University of Kansas Publications

Museum of Natural History

VOLUME 7 · 1952-1955

EDITORS

Museum of Natural History
UNIVERSITY OF KANSAS
LAWRENCE
1955

MUSEUM OF NATURAL HISTORY

UNIVERSITY OF KANSAS

LAWRENCE

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1955

26-421

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24-7812

Ecology of the Opossum on a Natural Area in Northeastern Kansas

BY

HENRY S. FITCH and LEWIS L. SANDIDGE

On the 590-acre University of Kansas Natural History Reservation where our study was made, the opossum, *Didelphis marsupialis virginiana* Kerr, is the largest predatory animal having a permanently resident population. The coyote, racoon and red fox also occur on the area but each ranges widely, beyond the Reservation boundaries. With the passing nearly a century ago of the larger animals of the original fauna, the buffalo, elk, deer, antelope, wild turkey, gray wolf and others, lesser herbivores and carnivores including the opossum and animals of similar size fell heir to their key positions of predominance at the peak of the food pyramid. These smaller animals, however, exert less powerful effects in controlling the general aspect of the biotic community, and affect it in different directions. The over-all ecology is greatly altered. The flora and fauna both are undergoing successional changes which will continue for a long time and probably will culminate in a biotic community much different from the original climax.

The opossum plays an important part in this process of change; being relatively large, numerous, and of omnivorous habits, it variously influences, directly and indirectly, the populations of its plant and animal associates, through a complex web of interrelationships. Several excellent field- and laboratory-studies of the opossum have been published (Hartman, 1928, 1952; Lay, 1942; Reynolds, 1945; Wiseman and Hendrickson, 1950) and the life history of this remarkable marsupial is already well known. The purpose of our study, therefore, was to gain a better understanding of the ecological relationships of the opossum in the particular region represented by the study area. To accomplish this, we gathered data concerning the animal's responses to climate and varying weather conditions; its annual cycle of breeding, growth and activity, movements, principal food sources, numbers, population turnover, and natural enemies. Although we did gain a somewhat better understanding of the opossum's ecology, results are remarkably meager in proportion to the large amount of time expended. The hours of work daily in setting and tending a line of live-traps ordinarily were rewarded with only a few records, sometimes none. Comparable time and effort directed to the study of smaller and more abundant kinds of animals has been far more productive of data. Field work was carried on in parts of 1949, 1950, 1951 and 1952.

Because opossums are nocturnal and rarely seen in the course of their regular activities, the present study is based mainly on information gained by live-trapping them. Several different sizes of traps of the type described by Fitch (1951) were used. The most successful were 2′ x 8″ x 8″ in dimensions although many of the larger ones

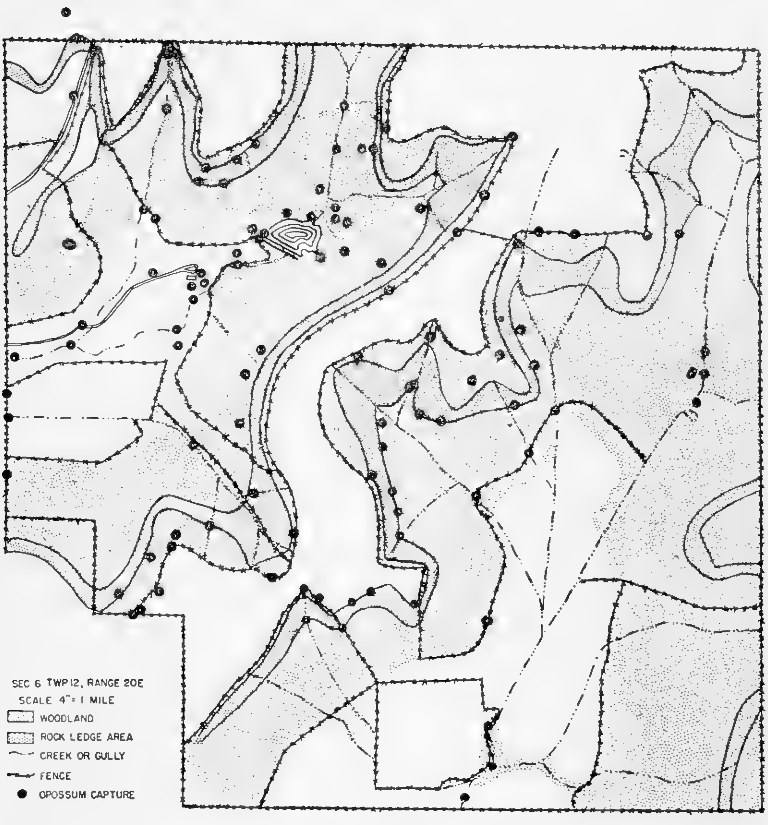

FIGURE 1. Map of the University of Kansas Natural History Reservation showing locations where opossums were live-trapped.

were also used. They were constructed of hardware cloth having a half-inch mesh. Live-trapping was begun in October 1949 by Fitch with a line of about a dozen traps. In the following month Sandidge joined in the field work. The trapping was continued throughout the winter and spring of 1949-1950 and was resumed the following fall and more traps were added from time to time until a maximum line of approximately 60 was attained. Sandidge's participation ended in December, 1950. The live-trapping was continued on a reduced scale by Fitch through the winter and spring of 1951 and some was done sporadically in the fall, winter and spring of 1951 to 1952.

Traps were baited with a variety of foods such as carcasses of small vertebrates, meat scraps, canned dog food, ground horse meat and bacon grease. At each capture, sex, weight, and individual formula of the opossum, based on toe-clipping and ear-clipping (Fitch, 1952), were recorded. Also recorded was the exact site of capture as located in one of 84 divisions of the Reservation and estimated in feet from some named landmark. Notes on breeding condition, pelage, injuries, parasites and general appearance were also taken at the time of capture. For opossums caught in 1951 and 1952, the hind foot measurement was recorded.

Often, attempt was made to follow the released opossum to determine the direction and distance of its homeward travel but this was difficult because of brushy terrain and secretive habits of the animal. An opossum being followed would almost invariably take refuge in a tree if it caught sight of the observer. Other information regarding the animal's habits was obtained from tracks in snow or soft soil and from the distribution and contents of scats. Carcasses of opossums which had fallen victim to predators were found on a few occasions and in some instances clues as to the identity of the predator were obtained. One hundred and seventeen opossums were live-trapped and handled a total of 276 times. Six of these were dead when first found in the traps. The remaining 111 were marked and released. In addition, 207 pouch-young carried by adult females were recorded and 115 of these were individually marked by toe-clipping. Some of the opossums that were marked while in the mother's pouch were subsequently recaptured when they were well-grown, independent young, or adults, affording information on growth and dispersal.

HABITAT

The habitats of the Reservation have been described briefly by Fitch (1952) and by Leonard and Goble (1952). More than half the area consists of steep wooded slopes with mixed second growth forest, consisting of elm, hickory, oak, walnut, ash, honey locust, hackberry and osage orange, in about that order of abundance, with thickets of blackberry, crabapple, wild plum and grape. Fallow fields and pastures of the upland and valley floors alternate with the woodland. The varied habitat provides numerous different food sources. Along the edges of the hilltops there is a nearly continuous limestone outcrop with a lower outcrop paralleling it. These rock ledges, well distributed throughout the area, provide an abundance of den sites and most of the opossums definitely trailed to a home base were found to be utilizing dens in the rock ledges. Two small creeks on the area have some water for most of the year. As compared with wooded bottomland of larger stream courses in Douglas County and those counties adjoining it, the Reservation area probably supports a relatively low population density of opossums. "Sign" has been found in much greater abundance in near-by areas supporting a heavier woodland.

Every part of the Reservation is used by opossums, but their activity is concentrated in the woodland, and all dens found were in woodland. Most parts of the fields are within 100 yards of the edge of the woodland and no point is more than 700 feet from the edge. Most of the opossums' foraging in fields was concentrated along the edge; otherwise they tended to follow creeks and gullies and they follow well worn trails more often than they do in the woods. Within the woodland, activity tended to be concentrated along the small streams, and along the rock ledges where den sites were plentiful. Throughout the annual cycle, and from year to year, there were minor shifts in areas of concentrated activity depending on seasonal changes in food sources such as thickets of wild plum, crabapple, blackberry and grape, with fruits ripening at slightly different times of year. The areas adjoining the Reservation offer somewhat similar habitat conditions, part woodland, part pasture land and some cultivated fields with corn or other crops which provide food sources for the opossum.

Under original conditions the area that is now the Reservation probably was marginal habitat for opossums, consisting mainly of open grassland with trees in small and scattered clumps, if indeed they were present at all. There has been steady encroachment of shrubs and trees, originally chiefly confined to near-by bottomlands such as those of the Kaw and Wakarusa valleys. Concurrently, the original hardwood forest of the bottomlands has mostly disappeared, and the land has been taken over for intensive agricultural use. The new upland forest provides a habitat different in many respects from the original bottomland forest. The species composition, in trees and other plants, is somewhat different, with more xeric types, especially on steep south slopes. Logs and large old hollow trees are scarce. The lack of such potential den sites is compensated for by the abundance of holes and crevices along hilltop rock ledges.

BEHAVIOR

Undisturbed opossums were seen in the course of their normal activities on only a few occasions, and behavior is known to us mainly from the sign and from observations made on those that were live-trapped. Ordinarily those taken in live-traps were found curled up in deep sleep from which they did not arouse until touched or until the trap was moved or jarred. Reactions to humans varied greatly in individuals and was not necessarily correlated with age or sex. Adult males were uniformly hostile to the trapper and reacted with harsh, low growls, with back arched and hair bristling. Although many adult females and young of both sexes were similarly hostile in behavior, others were not. Some cowered silently in the trap. Others showed hardly any uneasiness. A small proportion of them feigned death when handled or even before they were touched. Feigning was especially frequent in response to clipping of toes and ears when the animal was marked. In some that were handled, the feigning reaction was weak or incomplete, the animal arising almost immediately after collapsing or beginning to collapse in the feint.

Those that feigned death usually maintained the deception for not more than two or three minutes after a person had moved away out of sight. The opossum first raised its head and sniffed, listened, and looked about cautiously for a short time, with body and limbs still relaxed in the feigning posture. Failing to detect any sign of danger, it gradually shifted to a sitting position, and then to a standing one, from which it began moving away with many short pauses at first, and then more rapidly.

Upon being released, some opossums scrambled for shelter immediately; others stood their ground defiantly with back arched, hair bristling and fangs bared. One that was put on the defensive would usually maintain its stance for less than a minute if not further disturbed by movements of the trapper. It would then slowly turn its head and begin walking away with deliberate gliding movements, often pausing abruptly in the middle of its stride with one or two feet off the ground in a pose reminiscent of that of a bird dog making its "point." After moving away a few yards, it would gradually accelerate its pace in a scramble for shelter, but an occasional individual moved away unhurriedly, even foraging as it went.

On the few occasions when opossums were seen at night, their relative alertness and speed of movement contrasted with the sluggishness and seeming stupidity of those observed in daylight. Several were seen on roads in the beam of automobile headlights. These were quick to escape, running into thick roadside vegetation or woods to elude pursuit. Others were found in woodland, with

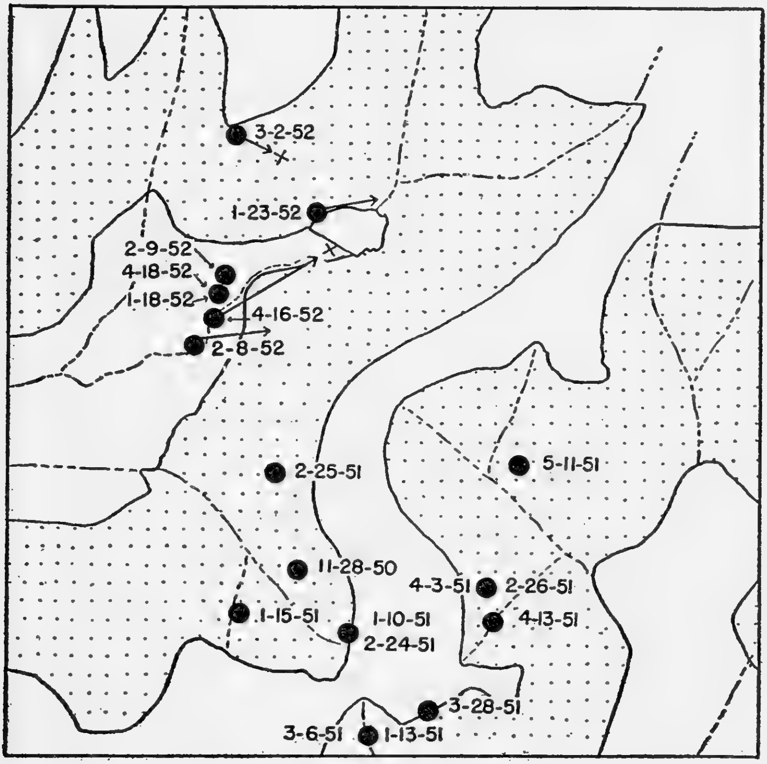

FIGURE 2. Half-mile-square area on Reservation, showing dates and successive sites of capture for two subadult male opossums; one opossum on upper half of map and other opossum on lower half. Arrows from circles show courses taken by released opossums that were followed to dens. (crosses).

the aid of a powerful flashlight as the investigator moved about on foot. They did not permit close approach, and escaped by running. One hid in a blackberry thicket. Several that were chased climbed trees when hard pressed. One that was overtaken, and others that were shaken out of trees and caught, showed fight, standing on the defensive, and slashing at the pursuer with a rapidity and vigor never encountered in those removed from traps in the daytime.

Nocturnal tendencies of the opossum were emphasized by the infrequency with which undisturbed individuals were seen in the daytime. In more than a thousand days of field work on the Reservation, opossums were found out on only four occasions. These occasional daytime forays seem to occur almost always in animals driven by hunger on winter days, when the temperature has suddenly risen

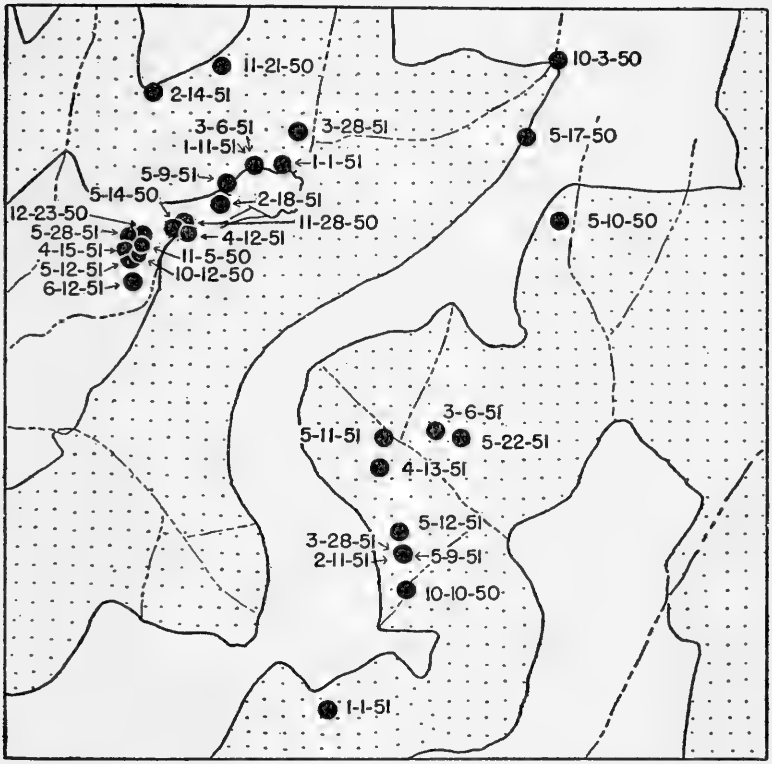

FIGURE 3. Half-mile-square area on Reservation, showing dates and successive sites of capture of an old adult male in upper half of map and an adult female in lower half.

after periods of severely cold weather that have imposed inactivity and fasting.

MOVEMENTS

Earlier field studies of the opossum have produced somewhat conflicting evidence and conclusions regarding the extent and manner of the opossum's travels. Lay (1942:158) live-trapped and marked 117 opossums on an 86-acre study area in eastern Texas over a two-year period and caught 29 of them at three or more different trapping stations. He found that "The average minimum area between the stations in these 29 home ranges was 11.5 acres. The mean of the greatest distances traveled between stations was 1460 feet, which would form a theoretical circle of 38.4 acres. . . . Separate individual territories are not important to opossums as home ranges overlapped in every instance." Reynolds, in central Missouri, concluded that: "The subsequent recovery of only 5 of 68 released animals, the reported capture of one individual 7 miles from the point of release nine months later, and the rapid repopulation of an area devoid of opossums at the close of the hunting season indicate that most opossums are nomadic." In southeastern Iowa, Wisemann and Hendrickson (1950:336) found that: "Recaptures, in 1942, of three opossums tagged in 1941 indicated a yearly mobility of one-fourth mile; four tagged in 1942 were recaptured within one-half mile from sites of tagging."

Opossums, like other animals, obviously make various types of movements. Ordinarily one tends to keep within a relatively small area that is familiar to it and that satisfies all its ecological requirements. This constitutes its home range. Many other animals, including various mammals, are characterized by territoriality; individuals, pairs or groups occupy definite areas, defended as territories, to the exclusion of other members of their species. Like Lay (*loc. cit.*) we found no evidence of territoriality in the opossum. In general, opossums are unsocial but not intolerant in their behavior. In the present study numerous individuals of both sexes and various sizes and ages were found to be occupying the same area simultaneously, with overlapping but no exact correspondence in home ranges. Occasionaly two or more opossums may use the same den, but each goes its own way on its foraging and it seems that no sociability is involved.

On many occasions opossums were tracked in soft snow or mud which retained footprints. Under conditions prevailing locally, it was difficult to follow such a trail for any great distance but trailing did divulge information concerning the type of route followed and the method of foraging. Opossums were found to have little inclination to follow beaten trails, either their own or those of other animals. A foraging opossum moved about in an extremely circuitous and erratic route, seldom taking more than a few steps without a change of direction, and frequently crossing its own course in a series of loops, some only a few feet or a few inches in diameter. In moving about, it is guided partly by the tactile and olfactory stimuli of objects on or beneath the ground surface which are potential food sources. Foraging consists of a succession of tests of such objects, as the animal moves from one to another. Opossums may habitually follow intermittent creeks or gullies or even roads when

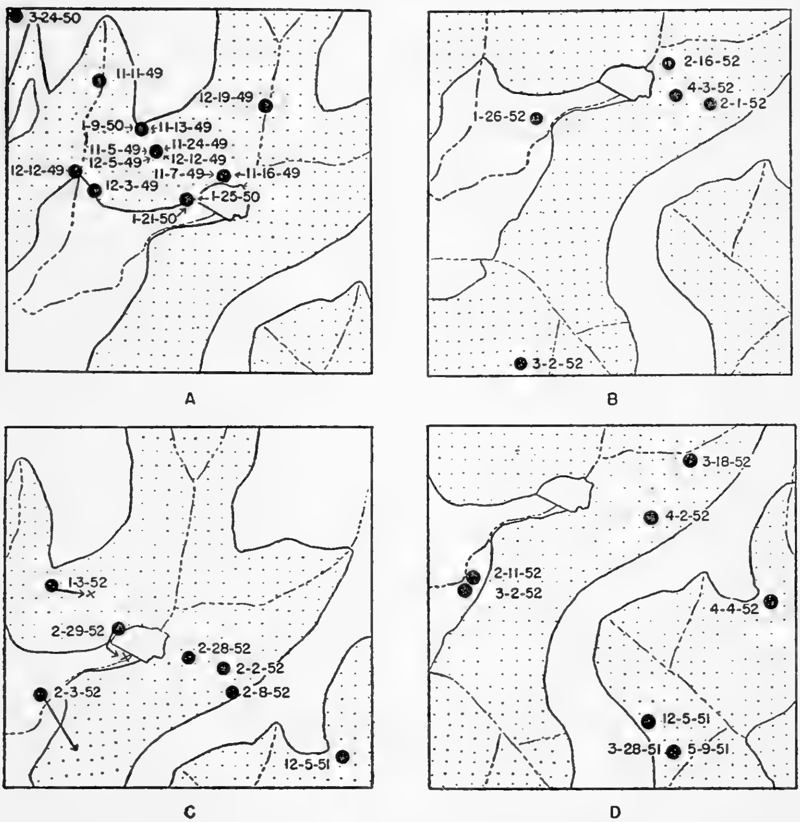

FIGURE 4. Quarter-mile-square areas on Reservation showing dates and successive sites of capture of individual opossums; (A) subadult male; (B) subadult male; (C) subadult male; (D) adult female. Arrows from circles show courses that were taken by released opossums that were followed; crosses show location of dens to which they were traced.

these provide better foraging than does the adjoining habitat. Metamorphosing amphibians may provide such a food source along a creek and the supply of crushed insects or other small animals along a road attracts the opossum. Food is found by turning chips and leaves, and by poking and probing in chinks and crevices with its snout and paws. On a few occasions short, well worn trails made by opossums were found, from dens to near-by feeding areas where grape tangles provided an abundant and readily available food source over periods of weeks. More often, an opossum follows no trail in its search for food, but seems to wander at random within its home range.

Evidence of the existence and extent of home range was obtained for those opossums that were trapped on several or many occasions. Records of each were usually well scattered over an area hundreds of feet in diameter. Limits of home ranges are not sharply defined and at any time the opossum may extend its range into new areas. It may shift to a new den from which areas beyond its original home range are readily accessible, and may then occupy a new home range overlapping part of the old one. Or, it may make a relatively long shift, to an area entirely distinct from the original home range and well separated from it. That such shifts are frequent was indicated by the brief span of records for most of the opossums live-trapped on the Reservation. After the first capture and marking an individual was often caught consistently over periods of weeks, only to drop out suddenly either having been eliminated or having moved elsewhere. Of the 111 opossums marked and released, 62 were caught only once and 25 others were recaptured only within a period of one or two months. Relatively few, only 24 (14 males and 10 females), had records extending over more than two months. Many of the opossums trapped were probably at or near the edges of their home ranges which barely overlapped the study area; consequently the chances of recapturing them were poor. Those caught well within the trapping area were much more likely to be recaptured.

Tracking of opossums suggested that having once left the home den, an animal ordinarily did not return until it had finished its nightly foraging, and wandered more or less at random over its home range. Successive capture sites for any one opossum might be near together or far apart with respect to its over-all range, but on the average, they would be separated by approximately half the breadth of the home range assuming the animal's activity to be evenly distributed over the whole area. Each of twenty-two opossums was caught at only two different trapping stations. For this group, the average distance between stations was 761 feet (657 feet for seven males and 810 feet for 15 females) indicating home ranges of approximately 42 acres in extent. Each of ten opossums was caught at three different stations; for these the distances between the first and second stations, between the first and third and between the second and third comprise three distinct movement records, and the average of all three probably affords a more reliable figure for the radius of the home range than does the single movement available for each of the 22 animals captured at only two stations. For these average individual movements the mean of this whole group of 10 was 841.5 feet. Each of five opossums was taken at 4 different trapping stations, and for each of these a record of six different movements was available. The average was 1016 feet. For the 37 opossums caught at two, three or four different trapping stations, the mean distance was 817 feet; this is an indication of home ranges of approximately 48 acres in extent. Each of thirteen opossums was caught at five or more trapping stations. The distribution of these stations affords a crude idea of the extent and position of each animal's home range, but ordinarily it might be expected that the area included between capture sites would be less than the animal's actual home range, because relatively few of the sites of capture would be on the margin of the home range. For this group, maximum distances between trapping stations averaged 1954 feet suggesting a home range of nearly 70 acres, larger than that computed for the opossums caught at only two, three, or four stations. However, for those caught at five or more stations, the time involved averaged longer and probably some had altered their ranges to invade new areas. Ranges may have been broadly oval rather than circular so that the maximum diameter measured between stations exceeded somewhat the average range diameter for each animal.

The opossums having home ranges entirely within the study area were those most likely to be caught repeatedly and at different locations, while those with ranges centering near the edge of the area, or outside of it tended to be caught at fewer locations and less frequently. For those animals with ranges partly outside the study area, the captures recorded would represent only one sector of the home range and would tend to be near together, so that many of the radii computed for individual home ranges are too small. Each average figure for home range is perhaps erroneously low for this reason. The error tends to be greatest for those taken at only two locations, and least for those trapped at the greatest number of different locations.

Approximate size of the usual home range is apparent from the several figures although various unknown or unmeasurable factors distort the data. The usual home range of the opossum in the area of the study is in the neighborhood of 50 acres or a little less. With the data available no significant differences in sizes of home ranges are discernible between males and females nor between adults and young of the year. Shifts occur frequently, contributing to population turnover, which may result in almost complete replacement of individuals in the course of a year's time, on an area of less than a square mile.

DISPERSAL OF YOUNG

One hundred and fifteen small young of 14 different litters were marked while still attached to the mother's teats in the pouches. A fairly high rate of mortality probably is normal in the small dependent young and further mortality probably resulted from the deleterious effects of examining and handling them and the females that carried them. At any rate, 47 of 208 young recorded, were missing at subsequent recaptures of the females, before the young were old enough to become independent. It is almost certain that the actual losses were much higher, because the records for each female cover only part of the period during which young are carried in the pouch.

Fifteen of these marked young of seven different litters were recaptured after periods of months, when they were well grown or adult and the locations of these recaptures afford information concerning the animals' dispersal. Their records are summarized below. Opossums that wandered much more than half a mile or at most three-fourths of a mile from the place of original capture were unlikely to be recaptured, and some originally recorded at sites near the edge of the study area might have moved beyond its boundary with much shorter shifts.

Sex	Date of capture and marking as pouch young	Date of recapture	Distance in feet
Female	April 14, 1951	September 22, 1951	1870
Female	May 6, 1950	February 28, 1952	1800
Female	May 14, 1950	December 31, 1950	1750
Female	March 28, 1951	January 23, 1952	1700
Female	May 11, 1951	November 9, 1951	1700
Female	May 11, 1951	March 2, 1952	1450
Female	April 2, 1950	October 7, 1950	1160
Female	April 14, 1951	May 19, 1952	1100
Male	May 11, 1951	February 3, 1952	800
Female	May 11, 1951	January 9, 1952	700
Female	April 2, 1950	October 3, 1950	700
Female	May 6, 1950	April 3, 1951	650
Female	March 28, 1951	February 2, 1952	500
Male	April 18, 1952	July 6, 1952	120
Female	April 2, 1950	April 14, 1951	10

Most of these opossums were recaptured within a year of the time they were marked as small young in the females' pouches, and on the average they had moved a little less than 400 yards. While the sex ratio was equal in the pouch young that were marked, it is noteworthy that all but two of the recaptured opossums were females; and of the two males, one was recaptured early, before it could have had time to wander far. The young males, after becoming independent must tend to wander much more widely, and to settle in new areas far removed from the mother's home range. It is unlikely that this dispersal of the young males is motivated either by rivalry and intolerance of larger males or by sexual drive. The dispersal occurs in late summer when there is no breeding activity, and when food is present in greatest abundance and variety.

FEEDING HABITS

The feeding habits of the opossum in Douglas County, northeastern Kansas, have been discussed by Sandidge (1953). His data were obtained from stomach analysis of specimens caught in steel traps. In the present study no stomachs were available for analysis as the opossums on the Reservation were not sacrificed for this purpose and effort was made to avoid mortality in those that were live-trapped. Information concerning their feeding habits was obtained mainly by examination of scats in the field. On this 590-acre tract maintained as a Natural Area with human disturbance kept to a minimum, the available food sources differed somewhat from those of other woodland areas and especially from those of cultivated or suburban areas as reported upon by Sandidge.

The feces or "scats" of the opossum are not liable to be confused with those of other mammals except possibly with those of the striped skunk or raccoon, both relatively uncommon on the Reservation. Favorite sites for deposition of opossum scats were at the bases of large trees, usually honey locusts or elms, near the animal's den. Accumulations of several dozen scats may collect in such situations. Often the opossums live-trapped were found to have deposited scats and many of these were saved for examination, although they were usually trampled, broken and mixed with earth and hair. Few scats were seen in the field throughout the summer. Their disintegration is rapid at that time of year because of the high temperature, frequent heavy rains, and abundance of dung-feeding insects. Scats were seen in greatest abundance in the fall, partly because the opossum population was then at its annual high point. During fall, wild fruits made up the greater part of the diet and were represented in almost every scat that was seen. Wild grape (*Vitis vulpina*) is an abundant woodland vine on the area and often forms dense tangles both in deep woods and in edge situations. Grape was the most abundant single item, and a large number of scats consisted exclusively of grape seeds and skins. In November and December opossums could be trapped most effectively by making sets in or near grapevine tangles where the animals were attracted by the abundant ripe fruits. The crops of wild grapes were especially heavy in 1948 (before live-trapping was begun) and in 1949, and scats containing them were noticed in those years especially. Opossums, too, were more numerous on the Reservation in 1948 and 1949 than they were in 1950, 1951, and 1952.

Hackberry fruit (*Celtis occidentalis*) was second to grape in importance and large numbers of scats were found to be composed mainly or entirely of the skins and seeds of this fruit. In the fall of 1951, these fruits were especially important and were the principal food source.

Wild plum (*Prunus americanus*) and wild crabapple (*Pyrus ioensis*) also are important in fall and winter and are present in many scats. In summer, blackberry, abundant on some parts of the Reservation, is an important food. Other wild fruits noticed in scats include those of cherry (*Prunus virginiana*) and climbing bittersweet (*Celastrus scandens*), and mast (acorn ?). In the fall of 1948, corn made up a large part of the contents of scats noticed. Crops of corn were grown on two fields of the Reservation in that year. In following years, corn was noticed less frequently in scats but still continued to be one of the important food items. Several cornfields adjoined the Reservation, and the scats containing the grain were observed mainly along the borders of these fields.

The crayfish is evidently the most important animal food, at least during the cooler half of the year when scats are seen in greatest numbers. Remains of crayfish were far more conspicuous than those of other invertebrates, and often made up the greater part of the scat. The sample of scats examined in the field, as noted below, are thought to be representative of the much larger number noticed but not examined in detail.

August 19, 1951, 16 scats. Food items in their approximate order of importance were: blackberry in six (100% in 5, 95% in 1); grape in five (100% in 2, 97% in 1, 95% in 1, 50% in 1); crayfish in three (100% in 1, 60% in 1, 40% in 1); wild plum in two (85% in 1, 5% in 1); wild crabapple in two (100% in both); insects in three (scarabaeid beetle 10% in 1, cicada 2% in 1, unidentified insect fragments in 5); fox squirrel in one (15%); unidentified plant fibers in one (40%).

September, 1951, 16 scats. Grape in seven (all or most of 5 scats and small percentages of 2 others); cherry in seven (all or most of 5 scats and small percentages of 2 others); crayfish in seven (all or most of 5 and small percentages of 2 others); rabbit in two, making up most of both; insects (grasshopper, and large black beetle) in two making up small percentages.

October, 1951, 8 scats. Hackberry in three, making up nearly all of them; grape in two (all of 1 and most of the other); wild plum in one (100%); mast (acorn?) in one, making up 100%; crayfish in one making up about half; fox squirrel in one making up the remainder of the scat containing crayfish; rabbit in one making up a small percentage.

November, 1951, 12 scats. Hackberry in five, making up all or most of four and a small part of the fifth; grape in five, making up all or most of four and a small part of the fifth; wild crabapple in three, making up all of two and most of the third; and cottontail in one, making up all of it.

January, 1952, 3 scats. Hackberry in all, making up all of two and most of the third; copperhead (scales of medium-sized adult) making up a fraction of the third scat. Pile of more than a dozen scats not individually separable, nearly all consisted mainly or entirely of hackberry fruits estimated at 2000; other contents chiefly crabapple and corn.

September, 1952, 8 scats. Grape in all, making up all of six and 90% of the seventh, and about 20% of the eighth; wild plum seeds in one making up 40%; blue feathers, evidently of a jay, in one, making up a trace; carabid beetles in one making up a trace.

October, 1952, about 14 scats, two separate (both consisting exclusively of grape) and the remainder mixed in two approximately equal piles, one pile consisting of grape, except for small quantity of fine fur; second pile consisting mainly of grape (about 90%) with small percentages of yellowjackets (*Vespula*, about 6 individuals, all in one scat), toe bones and fur of cottontail rabbit; a few scales of immature copperhead; and a snail.

November, 1952, 2 scats. Grape in both, making up all of one and about 90% of the other.

Sandidge (*loc. cit.*) found remains of cottontail rabbit in some of the stomachs he examined, but followed Reynolds (1945) in regarding these as carrion since the opossum was considered to be too inefficient a predator to catch and kill cottontails—prey approximating its own size and much superior in speed. Adult cottontails seem to be secure from opossum predation under ordinary circumstances. However, the opossum obtains some of its food by raiding the nests of small animals, including those of rabbits. At the Reservation, on May 21, 1951, at 9:00 P. M., distressed squealing of a rabbit was heard in high brome grass. Investigation revealed that a large male opossum had killed a young cottontail, weighing approximately 150 grams, and had started to eat it. This young rabbit, about the minimum size of young wandering outside the nest, evidently was pounced upon as it hid beneath the high grass.

Live-traps for mice, in lines or grids of 100 or more, often were set on the Reservation, and predators, including opossums, disturbed them on many occasions. Attacks sometimes resulted in release and escape of the trapped animal, and in other instances resulted in its being caught and eaten. In many instances identity of the predator could not be determined, but it is believed that such attacks by the opossum were relatively infrequent and inefficient. Steel traps set beside the mouse traps after consistent raids, to catch or discourage the predator, caught opossums on several occasions. These opossums usually had overturned mouse traps without opening them and when the trapped mouse was missing from the trap no evidence of its having been eaten was obtained. On other occasions raccoons were caught in the steel traps, and their raids were characterized by systematic and dextrous opening of the mouse traps and, frequently, by predation on the small mammals inside them.

Wire funnel traps set for reptiles along rock ledges also were often disturbed by predators, mainly skunks and opossums, both of which were caught on several occasions, when steel traps were used as a protective measure. The opossums often were attracted to the funnel traps by large insects such as camel crickets, grasshoppers and beetles, but also by trapped lizards including the skinks (*Eumeces fasciatus* and *E. obsoletus*) and the racerunner (*Cnemidophorus sexlineatus*). Both Sandidge (1953) and Reynolds (1945) recorded the five-lined skink (*E. fasciatus*) in opossum stomachs. On the Reservation this common lizard probably is one of the most frequent items of vertebrate prey of the opossum. Flat rocks a few inches in diameter frequently have been found flipped over; larger flat rocks and those solidly anchored in the ground often have been found partly undermined by opossums scratching away the loose dirt at their edges. Flat rocks similar to those found disturbed by opossums are the favorite resting places of the skinks, which, in cold or wet weather, are sluggish when beneath such shelters; this is especially true of female skinks that are nesting. The shape and size of some of the excavations suggested predation on skink nests. Other possible food sources in the same situation, in loose soil beneath flat rocks, include narrow-mouthed toads, lycosid spiders, beetles (mainly carabids such as *Pasimachus* and *Brachinus*) and occasionally, snails, centipedes and millipedes.

A pond, a little more than an acre in size, was a focal area for opossums and more were caught there than on any other part of the Reservation. Opossums that were trapped and marked on other parts of the Reservation were likely to be caught here sooner or later. Tracks in the mud showed that the edge was patrolled almost nightly by one or more opossums and this activity was especially noticeable when the pond was drying. Frogs were obviously the chief attraction inducing the opossums to forage there.

Of the 8 kinds of frogs and toads breeding at the pond, the bullfrog (*Rana catesbeiana*), leopard frog (*Rana pipiens*) and cricket frog (*Acris gryllus*) were most abundant, throughout the season and especially when drying occurred. All three probably are important foods of the opossum locally.

WEIGHTS

Opossums were weighed in the field, with small spring scales of 2000-gram capacity, graduated in 25-gram intervals. Weights recorded were accurate within a margin of about 10 grams. After other data were recorded, the opossum was offered the hook at the base of the scale, and usually bit and held fast. Then it could be suspended off the ground and a reading taken.

When the same opossum was trapped two or more times within a few days, weight was usually found to fluctuate sometimes more than 200 grams, or more than 10 per cent of the animal's body weight. Opossums recaptured soon after their original capture and toe-clipping were generally found to have lost weight, reflecting the deleterious effect of marking by this method. The temporary laming of the animals prevented them from traveling as far or as fast as they normally would have; consequently they probably obtained correspondingly less food. They were also handicapped in digging, grasping and climbing. Nineteen such animals taken within a month of the original capture and marking, averaged 94 per cent of their original weights. The minimum was 82 per cent. Only 2 of the 19 had gained.

The stumps of amputated toes did not heal rapidly in opossums —contrary to experiences with many other kinds of mammals, reptiles, and amphibians also marked by toe-clipping. For many weeks the toes remained unhealed, sore and swollen. In several instances after periods of months the clipped toe stumps were unhealed. This was observed even in some of the opossums that were marked as pouch young and recaptured when grown to nearly adult size.

Some adult opossums trapped were heavier than the 2000-gram capacity of the spring scale usually used in the field, and no definite weights were recorded for most of these animals. Some of them that were caught near the laboratory were brought there for weighing.

Even within the same age- and sex-group at any one time, opossums varied widely in general condition and in weight. Some were emaciated and sickly in appearance with sparse, ragged pelage, while others were in excellent condition, fat and with thick, glossy pelage. Seasonal trends are partly obscured by these differences in individuals, by the tendency to lose weight in those recently marked, and by the irregular fluctuations that occur in each animal.

The few opossums caught in summer were thin and appeared to be suffering from infestations of ectoparasites, especially chiggers (*Eutrombicula alfreddugesi*) and ticks (*Dermacentor variabilis*). Those trapped in October and November were mostly fat and in good condition. For individuals caught at different seasons, maximum weights were generally recorded in these two months. The maximum weight record of the study was one of an adult male weighing 5000 grams on December 23, 1950. The weight records of this individual were more complete than most and are recorded below to illustrate seasonal trends for adults. May 10, 1950, 1925 grams; May 14, 1830 grams; May 17, 1940 grams; November 5, 4540 grams; November 28, 4540 grams; December 23, 5000 grams; February 18, 1951, 3300 grams; March 6, 3080 grams; March 28, 3080 grams; May 28, 3080 grams; June 18, 2620 grams.

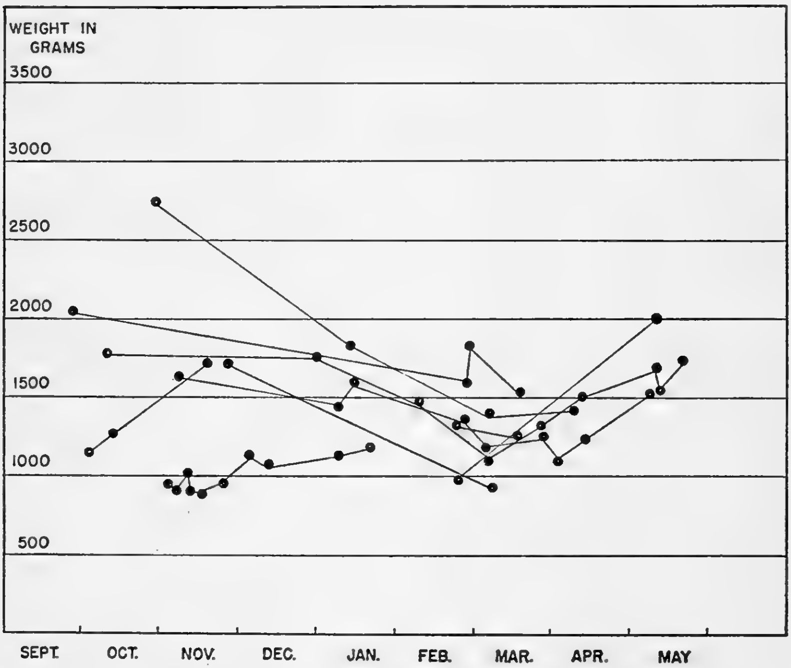

FIGURE 5. Weight changes in opossums live-trapped; lines connect successive weight records of the same individual, showing, in most, a downward trend throughout the winter and early spring, and an upward trend in late spring.

Of opossums that were trapped alive, the weight ranged from the maximum of 5000 grams to a minimum of 126 grams. The maximum in males was higher than in females. In fall, three rather poorly defined age-size groups were discernible in each sex: adults more than a year old and including all the largest individuals; large young born late the preceding winter and approaching small adult size; smaller young born in early summer and still less than half-grown. After November, young cease to gain, or gain slowly and irregularly through the winter and spring and adults tend to decline in weight, as food becomes scarce and frequent fasting is enforced by cold or stormy weather. The smaller young probably are subject to drastic reduction in numbers as a result, directly or indirectly, of severe winter weather. Many of these smaller young, weighing considerably less than 1000 grams, did not survive overnight when caught in live-traps in cool autumn weather, whereas adults and well-grown young generally survived exposure even for several successive nights in various extremes of weather conditions.

BREEDING SEASON

Hartman (1928:154) stated that there were at least two litters of young per year in the southern states with a small percentage of unusually fecund females producing a third litter. Lay, in eastern Texas, concluded (1942:155) that "The present investigation substantiates Hartman's deduction of two litters being normal, but fails to disclose any evidence of a third litter." He found females carrying young in the pouch only within the seven-months period January to July with definite peaks in February and June, and stated that second litters appear in the pouch from early April to as late as May 20 to 23. Reynolds (1945:362) found that the breeding season in central Missouri in 1941 and 1942 began about the first of February, with known or calculated birth dates of 42 litters rather evenly distributed throughout the periods February 12 to April 2, and May 16 to June 4. Eight of these females had given birth to young between March 16 and April 2, approximately six to nine weeks after the beginning of the breeding season. Reynolds assumed that these were individuals that had failed to find mates during the first oestrus of the season and that after completing the regular dioestrus of about 28 days they had then mated and borne young. Wiseman and Hendrickson (1950:333) in southeastern Iowa recorded a female with a litter no more than two days old on February 23, and several other females with young were estimated to have borne litters at approximately this same date, while still others bore litters as late as early March. Two lots of small young found in early June may have been second litters.

For the region represented by the present study, the data indicate a breeding season with later onset and sharply circumscribed limits as compared with an earlier onset and less circumscribed limits in Texas, central Missouri, and even southeastern Iowa, which is a little farther north. The available data indicate that there are two distinct and well-defined breeding seasons in the course of the annual cycle on the University of Kansas Natural History area. The whole population, including young of the preceding year, some still far below average adult size, breeds from about the middle of February into early March, and first litters are born mainly in early March. Individual females may vary as much as two to three weeks in the time of breeding, and varying weather conditions from year to year may hasten or delay onset of the breeding season. Data are recorded below for all females caught in March that were carrying litters.

Date	Weight of female in grams	Number of young	Development of young
March 1, 1952	2000	9	Newborn
March 2, 1952	1450	6	Newborn
March 2, 1952	1230	7	Newborn
March 5, 1950	1200	10	About 16 mm. snout to vent
March 5, 1950	1300	1	About 14 mm. snout to vent
March 6, 1951	1110	4	Newborn
March 18, 1952	1930	8	Not present when female was trapped on March 1
March 18, 1952	1520	6	
March 18, 1952	1230	12	About 40 mm. snout to vent
March 19, 1951	1000	8	Estimated 1 week old
March 22, 1950	1040	9	About 34 mm. snout to vent
March 24, 1950	1280	10	74 mm. snout to vent
March 24, 1950	1480	8	
March 27, 1950	965	8	Total length 26 mm., weight .8 g.
March 28, 1951	820	7	20 mm. crown to rump; born since previous capture of female on March 7
March 30, 1950	1325	9	Total length 33 mm.
March 31, 1952	1930	8	
March 31, 1952	1630	5	Total length 73 mm.

None of the females trapped in February was carrying young in the pouch, but probably some early litters are born in the last week of February or even earlier. By late March most of the females are carrying young in their pouches, and those which do not have young, have their pouches enlarged and vascularized for accommodation of the young. Presumably such females have already borne young and then lost them. Nearly all the litters seen in the latter half of March had young that were much larger than at birth.

Of 13 females examined in April, 12 were carrying young, and the remaining one was known to have been carrying a single young on March 1, but had lost it. Eleven females were examined in May, four of which were the same ones examined in April. Eight of the eleven females were carrying young; of the remaining three, one had lost the litter of young that it had been carrying when trapped in April. Two had empty pouches on May 19 and 20, but probably had successfully reared the litters of young which they had been carrying when trapped in April. The young of all those females trapped on different dates in April and May were in stages of growth indicative of birth about the first week in March. The latest date on which a female was recorded with first-litter young in the pouch was May 22, 1951, and these were the largest pouch young observed. Their eyes were recently opened, they were estimated to weigh 60 grams each with hind feet 20 mm. long. Young continue to grow rapidly after leaving the female's pouch. A young female caught on June 16, 1949, weighed 126 grams. For seven young caught on July 5 and 6, 1952, weights and hind-foot measurements were, for males: 660 grams, 52 mm.; 560 grams, 46 mm.; 550 grams, 48 mm.; 450 grams, 44 mm.; 370 grams, 44 mm.; 330 grams, 37 mm.; and for the one female: 430 grams, 46 mm.

The wide variation in size in this small group of young of nearly the same age is noteworthy. Size and condition of the females carrying them, number of competing litter mates, and early success or handicap in independent life causes so much divergence in size that at the age of four months some young are twice as large as others.

By late fall the young grow to small-adult size. For example, the female that weighed 126 grams when first caught on June 16, 1949, was recaptured on November 29, 1949, and on that date weighed 1710 grams.

A second breeding season ensues soon after the young of the first litter leave the pouch, and these young probably soon learn to shift for themselves. Second litters are usually born in early June. On June 14, 1952, a female was taken with young only a few days old in her pouch. On July 5, 1952, two females last taken on May 19 and May 20, with their pouches recently vacated by first litters, were found to have young the size of half-grown mice, evidently two to three weeks old. In the months of October, November, December and January, a total of 11 young, thought to represent second litters, were taken. Dates of capture, weights in grams and sexes were as follows:

Oct. 3, 1950	400 grams	male
Oct. 6, 1950	510 grams	female
Oct. 8, 1950	260 grams	female
Oct. 8, 1950	350 grams	female
Oct. 18, 1950	350 grams*	female
Dec. 5, 1951	630 grams	female
Dec. 30, 1950	710 grams	female
Jan. 1, 1951	660 grams	female
Jan. 1, 1950	700 grams*	male
Jan. 9, 1950	550 grams	male
Jan. 11, 1950	550 grams	male

* estimated

The hind foot measured 48 mm. and 51 mm., respectively, in the young weighing 630 grams and 660 grams. These young, born in early summer have grown, by October, to a size comparable with that attained in July by young of the early spring litters. The variation in size is also similar but with a little wider range. The summer breeding season may be somewhat more protracted than the breeding season in early spring.

Too few females were caught in summer to compare the summer breeding season with the early spring breeding season, with respect to size of litters, percentage of non-breeders, and other factors which might affect the size of the crop of young produced. It is not clear why, among opossums trapped in winter, the young born in early spring outnumber those born in early summer by about four to one. Some females are eliminated after rearing the first litter, and others, exhausted by rearing large first litters may fail to participate in the second breeding season. However, it seems that the young of the summer litters must be subject to other unusual and selective mortality factors which eliminate most of them by fall. That such factors vary from year to year is indicated by the changing ratio of summer-born young to other opossums in each of the three winter seasons when trapping was carried on.

NUMBERS OF YOUNG

Hartman (1952) has summarized his own findings and those of other authors regarding the embryology, birth, and early development of the opossum, and has corrected numerous popular misconceptions. He states that an average litter consists of about 21 eggs, but mentions much larger litters of up to as many as 56. However, many of these may fail to develop. The female normally has 13 functional nipples in her pouch and each one accommodates a single young. Excess young beyond this number are doomed, and soon perish from starvation if they reach the pouch after all the nipples are occupied. None of the females examined in the present study had a full complement of 13 young. Under unfavorable conditions, most or all of the young may fail to make the trip from the vaginal orifice to the pouch. Also, the pouch young are subject to heavy mortality, but observations concerning the time and cause of mortality are lacking.

Lay (*loc. cit.*) found an average of 6.8 pouch young in 65 litters examined in eastern Texas; Reynolds found an average of 8.9 (5 to 13) in 42 litters from Boone County, central Missouri; Wiseman and Hendrickson found an average of 9 (6 to 12) in southeastern Iowa. In the present study, 28 of the female opossums examined were carrying litters in their pouches, and all these females were caught in the months of March, April, May, June and July. The number of young varied from one to 12. Seven females each had seven young, six each had eight, three had six, three had five, and there were two each with nine, 10, and 12 young, and one each with one, four and 11 young. The average was 7.4 per litter. On several occasions females captured with young in their pouches and recaptured one or more times within a few weeks, were found to have lost some or all of the young. Some of the females examined probably had already lost parts of their litters. For instance, the female recorded with just one small young on March 1, probably had lost most of her litter and when recaptured a month later she did not have any young.

Nineteen yearling opossums were taken in the fall-winter-spring season of 1951-52; 42 per cent of the total, and 67 per cent of the females were individuals marked as pouch young the preceding spring. In the course of live-trapping, that spring, some first litters may have been missed. No second litters were marked because trapping was not continued into June and July when second litters are being carried by females. These figures suggest that the breeding population of females on an area consists chiefly of those born there the preceding spring.

COMPOSITION OF THE POPULATION

Sex ratio of opossums trapped was approximately 1:1; 59 males to 58 females. Age groups for opossums caught in the three seasons are shown in the following tabular fashion. For a few individuals age status was doubtful.

	1949-1950	1950-1951	1951-1952	Total
Old adults	11(25%)	9(26.4%)	11(39.2%)	31(29.2%)
Yearlings:				
Born in late winter	29(66%)	18(53.0%)	13(46.5%)	60(56.6%)
Born in late spring	4(9.1%)	7(20.6%)	4(14.3%)	15(14.2%)
Total	44	34	28	106

In the 1950-51 season, small young of the summer brood seemed unusually numerous. In the 1951-52 period, young of both age classes were relatively scarce and old adults made up an unusually high proportion of the population. Excluding the 14 marked pouch young that were later recaptured, there were only four of the total of 106 that were trapped in each of two seasons. One young less than a quarter grown, that was accidentally caught in a live-trap set for woodrats, was recaptured as a breeding adult the following winter. An adult male and two adult females each caught in the 1949-50 season were each recaptured repeatedly in the 1950-51 season. Ninety-five per cent replacement of the breeding population by the following breeding season is indicated by our figures. Only 3 (or 5 per cent) of the individuals of the population trapped and marked in the season of 1949-50, were recaptured among the 62 opossums recorded in the two subsequent seasons. Various mortality factors including predation, disease, and accidents account for some 70 per cent. These are replaced by first-year young which make up the greater part of the breeding population. The remaining 25 per cent presumably shift their ranges sufficiently in the course of a year to have moved beyond the limits of an area of the size encompassed by the present study.

POPULATION DENSITY

No precise measurement of the population density on the study area was obtained. It was not practical to capture every individual present there, and rapid population turnover, due to mortality and wandering, obscured the trends. The information obtained concerning movements of opossums suggest that one may habitually forage as much as 900 feet from its home base. Assuming that 900 feet is the typical cruising radius, the areas drawn upon by the trap lines in the three different seasons were approximately as follows: 1949-50—400 acres; 1950-51—350 acres; 1951-52—220 acres. In these same three seasons the numbers of opossums caught were, respectively, 46, 37, and 30. If these figures represent the numbers actually present, densities of one to 8.7 acres, one to 9.5 acres, and one to 7.3 acres are indicated. However, some opossums using the area probably were missed; and on the other hand, not all those caught in the course of a season were present there simultaneously. Many of those present early in the season would have moved away a few months later, and others would have moved in, replacing them. The number present at any one time could scarcely have been more than half the number caught in the entire season.

CENSUS WITH HALF-MONTHLY SAMPLING PERIODS

Sampling period	Number of individuals taken in period	Number of individuals taken in following period	Number of recaptures in following period	Computed population for sampling period
Early November 1949	3	7	1	21
Late November 1949	7	8	3	18.7
Early December 1949	8	11	3	29.3
Late December 1949	11	7	4	19.2
Early January 1950	7	3	1	21
Early March 1950	5	8	2	20
Late March 1950	8	6	3	16
Early April 1950	6	3	1	18
Late April 1950	3	6	2	9
Early May 1950	6	3	2	9
Early November 1950	1	3	1	3
Late December 1950	3	6	1	18
Early February 1951	4	13	3	17.3
Late February 1951	13	6	3	26
Early March 1951	6	4	3	8
Late March 1951	4	5	2	10
Early April 1951	5	1	1	5
Late April 1951	1	5	1	5
Early May 1951	5	3	2	7.5
Early February 1952	9	4	2	18
Late February 1952	4	9	1	36
Early March 1952	9	6	2	27
Late March 1952	6	5	2	15

CENSUS WITH MONTHLY SAMPLING PERIODS

Sampling period	Number of individuals taken in period	Number of individuals taken in following period	Number of recaptures in following period	Computed population for sampling period
November 1949	9	16	7	21
December 1949	16	9	3	48
March 1950	11	9	3	33
April 1950	9	7	2	32
October 1950	9	3	3	9
November 1950	3	3	1	9
December 1950	3	7	3	7
January 1951	7	14	3	33
February 1951	14	7	4	25
March 1951	7	5	3	12
April 1951	5	6	3	10
November 1951	3	6	1	18
December 1951	6	5	1	30
January 1952	5	11	3	18
February 1952	11	13	4	36
March 1952	13	9	5	23
April 1952	9	3	1	27

Crude census-figures were obtained by utilizing the Lincoln Index and computing the total on the basis of the ratio of marked (and recognizable) individuals to others caught in a sampling period. A large number of census figures were obtained over the three-year period of the study. Each separate census, however, was based on an inadequate sample as the number of marked individuals taken at each sampling, as recaptures from the previous sampling period, varied from one to five. While little confidence can be placed in any one census computation, the trends of figures from series of such computations reveal the approximate number of opossums on the area if due allowance is made for certain distorting factors. Presumably the differences in figures obtained at different samplings result chiefly from the margin of error in the data, although it is true that there is rapid change in the actual number of opossums.

The number of active opossums in the region of the study reaches a peak in late summer and early fall, when second litters of young have grown large enough to become independent. At this season the population contains a high proportion of young of the year. During the ensuing months of fall and winter there is a steady decrease in numbers, through various mortality factors, with no replacement until young are born about the first week of March. These young do not become independent until late May or early June, and during the intervening months there is a further reduction of the adults and yearlings, so that the active population reaches its annual low point in late spring. At that time of year most opossums are in poor physical condition.

The area represented by the opossums trapped totaled more than 500 acres, but not more than 400 acres were within the area drawn upon by the trap line at any one time. Usually the area represented at any one time by the trap line was less—100 to 350 acres, with from 25 to 45 traps. Traps were moved from time to time depending on the distribution of opossum sign and food sources, the weather, and the time available for this study. As a result, successive samples are not strictly comparable and a major source of error is introduced into the census computations. Lack of exact correspondence in the area represented by successive samples would result in a disproportionally small number of recaptures, and an erroneously high census computation. While adequate adjustment cannot be made, examination of the data suggests that census figures are too high, by as much as 50 per cent in many instances as a result of this factor, while in some other instances when there was little or no alteration of a trap line from one period to another, the census figure was not affected. In the winter of 1949-50, the area covered was most extensive, from 350 to 400 acres, and the numbers of opossums taken were correspondingly larger. In the 1950-51 season the area involved was approximately 220 acres, and in the 1951-52 season it was a little less than 200 acres. In view of the census figures obtained and the probable errors, it appears that the opossum population in early autumn is about one to 20 acres, and that by late spring it is reduced to not much more than half that number.

MORTALITY FACTORS

Many of the opossums trapped were suffering from injury, disease, or parasite infestation, and some were in critical conditions. A large adult male trapped on April 2, 1952, seemed to be dying from disease. It was much emaciated and the pelage was sparse and ragged, as if the animal had been sick for a long time. The skin had numerous light-colored pustules 1 to 2 mm. in diameter, and these were especially prominent on the ears, lips, and penis. When released, the opossum was too weak to move away. It was excited by movements of the trapper, and stood erect with violent involuntary rocking movements. After a few seconds it gradually slumped to the ground and subsided into quiescence. On the next day no trace of it could be found.

Most of the opossums caught in summer and early fall had eye infections, and all of them were infested with ticks (*Dermacentor variabilis*). Sometimes ticks were attached in dense clusters of several dozen on the animal's ears and scattered over other parts of the body.

In March and April, 1950, seven adult opossums were found dead in the traps. None of these showed any evidence of disease or injury and they were normal in appearance except that they were thin. It was concluded that death had resulted from exposure and starvation in the traps in these animals already in critical condition as a result of winter food scarcity and frequent fasting. Up to this time the procedure had been to check the trap line only on alternate days and no mortality had resulted, even in the coldest part of the winter. The implication is that by spring, opossums are in a condition so critical that they are unable to withstand exposure or fasting and die whenever weather conditions are unusually severe.

After these losses in the spring of 1950, trap lines were checked daily. However, in October, 1950, further mortality in traps resulted in the loss of three or more opossums. All three of these were rat-sized young of second litters. These young lacked the abundant supply of fat characteristic of larger opossums in fall, and seemingly were unable to withstand exposure to chilly nights. Such susceptibility to cold might result in heavy mortality in retarded second-litter young when cold weather of autumn is unseasonably early or is unusually severe.

Natural enemies of the opossum on the area include the redtailed hawk, horned owl and coyote. Because of the opossum's nocturnal habits it is rarely exposed to hawk predation. Food habits of the coyote on the area have not yet been investigated. Numerous instances of horned owl predation on opossums have been recorded in the literature. On January 15, 1950, an owl attacked an opossum caught in a live-trap. The trap was found overturned, and a few feet away were entrails and a quantity of opossum hair where the animal was eaten. Low vegetation in the vicinity had many fine down feathers of the owl clinging to it. On December 24, 1950, the carcass of a small adult opossum was found in a pasture near the edge of the woods. The head and tail were intact, but otherwise little more remained than the spinal column, girdles and larger limb bones. White excreta of a large bird beside the carcass indicated predation by a raptor, probably a horned owl.

SUMMARY

On a natural area, the University of Kansas Natural History Reservation, in Douglas County, northeastern Kansas, the population of opossums was studied, chiefly by live-trapping, in the fall-winter-spring seasons of 1949-50, 1950-51 and 1951-52. The study area provided a varied habitat of elm-oak-hickory woodland, pastureland, and fallow fields. Opossums use all parts of it, but concentrate their activities in the woodland.

Opossums being mainly nocturnal were rarely seen in the daytime, except when caught in traps. Reactions to humans varied; some were indifferent, some feigned death, others merely tried to escape, and some defended themselves vigorously, snarling and snapping.

No evidence of territorial behavior was found in the opossum. Many individuals of both sexes and various sizes, occurred together on the same area. Successive captures of individuals revealed the usual extent of home ranges, which averaged approximately 50 acres, and tended to a circular or broadly oval shape. No significant difference in size of home ranges between males and females, or between adults and well-grown young, was found. Of 115 young marked by toe-clipping while still in the females' pouches, 15 were recaptured after periods of months. All but two of these recaptured young were females which had settled down within a few hundred feet of the locations where they were born. The young males seem to wander much more extensively than do the females.

Feeding habits were investigated by field examination of scats found mainly in fall and winter. These consisted mainly of wild fruits, especially grape, blackberry, wild crabapple, wild plum, and

hackberry. Crayfish was the most important animal food. No comparable data for spring or summer were obtained because scats deteriorate rapidly in warm weather and were seldom found then. Clues as to the summer food were gained from sign. On many occasions opossums disturbed live-traps set for small animals, to obtain the voles, mice, skinks, or insects caught in them. Evidence of opossum activity such as digging and scratching was frequently noticed at the edges of rocks and in crevices, where such prey as skinks, narrow-mouthed toads, beetles, spiders and centipedes seek shelter. One opossum was observed to catch and kill a young cottontail.

The opossums trapped ranged in weight from 126 grams to 5000 grams but most weighed between 1000 and 2000 grams. After being trapped and marked by toe-clipping, animals usually lost weight, up to as much as 18 per cent of the original weight. Food scarcity and enforced fasting in cold weather caused a weight loss from November until the arrival of warm spring weather. By late April and May some opossums were emaciated and in critical condition.

The entire population of opossums, including the majority less than a year old, breeds in February, and litters are born mainly in the first half of March. The young develop rapidly in the female's pouch, and become independent in late May, and there is a second breeding season with young born mainly in the first half of June. By the onset of cool fall weather, young born in early spring have grown so that most are as large as small adults. The young born in early summer are still less than half-grown. The young of the second litter are less successful than those of the first litter and make up only a small part of the breeding population the following year. In 28 litters of young the average was 7.4, but probably some of these litters had already sustained losses.

In each of three different winters, the largest age group in the population of opossums was that of the newly matured young born in early spring. The old adults were the next most numerous group, and the second-litter young born in early summer were the least numerous. The figures obtained from live-trapping indicate an annual population turnover of approximately 95 per cent, with some 70 per cent eliminated by various mortality factors and replaced by young, the remaining 25 per cent shifting to new areas, with compensatory shifts of individuals replacing them.

The various mortality factors which regulate the numbers of opossums are not well known, and even less is known regarding the relative importance of the factors. Food supply and weather are obviously of major importance and closely interrelated in their effect on the population. One large adult opossum that was trapped seemed to be dying from disease and was scarcely able to stand; but others caught near-by before and after were unaffected. The horned owl is perhaps the most important natural enemy of the opossum on the Reservation, and instances of owl predation on opossums were noted.

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Transmitted May 4, 1953.

University of Kansas Publications
Museum of Natural History

Volume 7, No. 3, pp. 339-347, 1 figure in text

February 15, 1954

The Silky Pocket Mouse (Perognathus flavus) of México

BY

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University of Kansas
Lawrence
1954

University of Kansas Publications, Museum of Natural History

Volume 7, No. 3, pp. 339-347, 1 figure in text
Published February 15, 1954

University of Kansas
Lawrence, Kansas

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1954
25-1129

The Silky Pocket Mouse (Perognathus flavus) of México

by

Rollin H. Baker

Little has been added to our knowledge of the silky pocket mouse (*Perognathus flavus*) in México since the appearance of Osgood's (1900:23-26) revision of the genus. Davis (1944:390) recorded this mouse from several localities in central México, additional to the localities mentioned by Osgood. Twente and Baker (1951:120) listed the species from Jalisco, and Baker (1953:253) recorded it from Coahuila. In the past few years the University of Kansas Museum of Natural History has obtained specimens which extend the known geographic range and increase our knowledge of the geographic variation of this species. Osgood (*op. cit.*) had, for study, 45 specimens of *P. flavus* from México, mostly taken by Nelson and Goldman. This report is the result of an examination of 192 specimens.

Silky pocket mice are found in most of the desert situations on the Mexican Plateau and prefer sandy to rocky soils, in an altitudinal range of from 3250 feet in Coahuila to 8000 feet in Puebla. The mice often are not greatly attracted to mouse traps baited with chewed rolled oats; consequently *P. flavus* often is more abundant than trap-yields indicate. Larger collections of these mice often can be obtained by catching them by hand at night with a headlight than by any other means. In the summer of 1952, members of a University of Kansas field party in México caught by hand approximately half of the 98 *P. flavus* obtained. It was found also that at night these mice frequented the large hills of the harvester ant (*Pogonomyrmex*), seemingly being attracted there by seeds collected by the ants. Traps set near these ant hills provided better yields, and night-hunting in the vicinity of the hills often proved to be more fruitful, than in other situations.

Three subspecies of *Perognathus flavus* are known in México: Osgood (*op. cit.*) records *Perognathus flavus flavus* Baird from localities in Chihuahua and *P. f. mexicanus* Merriam from localities in six states in central México; *P. f. sonoriensis* Nelson and Goldman is known from a single, isolated locality in west-central Sonora. Study of the recently collected material indicates that there are three previously unnamed subspecies of *P. flavus* in México; these are described in the following accounts.

I am indebted to those in charge of the Biological Surveys Collection of the United States National Museum for permission to examine pertinent specimens of silky pocket mice. These are identified in the following accounts by the abbreviation (BSC); other specimens listed are in the Museum of Natural History, University of Kansas. Capitalized color terms are those of Ridgway, Color Standards and Color Nomenclature, Washington, D. C., 1912. Comparisons have been made, where possible, by using individuals of approximately the same age. For color of pelage, where possible, only specimens taken at approximately the same time of year have been used in comparisons. Measurements of both sexes are combined for comparative purposes, since no differences of statistical significance have been detected between sexes in dimensions of either the body or the skull. Assistance with field work is acknowledged from the Kansas University Endowment Association and the National Science Foun-

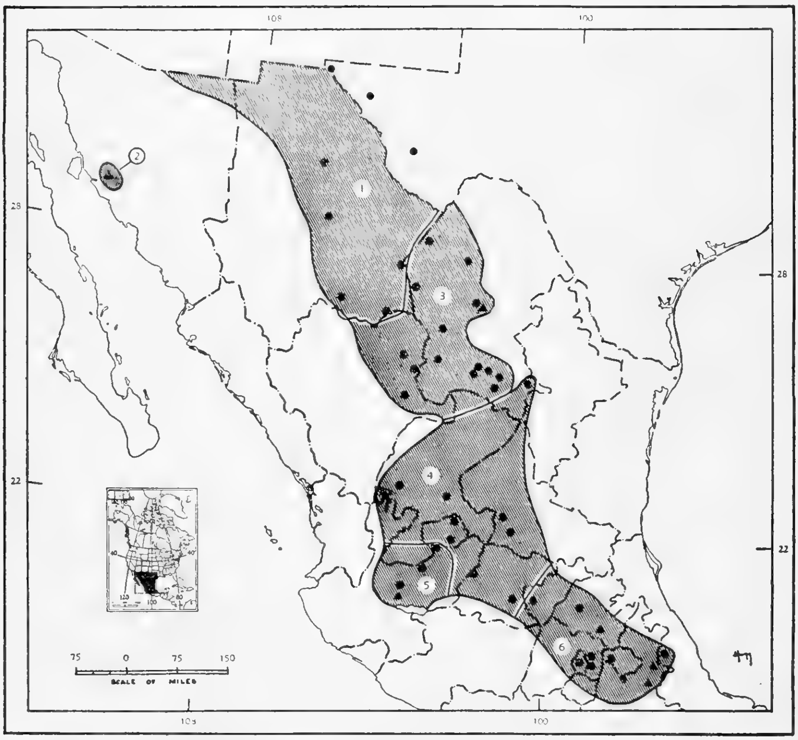

FIG. 1. Geographic ranges of the subspecies of *Perognathus flavus* in México.

1. *P. f. flavus*
2. *P. f. sonoriensis*
3. *P. f. pallescens*
4. *P. f. medius*
5. *P. f. parviceps*
6. *P. f. mexicanus*

dation. In Figure 1 the localities of capture of specimens examined by me are indicated by black circles; the localities for additional specimens known to me from only the literature are indicated by black triangles. In the lists of specimens examined and in additional records some localities of capture are in Italic type. These are localities that are not represented on the map because undue crowding or overlapping of symbols would have occurred.

Perognathus flavus mexicanus Merriam

Perognathus flavus mexicanus Merriam, Proc. Acad. Nat. Sci., Philadelphia, p. 265, September 27, 1894, type from Tlalpam, Distrito Federal, México.

Range.—South-central México from Querétaro and Hidalgo south at least to Morelos, Puebla and west-central Veracruz (see Figure 1).

Remarks.—*Perognathus flavus mexicanus* is the largest of the Mexican subspecies of *P. flavus* (see measurements, Table 1). Color of the upper parts (specimens in fresh pelage, July, from 6 mi. S and 1 mi. W Texcoco, México, approximately 19 miles NE of the type locality) is also distinctive, individual hairs being near (*c*) Light Ochraceous-Salmon, basally gray, and tipped with dusky but less so on sides. Topotypes in worn pelage (December) are paler, individual hairs being near (14′) Light Ochraceous-Buff with same degree of dusky on tips as in fresh pelage. Skulls of both series are long and broad with zygomata widely spreading anteriorly. Most specimens were taken on fine soils supporting a sparse growth of low vegetation and in, or adjacent to, cornfields.

Specimens examined.—Total, 50, from: *Querétaro:* 6 mi. E Querétaro, 7400 ft., 1. *Hidalgo:* Ixmiquilpan, 6000 ft., 2 (BSC). *Veracruz: 2 km. W Limón [=San Antonio Limón], 7800 ft.*, 1; 2 km. W Perote, 8000 ft., 1. *México*: 6 mi. S and 1 mi. W Texcoco, 7350 ft., 30; Cerro La Caldera, 11 mi. ESE Mexico [City], 2350 m., 1; *2 km. NE Tlapizahua*, 1; 4 km. ENE Tlalmanalco, 2290 m., 1. *Tlaxacala:* 4 mi. S and 5 mi. E Calpulalpan, 8000 ft., 1. *Distrito Federal:* Tlalpam, 7600 ft., 8 (BSC). *Puebla:* 7 mi. S and 3 mi. E Puebla, 6850 ft., 3.

Additional records (Davis, 1944:390).—*Hidalgo:* 85-97 km. N México City (near Pachuco), 8200 ft. *México: 22 km. E México City, 7600 ft.* *Puebla:* 10 km. W San Andres, 8000 ft.; Laguna Salada (near Alchichica), 8000 ft.

Perognathus flavus medius new subspecies

Type.—Female, adult, skin and skull; No. 48583, Univ. Kansas Mus. Nat. Hist.; 1 mi. S and 6 mi. E Rincón de Romos, 6550 ft. elevation, Aguascalientes; 14 July 1952; obtained by Rollin H. Baker, original no. 2215.

Range.—North-central México from southeastern Coahuila south through San Luis Potosí to Aguascalientes, extreme northern and extreme eastern Jalisco and Guanajuato (see Figure 1).

Diagnosis.—Size medium for the species (see measurements, Table 1); color of upper parts dusky buff, paler on sides; individual hairs Capucine Buff, basally gray and tipped with dusky (fresh pelage, July); lateral line and postauricular spot Capucine Buff; skull medium in size and broad in relation to length.

Comparisons.—From *P. f. mexicanus* (topotypes and specimens from 6 mi. S and 1 mi. W of Texcoco, México), found to the southeast, *P. f. medius* differs in: Total length, length of tail and length of hind foot less; color of upper parts lighter; skull averaging shorter in total length but no narrower across mastoids; rostrum narrower; zygomata less spreading anteriorly. For comparisons with subspecies to the north and west, see accounts of those subspecies to follow.

Remarks.—*Perognathus flavus medius* is medium-sized for the species and occupies a large range in north-central México. It seems to be the middle segment of a north-south cline in both size and color. Accordingly, in most characters this subspecies is intermediate, although distinct enough to be given subspecific recognition. Intergradation with *mexicanus* to the southeast is seen in specimens from eastern Guanajuato (5 mi. E Celaya); in color of upper parts they more closely resemble *mexicanus*, but in dimensions of the body and cranial characteristics, they more closely resemble *medius*, to which they here are assigned. Specimens from southeastern Coahuila (7 mi. S and 4 mi. E Bella Unión) agree with typical *medius* and show no evidence of intergradation with the subspecies to the north. These specimens were taken on an elevated plain with a barrier rim of mountains to the northward.

Specimens examined.—Total, 71, from *Coahuila:* 7 mi. S and 4 mi. E Bella Unión, 7200 ft., 20. *Zacatecas:* Valparaiso, 1 (BSC); 8 mi. SE Zacatecas, 7225 ft., 4. *San Luis Potosí: Ahualulco, about 6000 ft.*, 1 (BSC); Hacienda La Parada, about 6000 ft., 3 (BSC); Jesús María, 6000 ft., 2 (BSC). *Jalisco:* Huejuquilla, 5400 ft., 1 (BSC). *Aguascalientes:* 5 mi. NNE Rincón de Romos, 6400 ft., 6; *1 mi. S and 6 mi. E Rincón de Romos, 6550 ft.*, 17; 3 mi. SW Aguascalientes, 6100 ft., 1. *Guanajuato:* 4 mi. N and 5 mi. W León, 7000 ft., 5; Celaya, 2 (BSC); *5 mi. E Celaya, 6000 ft.*, 8.

Additional records.—*Zacatecas: Berriozabel* (Osgood, 1900:26).

Perognathus flavus parviceps new subspecies

Type.—Female, adult, skin and skull; No. 38402, Univ. Kansas Mus. Nat. Hist.; 4 mi. W and 2 mi. S Guadalajara, 5100 ft. elevation, Jalisco; 15 June 1950; obtained by J. R. Alcorn, original no. 12020.

Range.—Central and eastern Jalisco and possibly adjacent parts of Zacatecas to the north (see Figure 1).

Diagnosis.—Size small (see measurements, Table 1); color of upper parts dusky buff, paler on sides; individual hairs near (*c*) Light Ochraceous-Buff, basally gray and tipped with black (fresh pelage, June; specimen in worn pelage, March, Light Ochraceous-Buff); lateral line and postauricular spot near (*c*) Light Ochraceous-Buff; skull narrow; mastoidal region reduced.

Comparisons.—From *P. f. mexicanus* (topotypes and specimens from 6 mi. S and 1 mi. W Texcoco, México), found to the east, *P. f. parviceps* differs in: Tail and also body averaging shorter; color of upper parts lighter; skull shorter and narrower, occipitonasal length, frontonasal length, and mastoidal breadth averaging less. From *P. f. medius* (topotypes), found to the north and northeast, *P. f. parviceps* differs in: Tail and also body averaging shorter; color of upper parts slightly lighter but with a greater degree of dusky on tips of hairs; skull no shorter but averaging narrower, especially across mastoids.

Remarks.—*Perognathus flavus parviceps* is a small, dusky pocket mouse, being distinguished from adjacent subspecies principally by its small size and narrow skull. Specimens from northeastern Jalisco (1 mi. NE Villa Hidalgo) are referred to *parviceps* but approach *medius* in proportions of the skull, especially in breadth across the mastoidal region. In color these specimens resemble *parviceps* although in over-all appearance of upper parts the single adult is lighter, owing to a lesser degree of dusky on the tips of the hairs. Fragmentary specimens recorded from barn owl pellets from 21 miles SW of Guadalajara as *P. flavus* (Twente and Baker, 1951:120) are referred to this subspecies chiefly on geographic grounds.

Specimens examined.—Total, 20, from: *Jalisco:* 1 mi. NE Villa Hidalgo, 6500 ft., 2; 3 mi. NW Yahualica, 2; *1 mi. N and 7 mi. W Yahualica, 6600 ft.*, 1; 2 mi. N and ½ mi. W. Guadalajara, 8; *4 mi. W Guadalajara,* 1; *4 mi. W and 2 mi. S Guadalajara,* 6.

Additional record.—*Jalisco:* 21 mi. SW Guadalajara (Twente and Baker, 1951:120).

Perognathus flavus pallescens new subspecies

Type.—Male, adult, skin and skull; No. 40298, Univ. Kansas Mus. Nat. Hist.; 1 mi. SW San Pedro de las Colonias, 3700 ft. elevation, Coahuila; 9 February 1951; obtained by J. R. Alcorn, original no. 14177.

Range.—Central and western Coahuila, extreme eastern Chihuahua, northeastern Durango and probably northern Zacatecas and northwestern San Luis Potosí (see Figure 1).

Diagnosis.—Size small (see measurements, Table 1); color pale, upper parts dusky buff, paler on sides; individual hairs near (*e*) Pale Ochraceous-Salmon, basally gray and lightly tipped with dusky (pelage in February; color of specimen in fresh pelage, June, the same); lateral line and postauricular spot near (*e*) Pale Ochraceous-Salmon; skull small and narrow; mastoidal region reduced; upper molariform tooth-row at alveoli short.

Comparisons.—From *Perognathus flavus flavus* (topotypes and specimens from 10 mi. NE Marfa, Presidio County, Texas), found to the north and northwest, *P. f. pallescens* differs in: Hind foot averaging shorter; color of upper parts lighter and less buffy; skull narrower; mastoid bulla smaller; upper molariform tooth-row at alveoli averaging shorter. From *P. f. medius* (topotypes), found to the south, *P. f. pallescens* differs in: Tail, body, hind foot and ear averaging shorter; color of upper parts paler and less buffy; skull shorter and narrower, averaging less in occipitonasal length, frontonasal length and mastoidal breadth; mastoid bulla smaller; alveolar length of upper molariform tooth-row averaging less.

Remarks.—*Perognathus flavus pallescens* is a small, pale pocket mouse inhabiting desert plains of central and western Coahuila and adjacent Mexican states. No specimens of this species have been taken in northeastern Coahuila, where another small pocket mouse, *P. merriami,* is known to occur. Intergradation between *pallescens* and *flavus* seems to occur along the border between Chihuahua and Coahuila. Specimens from northwestern Coahuila (vicinity of Castillón) seem to be intergrades between *pallescens* and *flavus* but are referred to *pallescens* because three of the five specimens more closely resemble, especially in color, this subspecies. A specimen from 3 mi. SE Sierra Mojada is also considered to be *pallescens* because of color. A single mouse from the Sierra Almagre (12 mi. S Jaco) in extreme eastern Chihuahua is assigned, chiefly on the basis of darker color, to *flavus.*

No evidence of intergradation with *medius*, the subspecies adjacent to the south, is found. In eastern Durango and western Zacatecas there is an extensive area where pocket mice of this species seem not to occur. Intergradation probably occurs east of this area in San Luis Potosí. Fragmentary specimens recorded from owl pellets from 3 miles NW of Cuatro Ciénegas as *P. flavus* (Baker, 1953:253) are referred to this subspecies chiefly on geographic grounds.

Specimens examined.—Total, 41, from: *Coahuila: 6 mi. N and 2 mi. W Castillón, 3750 ft., 1;* 2 mi. SSE Castillón, 4050 ft., 4; *11 mi. N and 9 mi. W Tanque Alvarez, 4500 ft.,* 1; 6 mi. NW Tanque Alvarez, 3400 ft., 1; 3 mi. NE Sierra Mojada, 4100 ft., 1; 8 mi. N and 25 mi. W Cuatro Ciénegas, 4000 ft., 1; *5 mi. N and 19 mi. W Cuatro Ciénegas, 3250 ft.,* 4; 4 mi. N Acatita, 3600 ft., 2; 1 mi. SW San Pedro de las Colonias, 3700 ft., 4; La Pastora Rancho, 41 mi. W and 15 mi. N Saltillo, 2; 3 mi. N and 5 mi. W La Rosa, 1; 12 mi. N and 10 mi. E Parras, 3850 ft., 5; 1 mi. N San Lorenzo, 4200 ft., 4; N foot Sierra Guadalupe, 6400 ft., 10 mi. S and 5 mi. W General Cepeda, 3. *Durango:* 1 mi. WSW Mapimí, 3800 ft., 5; 4 mi. WSW Lerdo, 3800 ft., 1; 2 mi. N Cuencamé, 5200 ft., 1.

Additional record.—*Coahuila:* 3 mi. NW Cuatro Ciénegas (Baker, 1953:253).

TABLE 1. MEASUREMENTS (IN MILLIMETERS) OF ADULT PEROGNATHUS FLAVUS FROM MEXICO

	Total length	Length of tail	Length of hind foot	Occipitonasal length	Frontonasal length	Mastoidal breadth	Length of bulla	Interorbital breadth	Alveolar length of upper molariform tooth-row	Interparietal width
P. f. mexicanus, 6 mi. S and 1 mi. W Texcoco, 7350 ft. (KU)										
mean (27)	114.6	55.0	17.1	21.3	14.4	12.3	7.9	4.6	3.2	3.4
maximum	122	59	18	22.7	15.3	12.7	8.4	4.9	3.5	3.9
minimum	107	51	16	20.0	13.7	11.7	7.5	4.5	3.0	3.0
P. f. medius, 1 mi. S and 6 mi. E Rincón de Romos, 6550 ft. (KU)										
48583 ♀ (type)	111	52	17	20.7	13.9	.....	7.8	4.5	3.0	2.9
mean (17)	112.0	54.0	16.8	20.7	13.8	12.3	8.1	4.5	3.1	3.2
maximum	121	61	18	21.6	14.1	12.8	8.5	4.7	3.4	3.6
minimum	103	47	16	19.6	12.9	12.0	7.8	4.1	2.9	2.4
P. f. parviceps, vicinity of Guadalajara (KU)										
38402 ♀ (type)	113	52	17	20.9	13.9	12.2	7.9	4.6	3.2	3.3
mean (15)	106.9	48.5	17.0	20.4	13.8	11.8	7.8	4.5	3.2	3.4
maximum	113	53	18	21.0	14.4	12.5	8.0	4.7	3.3	3.7
minimum	100	43	16	19.5	13.4	11.4	7.4	4.3	3.0	2.9
P. f. pallescens, 1 mi. SW San Pedro de las Colonias, 3700 ft. (KU)										
40295 ♂	106	48	16	19.7	13.1	.....	7.9	4.1	3.0	3.0
40298 ♂ (type)	107	52	16	20.5	13.7	11.9	8.0	4.5	3.0	2.8
40300 ♀	110	50	15	20.0	13.4	.....	7.5	4.1	3.1	3.0
40305 ♂	104	50	15	.....	12.9	.....	8.1	4.1	3.1	3.9

Perognathus flavus flavus Baird

Perognatus [*sic*] *flavus* Baird, Proc. Acad. Nat. Sci., Philadelphia, 7:332, 1855, type from El Paso, El Paso County, Texas.

Range.—Southwestern Oklahoma, western Texas, New Mexico (except northwestern part), southeastern Arizona, northern and eastern Chihuahua, and probably northeastern Sonora (see Figure 1).

Remarks.—*Perognathus flavus flavus* is medium-sized for the species. Color of upper parts is distinctive, individual hairs being near (*c*) Pale Ochraceous-Buff, basally gray and tipped with dusky (specimens from type locality in worn pelage, December).

Specimens examined.—Total, 19, from: *Texas:* El Paso County: El Paso, 6 (BSC). Hudspeth County: Sierra Blanca, 1 (BSC). Presidio County: 1 mi. S Marfa, 4700 ft., 2. *Chihuahua:* Gallego, 2 (BSC); 4 mi. N and 2 mi. W Chihuahua, 4750 ft., 1; Sierra Almagre, 5300 ft., 12 mi. S Jaco, 1; Escalon, 4200 ft., 3 (BSC); 5 mi. E Parral, 5700 ft., 3.

Additional record from México.—Chihuahua: Chihuahua (Osgood, 1900:24).

Perognathus flavus sonoriensis Nelson and Goldman

Perognathus flavus sonoriensis Nelson and Goldman, Jour. Washington Acad. Sci., 24:267, June 16, 1934, type from Costa Rica Ranch, lower Sonora River, Sonora.

Range.—Low desert plains of west-central Sonora (see Figure 1).

Remarks.—Nelson and Goldman (1934:267) described *P. f. sonoriensis* from a single specimen taken on the Costa Rica Ranch in midwestern Sonora. They remark that the specimen is closely allied to *P. f. flavus* but is less dusky, has a shorter, broader skull and the hind foot is "apparently" shorter.

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25-1129

University of Kansas Publications
Museum of Natural History

Volume 7, No. 4, pp. 349-472, 47 figures in text, 4 tables
April 21, 1954

North American Jumping Mice (Genus Zapus)

BY

PHILIP H. KRUTZSCH

University of Kansas
Lawrence
1954

UNIVERSITY OF KANSAS PUBLICATIONS, MUSEUM OF NATURAL HISTORY

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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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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.

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University of Kansas Publications

Museum of Natural History

Volume 7, No. 4, pp. 349-472, 47 figures in text, 4 tables

April 21, 1954

North American Jumping Mice (Genus Zapus)

BY

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University of Kansas

Lawrence

1954

University of Kansas Publications, Museum of Natural History

Editors: E. Raymond Hall, Chairman, A. Byron Leonard,
Robert W. Wilson

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PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1954

25-1128

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Philip H. Krutzsch

CONTENTS

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*.

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′*

Condylobasal 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′

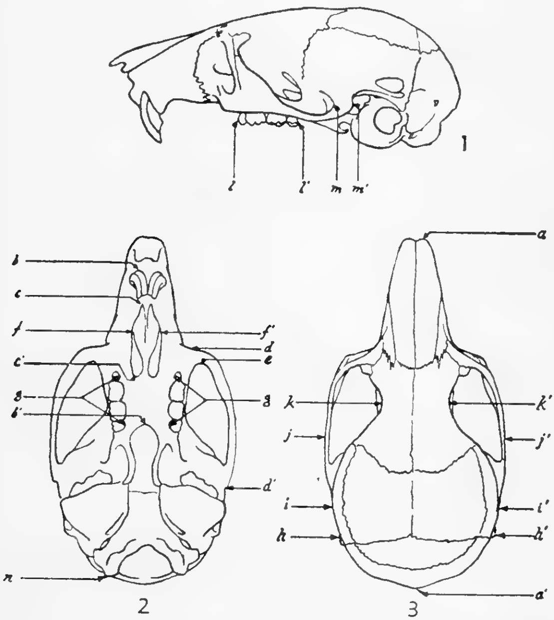
Mastoid breadth.—Greatest distance across mastoid bones perpendicular to long axis of skull. *h* to *h′*

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'*



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

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.
UU.	University of Utah 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 westernmost 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.

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 rinkeri* 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. rinkeri* 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. rinkeri, 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.

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 . . ."

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.

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 *Macrognathomys* 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.

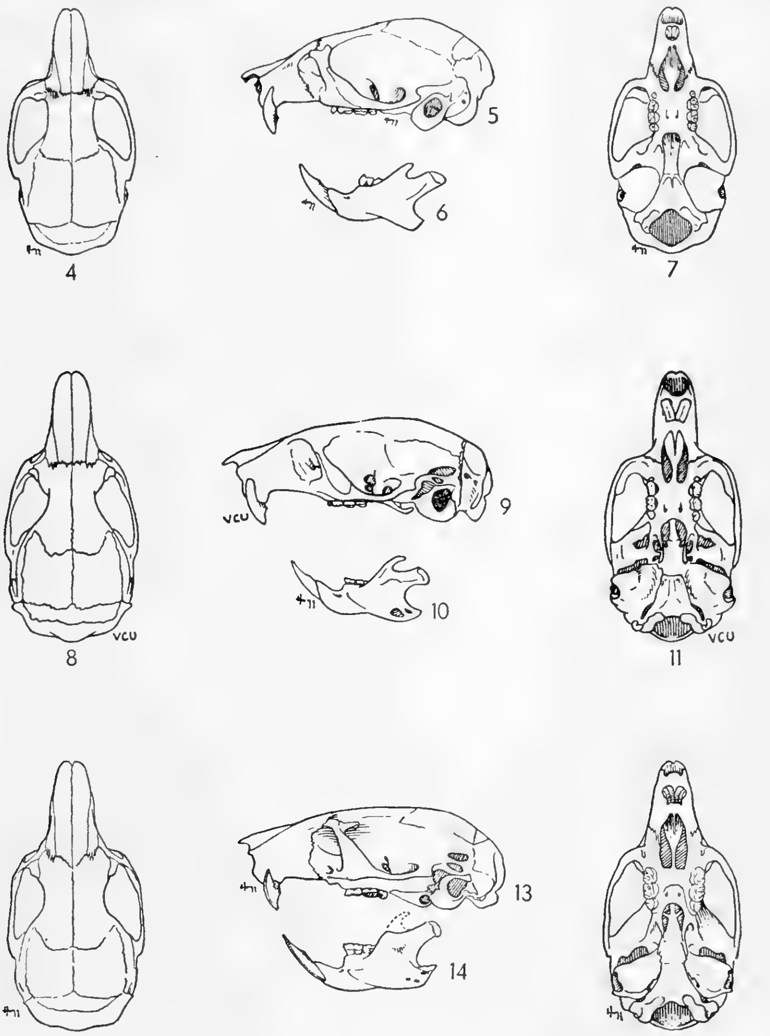
If it be assumed, as Matthew (1915) did and as Hooper (1952: 200) later on the generic level did, that the region of origin and center of dispersal for a given group of animals is characterized by the presence of the most progressive forms, then southeastern Canada and the northeastern United States 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).



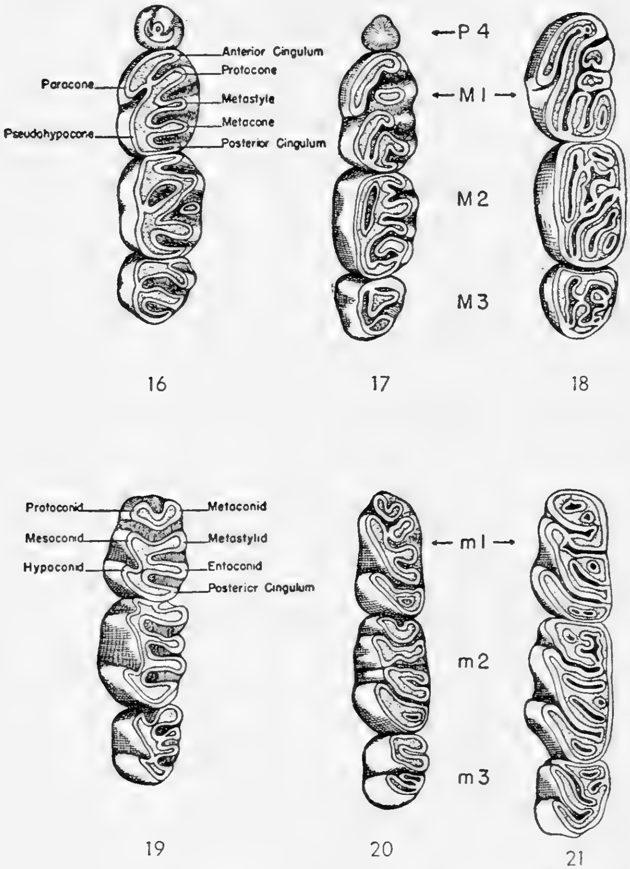
FIGS. 4-15. Three views of the skull and a lateral view of the left lower jaw of each of the Recent genera of the subfamily Zapodinae. ×1.5.

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, 5½ mi. N, 1¾ 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.

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, disimilarity between the groups in the dentition (tooth number and occlusal pattern), bacula, and ear ossicles pro-



FIGS. 16-21. Occlusal views of upper and lower right cheek-teeth, of the three Recent genera of the subfamily Zapodinae. ×12½.

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, Massachussetts.

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

vides 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.

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 quadritubercular 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.

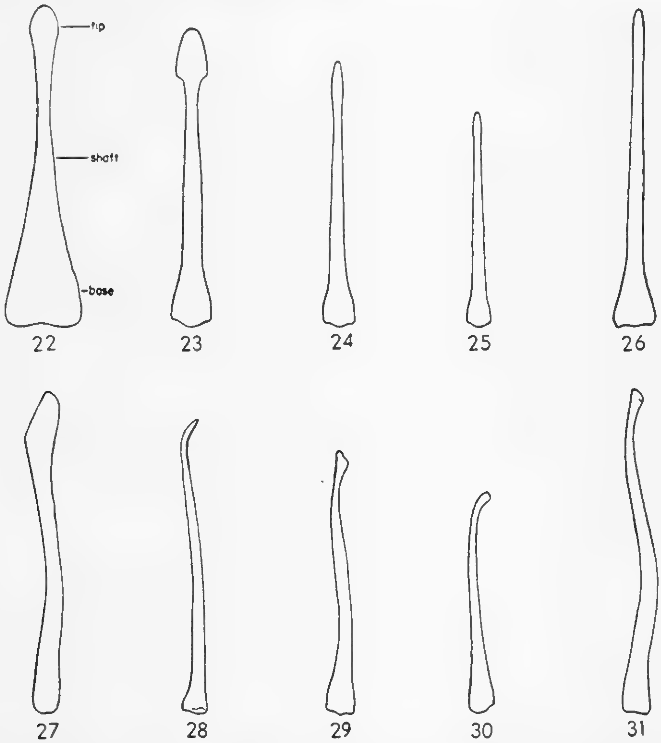
The absence of P4 in *Napaeozapus* would lead one to suspect that this genus has evolved at a more rapid rate than the historically older *Zapus* and *Eozapus* which still retain this structure. The small size of P4, even in the primitive *Eozapus,* indicates that it has long been of little use to the 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

	Eozapus	*Zapus*	*Napaeozapus*
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 *Eozapus*; 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 *Zapus* and *Eozapus*; 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.	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.	Narrow lingual re-entrant folds variable in number, as many as 3; anteroconid present; occlusal pattern complex; 2 labial re-entrant folds.

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).



FIGS. 22-31. Dorsal and lateral views of the bacula of the Recent genera (and species of the genus *Zapus*) of the subfamily Zapodinae. × 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, Massachussetts.

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.

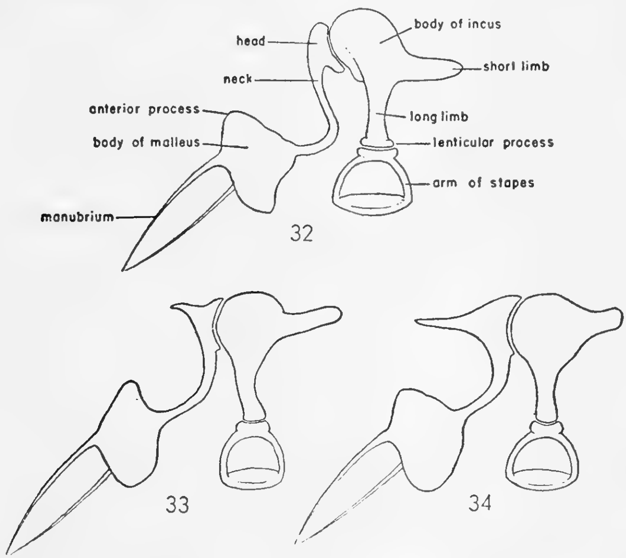
Instances of variation in the auditory region in mammals in general are small, even at the family level; therefore, these differences in the subfamily Zapodinae are offered as additional support for recognizing *Eozapus, Zapus,* and *Napaeozapus* as distinct genera. The distinctive features are chiefly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

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*.



FIGS. 32-34. Lateral views of the left ear ossicles (articulated) of the Recent genera of the subfamily Zapodinae. × 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.

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 conceiveably 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.

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*.

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 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 peripherial; 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. *rinkeri* (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.

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.

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. Provencher 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 measurments, 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).

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.

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,

35 36 37

FIGS. 35-37. Photomicrographs of underhairs (middle third) from each of the species of the genus *Zapus*. × 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, 1¾ mi. E Lawrence, Douglas County, Kansas.

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.

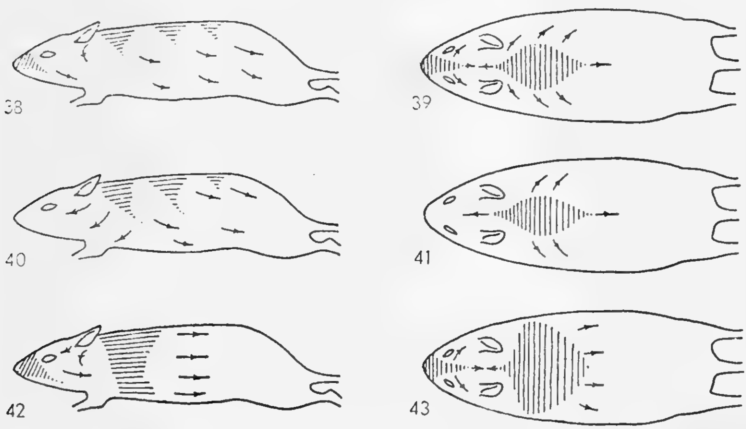
MOLT.—The sequence of molt for *Zapus* has been ascertained from examination of the study skins. In all species of this genus there seems to be only one annual molt in adults. In the young of the year this molt occurs after August first and before hibernation. All individuals of a single population do 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 ½ 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.

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.

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 groups	1	2	3	4	5	6
No. examined........	4	13	33	12	3	3
Body..............	70	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 9.5	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
Condylobasal 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 dention 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 anteriormedial to M3.

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

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	*Z. h. hudsonius*	*Z. p. princeps*	*Z. t. trinotatus*
No. examined	52	46	19
Mastoid width	2.85	1.98	2.21
Occipito-nasal 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

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.

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*

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; supercilliary 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.

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 widespreading; 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

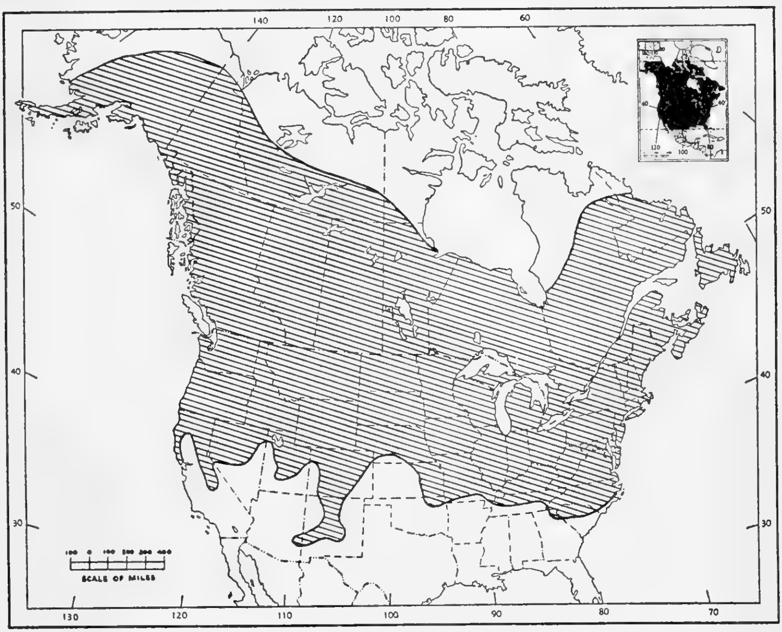


FIG. 44. Map showing distribution of the genus *Zapus.*

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 $\frac{I\ 1}{i\ 1}, \frac{C\ 0}{c\ 0}, \frac{P\ 1}{p\ 0}, \frac{M\ 3}{m\ 3} = 18$; 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.

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 lumbars 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

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.

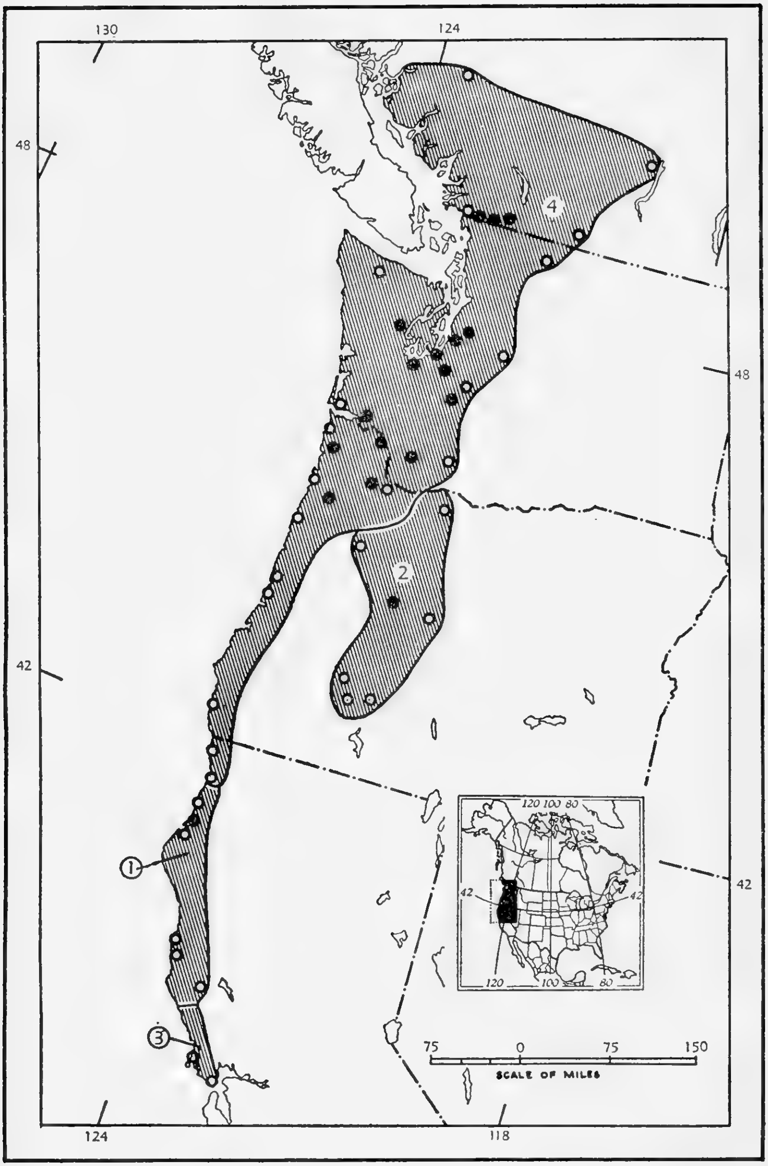


FIG. 45. Map showing distribution of *Zapus trinotatus*.

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.

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.

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.

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 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 3/10 mi. E Bayside,* 1 (MVZ); *12 mi. S Korbel, 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, ⅓ mi. E MacDonalds Ranch, 1 (MVZ); Russian Gulch State Park, 10 (MVZ).

Marginal records.—California: Trinidad; Russian Gulch State Park; Albion River, ⅓ 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; zygomata 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; zygomata 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. 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.

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 zygomata 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); *½ 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, Miscl. 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; zygomata narrow; braincase narrow; maxillary tooth-rows short; interorbital region narrow; incisive foramina short; palatal bridge relatively long; mastoid region relatively broad; occipitalnasal length short.

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. . . ., 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).

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); *Lihumption 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).

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 Skamokawa, 5 (MVZ). *Whatcom County:* Baker Lake, 2 (MVZ).

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: 3½ 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 sinoidal, 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.

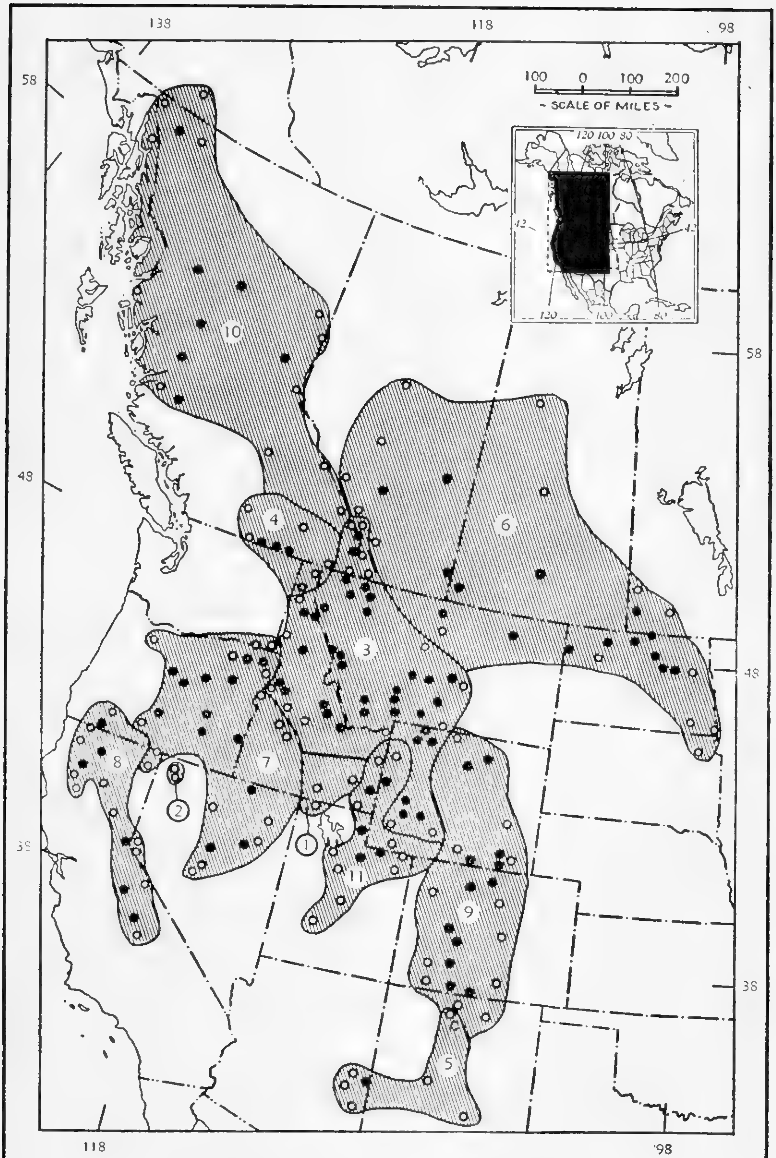


FIG. 46. Distribution of *Zapus princeps*.

Guide to subspecies
1. *Z. p. cinereus*
2. *Z. p. curtatus*
3. *Z. p. idahoensis*
4. *Z. p. kootenayensis*
5. *Z. p. luteus*
6. *Z. p. minor*
7. *Z. p. oregonus*
8. *Z. p. pacificus*
9. *Z. p. princeps*
10. *Z. p. saltator*
11. *Z. p. utahensis*

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 toothrows, 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.

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 bromegrass. 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.

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 acount 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. Idaho: Mt. Harrison, 10 mi. S Albion.

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.

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.

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 occipital-nasal 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 Potlutch 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.*

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).

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 Agusta, 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.

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; post-palatal 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 referrable 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.

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 Cocololla, 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 Cocololla, 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.

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.

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 characteristicly 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 Assini-*

boine, 4 (USBS); *head Eagle Creek, Bear Paw Mt's,* 7 (UM). *Valley Co.:* Glasgow, 1 (USBS).

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.:* $4\frac{3}{10}$ mi. N Bottineau, 2100 ft., 2; *3½ 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: $7\frac{1}{5}$ mi. E and $1\frac{1}{5}$ 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.

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*.

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, 2½ 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., 2½ 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, 2½ 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.

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. . . ., 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, Eldorado 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; post-palatal 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.

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 Siskiyon 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, ¼ mi. SW Woodfords, 5700 ft.,* 3 (MVZ); *Diamond Valley, 5500 ft., 1 mi. SE Woodfords,* 6 (MVZ); *Faith*

Valley, 1 (MVZ). *Eldorado 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); *1½ mi. N Mad River Bridge, 3000 ft., South Fork Mtn.*, 6 (MVZ); *1 mi. SW North Yolla Bolly Mtn.*, 14 (11 MVZ); *½ 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).

NEVADA: *Douglas County:* ½ mi. E Zephyr Cove, Lake Tahoe, 6400 ft., 1 (MVZ). *Ormsby County: S end Marlette Lake, 8000 ft.*, 2 (MVZ); *½ mi. S Marlette Lake, 8150 ft.*, 3 (MVZ). *Washoe County: ½ 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.; ½ 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, August 8, 1899.

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.

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 Amarillo, 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.

NEW MEXICO: *Rio Arriba Co.:* Tierra Amarillo, 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; Centenial, 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 ⅘ 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 Amarilla. Colorado: Florida; 6½ mi. SW Silverton; Meeker. Wyoming: Bridgers Pass, 18 mi. W Rawlins, 7500 ft.

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.

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 referrable to *Z. p. idahoensis.* Specimens from Mt. Revelastoke, 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); *Sitkine River, at Glenoria,* 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, Caribou 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).

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.*

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.: Currant 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).

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.

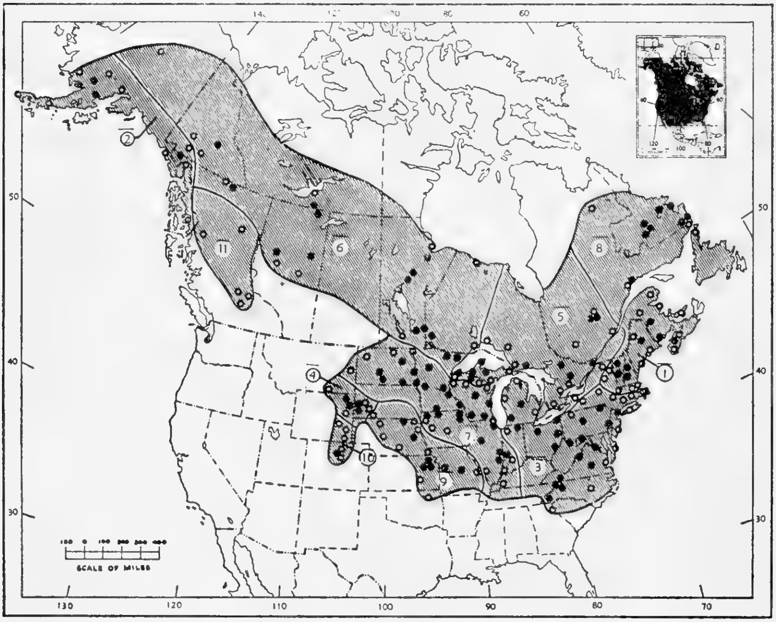


FIG. 47. Distribution of *Zapus hudsonius.*

Guide to subspecies
1. *Z. h. acadicus*
2. *Z. h. alascensis*
3. *Z. h. americanus*
4. *Z. h. campestris*
5. *Z. h. canadensis*
6. *Z. h. hudsonius*
7. *Z. h. intermedius*
8. *Z. h. ladas*
9. *Z. h. pallidus*
10. *Z. h. preblei*
11. *Z. h. tenellus*

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*.

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.

NATURAL HISTORY

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 adult-like 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."

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 concensus 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."

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.

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.

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.)

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.*

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.

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 shorty 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.

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.

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. P^4, M^1, M^2, m1 and m2 have emerged from the maxillary and dentary bones; M^3 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 rotton 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.

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.—Gaspe 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.

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 referrable 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, Worchester County, Massachussets, 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, Massachussets, 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*.

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).

MASSACHUSETTS: *Essex County: Essex,* 4 (Clev. MNH); Wilmington, 4 (3 USBS, 1 USNM). *Worchester County: Lunenberg,* 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. Streator, 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-Buff; belly white, frequently with a slight suffusion of Ochraceous-Buff; 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; occipitalnasal length relatively great.

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 Iliamma, 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 north-east 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).

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.

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 indistinguisable 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.

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. *Worchester County:* Assateagus, 5 mi. S Ocean City, 1 (USBS).

Massachusetts: *Barnstable County: West Falmouth,* 1 (USBS). *Bristol County: Raynham,* 1 (Clev. MNH). *Dukes County: Marthas Vineyard,* 1 (USBS); *West Chop, Marthas Vineyard,* 1 (Clev. MNH). *Nantucket County: Nantucket Island,* 1 (USNM). *Plymouth County:* Middleboro, 1 (USNM); *Plymouth,* 1 (UM); *Marshfield,* 6 (USBS); *Wareham,* 3 (1 Clev. MNH; 2 UM).

Michigan: *Alcona Co.: 2 mi. S Harrisville,* 2 (UM). *Allegan Co.: near junction Swan Creek and Kalamozoo 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); *Whitemore 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).

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, Vermillion 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: Assateagus, 5 mi. S Ocean City. North Carolina: Raleigh. Georgia: Athens. Indiana: Mineral Springs. Michigan: 9 mi. N Ludington.

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; zygomata 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).

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.:* 1½ 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: 1½ 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.

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 Jerboid 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; zygomata 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; zygomata 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; zygomata 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 Severen, 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 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.

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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.

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 ¼ 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; *¼ 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, ¼ mi. SE Thousand Island Lake, 2. *Keweenaw Co.:* Lake Manganese, 1 mi. SSE Copper Harbor, 5 (UM); *2⅕ 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.

Marginal records.—Alaska: Fairbanks. MacKenzie: Ft. Resolution. Manitoba: York Factory. Ontario: Fort Severn, Kenora District; Silver Islet, Thunder Day 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.

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); *Pistake 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).

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.: Horicorn 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.

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. . . ., 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, 5½ mi. N, 1¾ 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).

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.

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

KANSAS: *Brown Co.:* Horton, 1. *Douglas Co.:* Sec. 8, T. 123, R. 20E, 5½ mi. N, 1¾ mi. E Lawrence, 10; *5 mi. N and 1½ mi. E Lawrence,* 3; *Robinson Farm, 5 mi. N and 3 mi. E Lawrence,* 2; *4 mi. N, 2½ mi. E Lawrence,* 1; Lakeview, 2; *7½ 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.

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 nonadults), 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. Streator, 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.

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.

Number examined ♂♂ plus ♀♀	Breadth of braincase	Condylobasal length	Interorbital breadth	Mastoidal breadth	Length of maxillary tooth-row	Occipitonasal length	Palatal length	Zygomatic breadth	Zygomatic length
Zapus trinotatus eureka, 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
Zapus trinotatus montanus, 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	9.3
max......	10.5	21.3	4.6	10.9	4.1	24.6	10.7	12.2	9.4
min......	10.2	20.4	4.4	10.5	3.8	23.5	10.0	12.0	9.1
Zapus trinotatus orarius, 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
Zapus trinotatus trinotatus, Old Fort Clatsop, 100 ft., Oregon.									
8 mean.....	10.3	21.1	4.4	10.7	3.8	24.3	10.6	12.3	9.6
max......	10.6	21.8	4.8	11.0	3.9	25.0	11.0	12.7	10.2
min......	10.0	20.2	4.0	10.4	3.7	23.6	10.0	11.9	9.2
Cayuse Meadow, 3800 ft., 3½ 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	9.8
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	9.7
max......	10.9	21.9	4.6	11.5	4.3	25.0	10.9	13.1	9.8
min......	10.5	21.2	4.2	11.0	3.9	24.4	10.7	12.3	9.6

TABLE 5.—CONTINUED

Number examined ♂♂ plus ♀♀	Breadth of braincase	Condylobasal length	Interorbital breadth	Mastoidal breadth	Length of maxillary tooth-row	Occipitonasal length	Palatal length	Zygomatic breadth	Zygomatic length
	Zapus princeps cinereus, Raft River Mt's, Utah.								
4 mean	10.5	21.5	5.0	11.1	4.1	24.5	10.9	12.6	9.9
max	11.0	22.5	5.1	11.4	4.3	25.0	11.6	12.9	10.5
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
	Zapus princeps curtatus, 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
	Zapus princeps idahoensis, 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	9.5
max	10.3	21.8	4.4	11.1	4.2	24.8	11.0	12.6	9.9
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	9.5
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	9.7
max	10.6	21.8	4.5	11.5	4.1	25.4	11.1	12.9	10.2
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

TABLE 5.—CONTINUED

Number examined ♂♂ plus ♀♀	Breadth of braincase	Condylobasal length	Interorbital breadth	Mastoidal breadth	Length of maxillary tooth-row	Occipitonasal length	Palatal length	Zygomatic breadth	Zygomatic length
	Zapus princeps idahoensis, Waterton Lakes Park, Alberta.								
5 mean.....	10.6	21.4	4.6	10.7	4.1	24.5	10.8	12.2	9.7
max......	10.9	22.1	4.7	11.0	4.2	25.2	11.0	12.3	10.1
min......	10.3	21.0	4.4	10.4	4.0	24.2	10.6	11.8	9.3
	Zapus princeps kootenayensis, 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
	Zapus princeps luteus, 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	9.5
max......	10.0	20.1	4.8	10.6	3.8	23.7	10.3	11.6	9.7
min......	9.7	19.5	4.5	10.3	3.6	22.9	9.6	11.4	9.4
	Zapus princeps minor, 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	10.2
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	9.8
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

TABLE 5.—CONTINUED

Number examined ♂♂ plus ♀♀	Breadth of braincase	Condylobasal length	Interorbital breadth	Mastoidal breadth	Length of maxillary tooth-row	Occipitonasal length	Palatal length	Zygomatic breadth	Zygomatic length
	Zapus princeps oregonus, 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	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
	Zapus princeps pacificus, 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	10.5
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	10.4
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	9.5
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
	Zapus princeps princeps, Florida, Colorado.								
7 mean.....	10.2	21.4	4.6	10.5	3.7	24.9	11.1	12.3	9.9
max......	10.5	22.3	4.7	11.3	3.8	25.4	11.4	12.5	10.3
min......	9.7	20.7	4.3	9.8	3.5	23.9	10.9	11.9	9.3

TABLE 5.—CONTINUED

Number examined ♂♂ plus ♀♀		Breadth of braincase	Condylobasal length	Interorbital breadth	Mastoidal breadth	Length of maxillary tooth-row	Occipitonasal length	Palatal length	Zygomatic breadth	Zygomatic length
		Zapus princeps princeps, Half Way, Colorado.								
6	mean	10.1	21.7	4.6	10.8	3.9	24.9	11.0	12.3	9.9
	max.	10.3	22.0	4.8	11.1	4.0	25.8	11.3	12.7	10.2
	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
		Zapus princeps saltator, 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
		Zapus princeps utahensis, 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

TABLE 5.—CONTINUED

Number examined ♂♂ plus ♀♀	Breadth of braincase	Condylobasal length	Interorbital breadth	Mastoidal breadth	Length of maxillary tooth-row	Occipitonasal length	Palatal length	Zygomatic breadth	Zygomatic length
	Zapus princeps utahensis, Salamander Lake and Lambs Canyon, 9000 ft., Utah.								
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	10.3
min	10.7	21.5	4.5	11.0	3.9	24.6	10.7	12.6	9.7
	Zapus hudsonius acadicus, vicinity of St. Andrews, New Brunswick								
4 mean	9.6	19.8	4.1	10.2	3.5	23.0	10.1	10.8	9.5
max	9.8	19.9	4.2	10.3	3.7	23.1	10.2	11.1	9.7
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	9.2
max	9.8	19.8	4.5	10.1	3.6	23.3	10.1	11.3	9.4
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	9.2
max	9.9	20.6	4.4	10.6	3.7	23.8	10.6	11.3	9.6
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	9.4
max	9.7	20.1	4.3	10.4	3.5	23.5	10.4	11.4	9.5
min	9.3	19.7	4.0	10.3	3.4	23.3	9.9	11.0	9.3
	Zapus hudsonius alascensis, Lake Clark, Alaska.								
2 mean	9.5	19.3	4.3	10.0	3.6	22.8	9.9	10.7	9.2
max	9.6	19.6	4.4	10.0	3.6	23.0	9.9	10.7	9.2
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	9.5
max	10.0	20.0	4.5	10.6	3.7	24.2	10.4	11.1	9.8
min	9.6	19.0	4.0	9.8	3.5	22.5	9.6	10.2	9.2

TABLE 5.—CONTINUED

Number examined ♂♂ plus ♀♀	Breadth of braincase	Condylobasal length	Interorbital breadth	Mastoidal breadth	Length of maxillary tooth-row	Occipitonasal length	Palatal length	Zygomatic breadth	Zygomatic length
	Zapus hudsonius alascensis, 7 mi. SSE Haines, 10 ft., Alaska.								
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	9.6
max......	10.1	20.1	4.5	10.5	3.6	23.8	10.4	11.3	9.7
min......	9.8	19.5	4.4	10.5	3.5	23.2	10.0	11.2	9.5
	Zapus hudsonius americanus, Boyne Falls, Michigan.								
8 mean.....	9.5	18.7	4.1	9.7	3.3	22.0	9.5	11.0	9.1
max......	9.8	19.4	4.3	10.0	3.4	23.2	10.0	11.4	9.3
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	9.1
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	8.9
max......	9.6	19.1	4.4	9.2	3.5	22.5	9.8	10.7	8.9
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	8.5
max......	9.5	18.8	4.4	9.8	3.5	22.2	9.7	11.0	8.7
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	8.7
max......	9.3	18.9	4.5	9.7	3.3	22.0	9.7	10.8	8.9
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	9.2
min......	8.6	18.5	4.0	9.6	3.2	21.8	9.2	10.0	8.9

TABLE 5.—CONTINUED

Number examined ♂♂ plus ♀♀	Breadth of braincase	Condylobasal length	Interorbital breadth	Mastoidal breadth	Length of maxillary tooth-row	Occipitonasal length	Palatal length	Zygomatic breadth	Zygomatic length
	Zapus hudsonius americanus, Raleigh, North Carolina.								
3 mean.....	9.2	18.8	4.0	9.9	3.4	22.4	9.6	10.9	8.9
max......	9.6	19.7	4.2	10.4	3.5	23.0	9.9	10.9	9.4
min......	8.8	17.9	3.9	9.4	3.2	21.8	9.4	10.8	8.5
	Zapus hudsonius campestris, 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
	Zapus hudsonius canadensis, St. Methode, Quebec.								
4 mean.....	9.6	19.2	4.3	10.1	3.6	22.6	9.8	10.9	9.1
max......	9.9	19.7	4.5	10.2	3.7	23.5	10.1	11.2	9.4
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	9.3
min......	9.6	18.9	4.1	10.2	3.4	22.1	9.6	10.4	8.8
	Zapus hudsonius hudsonius, Fort Severn, Ontario.								
4 mean.....	9.9	19.3	4.2	9.9	3.5	22.7	9.6	10.9	9.2
max......	10.1	19.7	4.3	10.1	3.6	23.3	9.8	11.0	9.3
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	9.2
max......	9.9	19.8	4.6	10.1	3.7	23.1	10.0	10.8	9.6
min......	9.3	18.7	4.2	9.6	3.3	21.7	9.5	9.8	8.8

TABLE 5.—CONTINUED

Number examined ♂♂ plus ♀♀	Breadth of braincase	Condylobasal length	Interorbital breadth	Mastoidal breadth	Length of maxillary tooth-row	Occipitonasal length	Palatal length	Zygomatic breadth	Zygomatic length
	Zapus hudsonius hudsonius, Emma Lake, Saskatchewan.								
2 mean.....	9.8	19.4	4.3	9.9	3.6	22.7	9.8	10.9	9.0
max......	9.8	19.5	4.3	9.9	3.6	22.9	9.9	10.9	9.1
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	9.1
max......	9.8	19.4	4.2	10.0	3.5	22.6	9.9	10.5	9.2
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	9.1
max......	9.6	19.3	4.3	10.1	3.5	22.6	9.8	10.9	9.3
min......	9.5	18.7	4.3	9.7	3.4	21.7	9.5	10.3	8.9
	Zapus hudsonius intermedius, Blackner, North Dakota.								
2 mean.....	10.1	19.6	4.3	10.0	3.6	22.7	9.9	11.1	9.4
max......	10.1	20.0	4.4	10.4	3.7	23.2	9.9	11.4	9.7
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	9.1
max......	9.9	19.1	4.4	10.2	3.7	22.4	9.8	11.3	9.2
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	9.2
max......	9.7	19.6	4.3	10.0	3.6	23.0	9.9	11.0	9.5
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	9.4
max......	9.8	19.3	4.2	10.0	3.4	22.2	9.3	10.2	9.7
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

TABLE 5.—CONTINUED

Number examined ♂♂ plus ♀♀	Breadth of braincase	Condylobasal length	Interorbital breadth	Mastoidal breadth	Length of maxillary tooth-row	Occipitonasal length	Palatal length	Zygomatic breadth	Zygomatic length
	Zapus hudsonius intermedius, Jordan Cr., 3 mi. NE Fairmont, Ill.								
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
	Zapus hudsonius ladas, 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
	Zapus hudsonius pallidus, 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

TABLE 5.—CONCLUDED

Number examined ♂♂ plus ♀♀	Breadth of braincase	Condylobasal length	Interorbital breadth	Mastoidal breadth	Length of maxillary tooth-row	Occipitonasal length	Palatal length	Zygomatic breadth	Zygomatic length
	Zapus hudsonius pallidus, Valentine National Wildlife Refuge, Nebraska.								
1	10.0	19.6	4.5	10.5	3.5	22.9	10.0	11.6	9.3
	Zapus hudsonius preblei, 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
	Zapus hudsonius tenellus, 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	10.0	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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Transmitted October 9, 1953.

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University of Kansas Publications
Museum of Natural History

Volume 7, No. 5, pp. 473-477
April 21, 1954

Mammals from Southeastern Alaska

BY
ROLLIN H. BAKER
AND
JAMES S. FINDLEY

University of Kansas
Lawrence
1953

University of Kansas Publications, Museum of Natural History

Volume 7, No. 5, pp. 473-477
Published April 21, 1954

University of Kansas
Lawrence, Kansas

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1954

25-1126

Mammals from Southeastern Alaska

BY

ROLLIN H. BAKER and JAMES S. FINDLEY

The University of Kansas Museum of Natural History received from J. R. Alcorn and Albert A. Alcorn a sizable collection of mammals taken in the summer of 1951 in Alaska. In addition to visiting localities at which they had collected in 1947 and 1948 (see Baker, Univ. Kansas Publ., Mus. Nat. Hist., 5:87-117, 1951) the Alcorns obtained specimens from localities not previously visited in the vicinity of Anchorage and Haines and from Sullivan Island, a small, timbered island in the Lynn Canal. A part of the funds for field work was made available by the Kansas University Endowment Association. The loan of specimens for comparative study from the Biological Surveys Collection of the United States National Museum is acknowledged.

Sorex obscurus alascensis Merriam. Dusky Shrew.—Comparison of two specimens from 7 miles SSE Haines and eight from Sullivan Island (six from the northeast end of the island and two from the southeast end) with topotypes of *Sorex obscurus longicauda* Merriam from Wrangell, Alaska, and with topotypes of *Sorex obscurus alascensis* from Yakutat, Alaska, shows that our specimens are intermediate between the two named kinds. However in nine of ten characters these specimens more closely resemble *S. o. alascensis* than *S. o. longicauda.* Measurements of specimens from Wrangell and from localities progressively northward along the Alaskan coast reveal a decrease in size of the skull in a clinal fashion. Specimens from Sullivan Island are larger than those from the mainland south of Haines, which are in turn larger than specimens from 9 miles W and 4 miles N of Haines (reported upon by Baker, *op. cit.*). No step is apparent in this cline and assignment of specimens must be made on a somewhat arbitrary basis. Specimens from Juneau, Alaska, in the Biological Surveys Collection of the United States National Museum, were assigned by Jackson (N. Amer. Fauna, 51:128, 1928) to *S. o. alascensis* but seem to us to be closer to *S. o. longicauda.*

Sorex palustris navigator (Baird). Water Shrew.—Two males taken on August 5, at Peters Creek, elevation 300 ft., 20 miles NE of Anchorage provide a northwestern extension of the known range of this species. In external and cranial characters the males resemble *S. p. navigator* from 9 miles W and 4 miles N of Haines, Alaska, and from Washington County, Idaho. The specimens from Peters Creek do not agree with the description of *Sorex alaskanus* Merriam as given by Jackson (*op. cit.*:189) although one, a second year animal, has the lambdoidal crests exceptionally well developed, as does *S. alaskanus.*

Myotis lucifugus lucifugus (LeConte). Little Brown Myotis.—A male taken at Peters Creek, elevation 300 ft., 20 miles NE of Anchorage, is darker than specimens assigned to this subspecies from northeastern British Columbia (Muncho Lake). Eight skins and skulls (three adults and five young of the year) and 18 specimens in alcohol taken at Screw Creek, elevation 2600 ft., mile 742 (10 miles S and 50 miles E Teslin, Yukon Territory), British Columbia, seem typical of *M. l. lucifugus.* These were obtained on August 11, 1951, at the same locality where on July 1, 1947, a single bat assigned to *M. l. alascensis* Miller was taken (see Baker, *op. cit.*: 95). The latter specimen is readily distinguished by its darker color both above and below from those taken in 1951.

Tamiasciurus hudsonicus kenaiensis Howell. Red Squirrel.—A female taken at Peters Creek, elevation 300 ft., 20 miles NE of Anchorage, is referred to this subspecies after comparison with the published description of *T. h. kenaiensis* Howell (Proc. Biol. Soc. Washington, 49:136, 1936), with specimens of *T. h. preblei* Howell from Yerrick Creek, Alaska, and with *T. h. petulans* (Osgood) from 1 mile S of Haines.

Tamiasciurus hudsonicus petulans (Osgood). Red Squirrel.—Three specimens were taken on Chilkat Peninsula, elevation 10 ft., 7 miles SSE of Haines, Alaska, and one at the southeast end of Sullivan Island. These squirrels, taken in June and July, are molting on the sides, back and rump. Compared with the specimens from the mainland the male from Sullivan Island is paler on the back—near (*h*) Ochraceous-Tawny instead of near (14*j*) Sudan Brown (capitalized color terms from Ridgway, Color Standards and Color Nomenclature, Washington, D. C., 1912)—and paler on the tail; otherwise this specimen resembles those from the mainland.

Peromyscus maniculatus algidus Osgood. Deer Mouse.—Osgood (N. Amer. Fauna, 28:54, 1909) reported intergradation between *P. m. algidus* and *P. m. hylaeus* Osgood in the "region of Lynn Canal." One female from the mouth of the Endicott River, elevation 10 ft., seems referable to *algidus*. In comparison with two topotypes of *hylaeus* this specimen is not so dark and more nearly agrees with *algidus* from the Chilkat River, from 1 mile W of Haines and from Dezadeash Lake, Yukon Territory.

Phenacomys intermedius mackenzii Preble. Mountain Phenacomys.—An adult female was taken on 28 July at the southwestern end of Dezadeash Lake, elevation 2400 ft., in Yukon Territory (approximately 60 miles from the Alaskan boundary north of the Lynn Canal), the same place where a specimen was obtained in 1948 (see Baker, *op. cit.*:104).

Microtus longicaudus littoralis Swarth. Long-tailed Vole.—Six of these voles were taken on Sullivan Island (two at the northeast end and four at the southeast end) and another was trapped on the mainland at the mouth of the Endicott River. All seven resemble *M. l. littoralis* from the vicinity of Haines. One large adult male from the island has the following measurements: Total length, 202; length of tail, 71; length of hind foot, 21; height of ear from notch, 13.

Microtus oeconomus macfarlani Merriam. Tundra Vole.—Five specimens from 5 miles NNE of Gulkana, Alaska, 1700 ft., and four from Peters Creek, elevation 300 ft., 20 miles NE of Anchorage, Alaska, are assigned to this subspecies. In color they resemble *macfarlani* from eastern Alaska (14 miles E and 25 miles N of Fairbanks) and are darker than *M. o. operarius* (Nelson) from Tyonek, but judging from the description by Bailey (N. Amer. Fauna, 17:41, 1900), are not so dark as *M. o. yakutatensis* Merriam. These mice were taken inland from the coast. It is likely that the coastal population more nearly resembles either *operarius* or *yakutatensis*.

Erethizon dorsatum myops Merriam. Porcupine.—Skulls of two females obtained from the Chilkat Peninsula, elevation 10 ft., 7 miles SSE of Haines, Alaska, agree with those of the same sex of *myops* from Yerrick Creek, Alaska, and from 2 miles W of the Teslin River, Yukon Territory. The skull of the older animal has the longer nasals and more pronounced cranial ridges, which perhaps indicate a tendency toward *E. d. nigrescens* Allen, which occurs to the southward (see Anderson, Canadian Jour. Res., 21: 304, 1943).

Transmitted October 8, 1953.

25-1126

University of Kansas Publications
Museum of Natural History

Volume 7, No. 6, pp. 479-487

April 21, 1954

Distribution of Some Nebraskan Mammals

BY

J. KNOX JONES, JR.

University of Kansas
Lawrence
1954

University of Kansas Publications, Museum of Natural History

Editors: E. Raymond Hall, Chairman, A. Byron Leonard,
Robert W. Wilson

Volume 7, No. 6, pp. 479-487
Published April 21, 1954

University of Kansas
Lawrence, Kansas

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1954
25-2530

Distribution of Some Nebraskan Mammals

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J. Knox Jones, Jr.

Because military service will interrupt my study of Nebraskan mammals, I am here placing on record certain information on the geographic distribution of several species — information that is thought pertinent to current studies of some of my associates. Most of this information is provided by specimens recently collected by me and other representatives of the University of Kansas Museum of Natural History, although specimens from other collections provide some of the records herein reported. The other collections are the Biological Surveys Collection of the United States National Museum (USBS), the Hastings Museum (HM), the Nebraska Game, Forestation and Parks Commission (NGFPC), the University of California Museum of Vertebrate Zoology (MVZ), the University of Michigan Museum of Zoology (MZ) and the University of Nebraska State Museum (NSM). Grateful acknowledgment hereby is made to persons in charge of these several collections for lending the materials concerned. Specimens mentioned in the following accounts are in the University of Kansas Museum of Natural History, except as otherwise stated. All measurements are in millimeters. Color terms are those of Ridgway (1912). A part of the funds for field work was made available by the National Science Foundation and the Kansas University Endowment Association.

Sorex cinereus haydeni. (Baird). Cinereous Shrew.—Two male shrews were trapped on April 7, 1952, among rocks along an old railroad fill, 4 mi. N, ½ mi. E of Octavia, Butler County, thus extending the known geographic range of *S. c. haydeni* approximately 60 miles southward from a line connecting Perch, Rock County, Nebraska, with Wall Lake, Sac County, Iowa (see Jackson, 1928:52-53), and providing the first record of occurrence in the Platte River Valley. Two additional specimens, taken on July 17, 1952, are from 2½ mi. N of Ord, Valley County, along the Loup River, a tributary of the Platte from the north.

Blarina brevicauda carolinensis (Bachman). Short-tailed Shrew.—J. S. Findley and I, in a forthcoming paper, review the distribution of *Blarina brevicauda* in the Great Plains region, recording *B. b. carolinensis* from the extreme southeastern and southwestern counties of Nebraska. A series of five shrews of this species recently obtained from three miles south and two miles east of Nebraska City in Otoe County, average significantly smaller in both the cranial and the external measurements than typical *B. b. brevicauda* and fall well within the range of *carolinensis*. Average and extreme external measurements of the four adults from Otoe County, three males and one female, are as follows: Total length, 110 (109-112); length of tail-vertebrae, 24.2 (22-26); length of hind foot, 13.8 (13-14). Another specimen from 3 mi. S, 1½ mi. E of Peru, Nemaha County, also is referable to *carolinensis*. These recent records indicate that the range of *B. b. carolinensis* extends up the Missouri River Valley, approximately to Nebraska City, Otoe County. Five specimens from Louisville, Cass County, the next county northward, along the River, are referable to *B. b. brevicauda*.

Eptesicus fuscus fuscus. (Beauvois). BIG BROWN BAT.—One big brown bat was obtained on July 23, 1952, from one mile west of Niobrara, Knox County. While not so dark in dorsal coloration as some specimens of *E. f. fuscus* from eastern Nebraska (Cass and Sarpy counties), this specimen is noticeably darker than a series of *E. f. pallidus* from Ft. Niobrara Wildlife Refuge, 4 mi. E of Valentine, Cherry County, being near (16″ *j*) Snuff Brown as opposed to near (16′ *i*) Buckthorn Brown. Previous to the taking of this specimen, Webb and Jones (1952:277) reported as *E. f. pallidus* a specimen, saved as a skull only, which was picked up dead at Niobrara. It seems best to assign these two bats from the vicinity of Niobrara, Knox County, to *E. f. fuscus*.

Sciurus carolinensis carolinensis Gmelin. GRAY SQUIRREL.—An adult male gray squirrel shot by Mr. Terry A. Vaughan in the heavily timbered bluffs of the Missouri River, 3 mi. S, 2 mi. E of Nebraska City, Otoe County, on October 10, 1953, provides the only museum specimen of a gray squirrel from Nebraska known to me. Residents in the area concerned report small numbers of this squirrel as still occurring on the heavily wooded bluffs along the Missouri River in Nemaha, Otoe and Richardson counties, Nebraska, at least as far north as Nebraska City.

Gray squirrels from Nebraska have been reported twice before in the literature as follows: "Mouth of Platte [River]" (Baird, 1858: 262) and Barada, Richardson County (Jones and Webb, 1949:312). Swenk (1908:80), while listing no actual records, says of this squirrel, "Common in the timber along watercourses of southeastern

Nebraska, but greatly outnumbered everywhere by [*Sciurus niger*] *rufiventer*. I have no records west of the 97th meridian nor north of the Platte."

Spermophilus franklinii (Sabine). FRANKLIN GROUND SQUIRREL. —A specimen from 2 mi. NW of Lisco, in Morrill County (NSM 3324), extends the known geographic range of *S. franklinii* approximately 200 miles westward along the Platte River Valley from Kearney, Buffalo County (see Howell, 1938:134), and suggests a westward movement of this ground squirrel along the Platte River in recent years.

Perognathus flavescens flavescens Merriam. PLAINS POCKET MOUSE.—*P. f. flavescens* occurs in the Sand Hills and adjacent mixed-grass plains of central Nebraska. Eastern marginal records of occurrence are: Neligh, Antelope County, 2 (MVZ 1, NSM 1); 1 mi. E of Ravenna, Buffalo County, 2 (MZ); unspecified locality in Adams County, 1 (HM).

Perognathus flavescens perniger Osgood. PLAINS POCKET MOUSE. —This mouse occurs in northeastern Nebraska. Osgood (1904:127), in the original description of the subspecies, listed two specimens from Verdigris [Verdigre], Knox County. Additional records of occurrence are: Beemer, Cuming County, 2 (USBS); 1½ mi. SE of Niobrara, Knox County, 3; 1½ mi. S of Pilger, Stanton County, 2.

The two specimens from Beemer are typical *perniger*. All of the other Nebraskan specimens are intergrades between *P. f. flavescens*, geographically adjacent to the west, and *P. f. perniger* to the east but are best referred to *perniger* on the basis of greater total length, larger cranial measurements and darker dorsal coloration.

P. f. perniger was originally described (Osgood, *op. cit.*) on the basis of its darker dorsal coloration and encroachment of the lateral line on the posterior parts of the venter. The latter character is not present in all Nebraskan specimens. Mice from the two localities in Knox County have buffy underparts; those from other Nebraskan localities do not. Of nine specimens of *P. f. perniger* examined from Elk River, Sherburne County, Minnesota, none has buffy underparts whereas a specimen from Randolph, Fremont County, Iowa (NSM) does. In addition, in two of five specimens of *P. f. flavescens* from Kelso, Hooker County, (MZ) the lateral line encroaches on the underparts. The encroachment of the lateral line on the underparts, or failure of the line to do so, is thought to be only an individual variation and of no taxonomic use.

Perognathus flavus piperi Goldman. BUFFY POCKET MOUSE.—In the description of *P. f. bunkeri,* Cockrum (1951:206) allocated to the new subspecies, without comment, a specimen from Alliance, Box Butte County. I have examined this specimen along with all other Nebraskan specimens known to me and, although all approach *bunkeri* in cranial measurements, they seem best referred to *piperi* on the basis of darker dorsal coloration and larger external measurements. Additional records of occurrence, several of them marginal to the eastward, are: 10 mi. S of Antioch, Garden County, 1 (MZ); Kelso, Hooker County, 4 (MZ); 5 mi. N of Bridgeport, Morrill County, 1 (MVZ); 6 mi. N of Mitchell, Scotts Bluff County, 1 (NSM). A specimen not seen by me that was reported from Valentine, Cherry County (Beed, 1936:21), is presumably also best referred to *P. f. piperi.*

No specimens of *P. flavus* are known to me from south of the Platte River in southwestern Nebraska although they probably occur there. If so, they may be referable to *P. f. bunkeri,* which is found in counties of Kansas adjoining the southwestern part of Nebraska.

Perognathus hispidus paradoxus Merriam. HISPID POCKET MOUSE.—This subspecies occurs commonly in central- and western-Nebraska. Eastern marginal records of occurrence are: 2 mi. SE of Niobrara, Knox County, 1 (NGFPC); 4 mi. E, 2 mi. S of Ord, 1; Bladen, Webster County, 2 (HM).

Perognathus hispidus spilotus Merriam. HISPID POCKET MOUSE.—Jones and Webb (1949:312) first reported this subspecies in Nebraska as from 5 mi. SE of Rulo, Richardson County. Additional records of occurrence are: 3 mi. SW of Barnston, Gage County, 1 (NGFPC); Bennet, 1 (NSM), 9 mi. NW of Lincoln, 1 (NSM), 1½ mi. S of Lincoln, 1 (NSM), Lancaster County; Peru, Nemaha County, 1 (NGFPC); 3 mi. S, 2 mi. E of Nebraska City, Otoe County, 3; Barada, Richardson County, 1 (NSM); Pleasant Dale, Seward County, 1 (NSM); 1 mi. S of Williams, Thayer County, 1.

Glass (1947:179) referred a specimen from 9 mi. NW of Lincoln, Lancaster County, to *P. h. paradoxus.* In discussing the zone of intergradation between *spilotus* and *paradoxus,* geographically adjacent to the west, he wrote (*op. cit.*:178), "It is evident that it proceeds northeastwards, toward the Missouri River since 2 specimens from eastern Nebraska, a juvenile from Webster County and an adult from Lancaster County, are both typical *paradoxus.*" I have examined the specimen from Webster County referred to by Glass and agree that it is *paradoxus.* I have not seen the specimen from

9 mi. NW of Lincoln; however, another specimen from there, two others from Lancaster County, and one from Seward County (see above), are here referred to *P. h. spilotus,* rather than *P. h. paradoxus,* on the basis of notably darker dorsal coloration and smaller external and cranial measurements. The range of *P. h. spilotus* in Nebraska, as presently known, therefore, is limited to the eastern, more humid part of the State, south of the Platte River.

Peromyscus maniculatus osgoodi Mearns. DEER MOUSE.—Swenk (1908:95) reported this subspecies, under the name *Peromyscus nebrascensis,* from Glen, and Dice (1941:17) reported the subspecies from Agate, both localities being in Sioux County in the northwestern part of the State. Osgood (1909), however, did not mention Nebraskan specimens of this subspecies and excluded it from the State on his (*op. cit.*) distribution map of the subspecies of *P. maniculatus.* In addition, Quay (1948:181) reports, as *P. m. nebrascensis,* deer mice obtained by him in the badlands of northern Sioux County and adjacent Niobrara County, Wyoming. Four deer mice referable to *P. m. osgoodi* have been obtained from several localities on the Pine Ridge in Dawes County as follows: 3 mi. E of Chadron, 2; Chadron State Park, 1; 3 mi. SW of Crawford, 1. When compared with specimens of *P. m. nebrascensis,* geographically adjacent to the east, these mice are seen to be notably darker and less buffy than *nebrascensis* and to average significantly larger in both external and cranial measurements. All deer mice from the Pine Ridge and adjacent badlands of extreme northwestern Nebraska probably are best referred to *P. m. osgoodi.* External measurements of two adult females are respectively: Total length, 180, 175; length of tail-vertebrae, 78, 74; length of hind foot, 19, 20; length of ear, 17, 16.

Neotoma floridana campestris J. A. Allen. FLORIDA WOOD RAT.—Five wood rats from 5 mi. N, 2 mi. W of Parks, Dundy County, in extreme southwestern Nebraska, provide the first record of occurrence of this subspecies in Nebraska. These animals were trapped in outlying sheds at the Rock Creek State Fish Hatchery. Two large wood-rat houses were in a dense thicket of brush and young trees in a small draw on the west side of the most westwardly hatchery lake. Brown rats (*Rattus norvegicus*) inhabited a combination garage-storage barn at the hatchery and no wood rats were taken there.

Microtus pennsylvanicus pennsylvanicus (Ord). PENNSYLVANIA MEADOW MOUSE.—This subspecies occurs in eastern and central

Nebraska (see Bailey, 1900:18 and Swenk, 1908:104). Additional records of occurrence are as follows: 5 mi. E of Rising City, Butler County, 5; 4 mi. SE of Laurel, Cedar County, 1; Wayne, 2, and 2½ mi. E of Wayne, 1, Wayne County; 2½ mi. N of Ord, Valley County, 4.

Synaptomys cooperi gossii (Coues). COOPER LEMMING MOUSE.—Fichter and Hanson (1947:1-8) reported the first known occurrence of this microtine in Nebraska, recording specimens from several localities in Lancaster County and one from near Valentine, Cherry County. Recent records of this mouse which help to clarify its distribution in Nebraska are as follows: 4 mi. N, ½ mi. E of Octavia, Butler County, 1; 5 mi. N, 2 mi. W of Parks, Dundy County, 1; 1 mi. N of Pleasant Dale, Seward County, 1.

An adult female from Dundy County provides the westernmost record of distribution of the species in North America. The animal was trapped on November 1, 1952, in association with *Microtus pennsylvanicus modestus* in a marshy area at the Rock Creek State Fish Hatchery on spring-fed Rock Creek. The pelage on the back is notably darker than in *S. c. gossii,* and resembles *S. c. paludis* from the Cimarron River drainage in Meade County, Kansas, but in the sum total of its characters it most closely resembles *S. c. gossii* among named subspecies.

Mustela rixosa campestris Jackson. LEAST WEASEL.—The least weasel occurs in eastern and central Nebraska (see Swenk, 1926: 313-330 and Hall, 1951:192) but is known by only a single specimen from each locality of record save for the area around Inland, Clay County (Swenk, *op. cit.*). Additional records of the distribution of this mustelid in Nebraska are: Hastings, Adams County, 1 (HM); Schuyler, Colfax County, 1 (NGFPC); Goehner, Seward County, 1 (NSM); 10 mi. S of Ord, Valley County, 1 (NGFPC). The last mentioned specimen, a skull only, was obtained from a pellet of an unidentified raptorial bird.

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Transmitted January 11, 1954.

25-2530

University of Kansas Publications
Museum of Natural History

Volume 7, No. 7, pp. 489-506, 2 figures in text
July 23, 1954

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University of Kansas Publications, Museum of Natural History

Editors: E. Raymond Hall, Chairman, A. Byron Leonard,
Robert W. Wilson

Volume 7, No. 7, pp. 489-506, 2 figures in text
Published July 23, 1954

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Lawrence, Kansas

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1954

25-3560

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SYDNEY ANDERSON

Microtus montanus reaches the eastern limits of its geographic distribution in Wyoming and Colorado. There the mountains, but in general not the lowlands, are occupied by this species. A certain minimum of moisture may be of direct importance to the mouse and certainly is indirectly important, because certain hydrophytic or mesophytic grasses used by the mouse for food, for protection from enemies, and for shelter from the elements are dependent on the moisture. Areas suitable for *Microtus montanus* are separated by deserts that are dominated by sagebrush and other xerophytic plants or by forests or rocky exposures at higher altitudes. A relatively small percentage, probably less than ten per cent, of the total area even in the more favorable parts of the range of the species is suitable for occupancy. In these mice, as in other microtines (Elton, 1942; Piper, 1909), there are seasonal, and irregularly multiannual fluctuations in population density, which sometimes are extreme. Consequently the mice at some times seem to be absent from suitable habitats, and at some other times occur there in amazingly large numbers.

Because the species is broken up into partly isolated, or at times completely isolated, colonies or local populations it may be supposed that various evolutionary forces such as selection and random genetic drift operate to foster variation. The degree to which racial distinction is attained may depend upon these forces and the time available. In *Microtus montanus* in the eastern Rocky Mountains the degree of subspecific distinction is not great.

The study here reported upon is based on 1,187 specimens of *Microtus montanus* from Wyoming, Colorado, Idaho and Montana, and on work in the field. I spent approximately four months in the field in this area, in the summers of 1950, 1951, and 1952. The specimens studied were arranged according to localities and the larger series were compared statistically. Each of two series, totaling 136 specimens, was studied intensively to ascertain the kind and range of variation within single populations. Twenty-seven measurements, various proportions based on these measurements, and differences in color were analyzed. Fifteen characters, judged to be most significant, were selected for use in comparing all series. In addition, certain characters that can not be expressed easily by measurements, such as inflation of the auditory bullae and the curvature of the zygomatic arch, were observed. The studies by A. B. Howell (1924) of variation in *Microtus montanus yosemite* Grinnell in California and those by O. B. Goin (1943) of *Microtus pennsylvanicus pennsylvanicus* (Ord) were useful. The external measurements are from the collectors' field labels. The measurements of the skull all were taken with dial calipers reading to a tenth of a millimeter. The anteroposterior measurements of the skull all were taken along the shortest line between the points specified below and are not necessarily along a line parallel to the long axis of the skull. These measurements were taken on the left side of the skull whenever possible. Some of the skulls are damaged and therefore some measurements could not be taken and are omitted in the computations. Measurements are in millimeters.

The results of these studies were submitted to the Department of Zoology and the Graduate School of the University of Kansas in partial fulfillment of the requirements for the degree of Master of Arts (1952) and are available in manuscript form at the Museum of Natural History and the library of the University of Kansas.

EXPLANATION OF MEASUREMENTS

Caudal index.—the length of the tail expressed as a percentage of the length of the head and body. The length of the head and body is the collector's measurement of total length less the length of the tail.

CRANIAL MEASUREMENTS OF LENGTH.

Condylobasilar length.—from the exoccipital condyle to the most posterior point on the border of the alveolus of the upper incisor.

Alveolobasilar length.—from the posterior border of the alveolus of the third upper molar to the posterior border of the alveolus of the incisor.

Palatilar length.—from the anteriormost part of the posterior border of the bony shelf of the palate to the posteriormost part of the alveolus of the incisor.

Alveolar length of upper molar tooth-row.—from the most posterior point of the alveolus of the third upper molar to the most anterior point of the alveolus of the first upper molar.

MEASUREMENTS OF BREADTH.

Zygomatic breadth.—greatest transverse width.

Interorbital breadth.—the breadth of the interorbital constriction.

Lambdoidal breadth.—between the lateralmost points of the lambdoidal crest.

Prelambdoidal breadth.—between the medialmost margins of the prominent fenestrae in the posterodorsal parts of the squamosal bones. To these fenestrae Howell (1924:995) applied the adjective "prelambdoidal," but other authors have used other names (see Hill, 1935:127).

Depth of braincase.—shortest distance from the ventral side of the cranium at the suture between the basioccipital and basisphenoid bones to the dorsal surface of the cranium (usually not perpendicular to the long axis of the skull).

The history of our knowledge of *Microtus montanus* in this area begins with the early work of the United States Bureau of Biological Survey directed by C. H. Merriam (1891), and participated in by Vernon Bailey (1900, 1917), Merritt Cary (1911, 1917), and others. The changes in nomenclature which grew out of increased understanding of these mice through additional collecting are expressed in the synonymies under the accounts of subspecies. As a result of my studies two of the three subspecific names previously proposed for mice from this area have been retained although changes are proposed in the ranges assigned to the two subspecies and two additional heretofore unrecognized subspecies are named and described. Furthermore the additional specimens and my studies of variation make modifications in the characterization of these subspecies necessary. Not all of the samples here assigned to a single subspecies are identical and I therefore list and discuss some of the local variants.

Numerous members of summer field parties from the Museum of Natural History at the University of Kansas collected most of the specimens studied and wrote field notes that have been helpful. I am grateful to these persons and to Professor E. R. Hall and Dr. R. H. Baker for their assistance and helpful suggestions. Specimens in the following museums were made available by their respective curators: Chicago Natural History Museum by Mr. Colin C. Sandborn, The Museum of Zoology at the University of Michigan by Dr. E. T. Hooper, The American Museum of Natural History by Mr. G. G. Goodwin, The United States National Museum by Dr. David H. Johnson and the Biological Surveys Collection by Miss Viola S. Schantz. A fellowship from the National Science Foundation made possible the studies at the museums other than at the University of Kansas.

Microtus montanus nanus (Merriam)

Arvicola (Mynomes) nanus Merriam, N. Amer. Fauna, 5:62, July 30, 1891.
Microtus montanus nanus, Hall, Proc. Biol. Soc. Washington, 51:131, August 23, 1938.
Microtus nanus, Bailey, N. Amer. Fauna, 17:30, June 6, 1900 (part).
Microtus montanus caryi Bailey, Proc. Biol. Soc. Washington, 30:29, February 21, 1917.
Microtus nanus nanus, Cary, N. Amer. Fauna, 42:43, October 3, 1917 (part).

Type.—Adult male No. $\frac{23853}{31253}$, U. S. National Museum, Department of Agriculture collection, from Pahsimeroi Mountains, Custer County, Idaho; obtained by C. Hart Merriam and Vernon Bailey, September 16, 1890.

Range.—Idaho; southwestern Montana; most of the southwestern half of Wyoming; southward to central Colorado. See figure 1.

Comparisons.—Comparisons with subspecies named as new in this paper will be found in the accounts of those subspecies beyond. From *Microtus montanus fusus* Hall, the subspecies to the south, *M. m. nanus* from Idaho differs as follows: averages smaller; slightly darker and less reddish and less yellowish in color; slightly wider braincase (see measurement of prelambdoidal breadth); larger bullae.

Measurements.—Average (= arithmetical mean) measurements of 34 specimens, both male and female, from several localities in eastern Idaho are: total length, 151; length of tail, 39; hind foot, 19.2; condylobasilar length of the skull, 25.0; zygomatic breadth, 15.0; alveolar length of upper molar tooth-row, 6.4; prelambdoidal breadth, 8.9; and lambdoidal breadth, 11.7.

Average and extreme measurements of six adult males from near Pocatello, Bannock County, Idaho, and nine adult males from near Afton, Lincoln County, Wyoming, are, respectively, as follows: total length, 143(135-150), 163(143-179); length of tail, 35.1(33-38), 42.8(36-49); caudal index, 32.0(28.0-33.1), 35.7(30.6-41.9); hind foot, 18.9(18-20), 18.8(17-20); condylobasilar length of skull, 24.4(24.0-26.0), 25.6(24.5-26.2); alveolobasilar length, 14.1(13.7-14.5), 14.6(13.8-15.0); palatilar length, 13.2(12.9-13.6), 13.8(13.2-14.5); alveolar length of upper molar tooth-row, 6.3(6.1-6.5), 6.3(6.0-6.6); depth of braincase, 7.7(7.5-7.9), 8.0(7.7-8.3); lambdoidal breadth, 11.4(11.0-11.7), 12.0(11.3-12.7); prelambdoidal breadth, 9.1(8.6-9.4), 8.7(8.0-9.4); zygomatic breadth, 14.3(13.8-14.7), 15.3(14.4-16.3); interorbital breadth, 3.6(3.5-3.7), 3.5(3.3-3.7). The average length of the nasal bones in the series from Pocatello is 7.1 mm. The averages, which have not been included in Table 1, for three measurements of the series from Carbon County, Wyoming, are as follows (Encampment, males; Encampment, females; Savery, males; and Savery, females, respectively): alveolobasilar length, 14.4, 14.3, 14.5, 14.3; interorbital breadth, 3.5, 3.4, 3.5, 3.4; depth of braincase, 7.8, 7.6, 7.9, 7.6. Additional measurements are included in Table 1 for other series.

Discussion.—The name *Microtus montanus caryi* Bailey is here placed in synonymy under *M. m. nanus* (Merriam). Vernon Bailey (1917) in his description of *caryi* made four assumptions that have been found to be entirely or partly invalid. First, he assumed that this is an "extreme variant which gradually changes in characters across Nevada and Utah, and reaches its maximum variation in Wyoming." The differences pointed out in subsequent descriptions of subspecies found in the above area do not show a gradual change in any character, or in the number of characters, nor is *caryi* an extreme when compared with the other subspecies. Second, *Microtus nanus* was not, as Bailey assumed, a different species than *Microtus montanus.* Third, he assumed that the characteristics of adults of *nanus* were adequately ascertainable from the thirteen topotypes available to him. Subsequent sampling from Idaho shows that the series of specimens available to Bailey was made up mostly of young and subadult animals. Finally, *caryi* does not occupy as Bailey stated "the meadows along streams in the arid sagebrush country of the Bear River, Green River, and Wind River valleys" exclusively, or characteristically. When the localities from which the species actually is known are plotted, it seems that the arid basin serves as a barrier and that the species is more commonly and abundantly found in montane meadows in the Transition and Canadian life-zones.

Certain samples, here assigned to *M. m. nanus,* that vary from the average of the subspecies deserve comment. For example, mice from the area in Wyoming southwest of the Green River (in the Uinta Mountains) have relatively smaller feet, but are larger in both total length and size of skull. Specimens from near Afton, Lincoln County, Wyoming, are relatively large in both total length and size of skull. This series and specimens from Teton County, Wyoming, are intermediate between *nanus* from Idaho and the newly named subspecies from near Cody, Park County, Wyoming, described below, in terms of both darkness and the amount of reddish color. Mice from Laramie County are more richly reddish-brown. The specimens from near Savery, in Carbon County, Wyoming, are darker. The alveolobasilar length relative to the condylobasilar length is smaller in the series from along Deer Creek, 16 mi. S, 11 mi. W Waltman, Natrona County, Wyoming. The series from the southern tier of counties in Wyoming and some of the specimens from Colorado have relatively wider zygomatic arches. The specimens from southern Sweetwater County, Wyoming, are relatively paler, have a relatively longer tail and longer hindfeet, lesser condylobasilar length, and wider braincase. Most of these variations are of questionable significance; they may be chance variations owing to errors in sampling.

Much of the south-central part of the state is relatively low and relatively arid. This area includes the arid basin of the Green River and its major tributaries and the arid Red Desert along the continental divide in Sweetwater County. This area might have acted as a barrier to the mice; gene flow might have been prevented between the populations of the western part of the state and those farther east in the Medicine Bow Mountains and Laramie Mountains. Nevertheless geographic variations of subspecific worth have not taken place. The barrier has either not been of as long duration, or has not been so complete and effective, as the other barriers in the state, namely the Absaroka Range, the Big Horn Basin, the Shoshone Basin, and the valley of the North Platte River. These four barriers presumably have led to the differentiation of the two subspecies that are newly named beyond. Each of the two areas which is set apart by these barriers and in which one of the newly named subspecies has evolved is small; therefore there is a lesser amount of suitable habitat available for each of the newly named mice than there is for *M. m. nanus.* It is conceivable, therefore, that in periods of adverse conditions in each of the small areas the size of the effective breeding population may have been so small that random genetic drift could have operated effectively, or that selection was more critical than in a larger, more stable population. It is difficult to test these possibilities because the selective value of the taxonomic characters is unknown. The observed pattern of variation and facts of distribution are, however, not contradictory to the above possibilities.

Specimens examined.—Total, 993, distributed as follows: All specimens unless otherwise indicated are in the University of Kansas Museum of Natural History. Specimens in other museums are labeled as follows: Chicago Natural History Museum (Chi); University of Michigan, Museum of Zoology (Mich); American Museum of Natural History (AMNH); United States National Museum (USNM); Biological Surveys Collection (USBS). Localities that are not represented in Fig. 1 because overlapping or crowding of the symbols would result are Italicized. Localities are arranged from north to south by states, within a state from northwest to southeast by counties, and within a county from north to south.

Wyoming: *Yellowstone Park:* Canyon Camp, 1 (USBS); Lower Geyser Basin, 1 (USBS); Upper Yellowstone River, 2 (AMNH); *North end of Lake, Yellowstone National Park,* 2 (AMNH). *Teton Co.:* Pacific Creek, 1 (USBS); *Big Game Ridge,* 3 (USBS 1, Mich 2); *Whetstone Creek,* 7 (Mich); Moran and environs (6 localities within a 5 mile radius), 28 (USBS 2, Mich 5); *S fork Buffalo River,* 7 (AMNH); 2 mi. W pass, Black Rock Creek, 1 (USBS); *Jenny Lake,* 5 (Mich); Bar BC Ranch, 2½ mi. NE Moose, 6500 ft., 2; Teton Pass above Fish Creek, 1 (USBS); Jackson and environs, 142 (Mich 141); *Sheep Creek,* 2 (Mich). *Lincoln Co.: 13 mi. N, 2 mi. W Afton,* 2; *10 mi. N, 2 mi. W Afton,* 4; *9½ mi. N, 2 mi. W Afton,* 3; 9 mi. N, 2 mi. W Afton, 9; *7 mi. N, 1 mi. W Afton,* 12; Afton, 1 (USBS); Labarge Creek, 1 (USBS); Border, 6 (USBS); *Cokeville,* 2 (USBS); 6 mi. N, 2 mi. E Sage, 1; Cumberland, 5 (USBS). *Sublette Co.:* 34 mi. N, 4 mi. W Pinedale, 1; *33 mi. N, 2 mi. W Pinedale,* 6; *32 mi. N, 1 mi. W Pinedale,* 1; *31 mi. N Pinedale,* 4; Dell Creek, on Ferris Ranch, 7 (Mich); Horse Creek, 7800 ft., Merna, 4 (USBS); Big Piney, 1 (USBS). *Fremont Co.:* 17½ mi. W, 2½ mi. N Lander, 9500 ft., 3; *17 mi. W, 2 mi. N Lander, 9300 ft.,* 4; Milford and environs (5 localities within a 1 mile radius), 23 (USBS 4); 15½ mi. S, 7½ mi. W Lander, 9200 ft., 1; South Pass City, 8000 ft., 8 (USBS); *23½ mi. S, 5 mi. W Lander, 8600 ft.,* 7. *Natrona Co.:* Deer Creek, 16 mi. S, 11 mi. W Waltman, 6950 ft., 44; 6 mi. S, 2 mi. W Casper, 5900 ft., 4; *6⅘ mi. S, 2 mi. W Casper, 6100 ft.,* 1; *7 mi. S, 2 mi. W Casper, 6370 ft.,* 3; *10 mi. S Casper, 7750 ft.,* 33; Sun, 2 (USBS); *5 mi. W Independence Rock, 6000 ft.,* 4; *5 mi. W, 1 mi. S Independence Rock,* 2. *Converse Co.:* Beaver, 1 (USBS). *Uinta Co.: 1½ mi. W, ½ mi. S Cumberland,* 6; *16 mi. S, 2 mi. W Kemmerer, 6700 ft.,* 3; 10 mi. SW Granger, 3 (Mich); Fort Bridger, 6650 ft., 25 (USNM 6); 9 mi. S Robertson, 8000 ft., 9; *9½ mi. S, ½ mi. W Robertson, 8600 ft.,* 1; *10 mi. S, 1 mi. W Robertson, 8700 ft.,* 25; *14 mi. S, 2 mi. E Robertson, 9000 ft.,* 5; 4 mi. S Lonetree, 1 (USBS). *Sweetwater Co.:* Farson, 3; Bitter Creek, 3 (AMNH); Kinney

Ranch, 21 mi. S Bitter Creek, 6800 ft., 9 (USNM 1, AMNH 2); 32 mi. S, 22 mi. E Rock Springs, 7025 ft., on Vermillion Creek, 15. *Carbon Co.:* 18 mi. NNE Sinclair, 6500 ft., 10; Bridgers Pass, 18 mi. SW Rawlins, 7500 ft., 7; Saratoga, 1 (USBS); *6 mi. S, 13 mi. E Saratoga, 8500 ft.,* 5; *6 mi. S, 14 mi. E Saratoga, 8800 ft.,* 1; Lake Marie, 10,440 ft., 2; *1 mi. S Lake Marie,* 2; *½ mi. S, 2 mi. E Medicine Bow Peak, 10,800 ft.,* 1; Encampment (12 localities from 10 mi. N, 14 mi. E to 9 mi. N, 3 mi. E Encampment and from 6500 to 8400 ft.), 63; ¼ mi. N Riverside, 7380 ft., 2; S base Bridger Peak, 8800 ft., Sierra Madre Mountains, 1; *2 mi. S Bridger Peak, 9300 ft.,* 2; Savery (10 localities from 8 mi. N, 21 mi. E to 4 mi. N, 8 mi. E Savery and from 7300 to 8800 ft.), 80. *Albany Co.: 30 mi. N, 10 mi. E Laramie, 6760 ft.,* 6; *29¾ mi. N, 9½ mi. E Laramie, 6350 ft.,* 1; 26 mi. N, 4½ mi. E Laramie, 6960 ft., 8; *26¾ mi. N, 6½ mi. E Laramie, 6700 ft.,* 3; *3 mi. N, 13 mi. E Laramie, 7500 ft.,* 1; *7 mi. N, 2 mi. E Laramie,* 1 (Chi); 5 mi. N Laramie, 7400 ft., 15; *Laramie,* 4 (AMNH); *1 mi. E Laramie, 7160 ft.,* 4; 7$\frac{7}{10}$ mi. SSW Laramie, 7200 ft., 4; 6½ mi. S, 8¾ mi. E Laramie, 8200 ft., 1; *Headquarters Park, 10,200 ft., Medicine Bow Mountains,* 3 (USBS); Centennial, 8120 ft., 1; *2¼ mi. ESE Brown's Peak, 10,300 ft.,* 3; *3 mi. ESE Brown's Peak, 10,000 ft.,* 12; *2 mi. S Brown's Peak, 10,600 ft.,* 1; *Pole Mountain, 15 mi. SE Laramie,* 4 (USBS 3); *1 mi. SSE Pole Mountain, 8350 ft.,* 4; *2 mi. SW Pole Mountain, 8300 ft.,* 13; *3 mi. S Pole Mountain, 8100 ft.,* 1; Sherman, 2 (AMNH). *Laramie Co.:* 5 mi. N, 1 mi. W Horse Creek P. O., 7200 ft., 1; Meadow, 2 (USBS); 11 mi. N, 5½ mi. E Cheyenne, 5450 ft., 7; *7 mi. W Cheyenne, 6500 ft.,* 10; Cheyenne, 3 (USNM).

COLORADO: *Moffat Co.:* Lay, 6160 ft., 1 (AMNH). *Routt Co.:* Wright's Ranch, Yampa, 7700 ft., 2; Gore Range, 8 mi. E Toponas, 8000 ft., 2 (USBS). *Larimer Co.: 12½ mi. W, 1½ mi. S Rustic,* 1; 11 mi. W, 1 mi. S Rustic, 1; Cache La Poudre River, 1 (Chi); *Estes Park,* 3 (USBS 1, AMNH 2); 19½ mi. W, 2½ mi. S Loveland, 7280 ft., 6; *16 mi. W Loveland, 6840 ft.,* 1; 6 mi. W, ½ mi. S Loveland, 5200 ft., 1. *Rio Blanco Co.:* Meeker, 1 (USBS); *9½ mi. SW Pagoda Peak,* 7700 ft., 3; 5 mi. S Pagoda Peak, 9100 ft., 2. *Eagle Co.:* Eagle, 1 (USBS); Pando, 2 (USBS). *Grand Co.:* Mt. Whiteley, 2 (USBS); Arapahoe Pass, Rabbit Ear Mountains, 2 (USBS); Coulter (near Granby), 5 (USBS); *Arrowhead* (near Dale), 1 (USBS). *Boulder Co.:* ¾ mi. N, 2 mi. W Allenspark, 8400 ft., 4; *3 mi. S Ward,* 9000 ft., 3; Nederland, 16 (Chi). *Clear Creek Co.:* Mt. McLellan, 2 (USBS); Berthoud Pass, 4. *Park Co.:* Trout Creek Ranch, 2 mi. N Garo, 1 (USBS).

Specimens examined of *M. m. nanus* from eastern Idaho and Montana are as follows: IDAHO: *Custer Co.:* Challis, 7 (USBS); Mill Creek, Challis Nat. Forest, 1 (USBS); Pahsimeroi Mts., 12 (USBS); Lost River Mts., 1 (USBS). *Fremont Co.:* N fork Snake River, 10 mi. SW Island Park, 6200 ft., 2 (AMNH); Black Springs Creek, 4 mi. W Ashton, 5200 ft., 1 (AMNH); 5 mi. W St. Anthony, 5000 ft., 1 (AMNH). *Camas Co.:* Camas Prairie, Corral, 5100 ft., 2 (USBS). *Blaine Co.:* Alturas Lake, 3 (USBS); *Sawtooth Lake,* 2 (USBS); Craters of the Moon, Laidlow Park, 2 (Mich); Ticura, 10 mi. S Picabo, 1 (USBS); 19 mi. NE Carey (Lava Lake), 8 (Mich). *Butte Co.: 26 mi. SW Arco,* 12 (Mich). *Bingham Co.:* Shelley, 6 (USBS). *Bonneville Co.:* 10 mi. SE Irwin, 4 (USBS). *Owyhee Co.:* Three Creeks, 3 (USBS). *Twin Falls Co.:* Castlford Fenced Plot, 11 mi. W, 9 mi. S Twin Falls, 1. *Minidoka Co.: Heyburn,* 2 (USBS). *Cassia Co.:* 2 mi. S, 2 mi. W Burley, 5. *Bannock Co.:* Pocatello, 23 (USBS 4); Swan Lake, 1 (USBS). *Bear Lake Co.:* Montpelier Creek, 6700 ft., 3 (USBS). MONTANA: *Gallatin Co.:* W. Fork of W. Fork, Gallatin River, 1 (USBS). *Park Co.:* Lamar River, 7000 ft., 1 (USBS); Gardiner, 1 (USBS). *Sweet Grass Co.:* 14 mi. S Big Timber, 1 (USBS); *McLeod,* 1 (USBS); West Boulder Creek, 18 mi. SE Livingston, 2 (USBS).

Microtus montanus codiensis, new subspecies

Type.—Female, adult, skin and skull; No. 27578, Museum of Natural History, University of Kansas, from 3⅕ mi. E and ⅗ mi. S Cody, 5020 ft., Park Co., Wyoming; obtained on August 11, 1948, by James W. Bee, original number 18-8-11-48.

Range.—In northwestern Wyoming eastward from the Absaroka and Wind River ranges into the western part of the Big Horn Basin.

Diagnosis.—A relatively large *Microtus montanus;* tail actually and relatively long; hind foot actually but not relatively large; skull large; zygomatic expanse actually and relatively large; alveolobasilar length relatively large; upper molar tooth-row relatively long; color relatively light, not reddish.

Comparisons.—As compared with the specimens of *M. m. nanus* from Idaho, the size is larger (see diagnosis and measurements). Certain proportions which differ from those of *nanus* and which are not in close agreement with the observed differences with age in specimens of *nanus* of a size comparable to *codiensis* are relatively large alveolobasilar length, relatively long alveolar

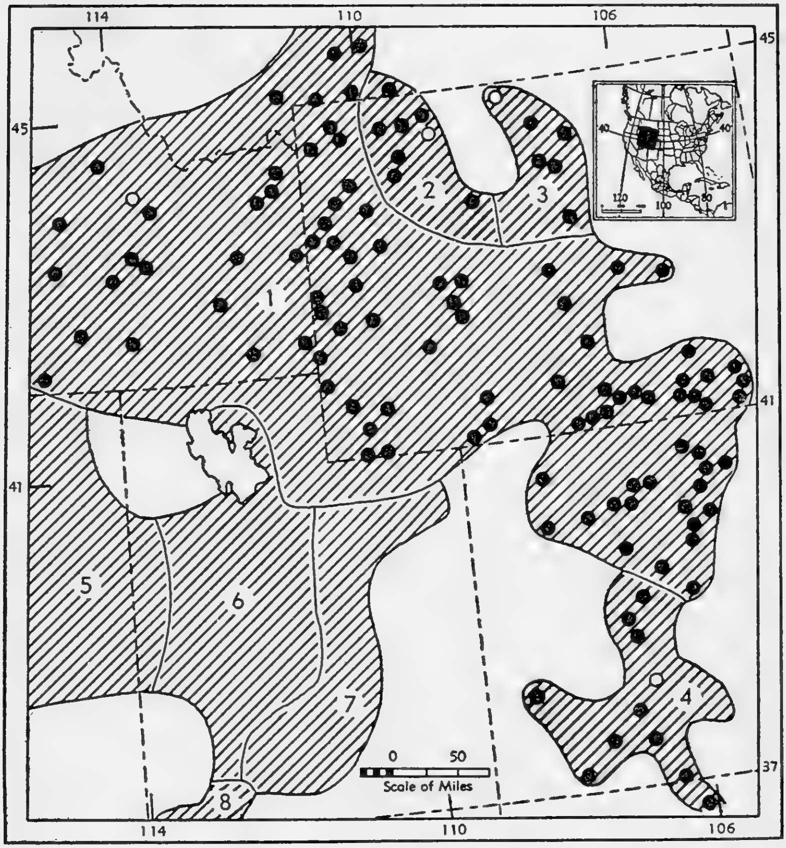

Fig. 1. Geographic range of *Microtus montanus* in Wyoming, Colorado, and adjacent areas. The solid circles represent localities from which specimens have been examined; the hollow circles represent type localities. The ranges of subspecies in Utah are after Durrant, 1952.

Guide to subspecies
1. *M. m. nanus*
2. *M. m. codiensis*
3. *M. m. zygomaticus*
4. *M. m. fusus*
5. *M. m. micropus*
6. *M. m. nexus*
7. *M. m. amosus*
8. *M. m. rivularis*

length of upper molar tooth-row, relatively wide-spreading zygomatic arches, and relatively long tail. The color in *codiensis* is lighter than in *nanus*. As compared to the new subspecies named below from the Big Horn Mountains to the east, *codiensis* is of similar size in head-body length, but has a relatively as well as actually longer tail; the hind foot averages longer; the upper molar tooth-row is relatively longer; the color is slightly paler and less grizzled; the bullae are larger and less flattened; the angle formed at the suture between the basioccipital and basisphenoid bones is less acute; and the region of the suture is less prominently elevated between the bullae when viewed from the ventral aspect. The pterygoid plates mesial and posterodorsal to the posterior

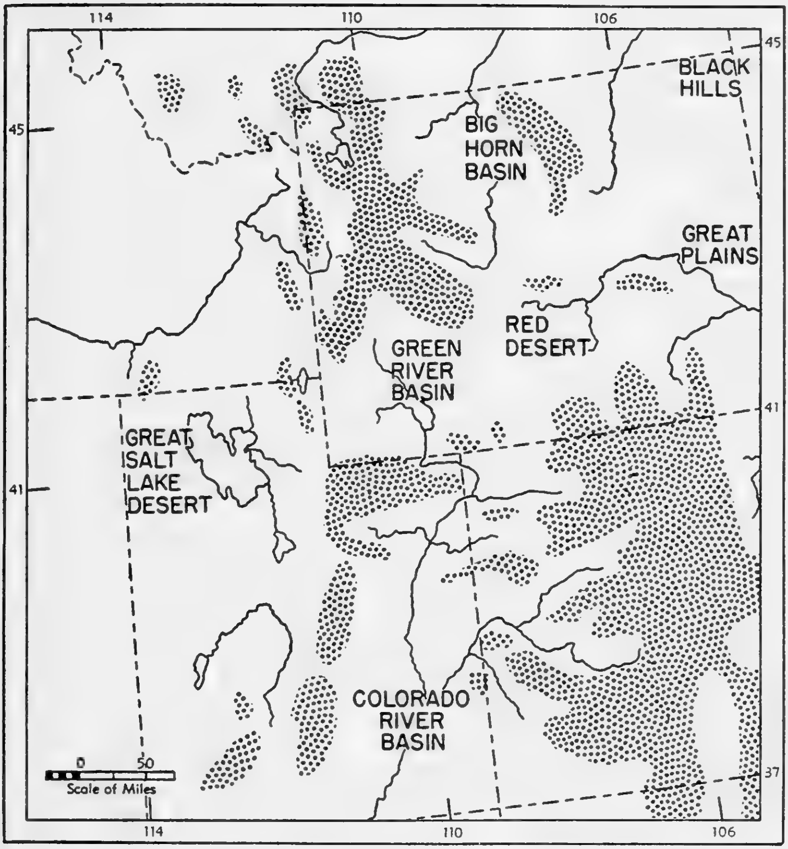

FIG. 2. Map showing the major barriers to *Microtus montanus* in Wyoming and Colorado; the barriers are the low areas named on the map (the name "Black Hills" is on the map for another reason; these hills are not a barrier). The major mountainous areas higher than approximately 8000 feet in elevation in Wyoming, Colorado and Utah are stippled. These mountainous areas include the habitat that is most suitable for the montane meadow mouse. The Black Hills are unoccupied by this species but these hills seem to be ecologically suitable for the species.

end of the last upper molar are less fenestrated, and the incisive foramina are less constricted posteriorly.

Measurements.—The average and the extremes for some measurements of 34 males and females, 27 from the type locality and 7 from other localities in the range assigned to this subspecies, are as follows: total length, 165(146-186); length of tail, 44.2(35-55); hind foot, 19.6(17-21); condylobasilar length of the skull, 25.5(24.0-27.5); zygomatic breadth, 15.6(14.7-16.6); alveolar length of upper molar tooth-row, 6.6(6.2-7.0); prelambdoidal breadth, 8.8(8.1-9.5); lambdoidal breadth, 12.0(11.2-12.8). As an indication of variability and for comparison with other series the coefficient of variability and two times the standard error of the mean for each measurement in this series are included in Table 1. The averages for some measurements of 27 topotypes are as follows: total length, 162; length of tail, 45.5; hind foot, 19.9; condylobasilar length, 25.6; palatilar length, 14.0; molar series, 6.6; alveolobasilar length, 14.9; zygomatic breadth, 15.6; interorbital breadth, 3.5; lambdoidal breadth, 12.1; prelambdoidal breadth, 8.9; depth of braincase, 7.8.

Discussion.—Three species of *Microtus* were collected by James W. Bee at the type locality. *Microtus montanus codiensis, Microtus longicaudus mordax,* and *Microtus pennsylvanicus modestus* were taken in the same runways in the same meadow, at the same time. *Microtus ochrogaster haydeni,* although not taken at this locality, occurs in the Big Horn Basin. These four species differ in their geographic ranges, being largely allopatric, except *M. montanus* and *M. longicaudus* which are sympatric. Although the different species have ecological preferences and habits which differ, several species of *Microtus* may occur together in local areas such as the above. Certain of the characteristics of *M. m. codiensis* are intermediate between those of the species *M. montanus* on one hand and those of the other three species on the other hand. Could interspecific hybridization between "good species" of *Microtus* take place in nature and possibly alter the characteristics of a local population?

Specimens examined.—Total, 50, distributed as follows (abbreviations for collections are given in the account of *M. m. nanus;* localities that are not represented in Fig. 1 because overlapping or crowding of the symbols would result are Italicized):

Montana: *Carbon Co.:* Beartooth Mountains, 2 (USBS); *Beartooth Lake,* 1 (USBS).

Wyoming: *Park Co.:* Black Mountain, head of Pat O'Hara Creek, 3 (USBS); 13 mi. N, 1 mi. E Cody, 5200 ft., 1; SW slope Whirlwind Peak, 9000 ft., 1; *5 mi. N Cody, 6300 ft.,* 1 (USBS); 3⅕ mi. E, ⅗ mi. S Cody, 31; Ishawooa Creek, 6300 ft., 2 (USBS); *Valley,* 1 (USBS); Needle Mountain, 10,500 ft., 4 (USBS). *Hot Springs Co.:* 3 mi. N, 10 mi. W Thermopolis, 4950 ft., 3.

Microtus montanus zygomaticus, new subspecies

Type.—Male, adult, skin and skull, No. 32761, Museum of Natural History, University of Kansas, from Medicine Wheel Ranch, 9000 ft., 28 mi. E Lovell, Big Horn County, Wyoming; obtained by R. Freiburg, original number 105.

Range.—The Big Horn Mountains of north-central Wyoming.

Diagnosis.—A large *Microtus montanus* with a relatively short tail; short molar series; broad zygomatic arches well rounded in lateral outline when viewed from above; small and flattened bullae; raised basioccipito-basisphenoid suture.

Comparisons.—For comparison with *M. m. codiensis* from the west, on the other side of the Big Horn Basin, see the account of that subspecies. In comparison with *nanus* this subspecies is slightly paler, in this respect showing more resemblance to *codiensis* although not so pale, and more grizzled or unevenly colored. This difference in color between *zygomaticus* and *codiensis* may not be of taxonomic significance. From both the topotypes of *nanus,* and the series of it from Wyoming, *zygomaticus* differs on the average in having a relatively shorter tail, a relatively shorter upper molar tooth-row, relatively more rounded and relatively more wide-spread zygomatic arches, and smaller more flattened bullae.

Measurements.—Average and extreme measurements of 24 adult males and females from several localities here referred to *M. m. zygomaticus* are as follows: total length, 159(150-175); length of tail, 37.6(31-46); hind foot, 18.6(17-20); condylobasilar length of the skull, 25.3(24.2-26.7); zygomatic breadth, 15.3(14.1-16.7); alveolar length of upper molar tooth-row, 6.2 (5.7-6.8); prelambdoidal breadth, 8.7(8.3-9.4); lambdoidal breadth, 11.9(11.0-12.5). Average and extreme measurements of a series of 12 adult male topotypes are as follows: total length, 159(144-174); length of tail, 36.4 (30-41); hind foot, 18.2(16-20); condylobasilar length of skull, 25.8(24.7-26.7); alveolobasilar length, 14.8(13.8-15.3); palatilar length, 13.8 (12.7-14.2); alveolar length of upper molar tooth-row, 6.4(5.9-6.6); zygomatic breadth, 15.9 (15.0-16.7); interorbital breadth, 3.6(3.4-3.7); lambdoidal breadth, 12.1 (11.5-12.5); prelambdoidal breadth, 8.6(8.3-8.9); depth of braincase, 8.0 (7.6-8.3).

Discussion.—This subspecies is separated from *M. m. codiensis* to the west by the Big Horn Basin. A series from along Buffalo Creek, 27 mi. N, 1 mi. E Powder River, 6075 ft., in Natrona County, Wyoming, is intermediate between the topotypes of *zygomaticus* and *nanus* in the characters cited above as distinguishing the two, but shows greater resemblance to *zygomaticus* in the shape of the zygomatic arch, in color which is paler than in topotypes of *zygomaticus,* and in the short hind foot. On these and on geographic grounds this population is referred to *zygomaticus.* Unfortunately we cannot be certain in many cases that an intermediate condition in a certain character indicates a genetically intermediate population and therefore true intergradation between the two subspecies to which the population is geographically intermediate. The topotypes of this subspecies are the most distinct of all the series which I have studied from the eastern Rocky Mountains, in terms of the degree of morphological departure from the norm for the species.

After *zygomaticus* the following populations are arranged according to their degree of deviation from this norm (*codiensis* deviates most): topotypes of *codiensis, fusus* and a population from southern Sweetwater County, Wyoming, and lastly the *nanus-caryi* complex. Within the latter group, as I have mentioned, there are a number of local variants most of which do not differ significantly and do not conform to any geographic pattern.

Specimens examined.—Total, 55, distributed as follows (abbreviations for collections are given in the account of *M. m. nanus;* localities that are not represented in Fig. 1 because overlapping or crowding of the symbols would result are Italicized): WYOMING: *Big Horn Co.:* Medicine Wheel Ranch, 9000 ft., 28 mi. E Lovell, 30; W slope, head of Trappers Creek, 9500 ft., 2 (USBS). *Washakie Co.:* 9 mi. E, 5 mi. N Tensleep, 7400 ft., 1. *Johnson Co.:* 7½ mi. W, 1 mi. S Buffalo, 6500 ft., 3; Big Horn Mountains, 3 (USBS). *Natrona Co.:* Buffalo Creek, 27 mi. N, 1 mi. E Powder River, 6075 ft., 16.

Microtus montanus fusus Hall

Microtus nanus, Bailey, N. Amer. Fauna, 17:30, June 6, 1900 (part); Cary, N. Amer. Fauna 33:123, August 17, 1911.

Microtus montanus fusus Hall, Proc. Biol. Soc. Washington, 51:131-134, August 23, 1938; Warren, The Mammals of Colorado, Univ. of Okla. Press, p. 229, 1942.

Type.—Male, adult, skin and skull; No. 61281, Museum of Vertebrate Zoology; 2½ miles east of summit of Cochetopa Pass, Saguache County, Colorado; Sept. 21, 1933; collected by Annie M. Alexander; original number 2568. Type not seen by me.

Range.—Southern Colorado and northern New Mexico.

Comparisons.—For comparison with *M. m. nanus,* the subspecies to the northward, see the preceding account of that subspecies. For comparison with *M. m. amosus* the subspecies to the west see Hall (1938) and Durrant (1952). I have not examined specimens of *amosus.*

Measurements.—Average and extreme measurements for 17 adults including both males and females from several localities in southern Colorado are as follows: total length, 160(136-179); length of tail, 42(35-55); hind foot, 19.2(17-23); condylobasilar length of the skull, 25.2(24.0-26.0); zygomatic breadth, 15.0(14.1-15.5); alveolar length of upper molar tooth-row, 6.4 (6.0-6.7); prelambdoidal breadth, 8.7(8.3-9.2); lambdoidal breadth, 11.7(11.1-12.6).

Average and extreme measurements of 4 adults (2 males and 2 females) from the type locality and 11 adults (4 males and 7 females) from other localities in southern Colorado are as follows: total length, 162(157-168), 157(137-169); length of tail (means only), 44.5, 40.5; hind foot, 18.8(18-19), 18.6(18-23); condylobasilar length of skull, 24.5(24.0-24.7), 25.2(24.3-26.1); alveolobasilar length, 14.2(13.9-14.5), 14.6(14.1-15.1); palatilar length, 13.2 (13.0-13.4), 13.5(13.1-14.2); alveolar length of upper molar tooth-row, 6.3 (6.0-6.6), 6.4(6.3-6.7); zygomatic breadth, 15.0(14.3-15.5), 14.9(14.1-15.5); interorbital breadth, 3.5(3.3-3.6), 3.5(3.3-3.7); lambdoidal breadth, 11.8(11.1-12.6), 11.7(11.2-12.3); prelambdoidal breadth, 8.6(8.3-9.2), 8.8(8.3-9.0); depth of braincase, 7.5(7.2-7.8), 7.6(7.1-7.9).

Discussion.—There is no sharp boundary between *M. m. fusus* of southern Colorado and the subspecies to the north, *M. m. nanus.* Although the line separating these two subspecies is drawn somewhat arbitrarily, on the whole the samples from north of this line more closely resemble *nanus.* All of the means for total length given above are larger than the maximum given in Hall's description of *fusus.* The caudal index (38 and 35% in two series) is slightly larger than that cited by Hall (33.3%) and is not significantly different from that in *nanus* (35.2%). The color in both young and old mice is variable, but in general is more yellowish, and less grayish, than in any other series studied.

There is a large area in western Colorado and eastern Utah, between the known ranges of *M. m. fusus* and *M. m. amosus* from which there are no specimens. Probably the species occurs only at certain places in this arid region which seems to be a partial barrier to the species.

Specimens of *M. montanus* from northern New Mexico have been referred previously to *M. m. arizonensis.* When he named *M. m. fusus,* Hall mentioned its resemblance to *arizonensis* in reddish coloration, but pointed out that *fusus* is less reddish. Of six specimens from Valle Santa Rosa, Jemez Mountains (USBS), 8500 ft., Rio Arriba County, New Mexico, three are immature, and the skulls of the remaining specimens are damaged. In reddish color and relatively large size these few specimens resemble *arizonensis* more than *fusus* although the locality of occurrence is closer to the geographic range of the northern *fusus* than to that of *arizonensis.* The identification of these specimens as *arizonensis* is provisional; additional specimens are needed from the area, 200 miles wide, which separates the ranges as now known of *arizonensis* in Arizona from the occurrence in New Mexico. There is a single specimen from this area, the damaged skull of which prevents conclusive identification. The specimen is either *M. montanus* or *M. mexicanus,* and is from Nutria, on the southern edge of the Zuni Mountains (USBS). Detailed comparison of *fusus* and *arizonensis* is not attempted here although it may be stated that in several characters *fusus* is intermediate between *arizonensis* to the south and *nanus* to the north.

Specimens examined.—Total, 89, distributed as follows (abbreviations for collections are given in the account of *M. m. nanus;* localities that are not represented in Fig. 1 because overlapping or crowding of the symbols would result are Italicized):

COLORADO: *Pitkin Co.:* 5 mi. W Independence Pass, 11,000 ft., 1 (Chi). *Lake Co.: Independence Pass, 12,095 ft.,* 2 (Chi). *Gunnison Co.: Gothic,* 2 (USBS); Decker's Ranch, Crested Butte, 2 (AMNH); Almont, 3 (USBS). *Montrose Co.:* Coventry, 5 (USBS 4, AMNH 1). *Saguache Co.:* Cochetopa

Pass and environs, 44 (USBS 22). *Hinsdale Co.:* Ruby Lake, 1 (USBS). *Mineral Co.:* 3 mi. E Creede, 1; 23 mi. S, 11 mi. E Creede, 9300 ft., 7. *La Plata Co.:* Florida, 6800 ft., 1. *Conejos Co.:* 1 mi. S, 19 mi. W Antonito, 10,200 ft., 3; *4 mi. S, 23 mi. W Antonito,* 1; *5 mi. S, 24 mi. W Antonito, 9600 ft.,* 9.

NEW MEXICO: *Rio Arriba Co.:* 6 mi. W Hopewell, 9900 ft., 6 (USBS); *Tusas River, 8700 ft.,* 1 (USBS).

Some measurements not given above are included in Table 1, together with the number of specimens and the sex if restricted to one sex. So that the variability can be evaluated more adequately,

TABLE 1. AVERAGE MEASUREMENTS, IN MILLIMETERS, OF ADULTS OF MICROTUS MONTANUS.

LOCALITY	No. of individuals averaged	Total length	Length of tail	Length of hind foot	Condylobasilar length	Alveolar length of upper molar tooth-row	Zygomatic breadth	Lambdoidal breadth	Prelambdoidal breadth
	M. m. codiensis, all								
Average	34	165.3	44.2	19.6	25.47	6.56	15.55	12.05	8.76
2 x stand. error	....	3.56	1.84	.395	.308	.067	.198	.144	.129
Coeff. variab.	....	6.0	11.6	5.6	3.5	3.0	3.65	1.20	1.47
	M. m. nanus, Eastern Idaho								
Average	21[1]	151.1	39.4	19.2	25.00	6.44	14.99	11.74	8.94
2 x stand. error	....	3.20	2.89	.293	.286	1.15	.295	.210	.182
Coeff. variab.	....	6.1	21.1	4.38	2.49	3.99	4.10	3.79	4.31
	M. m. nanus, Wyoming								
Teton Co.	35	160.5	40.7	18.6	25.16	6.51	15.17	11.86	8.77
Fremont Co.	26	157.0	41.4	19.6	25.23	6.25	15.05	11.88	8.91
Lincoln Co.	24	159.9	41.8	18.9	25.08	6.26	15.10	11.82	8.75
Uinta Co.	26	162.4	41.3	19.0	25.33	6.42	15.31	12.16	8.89
Sweetwater Co.	12	159.8	43.7	20.1	24.98	6.31	15.00	11.84	9.02
Natrona Co.	40	159.6	41.0	19.6	25.04	6.40	15.00	11.84	8.93
Carbon Co.	108	158.7	40.0	19.1	24.96	6.27	15.05	11.83	8.72
Encampment ♂	27	161	41.7	18.9	25.1	6.16	15.2	11.9	8.7
Encampment ♀	11	159	41.1	19.4	24.9	6.18	14.9	11.6	8.6
Savery ♂	23	159	41.0	19.2	25.3	6.32	15.2	12.2	8.8
Savery ♀	25	155	37.1	18.8	24.7	6.33	14.8	11.6	8.6
	M. m. nanus								
Northern Colo.	8	163.1	42.4	19.6	25.20	6.44	14.86	11.70	8.56
	M. m. fusus								
Southern Colo.	17[2]	159.8	42.4	19.2	24.97	6.43	14.98	11.73	8.69

[1] For external parts, 34 individuals were used.
[2] For external parts, 29 individuals were used.

the coefficient of variability and 2 times the standard error of the mean are included for the measurements in two series. The series consist of all the adult specimens (with a condylobasilar length of 24.0 mm. or more) of both sexes from the areas specified. Various barriers are shown in Fig. 2 for comparison with the distributions of the subspecies and the localities of known occurrence shown in Fig. 1. *Microtus montanus* has not been taken in the Black Hills area of extreme northeastern Wyoming. Suitable montane habitat is present and both *Microtus pennsylvanicus insperatus* and *Microtus longicaudus longicaudus* occur there. The arid basin of the Powder River presumably is a barrier that has prevented *M. montanus* from reaching this area.

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Transmitted March 22, 1954.

25-3560

UNIVERSITY OF KANSAS PUBLICATIONS
MUSEUM OF NATURAL HISTORY

Volume 7, No. 8, pp. 507-512
July 23, 1954

A New Subspecies of Bat (Myotis velifer) from Southeastern California and Arizona

BY

TERRY A. VAUGHAN

UNIVERSITY OF KANSAS
LAWRENCE
1954

University of Kansas Publications, Museum of Natural History

Volume 7, No. 8, pp. 507-512
Published July 23, 1954

University of Kansas
Lawrence, Kansas

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1954

25-3727

A New Subspecies of Bat (*Myotis velifer*) from Southeastern California and Arizona

BY

TERRY A. VAUGHAN

The first specimens of *Myotis velifer* from California were taken in 1909 by C. L. Camp at Needles, San Bernardino County (Grinnell, Univ. California Publ. Zool., 12:266, March 20, 1914), and subsequently this bat was recorded from farther south in the lower Colorado River Valley at the Riverside Mountains, Riverside County (Stager, Jour. Mamm., 20:226, May 14, 1939). West of the Rocky Mountains the species is known to occur also in at least the southern two-thirds of Arizona, southwestern New Mexico, and is recorded from Thistle Valley, Utah, on the basis of two young specimens in alcohol (Miller and Allen, Bull. U. S. Nat. Mus., 144:87, May 25, 1928). Through comparisons made possible by the acquisition, in the last few years, of mammals from many parts of Mexico by the Museum of Natural History of the University of Kansas, it became evident that *Myotis velifer* in California and Arizona was an heretofore unnamed subspecies. It may be known as

Myotis velifer brevis new subspecies

Myotis velifer, Grinnell, Univ. California Publ. Zool., 12:266, March 20, 1914; Grinnell, H. W., Univ. California Publ. Zool., 12:259, January 31, 1918.

Myotis velifer velifer, Miller and Allen, Bull. U. S. Nat. Mus., 144:87, May 25, 1928; Burt, Jour. Mamm., 14:115, May 15, 1933; Burt, Misc. Publ. Mus. Zool. Univ. Michigan, 39:22, February 14, 1938; Hatfield, Bull. Chicago Acad. Sci., 6:146, January 12, 1942.

Type.—Male, adult, No. 22631, Museum of Natural History, University of Kansas; Madera Canyon, 5,000 ft., Santa Rita Mountains, Pima County, Arizona; obtained on March 12, 1948, by J. R. Alcorn; original number 5571.

Range.—Lower Colorado River Valley in California and Arizona, through southern two-thirds of Arizona, southwestern New Mexico, and northern Sonora; southern limits of range unknown.

Diagnosis.—Size small (see measurements). Color pale, upper parts being near (16″*j*) Snuff Brown (capitalized color terms are of Ridgeway, Color Standards and Color Nomenclature, Washington, D. C., 1912); underparts dull Pinkish Buff to nearly white in some specimens; ears and flight membranes near (16″*l*) Olive Brown; skull small.

Comparisons.—From *Myotis velifer incautus* (J. A. Allen), *Myotis velifer brevis* differs in: Size smaller; color slightly darker; skull smaller. From *Myotis velifer peninsularis* Miller, *M. v. brevis* differs in: Size larger; color darker; skull larger. From *Myotis velifer velifer* (J. A. Allen), *M. v. brevis* differs in: Size smaller; pelage paler, with less extensive basal dark portion; skull smaller.

TABLE 1.—MEASUREMENTS, IN MILLIMETERS, OF MYOTIS VELIFER

	Sex	Number averaged	Average	Range
M. v. velifer, 4 km. E Las Vigas, 8,500 ft., Veracruz, Mexico.				
Total length	♂	15	97.1	92.0–101.0
" "	♀	9	99.0	93.0–103.0
Length of forearm	♂	27	44.1	42.1–46.0
" " "	♀	18	44.7	43.3–46.1
Condylobasal length	♂	15	15.9	15.4–16.2
" "	♀	9	16.0	15.7–16.4
Interorbital breadth	♂	15	4.2	3.9–4.2
" "	♀	9	4.1	3.9–4.3
Mastoid breadth	♂	15	8.4	8.2–8.5
" "	♀	9	8.4	8.2–8.6
Zygomatic breadth	♂	15	10.7	10.4–10.9
" "	♀	9	10.7	10.4–11.2
M. v. incautus, 4 mi. E Sherman, Major Co., Oklahoma.				
Total length	♂	11	101.5	97.0–107.0
Length of forearm	♂	9	45.4	44.6–47.3
Condylobasal length	♂	11	16.4	15.9–16.7
Interorbital breadth	♂	11	4.2	4.0–4.5
Mastoid breadth	♂	11	8.8	8.5–9.1
Zygomatic breadth	♂	11	10.9	10.5–11.3
M. v. brevis, Riverside Mtns., 35 mi. N Blythe, Riverside Co., California.				
Total length	♂	8	96.6	91.5–99.0
" "	♀	5	94.6	91.0–97.0
Length of forearm	♂	45	41.8	40.4–44.5
" " "	♀	6	42.1	40.7–43.4
Condylobasal length	♂	16	15.5	15.1–15.8
" "	♀	5	15.4	15.1–15.8
Interorbital breadth	♂	16	4.0	3.8–4.2
" "	♀	5	3.9	3.9–4.0
Mastoid breadth	♂	16	8.2	7.8–8.6
" "	♀	5	8.3	8.0–8.5
Zygomatic breadth	♂	15	10.4	10.2–10.7
" "	♀	5	10.4	10.1–10.6

Remarks.—Miller and Allen (*op. cit.* :90) considered specimens of *Myotis velifer* from Roosevelt, Arizona, to be intergrades between *M. v. velifer* and *M. v. incautus* because the color varied greatly and certain pale individuals resembled *incautus*. These workers regarded specimens from southern Arizona as nearly typical examples of *M. v. velifer*. I have examined the specimens from Roosevelt, Arizona, and many from various localities in the southern part of the state, and was impressed by the large amount of color variation. Marked variation in color at a single locality, however, is known in other bats. Benson (Jour. Mamm., 30:50, February 14, 1949), for example, found striking variation in *Myotis volans* in California. The specimens of *Myotis velifer* from Roosevelt, Arizona, referred to *M. v. velifer* by Miller and Allen (*op. cit.*:90), actually average significantly smaller than specimens of this subspecies from Mexico, and than specimens of the large subspecies *M. v. incautus* from the Great Plains, and therefore, with reference to size, are not intergrades between these subspecies. All of the Arizonan material is here referred to *M. v. brevis.*

The "bald spot," that is to say, the sparsely furred area between the shoulders, which is characteristic of this species, reaches its most extreme condition in *Myotis velifer brevis.* In most of thirty-five specimens taken in mid-June, 1953, in California, the nape of the neck, the interscapular area, and a connected area extending laterally onto each shoulder are so lightly furred that the skin shows through conspicuously. In one male of this series a strip approximately four millimeters wide extending along the mid-dorsal line from between the shoulders to the rump is mostly devoid of hair. These sparsely-furred areas are less evident in live animals than in study skins and specimens in alcohol, because the back of the head in life lies against the depression between the shoulders and conceals most of the thinly furred areas.

The pelage of *Myotis velifer brevis* is shorter than that of either *M. v. velifer* or *M. v. incautus* and gives the impression of being less dense. The dorsal hairs average approximately 4.5 millimeters long in *M. v. brevis* taken 35 miles north of Blythe, Riverside County, California, in May, eight millimeters in *M. v. velifer* collected at Las Vigas, Veracruz, in January, and six millimeters in *M. v. incautus* taken four and one half miles southwest of Sun City, Barber County, Kansas, in November. More than seasonal differences in length of pelage is indicated by measurements of additional specimens of each subspecies taken at different times of the year.

Considering its extensive geographic range and its occurrence in many contrasting environments, *Myotis velifer* varies little; and the variation that does occur is continuous. The change from the large, dark Mexican subspecies to the small, pale Arizonan subspecies is gradual. The reason may lie in the ecology of *M. velifer.* It seems that there are few barriers separating populations. Waterless areas and regions lacking suitable roosting places such as fissures in cliffs and outcrops of rocks, caves and buildings, may exclude the species from certain areas, but there are few areas of any great size within the range of the species that lack these features. Also, these bats are strong fliers; even between fairly distant colonies there may be considerable gene flow. The geographic variation observed probably is the result of adaptation, on the part of populations in different parts of the range of the species, to different environments. The lack of any effective barriers except possibly distance between populations tends to limit subspeciation and to cause gradual variation between subspecies. *M. v. peninsularis*, the subspecies at the southern tip of Baja California, is not considered in this discussion. So far as known, however, that subspecies is completely isolated from the mainland populations of *M. velifer.*

For the opportunity to examine specimens under their care I wish to thank Dr. William H. Burt of the University of Michigan Museum of Zoology, Dr. Rollin H. Baker of the Museum of Natural History of the University of Kansas, and Dr. Donald F. Hoffmeister of the University of Illinois Museum of Natural History. I am indebted also to persons in charge of the Biological Surveys Collection and the National Museum for the loan of critical material, and to Dr. E. Raymond Hall for suggestions. The following symbols are used to designate the source of specimens: BS—Biological Surveys Collection, IM—University of Illinois Museum of Natural History, KU—Museum of Natural History of the University of Kansas, MM—University of Michigan Museum of Zoology, NM—United States National Museum, TV—collection of Terry A. Vaughan.

Specimens examined.—Total, 110, distributed as follows:

Arizona: *Mohave Co.:* Big Sandy Creek, 3 BS. *Yavapai Co.:* Camp Verde, 3 KU. *Gila Co.:* 5 mi. SW Roosevelt, 8 BS. *Maricopa Co.:* Gila Bend, 1 BS. *Graham Co.:* Snow Flat, Graham Mountains, 1 IM; Bonita, Graham Mountains, 1 IM. *Pima Co.:* Tucson, 1 NM; Madera Canyon, 5000 ft., Santa Rita Mountains, 2 KU. *Santa Cruz Co.:* Madera Canyon, 6000 ft., Santa Rita Mountains, 2 KU. *Cochise Co.:* 8 mi. W Fort Huachuca, 26 IM; Hereford, 4 IM; 3 mi. SW Hereford, 1 IM; 14 mi. SW Fort Huachuca, 1 IM; San Bernardino Ranch, 4 NM.

California: *Riverside Co.:* Riverside Mountains, 35 mi. N Blythe, 51 (21 KU, 30 TV).

Sonora: Santa Maria Mine, El Tigre Mountains, 1 MM.

Transmitted March 22, 1954.

□

25-3727

UNIVERSITY OF KANSAS PUBLICATIONS
MUSEUM OF NATURAL HISTORY

Volume 7, No. 9, pp. 513-582, 4 pls., 1 fig. in text, 12 tables
November 15, 1954

Mammals of the San Gabriel Mountains of California

BY

TERRY A. VAUGHAN

UNIVERSITY OF KANSAS
LAWRENCE
1954

UNIVERSITY OF KANSAS PUBLICATIONS, MUSEUM OF NATURAL HISTORY

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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, México. By E. Raymond Hall and Bernardo Villa R. Pp. 249-256, 6 figures in text. July 26, 1948.
15. A new hylid frog from eastern Mexico. By Edward H. Taylor. Pp. 257-264, 1 figure in text. 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.
20. Three new beavers from Utah. By Stephen D. Durrant and Harold S. Crane. Pp. 407-417, 7 figures in text. December 24, 1948.
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.

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University of Kansas Publications
Museum of Natural History

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PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1954
25-5184

MAMMALS OF THE SAN GABRIEL MOUNTAINS OF CALIFORNIA

by

Terry A. Vaughan

CONTENTS

Introduction

This paper presents the results of a study of the mammals of the San Gabriel Mountains of southern California, and supplements the more extensive reports on the biota of the San Bernardino Mountains by Grinnell (1908), on the fauna of the San Jacinto Range by Grinnell and Swarth (1913), and on the biota of the Santa Ana Mountains by Pequegnat (1951).

The primary objectives of my study were to determine the present mammalian fauna of the San Gabriel Mountains, to ascertain the geographic and ecologic range of each species, and to determine the systematic status of the mammals. In addition, certain life history observations have been recorded.

Field work was done in the north-south cross section of the mountains from San Gabriel Canyon on the west, to Cajon Wash on the east; and from the gently sloping alluvium at the Pacific base of the mountains at roughly 1000 feet elevation on the south, over the crest of the range to the border of the Mojave Desert at an elevation of 3500 feet on the north. Camps were established at many points in the area with the object of collecting the mammals of each association and each habitat. Field work was begun in the San

Gabriels in November 1948, and was carried on intermittently until March 1952. I was unable to carry on field work in any summer.

For advice and assistance in various ways I am grateful to Drs. Willis E. Pequegnat, Walter P. Taylor, Henry S. Fitch, E. Raymond Hall, Mr. Steven M. Jacobs and my wife, Hazel A. Vaughan.

More than 350 mammals were prepared as study specimens; most of these are in the University of Kansas Museum of Natural History. Approximately a fifth of them are in the collection of the Department of Zoology at Pomona College, and a few are in the University of Illinois Museum of Natural History. No symbol is used to designate specimens in the University of Kansas Museum of Natural History. Specimens from the Department of Zoology of Pomona College and the University of Illinois Museum of Natural History are designated by PC and IM, respectively.

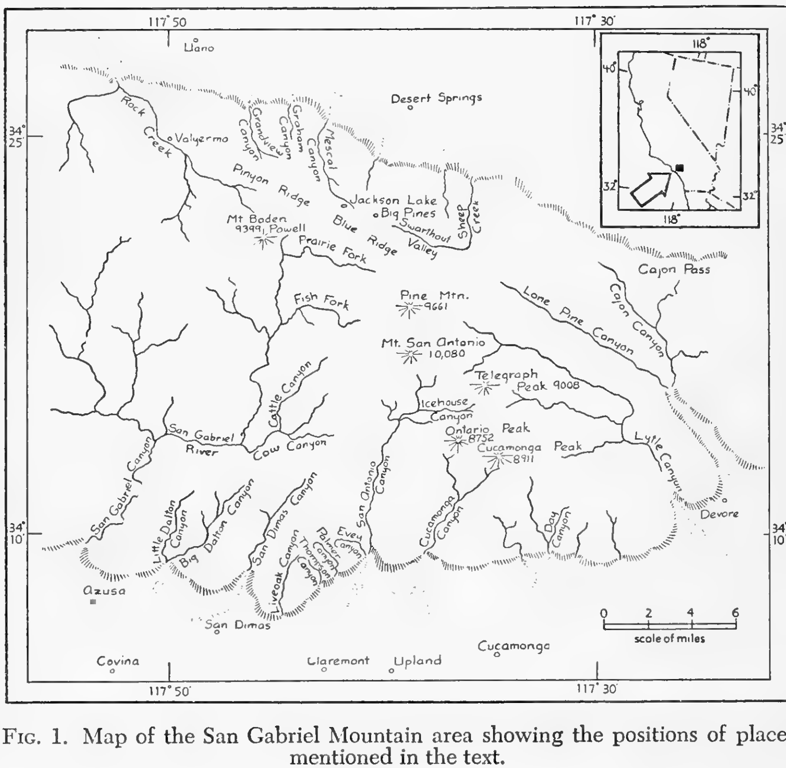

FIG. 1. Map of the San Gabriel Mountain area showing the positions of places mentioned in the text.

DESCRIPTION OF THE AREA

The San Gabriel Mountains are approximately sixty-six miles long, and average twenty miles wide. The main axis of the range trends nearly east and west, and extends from longitude 117°25′

to longitude 118°30′. The widest part of the range is bounded by latitude 34°7′ and latitude 34°30′.

The San Gabriel Mountains connect the Sierra Nevada with the Peninsular Ranges of southern California and Baja California. On the west the San Gabriels are bordered by the Tehachapi Mountains, which stretch northeastward to meet the southern Sierra Nevada; to the east, beyond Cajon Pass, the San Bernardino Mountains extend eastward and then curve southward to the broad San Gorgonio Pass, from which the San Jacinto Range stretches southeastward to merge with the Peninsular Ranges.

The rocks comprising the major part of the San Gabriel Mountains probably were intruded in Late Jurassic times, with severe metamorphic activity taking place concurrently. A long period of erosion followed after which deposition took place during much of the Tertiary. Deformation and uplift beginning in Middle Miocene times resulted in the formation of east-west-trending faults along both sides of the range. By repeated movements along these faults the Late Jurassic crystalline rocks were lifted above late Tertiary and Quaternary sediments and elevated above the surrounding terrain. Continued uplifts in post-Pleistocene time together with erosion in Recent times have shaped the San Gabriel Mountains (Oakeshott, 1937).

The alluvial slopes at the coastal base of the range give way to the foothills at roughly 1800 feet elevation; whereas the Mojave Desert merges with the interior foothills at elevations near 4000 feet. The crest or drainage-divide of the range varies from 6000 to 8000 feet in elevation, and many peaks are more than 8000 feet high. San Antonio Peak, the highest peak of the range, rises to an altitude of 10,080 feet. The mountains are characteristically steep and the slopes are deeply carved by canyons, the larger of which have permanent streams. The abruptness of the Pacific slope is in many places impressive. The horizontal distance from the top of Cucamonga Peak, at an elevation of 8911 feet, to the base of the coastal foothills directly to the south, at 2250 feet, an elevational difference of 6661 feet, is only 3.8 miles. From the base of Evey Canyon, at 2250 feet, to an unnamed peak to the northwest with an elevation of 5420 feet, the horizontal distance is 2.1 miles. Because of the steep, rocky nature of many of the slopes and the lack of soil on them, vegetation may be sparse even at high elevations. There are few meadows in the mountains.

Because the San Gabriels stand approximately thirty miles from the Pacific Ocean and are a partial barrier to Pacific air masses sweeping inland, the desert side and the coastal side of the range differ climatically. The coastal slope receives much heavier precipitation than the desert slope. The precipitation, for 1951, of 25.36 inches recorded at the mouth of San Antonio Canyon on the Pacific slope contrasts with 7.17 inches recorded at Valyermo at the desert base. Nearly all of the precipitation comes in winter. The higher parts of the range, above approximately 5000 feet, receive much of their mid-winter precipitation in the form of snow. Snow often extends down the desert slope well into the Joshua Tree belt. When there are heavy winter rains the channels of the usually dry washes are filled with rushing, turbid water. There are striking differences in temperature between the two sides of the range and between the lower elevations of the mountains and the higher parts. For example, in December 1951, the mean temperature at the base of San Antonio Canyon (2225 feet) at the coastal foot of the range was 55.4°F, while at Llano (3764 feet) at the desert base it was 43.7°F. In this same year the December mean for Table Mountain (7500 feet), on the desert slope, was 33.4°F. The temperature means for July, 1951, at San Antonio Canyon, Llano, and Table Mountain, were 77.3°F, 82.1°F, and 69.2°F respectively. The weather records for 1951 were used for illustration because average temperature and average precipitation for many other years are lacking for most of the weather stations in the area. There is an important difference in the humidity on the two sides of the range, but actual data are not available. At certain times, especially in spring, fog banks moving in from the Pacific Ocean frequently blanket the coastal base of the mountains and the foothills. On such days the fog generally "burns off" in the morning, but may persist into the afternoon or throughout the day. Never in my experience has fog spilled over the main part of the range far onto the desert slope, although the fog may push through the lower passes to be dissipated quickly in the dry desert atmosphere. The obvious differences in the biota on the two sides of the range are probably due to the contrasting climates.

BIOTIC PROVINCES AND ECOLOGIC ASSOCIATIONS

Because of the elevational extremes and attendant climatic contrasts in the San Gabriel Mountains, there is a rather wide range of environmental conditions. Four life-zones are represented: Lower Sonoran, Upper Sonoran, Transition, and Canadian. Within these zones certain ecologic communities can be recognized; these represent several biotic provinces. Table 1 shows the relationships between the environmental categories recognized by the writer in the San Gabriel Mountains. The biotic province and ecologic community system is that developed by Munz and Keck (1949), and the life-zone system is that of Merriam (1898).

TABLE 1.—RELATIONS OF THE MAJOR ENVIRONMENTAL CATEGORIES OF THE SAN GABRIEL MOUNTAINS.

Biotic province	Plant community	Life-zone	Slope
Californian	1. Coastal sage scrub 2. Southern oak woodland 3. Chaparral	Lower Sonoran Upper Sonoran Upper Sonoran	Pacific Pacific Pacific
Sierran	4. Yellow pine forest and limited areas of boreal flora	Transition Canadian	Pacific and Desert
Nevadan	5. Sagebrush scrub	Transition Upper Sonoran	Desert
Southern Desert	6. Pinyon-juniper woodland 7. Joshua tree woodland	Upper Sonoran Lower Sonoran	Desert Desert

The Californian Biotic Province dominates the biotic aspect of the coastal slope of the range. Thirty-nine out of the seventy-two mammals recorded from the San Gabriels are typical of this Province. The coastal sage-flats at the Pacific base of the mountains and the vast tracts of chaparral of the coastal slope are included in this Province.

Forming a hiatus between the Pacific and the desert slope is the Sierran Biotic Province consisting of coniferous forests on the crest of the range. The chipmunk (*Eutamias speciosus speciosus*) and the introduced black bear (*Ursus americanus californiensis*) are the only two mammals which can be considered typical of this area. On the higher peaks of the range, such as Mount San Antonio and Mount Baden Powell, the Canadian Life-zone is represented by certain boreal plants.

At scattered points along the crest of the range and on the desert slope, the Nevadan Biotic Province is represented by the sagebrush scrub association. No mammals can be considered typical of this region.

The Southern Desert Biotic Province occurs below 6000 feet elevation on the interior slope of the range, and markedly influences the mammal fauna of this slope. Twenty-one species of mammals are typical of this Province.

SCIENTIFIC AND COMMON NAMES OF PLANTS MENTIONED IN THIS REPORT

Pinus Lambertiana	Sugar Pine
P. monophylla	One-leaf Pinyon
P. ponderosa	Yellow Pine
P. contorta	Lodge-pole Pine
Pseudotsuga macrocarpa	Big-cone Spruce
Abies concolor	White Fir
Libocedrus decurrens	Incense-Cedar
Juniperus californica	Juniper
Ephedra sp.	Desert-Tea
Bromus sp.	Brome Grass
Yucca Whipplei	Spanish Bayonet
Y. brevifolia	Joshua Tree
Salix sp.	Willow
Alnus rhombifolia	Alder
Castanopsis sempervirens	Chinquapin
Quercus Kelloggii	California Black Oak
Q. agrifolia	California Live Oak
Q. dumosa	Scrub Oak
Eriogonum fasciculatum	California Buckwheat
Umbellularia californica	Bay, California-laurel
Ribes nevadense	Gooseberry
R. indecorum	Currant
R. Roezlii	Currant
Plantanus racemosa	Sycamore
Rubus vitifolius	Western Blackberry
Cercocarpus ledifolius	Mountain Mahogany
C. betuloides	Mountain Mahogany
Adenostoma fasciculatum	Greasewood
Purshia glandulosa	Antelope-brush
Prunus virginiana	Choke Cherry
P. ilicifolia	Holly-leaved Cherry
Larrea divaricata	Creosote Bush
Rhus diversiloba	Poisonoak
R. trilobata	Squaw Bush
R. laurina	Laurel Sumac
R. integrifolia	Lemonadeberry
R. ovata	Sugarbush
Rhamnus crocea	Buckthorn
Ceanothus sp.	Lilac
C. cordulatus	Snow-brush
Fremontia californica	California Slippery-elm
Opuntia occidentalis	Prickly-pear
Arctostaphylos sp.	Manzanita
Salvia mellifera	Black Sage
S. apiana	White Sage

Lycium Andersonii	Box-thorn
Haplopappus squarosus	
Chrysothamnus nauseosus	Rabbitbrush
Baccharis sp.	Mule Fat
Franseria dumosa	Burroweed
Artemisia tridentata	Basin Sagebrush
A. californica	Coastal Sagebrush
Lepidospartum squamatum	Scale-broom
L. latisquamatum	Scale-broom
Tetradymia spinosa	Cotton-thorn

Coastal Sage Scrub Association

MAJOR PLANTS

Artemisia californica	*Rhus integrifolia*
Salvia apiana	*Opuntia occidentalis*
Salvia mellifera	*Haploppapus squarrosus*
Eriogonum fasciculatum	

This association is restricted to the Pacific base of the range, is typical on the alluvium at the bases of the coastal foothills, and usually grades into the chaparral at about 1800 feet elevation. When seen from above, the rather level terrain of the association is broken sharply at the mouths of canyons by dry washes, and is limited below, to the south, by cultivated land. The coastal sagebrush is the most characteristic plant of this association, occurring in all undisturbed parts of the area.

There are several habitats within the coastal sage scrub association. These differ from one another chiefly on the basis of soil type. The soil of the rather level sageland in most places is rocky or gravelly, or, as adjacent to washes, it is finely sandy in texture, and supports the major plants of the association. Most of the eroded adobe banks at the bases of the foothills support these same plants, with white sage being the dominant species. Locally, as in damp hollows or cleared areas, there is grassland. Jumbles of boulders, sand, gravel, and steep cutbanks, are characteristic of the channels of dry washes, these areas supporting sparse vegetation. The fauna and flora of the washes are distinct from those of surrounding sage flats. Because they are included within the geographic limits of the coastal sage belt, however, the washes are discussed along with this association.

The abruptness with which one habitat gives way to another in this association causes sharp dividing lines between the local ranges of certain mammals. For example, in trap lines transecting dry washes and level sageland two assemblages of rodents were found. That part of the line amid the boulders and cutbanks of the wash took mostly *Peromyscus eremicus fraterculus* and *Neotoma lepida intermedia,* while *Perognathus fallax fallax, Dipodomys agilis agilis,* and *Peromyscus maniculatus gambeli* were taken in the adjacent sage flats. The steep adobe slopes of the foothills, which constitute the upper part of the coastal sage scrub association, are commonly inhabited by *Peromyscus californicus insignis,* which rarely occurs in the level tracts of sage a few yards away. Thus, this association is not homogeneous with regard to its rodent population; many of these species have local and discontinuous distributions.

The following list gives the results of about 500 trap nights (a trap night equals one trap set out for one night) in typical coastal sage-scrub association one-half mile southwest of the mouth of San Antonio Canyon, at 1700 feet elevation.

TABLE 2.—YIELD OF 500 TRAP-NIGHTS IN THE COASTAL SAGE SCRUB ASSOCIATION.

	Number	Per cent of total
Perognathus fallax fallax	31	30.7
Dipodomys agilis agilis	20	19.8
Reithrodontomys megalotis longicaudus	4	4.0
Peromyscus californicus insignis	4	4.0
P. eremicus fraterculus	7	6.9
P. maniculatus gambeli	20	19.8
Neotoma lepida intermedia	9	8.8
N. fuscipes macrotis	2	2.0
Microtus californicus sanctidiegi	4	4.0

The list below indicates the catch in 200 trap nights in San Antonio Wash, at 1700 feet elevation and within the realm of the coastal sage; all of the traps were set in rocky and sandy main channels of the wash.

TABLE 3.—YIELD OF 200 TRAP-NIGHTS IN SAN ANTONIO WASH.

	Number	Per cent of total
Perognathus fallax fallax	2	5.1
Peromyscus californicus insignis	2	5.1
P. eremicus fraterculus	26	66.7
Neotoma lepida intermedia	9	23.1

The prickly-pear cactus is of obvious importance to certain mammals of the coastal sage belt. This cactus is most common in disturbed areas such as sandy flats bordering washes, eroded adobe banks, and land once cleared by man. In these areas it is often the dominant plant with respect to area covered, usually growing in dense patches each covering approximately 150 square feet. It provides substitute nesting sites for *Neotoma lepida* in areas devoid of rock piles, and is probably the major factor governing the distribution of this wood rat in the sageland. Cottontails and brush rabbits use prickly-pear cactus extensively as refuge. Their forms and short burrows can be seen beneath many of the clumps of cactus.

This cactus serves as food for many mammals at least in the fruiting period in the fall. Usually only the fruit is eaten, but some pads are chewed by rabbits. The fruit or seeds of this plant are eaten by striped skunks, gray foxes, coyotes, pocket mice, kangaroo rats, wood rats, and probably white-footed mice.

The coyote is the dominant carnivore of the coastal sage flats. Many individuals spend the day in the adjacent chaparral-covered foothills and travel down into the flats at night to forage.

Southern Oak Woodland Association

MAJOR PLANTS

Alnus rhombifolia
Quercus agrifolia
Ribes indecorum
Rhus integrifolia
Rhus ovata
Rhus trilobata

This association is limited to the Pacific slope of the mountain range, occurs in the mouths of canyons and on the floors of canyons, and extends up the larger canyons to 4000 feet elevation or higher. In a few areas on the flats at the coastal base of the range the oaks replace the coastal sage.

The large oaks forming an overhead canopy and the lack of much undergrowth give the oak woodland a shaded parklike appearance. Few brushy or herbaceous plants grow in the mull-laden soil beneath the oaks. Some grasses, however, are present locally.

Two habitats are found in the oak woodland: the pure oak woodland and the riparian. Much of the oak woodland is in canyons and therefore near streams or seepages. The larger streams have bordering growths of alders, willows, and blackberries, inhabited by meadow mice and shrews that are normally absent from the adjacent oak woodland. *Neotoma fuscipes macrotis* and *Peromyscus californicus insignis* are commonly found in the riparian habitat, and *Peromyscus boylii* probably reaches peak abundance in the stream-side thickets and tangles of plant debris.

The rather open floor of the oak woodland is relatively devoid of mammal life. *Peromyscus californicus* and *Peromyscus boylii,* the only ground-dwelling rodents commonly found here, usually are taken near the limited areas of brushy growth, or the shelter afforded by logs and fallen branches. The paucity of shelter for small mammals seems to be an important factor limiting rodent populations in the oak woodland.

In the foothills of the San Gabriels the gray squirrel is restricted to the oak woodland, even though this association may be represented by only a narrow strip of canyon bottom oak trees. The presence or absence of "bridges" of oak woodland between mountains which are centers of gray squirrel populations and nearby ranges has probably been a major factor influencing the present geographic distribution of this animal.

The raccoon is the most abundant carnivore of the oak woodland, being especially common in the riparian habitat.

Chaparral Association

MAJOR PLANTS

Adenostoma fasciculatum
Rhamnus crocea
Quercus dumosa
Cercocarpus betuloides
Yucca Whipplei
Prunus ilicifolia
Ceanothus sp.
Arctostaphylos sp.
Umbellularia californica

This association is characteristic of the Pacific slope of the San Gabriels and extends from roughly 2000 feet elevation to 5000 or 6000 feet elevation. The ecotone between the chaparral and yellow pine forest associations covers a broad elevational belt, with chaparral following dry slopes up into coniferous forests, and conifers extending down north slopes surrounded by chaparral.

The chaparral association is characterized by tracts of dense brushy plants. These plants are from three to ten feet tall, their interlacing branches often forming nearly impenetrable thickets. Typically little herbaceous growth is present beneath the chaparral, the ground being covered with varying amounts of mull.

The effects of fire, slope, exposure, and elevation, make the chaparral association extremely varied with regard to habitats or plant formations. There are nearly pure stands of greasewood on the lower arid slopes; scrub oak, sumac, and lilac clothe less dry exposures; scrub oak and bay trees occur commonly amid granite talus; and locally groves of bigcone-spruce are found. Because of the many habitats present, and the difficulty of collecting in the chaparral, less was learned of the ecology of the mammals in this association than of those occurring elsewhere. The distribution of several chaparral-inhabiting mammals seems to be influenced by the distribution of locally characteristic plants, for example oak and bay woodland, or greasewood chaparral.

Several habitats within the chaparral community support few species of mammals and few individuals. Possibly the compact, rocky nature of the soil limits burrowing rodents, and the lack of herbaceous growth limits the food supply. Steep rocky slopes in San Antonio Canyon grown to mountain-mahogany and scrub oak were sparsely populated by *Peromyscus boylii rowleyi, Peromyscus californicus insignis,* and *Neotoma fuscipes macrotis.* Fifty traps set on such a slope for one night caught only three *Peromyscus.* Traps set in tracts of greasewood brush on dry south slopes at the head of Cow Canyon produced only California mice, *Peromyscus californicus insignis* Rhoads.

Following is a list of the mammals taken in the course of approximately 600 trap nights in the lower parts of the chaparral belt. All of the traps were set on slopes in San Antonio Canyon below 4000 feet elevation. The list gives a general indication of the relative numbers of rodents inhabiting one chaparral habitat: the arid greasewood-covered south slopes of the lower chaparral belt.

TABLE 4.—YIELD OF 600 TRAP-NIGHTS IN GREASEWOOD CHAPARRAL.

	Number	Per cent of total
Perognathus californicus dispar	4	10.0
Dipodomys agilis agilis	4	10.0
Peromyscus californicus insignis	25	62.5
Neotoma fuscipes macrotis	7	17.5

Heteromyids are evidently absent from the upper parts of the chaparral association, but cricetid rodents are common there beneath heavy clumps of lilac and in the talus beneath oaks and bay trees. The following list gives the mammals taken in the course of about 200 trap nights in the granite talus one half mile northwest of the mouth of Icehouse Canyon, at 5200 feet elevation.

TABLE 5.—YIELD OF 200 TRAP-NIGHTS IN THE UPPER PART OF THE CHAPARRAL ASSOCIATION.

	Number	Per cent of total
Eutamias merriami merriami	3	6.3
Peromyscus boylii rowleyi	38	79.2
Neotoma lepida intermedia	2	4.2
Neotoma fuscipes macrotis	5	10.4

The gray fox is the dominant carnivore of the chaparral association and forages widely in all habitats.

Yellow Pine Forest Association

MAJOR PLANTS

Pinus ponderosa
P. lambertiana
Libocedrus decurrens
Abies concolor
Quercus Kelloggii
Ribes nevadense
Ribes Roezlii
Arctostaphylos sp.
Ceanothus cordulatus

The crest of the range, from the upper limit of the chaparral association at roughly 6000 feet to the limited areas of boreal flora above 8500 feet elevation, is covered by yellow pine forests. On the desert slope of the range the coniferous forests which extend down to about 6000 feet represent the best development of this association, while the coniferous forests on the coastal side of the drainage divide are often more or less diluted by chaparral elements. For example, yellow pines on the Pacific face of Blue Ridge at 7000 feet elevation often grow in association with scrub oak and mountain-mahogany.

Few mammals are resident in the typical yellow pine forest as characterized by dense coniferous timber and little herbaceous or brushy growth. Here most of the species recorded actually find optimal conditions in an adjacent habitat. The forest probably harbors surplus individuals from adjacent preferred habitats, or, as in the case of chipmunks and ground squirrels, the forest often serves as forage ground while nearby brushy areas are utilized for breeding and shelter. The abundance of birds in the timber contrasts strikingly with the paucity of mammals there. The lack of a seed-producing understory, and the open duff-covered stretches of ground on which rodents would be extremely vulnerable to predation, probably in part account for the scarcity of rodents.

Within the general area encompassed by the yellow pine forest there are two major habitats, namely coniferous forest and chaparral.

The species of plants comprising the chaparral of the Transition Life-zone are different from those comprising the chaparral of the Upper Sonoran Life-zone on the Pacific slope. In the chaparral of the Transition Life-zone, basin sagebrush and snowbrush grow in extensive patches in clearings in the timber. Dense thickets of choke cherry cover many damp hollows, and these thickets harbor the houses of *Neotoma fuscipes.* The food and shelter afforded by these chaparral areas importantly influence the local distribution of rodents: for example, *Dipodomys agilis* and *Perognathus californicus* in the yellow pine area are found only in association with chaparral, being completely absent from wooded areas.

The severe winter weather in this association must force many of the mammals into periods of inactivity. Probably during the long periods in the winter when snow covers the ground the heteromyids and sciurids remain below ground.

Pinyon-Juniper Woodland Association

MAJOR PLANTS

Pinus monophylla
Juniperus californica
Quercus dumosa var. turbinella
Purshia glandulosa
Fremontia californica
Cercocarpus ledifolius
Yucca Whipplei

In the San Gabriel Mountains this association is limited to the desert slope and reaches its lower limit at the bases of the foothills and extends up to the lower edge of the yellow pine forests. The altitudinal extent of the pinyon-juniper association is from roughly 4000 to 6000 feet elevation.

Several habitats are evident within the pinyon-juniper belt. On north slopes in the upper part of this association, scattered stands of pinyon pines are found with dense patches of scrub oak intervening, while on other such slopes a dense chaparral is present, consisting primarily of scrub oak, mountain-mahogany, and California slippery-elm. In this type of chaparral several hundred trap nights yielded only two rodent species: *Neotoma fuscipes simplex* and *Peromyscus truei montipinoris.* There are few pinyons on the south slopes, especially in the lower parts of the association; many of these slopes are clothed with an open growth of manzanita and yucca, while northern exposures there support mostly scrub oak. Many of the flats of the pinyon belt are grown to basin sagebrush.

Following is a list of the mammals taken in about 400 trap nights at one locality in the pinyon-juniper association. The area supported a mixed growth of pinyon, scrub oak, mountain-mahogany, and antelope-brush, together with smaller brushy plants, and was at the head of Grandview Canyon, at an altitude of roughly 5000 feet.

TABLE 6.—YIELD OF 400 TRAP-NIGHTS IN THE PINYON-JUNIPER ASSOCIATION.

	Number	Per cent of total
Perognathus fallax pallidus	3	11.5
Dipodomys agilis fuscus	9	34.6
Peromyscus truei montipinoris	10	38.5
Neotoma fuscipes simplex	4	15.4

Although Munz and Keck (1949:101) considered the pinyon-juniper belt as one association, on the desert slope of the San Gabriels pinyons and junipers do not generally grow on common ground; but rather the juniper belt represents a well defined habitat occurring between the pinyon covered slopes and the flats that support Joshua trees. Because the mammalian populations of the pinyon belt and the juniper belt are somewhat different, the mammals of these areas are most conveniently taken up separately.

In the juniper belt the juniper tree is of marked ecologic significance; the distribution of *Peromyscus truei* and *Neotoma fuscipes* is determined here by the presence of junipers. At certain times of year the fruit of this plant is eaten by coyotes, kangaroo rats, and wood rats.

The list below indicates the results of approximately 500 trap nights in the juniper belt near Mescal Canyon, between 4000 and 5000 feet elevation.

TABLE 7.—YIELD OF 500 TRAP-NIGHTS IN THE JUNIPER BELT.

	Number	Per cent of total
Perognathus fallax pallidus	16	16.7
Dipodomys merriami merriami	3	3.1
Dipodomys panamintinus mohavensis	36	37.5
Peromyscus truei montipinoris	22	22.9
Peromyscus maniculatus sonoriensis	12	12.5
Neotoma lepida lepida	2	2.1
Neotoma fuscipes simplex	2	2.1
Onychomys torridus pulcher	3	3.1

PLATE 1

FIG. 1. View of typical coastal sage scrub association, showing in foreground white sage, and coastal sagebrush. The adobe banks beyond are grown mainly to white sage. Small mammals are abundant in this association, with *Dipodomys agilis, Perognathus fallax,* and *Sylvilagus audubonii* being characteristic of the area. Photo March 25, 1952, at mouth of San Antonio Canyon, 1800 feet elevation.

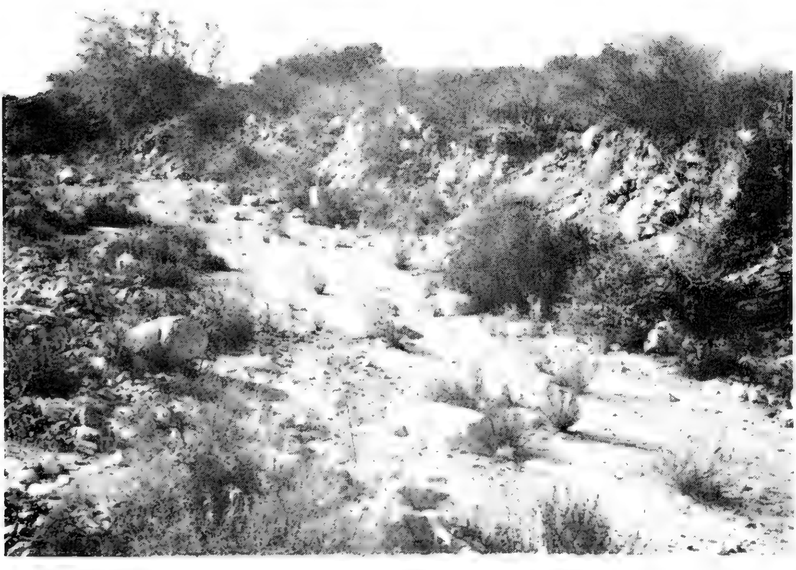

FIG. 2. View of a main channel in San Antonio Wash on Pacific slope. The wash is a distinct habitat in the coastal sage scrub association, and is the preferred habitat of *Peromyscus eremicus fraterculus* and *Neotoma lepida intermedia.* These rodents find shelter in the piles of boulders. Photo February 2, 1952, in San Antonio Wash, at 1700 feet elevation.

PLATE 2

Fig. 1. Southern oak woodland association. The open leaf-strewn floor of the woodland lacks shelter for ground-dwelling rodents and the population of rodents is small. *Peromyscus boylii rowleyi* is the commonest rodent. Photo March 10, 1952, in Evey Canyon, 2700 feet elevation.

Fig. 2. Yellow pine forest association, composed largely of yellow pines, white fir, and black oak. Photo April 27, 1952, at Big Pines, 6800 ft. elevation.

PLATE 3

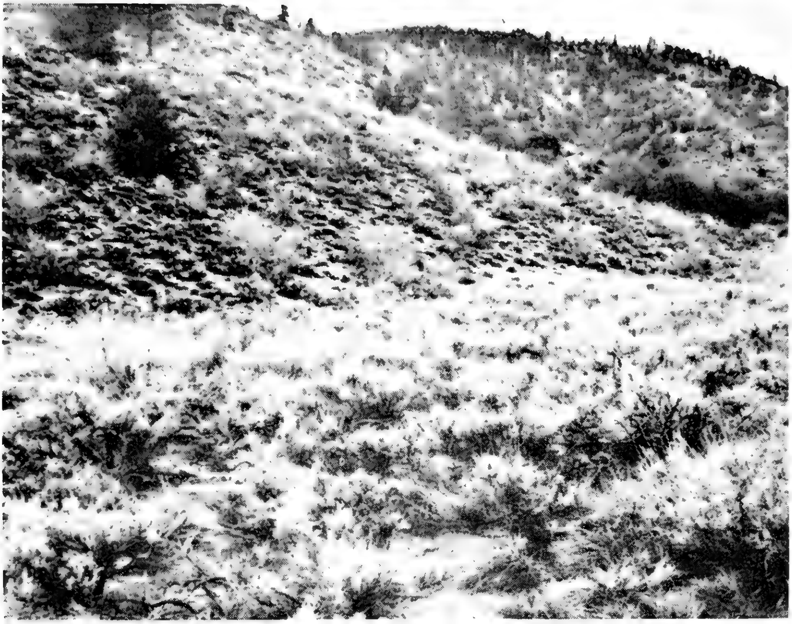

Fig. 1. View of the sagebrush scrub association showing a nearly pure stand of basin sagebrush. *Dipodomys agilis perplexus* and *Reithrodontomys megalotis longicaudus* occur in this association, and *Peromyscus truei montipinoris* is present where this association merges with the pinyon-juniper association. Photo April 27, 1952, in Swarthout Valley, 6200 feet elevation.

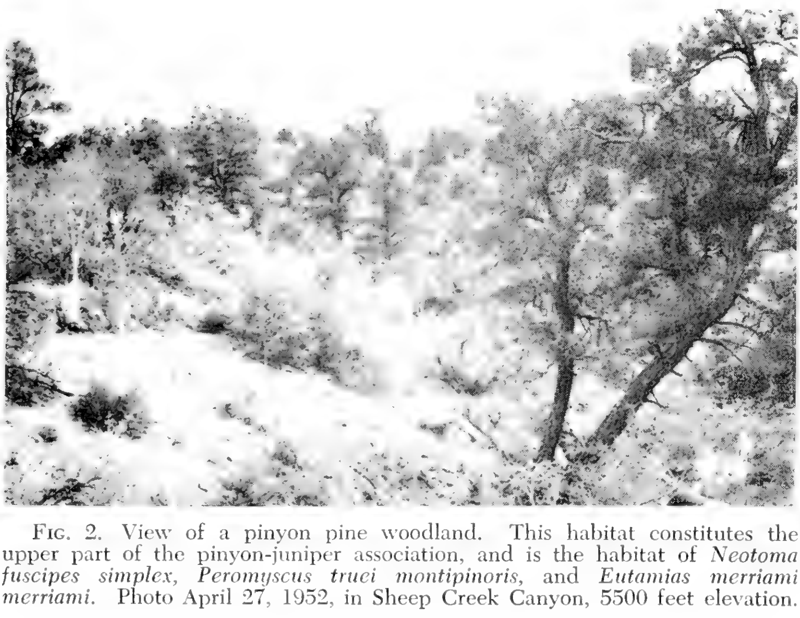

Fig. 2. View of a pinyon pine woodland. This habitat constitutes the upper part of the pinyon-juniper association, and is the habitat of *Neotoma fuscipes simplex, Peromyscus truei montipinoris,* and *Eutamias merriami merriami.* Photo April 27, 1952, in Sheep Creek Canyon, 5500 feet elevation.

Fig. 1. View of the juniper belt. This habitat forms the lower part of the pinyon-juniper association. *Perognathus fallax pallidus, Dipodomys panamintinus mohavensis,* and *Peromyscus truei montipinoris* are typical of this area. Photo April 27, 1952, at Desert Springs, 4300 feet elevation.

Fig. 2. Joshua tree woodland association. The characteristic mammals are *Dipodomys panamintinus mohavensis, D. merriami merriami,* and *Onychomys torridus pulcher.* Photo January 4, 1952, 6 miles east and 2 miles south Llano, 3600 feet elevation.

The biota of the washes that cut through the juniper belt in and below many of the larger canyons differs from that of the surrounding juniper-clad benches. Because the washes are in the same geographic area as the juniper belt they are discussed together. These washes on desert slopes are densely populated by rodents derived from adjacent areas, and support vegetation typical of higher floral belts in association with xerophytic, typically desert, species. In a sense, the washes serve to mix up the mammals of adjacent areas. For example, *Onychomys torridus pulcher* and *Peromyscus eremicus eremicus,* which are mammals typical of the desert, were found in Mescal Wash above their usual desert range; and *Peromyscus californicus insignis* and *Peromyscus boylii rowleyi,* which are chaparral inhabiting mammals, were found in the wash far removed from their chaparral environment. Washes are evidently effective agents in facilitating the dispersal of certain species of mammals. It is easy to envision a species crossing hostile habitats *via* dry washes to invade suitable niches in an area which is geographically and ecologically isolated from the original home of the species. Approximately 500 trap nights in Mescal Wash, at 4100 feet elevation, in the lower edge of the juniper belt, yielded the following mammals:

TABLE 8.—YIELD OF 500 TRAP-NIGHTS IN MESCAL WASH (DESERT SLOPE).

	Number	Per cent of total
Perognathus fallax pallidus	5	4.5
Dipodomys panamintinus mohavensis	43	38.7
Peromyscus californicus insignis	3	2.7
Peromyscus truei montipinoris	1	.9
Peromyscus boylii rowleyi	2	1.8
Peromyscus eremicus eremicus	28	25.0
Peromyscus maniculatus sonoriensis	23	20.5
Onychomys torridus pulcher	4	3.5
Neotoma lepida lepida	3	2.7

Dipodomys panamintinus mohavensis, Neotoma fuscipes simplex, and *Peromyscus truei montipinoris* are probably the most characteristic mammals of the pinyon-juniper association.

Sagebrush Scrub Association

MAJOR PLANTS

Bromus sp.	*Chrysothamnus nauseosus*
Artemisia tridentata	*Purshia glandulosa*

This association is found on only the crest and desert slope of the range between 5000 and 8000 feet elevation. There it characteristically occupies flats and clearings in the yellow pine forest and pinyon-juniper woodland. The dominant plant of the association is basin sagebrush, and in many places this plant forms mixed growths with snowbrush and *Haplopappus*. The low brush of this association is formed by closely spaced bushes with grasses growing between.

Because of its limited occurrence in the San Gabriel Mountains, this association there has relatively little effect on mammalian distribution. Locally, nevertheless, the presence of this association governs the distribution of certain mammals. For example, on Blue Ridge, islands of sagebrush amid the conifers provide suitable habitat for *Dipodomys agilis perplexus* and *Perognathus californicus bernardinus;* and in Swarthout Valley *D. a. perplexus, Reithrodontomys megalotis longicaudus,* and *Lepus californicus deserticola* are seemingly restricted to the sagebrush flats.

Joshua Tree Woodland Association

MAJOR PLANTS

Yucca brevifolia	*Tetradymia spinosa*
Lycium Andersonii	*Ephedra sp.*
Eriogonum fasciculatum	*Larrea divaricata*

This association is on the piedmont that dips toward the Mojave Desert from the interior base of the San Gabriels. The widely spaced Joshua trees with low bushes between, and the dry washes breaking the level terrain below the mouths of canyons are typical of this area. Field work was extended no farther down into the desert than about the 3500 foot level, where this association was still dominant.

Although the vegetation of this area is scattered and sparse, presenting a barren and sterile aspect, the area supports a rather high population of rodents. The soil at the bases of many large boxthorn- and creosote-bushes is perforated by burrow systems of *Dipodomys panamintinus* or *Dipodomys merriami,* and those burrows abandoned by kangaroo rats are used as retreats by *Onychomys torridus* and *Peromyscus maniculatus.* The mammals of this association are all characteristic of the fauna of the Mojave Desert, with the ranges of such species as the coyote and jack rabbit extending well up the desert slope of the mountains.

The mammals listed below were taken in 1948 in roughly 400 trap nights in the Joshua belt, at an elevation of 3500 feet, one mile below the mouth of Graham Canyon.

TABLE 9.—YIELD OF 400 TRAP-NIGHTS IN THE JOSHUA TREE BELT.

	Number	Per cent of total
Dipodomys panamintinus mohavensis	36	59.0
Dipodomys merriami merriami	15	24.6
Onychomys torridus pulcher	4	6.6
Peromyscus maniculatus gambeli	6	9.8

Populations of *Dipodomys merriami* and *D. panamintinus* fluctuate widely, possibly in response to weather cycles. In November of 1948 trapping in the Joshua belt showed that *panamintinus* outnumbered *merriami* approximately three to one, whereas in December of 1951, after a succession of unusually dry years, *merriami* was the more numerous. Further, *merriami* occurred in the lower parts of the juniper belt in 1951 where in 1948 it seemed to be absent.

Dipodomys merriami merriami and *Onychomys torridus pulcher* are diagnostic of the Joshua tree woodland association in the San Gabriel Mountains area, since few individuals of either species occur outside of this association.

ACCOUNTS OF SPECIES

Family DIDELPHIDAE

Didelphis marsupialis virginiana Kerr

Virginia Opossom

The opossum is common in and near small towns and cultivated areas at the Pacific base of the mountain range and does not thrive away from human habitation; extensive trapping in the coastal sage and chaparral belts produced no specimens except immediately adjacent to citrus groves. Pequegnat (1951:47) mentions that opossums in the Santa Ana Mountains of southern California are in the lower parts of the larger canyons, especially near human habitation.

Specimens examined.—Los Angeles County: Claremont, 1600 ft., 2 (PC).

Family TALPIDAE

Scapanus latimanus occultus Grinnell and Swarth

California Mole

Workings of moles were found on the Pacific slope of the mountains from 1600 feet at Claremont up to 7500 feet on Blue Ridge, and on the Pacific slope beneath basin sagebrush in Cajon Canyon one mile from desert slope Joshua-tree flats, but not on the desert slope, although moles probably occur on that slope in some of the places where there is suitable habitat.

Near Camp Baldy in the sandy soil beneath groves of alders moles seemed to be especially abundant. Although common on the coastal face of the range, moles shunned compact, dry, or rocky soils. In the greasewood chaparral one-half mile west of the mouth of Palmer Canyon, where the soil was hard and rocky, mole tunnels were in soft soil that had accumulated at the edge of a fire road beneath a steep road cut. The assumption is that this accumulation contained insects attractive, as food, to the moles.

Specimens examined, 2: Los Angeles County: Camp Baldy, 4200 ft., 1(PC); Claremont, 1600 ft., 1(PC).

Family SORICIDAE

Sorex obscurus parvidens Jackson

Dusky Shrew

Jackson (1928:124) recorded a specimen from Camp Baldy, 4200 feet, San Antonio Canyon.

Sorex ornatus ornatus Merriam

Ornate Shrew

Both of my specimens were taken amid riparian growth on the Pacific slope of the range.

Specimens examined, 2: Los Angeles County: San Antonio Canyon, 3500 ft., 1; Cobal Canyon, 5 mi. N Claremont, 1800 ft., 1 (PC).

Notiosorex crawfordi crawfordi (Coues)

Gray Shrew

One was taken in 1946 beneath a woodpile on the campus of Norton School, two miles northeast of Claremont, and examined by Dr. W. E. Pequegnat.

Family VESPERTILIONIDAE

Myotis yumanensis sociabilis H. W. Grinnell

Yuma Myotis

A female was taken in lower San Antonio Canyon, 2800 feet elevation, on September 27, 1951.

Myotis evotis evotis (J. A. Allen)

Long-eared Myotis

This species was observed and collected at several stations ranging from 2800 feet elevation in San Antonio Canyon, to Blue Ridge at 8200 feet, and down the desert slope to 6000 feet at Jackson Lake. This distribution encompasses most of the chaparral and yellow pine forest associations. Within these areas, however, this bat shows marked habitat preferences.

Woodland habitats seem to be preferred by *evotis.* At several ponds in lower San Antonio Canyon this bat was observed repeatedly as it foraged over the water and coursed low between rows of alders and *Baccharis.* At Blue Ridge in September, 1951, these bats foraged approximately six feet above the ground beneath the canopy of coniferous foliage and between the trunks of the trees.

Most of the bats were taken by stretching fine wires above the surface of a pond as outlined by Borell (1937:478). Collecting was generally carried on until at least 11:00 p. m., and the time at which each bat was taken at the pond was recorded, thereby making possible a rough estimate of the pre-midnight forage period of each bat commonly collected at the ponds. Usually bats taken at the start of their supposed forage period had empty or nearly empty stomachs, whereas those taken towards the end of their forage period had full or nearly full stomachs. *M. evotis* usually first appeared just at dark, well after the pipistrelles and California myotis had begun foraging. The forage period of *evotis* seemed to begin approximately 30 minutes after sunset and to end approximately two and one-quarter hours later.

Individuals of this species were taken from May 4, to October 14, 1951. A female taken on May 19, 1951, in San Antonio Canyon, carried one minute embryo, and one taken in the same locality on June 8, had one embryo four millimeters in length.

Specimens examined.—Total, 12, distributed as follows: Los Angeles County: San Antonio Canyon, 2800 ft., 11; Claremont, 1100 ft., 1 (P.C.).

Myotis volans interior Miller

Interior Long-legged Bat

Although seldom found to be plentiful, this bat was recorded from many points on both the coastal and desert slopes of the mountains. Specimens were taken in the chaparral association in San Antonio Canyon, near Jackson Lake among yellow pines, and in Mescal Canyon at the upper limit of the Joshua tree woodland. Bats, probably *volans,* were noted over sage flats at 8000 feet elevation on Blue Ridge. The only place where these bats appeared to be numerous was Jackson Lake on the interior slope; there, on September 19, 1951, *volans* appeared with the pipistrelles, and was the most common bat before dark.

An individual of this species taken on October 28, 1951, in a short mine-shaft in the pinyon belt at the head of Grandview Canyon was slow in its movements and felt as cold as the walls of the tunnel. It was late afternoon and the temperature outside the cave was below 40°F. The floor of the tunnel was covered with the hind wings of large moths of the genus *Catocala; volans* probably hung in the cave while eating them.

The series of *volans* from the San Gabriels shows that the two color phases of this bat both occur in the area. Two specimens from Jackson Lake contrast sharply with the rest of the series in their dark coloration. Benson (1949:50) states that color variation in a series of *volans* from a given locality may be striking.

This bat was collected in San Antonio Canyon from 50 minutes after sundown to two hours and 40 minutes after sundown. In this area these bats did not visit the ponds in large numbers as they seemed to do on the desert slope.

A female taken on May 29, 1951, contained one embryo nearly at term.

Specimens examined.—Total, 9, distributed as follows: Los Angeles County: Mescal Canyon, 8 mi. E and 5 mi. S Llano, 4900 ft., 1; 3 mi. W Big Pines, Swarthout Valley, 6000 ft., 3; San Antonio Canyon, 2800 ft., 5.

Myotis californicus californicus (Audubon and Bachman)

California Myotis

On the Pacific face of the mountain range this bat was recorded commonly below approximately 5000 feet elevation, where it seemed to be most common in the oak woodland of canyons. On the desert slope it was collected at Jackson Lake in yellow pine woodland, in Mescal Canyon in the juniper belt, and bats presumably of this species were observed at several points in the pinyon-juniper woodland.

Individuals of this species were often observed foraging from five to ten feet above the ground around the alders and *Baccharis* near San Antonio Creek, but they did not fly so low or so near the vegetation as did *Myotis evotis*. Here they were taken from 18 minutes to 55 minutes after sunset; this indicates an early and short forage period.

This bat may be active even in winter. On February 8, 1952, in lower San Antonio Canyon, a bat, probably of this species, was noted foraging; and collecting in early November, 1951, yielded specimens.

On May 22, 1951, a female obtained in San Antonio Canyon had one five-millimeter embryo, and subsequently all the females examined had embryos until June 12, when collecting was discontinued.

Specimens examined.—Total, 16, distributed as follows: Los Angeles County: Mescal Canyon, 4800 ft., 2; Jackson Lake, 6000 ft., 1 (PC); San Antonio Canyon, 3900 ft., 1; San Antonio Canyon, 2800 ft., 12.

Pipistrellus hesperus merriami (Dobson)

Western Pipistrelle

This is the most obvious if not the most common bat of the lower coastal slopes of the San Gabriels. In the spring and fall of 1951 individuals were noted from 1700 feet in the coastal sage scrub association to the white fir forests on Blue Ridge at 8200 feet elevation and were commonest in the rocky canyons of the lower Pacific slope below 4000 feet, and usually foraged near the steep canyon sides high above the canyon bottoms.

Pipistrelles were generally the first bats to appear in the evening, although the times of their appearance were irregular. In April and May, in lower San Antonio Canyon, they appeared from 28 minutes before sunset to 30 minutes after sunset, with the average time of appearance eight and one-half minutes after sunset. Like *Myotis californicus* this pipistrelle seemed to have a short and early foraging period. No pipistrelles were recorded at ponds later than one hour and five minutes after sunset, and usually they were not seen later than 40 minutes after sunset. Most of the specimens taken later than one half hour after sunset had full stomachs. More than 50 pipistrelles were captured at the ponds in San Antonio Canyon; six were kept for specimens. This species is probably present in the area throughout the winter. Pipistrelles were active in early April in Evey Canyon, were observed in early November in San Antonio Canyon, and on January 26, 1952, an individual was noted foraging near the mouth of Palmer Canyon. They are probably not active in winter on the colder desert slope of the mountains.

Pipistrelles often foraged in loose flocks of about half a dozen individuals. On many occasions these groups were first seen foraging high up above the canyon bottom, then, as it grew darker, they descended and foraged within 50 or 100 feet of the floor of the canyon. Immediately before dark these groups seemed to have forage beats; one minute several pipistrelles would be overhead, and the next minute none would be in sight.

A female taken in San Antonio Canyon on June 8, 1951, contained two five-millimeter embryos.

Specimens examined.—Total, 6, distributed as follows: Los Angeles County: San Antonio Canyon, 2800 ft., 5; Evey Canyon, 2400 ft., 1.

Pipistrellus hesperus hesperus (H. Allen)

Western Pipistrelle

This species was common in the spring and autumn of 1951 from the lower edge of the yellow pine forest down into the belt of Joshua trees. In early April on the desert slope at 4800 feet in Mescal Canyon, pipistrelles foraged on evenings when it was windy but not cold. On cold evenings (when the temperature was below roughly 45°F) none was seen. On windy nights the pipistrelles often forsook their usual high forage habits and foraged 15 feet or so above the ground where the vegetation and outcrops of rock broke the force of the wind. In 1951 no pipistrelles were noted on the desert slope later than October 15.

Specimens examined.—Los Angeles County: Mescal Canyon, 4800 ft., 4.

Eptesicus fuscus bernardinus Rhoads

Big Brown Bat

This bat was on the coastal slope from the sage scrub association at 1100 feet, up to 8000 feet on Blue Ridge, and on the desert slope down to the upper edge of the Joshua tree belt at 4800 feet in Mescal Canyon. It was the most common bat at the ponds in San Antonio Canyon in May and June of 1951, but in September and October of the same year none was obtained there.

On the Pacific slope of the San Gabriels the big brown bats segregate according to sex in the spring, the males occupying the foothills and mountains and the females the level valley floor at the coastal base of the range. Of 70 big brown bats captured in May and June of 1951, at the ponds in San Antonio Canyon, only one was a female. A large colony of more than 200 individuals in a barn near Covina, in the citrus belt, was composed of only females.

Times of capture of this bat at the ponds in San Antonio Canyon ranged from ten minutes after sunset to two hours and thirty minutes after sunset. Generally these bats came to the ponds in groups of several individuals, and often more than a dozen were captured in the course of an evening's collecting.

Specimens examined.—Total, 7, distributed as follows: Los Angeles County: Mescal Canyon, 4800 ft., 1; San Antonio Canyon, 2800 ft., 2; Covina, 1100 ft., 4 (2PC).

Lasiurus borealis teleotis (H. Allen)

Red Bat

One female was taken on September 30, 1951, in San Antonio Canyon, at 2800 feet elevation. The descriptions which the citrus growers of the Claremont and Glendora vicinity give of the bats they find occasionally hanging in their citrus trees accurately describe this species. Its seasonal occurrence there is unknown.

Lasiurus cinereus cinereus (Pasilot de Beauvois)

Hoary Bat

Specimens were collected in spring in 1951 at elevations of 2800 and 3200 feet in San Antonio Canyon, on the coastal slope, and in Mescal Canyon at 4900 feet, on the desert slope. Large, fast flying bats, probably of this species, were seen at Jackson Lake, 6000 feet elevation, on October 15, 1951.

Hoary bats are present in the San Gabriels in the fall, winter, and spring. In 1951 the last spring specimen was taken on June 11, in Mescal Canyon; then collecting was discontinued until late September when the first hoary bat was taken on the thirtieth of that month. From this date on into the winter hoary bats were recorded regularly. They seemed to be as common in early June as in most of April and May; possibly some remain in the San Gabriels throughout the summer.

In spring these bats seem to segregate by sex; of twelve kept as specimens and at least an equal number captured and released only one was a female. All were captured above 2800 feet.

Hoary bats seem to have a long pre-midnight forage period, having been captured at ponds from 21 minutes after sunset, to three hours and 26 minutes after sunset. Generally those taken early had empty stomachs and those taken later had full stomachs. On the night of May 24, 1951, a hoary bat captured two hours and five minutes after sunset had only a partially full stomach.

On May 25, 1951, an unusual concentration of hoary bats was observed at a pond at about 3200 feet elevation, in San Antonio Canyon (Vaughan, 1953). The day had been clear and warm, one of the first summerlike days of spring. Beginning at 30 minutes after sundown hoary bats were collected until two hours and 35 minutes after sundown; in this period 22 were caught and at least as many more observed. Many were released after being examined, whereupon they hung on the foliage of nearby alders to rest and dry themselves. This concentration of hoary bats may have been due to a sudden beginning of migration with a resultant concentration of bats at certain altitudinal belts. The warm weather might have set off the migration. On evenings that followed subsequent hot days no such concentration of hoary bats was seen. B. P. Bole (Hall 1946:156) observed a concentration of hoary bats on August 28, 1932, in Esmeralda County, Nevada.

Several captive *Myotis californicus* in a jar next to a pond in San Antonio Canyon set up a squeaking which seemed to attract a hoary bat. Repeatedly the large bat swooped over the jar.

Specimens examined.—Total, 12, distributed as follows: Los Angeles County: Mescal Canyon, 4900 ft., 2; San Antonio Canyon, 3200 ft., 2; San Antonio Canyon, 2800 ft., 8.

Antrozous pallidus pacificus Merriam

Pallid Bat

The pallid bat is probably the most common and characteristic bat of the citrus belt at the Pacific base of the mountains. Only once, on May 4, 1951, was this bat taken in the mountains. On that night two individuals were collected at 2800 feet in San Antonio Canyon. All of the other specimens and observations were from colonies in old barns and outbuildings in the citrus belt where these bats are found in spring, summer, and fall.

The impression gained by examining many mixed colonies of *Antrozous* and *Tadarida* was that the former greatly outnumbered the latter. For example, a small colony of bats in an old barn near San Dimas Wash consisted of about thirty pallid bats and five free-tails.

Large numbers of wings of moths of the family *Sphingidae*, and legs and parts of the heads of Jerusalem crickets (*Stenopelmatus* *fuscus*) were beneath an *Antrozous* night-roosting place in a barn near Upland.

Pallid bats were collected in 1951, from April 16 to October 17 but probably were active in the area into November.

Each of two pregnant females taken two miles northeast of San Dimas on April 20, 1951, carried two embryos 4 millimeters long.

Specimens examined.—Total, 6, distributed as follows: Los Angeles County: 2 mi. NE San Dimas, 1200 ft., 2 (1PC); Ontario, 1100 ft., 4 (3PC).

Family MOLOSSIDAE

Tadarida mexicana (Saussure)

Mexican Free-tailed Bat

This bat, regularly met with in the citrus belt at the coastal base of the range, occurred in small numbers with colonies of *Antrozous,* and was once found with a colony of *Eptesicus* near Covina. None of the females taken in April 1951 was pregnant.

Specimens examined.—Los Angeles County: 2 mi. NE San Dimas, 1200 ft., 4.

Eumops perotis californicus (Merriam)

Mastiff Bat

H. W. Grinnell (1918:373) mentioned individuals collected at Sierra Madre (at the coastal base of the San Gabriels west of the study area), and Sanborn (1932:351) reported specimens from Covina and Azusa. Probably this bat occurs locally all along the coastal base of the range.

Family LEPORIDAE

Lepus californicus bennettii Gray

California Jack Rabbit

This species was found in the coastal sage belt from Cajon Wash west to San Gabriel Canyon and was most plentiful in thin stands of sagebrush, and in and around citrus groves. Because of their preference for semi-open country, jack rabbits are absent from much of the coastal belt of sagebrush where the brush is fairly continuous, and they never were observed in the chaparral association.

Coyotes catch many jack rabbits and regularly forage around the foothill borders of the citrus groves for cottontails and jack rabbits.

A female examined on February 19, 1951, was pregnant, and one taken on March 15, 1951, carried three small embryos.

Specimens examined.—San Bernardino County: 2 mi. NW Upland, 1600 ft., 3 (PC).

Lepus californicus deserticola Mearns

California Jack Rabbit

There was sign of jack rabbits along the desert slope of the San Gabriels up to about 6700 feet, one-half mile west of Big Pines. They were fairly common in the Joshua tree belt, occurred less commonly in the juniper belt, and were present locally in small numbers in the pinyon-juniper association.

The population seemed to be at a low ebb from 1948 to 1952, when field work was done on the desert slope. I often hiked for an hour or more on the desert or juniper-covered benches without seeing a jack rabbit. The species was commoner in washes where as many as eleven were noted in two hours' hiking.

In December, 1951, below Graham Canyon, the leaves on large areas of many nearly recumbent Joshua trees had been gnawed down to their bases, and jack rabbit feces covered the ground next to these gnawings. Probably the Joshua tree is an emergency food used by the rabbits only when other food is scarce.

In years when the population of jack rabbits is not low they serve as a major food for coyotes. In the Joshua tree belt below Mescal Canyon, jack rabbit remains were fairly common in coyote feces, and tracks repeatedly showed where some coyote had pursued a jack rabbit for a short distance. A large male bobcat trapped in the juniper belt in Graham Canyon had deer hair and jack rabbit remains in its stomach.

Specimens examined.—Total, 7, distributed as follows: Los Angeles County: 6 mi. E and 1 mi. S Llano, 3500 ft., 4; Mescal Canyon, 4800 ft., 3.

Sylvilagus audubonii sanctidiegi (Miller)

Audubon Cottontail

Cottontails are common in the coastal sage scrub association and in and around citrus groves, but generally penetrate the mountains no farther than the lower limit of the chaparral association. They are everywhere on coastal alluvial slopes, except in the barren washes, and prefer patches of prickly-pear and often are loathe to leave its protection. After completely destroying a large patch of prickly-pear in the course of examining a wood rat house in the center of the cactus, I found hiding, in the main nest chamber of the house, a cottontail that dashed from its hiding place only when poked forceably with the handle of a hoe.

Cottontails are seldom above the sage belt in the chaparral associations, although along firebreaks and roads they occasionally occur there. Habitually cottontails escape predators in partly open terrain offering retreats such as low, thick brush, rock piles, and cactus patches; but on open ground beneath dense chaparral, cottontails may be vulnerable to predation.

Examinations of feces and stomach contents of the coyote reveals that it preys more heavily on cottontails than on any other wild species. Remains of several cottontails eaten by raptors were found in the sage belt.

In April, 1951, many young cottontails were found dead on roads in the sage belt, and a newly born cottontail was in the stomach of a coyote trapped four miles north of Claremont, on February 7, 1952.

Specimens examined.—Total, 3, distributed as follows: Los Angeles County: mouth of San Antonio Canyon, 2000 ft., 1 (PC). San Bernardino County: 2 mi. NW Upland, 1600 ft., 2 (PC).

Sylvilagus audubonii arizonae (J. A. Allen)

Audubon Cottontail

This subspecies was recorded on the interior slope from 5200 feet elevation, as at the head of Grandview Canyon, down into the desert, and was common in the sagebrush flats of the upper pinyon-juniper association. Piles of feces under thick oak and mountain-mahogany chaparral indicated that the rabbits often sought shelter there. Adequate cover is a requirement for this rabbit on the desert slope of the San Gabriels; in the juniper and Joshua tree belts the species occurs in washes where there is fairly heavy brush, and only occasionally elsewhere. In the foothills, when frightened from cover in one small wash cottontails often run up over an adjacent low ridge and seek cover in the brush of the next wash. In the wash below Graham Canyon tracks and observations showed that cottontails were taking refuge in deserted burrows of kit foxes.

In the pinyon-juniper association cottontails and jack rabbits probably occur in roughly equal numbers, but in the Joshua tree belt cottontails seem far less numerous than jack rabbits. In the course of a two hour hike in lower Mescal Wash, at about 3500 feet, eleven jack rabbits and two cottontails were noted.

Specimens examined.—Total, 2, distributed as follows: Los Angeles County: 6 mi. E and 1 mi. S Llano, 3500 ft., 1; Mescal Canyon, 4800 ft., 1.

Sylvilagus bachmani cinerascens (J. A. Allen)

Brush Rabbit

Brush rabbits inhabit the Pacific slope of the mountains from about 1200 feet in the coastal sagebrush belt up to at least 4500 feet in the chaparral, and are the only lagomorphs found commonly above the lower edge of the chaparral association. Here they were often on steep slopes beneath extensive and nearly impenetrable tracts of chaparral.

The ecologic niche of the brush rabbit is in brush where the plants form continuous thickets with little open ground. In the coastal sagebrush flats, areas supporting only scattered bushes are uninhabited by brush rabbits, while areas grown to extensive tracts of brush harbor them. When the brush rabbit's mode of escape from its enemies is considered, the reason for their habitat preference becomes more clear. Almost invariably these rabbits seek escape by running through the densest portions of the brush, never appearing in the open; in this way they travel quickly away from the source of danger without being observed. Because they avoid being seen in the open, and do not seek safety largely through running ability, they need continuous stretches of brush for escape. While hunting in the coastal sagebrush belt I have repeatedly seen frightened brush rabbits turn and dart beneath the bushes a few feet from a human being rather than be driven into the open.

A great horned owl shot in March, 1951, in the sage belt, had in its stomach the remains of a freshly killed adult brush rabbit. Although coyotes and brush rabbits often occur in the same general sections of the sage flats, remains of these rabbits have been notably scarce in coyote feces from these areas. This is probably because the coyote hunts along clearings and in open brushland, precisely the type of habitat avoided by brush rabbits.

Family SCIURIDAE

Sciurus griseus anthonyi Mearns

Western Gray Squirrel

Gray squirrels were on both slopes of the San Gabriels in oak woodland. A gray squirrel was observed in April of 1948, as it climbed a telephone pole adjacent to an orange grove near Cucamonga. This, and one noted bounding up a slope of greasewood chaparral near Cattle Canyon, were the only gray squirrels seen in areas which were not grown to oaks or adjacent to oak woodland. In the lower foothills gray squirrels were invariably found in association with valley oak, this plant forming limited woodland areas in canyon bottoms. In the upper chaparral association the squirrels frequented the large scrub oaks growing on talus slopes and canyon sides. In the yellow pine woodland, gray squirrels are restricted to black oaks, often where they formed mixed stands with the conifers. On the interior slope these squirrels were found only at the lower edge of the yellow pine woodland where black oaks are common. There, in the vicinity of Big Pines, they were present between roughly 5800 and 7000 feet, while on the Pacific slope they inhabited oak woodland from 1600 feet to about 7000 feet elevation.

In Live Oak Canyon in December of 1950, tracks indicated that a bobcat had killed a gray squirrel in a small draw beneath the oaks. In Evey Canyon on March 6, 1951, while watching for bats at late twilight, I observed a gray squirrel traveling through the branches of a nearby oak. A great horned owl glided into the oak in an attempt to catch the squirrel, which leaped quickly into a dense mass of foliage and escaped. For roughly ten minutes the owl perched in the oak watching its intended prey, then flew off down the canyon amid frantic scolding by the squirrel.

On March 17, 1951, a female gray squirrel taken at about 3500 feet elevation in San Antonio Canyon contained two embryos, each roughly 40 millimeters long.

Spermophilus beecheyi beecheyi (Richardson)

Beechey Ground Squirrel

From the coastal sage belt, into the yellow pine forest of the Pacific slope, this species is common on land cleared by man or disturbed in the course of construction, or on severely eroded slopes where the original climax vegetation is partly or completely absent. Thus in the sage belt, ground squirrels live along dirt roads through the brush, on the heavily eroded banks often found in the foothills, on land grazed closely by sheep, and in those parts of major washes such as San Antonio and Cucamonga washes where scatterings of huge boulders offer prominent vantage points. In San Antonio Canyon *Spermophilus* was restricted to the vicinity of roads and firebreaks, and an especially large colony of at least forty individuals lived at a dump one mile southwest of Camp Baldy at about 4500 feet elevation. Ground squirrels used burned stems of large laurel sumac as observation posts. Because of a preference for open areas offering unobstructed outlooks, ground squirrels originally probably did not penetrate the main belt of heavy chaparral on the Pacific slope of the range except in some of the large washes.

In the spring of 1951 and the preceding summer there was a marked increase in the ground squirrel population near Padua Hills as a result of sheep grazing on approximately one-half square mile of sage land. Grasses and smaller shrubs were eaten down to the ground, and in some places coastal sagebrush and *Haplopappus* were killed by browsing and trampling. The area formerly had a sparse growth of bushes with intervening growths of tall grasses and one colony of perhaps 20 ground squirrels; but after the sheep grazing the area was open brushland with large clear spaces on which the herbage was trimmed to the ground, and had at least four colonies of ground squirrels as large as the first. Also there were other ground squirrels established in various parts of the area. Probably the dry weather in the winter of 1950-51 with consequent retardation of the vegetation aided the spread of the squirrels in this area.

In the sage belt, most ground squirrels are dormant by December. In 1951, after a mild winter, squirrels were noted on January 25 near Padua Hills. On February 8, 1951, males in breeding condition were collected, and on March 16, a female taken near San Antonio Wash carried three small embryos. In early March of 1951, ground squirrels were active at 4500 feet elevation in San Antonio Canyon.

Specimen examined.—Los Angeles County: 1 mi. S and 2 mi. E Big Pines, 8000 ft., 1.

Spermophilus beecheyi fisheri (Merriam)

California Ground Squirrel

This ground squirrel inhabited the desert slope of the mountains up to 5000 feet elevation, and was most common in the juniper belt; burrows often were made under large junipers. In May, 1949, ground squirrels were common in the rocks adjacent to Mescal Wash at an elevation of 4500 feet. In an apple orchard near Valyermo, squirrels fed on the fallen fruit in early November of 1951.

No squirrel was seen in December, January, and February, indicating that all were below ground in winter.

Specimen examined.—San Bernardino County: Desert Springs, 4000 ft., 1 (PC).

Ammospermophilus leucurus leucurus (Merriam)

Antelope Ground Squirrel

Antelope ground squirrels were common in the Joshua tree woodland where they were noted up to 4500 feet elevation in Graham Canyon. None was found on the pinyon slopes, possibly because of the competition offered there by *Eutamias merriami*, or because the rocky nature of the soil there rendered burrowing difficult.

Although observed less often in winter than in summer, this species is active all year. On February 6, 1949, in Mescal Wash, an antelope ground squirrel was foraging over the snow which was at least six inches deep. These squirrels were attracted to the carcasses of rodents used as bait for carnivore sets, and caused a good deal of trouble by disturbing the traps.

Antelope ground squirrels used the topmost twigs of box-thorn bushes extensively as lookout posts, and many of their burrows were at the bases of these thorny bushes. This habit of regularly using observation posts is well developed in each species of ground squirrel found in the San Gabriels.

Specimens examined.—Los Angeles County: 6 mi. E and 1 mi. S Llano, 3500 ft., 2.

Eutamias speciosus speciosus (Merriam)

Lodgepole Chipmunk

This chipmunk was characteristic of the most boreal parts of the San Gabriel Mountains. It was recorded from 6800 feet elevation at Big Pines, to an altitude of approximately 9800 feet near Mt. San Antonio, and was common where coniferous timber was interspersed with snowbrush chaparral. In upper Icehouse Canyon and near Telegraph Peak these chipmunks were associated with lodgepole pines and chinquapin, and one mile east of Mt. San Antonio individuals were often observed in thickets of manzanita. This chipmunk usually shunned pure stands of coniferous timber except as temporary forage ground.

On Blue Ridge these chipmunks used the uppermost stems of snowbrush as vantage points, and when disturbed ran nimbly over thorny surfaces of the brush in seeking refuge in the tangled growth.

In early November of 1951, these animals were not yet in hibernation on Blue Ridge. They were noted on November 6, after the season's first snows had melted; on November 13, however, a cold wind with drifting fog kept most of them under cover, and only two were noted in the course of the day.

Specimen examined.—Los Angeles County: 1 mi. S and 2 mi. E Big Pines, 8100 ft., 1.

Eutamias merriami merriami (J. A. Allen)

Merriam Chipmunk

The lower limit of the range of this species, on the coastal face of the range, is roughly coincident with that of manzanita—that is to say, it begins in the main belt of chaparral above the lower foothills.

E. merriami seems to reach maximum abundance amid the granite talus, and scrub oak and *Pseudotsuga* growth at the upper edge of the chaparral association. It was absent, however, from all but the lower fringe of the yellow pine forest association.

On the desert slope *merriami* was partial to rocky areas in the pinyon-juniper association but was also in the black oak woods on the Ball Flat fire road near Jackson Lake. Nowhere was *Eutamias merriami* and *E. speciosus* observed on common ground.

Specimens examined.—Los Angeles County: San Antonio Canyon, 5500 ft., 2 (1 PC).

Glaucomys sabrinus californicus (Rhoads)

Northern Flying Squirrel

No specimens of this species were taken in the field work in the San Gabriels, nor did I find any rangers or residents of the mountains who had seen flying squirrels in the area. Nevertheless sign found in the white fir forests in the Big Pines area indicated that flying squirrels may occur there. On a number of occasions dissected pine cones were noted on the horizontal limbs and bent trunks of white firs. These cones were too large to have been carried there by chipmunks, and gray squirrels were often completely absent from the areas. I suspect that extensive trapping in the coniferous forests of the higher parts of the mountains would produce specimens of flying squirrels. Willett (1944:19) mentions that flying squirrels probably occur in the San Gabriel Mountains.

Family GEOMYIDAE

Thomomys bottae pallescens Rhoads

Valley Pocket Gopher

This gopher was found below about 5000 feet elevation in disturbed or open areas from Cajon Wash at Devore westward all along the coastal base of the San Gabriel Range. In the lower part of the chaparral belt the gopher evidently was absent from the chaparral-covered slopes, but was common along roads and on fire trails.

Burt (1932) and von Bloeker (1932) discuss the distribution of the three subspecies of this species, *pallescens, neglecta,* and *mohavensis,* which are in the San Gabriel Mountains area, and Burt indicates that *pallescens* grades toward *mohavensis* in the southern part of Antelope Valley.

Thomomys bottae neglectus Bailey

Valley Pocket Gopher

In the forests of yellow pine and white fir of the higher parts of the San Gabriel Mountains the workings of this gopher were common, and sign of its presence was found above 4500 feet on both slopes of the mountain range. The rocky character of the coastal slope seems to limit the occurrence of gophers, for they are not continuously distributed there. On the desert slope they occur locally down into the pinyon-juniper belt.

In the vicinity of Big Pines, on the interior slope, these gophers preferred broken forest where snow brush or other brush occurred; their workings, however, were also found beneath groves of conifers and black oaks. The abundance of earth cores resting on the duff indicated that this species is active in the snow in winter.

Specimens examined.—Total, 5, distributed as follows: Los Angeles County: 2 mi. E Valyermo, 4600 ft., 2; 3 mi. W Big Pines, 6000 ft., 1; 1 mi. S and 2 mi. E Big Pines, 8000 ft., 2.

Thomomys bottae mohavensis Grinnell

Valley Pocket Gopher

One specimen of this subspecies was taken on December 31, 1951, in the Joshua tree belt, eight miles east of Llano, 3700 feet elevation.

Family HETEROMYIDAE

Perognathus fallax fallax Merriam

San Diego Pocket Mouse

This pocket mouse is restricted to the coastal sage scrub association, and was recorded from Cajon Wash west to Live Oak Canyon. The mouse does not inhabit even the lower edge of the chaparral belt, but in the coastal sage flats is usually the most abundant rodent. In disturbed parts of the coastal sage belt *fallax* is less common, and was never trapped in channels of rocky washes. Trap lines in the eroded adobe banks of the foothills, where white sage and coastal sagebrush are the dominant plants, took mostly these pocket mice. Although the soil of such slopes is compact and seemingly is unsuitable for burrowing by heteromyids, *fallax* is the most common rodent. Because few burrows of pocket mice were noted there, it is possible that the many old unused burrows of *Spermophilus* and *Dipodomys* which honeycomb certain parts of adobe banks are used also by *fallax;* some of these burrows shelter *Peromyscus eremicus* and *Peromyscus californicus.*

These mice are inactive above ground in cold weather. In the sage belt near Thompson Canyon, where this subspecies had been found to be the most common rodent, none was trapped on the sub-freezing night of December 3, 1948, although other rodents were found in usual numbers. Individuals have been taken on nights of intermittent rain, yet none has been trapped on freezing nights.

This species is characteristically heavily infested by a large species of mite. Usually these mites congregate around the base of the tail.

On October 11, 1949, one lactating female and two carrying embryos were taken.

Specimens examined.—Total, 11, distributed as follows: Los Angeles County: 4 mi. N and 1 mi. E Claremont, 1900 ft., 5; 3 mi. N Claremont, 1600 ft., 6 (5 PC).

Perognathus fallax pallidus Mearns

San Diego Pocket Mouse

On the desert slope of the mountains this species is found in the part of the pinyon-juniper association that is between elevations of 4000 and 5200 feet. The mouse is absent from the higher chaparral and pinyon-covered slopes, but is present on south slopes in the pinyon belt where more open growths of pinyons and scrub oaks are interspersed with yucca. I recorded this pocket mouse from the vicinity of Cajon Pass west to Valyermo.

The local distribution of *pallidus* is striking because of its close positive correlation with the distribution of yucca. On benches around 5000 feet, where yuccas are scattered in their occurrence, *pallidus* is nearly always taken near (often right at the base of) this plant. Lower in the juniper belt the dry rocky south slopes supporting yucca plants are well populated by *pallidus,* while adjacent flats, and north slopes grown to antelope brush and scrub oak, are completely uninhabited. Near the mouth of Grandview Canyon, on steep rocky southern exposures grown sparsely to burro weed and yucca, one hundred traps produced in one night eight *pallidus* and no other rodents. Here many of these pocket mice were trapped on large fractured rock outcroppings, where most or all of the mice probably lived in the daytime in the deep cracks; in any event no burrows were noted near these rocks.

This species prefers barren slopes supporting yucca plants. These plants produce large seeds which are staple food items for *P. f. pallidus* and other rodents during the lean part of the year, that is to say, late summer and autumn. Many of the dry capsules of the yucca plants were examined in October, 1951, and these generally still contained a few seeds. Pocket mice taken in October usually carried in their cheek pouches seeds of yucca together with some other material, and often they carried only the seeds of yucca. Probably the wind shakes only a few seeds out of the capsules at a time, thus tending to drop the seeds over a fairly long period.

Trapping in winter in the juniper belt revealed that these pocket mice were not active above ground on nights colder than about 40° F. On nights when the temperature was about 36° F. none was taken, but on the one night in late December, 1948, when the minimum was 44° F., several specimens were taken. In this same area in May 1949, pocket mice were the most numerous rodents. Because of their evident sensitivity to cold weather, these mice must remain below ground for weeks at a time during the cold weather of December and January.

Specimens of *pallidus* from the desert slope of the San Gabriels are grayer (less brown) than specimens taken farther southeast in the Mojave and Colorado deserts. Further sampling of populations of *Perognathus fallax* from areas adjacent to the San Gabriels might demonstrate differences of sufficient magnitude to warrant subspecific distinction of the San Gabriel population. Possibly, however, the San Gabriel series manifests only local variation in the race *pallidus*. Grinnell (1933:54) characterizes the ecological niche of the race *pallidus* as being "open, sandy ground, often . . . surrounded by rocky slopes," whereas these pocket mice in the San Gabriels inhabited gravelly or rocky juniper-dotted benches.

Specimens examined.—Total, 11, distributed as follows: Los Angeles County: 5 mi. E and 4 mi. S Llano, 4500 ft., 7; 2 mi. E Valyermo, 4500 ft., 3; 4 mi. E Valyermo, 5000 ft., 1.

Perognathus californicus dispar Osgood

California Pocket Mouse

Mice of this subspecies were recorded from the lower chaparral association below about 4000 feet elevation along the coastal face of the San Gabriel Range. They were trapped on greasewood-covered slopes, in mixed growths of white sage and buckwheat, and beneath scrub oak and lilac chaparral; however none was taken in the heavy chaparral of the upper parts of the chaparral association.

One small juvenile in gray pelage was taken in San Antonio Canyon on October 1, 1951.

Specimens examined.—Total, 5, distributed as follows: San Bernardino County: Lytle Canyon, 4000 ft., 2 (PC). Los Angeles County: San Antonio Canyon, 3000 ft., 3.

Perognathus californicus bernardinus Benson

California Pocket Mouse

On Blue Ridge these mice were recorded between 7100 and 8000 feet elevation. Here they were restricted to dense tracts of snowbrush and sagebrush, often where these tracts were interspersed with, or beneath, open groves of conifers. These mice seemed to favor areas where this thick brush was broken by patches of open, grass-covered ground. Benson (1930:450) records this subspecies from Swarthout Valley, near Big Pines, at 6860 feet elevation.

While setting traps for pocket gophers one mile southwest of Big Pines, in September of 1951, I frightened a pocket mouse from its burrow. The animal jumped into the tangle of interlacing twigs of a nearby clump of snowbrush, and with great dexterity climbed into the center of the bush, where it was lost to view. I was surprised at the facility with which this saltatorial rodent traveled through the network of small branches.

In winter, in areas inhabited by this mouse, snow covers the ground for long periods during which these mice are probably forced to remain below ground.

Specimens examined.—Los Angeles County: 1 mi. S and 2 mi. W Big Pines, 7400 ft., 2.

Dipodomys panamintinus mohavensis (Grinnell)

Panamint Kangaroo Rat

This rat is common in the Joshua tree and juniper belts, and locally penetrates the pinyon belt at about 5000 feet elevation. It occurs regularly along the entire desert slope of the San Gabriel Mountains.

The upper limit of the range of this species roughly coincides with the upper limit of the juniper belt, and within this range it was found to inhabit areas having widely different soil types. It occurred on the sandy ground of desert washes, the gravelly soil of the juniper-clad benches, and the mixed sandy and rocky ground of washes in canyons. A preference is shown by *panamintinus* for fairly level ground. Rough terrain or steep slopes are generally avoided, whereas rather large colonies of these kangaroo rats are found in small flats of the desert foothills.

Below about 4500 elevation on the interior slope this species was the most numerous rodent, and seemed to reach maximum abundance in the Joshua tree association. About 500 trap-nights in the juniper belt near Graham Canyon yielded 31 specimens, whereas about 300 trap-nights in Joshua tree flats took 34 individuals.

The cheek pouches of many specimens taken in early winter contained green shoots of grass and little dry material. On many occasions rat traps set next to wood rat nests beneath large junipers produced *panamintinus*, and many of these animals had their cheek pouches crammed full of juniper berries.

In December, 1948, *panamintinus* was trapped consistently on nights when the temperature dropped to below 20° F. On December 27, 1948, after a three inch snowfall, tracks of this species were noted in the snow at the mouth of Mescal Canyon.

Parts of the skulls of this species were found in many coyote feces from the desert slope.

Specimens examined.—Total, 11, distributed as follows: Los Angeles County: Mescal Wash, 4000 ft., 8 (6 PC); 2 mi. E Valyermo, 4600 ft. 3.

Dipodomys merriami merriami Mearns

Merriam Kangaroo Rat

This kangaroo rat barely enters the area under consideration and is almost restricted to the Joshua tree association, for only a few individuals were taken at the lower edge of the juniper benches. This species inhabits the Joshua tree belt all along the desert base of the San Gabriels.

As mentioned in the description of the Joshua tree association, the relative numbers of *Dipodomys merriami* and *D. panamintinus* shifted from 1948 to 1951, possibly concurrent with the seasons of low rainfall in this period. Whereas in 1948 *merriami* was decidedly less abundant than *panamintinus* in the Joshua tree belt, in 1951 the numbers were reversed.

In December, 1951, it was found by tending the traps in the early evening that *merriami* foraged fairly early before the ground had frozen solidly.

Specimens examined.—Los Angeles County: 2 mi. NW mouth of Graham Canyon, 3500 ft., 5 (PC).

Dipodomys merriami parvus Rhoads

San Bernardino Kangaroo Rat

One specimen of this subspecies was trapped on November 26, 1951, in a sandy channel of Cajon Wash near Devore beneath a clump of scale-broom.

Dipodomys agilis agilis Gambel

Pacific Kangaroo Rat

This species was found below about 4000 feet elevation all along the coastal face of the range and reached maximum abundance in the level tracts of coastal sage. It was one of the most abundant rodents there, usually being second to *Perognathus fallax* in point of numbers. Large colonies of kangaroo rats occurred locally on sandy ground adjacent to large washes. The rats were found sparingly on the foothill adobe banks and in the greasewood chaparral of the lower foothills, but in heavy chaparral where a layer of plant debris covered the ground, such as on north slopes grown to scrub oak and lilac, kangaroo rats were completely absent. Thus, in the lower chaparral belt, this rodent had a discontinuous distribution.

The coyote probably is one of the major predators of these kangaroo rats; remains of this rodent were often found in coyote feces, and coyotes excavated many burrow systems in large kangaroo rat colonies in the sandy ground near San Antonio Wash. The soil there is so soft that coyotes probably were often successful in digging out their prey. The shed skin of a large Pacific rattlesnake (*Crotalus viridis helleri*) was found four feet inside the mouth of a kangaroo rat burrow; probably this reptile preys on *agilis*. Great horned owls (*Bubo virginianus pacificus*) come down nightly from the chaparral to hunt in the sage flats. Beneath the perches of these owls I have found pellets containing bones of *agilis*.

Specimens examined.—Total, 13, distributed as follows: Los Angeles County: San Antonio Wash, 1900 ft., 11 (10 PC); 4 mi. NE Claremont, 1600 ft., 2.

Dipodomys agilis perplexus (Merriam)

Pacific Kangaroo Rat

All the specimens of this species from the desert slope of the San Gabriel Range are referred to the subspecies *perplexus*. They were taken in brushy habitats between the elevations of 4500 and 7400 feet. Throughout much of this area *perplexus* was found only in certain restricted areas more or less surrounded by inhospitable ground. For example, at 7400 feet on Blue Ridge, they were found occasionally in the strips of sagebrush and lilac brush which locally capped this ridge. Often these patches of chaparral on Blue Ridge were surrounded by areas unsuitable for kangaroo rats: on the Pacific slope, talus, oaks, and yellow pines prevailed; on the ridge scattered yellow pine groves were present; and on the steep desert slope there were yellow pines and white firs. In Swarthout Valley *perplexus* was found in flats that supported basin sagebrush and *Haploppus,* while the coniferous forests to the south, and pinyon-covered slopes to the north were uninhabited. On flats supporting antelope brush and juniper, *perplexus* was often common, but it did not penetrate the chaparral of adjacent slopes grown to scrub oak and mountain-mahogany. In general then, *perplexus* was found in fairly open brushy flats or slopes, even where these were surrounded by unsuitable habitats.

Specimens of *D. agilis* from the desert slope two miles east of Valyermo are referrable to the subspecies *perplexus.* A series taken in Cajon Wash at Devore, on the Pacific slope, is intermediate between *agilis,* of the coastal slope of the San Gabriels, and *perplexus* of the desert slope, but approaches more nearly the later subspecies. Thus, different subspecies of *D. agilis* occur on opposite slopes of the San Gabriel Mountains, with intergradation taking place in the Cajon Pass area and probably also at the west end of the Mountains.

Both scrub oak acorns and juniper berries were found in the cheek pouches of this subspecies, and one immature individual taken in Swarthout Valley had its cheek pouches stuffed with approximately 550 seeds of brome grass.

On November 13, 1951, at 7500 feet on Blue Ridge, a small juvenile was taken; it must have been born not earlier than September.

Specimens examined.—Total, 17, distributed as follows: Los Angeles County: 2 mi. E Valyermo, 4600 ft., 3; 5 mi. E Valyermo, 1; 1 mi. E Big Pines, 6600 ft., 6; 1 mi. S and 2 mi. W Big Pines, 7400 ft., 2. San Bernardino County: Cajon Wash, ½ mi. SW Devore, 2200 ft., 5.

Family CRICETIDAE

Reithrodontomys megalotis longicaudus (Baird)

Western Harvest Mouse

This species inhabited grassy areas of the coastal sage belt, and reached maximum abundance on cleared land grown thickly to weeds and scattered brush. The mouse was only locally abundant —being scarce throughout much of the sage belt—but was found under contrasting conditions. In San Antonio Wash the species was taken among rocks and sparse weeds, at Palmer Canyon specimens were trapped on a barren ridge sparsely clothed with greasewood and white sage, and also one mile E of Big Pines in flats supporting basin sagebrush and a fairly dense growth of grasses. The western harvest mouse was recorded from 1500 feet elevation to 3200 feet on the Pacific slope, and at 6600 feet near Big Pines on the desert slope.

Those specimens of harvest mice from near Big Pines may be grading toward the desert race *megalotis;* my series of specimens from this locality, however, is too small for clear indications on this point.

Individuals in juvenal pelage were taken on November 26, 1951, near Devore.

Specimens examined.—Total, 6, distributed as follows: Los Angeles County: 1 mi. E Big Pines, 6600 ft., 2; Palmer Canyon, 2000 ft., 1; 4 mi. N Claremont, 1700 ft., 3 (PC).

Peromyscus eremicus eremicus (Baird)

Cactus Mouse

In Mescal Wash on the desert slope of the San Gabriels, this mouse was one of the most abundant mammals and was the only rodent other than *Peromyscus maniculatus* regularly trapped in the barren channels of washes. In Mescal Wash, at an altitude of 4000 feet, *eremicus* occurred along with the chaparral-inhabiting *Peromyscus boylii* and *Peromyscus californicus.* The two species last mentioned were associated with the occasional large patches of manzanita, antelope brush, and other brush of the wash, whereas *eremicus* was trapped in the rocky and sandy channels among scattered bushes of scale-broom. No specimens of *eremicus* were taken on the juniper-clad benches adjacent to the wash.

Specimens examined.—Los Angeles County: Mescal Wash, 4000 ft., 10 (4 PC).

Peromyscus eremicus fraterculus (Miller)

Cactus Mouse

This mouse was recorded from 1900 feet elevation, one mile south of the mouth of San Antonio Canyon, to 3200 feet elevation in Cajon Canyon. This subspecies is characteristic of the sage belt and shows a strong preference for the rough rocky areas found in dry washes. Although in many areas the channels of the washes are immediately adjacent to sandy sagebrush-covered flats, *eremicus* is not common in the latter areas. Rocks seem to be essential to *eremicus,* for sandy areas in the sageland which were devoid of rocks yielded only an occasional specimen. For example, 100 trap-nights in the main channel of San Antonio Wash yielded 23 *eremicus* and only six other rodents; while in the sandy sage areas nearby 200 trap-nights yielded only one *eremicus* and 32 other rodents.

In lower San Antonio Canyon *eremicus* seemed restricted to the rocky canyon bottom, none having been trapped on the steep slopes nearby. This subspecies occurs commonly, however, on the adobe banks grown to white sage at the base of the foothills. There *eremicus* occurred on common ground with *Perognathus fallax fallax*, and was often the only *Peromyscus* taken.

This species may be restricted by temperature; washes above 4000 feet elevation, which seemed suitable were uninhabited by these mice.

On December 1, 1949, two females taken at the mouth of Palmer Canyon had well advanced embryos. A female trapped in San Antonio Canyon on September 19, 1951, was lactating. Juveniles were caught in the sage belt in October, 1951.

Specimens examined.—Total, 6, distributed as follows: Los Angeles County: San Antonio Canyon, 2500 ft., 1; San Antonio Wash, 1800 ft., 5 (PC).

Peromyscus californicus insignis Rhoads
California Mouse

This mouse inhabits areas supporting chaparral on the coastal slope of the San Gabriels below 5000 feet. In the chaparral it is usually the most plentiful rodent, being dominant on slopes which have been burned over and on which greasewood chaparral has taken over. On one such slope at the head of Cow Canyon, at 4500 feet, this was the only rodent trapped, although an occasional wood rat house was noted. Trapping records gave the impression that this form was the most ubiquitous rodent in the entire chaparral belt. Nearly every trap line, even in such non-productive areas as oak woodland, took the California mouse; and in many areas, as in thick lilac brush, this mouse was by far the most abundant rodent. Specimens were taken on the damp ground next to San Antonio Creek, and in the riparian growth. In San Antonio Wash the California mouse was found in thickets of laural sumac and lemonade berry, or other large shrubs, but were absent from most of the adjacent sageland. The one place where they were found away from heavy brush was on a series of barren adobe banks, near Palmer Canyon, clothed mostly with white sage. Here they found shelter in the unused burrows of kangaroo rats and ground squirrels.

The only place on the desert slope where this species was taken was in Mescal Wash. There it was taken occasionally near the large clumps of antelope-brush and manzanita which grew in the main channels of the wash.

Lactating females of this species were taken in October, 1949, and February, 1950. Two pregnant females were trapped on February 25, 1950, at the mouth of Palmer Canyon.

Specimens examined.—Total 16, distributed as follows: Los Angeles County: Mescal Wash (4200 ft., 4; 4300 ft., 1; 4500 ft., 1), 6(2IM); San Antonio Canyon, 4500 ft., 1; San Antonio Canyon, 3000 ft., 5; mouth of Palmer Canyon, 1900 ft., 4 (PC).

Peromyscus maniculatus gambeli (Baird)

Deer Mouse

This species occurs from 1000 feet elevation to above 9000 feet elevation on the Pacific slope of the Mountains, but although probably the most widespread rodent in the area it is absent from many habitats. This mouse reaches maximum abundance in the coastal sage scrub association, particularly where the soil is sandy with scattered vegetation—usually coastal sagebrush and black sage. On the foothill adobe slopes none was trapped, nor have any been taken in most of the chaparral habitats. A few *gambeli* were trapped amid the talus beneath growths of scrub oak and bay trees in San Antonio Canyon, at 4300 feet elevation. On Blue Ridge, at elevations of from 7200 feet to 8300 feet, this mouse inhabited areas clothed with snowbush, basin sagebrush, currant, and scattered conifers, and was found sparingly in the coniferous forests. Thus this species lives on contrasting soil types in association with many different vegetational assemblages, from the coastal base to the crest of the range.

There is a rather wide variation in color in *gambeli* from the San Gabriels. Certain individuals taken in open, sandy coastal sage areas are pale, some being indistinguishable from examples of *sonoriensis* taken in the pinyon-juniper association on the desert slope. Specimens from San Antonio Canyon have somewhat darker pelage than those from the sage belt, and than individuals taken on Blue Ridge. Possibly a large series of *Peromyscus maniculatus* from the San Gabriel Mountains would show definite local trends in color of pelage.

This species is active on sub-freezing and rainy nights as evidenced by trapping results, and at Big Pines there were tracks around the bases of conifers after a heavy snowfall in December,

1951. Several females taken in the sage belt in October, 1948, carried embryos, and a lactating female was recorded from Blue Ridge on November 13, 1951. Juveniles have been taken in September, October, November, and December.

Specimens examined.—Total, 9, distributed as follows: Los Angeles County: 1 mi. S and 2 mi. W Big Pines, 7400 ft., 3; 1 mi. S and 2 mi. E Big Pines, 8200 ft., 1; 4 mi. NE Claremont, 1900 ft., 2; San Antonio Wash, 1800 ft., 3 (PC).

Peromyscus maniculatus sonoriensis (Le Conte)

Deer Mouse

This subspecies is associated with contrasting types of soil and vegetation. It is seemingly absent from the upper pinyon-juniper sage flats and areas grown to chaparral, but is fairly common on the gravelly benches dotted with junipers, and in the washes issuing from the canyons on the desert slope. It is present in small numbers in the Joshua tree association.

In 1951 the numbers of *sonoriensis* were noticeably less than in 1948; probably this was correlated with the series of dry winters in this period. In December, 1948, this animal was one of the most common rodents in Mescal Wash, 200 trap-nights yielding thirteen specimens; but in November, 1951, none was taken. In parts of the juniper belt, where an average of about six *sonoriensis* was taken per 100 trap-nights in 1948, the average had dropped to one per 100 trap-nights in 1951.

Specimens of this species from the desert slope of the mountains have been assigned to the subspecies *sonoriensis*. Those from Blue Ridge tend toward *sonoriensis* in color, and may be considered as intergrades between this subspecies and *gambeli*.

This species was active on nights when the temperature was as low as 10° F., and individuals were trapped in the juniper belt in December, 1948, when four inches of snow lay on the ground.

Gray-pelaged juveniles were taken on the desert slope in December, 1948, and a female taken in Mescal Canyon on December 22 of this year carried four embryos near term.

Specimens examined.—Total, 11, distributed as follows: Los Angeles County: 8 mi. E and 4 mi. S Llano, 4000 ft., 6 (4 PC); Mescal Canyon, 4800 ft., 5.

Peromyscus boylii rowleyi (J. A. Allen)

Brush Mouse

The main range of this mouse in the San Gabriel Mountains lies between 1600 and 6000 feet elevation on the Pacific slope of the Mountains, thus encompassing much of the chaparral and oak woodland associations. It was the most common mammal in the oak woodland association in the lower foothills and often was trapped there on leaf mold beneath the oaks. While trapping for shrews I regularly took this species in riparian growth right down to the edge of the water. In San Antonio Canyon many *boylii* were trapped beneath logs and dense vegetation, and on wet seepage slopes adjacent to the creek.

This species shows a definite predilection for rocky habitats where these occur in the chaparral. In heavy lilac brush near Camp Baldy *Peromyscus boylii* was outnumbered by *P. californicus*, yet where talus slopes or boulder piles occurred *boylii* was more numerous. At the head of Cow Canyon amid boulders beneath scrub oak, bay, and big cone-spruce, this species was especially abundant and no other *Peromyscus* was taken.

Of special interest is the occurrence of this mouse on the desert slope of the mountains; there it was taken beneath scrub oaks in the pinyon-juniper association at the mouth of Mescal Canyon, and amid boulder and debris piles in Mescal Wash at 4000 feet elevation. While manzanita and scrub oak grew in the wash at the points of capture, the animals were actually surrounded by the desert conditions of the Joshua woodland, and associated with such desert forms as *Onychomys torridus pulcher* and *Peromyscus eremicus eremicus*.

Immature individuals were taken in October, November, February, and March, and a female with two large embryos was taken near Icehouse Canyon on November 8, 1951.

Specimens examined.—Total, 8, distributed as follows: Los Angeles County: Mescal Wash, 4000 ft., 1; Mescal Canyon, 4800 ft., 2; San Antonio Canyon, 5200 ft., 2; San Antonio Canyon, 4500 ft., 1; San Antonio Canyon, 2800 ft., 1; Thompson Canyon, 1800 ft., 1 (PC).

Peromyscus truei montipinoris Elliot

Piñon Mouse

Only once was this mouse found outside the pinyon-juniper association of the desert slope; in November, 1949, several were collected near Cajon in mixed manzanita, scrub oak, and greasewood chaparral. This was the only *Peromyscus* of regular occurrence in the pinyon-juniper area, and was recorded from the upper limit of this association, near Jackson Lake, at 6000 feet, to the lower limit of the association at the mouth of Graham Canyon at roughly 4000 feet elevation.

Although in the juniper belt *truei* often occurs on common ground with *Peromyscus maniculatus sonoriensis,* the habitat preferences of these animals are generally complementary. Where the mice occur together, traps set in a variety of locations caught *Peromyscus maniculatus,* but typically traps set amid the brush or on the open ground away from the junipers were productive. On the contrary *truei* was invariably trapped quite near the junipers and often in association with the large nests of *Neotoma fuscipes simplex.* In fact traps set right on the beds of litter beneath the junipers were most likely to catch *truei.* Records kept of trapping localities show that *truei* was without exception trapped within twenty feet of some treelike shelter such as junipers, pinyons, Joshua tree or scrub oaks. Thus *Peromyscus maniculatus* occupies the open stretches between the trees, while *truei* inhabits the ground beneath and immediately adjacent to the trees. In Nevada the piñon mouse prefers rocky areas (Hall, 1946:520). In the San Gabriel Mountains this mouse does not seem to have this predilection.

In the juniper belt *truei* was second to *Dipodomys panamintinus* in point of numbers. In the course of 500 trap-nights in the juniper belt twenty-two *truei* were taken with thirty-six *Dipodomys.*

I consider my series of *Peromyscus truei* from the desert slope of the San Gabriels to represent the subspecies *montipinoris.* The series is closely comparable to specimens of the subspecies *montipinoris* in the California Museum of Vertebrate Zoology from the Mount Pinos area, but differs from specimens of the race *chlorus* from the San Bernardino Mountains in certain diagnostic characteristics. In his recent paper on *Peromyscus truei,* Hoffmeister (1951) considered the populations of this species in the San Gabriels to be of the race *chlorus.* Hoffmeister had only one specimen available from the San Gabriel Mountains (Lytle Creek, on the Pacific slope) which was intermediate between *montipinoris* and *chlorus,* but on the basis of cranial measurements it was referred to the race *chlorus.* Specimens of *Peromyscus truei* from the eastern end of the desert slope of the San Gabriel Mountains and the Cajon Pass area would probably demonstrate that the race *montipinoris,* which occupies the desert slope of the San Gabriels, intergrades with the race *chlorus,* which occurs in the San Bernardino Range immediately to the east, in the Cajon Pass area. Although *montipinoris* occurs on the desert slope of the San Gabriels, *chlorus* may occur on the Pacific slope. I took no specimens of the piñon mouse on the Pacific slope of the San Gabriel Mountains.

In December, 1948, many small juveniles were taken in the juniper belt, and on October 15, 1951, two females trapped at the head of Grandview Canyon had embryos: one three and the other four. On November 13, 1951, a partially gray-pelaged subadult female was trapped which had recently suckled young.

Specimens examined.—Total, 17, all in Illinois Museum of Natural History, distributed as follows: Los Angeles County: Mescal Canyon, 4500 ft., 8 mi. SE Llano, 11; Mescal Canyon, 4300 ft., 2; 6 mi. SE Valyermo, 5100 ft., 1; Grandview Canyon, 6 mi. SE Valyermo, 5100 ft., 1. San Bernardino County: 1 mi. W Cajon, 3200 ft., 2.

Onychomys torridus pulcher Elliot

Southern Grasshopper Mouse

Grasshopper mice seemed to be partial to the more sandy parts of the Joshua tree flats where the mice were trapped regularly but not abundantly. This mouse inhabited the barren sandy channels of Mescal Wash but was rare on the adjacent juniper-clad benches. In the arid, sandy washes this typical desert rodent penetrated the high pinyon-juniper association.

Wherever grasshopper mice occurred they were outnumbered by most of the other rodent species. For example, on November 26, 1949, below Graham Canyon, 100 snap traps yielded 10 *Dipodomys panamintinus mohavensis*, 2 *Dipodomys merriami merriami*, 4 *Peromyscus maniculatus sonoriensis*, and 3 *Onychomys torridus pulcher*.

Where abandoned kangaroo rat burrows were common in the Joshua tree belt these burrows were used as retreats by *Onychomys*. Some traps set at the entrances to old burrows caught grasshopper mice.

Specimens examined.—Total, 7, distributed as follows: Los Angeles County: 8 mi. E and 3 mi. S Llano, 3500 ft., 1; Mescal Wash, 4200 ft., 5 (3 PC); 2 mi. S Valyermo, 4600 ft., 1 (PC).

Neotoma lepida intermedia Rhoads

Desert Woodrat

This species was on the Pacific face of the Mountains from 1600 feet elevation in the coastal sage belt, to 4800 feet elevation in open groves of big cone-spruce and scrub oak of the chaparral association.

The local distribution of this woodrat is determined by suitable nesting sites. Although taken in different types of vegetation, *lepida*, without exception, was associated with rocky areas or areas supporting patches of prickly-pear cactus. In the channels of San Antonio Wash, *lepida* was commonly associated with jumbles of boulders and boulder-dotted cut banks. There the vegetation is sparse, and the rats dwell among the rocks; only their droppings and faint trails indicate their presence. Among boulders *lepida* builds only small houses of sticks and debris, and even these only occasionally. The effect of the prickly-pear cactus on the distribution of *lepida* in the sageland is striking; trap lines there yielded no woodrats where extensive rock piles and patches of prickly-pear were absent, but many rats were taken where patches of prickly-pear are plentiful. On an acre supporting coastal sagebrush at the mouth of San Antonio Canyon, at 1800 feet elevation, there were fourteen patches of prickly-pear, each covering at least thirty square feet. In these patches there were thirteen occupied woodrat nests. Only one patch lacked an occupied nest, and this one contained the remains of an old nest. On this acre there were at least thirteen individuals. In the sagebrush belt only an occasional large patch of cactus lacks a woodrat house occupied by *lepida*. Seemingly *Neotoma fuscipes* does not build houses in patches of prickly-pear.

Most of the houses built by *Neotoma lepida* are small and simple as compared to those of *Neotoma fuscipes*, and often in rocky areas no nests are in evidence. The most elaborate nests are built among the pads and spines of the prickly-pear and under laurel sumac or other large shrubs growing near washes. One of three houses examined at the mouth of San Antonio Canyon was on sandy ground in a patch of *Opuntia* measuring approximately 11 x 14 feet. The house was 14 inches high and 41 x 37 inches at the base. It was built around the main stem of the prickly-pear and a rock about 10 inches in diameter. The house was constructed of sticks of coastal sagebrush and buckwheat, and was dotted with dissected fruits and flowers of the prickly-pear. The main chamber was arched over by the main stem of the prickly-pear and was roughly 12 x 19 inches, inside dimensions, being reached through two three-inch openings, one on the east side of the chamber and one on the north side of the chamber. Two cup-shaped nests were inside the chamber, these being constructed mostly of grasses, and each resembling a well constructed bird nest 4 inches in diameter. The grass nests were free of feces, but feces were piled up against the west side of the chamber with many snail shells and dissected fruits and flowers of prickly-pear. Thirty-five inches from the main chamber was a third grass nest on the ground beneath a cluster of cactus pads. Next to this there was a blind burrow about eight inches long, and one and three-quarters inches in diameter. No burrow led to the main chamber, in this or in either of the other houses, but all had at least one short blind burrow beneath the house.

At many houses there were one to three grass nests outside the house on the ground, within four feet of the house. From each nest a well worn path lead to the house. Traps set in these nests invariably caught woodrats.

The many prickly-pear fruits and snail shells in and around the houses of *lepida* probably were remnants of food. So many of the rodents caught in traps near woodrat nests were partly eaten—usually the brains were taken—that I suspect the woodrats of eating their relatives. The heads of many composite annuals were piled near woodrat nests.

Immature individuals were taken in September, October, and early November, and on September 26, 1951, a lactating female was trapped near Palmer Canyon.

An old female bobcat trapped in Thompson Canyon had masses of cactus thorns beneath her skin, especially about the forelegs. These thorns were probably received while she was foraging in growths of prickly-pear for woodrats. The other bobcats from San Antonio Wash also had accumulations of thorns under the skin of the forelegs. Fragments of the skulls of *Neotoma lepida* were recovered from horned owl pellets and coyote feces.

Specimens examined.—Total, 7, distributed as follows: Los Angeles County: San Antonio Canyon, 4500 ft., 2; San Antonio Wash, 1800 ft., 5 (2 PC).

Neotoma lepida lepida Thomas

Desert Woodrat

These woodrats were present in rocky situations along the desert slope from the lower edge of the juniper belt down into the desert. Specimens were taken in piles of boulders in Mescal Wash, and amid rock outcroppings on the steep, barren, south slopes at the base of Grandview Canyon, whereas none was found on the juniper-clad benches.

This woodrat built no nests in rocky areas; however, in the Joshua tree belt *N. l. lepida* often built small nests at the bases of large standing or prostrate Joshua trees. There sticks from creosote bushes, along with cow dung and small stones were favorite building materials. Judging from the large number of unused woodrat nests in the Joshua tree flats it seemed that this rat was formerly far more common than it was in the period of this study.

Specimens examined.—Total, 9, distributed as follows: Los Angeles County: 6 mi. E and 1 mi. S Llano, 3500 ft., 4; Mescal Wash, 4200 ft., 5 (3PC).

Neotoma fuscipes macrotis Thomas

Dusky-footed Woodrat

This subspecies was widely distributed along the coastal slope of the mountains from the coastal sage belt, at roughly 1600 feet, up to 6500 feet at the lower edge of the yellow pine forest and was most common in the chaparral association.

In the coastal sage belt these woodrats are restricted to wash areas where large chaparral plants such as lemonadeberry and laurel sumac are used as nesting sites. In San Antonio Wash the occasional large juniper trees almost invariably harbor the nests of *fuscipes.* The general absence of suitable nesting sites in the sage belt probably limits the spread of *fuscipes* in this area.

In the upper part of the chaparral belt in talus these woodrats live beneath the angular boulders and build no visible houses. Several areas of talus occupied by woodrats were examined carefully and no sign of houses was noted.

Two juveniles were found in the stomach of a rattlesnake (*Crotalus viridis helleri*) killed in May, 1948, at the mouth of Evey Canyon. Remains of woodrats were found in feces of the coyote and gray fox.

Lactating females of this species were taken on March 16, and October 2, 1951.

Specimens examined.—Total, 4, distributed as follows: San Bernardino County: Icehouse Canyon, 5500 ft., 2. Los Angeles County: San Antonio Canyon, 2800 ft., 2.

Neotoma fuscipes simplex True

Dusky-footed Woodrat

These rats were recorded from the yellow pine forests on Blue Ridge, at 8100 feet, down to the lower edge of the juniper belt, at 3800 feet. Their presence there as elsewhere was determined by the occurrence of adequate cover. On Blue Ridge they were taken in and near patches of snowbrush, currant, and choke cherry, and one was taken beneath a pile of logs where no nest was in evidence.

The thickets of choke cherry in hollows on Blue Ridge were favored house-building sites of woodrats. Among the tangle of branches large nests were built, and in September, 1951, the remains of choke cherry fruit and gnawings on the limbs of these plants indicated that woodrats were active throughout these extensive patches of brush.

In the pinyon-juniper association most of the large plants were used as nesting sites, but scrub oak, seemed to be especially preferred. Because it often grew in a twisted irregular form with the foliage nearly reaching the ground, the oak offered good shelter for the woodrat nests. In an acre of scrub oak and mountain mahogany brush one-half mile north of Jackson Lake, at 6100 feet, thirteen occupied woodrat nests were found. In the juniper belt, houses were of more irregular occurrence, and were always beneath juniper trees, usually beneath the largest and most widely spreading individuals.

Those specimens from Blue Ridge, on the crest of the San Gabriels, are intergrades between the coastal race *macrotis* and *simplex* of the desert slope. Although specimens vary widely in color, comparison with series of these two subspecies in the California Museum of Vertebrate Zoology indicates that all specimens from the desert slope of the San Gabriels are referable to the race *simplex*. Two specimens of this species from the granite talus above the base of Icehouse Canyon at 5500 feet on the Pacific slope, grade strongly toward *simplex*. Hooper (1938:231) mentions that specimens of this species taken along the San Gabriel and San Bernardino ranges may be intermediate between *simplex* and *macrotis*.

At the head of Grandview Canyon, tracks indicated that a coyote had foraged for about one half mile along the edge of a tract of dense oak and pinyon growth. It seemed as if the animal had been foraging for woodrats. A gray fox trapped near Graham Canyon, in the juniper belt, had in its stomach the remains of a freshly killed adult woodrat. The remains of an adult woodrat were found in the stomach of a rattlesnake (*Crotalus viridis helleri*) obtained on the desert slope of the mountains.

Specimens examined.—Total, 6, distributed as follows: Los Angeles County: 6 mi. E Valyermo, 5600 ft., 1; 1 mi. E Big Pines, 6600 ft., 2; 1 mi. S and 3 mi. W Big Pines, 6000 ft., 1; 1 mi. S and 2 mi. E Big Pines, 8100 ft., 2.

Microtus californicus sanctidiegi R. Kellogg

California Meadow Mouse

Owing to the paucity of extensive areas of grassland in the San Gabriels, this is one of the least common rodents of the area. It inhabits, however, even small patches of grassland up to 4000 feet elevation on the Pacific slope, and is locally plentiful. For example, a small patch of grassland amid the chaparral at the mouth of

Palmer Canyon supported many *Microtus*, and in San Antonio Canyon at about 3000 feet elevation meadow mice were found amid boulders and yuccas in a small grassy area near the stream.

Specimens examined.—Total, 3, distributed as follows: Los Angeles County: San Antonio Canyon, 2800 ft., 1; Palmer Canyon, 2100 ft., 1; 4 mi. N Claremont, 1800 ft., 1.

Family URSIDAE

Ursus americanus californiensis J. Miller

Black Bear

Eleven black bears were introduced into the San Gabriel Mountains "near Crystal Lake" in November 1933 from the Sierra Nevada (Burghduff, 1935:83). I do not know whether or not there have been subsequent introductions. There are still bears present in the higher parts of the mountains, especially north of the study area, where they seem to be maintaining their numbers. The grizzly bear that formerly occurred in the San Gabriel Mountains was exterminated there some years before the black bear was introduced.

Family PROCYONIDAE

Bassariscus astutus octavus Hall

Ring-tailed Cat

Large sections of the San Gabriel Mountains are uninhabited by this species, while locally, in the chaparral belt near water, ring-tails are common. Many reports of ring-tails were received from owners of cabins and homes who reside in the canyons at the Pacific base of the mountains. Because of the distinctive appearance of this animal it is likely that many of these reports were accurate. The reports testified to the presence of ring-tails in San Gabriel Canyon, Dalton Canyon, Palmer Canyon and San Antonio Canyon. Hall (1927:41) lists specimens from San Antonio Canyon. Kenneth Hill of Upland told me that ring-tailed cats often have been trapped above that town near citrus nurseries that are regularly irrigated. This species probably is not present on the desert slope of the range.

The only specimen that I took was a female weighing one pound and fourteen ounces. It was trapped on March 24, 1951, among granite boulders, beneath scrub oak and bay trees, near the mouth of Icehouse Canyon, at 5500 feet elevation.

Procyon lotor psora Gray

Raccoon

The raccoon was one of the most common carnivores in the San Gabriels and was found on both slopes of the range. Tracks were noted and one old male was trapped at the base of the Pacific slope foothills at 1900 feet elevation, and raccoons were captured at several localities from this point up to 5500 feet in San Antonio Canyon. They were noted on Blue Ridge at about 8000 feet elevation foraging around the camp grounds. On the desert slope they occurred down to the lower edge of the pinyon-juniper belt, for example near the mouth of Sheep Creek Canyon.

Sign of raccoons was most often found near water; tracks, however, indicated that these animals, along with other carnivores, used fire roads for traveling through the chaparral. In a small draw one-half mile east of the mouth of Thompson Canyon two raccoons were trapped although the only water was a series of small, disconnected seepage pools beneath the valley oaks.

A raccoon freed from a small steel trap in San Antonio Canyon concealed itelf in an unusual but extremely effective manner. When released the coon splashed up the middle of the small creek nearby to a place where some dead alders had fallen over and shaded the water—here the animal squatted down in the stream. The raccoon was mostly submerged, its tail was floating, and its back and the top of its head and snout were above water. With most of its body under water, and with the maze of alder logs above casting a broken pattern of light and shade, it was well hidden. When closely pressed the raccoon hid in the same manner several times before it disappeared up a rocky draw into the scrub oak brush.

In the autumn of 1951, raccoons fed on grapes at the Sycamore Valley Ranch one mile south of Devore. The one specimen (P. C.) saved, an old male from ½ mi. W Palmer Canyon, had remains of beetles in its stomach and weighed slightly more than 13 pounds.

Family MUSTELIDAE

Mustela frenata latirostra Hall

Long-tailed Weasel

Several weasels were found dead on roads in the coastal sage belt near San Antonio and Lytle canyons.

Taxidea taxus neglecta Mearns

Badger

I found no sign of badgers on the Pacific slope of the range, but James Wolfort, employed by the state Fish and Game Commission to trap coyotes, reported that in 1948 he trapped also several badgers at the coastal foot of the range in the San Fernando Valley area which is west of the study area.

Taxidea taxus berlandieri Baird

Badger

Many old badger diggings were found in the Joshua tree woodland and pinyon-juniper associations of the desert slope, but none of the animals was observed nor were specimens secured. Mr. E. A. Eberle who has trapped for many winters in the vicinity of Mescal Canyon stated that he caught badgers occasionally.

I examined the skin of a badger taken at Llano which showed the characteristic paleness of the desert subspecies *berlandieri*.

Mephitis mephitis holzneri Mearns

Striped Skunk

The populations of striped skunks in the San Gabriels center around cultivated land at the Pacific foot of the range. Citrus groves, grape vineyards, and areas once cleared by man are preferred to coastal sagebrush flats. The cultivated areas now probably support many more skunks than were there under original conditions. I have many sight records of striped skunks which I obtained while driving through the citrus groves at night. Only once was the striped skunk noted in the chaparral; all the other records were from the coastal sagebrush belt.

In addition to insects and small mammals, grapes are eaten regularly by skunks in vineyards, and the fruit of the prickly-pear cactus is often eaten. Near the mouth of Thompson Canyon feces examined in October 1948, contained almost exclusively the remains of prickly-pear fruit.

A male taken one-half mile south of Devore weighed five pounds and four ounces.

Specimens examined, 2: San Bernardino County: ½ mi. S Devore, 2200 ft., 1. Los Angeles County: 3 mi. N Claremont, 1500 ft., 1 (PC).

Spilogale gracilis microrhina Hall

Spotted Skunk

Spotted skunks are common locally in the coastal sage scrub association and lower chaparral association on the coastal face of the mountains, mainly between 1000 and 4000 feet elevation; but they have been reported from Icehouse Canyon at 5000 feet, and I took one above the mouth of this canyon at 5500 feet elevation. A few spotted skunks may inhabit the lower desert slope of the mountains; here feces thought to be those of spotted skunks have been found, and a bobcat trapped near the head of Grandview Canyon smelled strongly of skunk.

The spotted skunk usually was in rocky habitats. In the sage flats, sign (mostly feces and tracks) usually was near rock piles and around human developments such as rock walls, old outbuildings and houses. Specimens taken in the chaparral were trapped near granite outcroppings.

In the autumn of 1950, at my house near the mouth of Palmer Canyon, a family of spotted skunks lived under the floors. Night after night they scratched under the floor and chattered in high-pitched rasping notes, and on several evenings one walked complacently into the living room. It finally became necessary to trap and deport most of these skunks. In all, nine skunks were trapped; these probably represented more than the original residents. One male was descented and allowed to remain. It spent most of the daylight hours asleep in an old shower room where the many gaps between the rock work and the boards allowed him entrance. Through no special efforts on our part he became tame enough to climb over us in order to get food left on the kitchen sink, and he would eat calmly while we sat only inches away from him.

Feces from sage areas contained mostly remains of insects and small rodents whereas many samples of feces from chaparral areas contained, in addition, shells of snails. Feces examined represent all months of the year.

Specimens examined.—Los Angeles County: mouth of San Antonio Canyon, 2 (PC).

Family CANIDAE

Canis latrans ochropus Eschscholtz

Coyote

Coyotes inhabit the sagebrush flats and foothills up to at least 4000 feet all along the Pacific base of the San Gabriels. This species seems most common at the foot of the range where large dry washes prevent man from occupying the land immediately adjacent to the foothills, and are the dominant carnivores of the coastal sage belt. Repeated observations have indicated that although many individuals range into the higher foothills they seldom are found deep in the major canyons or chaparral slopes. Coyotes rarely occur at 3000 or 4000 feet in San Antonio Canyon where it cuts into the realm of heavy chaparral; yet on steep foothill slopes and ridges, which are adjacent to the flat land, these animals range up to at least 4000 feet. Being hunters primarily of rather open land many coyotes go into the foothills only to find daytime refuge, traveling down dirt roads, ridges, and firebreaks, to forage at night in the sage flats. Coyote feces from the foothills, at about 3500 feet, contained predominantly the remains of such food items as cottontails, chickens, and jack rabbits. These animals could have been found only in the flats. This is additional evidence that coyotes do the major part of their hunting at the base of the range.

Observations of coyote tracks and trapping records have shown that these animals hunt mostly in the more open parts of the sage flats. Coyotes frequent areas of scattered brush, sandy areas, wash channels, and old roads, and seemingly shun dense brush. Many coyotes actually hunt for rabbits in the citrus groves near the foothills. On several evenings I traced their howling to orange groves, and Mr. Kenneth Hill of Upland told me of often seeing coyotes in his orange groves at night.

The forage beats of several coyotes were discovered in connection with trapping specimens of these animals. In January, 1952, two coyotes, probably a mated pair, traveled nightly from the slopes immediately west of Evey Canyon, at about 3100 feet, down into the sagebrush adjacent to the west side of San Antonio Wash, at about 1700 feet elevation. The route led down open ridges, then for about one half mile across a level, cultivated plateau, and then swung over the eroded banks near the lowermost point of the plateau onto the level sage flats. The distance covered by this route from the foothills down to the flats was somewhat more than a mile, with about a 1400 foot difference in elevation between the daytime retreat and the nocturnal forage area. Another route, seemingly used by only one coyote, was somewhat longer. This animal followed fire breaks and ridges from above Thompson Canyon down onto a fire road, and then into the lower end of Palmer Canyon where it entered the flats. This route covered about three miles in coming from the foothills to the flats. Feces of this coyote often contained the remains of white leghorn chickens which had been found at a refuse pile near several chicken ranches one-half mile from the base of Palmer Canyon.

Although no definite idea could be gained of the population density of coyotes in the area, it was clear that in certain localities they were, as carnivores go, abundant. After one large male was obtained in the flats at the base of Cobal Canyon, at least two other individuals were heard howling in this immediate area, and their tracks were noted repeatedly on dirt roads. One night early in January, 1952, immediately west of the head of San Antonio Wash, the voices of six coyotes could be picked out separately from a chorus of coyote howls which came from several different directions in the wash.

Many field examinations of coyote feces left the impression that chickens and lagomorphs made up the bulk of the coyote's food on the coastal slope. To check this a study of 39 sets of scats collected at various localities on the coastal slope was made in the laboratory, the results being shown in Table 10. Remains of one of the three species of rabbits, cottontails, jack rabbits, or brush rabbits, occurred in 72 per cent of the feces examined. Cottontails, it will be noted, were preyed upon more heavily than any other wild species, remains of this form being found in 33 per cent of the feces. The prevalence of chicken remains in coyote feces does not imply that these animals were killed by the coyotes. All of the chickens could have been found dead in the refuse piles of the many chicken ranches. In addition, the chickens were raised in wire cages above the ground where they were nearly invulnerable to predation. That coyotes may at times kill deer in this area was suggested by the finding of tracks in the sand in San Antonio Wash which clearly indicated that a deer had been closely pursued by a coyote. The tracks were lost in a stretch of brush so the outcome of the chase could not be determined. Near the mouth of Lytle Creek Canyon, in November, 1951, coyote feces contained mostly remains of grapes from nearby vineyards. Also, above Cucamonga, coyotes were found to be feeding heavily on grapes. This must be a rather unsuitable form of nourishment for coyotes, for many of the grapes in the feces appeared nearly unaltered despite their trip through the alimentary canal.

The six coyotes taken on the Pacific slope are fairly uniform in coloration; the occurrence of white tipping on the tails of most of the specimens, instead of the usual solid black tip, is notable. Three skins, those of a male and two females, have patches of white hairs at the tips of the tails; two skins, of a male and a female, show only scattered white hairs at the tips of the tails; and the skin of one female has a solidly black-tipped tail. An additional female,

TABLE 10.—RESULTS OF EXAMINATIONS OF THIRTY-NINE SETS OF COYOTE FECES FROM THE PACIFIC SLOPE OF THE SAN GABRIEL MOUNTAINS. FECES WERE DEPOSITED IN AUTUMN AND WINTER (SEPTEMBER TO FEBRUARY).

Food item	Number of sets of feces which contained food item	Percentages of occurrence*
chicken	18	46.2
Sylvilagus audubonii	13	33.3
Lepus californicus	10	25.6
Sylvilagus bachmani	5	12.8
Odocoileus hemionus	5	12.8
rodents (unidentified)	5	12.8
Dipodomys agilis	4	10.3
Neotoma species	3	7.7
Mephitis mephitis	3	7.7
Carrion beetle	2	5.1
passerine bird	1	2.67
bot fly larva	1	2.67
snail shell	1	2.67
scorpion	1	2.67
Jerusalem cricket	1	2.67
sheep hair	1	2.67
Lynx rufus	1	2.67
Kitten of wildcat or housecat	1	2.67
Lophortyx californica	1	2.67
grapes	1	2.67
grass	1	2.67

* This is an expression, in percentage, of the number of sets of feces which contained the particular food item out of the total of thirty-nine sets examined.

trapped by David Leighton in Thompson Canyon, had a large patch of white hairs at the tip of the tail. Grinnell, Dixon, and Linsdale (1937:501) mention that only an occasional individual (female?) has a white-tipped tail.

Weights are available for four specimens: two coyotes trapped in San Antonio Wash, a male and a female, weighed 20.5 and 23.2 pounds respectively; a female from the mouth of San Antonio Canyon weighed 21.6 pounds; and a large male from the mouth of Thompson Canyon weighed 29.3 pounds.

Specimens examined.—Total, 6, distributed as follows: Los Angeles County: Live Oak Canyon, 3000 ft., 1; mouth of San Antonio Canyon, 2000 ft., 1; 4 mi. N Claremont, 1600 ft., 2; 4 mi. NE Claremont, 1600 ft., 1; 3 mi. NE Claremont, 1600 ft., 1.

TABLE 11.—CRANIAL MEASUREMENTS OF CANIS LATRANS OCHROPUS FROM THE COASTAL SLOPE OF THE SAN GABRIEL MOUNTAINS.

	Four females		Two males	
	Averages	Extremes	Averages	Extremes
Condylobasal length	180.67	174.2—183.3	188.35	179.2—197.5
Palatal length	91.57	88.0— 95.0	97.15	91.6—102.7
Zygomatic breadth	90.15	88.9— 92.0	95.60	88.8—102.5
Interorbital breadth	29.12	27.9— 29.9	31.45	28.1— 34.8
Length of maxillary toothrow	85.00	80.4—89.80	88.00	83.4— 92.6
Length of upper carnassial	18.30	17.8— 19.0	18.70	18.1— 19.3

Canis latrans mearnsi Merriam

Coyote

Coyotes are common on the desert slope of the San Gabriels below about 6000 feet elevation. They seem not, or only rarely, to penetrate the yellow pine forest belt, but tracks have been found occasionally near the lower edge of the forest, as at the head of Mescal Canyon. In the more open parts of the pinyon-juniper association, sign of coyotes was noted and they were the dominant carnivores in the juniper belt and Joshua tree woodland.

In the upper part of the pinyon-juniper association coyotes travel and forage in sage flats, along ridges, and in sandy draws, avoiding the extensive patches of scrub oak and mountain mahogany, and the steep, rocky, pinyon-covered slopes. It is apparent that the local ranges of the coyote and the gray fox in the pinyon-juniper belt are complementary, the gray fox keeping to the more thickly wooded or brushy parts of the area, and the coyote staying in the relatively open sections. Probably there is little competition for food there between these two canids.

As evidenced by tracks, coyotes commonly traveled and hunted along desert washes, probably because of the larger population of rodents and rabbits there. Below Graham Canyon three fairly recently inhabited dens of coyotes were found in the cutbanks at the edge of a dry wash in December of 1951. The cutbanks were six to ten feet high, and the dens were dug into the banks about three feet above the floor of the wash.

On the evening of October 20, 1948, near Desert Springs, Steven M. Jacobs and I set out a line of fifty wooden live traps for kangaroo rats. That night we slept about 300 yards from the middle of the line which was roughly three quarters of a mile long. When we tended the traps the next morning we found the tracks of a coyote over our own tracks of the previous day, and the first trap that had seemingly held a kangaroo rat was chewed and dragged for about fifty feet. Each trap that had held a rodent had been turned upside down so that the door had opened. At one point in the line where we had walked for about two hundred yards without setting a trap the coyote had followed every twist and turn of our trail. The animal had followed out the entire trap line and removed approximately eight rodents from the traps, reducing our take to one *Dipodomys* and one *Peromyscus.*

Examinations of feces showed that in the period from 1948 to 1952, while populations of jack rabbits were low in the Mojave Desert, the coyotes had fed extensively on smaller mammals such as kangaroo rats, and to some extent on fruit. By contrasting the present food habits of coyotes on the desert and coastal slopes of the mountains support is afforded for Errington's (1937:243) statement that predation is "a by-product of population." On the desert slope, with low populations of rabbits, the coyotes have turned to lesser species of prey; while on the Pacific slope, where populations of rabbits were high, the rabbits made up the major portion of the coyote's diet. On the desert slope, remains of the following food items were identified from coyote feces: kangaroo rats, mule deer, jack rabbits, passerine bird, manzanita and juniper fruit, beetles, grapes and apples. Near Valyermo, coyote feces were composed mostly of apples from nearby orchards. A female coyote killed below Grandview Canyon had its stomach and intestines stuffed with apples in large chunks. In the juniper belt, berries of juniper were often eaten by coyotes.

The three specimens of coyotes from the desert slope are clearly referable to the desert race *C. l. mearnsi,* both with regard to cranial and pelage characteristics. Although I collected no specimens from Cajon Pass or the passes at the west end of the range, it is in these places that intergradation might be expected to occur between the desert race *C. l. mearnsi* and the coastal and valley subspecies *C. l. ochropus,* as the higher parts of the San Gabriels seem to constitute a barrier to coyotes.

A subadult female coyote taken in the Joshua tree belt near Graham Canyon weighed 20.8 pounds.

Specimens examined.—Los Angeles County: 6 mi. E and 2 mi. S Llano, 3600 ft., 3 (2 PC).

Vulpes macrotis arsipus Elliot

Kit Fox

The kit fox barely enters the area under consideration. In the Joshua tree belt, below about 3500 feet elevation, tracks were most often noted in washes and on the adjacent sandy ground. The highest place where tracks were seen was a small sandy draw below the mouth of Graham Canyon at an altitude of roughly 3900 feet.

In the Joshua tree belt many old burrows were found but none was occupied. I believe these foxes are returning to this area where once they were common. In the winter of 1948 no sign of kit foxes was found, although intensive field work was done in the Joshua tree belt in the Mescal Canyon area. In December of 1951, in the same locality, sign was obvious and an individual was trapped below Grandview Canyon at 3500 feet elevation. Possibly since the use of poison for carnivores has been discontinued in this district the foxes are repopulating the area.

The one specimen taken, a sub-adult female, weighed two pounds and fourteen ounces.

Specimen examined.—Los Angeles Co.: 6 mi. E & 1 mi. S Llano, 3500 ft., 1.

Urocyon cinereoargenteus californicus Mearns

Gray Fox

The gray fox is widely distributed in the San Gabriel Mountains, occurring on both slopes of the range wherever extensive tracts of chaparral are present. They reach maximum abundance in the chaparral association of the coastal slope. Individuals have been observed occasionally at night in coastal sage areas at the Pacific foot of the mountains; however they seem to be less common here and probably come out of the adjacent chaparral to forage in the flats at night. Gray foxes occur all the way up the Pacific slope into the yellow pine woodland at 7500 feet, and from 6200 feet elevation on the desert slope down to the upper limit of the Joshua trees as, for example, near Mescal Canyon at 4700 feet.

On the Pacific face of the mountains the gray fox probably is the dominant carnivore in terms of its effect on prey species, first, because of its abundance, and second, because of its forage habits. Some appreciation of the abundance of the gray fox may be gained from trapping records. On a fire road at the head of Thompson Canyon, at 2500 feet, two settings of traps about one-quarter mile apart were maintained for four nights. In this time four gray foxes were trapped. At the head of Cow Canyon, at 4500 feet, one trap set on a deer trail caught five gray foxes in five nights. At the end of this time fox tracks were noted about 100 yards away from the set, and another fox was trapped about one quarter mile away. In addition to their abundance, the forage habits of gray foxes are such as to bring them into most habitats present in the chaparral association. Tracks and feces indicate that foxes forage under dense brush, on open rocky ridges, in riparian growth, on talus slopes, and in groves of big cone-spruce and scrub oak.

Trapped foxes, if uninjured by the trap, were usually released. One fox was released on a small trail through thick vegetation consisting mainly of snowbrush. When freed, the fox whirled and darted through a patch of snowbrush for about seventy-five feet, then turned and disappeared beneath some large bay trees. Although the brush through which it ran was dense, the fox seemed to run at full speed. The success of gray foxes as predators in the chaparral is probably due in large measure to their agility amid dense cover.

The three specimens from the desert slope are referable to the coastal subspecies, *U. c. californicus,* rather than the desert subspecies, *U. c. scottii.* In all respects they resemble foxes taken on the Pacific slope; cranial measurements are near the maximum for the large *U. c. californicus,* and not small as would be expected if they were grading toward the smaller *U. c. scottii.* Floors of desert valleys north of the San Gabriel Mountains probably isolated foxes there from *U. c. scottii* found in the higher ranges of the Mojave

Desert. Consequently one would expect no intergradation between the coastal and desert races in the San Gabriel Mountains.

An old female trapped on March 18, 1951, in San Antonio Canyon, had three embryos each about 105 mm. long from rump to crown, and weighed 9.2 lbs. The average weight of four non-pregnant females was 6.8 lbs., whereas the average of six males was 7.5 lbs.

Specimens examined.—Total, 11, distributed as follows: Los Angeles County: Mescal Canyon, 4800 ft., 1; 4 mi. E Valyermo, 5200 ft., 2; Cow Canyon, 4500 ft., 2; San Antonio Canyon, 3000 ft., 1; Thompson Canyon, 2500 ft., 2 (PC); ½ mi. W Palmer Canyon, 2000 ft., 3 (PC).

Family FELIDAE

Lynx rufus californicus Mearns

Wildcat

Wildcats range over the whole of the San Gabriel Range, with the possible exception of the tops of the highest peaks such as Mt. San Antonio and Mt. Baden Powell. Sign of these animals has been observed, or specimens have been taken, from the coastal sage belt up to about 8500 feet in the yellow pine forests on Blue Ridge. The subspecies *baileyi* occurs on the desert slope of the range.

Wildcats are most common in the chaparral belt where they forage widely from the ridges down into the canyons. Judging from trapping records bobcats are not so common here as the gray fox.

Bobcats occur in the sage belt, where they are most common in the broken country around washes and in brushy areas. Although bobcats and coyotes occupy the same general areas here, the habitat preferences of these animals seem to be different, with coyotes occupying the more open country. An indication of the hunting habits of bobcats is furnished by the occurrence of masses of prickly-pear thorns beneath the skin of the legs, particularly the forelegs, of three specimens trapped in the sage belt. These thorns probably were acquired while the bobcats foraged for woodrats or cottontails in the patches of prickly-pear, which are locally abundant in the sage belt.

On March 12, 1951, a small subadult female bobcat, trapped at 4000 feet in San Antonio Canyon, was found dead in the trap and had numerous deep cuts around its head and shoulders, and severe bruises on the right shoulder. The spacing of the cuts, and the tracks around the set, indicated that while held in the trap this animal had fought with a second bobcat that had inflicted the fatal wounds. It seems unlikely that the fight was caused by a male attempting to copulate with the female held in the trap, for the female was found to be carrying an embryo.

In Live Oak Canyon, in December, 1950, tracks and bits of fur indicated that a bobcat had killed and eaten a gray squirrel. Remains of cottontails were found in the stomachs of two bobcats. All six bobcats from the Pacific slope had nematode worms in the pyloric end of the stomach.

Two females obtained on March 12 and 19, 1951, each had one embryo approximately one inch long (rump to crown).

The following list gives the weight of each of the specimens from the Pacific slope of the San Gabriels.

Specimens examined.—Total, 8, distributed as follows: Los Angeles County: San Antonio Canyon, 4000 ft., 1; San Antonio Canyon, 3200 ft., 1; 4 mi. N Claremont, 1900 ft., 2; Thompson Canyon, 1800 ft., 1; 3 mi. NE Claremont, 1700 ft., 2; Little Dalton Canyon, 1500 ft., 1 (PC).

TABLE 12.—WEIGHTS OF LYNX RUFUS CALIFORNICUS FROM THE SAN GABRIEL MOUNTAINS.

sex and age	locality	date	weight
♂ ad.	3 mi. NE Claremont, 1700 ft.	January 20, 1951	18.8 lbs.
♂ sad.	4 mi. N Claremont, 1900 ft.	March 9, 1951	12.5 "
♀ ad.	Thompson Canyon, 1800 ft.	January 15, 1948	13.2 "
♀ sad.	4 mi. N Claremont, 1900 ft.	January 26, 1951	11.3 "
♀ ad.	3 mi. NE Claremont, 1700 ft.	January 27, 1951	13.8 "
♀ sad.	San Antonio Canyon, 4000 ft.	March 12, 1951	7.9 "
♀ sad.	San Antonio Canyon, 3200 ft.	March 17, 1951	11.2 "

Lynx rufus baileyi Merriam

Wildcat

This subspecies is widely distributed on the desert slope of the range, and was recorded down to the lower edge of the juniper belt. Tracks were observed on many occasions in yellow pine forest, but wildcats seemed to be commonest in the brushy parts of the pinyon-juniper association. Two were trapped in small draws lined with pinyons and scrub oak, and two at the base of rocky pinyon-covered slopes. Only occasionally were tracks noted in the lower part of the juniper belt. Bobcats are most numerous where woodrats also reach peak abundance, suggesting that woodrats are a major food.

The four specimens from the desert slope, although exhibiting a wide range of variation, are all representatives of the desert race *baileyi*. A yearling male from near the head of Grandview Canyon, at 5200 feet elevation, has the profuse black spotting of the subspecies *californicus*, but the general pallor dorsally is characteristic of the desert subspecies. An adult female, from 4700 feet elevation in Graham Canyon, shows the double mid-dorsal black line and the distinct black markings around the face characteristic of *californicus*, but is otherwise pale with reduced black patterns on the backs of the ears. The other two specimens, an adult male and a yearling female, are typical examples of *baileyi*, pale, and with reduced black markings. None of the specimens of bobcats from the coastal slope of the mountains showed characters approaching those of *baileyi*. It seems, therefore, that these two subspecies intergrade on the interior slope of the range.

A yearling male weighed 12 pounds, and a yearling female weighed 10.5 pounds. An old male weighed 19.6 pounds, and an adult female weighed 15.1 pounds.

Remains of deer were in two of the bobcat stomachs, and one of these stomachs also contained jack rabbit remains. Approximately a dozen nematodes (stomach worms) were in the stomach of one of the larger male specimens.

Specimens examined.—Total, 4, distributed as follows: Los Angeles County: Mescal Canyon, 4800 ft., 1; Graham Canyon, 4700 ft., 1; Grandview Canyon, 5200 ft., 2.

Felis concolor californica May

Mountain Lion

Several cabin owners near the mouth of Icehouse Canyon reported seeing a lion in that area in 1950, and others said they saw huge cat tracks in Icehouse Canyon. State Trapper James Wolfort reported that he trapped two lions on the coastal face of the range in 1947. Authentic reports indicate that mountain lions occur in remote sections on both slopes of the range, and in these areas mountain lions probably are as common as they ever were.

Family CERVIDAE

Odocoileus hemionus californicus (Caton)

Mule Deer

Mule deer are common in chaparral areas on both slopes of the San Gabriel Mountains. The animals or their tracks have been observed from the coastal sagebrush flats up to about 9200 feet on Mount San Antonio, and on the desert slope down to the lower limit of the juniper belt.

Deer are plentiful in the upper chaparral belt, and large bands are often noted there in spring. These bands may form in the up-mountain migration and reoccupation of areas which were covered by winter snows. A band of fourteen was observed on March 17, 1951, one mile east of the mouth of Cattle Canyon, and bands of about half a dozen individuals each were often noted in March, 1951, at the base of Icehouse Canyon. Cronemiller and Bartholomew (1950) gave a good account of the mule deer in the chaparral belt of the San Gabriel Mountains.

On Blue Ridge in the fall of 1951, deer were plentiful, usually being observed near patches of snowbrush and sage. They were seldom found in the coniferous forests. On November 6, 1951, while tending a line of snap traps before sunup, I startled a deer from its bed at one edge of a several-acre patch of snowbrush. In synchrony with the noise made by this deer's rising five other deer in various parts of the brush patch leaped up and made off. When bedded down in these extensive brush tracts deer are probably safe from an undetected approach, for a noiseless approach through the brush is impossible.

Two deer skulls from the San Gabriels were examined: that of an adult male from Evey Canyon, and that of an adult female from the mouth of Palmer Canyon. Using as a basis for comparison the cranial measurements for the subspecies *californicus* and *fuliginatus* given by Cowan (1933:326), these skulls were subspecies *californicus*. In none of the cranial characteristics considered did they tend toward the southern race *fuliginatus*. A young adult male, however, which was killed by a car near Cajon Pass on October 2, 1951, showed pelage characteristics of *fuliginatus*. Its fresh winter pelage was dark, and had the distinct black mid-dorsal line and the broad dorsal line on the tail mentioned by Cowan (*ibid.*) as distinguishing marks of the race *fuliginatus*. Its cranial measurements were not taken. Judging from this limited material the deer in the central part of the range, that is to say, in the San Antonio Canyon region, are of the race *californicus,* while *fuliginatus* may penetrate the extreme eastern end of the range.

Deer hair and bones were often found in coyote feces from the sagebrush belt. Some of these records may represent deer eaten as carrion. On February 6, 1952, tracks across a sandy channel in San Antonio Wash demonstrated that a deer had been closely pursued by a coyote. The deer had leaped from a cutbank onto the sand, had whirled around in several sharp turns, and had run into the adjacent brush. The tracks of a running coyote followed every twist of the deer's trail. The trail was followed into the brush where it was lost. Two bobcats trapped near Graham Canyon on the desert slope had hair and bones of deer in their stomachs.

Specimens examined, 2: Los Angeles County: Evey Canyon, 2100 ft., 1 (PC); Palmer Canyon, 1900 ft., 1 (PC).

Family BOVIDAE

Ovis canadensis nelsoni Merriam

Bighorn

Bands of bighorn sheep occur on some of the higher and more rugged peaks of the San Gabriel Mountains. Although I never sighted the animals themselves, I have seen abundant signs of their presence on the ridge sloping west from Telegraph Peak at about 9000 feet elevation. Several bands reportedly range in the head of San Antonio Canyon, and to the south on Telegraph, Ontario, and Cucamonga peaks. The sheep usually stay in the higher sections of the range, generally above about 7000 feet elevation. According to district Ranger A. Lewis some bighorns summer in the lower East Fork of San Gabriel Canyon. The subspecific status of the bighorns in the San Gabriel Mountains has not been definitely determined. Following Grinnell (1933:211) they are here referred to *nelsoni.* If the band can be preserved without introduction of "alien" stock, the United States Forest Service and the California Fish and Game Commission will have registered an achievement that will be applauded by all persons who are interested in American wildlife.

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Transmitted July 20, 1954.

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25-5184

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University of Kansas Publications
Museum of Natural History

Volume 7, No. 10, pp. 583-586
November 15, 1954

A New Bat (Genus Pipistrellus) from Northeastern México

BY

ROLLIN H. BAKER

University of Kansas
Lawrence
1954

University of Kansas Publications, Museum of Natural History

Volume 7, No. 10, pp. 583-586
Published November 15, 1954

University of Kansas
Lawrence, Kansas

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1954

25-5677

A New Bat (Genus Pipistrellus) from Northeastern México

by

Rollin H. Baker

The eastern pipistrelle, *Pipistrellus subflavus* (Cuvier) in the western part of its range, occurs along the Río Grande and its tributaries as far west as northern Coahuila and Val Verde County, Texas. Specimens from those places represent a heretofore undescribed subspecies which may be named and described as follows:

Pipistrellus subflavus clarus new subspecies

Type.—Female, adult, skin and skull; No. 48270, Univ. Kansas Mus. Nat. Hist.; 2 mi. W Jiménez, el. 850 ft., Coahuila; 19 June 1952; obtained by Rollin H. Baker, original No. 2062.

Range.—Known from northern Coahuila and adjacent parts of southwestern Texas.

Diagnosis.—Size large (see measurements); upper parts pale, near (*c*) Cinnamon-Buff (capitalized color term after Ridgway, Color Standards and Color Nomenclature, Washington, D. C., 1912); skull large; zygomata expanded laterally.

Comparisons.—Compared with *Pipistrellus subflavus subflavus* (specimens from Marshall Hall in Maryland, Raleigh in North Carolina, and Barber County in Kansas) *P. s. clarus* is paler, of approximately equal size, and has the zygomata slightly more expanded laterally. From *Pipistrellus subflavus veracrucis* (Ward), specimens from 4 km. E Las Vigas, el. 8500 ft., Veracruz, *P. s. clarus* differs in being larger, paler, and in having a larger skull.

Remarks.—*Pipistrellus subflavus clarus* is the palest subspecies of the eastern pipistrelle. Of the specimens assigned to *clarus* (all taken in May and June), only two are sufficiently dark to compare favorably with examples of typical *subflavus*. A specimen (KU 60296) assigned to *P. s. subflavus* from Rancho Pano Ayuctle, el. 300 ft., 6 mi. N Gómez Farías, Tamaulipas, is much darker than *clarus*. A specimen recorded from Devils River, Texas, by V. Bailey (N. Amer. Fauna, 25:211, October 24, 1905) has not been examined by me but presumably is *P. s. clarus*.

Pipistrellus subflavus clarus was taken along the Río San Diego and the Río Sabinas, both tributaries of the Río Grande, where park-like stands of pecan, cypress, willow and other trees bordered these streams. The species was not found at stock ponds or along stream courses in adjacent places where such trees were absent. Funds

for financing field work were made available by the Kansas University Endowment Association and the National Science Foundation.

Measurements.—Measurements of the holotype and average and extreme measurements of 5 adult females from the type locality, including the holotype, are, respectively, as follows: Total length, 85, 88.0 (85-92); length of tail vertebrae, 43, 40.8 (36-45); length of hind foot, 9, 9.4 (8.5-11); height of ear from notch, 12, 12.6 (12-13); length of forearm, 33.8, 33.4 (32.9-33.8); length of tibia, 14.8, 14.6 (14.5-14.8); greatest length of skull, 13.3, 13.1 (12.7-13.3); condylobasal length, 12.6, 12.4 (12.1-12.6); breadth of braincase, 7.0, 6.8 (6.7-7.0); zygomatic breadth, 8.1, 8.0 (7.8-8.2); mastoid breadth, 7.1, 6.9 (6.5-7.1); length maxillary tooth-row, 4.5, 4.5 (4.4-4.6).

Specimens examined.—Those from Texas are in the collection of the United States National Museum, and those from Coahuila are in University of Kansas Museum of Natural History. Total, 21. TEXAS: Comstock, 1; Del Rio, 2. COAHUILA: 2 mi. W Jiménez, 850 ft., 15; 2 mi. S and 3 mi. E San Juan de Sabinas, 1160 ft., 3.

Transmitted August 23, 1954.

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25-5677

University of Kansas Publications
Museum of Natural History

Volume 7, No. 11, pp. 587-590
November 15, 1954

A New Subspecies of Pocket Mouse from Kansas

BY

E. RAYMOND HALL

University of Kansas
Lawrence
1954

University of Kansas Publications, Museum of Natural History

Editors: E. Raymond Hall, Chairman, A. Byron Leonard,
Robert W. Wilson

Volume 7, No. 11, pp. 587-590
Published November 15, 1954

University of Kansas
Lawrence, Kansas

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1954

25-5678

A New Subspecies of Pocket Mouse from Kansas

by

E. Raymond Hall

When preparing distribution maps for a revised list of the Mammals of Kansas it became apparent to me that pocket mice of the species *Perognathus flavescens* from south-central Kansas and adjoining parts of Oklahoma were without a subspecific name. The new subspecies is named and described below.

Perognathus flavescens cockrumi new subspecies

Holotype.—Female, subadult (P4 moderately worn), skin with skull, No. 13045, Univ. Kansas Mus. Nat. Hist.; 4½ mi. NE Danville, Harper Co., Kansas; December 1, 1939; obtained by Sam Tihen; original No. 99 of J. A. Tihen.

Range.—South-central Kansas south at least into Dewey County, Oklahoma.

Diagnosis.—Size small; upper parts Ochraceous-Buff (capitalized color terms after Ridgway, Color Standards and Color Nomenclature, Washington, D. C., 1912) heavily suffused with black; postauricular patches and a band 8 mm wide on each side Ochraceous-Buff; subauricular spot, underparts, and forefeet white; hind feet slightly dusky; tail brownish above and white below. Skull small; tympanic bullae small; rostrum wide; skull indistinguishable from that of *P. f. flavescens* from the same latitude in western Kansas.

Comparisons.—*Perognathus flavescens cockrumi* averages approximately 12 per cent smaller in linear measurements than the more northern *Perognathus flavescens perniger* Osgood (from Knox, Stanton and Cumming counties, Nebraska) but color of upper parts is essentially the same. From the more western *Perognathus flavescens flavescens* Merriam (from Seward, Hamilton and Morton counties, Kansas), *cockrumi* differs in being darker in all parts of the pelage except on the underparts which are white in both subspecies; the parts of the hairs that are Ochraceous-Buff in *cockrumi* are Light Ochraceous-Buff in *flavescens;* the back of *cockrumi* is blackish instead of yellowish. From the more southern *Perognathus flavescens copei* Rhoads (topotypes examined but not at hand as I write), *cockrumi* differs in duller more blackish (less bright and less reddish) upper parts. From *Perognathus merriami gilvus,* of more southern distribution, the new subspecies differs in much smaller tympanic bullae and wider rostrum.

Measurements.—The type, a male (35331/47596 U. S. B. S., from Cairo, Kansas, showing some wear on P4), and another male (60165 K. U., from Barber Co., Kansas, showing much wear on P4) measure, respectively: Total length, 114, 120, 124; tail, 51, 55, 58; hind foot, 17, 17, 18; occipitonasal length, ——, 21.0, 21.6; condylobasal length (condyles to anterior end of premaxillae), 18.5, 18.6, 19.3; frontonasal length, ——, 14.1, 14.3; mastoidal breadth, 10.5, 11.2, 11.2; length of bulla, 6.8, 7.1, 6.8; interorbital breadth, 4.7, 4.8, 5.1; alveolar length of upper molariform tooth-row, 3.1, 3.1, 3.0; interparietal breadth, 4.3. 4.6, 4.7.

Remarks.—The subspecific name *cockrumi* is proposed in recognition of Dr. E. Lendell Cockrum's important contribution to our knowledge of the mammals of Kansas. Dr. W. Frank Blair recently suggested to me that the two specimens examined by him from Kansas (the one from Ellsworth County and the one here designated as holotype) should not be referred to *Perognathus flavescens copei* Rhoads, as Cockrum (Univ. Kansas Publ., Mus. Nat. Hist., 7:146, August 25, 1952) had done, because *copei* is paler, instead of darker, than *P. f. flavescens.* It was Dr. Blair's suggestion which lead me to realize that the subspecies in south-central Kansas lacked a name.

Through the courtesy of Miss Viola S. Schantz I have examined three of the four specimens from Cairo, Kansas, that Osgood (N. Amer. Fauna, 18:21, September 20, 1900) referred to *Perognathus flavescens* before any subspecies of that species had been recognized. The specimens from Cairo are intermediate in color, as they are also in geographic position, between *P. f. flavescens* from western Kansas and *P. f. cockrumi* from south-central Kansas but show more resemblance to the latter and therefore are referred to *P. f. cockrumi.* The specimens, excepting the three from Cairo, are in the Museum of Natural History at the University of Kansas.

Specimens examined.—Total, 10 distributed as follows:

Kansas: ELLSWORTH CO.: 1½ mi. S Wilson, 1. PRATT CO.: Cairo, 3 (U.S. B.S.). BARBER CO.: Plum Thicket Farm [= 1 mi. E and 3 mi. N Sharon], 4. HARPER CO.: 4½ mi. N Danville, 1.

Oklahoma: DEWEY CO.: 6 mi. W and ½ mi. S Canton, 1.

Transmitted August 23, 1954.

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25-5678

UNIVERSITY OF KANSAS PUBLICATIONS
MUSEUM OF NATURAL HISTORY

Volume 7, No. 12, pp. 591-608
March 15, 1955

Geographic Variation in the Pocket Gopher, Cratogeomys castanops, in Coahuila, México

BY

ROBERT J. RUSSELL AND ROLLIN H. BAKER

UNIVERSITY OF KANSAS
LAWRENCE
1955

University of Kansas Publications, Museum of Natural History

Editors: E. Raymond Hall, Chairman, A. Byron Leonard,
Robert W. Wilson

Volume 7, No. 12, pp. 591-608
Published March 15, 1955

University of Kansas
Lawrence, Kansas

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1955

25-5679

Geographic Variation in the Pocket Gopher, Cratogeomys castanops, in Coahuila, México

By

Robert J. Russell and Rollin H. Baker

The plateau pocket gopher, *Cratogeomys castanops,* inhabits open lands from southeastern Colorado southward onto the Mexican Plateau as far south as southern San Luis Potosí and southeastern Zacatecas and southeastward to the Coastal Plain of northern Tamaulipas. This species occurs at elevations from as low as 26 feet at Matamoras in Tamaulipas to as high as 8700 feet in valleys of southeastern Coahuila. In 1934, Nelson and Goldman (Proc. Biol. Soc. Washington, 47:135-154, June 13, 1934) revised the genus *Cratogeomys* and decided that six subspecies of *C. castanops* occurred in Coahuila. In the present account, we describe four previously unknown subspecies from Coahuila, exclude from the state two others recorded from there by Nelson and Goldman, and show that three others named previously from adjacent Mexican states do occur in Coahuila. This makes eleven subspecies now known from that state. From Coahuila Nelson and Goldman had 35 study specimens of *C. castanops* from seven localities and we have had 234 specimens from 63 localities. Consequently we have been able to define with greater certainty, than formerly was possible, the geographic distribution of *C. castanops* in this Mexican state and similarly analyze more completely the geographic variation.

Coahuila is near the center of the geographic range of *C. castanops.* The occurrence of 11 subspecies within the state seems to be the result of partial or perhaps, in some cases, total isolation of populations of *C. castanops* because of the highly dissected topography and the variability of the soil. *Cratogeomys castanops* is a sedentary animal preferring open plains mantled by suitable soils, preferably sandy in texture, in which the animals can dig their elaborate underground systems of runways. Thin soils of hard texture and rocky soils do not offer optimum habitat for *C. castanops,* and the animals usually are absent or uncommon in such situations. Desert mountains with their thin rocky soils, elevated passes, perpendicular rocky cliffs, and stands of oaks and conifers at higher elevations present impassable barriers for pocket gophers of this species. The Río Grande, bordering Coahuila to the north, in many places flowing through steep-walled cañons, also seems to be a barrier that this fossorial rodent does not cross; distinct subspecies occur on the two sides of the river directly opposite each other (also see Nelson and Goldman, *op. cit.*:143). Smaller streams, such as the Río Salado, Río Nazas and Río Salinas, seem to be unimportant barriers to the passage of these pocket gophers. The food supply of *C. castanops* seems adequate in most situations and consequently food is unimportant in governing the distribution of this species. Principal foods of *C. castanops* are fleshy tuberous roots of well-distributed desert shrubs, but in the valleys of the high mountains of southeastern Coahuila, where desert shrubs are absent, roots and leaves of low-growing forbs are eaten.

Three distinct habitats for *C. castanops* occur in Coahuila. The state is crossed by a series of mostly impassable, mountainous ridges beginning at the northwestern boundary at the Cañon de Boquillas on the Río Grande and extending southeastward to the east-central border. This divides Coahuila into a more humid and less elevated northeastern area which is an inland extension westward of the Coastal Plain and a more arid and higher western and southern area which is a part of the "Mesa del Norte" of the Mexican Plateau. In the extreme southeast the still higher elevated plains and intermontane valleys within the Sierra Madre Oriental afford a third habitat for populations of this species. The subspecies of these pocket gophers found in any one of these three habitats show greater affinity to each other than they do to any subspecies found in the other habitats.

Generally speaking, populations of *C. castanops* from northeastern Coahuila are related, as a group, in color and cranial features. Partial isolation of subspecies in this area results chiefly from discontinuity of suitable soils rather than from topography. These pocket gophers occur most commonly in the deep, sandy soils which are found along streams, especially where farm lands are irrigated. In western and southern Coahuila, mountains extending in both north-south and east-west directions act as partial barriers to the passage of *C. castanops*. Within this large area, pocket gophers occur in desert basins many of which are enclosed on two or more sides by mountains. Even so, with the exception of the smaller *C. c. consitus* of northwestern Coahuila, all known subspecies occurring at lower elevations in the western and southern part of the state show close relationships in color and cranial features. Those subspecies in the higher parts of southeastern Coahuila by their small size and dark color reflect to a high degree their isolation in an elevated habitat.

Males of *C. castanops* differ greatly from females of equal age; consequently animals of the same sex, as well as of the same age, are used herein for taxonomic comparisons. Since, of any given age-group, females show less individual variation than do males, we have relied more on the characteristics of the females in this taxonomic study. Only specimens taken at approximately the same times of the year have been compared for color of pelage. Capitalized color terms are those of Ridgway, Color Standards and Color Nomenclature, Washington, D. C., 1912. Specimens made available through the courtesy of the authorities of the Biological Surveys Collection of the United States National Museum are indicated in the accounts of subspecies as BSC; other specimens listed are in the collection of the University of Kansas Museum of Natural History. Assistance with field work is acknowledged from the Kansas University Endowment Association and the National Science Foundation.

In any one of the lists of "Specimens examined" beyond, the order of arrangement of the localities is from north to south. Those localities listed in Roman type are represented on the distribution map (Figure 1) by blacked-in circles. Each of several circles covers two or more localities because the localities are close together. In any such instance the northernmost place is listed in Roman type and the names of the other places follow in Italic type. Measurements in millimeters are given in table 1 for females and in table 2 for males.

Cratogeomys castanops convexus Nelson and Goldman

1934. *Cratogeomys castanops convexus* Nelson and Goldman, Proc. Biol. Soc. Washington, 47:142, June 13, type from 7 mi. E Las Vacas [= Villa Acuña], Río Grande Valley, Coahuila (opposite Del Río, Texas).

Distribution.—Extreme northern Coahuila, east and north of the Serranías del Burro (see fig. 1).

Diagnosis.—Previously known from only one specimen, a subadult female, this subspecies has not been well diagnosed. At hand we have five near topotypes of *convexus* (including two adult females and one adult male) and specimens assignable to this subspecies from several other localities. This subspecies may be characterized as follows: Size medium (see tables 1 and 2); dorsal profile of skull convex in females and flat, especially posteriorly, in males; zygomata weakly constructed and not widely flaring; mastoid and tympanic bullae inflated; nasals short; rostrum broad and short; maxillary teeth large.

Comparisons.—From topotypes of *Cratogeomys castanops angusticeps* Nelson and Goldman, found to the north and east across the Río Grande in Texas,

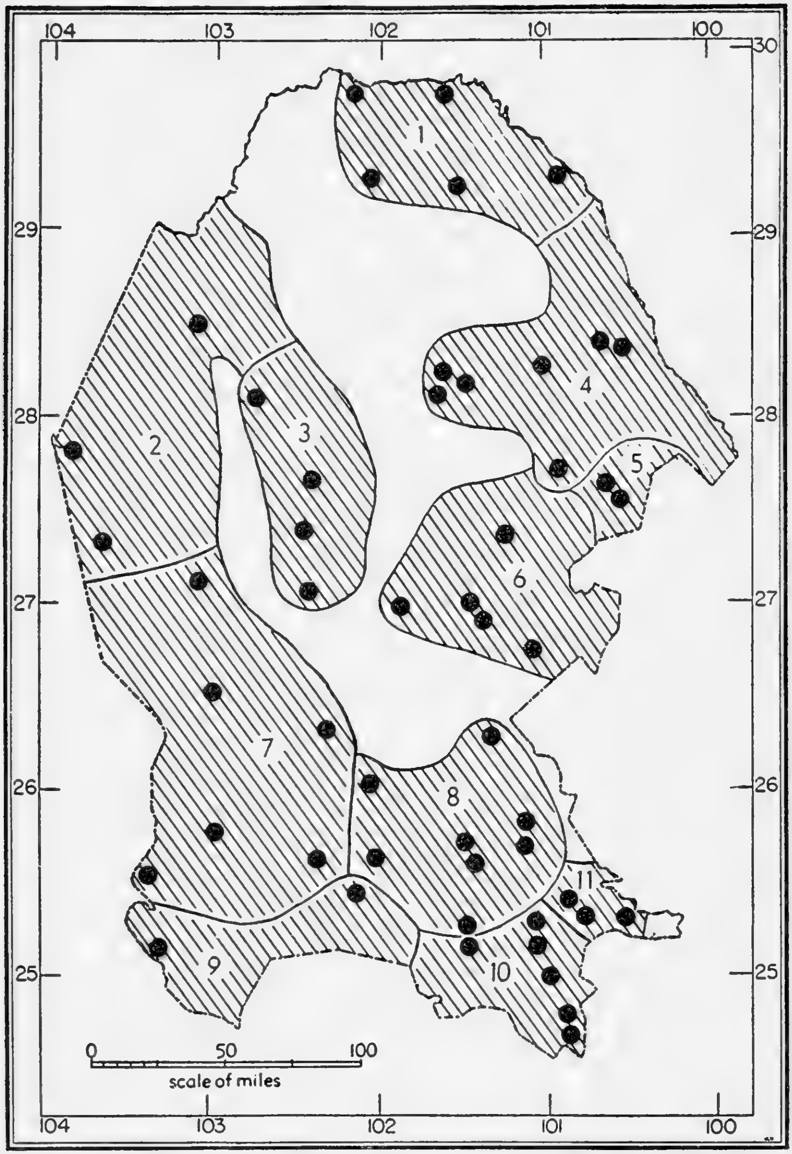

FIG. 1. Geographic ranges of the subspecies of *Cratogeomys castanops* found in Coahuila, México.

Guide to subspecies

1. *C. c. convexus*
2. *C. c. consitus*
3. *C. c. sordidulus*
4. *C. c. bullatus*
5. *C. c. ustulatus*
6. *C. c. jucundus*
7. *C. c. excelsus*
8. *C. c. subsimus*
9. *C. c. goldmani*
10. *C. c. subnubilus*
11. *C. c. planifrons*

convexus differs in: Body larger; upper parts more reddish, especially on sides; skull with zygomata less heavy, nasals broader, pterygoids smaller, maxillary teeth larger. For comparisons of *convexus* with the subspecies of *C. castanops* found to the west, south and southeast, see accounts of the subspecies to follow.

Remarks.—The geographic range of *convexus* is restricted, being bounded on the west and southwest by mountains, especially the Serranías del Burro, and on the north and east by the Río Grande. The range of the subspecies found to the southeast may not be continuous with that of *convexus.* At least, in the area between Villa Acuña and Piedras Negras, along the Río Grande, no specimens were obtained and no sign was observed. We suspect that in this area the species occurs only locally if at all.

A specimen taken near the Río Grande in Coahuila, opposite Samuels, Texas, and assigned to *Cratogeomys castanops clarkii* by Nelson and Goldman (*op. cit.* :140), has been examined by us and is referable to *convexus.* This specimen is typical of *convexus* except for the lesser inflation of the mastoid bullae and tympanic bullae. Conspicuous differences between *convexus* and *angusticeps* indicate that the Río Grande is an effective barrier to passage by these rodents.

Specimens examined.—Total, 14, all from Coahuila: Río Grande, 17 mi. S Dryden, Terrell Co., Texas, 6; Río Grande, opposite Samuels, Val Verde Co., Texas, 1 (BSC); Villa Acuña, 5; Cañon del Cochino, 21 mi. E and 16 mi. N Piedra Blanca, 1; 11 mi. W Hda. San Miguel, 1.

Cratogeomys castanops bullatus new subspecies

Type.—Female, adult, skin and skull, No. 48498, Univ. Kansas Mus. Nat. Hist., 2 mi. S and 6½ mi. E Nava, 810 ft., Coahuila; 16 June 1952; obtained by Robert J. Russell, original number 276.

Distribution.—Desert lowlands of northeastern Coahuila, from the Río Grande to as far southwestward as the Río Sabinas (see fig. 1).

Diagnosis.—Body medium for the species (see tables 1 and 2); tail long; hind foot small; upper parts Light Ochraceous-Buff (in summer pelage) and Orange-Buff (in winter pelage), bases of hairs Plumbeous; underparts white to pale buffy; skull small, broad and slightly convex in dorsal outline; zygomata widely flaring; palate short; rostrum short; nasals short; mastoid and tympanic bullae inflated; basioccipital with lateral edges parallel; maxillary teeth small.

Comparisons.—From *Cratogeomys castanops convexus*, found to the north, *bullatus* differs in: Hind foot shorter; skull much broader in relation to length; rostrum narrower but, relative to length of skull, wider; tympanic bullae slightly more inflated; incisors and maxillary teeth smaller. From topotypes of *Cratogeomys castanops angusticeps*, found across the Río Grande and upstream from localities where *bullatus* is known to occur, *bullatus* differs in: Body slightly smaller; color paler, especially on sides; skull shorter and broader; rostrum shorter and broader; nasals shorter; mastoid and tympanic bullae more inflated; maxillary teeth smaller. For comparisons of *bullatus* with the subspecies of *C. castanops* found to the west and south, see accounts of the subspecies to follow.

Remarks.—*Cratogeomys castanops bullatus* in small size resembles *C. c. tamaulipensis* Nelson and Goldman of the lower Río Grande Valley in Tamaulipas, but the two differ markedly in cranial features. *Cratogeomys c. bullatus* is smaller than *convexus* but these two subspecies resemble each other in color and cranial characters. Both have an arched skull, inflated mastoid and tympanic bullae, short nasals, and a short rostrum. Comparison of *bullatus* with *angusticeps,* which occurs across the Río Grande but not directly opposite the range of *bullatus,* indicates that these two subspecies are less closely related than *bullatus* is to *tamaulipensis* and *convexus.*

Cratogeomys castanops bullatus is especially common in sandy soils in the vicinity of Nava where the mounds were in fallow irrigated fields and other open places between extensive live oak thickets. South and west of the Río Grande the animals were less abundant and lived in heavier soils usually as individuals or in small groups. Specimens were taken at elevations from as low as 800 feet to as high as 2,000 feet.

Specimens examined.—Total, 24, from: 2 mi. S and 6½ mi. E Nava, 810 ft., 2; 2 mi. S and 12 mi. E Nava, 800 ft., 1; *3 mi. S and 12 mi. E Nava, 800 ft.,* 4; 29 mi. N and 6 mi. E Sabinas, 5; 10 mi. E Hacienda La Mariposa, 2000 ft., 1; La Gacha [= La Concha], 1600 ft., 8; 8 mi. S and 8 mi. E Hacienda La Mariposa, 1900 ft., 1; 9 mi. S and 11 mi. E Sabinas, 1050 ft., 2.

Cratogeomys castanops ustulatus new subspecies

Type.—Female, adult, skin and skull, No. 34589, Univ. Kansas Mus. Nat. Hist., Don Martin, 800 ft., Coahuila; 19 August 1949; obtained by W. Kim Clark, original number 1034.

Distribution.—Extreme northeastern Coahuila from the vicinity of Presa Don Martin southward into northwestern Neuvo León in the valley of the Río Salado and its tributaries at least as far south as the vicinity of Vallecillo (see fig. 1).

Diagnosis.—Body large for species (see tables 1 and 2); hind foot short; upper parts Apricot Buff (in fresh summer pelage) and Salmon-Buff strongly mixed with black (in fresh winter pelage); underparts Light Ochraceous-Buff; skull large, especially in females, and broad; zygomatic arches widely flaring; palate long; rostrum broad; nasals long; mastoid and tympanic bullae not conspicuously inflated; incisors narrow; maxillary teeth large.

Comparisons.—From *Cratogeomys castanops bullatus* found to the north, *ustulatus* differs in: Body larger; tail shorter; upper parts darker, more rufous and less buffy; skull larger, especially in palate, nasals, and rostrum; zygomata more widely flaring; tympanic bullae less inflated; incisors slightly larger; maxillary teeth larger. From topotypes of *Cratogeomys castanops tamaulipensis* found to the southeast, *ustulatus* differs in: Body larger; upper parts, in winter pelage, darker, more rufous and less buffy; underparts paler; skull larger, especially in palate, rostrum and nasals; zygomata more widely flaring; tympanic bullae more inflated; pterygoids larger; basioccipital narrower, its sides parallel instead of convex; maxillary teeth smaller. From *Cratogeomys castanops subsimus,* found to the southwest, *ustulatus* differs in: Tail shorter; hind foot smaller; upper parts darker, more rufous and less pinkish-buff; skull shorter; zygomata less widely flaring; palate shorter; rostrum averaging slightly narrower; nasals shorter; incisors narrower; maxillary teeth slightly smaller. For comparison of *ustulatus* with the subspecies of *C. castanops* to the southwest, see account of that subspecies to follow.

Remarks.—*Cratogeomys castanops ustulatus* is a large-sized pocket gopher with a relatively larger skull. In size of skull, *ustulatus* is exceeded only by *C. c. subsimus* found beyond the mountains in the southern part of Coahuila. In size, *ustulatus* differs so markedly from *bullatus* that the two can be distinguished easily by this feature alone. The skull of *C. c. convexus* approaches that of *ustulatus* in size, but is smaller in all respects, save breadth of rostrum.

This pocket gopher is found commonly along the Río Salado and its watershed. Fallow cotton fields in the vicinity of Anahuac [= Rodríques], Nuevo León, are preferred living places. This subspecies was found at elevations as high as 1000 feet and as low as 600 feet.

Specimens examined.—Total, 10, from: Don Martin, 800 ft., 5; *base of Don Martin Dam,* 2; *2 mi. SE Don Martin Dam, along Río Salado,* 2; 5 mi. SE Don Martin, 1.

Records from Nuevo León.—Total, 14, from: 9 mi. N and 2 mi. W Anahuac [= Rodríques], 1; 4 mi. N and 1 mi. W Anahuac [= Rodríques], 5; 3 mi. N Lampazos, 4; 1 mi. N Vallecillo, 1000 ft., 1; Vallecillo, 20 mi. S Río Salado, 1000 ft., 3.

Cratogeomys castanops jucundus new subspecies

Type.—Female, adult, skin and skull; No. 56603, Univ. Kansas Mus. Nat. Hist.; Hermanas, 1205 ft., Coahuila; 5 December 1953; obtained by Robert W. Dickerman, original number 2051.

Distribution.—Arid plains and broad intermontane valleys of east-central Coahuila (see fig. 1).

Diagnosis.—Body largest for the species (see table 1); tail long; hind foot large; upper parts in winter pelage Ochraceous-Buff, in summer pelage Antimony Yellow; underparts Pale Ochraceous-Buff; skull medium in size, broad; zygomata moderately flaring; palate medium in length; rostrum broad; nasals moderately long; maxillary teeth small.

Comparisons.—From *Cratogeomy castanops ustulatus,* found to the east, *jucundus* differs in: Body larger; tail longer; hind foot larger; upper parts paler, more ochraceous and less rufous; skull averaging smaller; zygomata slightly less expanded laterally; palate and nasals shorter; squamosal breadth less; mastoid bullae less inflated, especially in females; rostrum slightly narrower; maxillary tooth-row shorter. From topotypes of *Cratogeomys castanops tamaulipensis,* found to the southeast, *jucundus* differs in: Body larger; tail longer; hind foot smaller; upper parts, in winter pelage, paler, more ochraceous and less rufous; skull larger; zygomata more widely flaring; palate longer; rostrum broader; tympanic bullae more inflated; basioccipital with sides parallel instead of convex; maxillary teeth smaller. From *Cratogeomy castanops excelsus,* found to the southwest, *jucundus* differs in: Body larger; hind foot averaging larger; upper parts darker, more ochraceous, and less buffy; underparts darker, more buffy and less whitish; skull slightly smaller; zygomata less widely flaring, especially in females; palate shorter; nasals shorter; squamosal breadth less; mastoid bullae more inflated; incisors narrower. From *Cratogeomys castanops subsimus,* found to the south, *jucundus* differs in: Body larger; tail shorter; hind foot shorter; upper parts paler, more ochraceous and less yellowish; skull smaller; zygomata less widely expanded laterally; palate and nasals shorter; rostrum narrower; squamosal breadth less; maxillary tooth-row shorter. From *Cratogeomys castanops bullatus,* found to the north, *jucundus* differs in: Body larger; tail averaging longer; hind foot larger; color of upper parts more ochraceous and less rufous; underparts darker, more buffy and less whitish; skull larger, especially in length, in width across zygomata, in lengths of palate, rostrum and nasals; mastoid and tympanic bullae less inflated; squamosal breadth greater.

Remarks.—*Cratogeomys castanops jucundus* is large, exceeding *subsimus* in dimensions of the body, but differing from *subsimus* in relatively smaller skull. Passage to the north and northeast by *jucundus* is at least partly blocked by inhospitable mountainous country; the resulting semi-isolation may be one reason for the distinctive characteristics of *jucundus* compared with those of *bullatus* and *ustulatus.* Two specimens from Monclova, assigned to *tamaulipensis* by Nelson and Goldman (*op. cit.*:142), are here referred to *jucundus* on the basis of cranial characters and size.

Specimens were trapped in fallow irrigated fields in the vicinity of Monclova. Others were taken in deep soils in desert flats.

Specimens examined.—Total, 19, from: Hermanas, 1205 ft., 9; *1 mi. S Hermanas,* 2; 1 mi. N and 13 mi. E Cuatro Ciénegas, 2; 5 mi. N and 2 mi. W Monclova, 1; *2 mi. N and 1 mi. E Monclova,* 1; Monclova, 2 (BSC); Hisachalo [= Huisachalo], 2.

Cratogeomys castanops sordidulus new subspecies

Type.—Female, adult, skin and skull; No. 56614, Univ. Kansas Mus. Nat. Hist.; 1.5 mi. NW Ocampo, 3300 ft., Coahuila; 16 December 1953; obtained by Robert W. Dickerman, original number 2164.

Distribution.—Desert plains of north-central Coahuila, surrounded for the most part by higher mountainous country (see fig. 1).

Diagnosis.—Body large for species (see tables 1 and 2); tail short; hind foot large; upper parts Ochraceous-Buff (in summer pelage) and Orange-Buff (in fresh winter pelage); underparts Pale Ochraceous-Salmon; skull medium in size and narrow; zygomata narrow; rostrum narrow; palate short; nasals medium in length; basioccipital small and narrow; mastoid bullae not greatly inflated; tympanic bullae inflated; incisors small; maxillary teeth small.

Comparisons.—From *Cratogeomys castanops jucundus,* found beyond the mountains to the southeast, *sordidulus* differs in: Body smaller; tail shorter; hind foot slightly smaller; upper parts darker, more ochraceous and less yellowish, with plumbeous bases of hairs more conspicuous; underparts darker, more buffy and less whitish; skull slightly shorter, more nearly flat, and narrower; zygomata less widely flaring; rostrum narrower; mastoid bullae less inflated; incisors and maxillary teeth slightly smaller. From *Cratogeomys castanops excelsus,* found to the south and southwest, *sordidulus* differs in: Body slightly smaller; tail shorter; hind foot slightly larger; upper parts darker, more ochraceous and less pinkish-buff; underparts darker, more buffy and less whitish; skull smaller and narrower; zygomata less widely flaring; sides more nearly parallel and not expanded anteriorly; palate shorter; rostrum narrower and, in relation to greatest length of skull, longer; tympanic bullae slightly more inflated; incisors and maxillary teeth smaller. From *Cratogeomys castanops consitus,* found to the north and west, *sordidulus* differs in: Body larger; hind foot larger; upper parts paler, more ochraceous and less rufous; skull decidedly larger and wider; zygomata more widely flaring; palate and nasals longer; rostrum broader; mastoid bullae and tympanic bullae larger; maxillary teeth smaller. From topotypes of *Cratogeomys castanops clarkii* (Baird), found to the northwest, *sordidulus* differs in: Body larger; tail shorter; upper parts, in winter pelage, paler, more ochraceous and less dark-rufous; skull slightly smaller and narrower; rostrum narrower; nasals slightly shorter; sides of basioccipital more nearly parallel instead of wedge-shaped; mastoid bullae less inflated; incisor and maxillary teeth smaller. From *Cratogeomys castanops convexus,* found to the northeast, *sordidulus* differs in: Body larger; tail shorter; upper parts slightly darker, more ochraceous and less buffy; skull narrower; zygomata more nearly parallel and less expanded anteriorly; rostrum narrower and longer; nasals longer; squamosal breadth greater; mastoid bullae less inflated; maxillary teeth smaller. From *Cratogeomys castanops bullatus,* found to the east, *sordidulus* differs in: Body larger; hind foot larger; upper parts darker, more ochraceous and less buffy; skull larger in all respects; zygomata more widely flaring; tympanic bullae less inflated; maxillary teeth larger.

Remarks.—*Cratogeomys castanops sordidulus* is limited to the Llano de Ocampo, an elevated, desert plain surrounded on three sides, west, south and east, by higher mountainous country which seems to bar the passage of this rodent. On the eastern side this barrier extends north to the very banks of the Río Grande in the Cañon de Boquillas. This subspecies, therefore, is in contact with other populations of *Cratogeomys* only to the north and northwest. This subspecies is well characterized by size, color and cranial characteristics.

Cratogeomys castanops sordidulus is not abundant; groups of mounds constructed by one or a few individuals were found in widely separated places. Mounds were often small, appeared old and, in other ways, were inconspicuous on arid flats. The animals were taken at elevations as low as 3250 feet and as high as 4150 feet.

Specimens examined.—Total, 13, from: 50 mi. N and 20 mi. W Ocampo, 4150 ft., 1; 18 mi. S and 14 mi. E Tanque Alvarez, 4000 ft., 4; 1½ mi. NW Ocampo, 3300 ft., 6; *Ocampo,* 1; 5 mi. N and 19 mi. W Cuatro Ciénegas, 3250 ft., 1.

Cratogeomys castanops consitus Nelson and Goldman

1934. *Cratogeomys castanops consitus* Nelson and Goldman, Proc. Biol. Soc. Washington, 47:140, June 13, type from Gallego, 5500 ft., Chihuahua.

Distribution.—Arid high plains from central Chihuahua, east and southeast at least into northwestern Coahuila (see fig. 1).

Comparisons.—From *Cratogeomys castanops lacrimalis* Nelson and Goldman, specimens from Boquillas and Marathon north of the Río Grande in Texas, *consitus* differs in: Body smaller; tail and hind foot shorter; upper parts paler, more light buffy and less rufous; underparts paler, light buffy instead of dark buffy; skull decidedly smaller; zygomata slightly less widely flaring; palate especially shorter; rostrum narrower; squamosal breadth less; incisors smaller. From topotypes of *Cratogeomys castanops clarkii,* found to the north along the Río Grande, *consitus* differs in: Body smaller; tail and hind foot shorter; upper parts paler, more buffy and less rufous; skull markedly smaller, especially in palate and nasals; zygomata less widely flaring; tympanic bullae more inflated; mastoid bullae less inflated; basioccipital parallel-sided as opposed to wedge-shaped. From *Cratogeomys castanops convexus,* found to the east, *consitus* differs in: Body smaller; tail and hind foot shorter; upper parts paler, more buffy and less ochraceous; underparts paler, white or light buffy instead of pale ochraceous; skull smaller; zygomata less widely flaring; palate shorter; rostrum decidedly narrower and, relative to length of skull, longer; squamosal breadth less; incisors smaller. From *Cratogeomys castanops excelsus,* found to the south, *consitus* differs in: Size smaller; tail and hind foot shorter; upper parts darker, more rufous and less pinkish-buff; skull conspicuously smaller, especially in palate, rostrum, and nasals; zygomata less widely flaring; mastoid bullae and tympanic bullae more inflated; incisors smaller; maxillary teeth relatively larger. For comparison of *consitus* with *Cratogeomys castanops sordidulus,* see previous account.

Remarks.—*Cratogeomys castanops consitus* is a small pocket gopher (see tables 1 and 2); the largest adult available to us is much smaller than the smallest adult of any adjacent subspecies. Specimens from Coahuila assigned to *consitus* compare favorably with topotypes although those from the vicinity of Jaco are smaller, paler and have a narrower rostrum and smaller maxillary teeth. An immature male trapped three miles northeast of Sierra Mojada is tentatively assigned to *consitus.* This subspecies seems to be rare in northwestern Coahuila and small colonies are widely scattered.

Cratogeomys castanops clarkii (Baird) may occur along the Río Grande in extreme northwestern Coahuila. No specimens are known from Coahuila, and none was found in the vicinity of Boquillas, Coahuila, in 1952.

Specimens examined.—Total, 8, from: 3 mi. N and 9 mi. E El Pino, 1; 6 mi. E Jaco, Chihuahua, *in* Coahuila, 6; 3 mi. NE Sierra Mojada, 1.

Cratogeomys castanops excelsus Nelson and Goldman

1934. *Cratogeomys castanops excelsus* Nelson and Goldman, Proc. Biol. Soc. Washington, 47:143, June 13, type from San Pedro, 10 mi. W Laguna de Mayrán, Coahuila.

Distribution.—Desert plains of southwestern Coahuila and northeastern Durango (see fig. 1).

Comparisons.—*Cratogeomys castanops excelsus* is characterized by large size and pale color; it is the palest subspecies of *C. castanops.* Of adjacent subspecies, *excelsus* most closely resembles *C. c. subsimus* which occurs to the east and resembles least *C. c. consitus,* which occurs to the northwest.

From *Cratogeomys castanops subsimus,* found to the east, *excelsus* differs in: Body averaging slightly larger; tail and hind foot shorter; upper parts paler, more light buffy and less yellowish; skull smaller; palate especially shorter; rostrum narrower; nasals shorter; incisors slightly smaller; maxillary tooth-row shorter. Compared with topotypes of *C. c. goldmani,* found to the south, *excelsus* differs in: Body larger; hind foot smaller; upper parts in winter pelage paler, more buffy and less rufous; skull larger; zygomata more widely flaring; rostrum broader; nasals shorter; tympanic bullae larger and more inflated; maxillary teeth larger.

Specimens of *excelsus* from the vicinity of Torreón, in southwestern Coahuila, are slightly smaller in cranial dimensions than more typical examples of the subspecies. In small size, at least, these specimens show some resemblance to *goldmani* to the south. The range of *excelsus* approaches that of *C. c. consitus* in west-central Coahuila (see fig. 1), but no evidence of intergradation between these two subspecies could be ascertained. For comparison of *excelsus* with *consitus,* see account of the latter.

Remarks.—*Cratogeomys castanops excelsus* lives in the deep soils of the arid interior basin of southwestern Coahuila and adjacent parts of Durango. This animal is common in the cultivated areas in, and in the vicinity of, the formerly extensive Laguna de Mayrán. East of this laguna the land becomes progressively higher, and *C. c. subsimus* occurs in the higher, more dissected part of this area.

Specimens examined.—Total, 33, from: 8 mi. E and 2 mi. S Americanos, 3500 ft., 3; 4 mi. N Acatita, 3600 ft., 9; 20 mi. S El Hundido, 1; San Pedro, 2 (BSC); *1 mi. SW San Pedro de las Colonias, 3700 ft.,* 4; 10 mi. N and 11 mi. W San Lorenzo, 2; 2 mi. E Torreón, 12.

Cratogeomys castanops subsimus Nelson and Goldman

1934. *Cratogeomys castanops subsimus* Nelson and Goldman, Proc. Biol. Soc. Washington, 47:144, June 13, type from Jaral, Coahuila.

Distribution.—Desert plains and lower foothills of mountains in south-central Coahuila (see fig. 1).

Comparisons.—From *Cratogeomys castanops goldmani,* found to the southwest, *subsimus* differs in: Body larger; hind foot larger; upper parts paler, more yellowish and less rufous; skull larger and rougher, having more prominent ridges and crests and deeper fossae for attachment of muscles; zygomata more widely flaring; palate longer; rostrum broader; nasals longer; squamosal breadth greater; maxillary teeth larger. From *C. c. subnubilus,* found to the south,

TABLE 1. MEASUREMENTS OF ADULT FEMALE CRATOGEOMYS FROM COAHUILA, MÉXICO

No. av. or cat. no.	Total length	Length of tail	Length of hind foot	Condylobasal length	Zygomatic breadth	Length of palate	Breadth of rostrum	Length of nasals	Squamosal breadth	Alveolar length of maxillary tooth-row
				C. c. convexus, Villa Acuña						
52259	260	86	37	50.6	31.7	33.8	11.7	16.7	29.1	9.3
52261	265	83	38	49.3	31.6	32.9	11.8	15.8	28.9	10.6
				C. c. bullatus, vicinity of Nava						
5 Av.	256	80	36	47.4	30.6	32.6	10.7	17.1	27.9	9.5
Min.	242	72	35	47.0	30.6	32.3	10.0	16.5	27.5	9.2
Max.	263	85	37	47.7	31.1	32.9	11.6	17.8	28.2	9.8
				C. c. ustulatus, vicinity of Don Martin						
8 Av.	273	74	36	51.4	33.5	35.4	11.8	18.8	30.1	10.0
Min.	261	64	35	50.7	32.6	34.8	11.0	17.8	29.1	9.3
Max.	280	83	38	52.1	34.1	36.5	12.5	19.2	30.8	10.6
				C. c. jucundus, Hermanas						
4 Av.	296	85	39	50.9	33.0	34.6	11.5	18.0	29.6	9.4
Min.	294	83	38	49.8	32.1	33.8	11.0	17.0	29.0	9.1
Max.	298	86	39	51.8	33.8	35.0	11.6	18.6	30.1	9.6
				C. c. sordidulus, 1.5 mi. NW Ocampo						
3 Av.	276	79	37	50.4	31.7	34.6	10.9	18.2	30.0	9.1
Min.	270	75	36	49.5	30.6	33.8	10.3	17.7	29.8	8.9
Max.	288	85	39	51.4	32.4	35.2	11.4	18.5	30.1	9.2
				C. c. consitus, 6 mi. E Jaco, Chihuahua, *in* Coahuila						
4 Av.	229	74	32	43.8	28.1	29.6	9.7	16.0	26.2	8.9
Min.	226	68	31	42.6	27.3	29.4	9.4	15.5	25.7	8.1
Max.	232	78	32	45.8	28.8	29.9	9.9	16.2	26.9	9.2
				C. c. excelsus, 4 mi. N Acatita						
4 Av.	284	82	37	51.4	34.1	35.4	11.6	18.9	31.2	9.5
Min.	274	77	35	51.1	33.6	34.7	10.4	18.4	30.5	9.2
Max.	291	86	38	51.6	34.9	36.1	12.1	20.1	31.7	9.9
				C. c. subsimus, 12 mi. N and 10 mi. E Parras						
34937	287	87	39	53.1	34.9	36.9	11.5	19.4	31.7	10.5
				Jaral (BSC)						
51049	295	104	40	53.2	34.1	36.9	12.6	18.7	29.7	10.0
				C. c. goldmani, 1 mi. S Jimulco						
55611	250	85	35	46.0	32.6	31.4	10.7	16.3	27.8	9.8
				C. c. subnubilus, 1 mi. S Carneros						
33128	220	65	29	40.8	27.9	27.2	8.7	12.7	24.7	8.1
				2 mi. W San Miguel						
33132	222	65	30	40.4	26.3	26.6	8.1	13.2	24.5	8.4
				1 mi. N Agua Nueva						
33127	220	74	29	41.8	24.6	28.4	8.3	14.2	23.9	8.4
				8 mi. N La Ventura						
34934	235	76	30	42.2	27.9	28.5	9.0	14.3	26.3	7.8
				C. c. planifrons, 12 mi. W San Antonio de las Alazanas						
5 Av.	244	66	32	43.7	28.0	29.1	9.4	14.5	26.2	8.6
Min.	239	62	31	43.3	27.5	28.7	8.9	13.6	25.3	8.3
Max.	247	69	33	44.3	28.5	29.4	9.7	15.3	26.8	8.9

TABLE 2. Measurements of Adult Male Cratogeomys from Coahuila, México

No. av. or cat. no.	Total length	Length of tail	Length of hind foot	Condylobasal length	Zygomatic breadth	Length of palate	Breadth of rostrum	Length of nasals	Squamosal breadth	Alveolar length of maxillary tooth-row
				C. c. convexus, Villa Acuña						
52260	275	89	39	55.0	34.4	37.0	12.6	20.0	30.9	10.4
				C. c. bullatus, 3 mi. S and 12 mi. E Nava						
48500	261	80	36	49.7	35.3	34.4	12.4	17.1	29.2	9.5
				La Gacha						
57028	250	76	34	49.9	34.0	34.4	11.5	16.6	28.4	9.3
				C. c. ustulatus, Don Martin						
34587	280	75	37	54.6	37.3	38.2	13.7	20.6	31.8	10.3
				C. c. jucundus, Hermanas						
56605	311	80	42	56.9	38.7	40.1	13.3	21.0	32.3	9.9
				C. c. sordidulus, 1.5 mi. NW Ocampo						
56733	307	88	37	57.5	49.6	40.3	13.6	22.1	33.1	10.3
				C. c. consistus, 3 mi. N and 9 mi. E El Pino						
54547	289	94	36	53.8	32.6	37.1	12.7	18.8	29.5	9.6
				C. c. excelsus, 2 mi. E Torreón						
40224	315	97	41	54.7	37.8	37.6	12.1	19.5	31.4	9.8
				C. c. subsimus, Hda. El Tulillo, 5 km. S Hipolito						
35772	315	105	40	56.4	35.3	39.5	12.5	20.8	33.8	10.6
				2 mi. N Santa Cruz						
48517	316	89	40	58.2	37.9	40.3	14.1	21.7	34.8	10.3
				C. c. goldmani, W foot Pico de Jimulco						
55610	255	82	36	48.9	33.4	33.4	11.7	17.7	29.6	9.3
				C. c. subnubilus, Carneros (BSC)						
79484	247	86	34	45.3	30.9	30.8	9.6	15.7	28.4	8.5
				8 mi. N La Ventura						
34932	250	79	34	46.3	31.8	31.0	9.6	16.4	28.7	8.4
				C. c. planifrons, 4 mi. S and 6 mi. E Saltillo						
35779	254	76	34	48.0	32.2	32.6	9.8	16.6	28.0	8.6
35780	272	85	35	48.8	33.2	34.1	10.5	17.5	29.9	9.5
				12 mi. S and 2 mi. E Arteaga						
33122	255	72	35	47.0	32.3	31.2	10.5	15.5	28.7	9.0

subsimus differs in: Body larger; tail and hind foot shorter; upper parts paler, more yellowish-buff and less blackish; skull decidedly larger in all respects. From *C. c. planifrons*, found at higher elevations to the southeast, *subsimus* differs in the same respects as *subsimus* differs from *subnubilus*. For comparisons between *subsimus* and subpecies to the west, north and northeast, see accounts above.

Remarks.—*Cratogeomys castanops subsimus* is the largest known subspecies of the species in cranial dimensions, but is exceeded in size of body by *C. c. jucundus* to the north. Of adjacent subspecies, *subsimus* is the most closely related to *excelsus* and shows little or no relationship to the smaller and darker *C. c. subnubilus* and *C. c. planifrons*, which are found at higher elevations to the south and southeast, respectively. Movements by *subsimus* to the north, east, and south are barred by inhospitable mountains. Specimens of *subsimus* from the northeastern part of its range are larger and darker than other specimens assigned to this subspecies. An adult female, assigned to *subsimus*, from the vicinity of Santa Rosa is noticeably smaller and paler than typical specimens of this subspecies.

Cratogeomys castanops subsimus occurs in scattered colonies in sandy soils principally in the upper drainage of the Río Salinas. Specimens have also been taken from the foothills of the Sierra Madre Oriental and westward on the elevated desert plains.

Specimens examined.—Total, 22, from: 3 mi. S and 3 mi. E Muralla, 3800 ft., 3; 2 mi. N Santa Cruz, 2; 21 mi. S and 11 mi. E Australia, 4400 ft., 6; Jaral, 3860 ft., 4 (BSC); *Hacienda El Tulillo, 5 km. S Hipolito*, 2; 17 mi. N and 8 mi. W Saltillo, 5200 ft., 1; 3 mi. N and 5 mi. W La Rosa, 3600 ft., 1; 12 mi. N and 10 mi. E Parras, 5000 ft., 1; N foot Sierra Guadalupe, 9 mi. S and 5 mi. W General Cepeda, 6200 ft., 1; *N foot Sierra Guadalupe, 10 mi. S and 5 mi. W General Cepeda, 6500 ft.*, 1.

Cratogeomys castanops goldmani Merriam

1895. *Cratogeomys castanops goldmani* Merriam, N. Amer. Fauna 8:160, January 31, type from Cañitas, Zacatecas.

Distribution. — Plains of northeastern Zacatecas, northward into extreme southwestern Coahuila (see fig. 1).

Comparisons.—Compared with *Cratogeomys castanops subnubilus*, found to the east, *goldmani* differs in: Body larger, tail and hind foot longer; color paler, more rufous and less blackish; skull larger; zygomata more widely flaring; palate larger; rostrum broader; nasals longer; maxillary teeth larger. Compared with *Cratogeomys castanops rubellus* Nelson and Goldman, found to the southeast, *goldmani* differs in: Body and skull smaller; zygomata less widely flaring; palate shorter; rostrum narrower; maxillary teeth smaller.

Remarks.—Records of *goldmani* given here extend the known range of this subspecies northward into southwestern Coahuila. Specimens assigned to this subspecies from Coahuila compare favorably with topotypes of *goldmani* (see tables 1 and 2) but are slightly paler, and in this respect show some relationship to *excelsus.* The ranges of these two subspecies however, are partly isolated by mountainous country in southern Coahuila.

Specimens examined.—Total, 6, from: W foot Pico de Jimulco, 4600 ft., 1; *Valley Río Aquanaval, 1 mi. S Jimulco,* 4; 1½ mi. N Parras, 1.

Cratogeomys castanops subnubilus Nelson and Goldman

1934. *Cratogeomys castanops subnubilus* Nelson and Goldman, Proc. Biol. Soc. Washington, 47:145, June 13, type from Carneros, 6800 ft., Coahuila.

Distribution.—Intermontane valleys and plains of southeastern Coahuila and probably adjacent parts of Zacatecas, San Luis Potosí and Nuevo León (see fig. 1).

Comparisons.—*Cratogeomys castanops subnubilus* needs close comparison only with *Cratogeomys castanops planifrons,* found to the east and from which *subnubilus* differs in: Body, hind foot and skull smaller; upper parts, in summer pelage, paler, more rufous-buff and less dark russet; underparts paler, more whitish and less blackish; hairs of hind foot reddish rather than blackish; zygomata more widely flaring; palate shorter, especially in females; rostrum broader, especially in females; nasals slightly smaller; squamosal breadth greater; incisors narrower, especially in males; maxillary teeth smaller. From *Cratogeomys castanops rubellus* Nelson and Goldman, found to the south in San Luis Potosí, *subnubilus* differs in: Body, hind foot and all parts of skull smaller; upper parts and underparts darker, more blackish and less rufous.

Remarks.—*Cratogeomys castanops subnubilus* is the smallest subspecies of *C. castanops* (see tables 1 and 2). This subspecies is dark and lives at high elevations (5500 ft. to 6800 ft.) in deep valley soils in relatively isolated intermontane valleys and elevated plains. It is differentiated to a much higher degree from adjacent subspecies of *C. castanops* than is usual in this species, and no intergrades between *subnubilus* and other subspecies have been taken. In the Sierra Guadalupe, *subnubilus* was trapped at 6700 feet within two miles of a place where *subsimus* was taken at 6500 feet.

Specimens examined.—Total, 31, from: 1 mi. N Agua Nueva, 5500 ft., 1; Domingo Cañon, Sierra Guadalupe, 6700 ft., 11 mi. S and 4 mi. W General Cepeda, 1; Carneros, 6800 ft., 6 (BSC); *1 mi. S Carneros, 6000 ft.,* 4; 2 mi. W San Miguel, 5500 ft., 3; 8 mi. N La Ventura, 6000 ft., 10; La Ventura, 5600 ft., 6 (BSC).

Cratogeomys castanops planifrons Nelson and Goldman

1934. *Cratogeomys castanops planifrons* Nelson and Goldman, Proc. Biol. Soc. Washington, 47:146, June 13, type from Miquihuana, 5000 ft., Tamaulipas (listed, by mistake, as southern Nuevo León).

Distribution.—Elevated montane valleys of Sierra Madre Oriental of extreme southeastern Coahuila, south and east into southwestern Nuevo León and Western Tamaulipas (see fig. 1).

Remarks.—Specimens from Coahuila assigned to *planifrons* compare favorably with topotypes of this subspecies although they are slightly larger in cranial dimensions (see tables 1 and 2). This small subspecies is darker and slightly larger than *subnubilus* but in other ways is most closely related to *subnubilus*. *Cratogeomys c. planifrons* shows little relation to other adjacent subspecies, including *tamaulipensis*, *subsimus* and *rubellus*, all of which are considerably larger and paler.

Cratogeomys castanops planifrons is found in both deep and shallow soils of the high, open valleys of the Sierra Madre Oriental; in Coahuila it was taken at elevations as low as 7200 feet and as high as 8700 feet.

Specimens examined.—Total, 50, from: 4 mi. S and 6 mi. E Saltillo, 7500 ft., 7; 7 mi. S and 4 mi. E Bella Union, 7200 ft., 14; *12 mi. W San Antonio de las Alazanas*, 16; *12 mi. S and 2 mi. E Arteaga, 7500 ft.*, 11; 2 mi. E and 2 mi. N San Antonio de las Alazanas, 8700 ft., 2.

Transmitted August 23, 1954.

UNIVERSITY OF KANSAS PUBLICATIONS
MUSEUM OF NATURAL HISTORY

Volume 7, No. 13, pp. 609-612
April 8, 1955

A New Cottontail (Sylvilagus floridanus) From Northeastern Mexico

BY

ROLLIN H. BAKER

UNIVERSITY OF KANSAS
LAWRENCE
1955

University of Kansas Publication, Museum of Natural History

Editors: E. Raymond Hall, Chairman, A. Byron Leonard,
Robert W. Wilson

Volume 7, No. 13, pp. 609-612
Published April 8, 1955

University of Kansas
Lawrence, Kansas

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1955

25-6582

A New Cottontail (Sylvilagus floridanus) From Northeastern Mexico

By

Rollin H. Baker

Mammals obtained in the mountains of central Coahuila in April, 1954, include four examples of a large cottontail, *Sylvilagus floridanus,* which, not being referable to any recognized subspecies, are named and described as follows:

Sylvilagus floridanus nelsoni new subspecies

Type.—Female, adult, skin and skull; No. 57771, Univ. Kansas Mus. Nat. Hist.; 22 mi. S and 5 mi. W Ocampo, 5925 ft., Coahuila; 4 April 1954; obtained by Rollin H. Baker, original No. 2571.

Range.—Known only from higher elevations of the Sierra de la Madera in central Coahuila; probably occurs in other montane areas in central Coahuila and also those in northern Coahuila.

Diagnosis.—Size large (see measurements); upper parts pale gray, mixed with black, tinged with Pale Ochraceous-Buff (capitalized color terms after Ridgway, Color Standards and Color Nomenclature, Washington, D. C., 1912) on head, back, and flanks; sides (except for flanks) and rump Pearl Gray in over-all appearance when viewed from a distance of two feet; skull large; auditory bullae inflated; rostrum broad; cranium moderately expanded laterally.

Comparisons.—From *Sylvilagus floridanus robustus* (Bailey), specimens from the Davis and Chisos mountains, Texas, examined through the courtesy of the Department of Wildlife Management, A & M College of Texas, and the Museum of Zoology, University of Michigan, *nelsoni* differs in: upper parts paler gray in over-all appearance with buffy tinge paler and less conspicuous, especially on back and ears (only specimens taken from March to May compared); rostrum broader and more nearly flat anteriorly; cranium less inflated laterally; external auditory meatus almost round in adult *nelsoni* instead of ovate; auditory bullae less inflated laterally. From *Sylvilagus floridanus chapmani* (Allen), specimens from northeastern Coahuila, *nelsoni* differs in: size much larger in all parts; upper parts paler gray and not so brown; auditory bullae more inflated. From *Sylvilagus floridanus orizabae* (Merriam), specimens from southeastern Coahuila, western Nuevo León, Distrito Federal, and Morelos, *nelsoni* differs in: size slightly larger; upper parts much less brown (only specimens taken in early spring compared); auditory bullae more inflated. From *Sylvilagus floridanus holzneri* (Mearns), one specimen taken in July from Durango, *nelsoni* differs in: upper parts much less brown; auditory bullae more inflated; cranium less inflated laterally; external auditory meatus almost round in adult *nelsoni* instead of ovate.

Remarks.—*Sylvilagus floridanus nelsoni* resembles closely *S. f. robustus* of western Texas, especially in size and color. Other adjacent subspecies, *chapmani, orizabae,* and *holzneri,* are much browner although in size and cranial characteristics *nelsoni* does not differ markedly from the two subspecies last mentioned.

There is evidence that a large cottontail exists also in the Sierra del Carmen, Sierra del Pino, Sierra de San Marcos and other higher mountains in northern and central Coahuila. Edward W. Nelson, for whom this subspecies is named, first reported (N. Amer. Fauna, 29:195, August 31, 1909) the occurrence of a large, mountain-dwelling, cottontail in Coahuila but was unsuccessful in capturing specimens. This large, pale animal is secretive and usually confines its activities to mixed grass and chaparral. The specimens taken in the Sierra de la Madera were shot either in early evening or after dark with the aid of an electric head lamp. Animals seen did not venture more than 15 feet from clumps of heavy oak brush.

Measurements.—Measurements of the holotype and an adult female (from 21 mi. S and 4 mi. W Ocampo, 5700 ft., Coahuila), respectively, are: total length, 405, 421; length of tail vertebrae, 48, 51; length of hind foot, 98, 97; height of ear from notch in flesh, 76, 72 (in dried skin, 67, 69); basilar length, 56.2, 57.9; zygomatic breadth, 34.1, 35.9; postorbital constriction, 11.1, 11.0; length of nasals, 30.3, 35.1; length of auditory bullae, 12.5, 12.8; greatest breadth of braincase, 26.7, 26.8; greatest width of nasals, 16.1, 16.3; alveolar length of upper molariform tooth-row, 13.4, 13.7.

Specimens examined.—Total, 4, from Coahuila as follows: 20 mi. S and 4 mi. W Ocampo, 5300 ft., 2; 21 mi. S and 4 mi. W Ocampo, 5700 ft., 1; 22 mi. S and 5 mi. W Ocampo, 5950 ft., 1.

Transmitted September 15, 1954.

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25-6582

UNIVERSITY OF KANSAS PUBLICATIONS
MUSEUM OF NATURAL HISTORY

Volume 7, No. 14, pp. 613-618

June 10, 1955

Taxonomy and Distribution of Some American Shrews

BY

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UNIVERSITY OF KANSAS
LAWRENCE
1955

University of Kansas Publications, Museum of Natural History

Volume 7, No. 14, pp. 613-618
Published June 10, 1955

University of Kansas
Lawrence, Kansas

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1955

25-7329

Taxonomy and Distribution of Some American Shrews

by

James S. Findley

Sorex cinereus ohionensis Bole and Moulthrop.—In their description of this subspecies from Ohio, Bole and Moulthrop (1942:89-95) made no mention of specimens in the United States Biological Surveys Collection from Ellsworth and Milford Center, Ohio, which stand in the literature (see Jackson, 1928:49) as *Sorex cinereus cinereus*. These two localities lie south of the geographic range ascribed to *S. c. ohionensis* by Bole and Moulthrop. Examination of the two specimens, United States Biological Surveys Collection, Catalogue No. 70566, and United States National Museum, No. 19434, respectively, both of which are alcoholics, reveals that they are referable to the subspecies *ohionensis* rather than to *S. c. cinereus*. This reference is made on the basis of small size, short tail (33 and 31 millimeters, respectively), and fourth upper unicuspid as large as third (the specimen from Milford Center lacks the skull). The occurrence at Milford Center provides a southward extension of known range for *S. c. ohionensis* of approximately 70 miles. *S. c. cinereus* seems not to occur in Ohio.

Cryptotis micrura (Tomes).—Davis (1944:376) assigned a *Cryptotis* from Boca del Río, Veracruz, to *Cryptotis parva berlandieri* (Baird). Comparison of this specimen, Texas Cooperative Wildlife Collections, No. 2765, with 8 specimens of *C. micrura* from various parts of northern Veracruz and with 9 *C. parva* from southern Tamaulipas reveals that the shrew from Boca del Río is referable to *Cryptotis micrura*. The series of 8 specimens in the University of Kansas Museum of Natural History from Altamira, Tamaulipas, provides the southernmost known record of *Cryptotis parva berlandieri*. These 8 specimens are typical of *C. p. berlandieri* and show no approach to *C. micrura*. Average and extreme cranial measurements of 7 specimens from 1 mi. S Altamira are: condylobasal length, 15.6 (15.2-16.1); palatal length, 6.6 (6.4-6.7); maxillary tooth-row, 5.7 (5.4-5.8); cranial breadth, 7.6 (7.4-8.0); least interorbital breadth, 3.5 (3.4-3.7); maxillary breadth, 5.0 (4.8-5.2). Cranial measurements of 8 specimens of *C. micrura* from various localities in northern Veracruz (1 km. E Mecayucan, 1; 7 km. NNW Cerro Gordo, 3; Teocelo, 2; 7 km. W El Brinco, 1; 5 km. N Jalapa, 1) are: condylobasal length, 17.1 (16.6-17.4); palatal length, 7.1 (6.9-7.4); maxillary tooth-row, 6.2 (5.9-6.4); cranial breadth, 8.5 (8.3-8.6); least interorbital breadth, 3.7 (3.6-4.1); maxillary breadth, 5.3 (5.1-5.6). *C. parva* and *C. micrura* may intergrade but a distance of 140 miles separates the geographic ranges as now known of the two kinds and every specimen examined by me is clearly referable to one or the other of the two named kinds and shows no evidence of intergradation.

Notiosorex crawfordi crawfordi Baird.—A specimen in the Museum of Natural History from Jaumave, and one from Palmillas, Tamaulipas, collected by Gerd Heinrich, provide records of the easternmost margin of the range of this species in Mexico. Assignment is made to the subspecies *crawfordi* on geographic grounds. The two specimens differ from a male from 13 mi. S and 15 mi. W Guadalajara, Jalisco, referred (Twente and Baker, 1951:121) to *N. c. evotis* (Coues) in slightly larger size; however two skulls from owl pellets from 21 mi. SW Guadalajara, also referred to *evotis* (*loc. cit.*), seem to me to differ in no important way from skulls of the Tamaulipan specimens. Measurements of the Tamaulipan specimens, both females, 54932 KU and 54933 KU, are respectively: condylobasal length, —, 16.7; palatal length, —, 7.2; maxillary tooth-row, 6.6, 6.1; cranial breadth, 8.3, 8.1; least interorbital breadth, —, 3.5; maxillary breadth, —, 5.1; total length, 90, 90; tail, 28, 30; hind foot, 11.0, 11.5; ear, 8, 8.

The only other eastern Mexican record of *N. crawfordi* is based on two skulls from owl pellets collected 3 mi. NW Cuatro Cienegas, Coahuila (Baker, 1953:253).

Sorex oreopolus emarginatus Jackson.—A first-year female *Sorex*, KU 54346, obtained by Rollin H. Baker from 7 mi. SW Las Adjuntas, 8900 ft., Durango, seems closest, among Mexican shrews that I have examined, to two specimens of *S. emarginatus* from Plateado, 7600 to 8500 ft., Zacatecas. Measurements of the Las Adjuntas specimen are: total length, 88; tail, 39; hind foot, 13; palatal length, 7.2; maxillary tooth-row, 6.4; maxillary breadth, 4.9; least interorbital breadth, 3.6.

Sorex emarginatus previously was known only from Plateado and the type locality, Bolanos, Jalisco. Comparison of these three specimens with specimens of other species of Mexican shrews of the *S. saussurei* group leads me to conclude that the group contains two species rather than four as was previously thought. *Sorex emarginatus, S. ventralis,* and *S. oreopolus* seem to me to be conspecific. All three nominal species are relatively small, short-tailed shrews. The skulls of the three kinds resemble one another in relatively short rostrum and in dental details. Slight differences in cranial proportions differentiate the three and they should, until more specimens of each are obtained and studied, retain subspecific rank. The specific name, *Sorex oreopolus* Merriam 1892, should apply to the three kinds since it antedates the names *ventralis* and *emarginatus.* The two names last given, therefore, should stand as *Sorex oreopolus ventralis* Merriam and *Sorex oreopolus emarginatus* Jackson. The two species, the large *S. saussurei,* and the small *S. oreopolus,* as the latter is here understood, occur together over an extensive region in southern Mexico. In other parts of North America a large and a small species of *Sorex* often occur together in a given area.

The Las Adjuntas specimen was taken only 10 miles southwest of El Salto, Durango, the type locality of *S. durangae* Jackson. Jackson (1928:101) placed *durangae* in the *Sorex vagrans-obscurus* species group, but the two specimens available to him were second year adults with the teeth so much worn that diagnostic characters are not visible on them. I have examined these two specimens (United States Biological Surveys Collection 94539 and 94540) and find that in bodily and cranial proportions they resemble *Sorex s. saussurei,* and I so assign them.

Sorex milleri Jackson.—Koestner (1941:10) reported 5 *Sorex* from Cerro Potosi, near La Jolla, Municipio de Galeana, Nuevo Leon, as *Sorex emarginatus.* Comparison of 4 of these specimens (Chicago Museum of Natural History, 48227, 48228, 48229, 48230) with two *S. emarginatus* from Plateado, Zacatecas, and specimens of other species of *Sorex* indicates that the Cerro Potosi shrews differ in many features from *emarginatus,* but closely resemble, in size and cranial characters, a specimen (F. W. Miller, No. 20) of *S. milleri* from Sierra del Carmen, Coahuila, and seems to be referable to that species which was not named when Koestner (*loc. cit.*) recorded his specimen. The range of *S. milleri* is therefore extended southwestward to western central Nuevo Leon.

Comparison of *S. milleri* with specimens of other species of North American *Sorex* leads me to conclude that *S. milleri* is most closely related to *S. cinereus* Kerr, and should be included in the *S. cinereus* group rather than in the *S. vagrans-obscurus* group.

Sorex cinereus and *S. milleri* are alike, and both differ from even the smallest *S. vagrans* in relatively long and narrow rostrum, narrow teeth, smaller skull, and in having the third upper unicuspid more often equal to or smaller than, rather than larger than, the fourth unicuspid.

I judge *S. milleri* to be a relict population of *S. cinereus,* isolated in the mountains of northeastern Mexico, probably in the late Pleistocene. *Sorex cinereus* reported from Pleistocene deposits in San Josecito Cave, Nuevo Leon (Findley, 1953:635), probably represents a population ancestral to the modern *S. milleri. Sorex milleri* should retain specific status because of constant cranial differences from *S. cinereus,* particularly relatively broader rostrum.

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25-7329

University of Kansas Publications
Museum of Natural History

Volume 7, No. 15, pp. 619-624, 2 figs. in text

June 10, 1955

The Pigmy Woodrat, Neotoma goldmani, Its Distribution and Systematic Position

BY

DENNIS G. RAINEY AND ROLLIN H. BAKER

University of Kansas
Lawrence
1955

University of Kansas Publications, Museum of Natural History

Editors: E. Raymond Hall, Chairman, A. Byron Leonard,
Robert W. Wilson

Vol. 7, No. 15, pp. 619-624
Published June 10, 1955

University of Kansas
Lawrence, Kansas

PRINTED BY
FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
1955

25-7820

The Pigmy Woodrat, Neotoma goldmani, Its Distribution and Systematic Position

By

Dennis G. Rainey and Rollin H. Baker

The pigmy woodrat, *Neotoma goldmani* Merriam, the smallest known member of the genus, inhabits rocky areas in the elevated desert regions of the northern part of the Mexican Plateau (Mesa del Norte). Goldman (N. Amer. Fauna, 31:82, October 10, 1910) had for study ten specimens from two localities in Coahuila. Since his report, Dalquest (Louisiana State Univ. Studies, Biol. Sci. Ser. No. 1:162, December 28, 1953) extended the known distribution of this species approximately 225 miles southward into San Luis Potosí, where he reported animals from five localities. Field workers from the Museum of Natural History at the University of Kansas recently have taken *goldmani* in the Mexican states of Chihuahua, Coahuila, Durango, Zacatecas and San Luis Potosí, and now we can define, with greater accuracy, the geographic range of this species (see fig. 1 and list of specimens examined).

Goldman (*loc. cit.*), relying chiefly on external appearance, placed *goldmani* in the *desertorum* group, now known as the *lepida* group (Goldman, Jour. Mamm., 13:67, February 9, 1932). Blossom (Occ. Papers Mus. Zool., Univ. Michigan, 315:3, May 29, 1935) thought that *goldmani* might be a subspecies of *lepida* but that intergradation between the two had not been demonstrated. Our newly acquired material, instead of confirming the opinions of Goldman and Blossom, shows that *goldmani* is more closely related to *Neotoma albigula.*

Externally *goldmani* resembles *Neotoma lepida* (examples from California, Utah, and Colorado) in having long, silky pelage; ochraceous buffy coloring, especially along sides; and underparts basally plumbeous except for a small throat patch where the hairs are entirely white in some individuals. In *albigula* this patch of white hairs usually is much larger and more conspicuous. Cranially, instead of resembling the *lepida* group (including *Neotoma stephensi*), *goldmani* looks more nearly like a miniature *albigula* (specimens of *albigula* from Coahuila). The auditory bullae, in relation to the length of the skull, are of comparable size in *gold-*

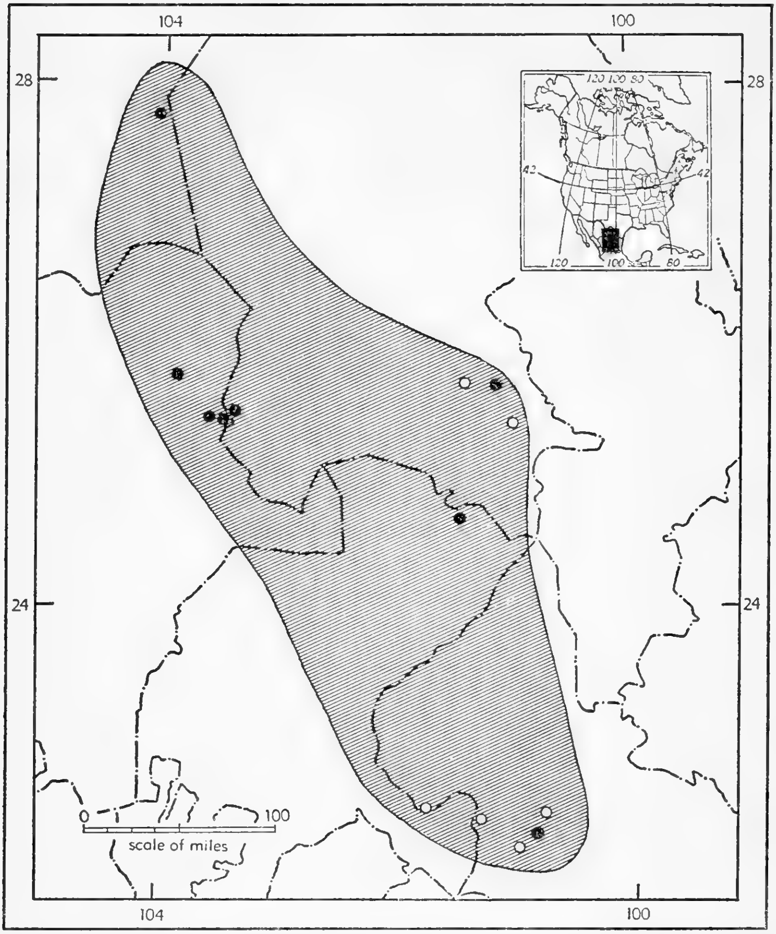

FIGURE 1. Distribution of the pigmy woodrat, *Neotoma goldmani*. Solid circles represent specimens examined; hollow circles represent others reported but not examined.

mani and *albigula* whereas those of the *lepida* group are proportionately much larger. Moreover, the posterior margin of the palatal bridge is concave in *goldmani* and *albigula* instead of truncate as in the *lepida* group. *Neotoma goldmani* differs from both *albigula* and *lepida* in: ascending branches of premaxillaries broader posteriorly; supraorbital ridges less pronounced; rostrum less massive; interparietal broader in relation to width of cranium; interorbital space, relative to length of skull, wider; and upper molar teeth broader in relation to their length.

The baculum of *goldmani,* when compared with bacula and with figures of these bones in Burt and Barkalow (Jour. Mamm., 23:291 and 293, August 13, 1942) of species representing the *floridana, lepida, albigula, mexicana, fuscipes,* and *cinerea* groups, was found to resemble most closely the baculum of *albigula* in general proportions (ratio of length to lateral diameter of base) and in having a distinct knob at the distal end. The baculum of *goldmani* differs slightly from that of *albigula* in having a less downwardly curved shaft and in having a less pronounced median dorsal depression at the proximal end. Although *goldmani* bears some external resemblance to *lepida,* the cranial characters mentioned above and the size and shape of the baculum show that *goldmani* is best arranged as a member of the *albigula* group.

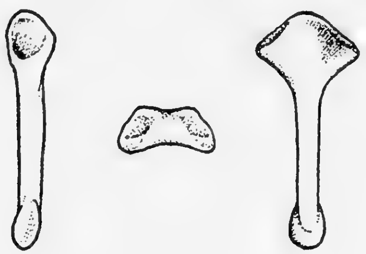

FIGURE 2. Dorsal, end (proximal), and lateral views of the baculum of *Neotoma goldmani*, adult, No. 40758 KU, × 5.

Measurements (in millimeters) of the mature baculum (fig. 2, No. 40758 KU) are: total length, 6.2; lateral diameter of base, 2.6; dorso-ventral diameter of base, 1.4; lateral diameter of the shaft near the middle of the bone, 0.6. Except for being smaller, the bacula of the younger *goldmani* are like the mature ones.

Assistance with field work is acknowledged from the Kansas University Endowment Association and the National Science Foundation. The figures were drawn by Victor Hogg. Bacula were prepared for study following the method outlined by White (Jour. Mamm., 32:125, February 15, 1951).

Specimens examined.—Total, 15, all in the Museum of Natural History at the University of Kansas. Localities within any one state are arranged from north to south. *Chihuahua:* Sierra Almagre, 6000 ft., 12 mi. S Jaco, 1. *Coahuila:* 17 mi. N and 8 mi. W Saltillo, 5200 ft., 2; 3 mi. SE Torreón, 3800 ft., 7. *Durango:* 1 mi. SSE Mapimí, 4100 ft., 1; 4 mi. WSW Lerdo, 3800 ft., 1; 5 mi SE Lerdo, 3800 ft., 1. *Zacatecas:* Conception del Oro, 7680 ft., 1. *San Luis Potosí:* 10 mi. NE San Luis Potosí, 6000 ft., 1.

Other records.—Coahuila: Jaral; Saltillo (Goldman, 1910:82). *San Luis Potosí:* Cerro Peñon Blanco; Ventura; Santa Teresa; city of San Luis Potosí (Dalquest, *loc. cit.*).

Transmitted February 8, 1955.

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New systematic names are in **boldface** type

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FERD VOILAND, JR., STATE PRINTER
TOPEKA, KANSAS
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