.5	3.7	23.4	9.9	11.5	9.0
max	10.0	20.1	4.8	10.6	3.8	23.7	10.3	11.6	9.0
min	9.7	19.5	4.5	10.3	3.6	22.9	9.6	11.4	9.4
<i>Zapus princeps minor</i> , 2 mi. W Fort Totten, 1400 ft., No. Dakota.									
11 mean	9.9	20.5	4.5	10.6	3.7	23.7	10.5	11.8	9.6
max	10.1	20.8	4.8	10.8	3.8	24.2	10.7	12.1	9.9
min	9.7	20.0	4.4	10.4	3.6	23.4	10.2	11.4	9.3
Near Bottineau, North Dakota.									
4 mean	10.1	20.9	4.6	10.6	3.8	24.1	10.8	12.3	10.0
max	10.2	21.3	4.7	10.9	3.8	24.5	10.9	12.5	10.0
min	10.1	20.6	4.5	10.4	3.7	23.8	10.7	12.1	9.9
Head Eagle Cr., Bear Paw Mt's, Montana.									
7 mean	10.0	20.8	4.6	10.7	3.8	24.2	10.7	12.1	9.0
max	10.5	21.3	4.7	10.9	4.0	24.7	11.1	12.5	10.0
min	9.8	20.3	4.4	10.5	3.6	23.2	10.3	11.9	9.7
N Maple Cr., Cypress Hills, Saskatchewan.									
10 mean	10.1	21.2	4.6	10.7	3.9	24.5	10.9	12.3	9.8
max	10.4	21.7	4.9	10.8	4.0	24.8	11.3	12.7	10.0
min	9.9	20.4	4.4	10.5	3.6	24.0	10.5	11.8	9.6
<i>Zapus princeps oregonus</i> , Parker Cr., Warner Mt's, 5500 ft., Cal.									
12 mean	10.6	21.6	4.7	11.1	4.2	25.0	11.1	12.6	[45]10.2
max	11.0	22.2	4.9	11.6	4.4	25.7	11.4	13.0	10.9
min	10.2	21.2	4.3	10.8	4.0	24.5	10.7	12.4	9.9
Cobb Cr., 6 mi. SW Mt'n City, Nevada.									
12 mean	10.7	21.6	5.0	11.2	4.1	25.0	11.2	12.6	10.0
max	11.1	22.1	5.2	11.4	4.3	25.7	11.8	13.0	10.3
min	10.5	21.0	4.6	10.7	3.8	24.4	10.9	12.2	9.5
Wisconsin Cr., 8000 ft., Nevada.									
10 mean	10.6	21.6	4.9	11.2	4.0	24.8	11.1	12.4	9.5
max	10.8	22.2	5.0	11.5	4.2	25.2	11.4	12.8	9.6
min	10.3	21.2	4.6	10.8	3.9	24.1	10.6	12.2	9.3
North Fork Malheur River, 21 mi. SE Prairie City, 5000 ft., Ore.									
10 mean	10.6	21.5	4.7	11.3	4.2	24.8	11.0	12.7	9.9
max	11.2	22.3	5.2	11.6	4.4	26.2	11.7	13.2	10.9
min	10.0	20.8	4.3	10.9	4.0	23.5	10.5	12.4	9.7
<i>Zapus princeps pacificus</i> , North Fork Coffee Cr., 4500 ft., Calif.									
8 mean	10.4	21.5	4.7	10.9	3.9	24.8	11.1	12.5	10.0
max	10.8	22.4	5.0	11.4	4.0	25.2	11.4	13.2	10.0
min	10.0	20.7	4.5	10.7	3.8	24.0	10.5	12.0	9.6

	Jackson Lake, 5900 ft., California.									
7 mean	10.4	21.5	4.5	11.1	4.0	24.9	11.0	12.6	10.0	
max	10.6	22.1	4.6	11.5	4.1	25.5	11.4	12.9	10.0	
min	10.1	20.7	4.3	10.5	3.8	23.5	10.0	12.2	9.6	
	Head of Lyle Canyon, 9700 ft., California.									
7 mean	10.3	20.8	4.7	10.6	3.8	24.0	10.5	12.3	9.0	
max	10.5	21.8	5.0	11.0	4.0	24.6	10.8	12.7	10.0	
min	10.0	20.0	4.5	10.2	3.5	23.0	10.0	11.8	9.0	
	<i>Zapus princeps princeps</i> , Florida, Colorado.									
7 mean	10.2	21.4	4.6	10.5	3.7	24.9	11.1	12.3	9.0	
max	10.5	22.3	4.7	11.3	3.8	25.4	11.4	12.5	10.0	
min	9.7	20.7	4.3	9.8	3.5	23.9	10.9	11.9	9.3	
	<i>Zapus princeps princeps</i> , Half Way, Colorado.									
6 mean	10.1	21.7	4.6	10.8	3.9	24.9	11.0	12.3	9.0	[456]
max	10.3	22.0	4.8	11.1	4.0	25.8	11.3	12.7	10.0	
min	10.0	21.2	4.5	10.5	3.8	24.2	10.7	12.1	9.6	
	8 mi. N, 19½ mi. E Savery, Wyoming.									
11 mean	10.2	21.2	4.5	10.9	3.9	24.5	10.8	12.2	9.7	
max	10.5	21.8	4.7	11.1	4.1	25.0	11.1	12.5	10.2	
min	10.0	20.8	4.2	10.6	3.7	23.7	10.5	12.0	9.3	
	21½ mi. S, 24½ mi. W Douglas, 7600 ft., Wyoming.									
11 mean	10.1	21.2	4.6	10.9	4.0	24.6	10.8	12.3	9.8	
max	10.4	21.9	4.9	11.2	4.1	25.0	11.2	12.8	10.1	
min	9.9	20.7	4.5	10.8	3.8	24.2	10.5	12.0	9.5	
	Medicine Wheel Ranch, 28 mi. E Lovell, 9000 ft., Wyoming.									
20 mean	10.3	21.5	4.7	11.2	4.0	24.7	11.0	12.6	10.0	
max	10.6	22.2	4.9	11.5	4.2	25.3	11.4	12.9	10.4	
min	10.0	20.7	4.4	10.8	3.8	24.1	10.6	12.2	9.8	
	<i>Zapus princeps saltator</i> , Stikine River at Glenora, British Columbia.									
17 mean	10.4	21.3	4.4	10.9	4.1	24.3	10.7	12.5	9.6	
max	10.7	22.2	4.5	11.4	4.5	25.0	11.4	13.0	10.0	
min	9.8	20.5	4.1	10.6	3.8	23.3	10.3	12.0	9.3	
	Hazelton, 959 ft., British Columbia.									
15 mean	10.4	21.6	4.5	11.0	4.0	24.6	10.9	12.5	9.8	
max	10.8	22.3	4.7	11.6	4.2	25.5	11.4	12.9	10.0	
min	9.9	20.7	4.2	10.7	3.8	23.7	10.5	11.7	9.4	
	<i>Zapus princeps utahensis</i> , near Robertson, 8700 ft., Wyoming.									
15 mean	10.7	22.0	5.0	11.2	4.1	25.4	11.1	13.2	9.9	
max	11.1	22.6	5.1	11.6	4.2	26.4	11.7	14.0	10.3	
min	10.3	21.0	4.7	10.8	3.9	24.6	10.8	12.4	9.6	
	3 mi. N and 11 mi. E Alpine, 5650 ft., Wyoming.									
17 mean	10.6	22.1	4.7	11.3	4.1	25.3	11.3	13.0	9.9	
max	11.0	23.0	4.9	11.7	4.3	26.2	11.8	13.5	10.5	
min	10.3	21.3	4.4	10.8	4.0	24.2	10.7	12.1	9.5	
	<i>Zapus princeps utahensis</i> , Salamander Lake and Lambs Canyon, 9000 ft., Utah. [460]									
9 mean	10.9	22.0	4.8	11.2	4.1	25.2	11.1	13.1	10.0	
max	11.3	22.4	5.0	11.3	4.3	25.9	11.4	13.3	10.0	
min	10.7	21.5	4.5	11.0	3.9	24.6	10.7	12.6	9.7	
	<i>Zapus hudsonius acadicus</i> , vicinity of St. Andrews, New Brunswick.									
4 mean	9.6	19.8	4.1	10.2	3.5	23.0	10.1	10.8	9.0	
max	9.8	19.9	4.2	10.3	3.7	23.1	10.2	11.1	9.0	
min	9.2	19.7	3.9	10.0	3.3	22.8	9.9	10.4	9.2	
	Sebec Lake, Maine.									
3 mean	9.6	19.5	4.3	10.0	3.5	23.0	10.0	10.7	9.0	
max	9.8	19.8	4.5	10.1	3.6	23.3	10.1	11.3	9.0	

min	9.4	19.0	4.0	9.7	3.4	22.6	9.9	9.9	9.0
	2 mi. S Center Ossipee, New Hampshire.								
10 mean	9.6	19.8	4.2	10.1	3.5	23.3	10.0	10.8	9.3
max	10.0	20.5	4.6	10.4	3.6	24.0	10.3	11.0	9.9
min	9.2	18.9	3.8	9.7	3.2	22.3	9.6	10.6	8.8
	Berlin, New York.								
6 mean	9.5	19.5	4.3	10.1	3.5	22.9	9.8	10.8	9.0
max	9.9	20.6	4.4	10.6	3.7	23.8	10.6	11.3	9.0
min	9.2	18.8	4.2	9.5	3.4	21.8	9.3	10.4	8.6
	Lake Kedgemakooge, Nova Scotia.								
5 mean	9.5	19.9	4.2	10.3	3.5	23.4	10.2	11.3	9.0
max	9.7	20.1	4.3	10.4	3.5	23.5	10.4	11.4	9.0
min	9.3	19.7	4.0	10.3	3.4	23.3	9.9	11.0	9.3
	<i>Zapus hudsonius alascensis</i> , Lake Clark, Alaska.								
2 mean	9.5	19.3	4.3	10.0	3.6	22.8	9.9	10.7	9.0
max	9.6	19.6	4.4	10.0	3.6	23.0	9.9	10.7	9.0
min	9.4	19.1	4.2	9.9	3.5	22.6	9.9	10.7	9.2
	Frosty Peak, Yakutat Bay, Alaska.								
3 mean	9.8	19.7	4.2	10.3	3.6	23.5	10.1	10.8	9.0
max	10.0	20.0	4.5	10.6	3.7	24.2	10.4	11.1	9.0
min	9.6	19.0	4.0	9.8	3.5	22.5	9.6	10.2	9.2
	<i>Zapus hudsonius alascensis</i> , 7 mi. SSE Haines, 10 ft., Alaska. [461]								
14 mean	9.9	20.0	4.2	10.4	3.6	23.7	10.2	11.0	9.4
max	10.1	20.5	4.4	10.8	3.7	24.6	10.7	11.4	9.8
min	9.8	19.5	4.0	10.2	3.4	23.0	9.8	10.4	9.0
	SW end Dezadeash Lake, Yukon.								
2 mean	10.0	19.8	4.5	10.5	3.6	23.5	10.2	11.3	9.0
max	10.1	20.1	4.5	10.5	3.6	23.8	10.4	11.3	9.0
min	9.8	19.5	4.4	10.5	3.5	23.2	10.0	11.2	9.5
	<i>Zapus hudsonius americanus</i> , Boyne Falls, Michigan.								
8 mean	9.5	18.7	4.1	9.7	3.3	22.0	9.5	11.0	9.0
max	9.8	19.4	4.3	10.0	3.4	23.2	10.0	11.4	9.0
min	9.3	18.3	3.8	9.4	3.0	21.5	9.0	10.3	9.0
	Ann Arbor, Michigan.								
3 mean	9.5	18.6	4.2	9.9	3.3	22.0	9.5	10.9	9.0
max	9.6	18.8	4.4	10.0	3.3	22.4	9.8	11.0	9.0
min	9.4	18.5	3.8	9.8	3.2	21.9	9.3	10.8	8.9
	Montauk Point, L. I., New York.								
2 mean	9.4	18.8	4.3	9.2	3.5	22.2	9.7	10.6	8.0
max	9.6	19.1	4.4	9.2	3.5	22.5	9.8	10.7	8.0
min	9.2	18.4	4.2	9.2	3.4	21.9	9.5	10.5	8.9
	Mays Landing, New Jersey.								
2 mean	9.4	18.8	4.4	9.8	3.4	22.1	9.6	10.9	8.0
max	9.5	18.8	4.4	9.8	3.5	22.2	9.7	11.0	8.0
min	9.3	18.7	4.4	9.8	3.2	22.0	9.5	10.8	8.2
	Laurel, Maryland.								
3 mean	9.1	18.6	4.3	9.6	3.3	22.0	9.5	10.6	8.0
max	9.3	18.9	4.5	9.7	3.3	22.0	9.7	10.8	8.0
min	8.9	18.2	4.1	9.5	3.3	21.9	9.2	10.4	8.6
	Hampton, Virginia.								
3 mean	9.0	18.8	4.1	9.7	3.3	21.9	9.4	10.6	9.0
max	9.3	18.9	4.1	9.8	3.3	22.0	9.6	11.1	9.0
min	8.6	18.5	4.0	9.6	3.2	21.8	9.2	10.0	8.9

	<i>Zapus hudsonius americanus</i> , Raleigh, North Carolina.									
3 mean	9.2	18.8	4.0	9.9	3.4	22.4	9.6	10.9	[468]	10
max	9.6	19.7	4.2	10.4	3.5	23.0	9.9	10.9		9.0
min	8.8	17.9	3.9	9.4	3.2	21.8	9.4	10.8		8.5
	<i>Zapus hudsonius campestris</i> , 3 mi. NW Sundance, 5900 ft., Wyo.									
19 mean	9.7	19.9	4.3	10.4	3.6	23.2	10.0	11.1		9.5
max	10.0	20.8	4.5	10.9	3.8	24.2	10.5	11.8		10.0
min	9.4	19.2	3.8	10.1	3.4	22.4	9.5	10.7		9.2
	Palmer Gulch, Black Hills, South Dakota.									
11 mean	9.8	20.2	4.3	10.5	3.7	23.4	10.1	11.4		9.6
max	10.2	21.4	4.5	11.1	3.9	24.9	10.9	12.0		10.2
min	9.5	19.0	4.2	10.1	3.5	21.9	9.5	10.7		9.0
	<i>Zapus hudsonius canadensis</i> , St. Methode, Quebec.									
4 mean	9.6	19.2	4.3	10.1	3.6	22.6	9.8	10.9		9.0
max	9.9	19.7	4.5	10.2	3.7	23.5	10.1	11.2		9.0
min	9.1	18.5	3.9	9.9	3.3	21.7	9.5	10.7		8.7
	Pancake Bay, Algoma District, Ontario.									
11 mean	9.6	18.8	4.1	10.0	3.5	22.2	9.6	10.4		9.2
max	10.0	19.4	4.4	10.3	3.6	22.8	9.7	10.6		9.7
min	9.2	18.3	3.8	9.6	3.3	21.8	9.2	9.8		8.6
	Franz, Ontario.									
5 mean	9.8	19.4	4.2	10.3	3.5	22.6	9.8	10.7		9.0
max	10.0	19.8	4.3	10.5	3.6	23.2	10.2	11.1		9.0
min	9.6	18.9	4.1	10.2	3.4	22.1	9.6	10.4		8.8
	<i>Zapus hudsonius hudsonius</i> , Fort Severn, Ontario.									
4 mean	9.9	19.3	4.2	9.9	3.5	22.7	9.6	10.9		9.0
max	10.1	19.7	4.3	10.1	3.6	23.3	9.8	11.0		9.0
min	9.8	19.0	4.0	9.7	3.4	22.0	9.3	10.7		9.0
	Oxford House, Manitoba.									
6 mean	9.6	19.1	4.4	9.9	3.5	22.3	9.7	10.4		9.0
max	9.9	19.8	4.6	10.1	3.7	23.1	10.0	10.8		9.0
min	9.3	18.7	4.2	9.6	3.3	21.7	9.5	9.8		8.8
	<i>Zapus hudsonius hudsonius</i> , Emma Lake, Saskatchewan.									
2 mean	9.8	19.4	4.3	9.9	3.6	22.7	9.8	10.9	[469]	10
max	9.8	19.5	4.3	9.9	3.6	22.9	9.9	10.9		9.0
min	9.8	19.3	4.2	9.9	3.5	22.4	9.6	10.9		8.9
	Lac la Nonne, Alberta.									
4 mean	9.8	19.1	4.2	10.0	3.4	22.4	9.7	10.5		9.0
max	9.8	19.4	4.2	10.0	3.5	22.6	9.9	10.5		9.0
min	9.7	18.8	4.1	9.9	3.3	22.2	9.6	10.5		8.9
	1 mi. NW Junct. Irons Cr. and Laird River, British Columbia.									
3 mean	9.6	19.0	4.3	9.9	3.5	22.2	9.7	10.6		9.0
max	9.6	19.3	4.3	10.1	3.5	22.6	9.8	10.9		9.0
min	9.5	18.7	4.3	9.7	3.4	21.7	9.5	10.3		8.9
	<i>Zapus hudsonius intermedius</i> , Blackner, North Dakota.									
2 mean	10.1	19.6	4.3	10.0	3.6	22.7	9.9	11.1		9.0
max	10.1	20.0	4.4	10.4	3.7	23.2	9.9	11.4		9.0
min	10.0	19.1	4.1	9.8	3.4	22.2	9.8	10.8		9.0
	Cannon Ball, North Dakota.									
2 mean	9.8	19.1	4.4	10.1	3.6	22.0	9.5	11.0		9.0
max	9.9	19.1	4.4	10.2	3.7	22.4	9.8	11.3		9.0
min	9.6	19.0	4.3	9.9	3.4	21.8	9.2	10.7		9.0
	Elk River, Minnesota.									
8 mean	9.5	19.2	4.2	9.9	3.4	22.5	9.6	10.6		9.0
max	9.7	19.6	4.3	10.0	3.6	23.0	9.9	11.0		9.0

min	9.2	18.9	4.0	9.9	3.3	22.1	9.4	10.2	9.0
	E Okeboji Lake, Iowa.								
3 mean	9.6	19.3	4.2	9.9	3.4	22.2	9.3	10.2	9.0
max	9.8	19.3	4.2	10.0	3.4	22.2	9.3	10.2	9.0
min	9.4	19.3	4.2	9.8	3.4	22.2	9.2	10.2	9.0
	Turkey Run State Park, Indiana.								
2 mean	9.5	18.9	4.2	9.6	3.5	22.3	9.8	10.4	9.0
max	9.6	18.9	4.4	9.6	3.6	22.4	9.8	10.8	9.0
min	9.4	18.9	4.0	9.6	3.3	22.2	9.8	10.0	9.0
	<i>Zapus hudsonius intermedius</i> , Jordan Cr., 3 mi. NE Fairmont, Ill. [464]								
5 mean	9.6	19.4	4.1	10.1	3.6	22.6	10.0	10.7	9.2
max	9.9	19.8	4.2	10.3	3.8	23.4	10.5	11.6	9.6
min	9.3	18.9	4.0	10.0	3.4	21.9	9.5	10.3	8.9
	Rib Hill, Wisconsin.								
5 mean	9.6	19.0	4.3	10.1	3.4	22.6	9.7	10.8	9.0
max	10.0	19.8	4.4	10.5	3.6	23.7	10.2	11.2	9.3
min	9.4	18.4	4.1	9.7	3.2	21.9	9.4	10.3	8.7
	Lake St. Germain, Wisconsin.								
5 mean	9.7	18.9	4.1	10.1	3.5	22.5	9.6	10.5	9.0
max	9.9	19.5	4.3	10.2	3.6	23.2	10.0	10.8	9.3
min	9.5	18.4	3.9	9.8	3.3	21.8	9.0	10.2	8.5
	<i>Zapus hudsonius ladas</i> , Northwest River, Labrador.								
6 mean	9.5	19.0	4.2	10.2	3.6	22.4	9.7	10.9	9.0
max	9.6	20.0	4.4	10.3	3.6	23.2	10.2	11.0	9.4
min	9.3	18.4	4.0	10.0	3.5	21.5	9.4	10.6	8.8
	Moisie Bay, Labrador.								
4 mean	9.8	19.1	4.3	10.0	3.4	22.8	9.6	11.0	9.1
max	9.8	19.7	4.4	10.0	3.5	23.5	10.1	11.3	9.8
min	9.7	18.6	4.1	9.9	3.3	22.1	9.3	10.8	8.9
	<i>Zapus hudsonius pallidus</i> , Mohawk Park, Oklahoma.								
2 mean	9.7	18.4	4.3	9.9	3.7	21.5	9.3	11.0	8.7
max	10.1	18.8	4.3	9.9	3.7	21.8	9.4	11.0	8.7
min	9.3	18.0	4.3	9.8	3.7	21.1	9.2	11.0	8.6
	vicinity of Lawrence, Kansas.								
10 mean	9.2	18.8	4.4	9.8	3.4	21.6	9.7	10.9	9.0
max	9.5	19.4	4.8	10.2	3.6	22.4	10.1	11.6	9.4
min	8.9	18.1	4.0	9.3	3.3	21.0	9.0	10.3	8.8
	2 mi. S Schuyler, Nebraska.								
1	9.2	18.5	4.4	9.5	3.3	21.5	9.6	10.4	9.1
	<i>Zapus hudsonius pallidus</i> , Valentine National Wildlife Refuge, Nebraska. [465]								
1	10.0	19.6	4.5	10.5	3.5	22.9	10.0	11.6	9.3
	<i>Zapus hudsonius preblei</i> , Loveland, Colorado.								
2 mean	9.6	18.5	4.1	10.0	3.6	22.3	9.6	10.4	9.1
max	9.6	19.0	4.2	10.0	3.6	22.4	9.8	10.6	9.1
min	9.5	18.0	3.9	10.0	3.6	22.2	9.4	10.2	9.1
	Spring Hill, 12 mi. N Laramie Peak, 6300 ft., Wyoming.								
1	9.8	19.2	4.1	10.2	3.6	22.8	10.2	10.7	9.3
	<i>Zapus hudsonius tenellus</i> , Hazelton, 959 ft., British Columbia.								
2 mean	9.6	19.4	4.4	10.1	3.5	22.9	9.6	10.9	9.2
max	9.6	19.5	4.4	10.2	3.5	23.0	9.6	10.9	9.2
min	9.6	19.3	4.3	10.0	3.4	22.7	9.6	10.8	9.2
	Cottonwood P. O., British Columbia.								
2 mean	9.5	19.5	4.4	10.1	3.5	22.8	9.7	10.8	9.2

max	9.6	19.6	4.5	10.2	3.5	22.8	9.8	10.9	9.3
min	9.3	19.4	4.2	10.0	3.4	22.7	9.6	10.7	9.1
S end Swan Lake, British Columbia.									
2 mean	9.4	19.7	4.1	10.0	3.6	22.9	10.1	10.9	9.5
max	9.4	19.7	4.2	10.2	3.6	23.2	10.2	10.9	9.6
min	9.3	19.6	4.0	9.8	3.5	22.6	10.0	10.8	9.4
Indianpoint Lake, 15 mi. NE Barkerville, British Columbia.									
4 mean	9.6	18.9	4.1	9.9	3.4	21.9	9.5	10.8	9.0
max	9.6	19.6	4.2	10.0	3.6	23.0	9.8	11.3	9.4
min	9.4	18.3	4.0	9.8	3.3	21.3	9.1	10.2	8.8

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 2. The systematic status of *Eumeces pluvialis* Cope, and noteworthy records of other amphibians and reptiles from Kansas and Oklahoma. By Hobart M. Smith. Pp. 85-89. August 15, 1946.
 3. The tadpoles of *Bufo cognatus* Say. By Hobart M. Smith. Pp. 93-96, 1 figure in text. August 15, 1946.
 4. Hybridization between two species of garter snakes. By Hobart M. Smith. Pp. 97-100. August 15, 1946.
 5. Selected records of reptiles and amphibians from Kansas. By John Breukelman and Hobart M. Smith. Pp. 101-112. August 15, 1946.
 6. Kyphosis and other variations in soft-shelled turtles. By Hobart M. Smith. Pp. 117-124, 3 figures in text. July 7, 1947.

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7. Natural history of the prairie vole (Mammalian Genus *Microtus*). By E. W. Jameson, Jr. Pp. 125-151, 4 figures in text. October 6, 1947.
 8. The postnatal development of two broods of great horned owls (*Bubo virginianus*). by Donald F. Hoffmeister and Henry W. Setzer. Pp. 157-173, 5 figures in text. October 6, 1947.
 9. Additions to the list of the birds of Louisiana. By George H. Lowery, Jr. Pp. 177-192. November 7, 1947.
 10. A check-list of the birds of Idaho. By M. Dale Arvey. Pp. 193-216. November 29, 1947.
 11. Subspeciation in pocket gophers of Kansas. By Bernardo Villa-R. and E. Raymond Hall. Pp. 217-236, 2 figures in text. November 29, 1947.
 12. A new bat (Genus *Myotis*) from Mexico. By Walter W. Dalquest and E. Raymond Hall. Pp. 237-244, 6 figures in text. December 10, 1947.
 13. *Tadarida femorosacca* (Merriam) in Tamaulipas, Mexico. By Walter W. Dalquest and E. Raymond Hall. Pp. 245-248, 1 figure in text. December 10, 1947.
 14. A new pocket gopher (*Thomomys*) and a new spiny pocket mouse (*Liomys*) from Michoacán, Mexico. By E. Raymond Hall and Bernardo Villa-R. Pp. 249-256, 6 figures in text. July 26, 1948.
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 16. A new extinct emydid turtle from the Lower Pliocene of Oklahoma. By Edwin C. Galbreath. Pp. 265-280, 1 plate. August 16, 1948.
 17. Pliocene and Pleistocene records of fossil turtles from western Kansas and Oklahoma. By Edwin C. Galbreath. Pp. 281-284. August 16, 1948.
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 19. Speciation in the Brazilian spiny rats (Genus *Proechimys*, Family *Echimyidae*). By João Moojen. Pp. 301-406, 140 figures in text. December 10, 1948.
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 21. Two new meadow mice from Michoacán, Mexico. By E. Raymond Hall. Pp. 423-427, 6 figures in text. December 24, 1948.
 22. An annotated check list of the mammals of Michoacán, Mexico. By E. Raymond Hall and Bernardo Villa-R. Pp. 431-472, 2 plates, 1 figure in text. December 27, 1949.
 23. Subspeciation in the kangaroo rat, *Dipodomys ordii*. By Henry W. Setzer. Pp. 473-573, 27 figures in text, 7 tables. December 27, 1949.
 24. Geographic range of the hooded skunk, *Mephitis macroura*, with description of a new subspecies from Mexico. By E. Raymond Hall and Walter W. Dalquest. Pp. 575-580, 1 figure in text. January 20, 1950.
 25. *Pipistrellus cinnamomeus* Miller 1902 referred to the Genus *Myotis*. By E. Raymond Hall and Walter W. Dalquest. Pp. 581-590, 5 figures in text. January 20, 1950. [ii]
 26. A synopsis of the American bats of the Genus *Pipistrellus*. By E. Raymond Hall and Walter W. Dalquest. Pp. 591-602, 1 figure in text. January 20, 1950.
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 - *2. A quantitative study of the nocturnal migration of birds. By George H. Lowery, Jr. Pp. 361-472, 47 figures in text. June 29, 1951.
 3. Phylogeny of the waxwings and allied birds. By M. Dale Arvey. Pp. 473-530, 49 figures in text, 13 tables. October 10, 1951.
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 2. Two new moles (Genus *Scalopus*) from Mexico and Texas. By Rollin H. Baker. Pp. 17-24. February 28, 1951.
 3. Two new pocket gophers from Wyoming and Colorado. By E. Raymond Hall and H. Gordon Montague. Pp. 25-32. February 28, 1951.
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- canicaudus Miller. By E. Raymond Hall and Keith R. Kelson. Pp. 73-79. October 1, 1951.
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 28. The pocket gophers (Genus Thomomys) of Coahuila, Mexico. By Rollin H. Baker. Pp. 499-514, 1 figure in text. June 1, 1953.
 29. Geographic distribution of the pocket mouse, Perognathus fasciatus. By J. Knox Jones, Jr. Pp. 515-526, 7 figures in text. August 1, 1953.
 30. A new subspecies of wood rat (Neotoma mexicana) from Colorado. By Robert B. Finley, Jr. Pp. 527-534, 2 figures in text. August 15, 1953.
 31. Four new pocket gophers of the genus Cratogeomys from Jalisco, Mexico. By Robert J. Russell. Pp. 535-542. October 15, 1953.
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 33. Taxonomy of the chipmunks, Eutamias quadrivittatus and Eutamias umbrinus. By John A. White. Pp. 563-582, 6 figures in text. December 1, 1953.
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- *Vol. 6. (Complete) Mammals of Utah, *taxonomy and distribution*. By Stephen D. Durrant. Pp. 1-549, 91 figures in text, 30 tables. August 10, 1952.
- Vol. 7. *1. Mammals of Kansas. By E. Lendell Cockrum. Pp. 1-303, 73 figures in text, 37 tables. August 25, 1952.
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- and Lewis L. Sandidge. Pp. 305-338, 5 figures in text. August 24, 1953.
3. The silky pocket mice (*Perognathus flavus*) of Mexico. By Rollin H. Baker. Pp. 339-347, 1 figure in text. February 15, 1954.
4. North American jumping mice (Genus *Zapus*). By Philip H. Krutzsch. Pp. 349-472, 47 figures in text, 4 tables. April 21, 1954.
- More numbers will appear in Volume 7.

Transcriber's Notes

All obvious typos corrected. In Table 5 on the Swan Lake row, the Mean value for the Palatal length was corrected to 10.1 mm as there were only two values averaged (10.0 and 10.2). Abbreviation inconsistencies for mountain(s) were retained. Where a publication name contains an alternate spelling of a word, it was retained (example, Athabaska). The author Bernardo Villa-Ramirez is sometimes listed with the hyphen and sometimes without. For consistency, they were standardized with a hyphen.

Typographical Corrections

Page(s)	Correction
380	dention → dentition
412, 414	Eldorado → El Dorado
417	Sitkine River, at Glenoria → Stikine River, at Glenora

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