6-3-1958

Distribution and Variation of Chipmunks of the Eutamias Quadrivittatus Group in New Mexico

Eugene D. Fleharty

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A Thesis

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This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of the University of New Mexico in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

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ACKNOWLEDGMENTS

I greatly appreciate the suggestions received during the course of this work from Professors C. Clayton Hoff, William J. Koster, and Raymond C. Jackson, and I am grateful to Professors W. B. Davis, D. F. Hoffmeister, E. L. Cockrum, and E. R. Hall, who are in charge of the collections from which specimens were borrowed. Fellow students R. O. Megard and A. H. Harris provided the photographs and illustrations of the bacula, and my wife, Jo Ann, typed the manuscript. Special thanks go to Professor James S. Findley who guided me in research and supervised the writing of this manuscript.

I received financial support from the National Science Foundation during two months in the summer of 1957.

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Chapter I

INTRODUCTION

In New Mexico there are two currently recognized species of chipmunks of the Eutamias quadrivittatus group, E. quadrivittatus (Say) and E. cinereicollis (Allen). Eutamias q. quadrivittatus occurs in northern New Mexico, south into the Manzano Mountains, east to Tucumcari, and west into the Chuska Mountains. Eutamias c. cinereicollis (Allen) occurs in the San Francisco Mountains of Arizona and extends southeasterly on the Mogollon Plateau into the White Mountains in eastern Arizona. Eutamias c. cinereus Bailey occurs in the Mogollon, Black, San Mateo, and Magdalena ranges in New Mexico, while E. c. canipes Bailey is found east of the Rio Grande Valley in the Gallinas Mountains near Corona, the Jicarilla, Capitan, White, and Sacramento Mountains of New Mexico, and in the Guadalupe Mountains of Texas.

The differences in external and cranial measurements between E. quadrivittatus and E. cinereicollis are subtle, and seemingly the distinction between the two species is chiefly in color. The relationship between these two forms needs clarification. When in the present study of chipmunks from New Mexico a marked difference between E. c. canipes and the other two subspecies of E. cinereicollis was revealed, the problem arose as to the relationship and identity of other populations of E. cinereicollis.

Studies of chipmunks in adjacent areas may add to an understanding of the relationships among chipmunks of the E. quadrivittatus group in New Mexico. Eutamias umbrinus umbrinus (Allen) from the highlands of

Utah and Wyoming (Uinta County) seems to be closely related to some New Mexican forms herein considered, as do the three subspecies of E. bulleri (Allen) in Mexico. Eutamias b. durangae Allen occurs in the Sierra Madre Occidental from southern Durango north to southern Chihuahua, E. b. bulleri (Allen) occupies the southern Sierra Madre in Zacatecas, and E. b. solivagus Howell is reported from the Sierra Guadalupe and the northern Sierra Madre Oriental, Coahuila.

The purpose of this investigation, therefore, is to attempt to elucidate the taxonomic relationships between the various populations of the Eutamias quadrivittatus group of chipmunks in New Mexico and some adjacent areas.

Chapter II

LITERATURE SURVEY

The first to deal with the Eutamias quadrivittatus group of chipmunks in New Mexico was Arthur H. Howell (1929, pp. 23-157), who assigned chipmunks of this group from northern New Mexico to Eutamias q. quadrivittatus and those from the southern New Mexican mountains to Eutamias cinereicollis. Howell (op. cit., p. 102) stated that those chipmunks from the southeastern mountains in New Mexico, currently recognized as Eutamias cinereicollis canipes, approach the species E. bulleri (Allen) in several characteristics such as in the breadth and blackness of the ocular stripe and in the large size of the skull and that this population might possibly represent a distinct species.

Vernon Bailey (1931, pp. 81-89), in his treatment of the chipmunks in the Mammals of New Mexico followed the arrangement of Howell (op. cit.).

The most recent student to deal with the E. quadrivittatus group in relation to this area was John White (1953a and b). He (1953a), using the baculum extensively as an aid in separating chipmunks into groups and species, discussed the relationships of chipmunks in western North America but did not alter the groupings, as then recognized, of chipmunks in New Mexico. However, his material included only one baculum of E. cinereicollis, this from the White Mountains of Arizona, and only two of E. bulleri, these from Mexico.

Chapter III

MATERIALS AND METHODS

Of the 214 skins and skulls assembled for study there were 138 adult skins and 156 adult skulls; 73 of the specimens included bacula. These specimens were grouped according to locality, age, and sex. Unless otherwise indicated the specimens are preserved in the University of New Mexico Collection of Vertebrates. Specimens borrowed from other institutions are identified by the following symbols.

KU.--University of Kansas, Museum of Natural History

AU.--University of Arizona, Department of Zoology

TCRC.--Texas Cooperative Research Collection, Agricultural and Mechanical College of Texas

UI.--University of Illinois, Museum of Natural History

The chipmunks were separated into three age classes on the basis of the condition of the third upper molar. The animals were designated as adults if the molar was worn sufficiently that the dentine could be seen, as subadults if the molar was fully erupted but dentine was not visible, and as juveniles if the molar was not fully erupted.

Because there was a constant difference between adults and subadults in the external and cranial measurements, only adult individuals were used in comparisons of these characteristics. Since no difference was found to exist between the bacula of adults and subadults, both were used in the comparisons. Because no significant differences were noted in cranial and external measurements between adult males and females, the sexes were combined in the comparions. Only those animals

designated as adults and with full summer pelage were used in the comparison of color.

All cranial and bacular measurements were taken by the author and are recorded in Tables I and III respectively. The cranial measurements were taken with a dial caliper and the bacular measurements with an eyepiece micrometer in a binocular microscope.

The cranial measurements taken were greatest length of skull, zygomatic breadth, least interorbital breadth, cranial breadth, cranial depth, alveolar length of maxillary tooth row, length of nasals, and width of nasal bones. All measurements except the latter are defined by Cockrum (1955, pp. 34-37). The width of nasal bones was taken between the junctures of the premaxillary, frontal, and nasal bones on either side of the rostrum.

The external measurements taken were total length, length of tail, length of hind foot, and height of ear from notch (Cockrum, 1955, p. 33).

The bacular measurements taken were as follows:

Width of base.--The greatest width of the base.

Width of shaft.--The least width of the shaft.

Width of tip at keel.--Width of the tip on a level with the highest point of the keel.

Length of keel.--The greatest length parallel to the long axis of the tip.

Angle formed by shaft and tip.--The angle enclosed by the straight line between the most ventral portion of the base and the ventral point where the tip begins and the line between the origin of the tip and the distal end of the tip.

Length of shaft.--The greatest length along the ventral side of the shaft between the most proximal point and the point where the tip begins.

Bacula of the chipmunks were cleaned by first soaking them briefly in water and then in a two per cent KOH solution in a warm water bath for approximately three minutes when they were removed and the soft tissue removed by teasing. After study, the bacula were mounted on micro-paleontological slides for storage.

The color map was prepared by first selecting a representative specimen in full summer pelage from each population within the range of each species considered. These representative specimens were ranked from light to dark on the basis of the color of each of fourteen body areas such as the dorsal side of the hind foot, the mid-dorsal dark stripe, the nape, and others. A number was given to each individual on the basis of each ranking. With respect to the body area being studied, the lightest specimen was given the smallest number and successively darker specimens were given higher numbers. Thus fourteen numbers were assigned each specimen, and for each these numbers were totaled. As a result, the darkest specimen of each species with respect to all body areas studied received the largest number. The population represented by this specimen is pictured on figure 11 as a solid dot. Lighter populations are pictured as dots which are incomplete to the extent that the color of each sample is lighter than that of the darkest population.

The synonymy of each subspecies includes the earliest available name and a reference to the first published use of the currently accepted combination.

Chapter IV

RESULTS

There are three distinct types of bacula found among chipmunks of the E. quadrivittatus group in New Mexico, and these differ in respect to length of shaft, width of base, and angle formed by shaft and tip (see table III and figures 3 and 4), as well as in the general shape. The three types, designated for convenience types I, II, and III, are shown in figure 8.

The baculum, a bone in the penis of some mammals, has in chipmunks a proximal portion termed the shaft, a distally upturned portion, the tip, and a ridge projecting dorsally from and parallel to the long axis of the tip, the keel. The shaft, which is longer than the tip, has no projecting ridges but has a dextral twist where it narrows. The hollow proximal end of the shaft is the widest and is termed the base. The tip, which bears the keel, has no other prominent irregularities.

The length of shaft, length of tip, and angle formed by shaft and tip were difficult to measure on bacula of E. cinereicollis because of the absence of a clear cut juncture between shaft and tip. Location of this juncture was often a matter of subjective judgment.

Bacula of type I have a shorter shaft (2.97-3.40), a wider base (.84-1.00), and an angle that is more acute (112-121.5°) than those of the others. Type II bacula have a longer shaft (4.27-5.72), a narrower base (.49-.87), and a greater angle (136-148°) than those of type I or of type III. Bacula of type III are intermediate between types I and II in the characteristics mentioned above. All bacula examined have a dextral twist approximately where the shaft narrows.

Type I is found in chipmunks from the Gallinas, Capitan, Sacramento, and Guadalupe Mountains; type II in those animals from the San Francisco Mountains in Arizona, and the Mogollon, Black, San Mateo, and Magdalena ranges in New Mexico; and type III in those chipmunks from the Chuska, Zuni, and Sandia Mountains and Mount Taylor.

Within type I no significant qualitative or quantitative differences were noted from population to population. Type I bacula, in general appearance, somewhat resemble those from specimens of Eutamias bulleri durangae taken three to seven miles southwest of Las Adjuntos in Durango, Mexico, as well as the picture and measurements of the baculum of E. umbrinus umbrinus given by White (1953b, pp. 626 and 629). However, the bacula of E. b. durangae have a longer shaft, a slightly wider base, and a slightly greater angle whereas the baculum of E. umbrinus has a shorter shaft and a smaller angle.

Both the bacula of type I and the bacula from E. bulleri durangae differ from the baculum of E. b. bulleri from Sierra de Valparaíso, Zacatecas, Mexico, pictured by White (1953b, pp. 628-629). The shaft of the baculum of E. b. durangae is longer, the angle is greater, and the height of the keel is less than in E. b. bulleri. The bacula of type I differ from bacula of E. b. bulleri in having a larger angle and shorter keel, while the shafts of the bacula of both type I and of E. b. bulleri are approximately the same length. No bacula from Eutamias bulleri solivagus were examined.

Other than a greater average length of shaft in specimens from the San Mateo and Magdalena Mountains as compared with those from the Black and Mogollon ranges in New Mexico and the San Francisco Mountains in Arizona, no other qualitative or quantitative differences were noted in bacula of type II.

No significant variations were noted in the bacula of type III from one locality to another. According to White (1953b, p. 621) the bacula of E. q. quadrivittatus are larger than those of E. q. hopiensis, a subspecies found in southeastern Utah, southwestern Colorado, and northeastern Arizona.

Type III bacula are found in those chipmunks recognized as E. q. quadrivittatus; type II bacula belong to the chipmunks currently regarded as E. c. cinereus and E. c. cinereicollis; and type I bacula are found in the chipmunks currently referred to as Eutamias cinereicollis canipes.

The baculum of E. c. canipes differs greatly from that of E. c. cinereus and E. c. cinereicollis (see figure 6). Since there is fully as much difference here as there is between the bacula of chipmunks recognized as full species by White (1953b, pp. 615-629), the problem arises as to the status of E. c. canipes because on the basis of the baculum it cannot logically be regarded as a subspecies of E. cinereicollis. As mentioned above the type I bacula resemble in some ways both those of E. bulleri and E. umbrinus. However, adequate series of bacula of these two species have not been examined, and further study may reveal a specific affinity between one or both of the latter and E. c. canipes.

A conservative course is followed here, and the chipmunks found in the Gallinas, Capitan, Sacramento, and Guadalupe Mountains are given the available epithet of Eutamias canipes Bailey, first applied to chipmunks of the Guadalupe Mountains. Using the baculum as a conservative taxonomic criterion to separate species, three species of chipmunks of the Eutamias quadrivittatus group may be recognized in New

Mexico--Eutamias quadrivittatus (Say), Eutamias cinereicollis (Allen), and Eutamias canipes Bailey.

Details of geographic variation within these three species are given in the species accounts which follow.

Eutamias canipes Bailey

In addition to the bacular characteristics previously described, chipmunks from the Sacramento Mountains differ from E. cinereicollis in larger size. Eutamias canipes from the Guadalupe Mountains is paler in color but similar in size to animals designated as E. cinereicollis. From E. quadrivittatus E. canipes differs in being grayer and paler. Animals from the Sacramento Mountains are larger than E. quadrivittatus while those from the Guadalupe Mountains do not differ significantly from it in size.

Within the range of E. canipes there is considerable geographic variation. For example, animals from the Sacramento Mountains are much larger and darker in color than are those from the Guadalupe, Capitan, and Gallinas Mountains (see figure 11). However, only four specimens from the Capitan and two from the Gallinas Mountains were examined. On geographical grounds it might be expected that animals from these last two mountain ranges would show more affinities to those from the Sacramento Mountains. Compared with specimens of E. bulleri, the animals from the Sacramento Mountains do not differ significantly in most cranial and external measurements (see tables I and II).

Eutamias canipes is common in areas with numerous fallen trees and in rocky places such as along road cuts in forests of spruce, Douglas fir, and yellow pine. The species has been reported from the malpais west of Carrizozo (Benson, 1933, p. 24).

The varying populations mentioned above may be formally described as follows.

Eutamias canipes sacramentensis new subspecies

Type.--Obtained in the Sacramento Mountains, 1 mi. S Cloudcroft, altitude 9000 ft., Otero Co., New Mexico, July 4, 1957, by Eugene Fleharty; adult male, skin, skull, and baculum; No. 2984, University of New Mexico Collection of Vertebrates; original number, 90.

Range.--Known only from the Sacramento Mountains in New Mexico.

Diagnosis.--Size large, largest of the E. quadrivittatus group in New Mexico; average and extreme measurements of 14 specimens from the type locality are: total length, 243 (227-264); tail, 102 (91-108); hind foot, 34.6 (34.0-36.0). General tone of upper parts dark; dark dorsal stripes black and light stripes gray; gray on shoulders and on dorsal surface of hind feet. Baculum with short shaft, wide base, and angle less than 121 degrees; average and extreme measurements of ten specimens from the type locality are: length of shaft, 3.23 (3.10-3.49); width of base, .91 (.78-1.00); angle formed by shaft and tip, 117° (112-121°).

Comparisons.--Differs from E. c. canipes in being darker and larger. There is no significant difference in bacular structure. For comparisons with the other species, see the accounts of those forms.

Specimens examined.--Total number, 30 (14 adults, 10 bacula).

NEW MEXICO: Otero Co.: 1 mi. S Cloudcroft, Sacramento Mts., 30.

Eutamias canipes canipes Bailey

Eutamias cinereicollis canipes Bailey, Proc. Biol. Soc. Washington, 15:117, June 2, 1902.

Type.--Obtained at the head of Dog Canyon, Guadalupe Mountains, Culberson Co., Texas, August 24, 1901, by Vernon Bailey; adult female, skin and skull; No. 109229, United States National Museum (Biological Surveys Collection); original number, 7827.

Range.--Guadalupe Mountains, Texas.

Diagnosis.--General color of upper parts pale; dorsal dark stripes deep brown and light stripes gray; grayish wash on shoulders and neck; dorsal surface of hind feet light gray. Size medium; average and extreme measurements of 13 specimens from the Guadalupe Mountains are: total length, 204 (160-230); tail, 85 (65-97); hind foot, 33.5 (29.0-34.0). Baculum with short shaft, wide base, and angle less than 122 degrees.

Comparisons.--For comparisons with E. c. cinereus, E. c. cinereicollis and E. q. quadrivittatus, see the accounts of those forms.

Specimens examined.--Total number, 13 (13 adults, 2 bacula).

TEXAS: Culberson Co.: The Bowl, Guadalupe Mts., 13 (10 TCRC).

Eutamias canipes ssp.

Range.--Gallinas and Capitan Mountains in New Mexico.

An insufficient number of specimens was collected from the above-mentioned mountain ranges to permit an understanding of the relationship of these animals with the named subspecies of E. canipes.

Specimens examined.--Total number, 6 (5 adults, 3 bacula).

NEW MEXICO: Lincoln Co.: 3 mi. S and 9 mi. W Corona, Red Cloud Canyon, Gallinas Mts., 2; 5 mi. N and 9 mi. E Capitan, Capitan Mts., 4.

Eutamias cinereicollis (Allen)

In addition to the bacular differences described previously, E. cinereicollis differs from E. quadrivittatus in having darker dorsal coloration with a distinctive gray wash across the shoulders and neck.

Within the range of E. cinereicollis there is little geographical variation in color or size; the two recognized subspecies being separated mainly on the basis of minor bacular differences (see table III and figures 3 and 4).

Howell (1929, pp. 100-101) designated chipmunks from the Organ Mountains as E. c. cinereus. In this study no animals from the Organ Mountains were examined. According to Richard F. Johnston, formerly of New Mexico College of Agriculture and Mechanic Arts, the specimen listed by Howell as being at that college is no longer extant.

These chipmunks are found in forests of yellow pine, spruce, and Douglas fir in areas with either many rotten logs or rock slides.

The populations mentioned in the preceding paragraphs have been placed in two subspecies which are as follows:

Eutamias cinereicollis cinereicollis (Allen)

Tamias cinereicollis Allen, Bul. Amer. Mus. Nat. Hist., 3:94, June, 1890.

Eutamias cinereicollis cinereicollis Howell, Jour. Mamm., 3:184, August 4, 1922.

Type.--Obtained on San Francisco Mountain, Coconino Co., Arizona, by C. Hart Merriam and Vernon Bailey; adult female, skin and skull; No. 17597/24533, United States National Museum (Biological Surveys Collection); original number, 260.

Range.--San Francisco Mountains in Arizona, extending southeasterly along the Mogollon Plateau into the White and Blue Mountains in Arizona and in the San Francisco, Mogollon, and Black ranges in New Mexico.

Diagnosis.--Size medium; average and extreme external measurements of six specimens from the type locality are: total length, 225 (219-

234); tail, 98 (93-105); hind foot, 34.7 (34.0-36.0). General color of upper parts dark; dorsal dark stripes black and light stripes gray; gray wash present across neck and shoulders. Average and extreme bacular measurements of four specimens from the type locality are: length of shaft, 4.95 (4.85-5.14); width of base, .70 (.65-.78); angle formed by tip and shaft, 140° (138-149°).

Comparisons.--Differs from E. cinereicollis cinereus in having a shorter bacular shaft. Differs from E. canipes canipes by being darker above and in having shaft of the baculum longer, its base narrower, and angle formed by tip and shaft greater. From E. canipes sacramentensis it differs in its smaller size in addition to the bacular differences mentioned above. See account of E. q. quadrivittatus for comparisons with that subspecies.

Specimens examined.--Total number, 88 (50 adults, 31 bacula).

ARIZONA: Coconino Co.: 7 mi. N Flagstaff, San Francisco Mts., 6; 9 mi. N Flagstaff at Fort Valley, San Francisco Mts., 2 AU; Doyles' Saddle, San Francisco Mts., 1 AU. Apache Co.: West Fork of the Black River, 8 AU; 25 mi. S Upper West Fork of the Black River, Springerville, 1 AU; 2 mi. E Phelps Ranger Station, White Mts., 1 AU; Escudilla Mt., 1 UI. Greenlee Co.: 4 mi. NE Hannagan Meadow, Blue Mts., 10 UI.

NEW MEXICO: Grant Co.: 15 mi. E and 6 mi. N Santa Rita, Iron Canyon, Black Range, 28. Catron Co.: 10 mi. E Mogollon, Willow Creek, Mogollon Mts., 30.

Eutamias cinereicollis cinereus Bailey

Eutamias cinereicollis cinereus Bailey, Proc. Biol. Soc. Washington, 26:130, May 21, 1913.

Type.--Obtained in Copper Canyon, Magdalena Mountains, New Mexico, September 1, 1909, by E. A. Goldman; adult male, skin and skull; No. 167029, United States National Museum (Biological Surveys Collection); original number, 20435.

Range.--Limited to the San Mateo and Magdalena Mountain ranges in New Mexico.

Diagnosis.--General color of upper parts dark; dorsal dark stripes black and light stripes gray. Grayish wash on shoulders and nape. Size medium; average and extreme external measurements of eight specimens from the San Mateo Mountains are: total length, 215 (203-227); tail, 89 (75-96); hind foot, 34.0 (33.0-36.0). Baculum with long shaft and narrow base. Average and extreme bacular measurements of five specimens from the San Mateo Mountains are: length of shaft, 5.30 (5.04-5.72); width of base, .69 (.52-.78); angle formed by shaft and tip, 139.5° (136.0-142.5°).

Comparisons.--See accounts of E. q. quadrivittatus and E. c. cinereicollis for comparison with these forms. Averages smaller than E. canipes sacramentensis in most skull and external measurements. General color of upper parts darker than in E. c. canipes. Baculum differs from both subspecies of canipes in longer shaft, narrower width of base, and greater angle formed by tip and shaft.

Specimens examined.--Total number, 13 (10 adults, 7 bacula).

NEW MEXICO: Socorro Co.: 11 mi. S and 3½ mi. E Magdalena, 1½ mi. E South Baldy, Magdalena Mts., 3; Mt. Withington, San Mateo Mts., 10.

Eutamias quadrivittatus (Say)

In New Mexico this species is represented by one subspecies, E. q. quadrivittatus (Say). A thorough study of this animal in New Mexico

was not carried out because the main objective of this study is to reveal the relationship between E. quadrivittatus and its relatives to the south.

In addition to the bacular differences mentioned previously E. quadrivittatus differs from those animals recognized as E. canipes and E. cinereicollis in having a much lighter and brighter dorsal coloration, particularly on the shoulders and sides. There is no significant difference in most cranial and external measurements (see tables I and II and figures 5, 6 and 7).

Specimens examined.--Total number, 64 (56 adults, 17 bacula).

NEW MEXICO: Torrance Co.: 3 mi. W and 1 mi. N Manzano, New Canyon Camp, Manzano Mts., 7. Bernalillo Co.: Carolina Canyon, Manzano Mts., 1; Embudo Canyon, Sandia Mts., 6; Tree Springs, Sandia Mts., 7; Capulin Camp Ground, Sandia Mts., 1; Madera Canyon, Sandia Mts., 1; Juan Tabo, Sandia Mts., 1; 3½ mi. E Sandia Crest, Sandia Mts., 2; Sandia Crest, Sandia Mts., 13; Sandia Crest Road, R5E, T11N, Sandia Mts., 10. Valencia Co.: ½ mi. NE La Mosca Peak, Mt. Taylor, 7; Mirabal Springs, Mt. Taylor, 4. San Juan Co.: Washington Pass, Chuska Mts., 4. McKinley Co.: 1 mi. E McGaffey, Zuni Mts., 6. Sandoval Co.: Fenton lake, 10 mi. N Jemez Springs, Jemez Mts., 1; 5 mi. N Jemez Springs, Jemez Mts., 1. Taos Co.: 4 mi. NE Tres Ritos, Sangre de Cristo Mts., 1.

Chapter V

DISCUSSION

Most of the populations of chipmunks of the E. quadrivittatus group in New Mexico are isolated on separate mountain ranges. Whether each population should be regarded a distinct species or as subspecies of a single polytypic species is a question that can be finally answered only by examining their interfertility relationships in nature. However, these populations are arranged in allopatric disjunct fashion and the presence or absence of biological reproductive isolation cannot be tested except by experimental crosses in the laboratory, and even if chipmunks from allopatric populations did interbreed under these circumstances, it would not necessarily follow that they would do so in the wild.

Because reproductive isolation is correlated with a certain amount of morphological difference in sympatric species of chipmunks it might be possible to make a reasonable assumption regarding the potentiality of interbreeding in nature between members of allopatric populations by comparing the amount of difference between allopatric populations with that between true sympatric species. The degree of morphological difference observed between interbreeding subspecies might also provide evidence in that it might suggest how much difference can occur without reproductive isolation. Differences between the allopatric species E. cinereicollis and E. canipes are of the same magnitude as those between the sympatric species E. quadrivittatus and E. minimus.

Chipmunks from the Gallinas, Capitan, Sacramento, and Guadalupe Mountains could not be satisfactorily identified using White's (1953b, p. 615) key based on the baculum. He separates E. bulleri from E. umbrinus and E. palmeri on the basis of the height of the baculsr keel expressed as a fraction of the length of the tip. According to White (1953b, p. 615) the height of the keel is one-half in E. bulleri and one-fourth the length of the tip in E. umbrinus and E. palmeri. In chipmunks from the localities listed above the height of the keel is approximately one-third of the length of the tip. Seemingly, on the basis of the baculum, the relationships within the E. quadrivittatus group are more complex than was once thought and should be examined more carefully.

In the populations of chipmunks studied, certain skull measurements varied greatly both interspecifically and intraspecifically, but as far as could be determined, there is no pattern with respect to geographical area, altitude, or habitat. Because of this variation in cranial measurements, the skull is not useful in distinguishing species herein recognized but is of value in separating some subspecies.

One well-marked color cline extending east and west was noted among populations of E. q. quadrivittatus. The brightest colored animals are found in the west where the range of E. q. quadrivittatus comes into close proximity with that of the lighter colored subspecies E. q. hopiensis, while populations from successively more eastern stations are increasingly dark.

E. canipes from the Gallinas, Capitan, and Guadalupe Mountains are pale, whereas those from the Sacramento Mountains are dark. No color cline is noted in this species, but the lighter animals came

from areas where the vegetation is not so lush and the soil is pale.

Although color varies both between and within species, in some cases color can be used to separate both species and subspecies.

In general, the head and body and hind foot length varied little among most populations of the E. quadrivittatus group in New Mexico; however chipmunks from the Sacramento Mountains were significantly larger than those from any other areas.

Within species of chipmunks recognized here there was usually no significant variation in the baculum, this conservative structure being diagnostic on the species level. However, the subspecies of E. cinereicollis differ slightly in length of bacular shaft. The bacula of animals designated as E. quadrivittatus are approximately intermediate in structure between those of E. cinereicollis and of animals referred to E. canipes and E. umbrinus. Not only the baculum is intermediate for it is interesting to note that the range of E. quadrivittatus is also located between those of E. cinereicollis and E. umbrinus.

An examination of the list of boreal mammals in western United States reveals that there are more allopatric species of chipmunks currently recognized than of any other single boreal mammal. For example, aside from E. minimus, E. amoenus, and the E. dorsalis-merriami complex, nine allopatric species of large striped chipmunks are recognized by White (1953b, pp. 621-631). Arranged in species groups, these are: in the E. quadrivittatus group, E. quadrivittatus, E. ruficaudus, E. cinereicollis, and E. quadrimaculatus; and in the E. speciosus group, E. speciosus, E. panamintinus, E. umbrinus, E. palmeri, and E. bulleri. An explanation of this fact might well be sought.

One explanation might be that chipmunks differentiate faster on isolated mountain ranges than do other boreal mammals. Another might be that undue significance has been attributed to the features that distinguish populations of chipmunks.

It has been noted in this study that the differences between local populations are sometimes subtle, as for example, the differences between E. c. cinereicollis and E. c. cinereus. Other local populations are more strongly differentiated as is the case with E. c. sacramentensis and its neighbors. More differentiation involves bacular changes and even these may be of different degrees; witness the moderate differences between bacula of E. canipes, E. bulleri durangae, and E. b. bulleri and the more trenchant differences between, say, E. canipes and E. cinereicollis. Could it be that the several allopatric species recognized by White (1953b) comprise a single polytypic species assemblage comparable to other western boreal species such as Cleithrionomys gapperi or Tamiasciurus hudsonicus? We might expect chipmunks to have had somewhat the same history as other western boreal mammals and still no others have developed so many species.

Chapter VI

CONCLUSIONS

1. In New Mexico there are three species of the Eutamias quadrivittatus group of chipmunks that differ from one another in well-marked bacular features. These species are E. quadrivittatus, E. cinereicollis, and E. canipes.
2. Eutamias quadrivittatus is represented by one subspecies, E. q. quadrivittatus, which is found in northern New Mexico from Tucumcari, south into the Manzano Mountains, and west into the Chuska Mountains.
3. Eutamias cinereicollis is composed in New Mexico of two slightly marked subspecies: Eutamias c. cinereicollis is found in the Mogollon Mountains and Black Range, and E. c. cinereus is found in San Mateo and Magdalena Mountains.
4. Eutamias canipes is represented by at least one subspecies in New Mexico. Eutamias c. sacramentensis is found in the Sacramento Mountains, Otero County, New Mexico. Chipmunks of this species in the Gallinas and Capitan Mountains seem distinctive but are not assigned to a named subspecies in this study. A closely related subspecies E. c. canipes is found just south of the New Mexican state line in the Guadalupe Mountains, Culberson County, Texas.

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Table I

Cranial Measurements of *Eutamias*

Sequence of measurements: Arithmetic mean; standard error of mean; minimum; maximum; number examined if different than number listed in the heading.

Skull Length	Length of Nasals	Zygomatic Breadth	Least Interorbital Breadth	Cranial Breadth	Alveolar Length of Maxillary Tooth Row	Width of Nasals	Cranial Depth
			***Eutamias canipes* ssp.**				
			Gallinas Mts. (1)				
33.5	10.9	19.3	7.6	16.0	5.4	3.3	14.1
			Capitan Mts. (4)				
35.9	11.6	19.3	8.0	16.2	5.8	3.1	14.6
.16	.20	.29	.16	.16	.07	.11	.16
34.7	11.3	18.6	7.6	15.9	5.5	2.8	14.3
37.4	12.3	20.0	8.5	16.6	5.9	3.4	15.1
			Eutamias canipes sacramentensis				
			Sacramento Mts. (14)				
37.4	11.9	20.0	8.0	17.0	5.7	3.4	14.6
.23	.15	.11	.08	.08	.05	.06	.07
36.3	10.8	19.4	7.4	16.6	5.3	2.9	14.2
39.2	12.6	20.9	8.6	17.7	5.9	3.7	14.9
(13)		(12)		(11)			(11)
			Eutamias bulleri durangae				
			Las Adjuntas, Durango, Mexico (5)				
37.8	11.6	20.3	8.6	16.6	6.3	2.8	15.6
.61	.29	.22	.09	.28	.09	.13	.17
36.5	10.8	19.9	8.3	15.6	6.0	2.3	15.4
39.7	12.8	20.8	8.9	17.0	6.5	3.2	16.0
(4)		(3)		(4)			(3)

Table I continued

Eutamias bulleri solivagus

San Antonio de las Alazanas, Coahuila, Mexico (3)

36.4	10.7	19.5	8.3	16.5	5.6	2.8	14.7
-	-	-	-	-	-	-	-
35.8	10.2	19.4	8.0	16.5	5.5	2.5	14.6
36.9	11.0	19.6	8.8	16.5	5.8	3.2	14.7
(2)							

Eutamias cinereicollis cinereicollis

Black Range (13)

35.6	10.7	19.4	7.8	16.3	5.7	2.8	14.1
.25	.15	.16	.07	.13	.04	.12	.07
34.1	10.0	18.5	7.2	15.4	5.4	2.0	13.5
36.7	11.5	20.2	8.4	16.9	6.0	3.5	14.5
(11)		(12)					

Mogollon Mts. (17)

36.0	10.7	19.6	7.9	16.5	5.7	3.0	14.4
.18	.09	.08	.06	.07	.05	.08	.05
34.7	10.1	19.0	7.3	15.9	5.2	2.5	14.0
37.1	11.1	20.2	8.2	16.9	6.0	3.5	14.7
(14)	(14)	(15)	(16)	(15)	(15)	(14)	(10)

Blue Range (6)

36.2	10.9	19.8	8.0	16.3	5.7	3.4	14.5
.16	.17	.05	.07	.07	.09	.14	.07
35.5	10.5	19.6	7.7	16.0	5.4	3.0	14.3
36.8	11.6	20.0	8.2	16.5	6.0	4.0	14.8

San Francisco Mts. (6)

35.9	10.0	19.6	8.0	16.5	5.7	3.5	14.7
.23	.17	.13	.03	.10	.09	.07	.12
35.3	9.4	19.0	7.9	16.1	5.3	3.1	14.2
36.5	10.4	20.0	8.1	17.0	5.9	3.6	15.0
(4)	(5)			(5)			(5)

West Fork Black River (6)

35.3	10.2	19.5	7.9	16.3	5.6	3.3	14.4
.33	.27	.09	.09	.17	.06	.18	.09
34.2	9.2	19.2	7.7	15.8	5.4	2.6	14.1
36.2	10.9	20.0	8.3	17.0	5.8	3.8	14.7
(5)	(5)					(5)	

Table I continued

White Mts. (1)

35.8	10.8	20.7	8.7	16.4	5.5	3.0	14.5

Springerville, Arizona (1)

35.4	9.9	19.5	8.5	16.2	6.0	3.2	14.5

Eutamias cinereicollis cinereus

San Mateo Mts. (8)

36.1	10.8	19.4	7.8	16.2	5.7	3.1	14.4
.15	.15	.16	.14	.13	.09	.18	.13
35.3	10.0	18.8	7.2	15.6	5.3	2.2	14.0
36.5	11.3	20.0	8.6	16.6	6.0	4.0	14.9
(7)	(7)	(6)		(7)			(6)

Magdalena Mts. (2)

36.0	10.9	19.1	7.9	16.1	5.8	2.1	14.3
-	-	-	-	-	-	-	-
35.9	10.8	19.1	7.7	16.1	5.8	2.1	14.3
36.0	10.9	19.1	8.1	16.1	5.8	2.1	14.3
		(1)		(1)		(1)	

Eutamias quadrivittatus quadrivittatus

Chuska Mts. (4)

34.7	10.6	19.4	7.9	16.2	5.7	2.6	14.0
-	-	-	-	-	-	-	-
33.8	9.9	18.7	7.8	15.9	5.6	2.5	13.6
35.8	11.5	19.8	8.1	16.4	5.8	2.6	14.6
	(3)	(3)	(3)		(3)	(2)	(3)

Zuni Mts. (6)

35.1	10.4	19.4	7.8	16.3	5.6	2.6	14.2
.28	.17	.19	.13	.10	.06	.10	.07
34.4	9.9	18.8	7.3	15.7	5.4	2.1	14.0
36.1	11.0	20.0	8.3	16.6	5.8	3.0	14.4

Mt. Taylor (6)

36.3	11.3	19.6	8.0	16.7	5.8	2.2	14.7
.20	.11	.24	.17	.09	.07	.10	.06
35.9	10.9	18.6	7.6	16.5	5.5	1.9	14.5
37.2	11.6	20.3	8.6	17.1	5.9	2.5	14.9
			(5)	(5)			

Table I continued

Jemez Mts. (2)

36.0	10.7	19.8	7.8	16.9	6.0	2.9	14.7
–	–	–	–	–	–	–	–
35.4	10.7	19.2	7.7	16.8	5.7	2.9	14.6
36.5	10.7	20.4	7.9	16.9	6.2	2.9	14.8

Sangre de Cristo Mts. (1)

35.6	10.5	19.8	7.9	16.5	5.5	2.5	14.3

Sandia Mts. (32)

35.7	10.6	19.5	8.0	16.6	5.7	2.5	14.3
.12	.08	.07	.04	.06	.03	.05	.05
34.6	9.7	18.5	7.3	16.0	5.3	2.1	13.6
37.0	11.8	20.2	8.3	17.4	6.0	3.2	14.8
(30)				(30)			(30)

Manzano Mts. (5)

35.8	10.6	19.7	8.4	16.5	5.8	2.4	14.2
.19	.18	.05	.08	.08	.09	.16	.13
35.3	9.4	19.6	8.2	16.3	5.5	2.2	13.8
36.6	11.1	19.8	8.6	16.8	6.1	3.1	14.5
		(4)					

Table II

External Measurements of Eutamias

Sequence of measurements: Arithmetic mean, standard error of mean, minimum, maximum, number examined if different than number listed in the heading.

Total Length	Length of Tail	Length of Hind Foot	Height of Ear from Notch
	Eutamias canipes ssp.		
	Gallinas Mts. (1)		
220	96	34	18
	Capitan Mts. (4)		
218	95	34.1	19.3
-	-	-	-
196	95	32.5	18
220	96	37	22
	Eutamias canipes sacramentensis		
	Sacramento Mts. (14)		
243	102	34.6	20.2
2.7	1.3	.17	.26
227	91	34	18
264	108	36	21
(13)	(13)		
	Eutamias canipes canipes		
	Guadalupe Mts. (13)		
204	85	33.5	18.6
4.85	2.65	.64	.41
160	65	29	15
230	97	34	21

Table II continued

Eutamias bulleri durangae

Las Adjuntas, Durango, Mexico (5)

222	82	35.4	22
4.94	7.95	.60	.84
205	55	34	19
234	95	37	24
(4)	(4)		

Eutamias bulleri solivagus

San Antonio de las Alanzanas, Coahuila, Mexico (3)

224	93	32	20.7
-	-	-	-
220	92	31	18
230	95	33	22

Eutamias cinereicollis cinereicollis

Black Range (13)

219	90	34.3	19.3
3.9	2.0	.35	.20
194	79	31	18
242	100	36	20
(11)	(11)		

Mogollon Mts. (17)

228	97	34.2	19.5
1.5	1.14	.12	.21
217	91	33	18
242	115	35	21

Blue Range (6)

229	102	34.3	21.3
3.05	.78	.69	.51
217	94	32	19
238	113	36	23

San Francisco Mts. (6)

225	98	34.7	20
2.1	.9	.28	.20
219	93	34	19
234	105	36	20

Table II continued

West Fork Black River (7)

223	98	35	20
6.1	5.1	.53	.53
198	72	33	17
244	110	37	22
(6)	(6)		

Springerville, Arizona (1)

221	84	33	19

White Mts. (1)

227	87	33	17

Eutamias cinereicollis cinereus

San Mateo Mts. (8)

215	89	34.0	18.9
2.34	2.39	.31	.25
203	75	33	18
227	96	36	20

Magdalena Mts. (2)

215.5	86	33	18
-	-	-	-
214	84	33	18
217	88	33	18

Eutamias quadrivittatus quadrivittatus

Chuska Mts. (4)

220	94	33.8	18.5
-	-	-	-
205	83	32.5	17
239	106	36	19

Zuni Mts. (6)

223	97	34	16.8
2.58	1.53	.00	.49
214	92	34	15
232	102	34	19

Table II continued

Mt. Taylor (6)			
226	98	34.4	19.4
3.13	1.66	.14	.73
220	94	34	18.5
232	103	35	20
(4)	(4)		
Jemez Mts. (2)			
223.5	93.5	35	17.5
-	-	-	-
221	91	35	17
226	96	35	18
Sangre de Cristo Mts. (1)			
238	101	33.5	17
Sandia Mts. (24)			
219	97	34.3	18.9
2.5	1.3	.17	.39
197	75	33	15
239	105	36	23
(21)	(21)		
Manzano Mts. (4)			
227	97.6	33.8	19
-	-	-	-
216	87	33	18
242	109	35	20
(3)	(3)		

Table III

Bacular Measurements of Eutamias

Sequence of measurements: Arithmetic mean; standard error of mean; minimum; maximum; number examined if different than number listed in the heading.

Length of Shaft mm.	Length of Tip mm.	Length of Keel mm.	Width of Base mm.	Width of Shaft mm.	Width of Tip at Keel mm.	Angle formed by tip and shaft . degrees
			Eutamias canipes ssp.			
			Gallinas Mts. (1)			
3.40	1.68	.58	.87	.29	.49	121.5
			Capitan Mts. (2)			
3.30	1.70	.63	.92	.39	.44	114
-	-	-	-	-	-	-
3.10	1.65	.58	.87	.38	.39	113
3.49	1.75	.68	.97	.39	.49	115
			Eutamias canipes sacramentensis			
			Sacramento Mts. (10)			
3.23	1.69	.62	.91	.31	.48	117
.03	.03	.02	.03	.02	.01	.80
3.10	1.51	.58	.78	.20	.45	112
3.49	1.81	.68	1.00	.39	.49	121
			Eutamias canipes canipes			
			Guadalupe Mts. (2)			
3.14	1.68	.62	.87	.29	.56	117
-	-	-	-	-	-	-
2.97	1.62	.58	.84	.29	.53	116
3.30	1.75	.65	.90	.29	.58	118

Table III continued

Eutamias bulleri durangae

Las Adjuntas, Durango, Mexico (3)

4.14	1.94	.78	.99	.32	.49	123
-	-	-	-	-	-	-
3.88	1.94	.78	.97	.29	.39	118
4.37	1.94 (2)	.78 (2)	1.00	.39	.58 (2)	128

Eutamias cinereicollis cinereicollis

Black Range (14)

4.63	1.73	.64	.60	.29	.41	141
.05	.03	.02	.02	.01	.00	.69
4.27	1.55	.49	.49	.26	.39	137.5
5.04	1.94	.78	.78	.34	.53 (13)	148

Mogollon Mts. (13)

4.79	1.82	.70	.69	1.27	.38	144
.07	.03	.02	.03	.01	.01	.82
4.46	1.55	.58	.58	.19	.29	138
5.14	1.94	.78	.87	.29	.49	148
(12)	(12)	(12)			(11)	(11)

San Francisco Mts. (4)

4.95	1.84	.71	.70	.29	.43	140
-	-	-	-	-	-	-
4.85	1.75	.68	.65	.29	.39	138
5.14	1.94	.78	.78	.29	.45 (3)	144

Eutamias cinereicollis cinereus

Magdalena Mts. (2)

5.49	1.80	.63	.68	.29	.39	139.5
-	-	-	-	-	-	-
5.34	1.75	.58	.58	.29	.39	139
5.63	1.84	.68	.78	.29	.39	140

San Mateo Mts. (5)

5.30	1.78	.64	.69	.28	.39	139.5
-	-	-	-	-	-	-
5.04	1.75	.58	.52	.26	.39	136
5.72	1.84	.68	.78	.29	.39	142.5

Table III continued

Eutamias quadrivittatus quadrivittatus

Chuska Mts. (2)

3.40	1.31	.58	.68	.24	.39	129.5
-	-	-	-	-	-	-
3.30	1.26	.58	.68	.19	.39	129
3.49	1.36	.58	.68	.29	.39	130

Zuni Mts. (2)

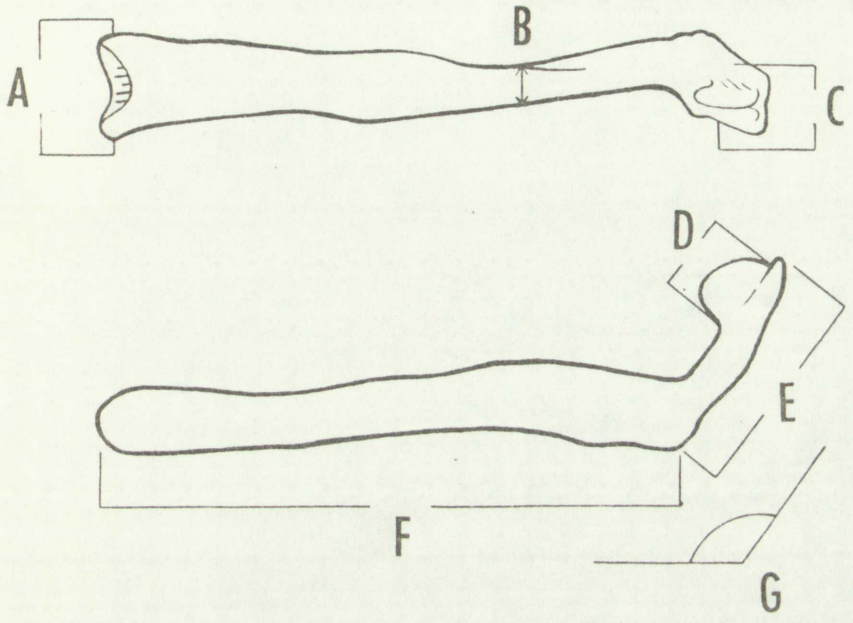
3.30	1.44	.67	.67	.22	.42	133.3
-	-	-	-	-	-	-
3.30	1.36	.65	.65	.19	.39	131.5
3.30	1.46	.68	.68	.24	.45	135

Mt. Taylor (2)

3.64	1.46	.63	.81	.25	.42	129
-	-	-	-	-	-	-
3.59	1.46	.58	.78	.24	.39	127
3.69	1.46	.68	.84	.26	.45	131

Sandia Mts. (11)

3.73	1.46	.60	.67	.24	.43	127.9
.06	.03	.01	.02	.01	.01	.81
3.40	1.26	.58	.58	.19	.39	123
4.17	1.55	.68	.78	.29	.49	133



Figs. 1 and 2. Showing where certain bacular measurements were taken. X20. Based on the baculum from Eutamias quadrivittatus quadrivittatus, from the Sandia Crest, Sandia Mountains, Bernalillo Co., New Mexico, UNMCV 3301. A. width of base; B. width of shaft; C. width of tip at keel; D. length of keel; E. length of tip; F. length of shaft; G. angle formed by shaft and tip.

Fig. 3. Angle formed by shaft and tip of baculum. The horizontal line represents the extremes, the mid vertical line the arithmetic mean, the vertical lines closest to the mean enclose plus or minus two standard errors of the mean, and the vertical lines farthest from the mean enclose plus or minus one standard deviation of the mean.

Eutamias canipes

a. 5 mi. N and 9 mi. E Capitan, Capitan Mts., Lincoln Co., New Mexico.

b. 1 mi. S Cloudcroft, Sacramento Mts., Otero Co., New Mexico.

c. The Bowl, Guadalupe Mts., Culberson Co., Texas.

Eutamias bulleri

d. 3 to 9 mi. SW Las Adjuntas, Durango, Mexico.

Eutamias quadrivittatus

e. 1 mi. E McGaffey, Zuni Mts., McKinley Co., New Mexico.

f. Sandia Crest, Tree Springs, Embudo Canyon, Sandia Mts., Bernalillo Co., New Mexico.

g. Washington Pass, Chuska Mts., San Juan Co., New Mexico.

h. La Mosca Peak, Mt. Taylor, Valencia Co., New Mexico.

Eutamias cinereicollis

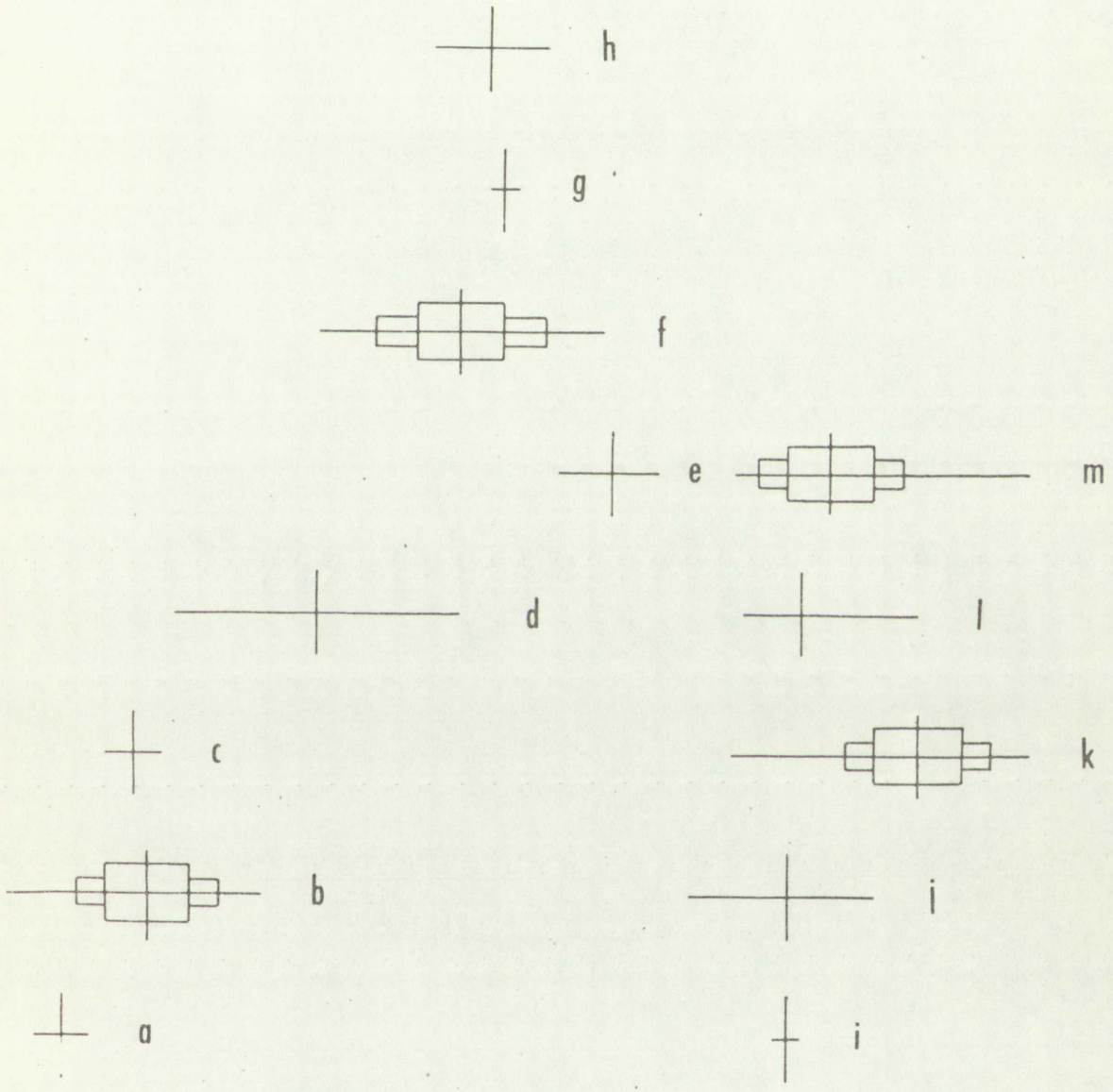
i. 11 mi. S and $3\frac{1}{2}$ mi. E Magdalena, Magdalena Mts., Socorro Co., New Mexico.

j. Mt. Withington, San Mateo Mts., Socorro Co., New Mexico.

k. Willow Creek, Mogollon Mts., 10 mi. E Mogollon, Catron Co., New Mexico.

l. San Francisco Mts., 7 and 9 mi. N Flagstaff, Coconino Co., Arizona.

m. Iron Canyon, Black Range, 15 mi. E and 6 mi. N Santa Rita, Grant Co., New Mexico.


h
g
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115
125
135
145
Degrees

Fig. 4. Width of base of baculum expressed as a percentage of the length of shaft.

Eutamias quadrivittatus

a. Washington Pass, Chuska Mts., San Juan Co., New Mexico.

b. La Mosca Peak, Mt. Taylor, Valencia Co., New Mexico.

c. 1 mi. E McGaffey, Zuni Mts., McKinley Co., New Mexico.

d. Sandia Crest, Tree Springs, Embudo Canyon, Sandia Mts., Bernalillo Co., New Mexico.

Eutamias cinereicollis

e. 11 mi. S and 3½ mi. E Magdalena, Magdalena Mts., Socorro Co., New Mexico.

f. Mt. Withington, San Mateo Mts., Socorro Co., New Mexico.

g. Iron Canyon, Black Range, 15 mi. E and 6 mi. N Santa Rita, Grant Co., New Mexico.

h. Willow Creek, Mogollon Mts., 10 mi. E Mogollon, Catron Co., New Mexico.

i. San Francisco Mts., 7 and 9 mi. N Flagstaff, Coconino Co., Arizona.

Eutamias canipes

j. 5 mi. N and 9 mi. E Capitan, Capitan Mts., Lincoln Co., New Mexico.

k. 1 mi. S Cloudcroft, Sacramento Mts., Otero Co., New Mexico.

l. The Bowl, Guadalupe Mts., Culberson Co., Texas.

Eutamias bulleri

m. 3 to 9 mi. SW Las Adjuntas, Durango, Mexico.

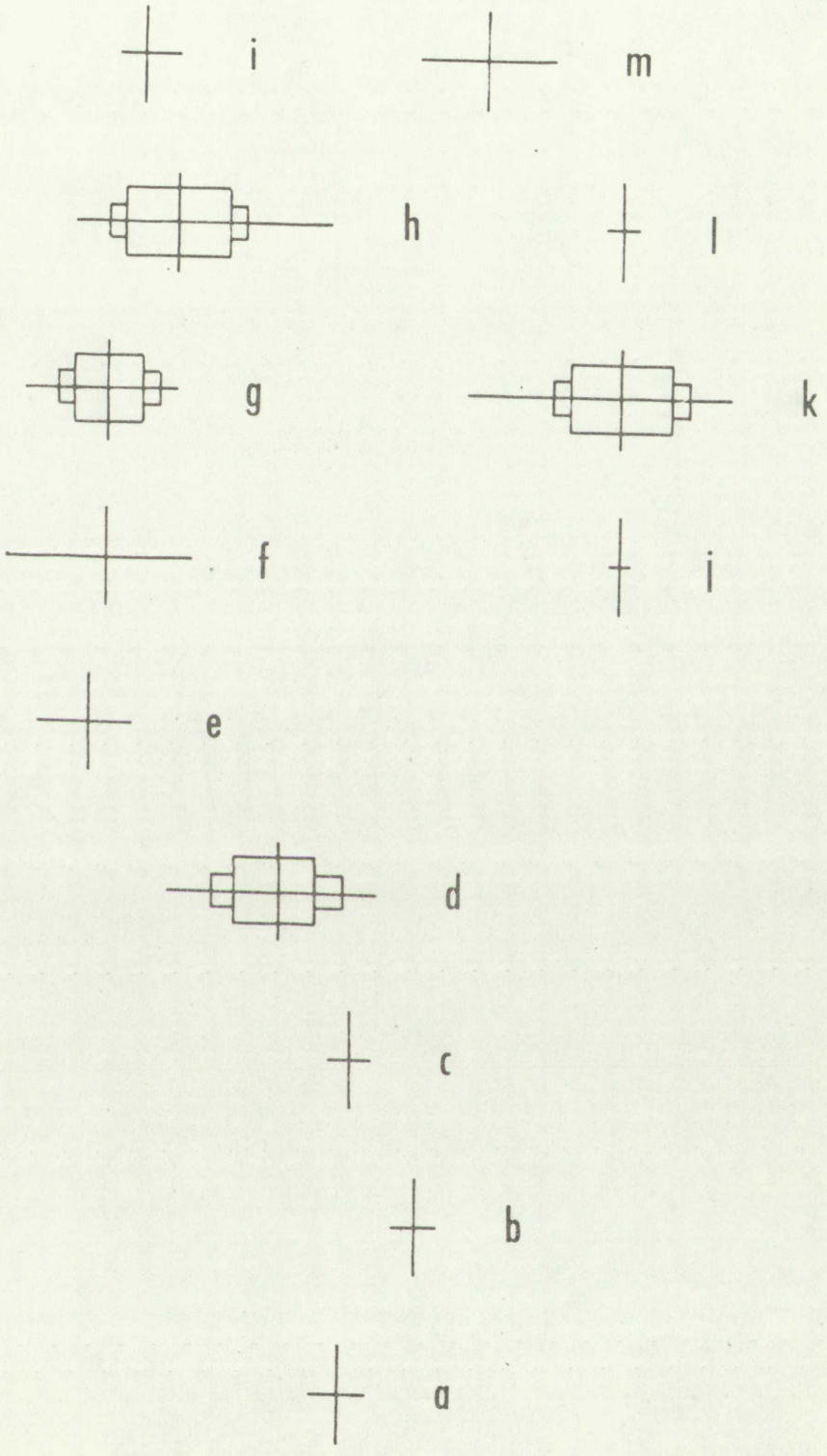

i
m
h
l
g
k
f
j
e
d
c
b
a
10
20
30
Percent

Fig. 5. Skull length of chipmunks. (The symbols used here are the same for Figs. 6 and 7.)

Eutamias quadrivittatus

A. Washington Pass, Chuska Mts., San Juan Co., New Mexico.

B. 1 mi. E McGaffey, Zuni Mts., McKinley Co., New Mexico.

C. La Mosca Peak, Mt. Taylor, Valencia Co., New Mexico.

D. 10 and 5 mi. N Jemez Springs, Sandoval Co., New Mexico.

E. 4 mi. NE Tres Ritos, Taos, Co., New Mexico.

F. Sandia Crest, Tree Springs, Embudo Canyon, Sandia Mts., Bernalillo Co., New Mexico.

G. Red Canyon and Carolina Canyon, Manzano Mts., Torrance Co., New Mexico.

Eutamias canipes

H. 3 mi. S and 9 mi. W Corona, Gallinas Mts., Lincoln Co., New Mexico.

I. 5 mi. N and 9 mi. E Capitan, Capitan Mts., Lincoln Co., New Mexico.

J. 1 mi. S Cloudcroft, Sacramento Mts., Otero Co., New Mexico.

K. The Bowl, Guadalupe Mts., Culberson Co., Texas.

Eutamias bulleri

L. 13 mi. E San Antonio de las Alazanas, Coahuila, Mexico.

M. 3 to 9 mi. SW Las Adjuntas, Durango, Mexico.

Eutamias cinereicollis

N. 11 mi. S and $3\frac{1}{2}$ mi. E Magdalena, Magdalena Mts., Socorro Co., New Mexico.

O. Mt. Withington, San Mateo Mts., Socorro Co., New Mexico.

P. Iron Canyon, Black Range, 15 mi. E and 6 mi. N Santa Rita, Grant Co., New Mexico.

Fig. 5. continued.

Q. Willow Creek, Mogollon Mts., 10 mi. E Mogollon, Catron Co., New Mexico.

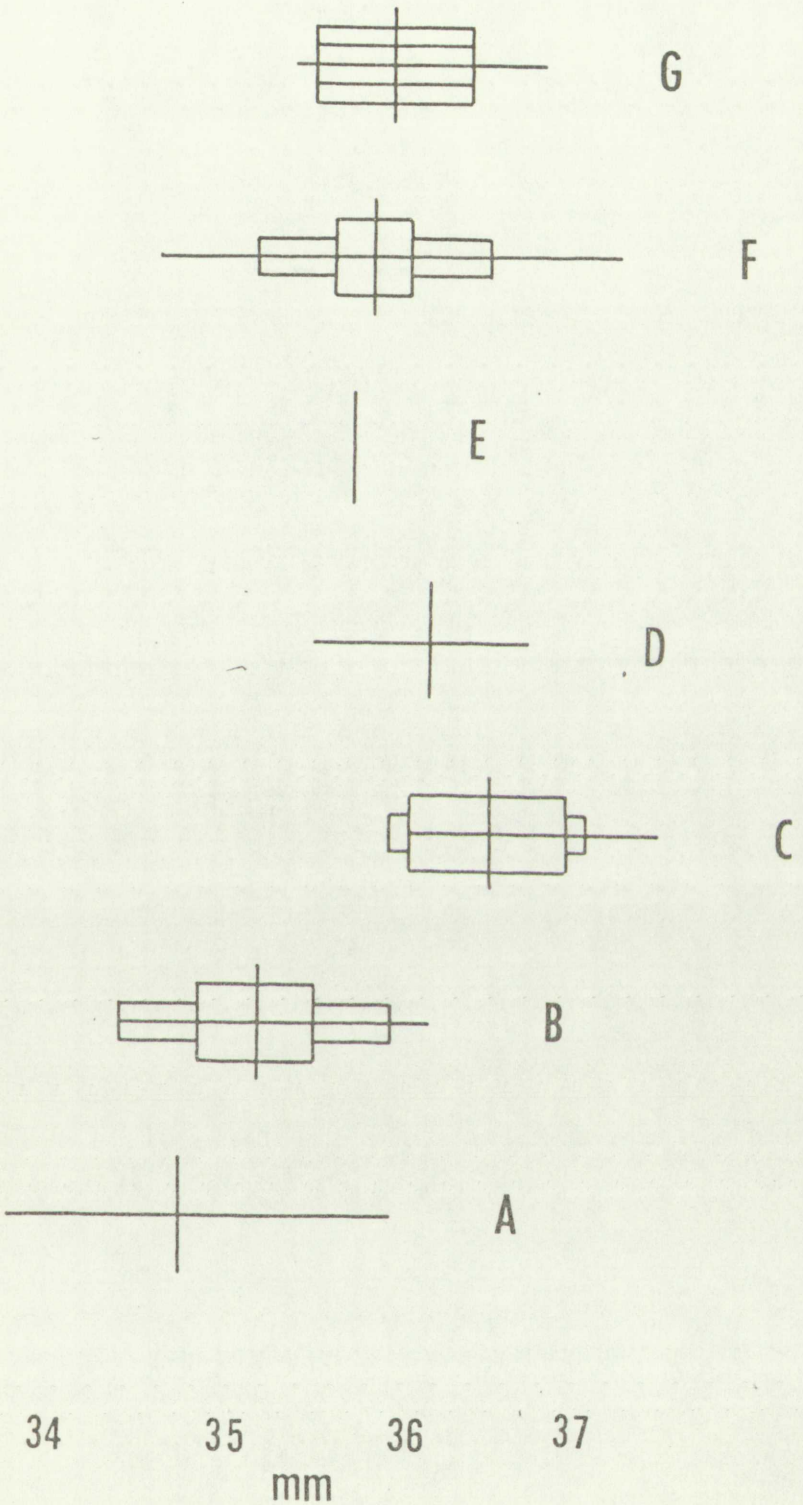
R. 4 mi. NE Hannagan Meadow, Blue Range, Greenlee Co., Arizona.

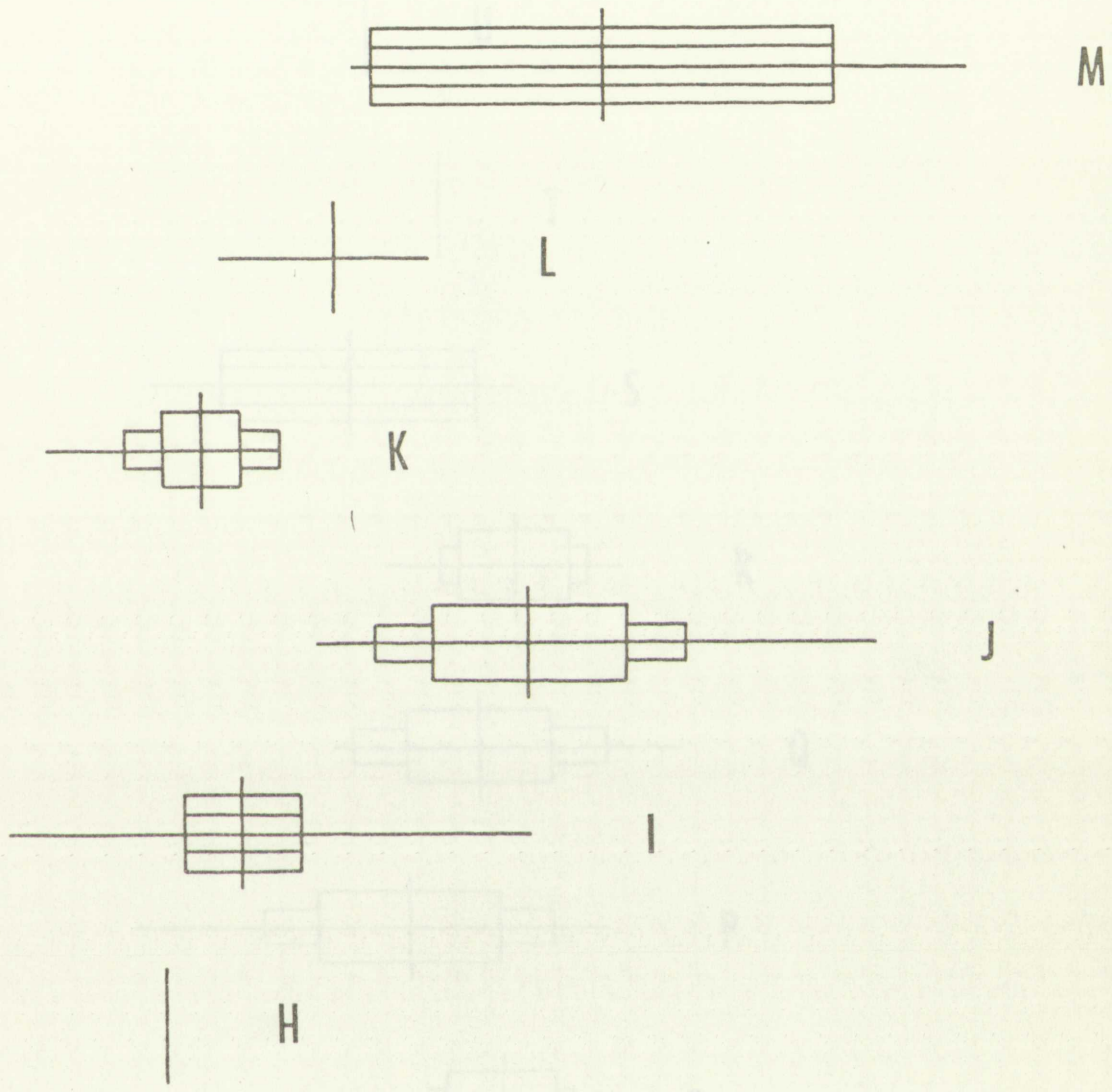
S. West Fork of the Black River, Apache Co., Arizona.

T. 2 mi. E of Phelps Ranger Station, White Mts., Apache Co., Arizona.

U. 25 mi. S Upper W Fork of Black River, Springerville, Apache Co., Arizona.

V. San Francisco Mts., 7 and 9 mi. N Flagstaff, Coconino Co., Arizona.


G
F
E
D
C
B
A
34
35
36
37
mm


M
L
K
J
I
H
35
36
37
38
39
mm

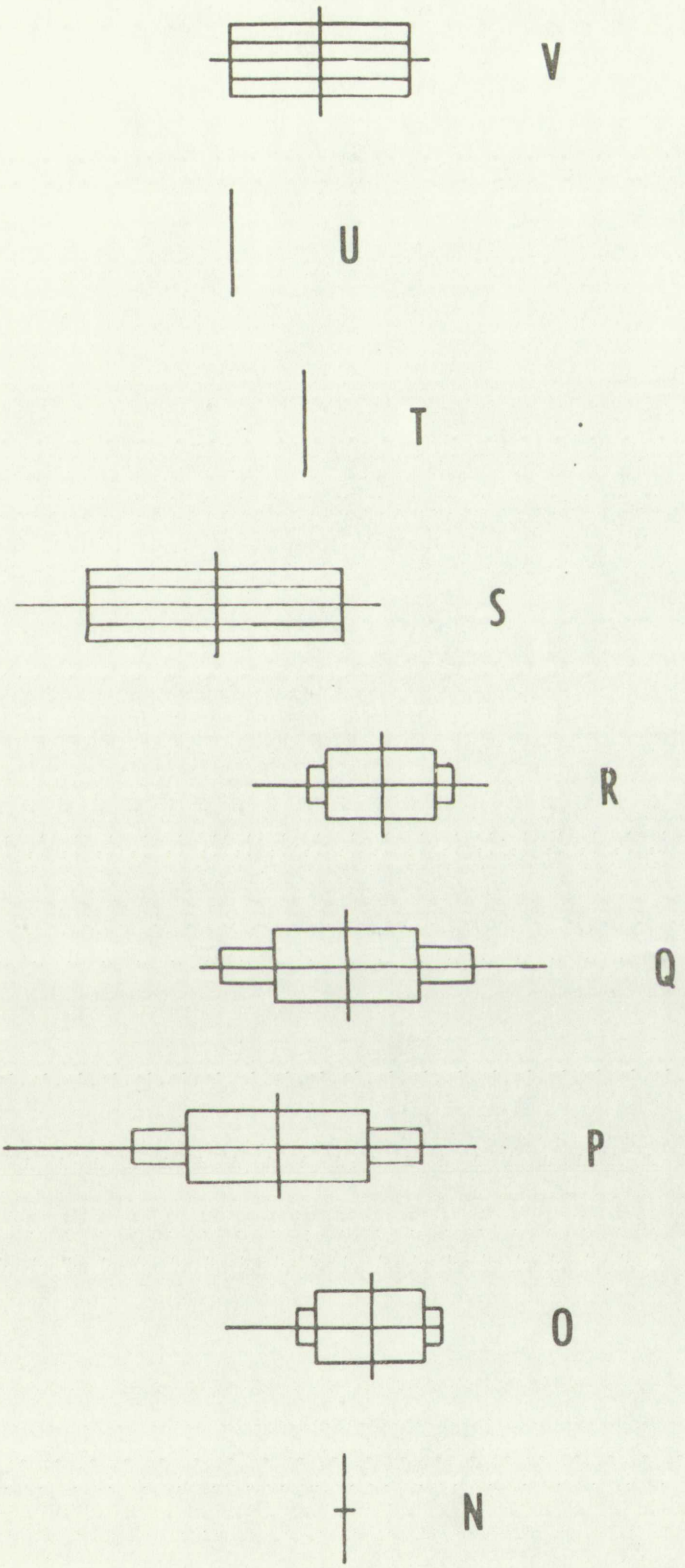
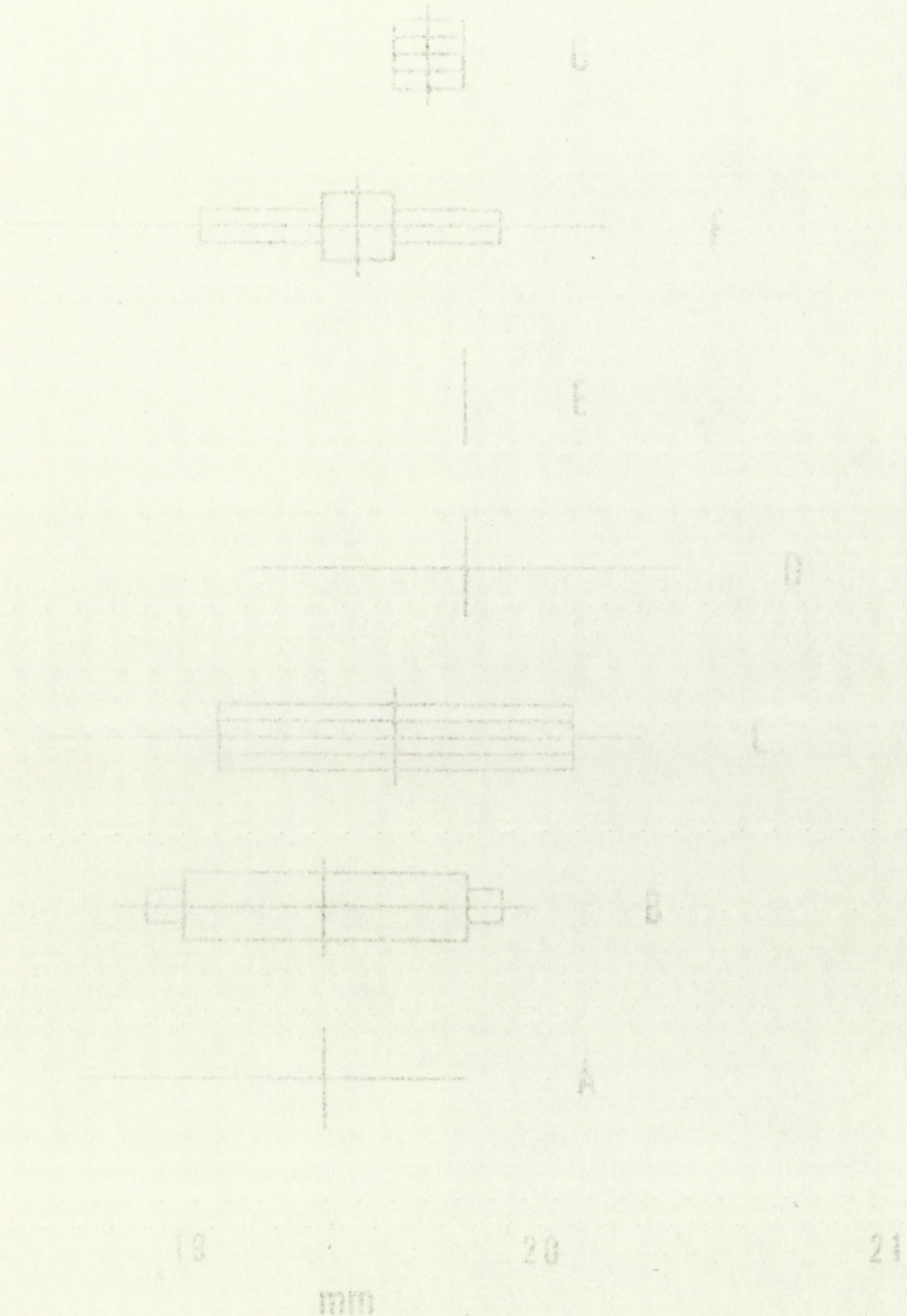
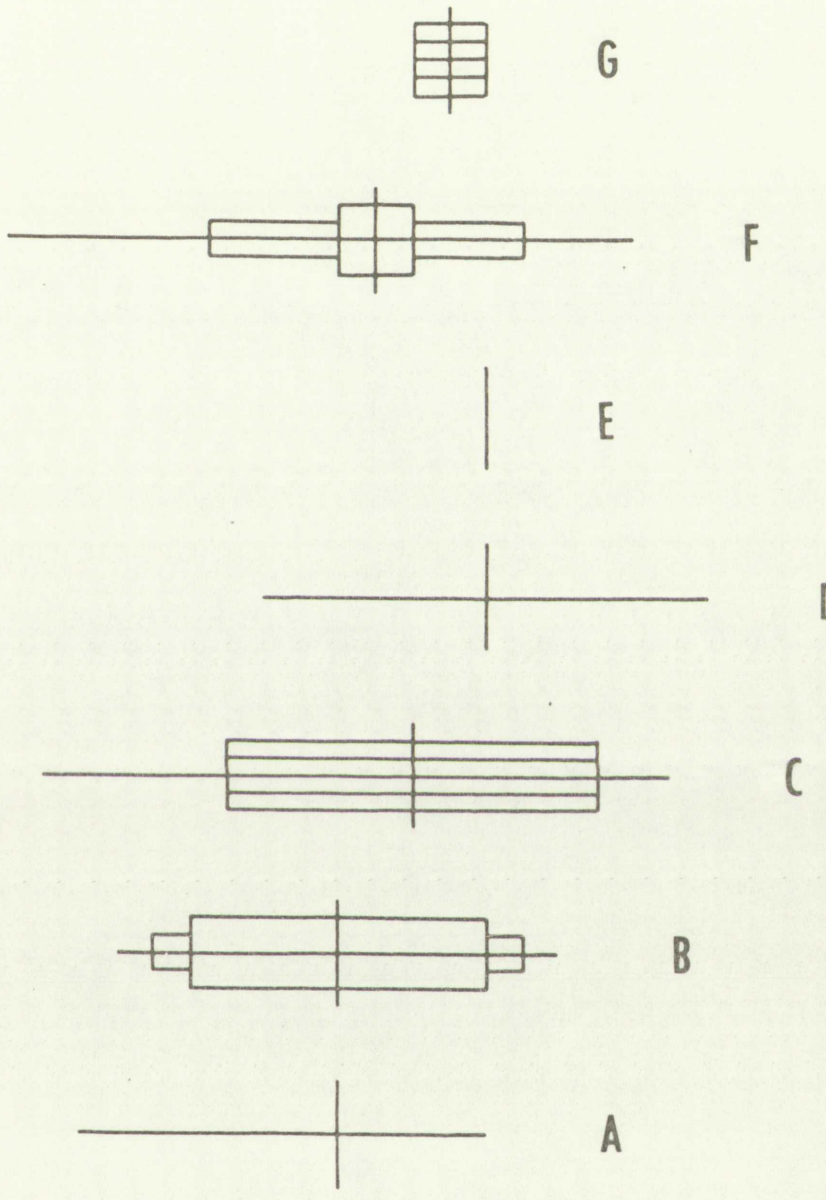

V
U
T
S
R
Q
P
O
N
34
35
36
37
mm

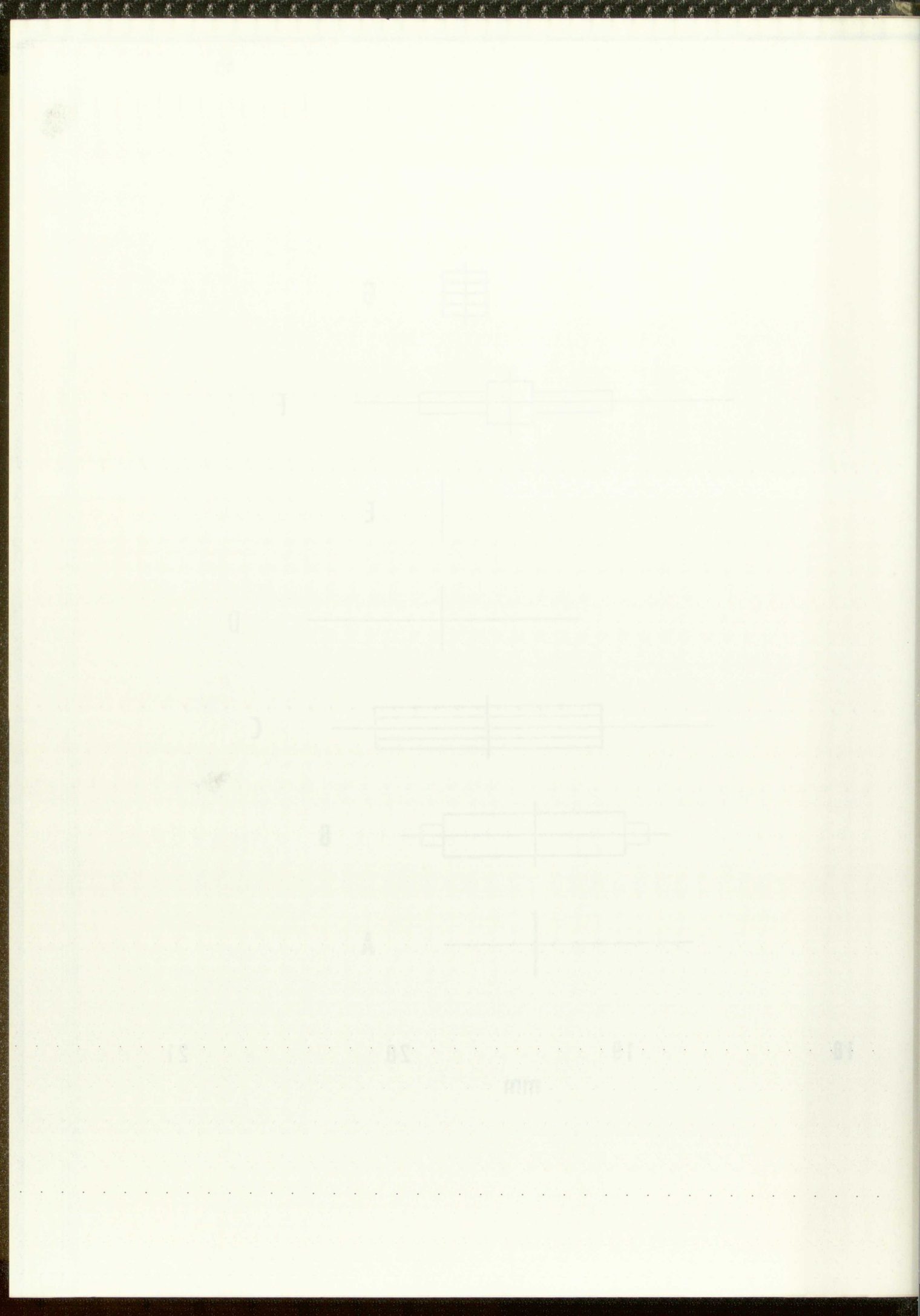
Fig. 6. Zygomatic breadth of chipmunks. The symbols are the same as used in Fig. 5.

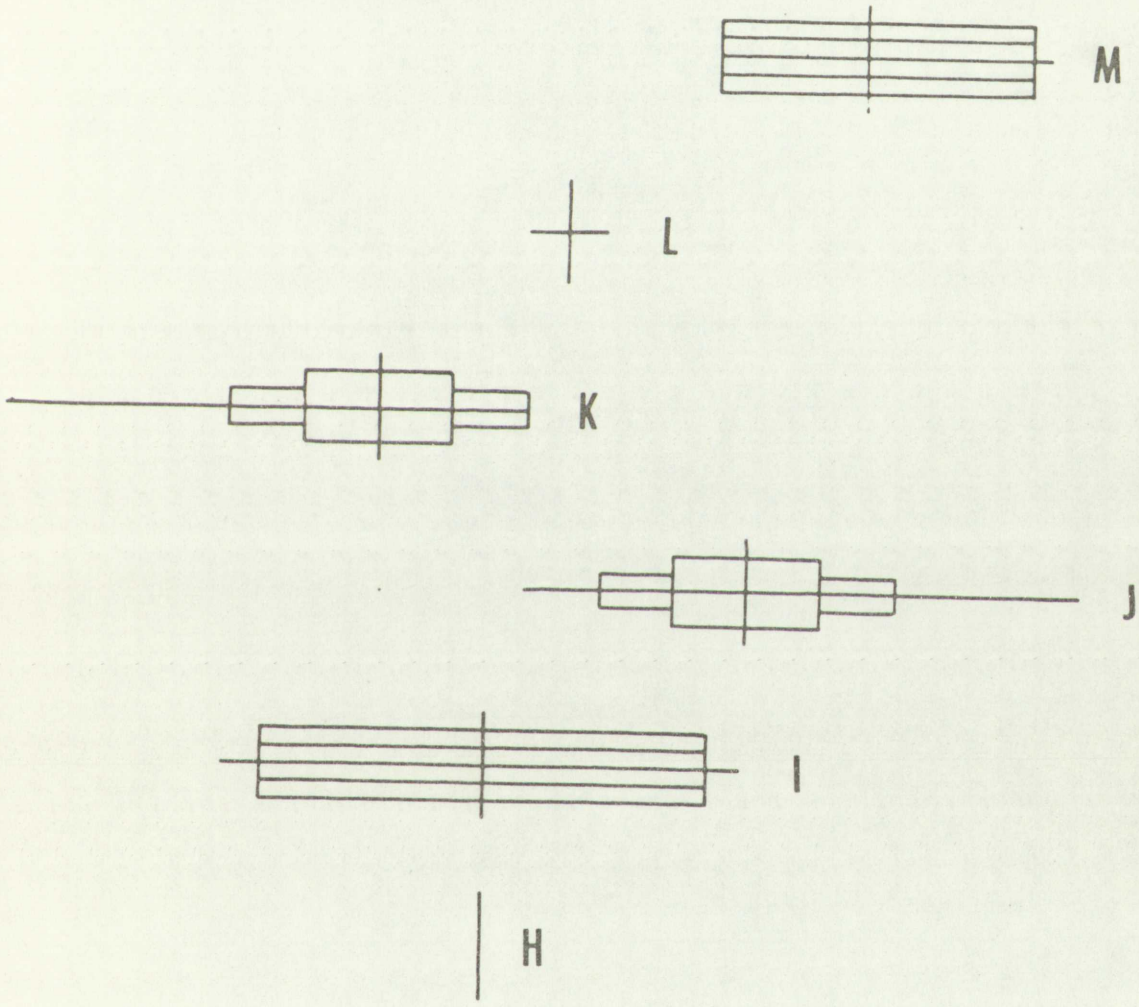




18 19 20 21

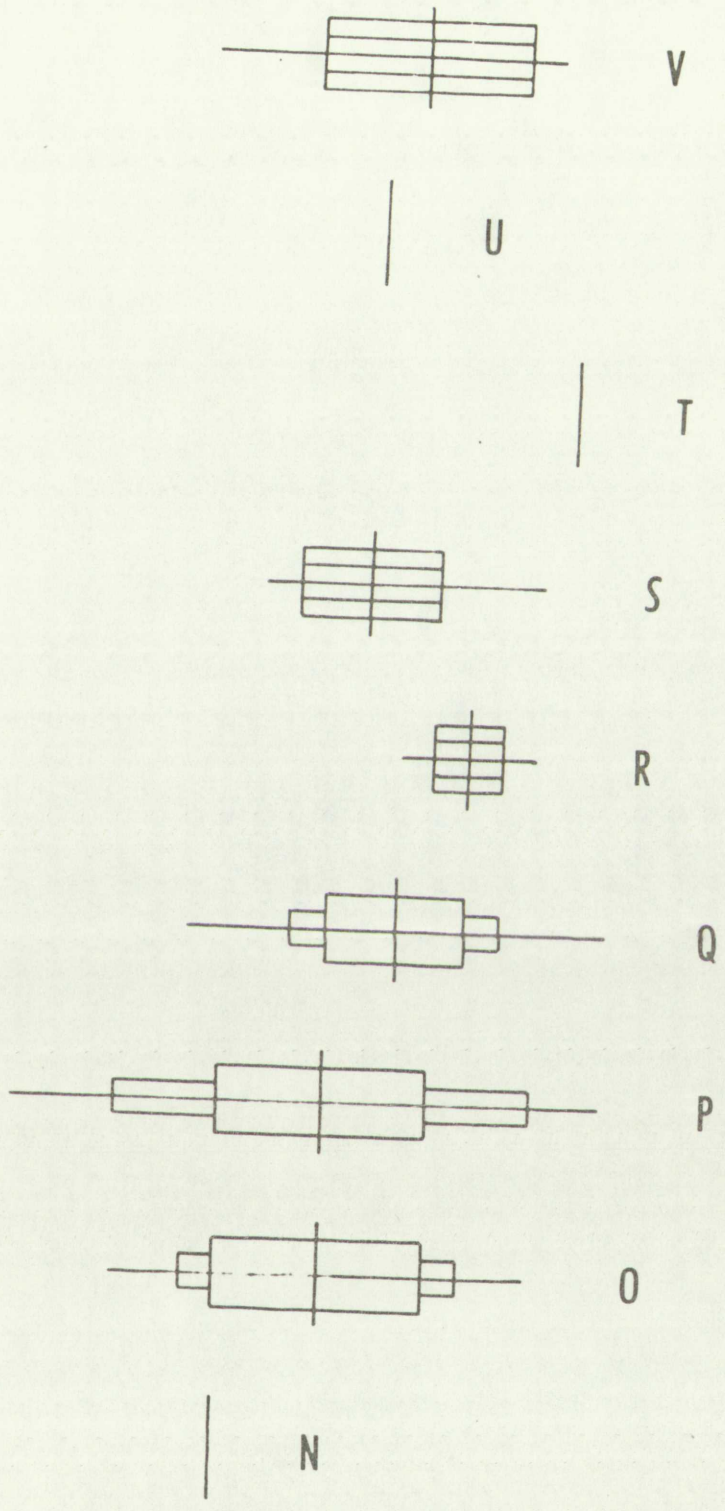
mm





18 19 20 21

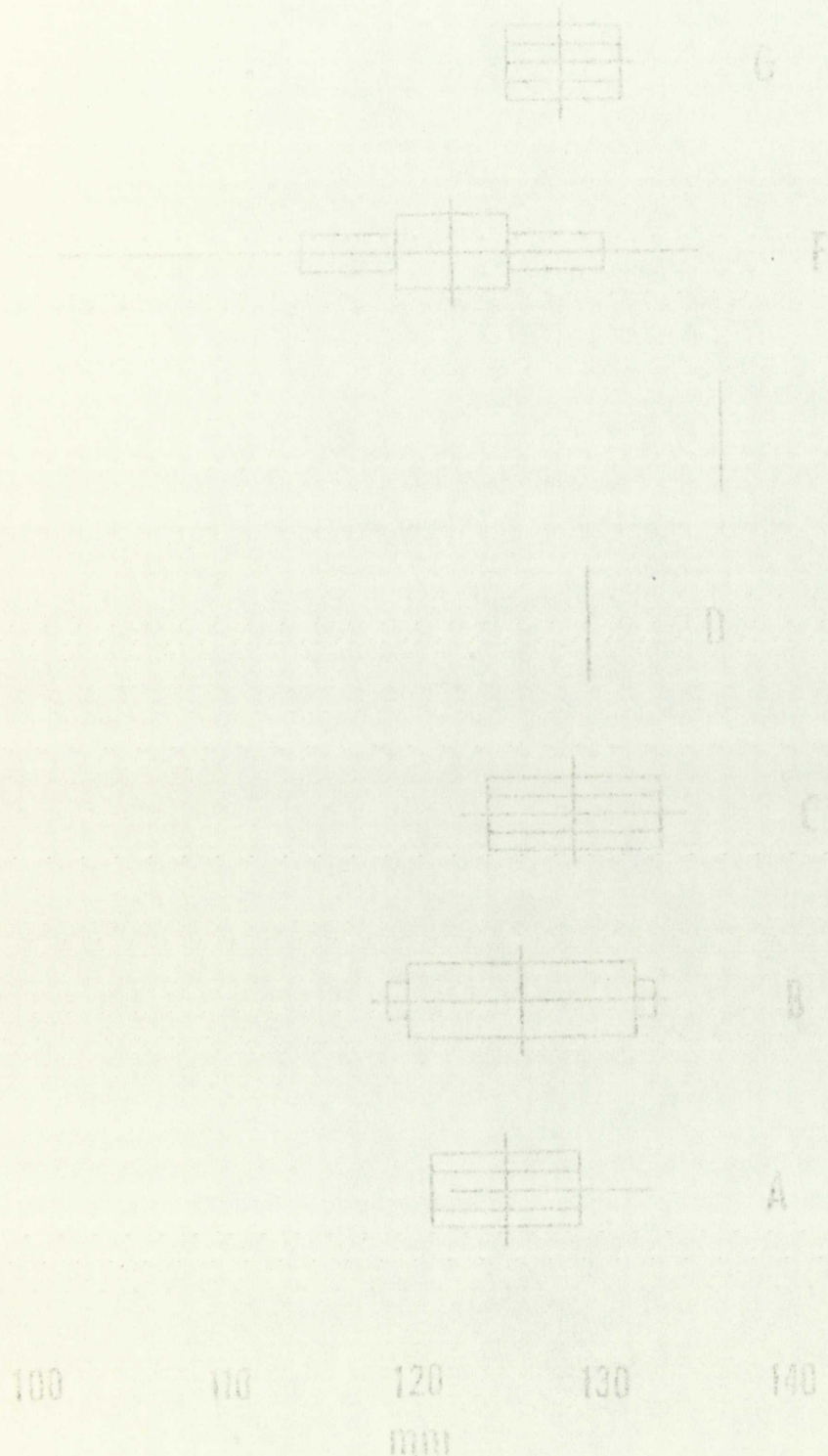
mm

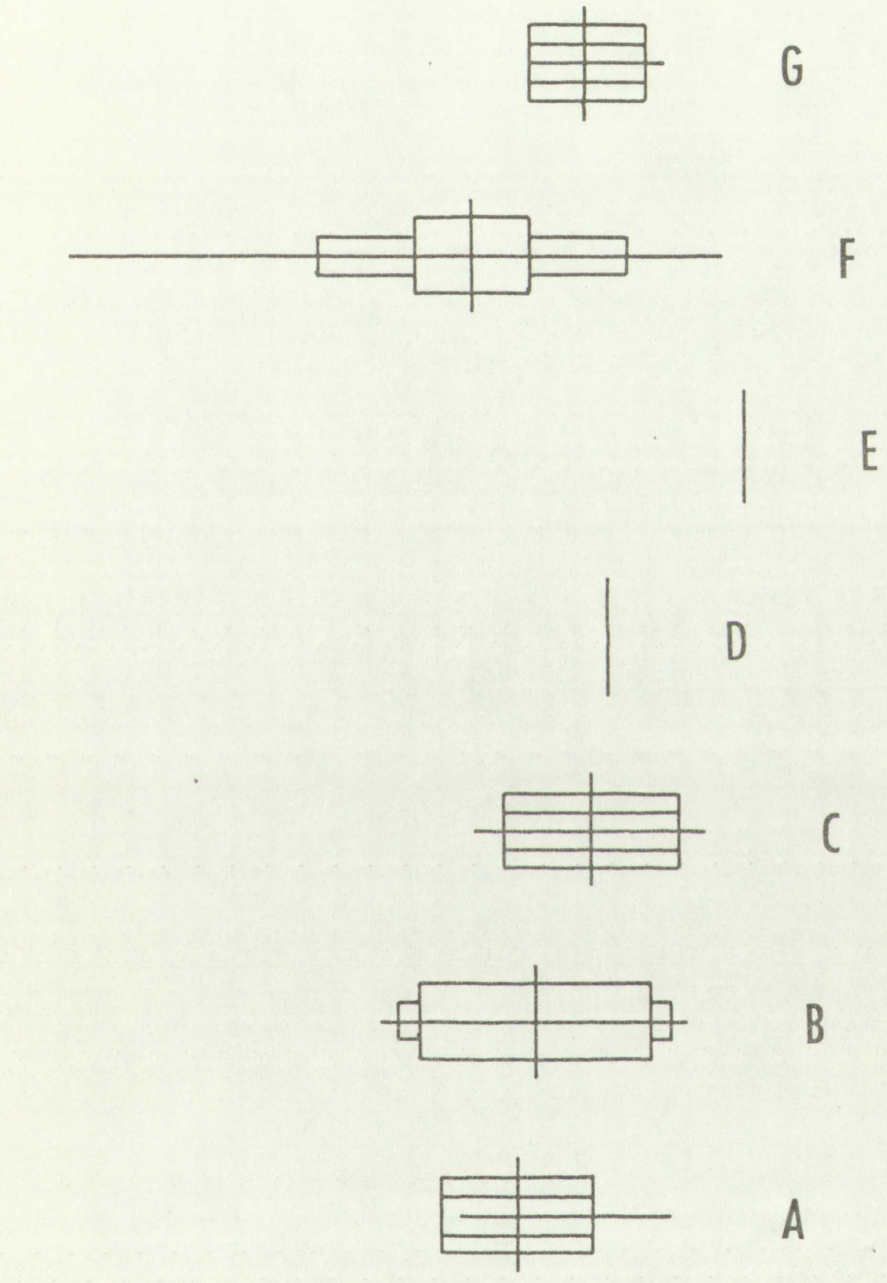


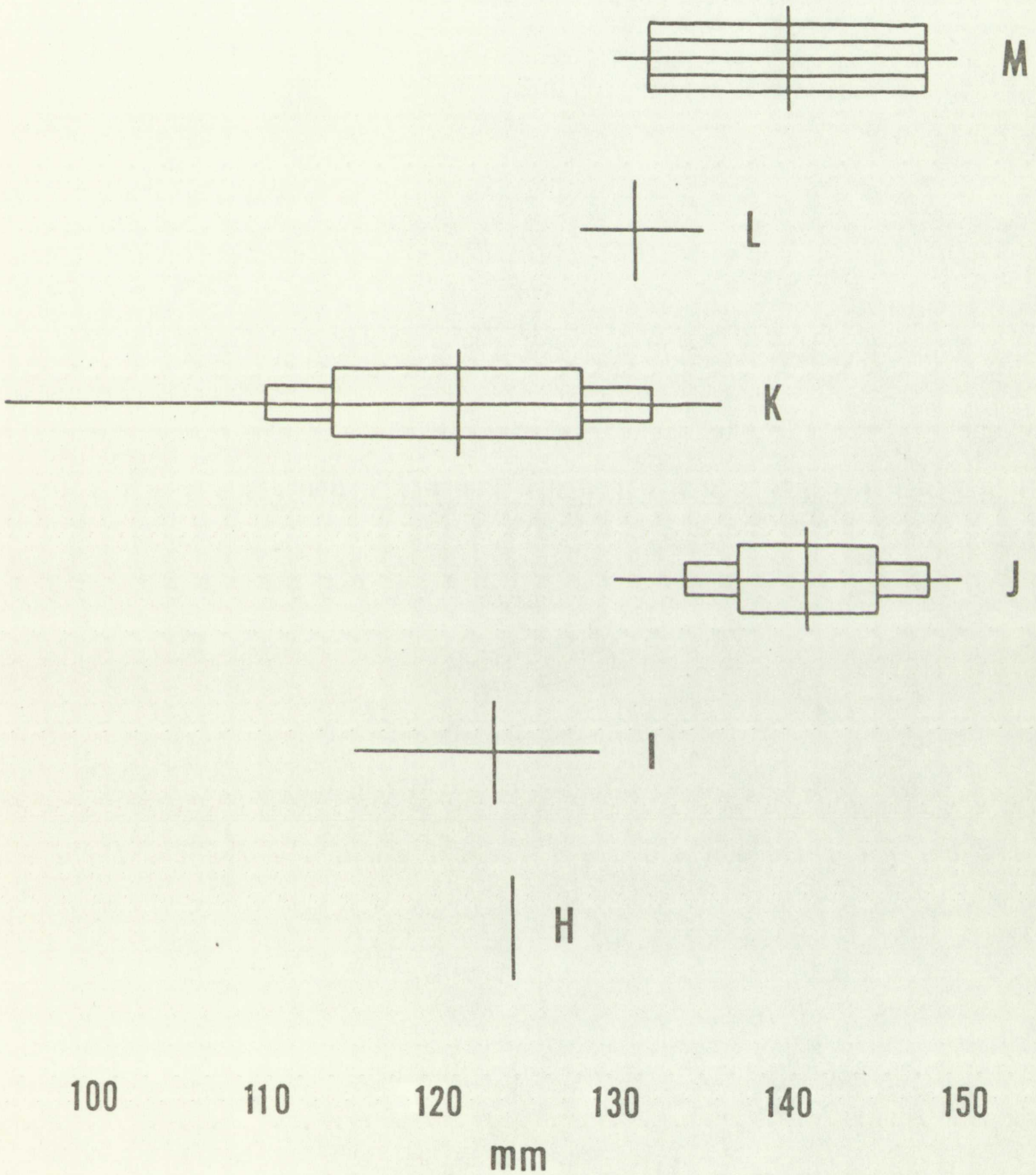
18 19 20

mm

Fig. 7. Head and body length of chipmunks. The symbols are the same as used in Fig. 5.




G
F
E
D
C
B
A
100
110
120
130
140
mm


M
L
K
J
I
H
100
110
120
130
140
150
mm

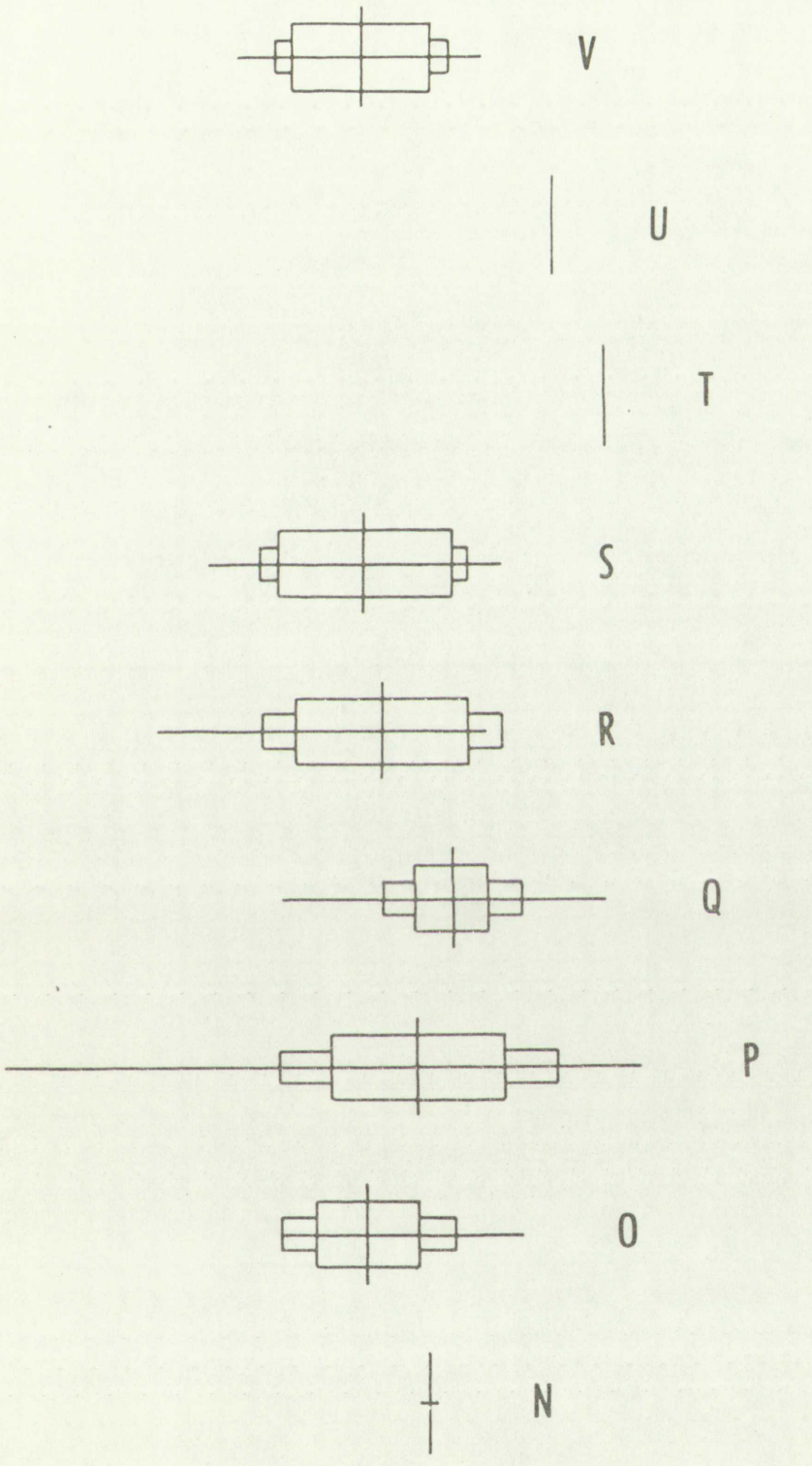
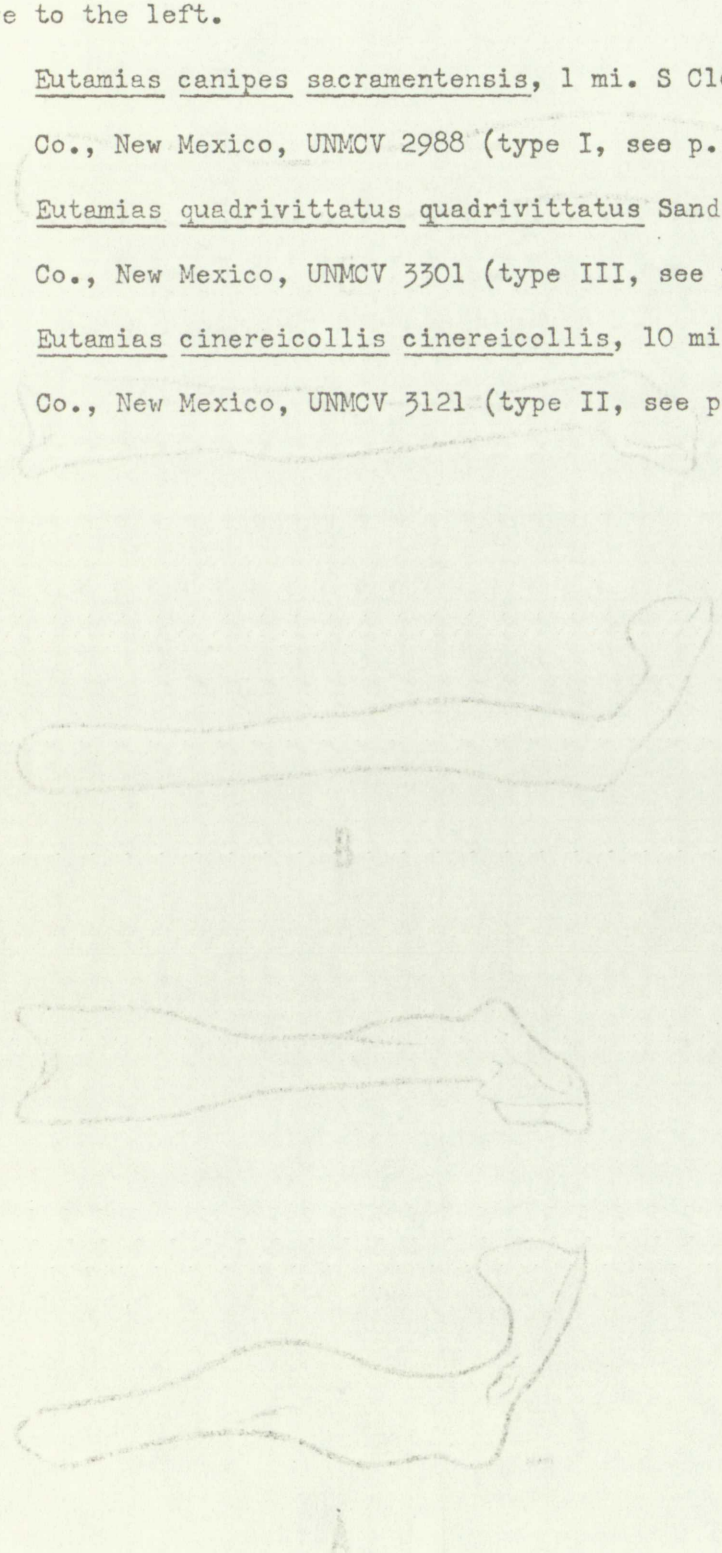

V
U
T
S
R
Q
P
O
N
110
120
130
140
150
mm

Fig. 8. The three main types of bacula in the chipmunks of the E. quadrivittatus group in New Mexico. For each of the three types the bottom figure is a lateral and the top a dorsal view. The proximal ends are to the left.

A. Eutamias canipes sacramentensis, 1 mi. S Cloudcroft, Otero Co., New Mexico, UNMCV 2988 (type I, see p. 7).

B. Eutamias quadrivittatus quadrivittatus Sandia Crest, Bernalillo Co., New Mexico, UNMCV 3301 (type III, see p. 7).

C. Eutamias cinereicollis cinereicollis, 10 mi. E Mogollon, Catron Co., New Mexico, UNMCV 3121 (type II, see p. 7).



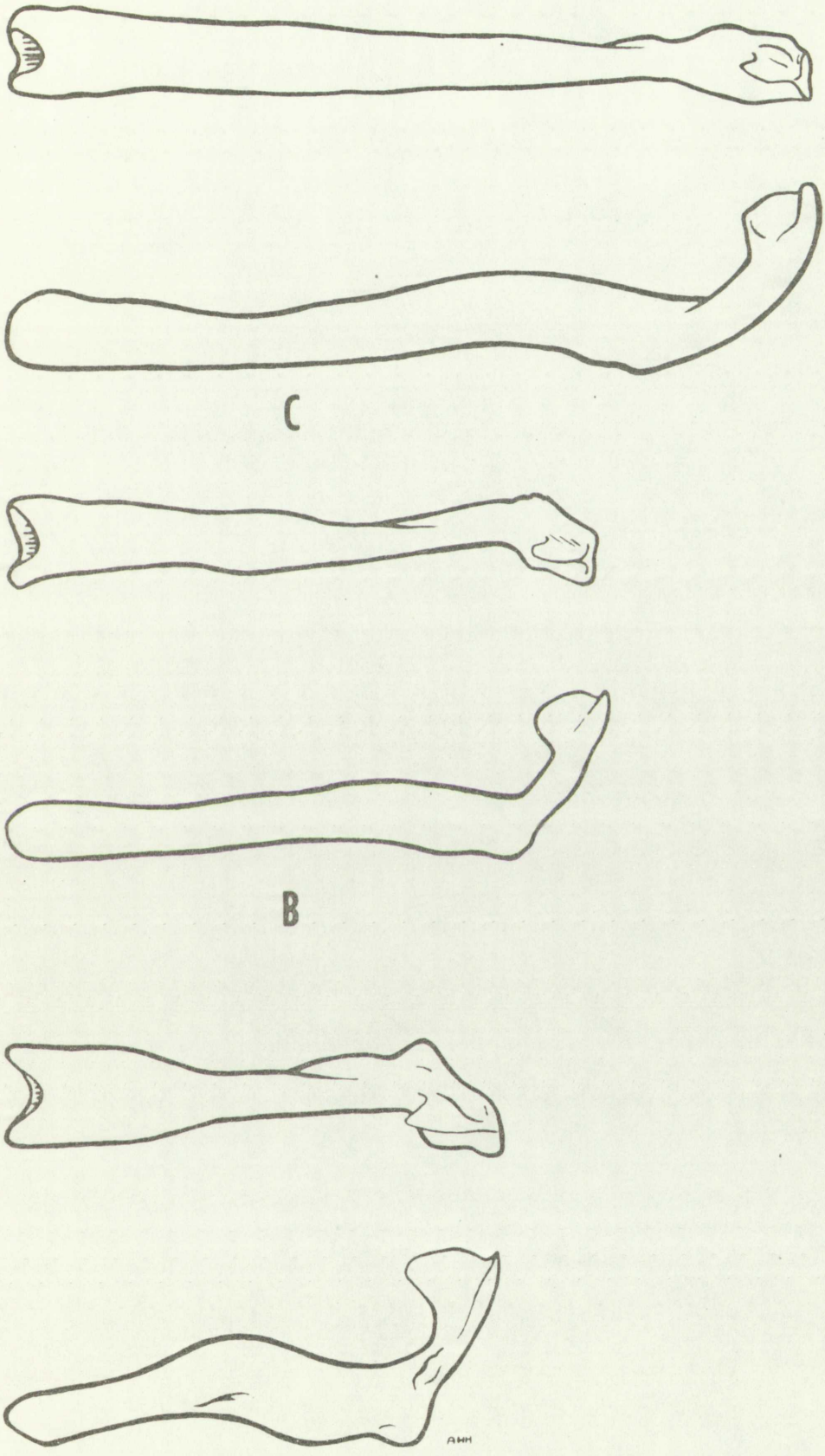

C
B
A

Fig. 9. Range map showing the distribution of chipmunks studied and the collecting stations.

A. Eutamias quadrivittatus

1. Washington Pass, Chuska Mts., San Juan Co., New Mexico.
2. 1 mi. E McGaffey, Zuni Mts., McKinley Co., New Mexico.
3. La Mosca Peak, Mt. Taylor, Valencia Co., New Mexico.
4. 10 and 5 mi. N Jemez Springs, Sandoval Co., New Mexico.
5. 4 mi. NE Tres Ritos, Taos Co., New Mexico.
6. Sandia Crest, Tree Springs, Embudo Canyon, Sandia Mts., Bernalillo Co., New Mexico.
7. Red and Carolina Canyons, Manzano Mts., Torrance Co., New Mexico.

B. Eutamias cinereicollis

8. E. c. cinereus, 11 mi. S and 3½ mi. E Magdalena, Magdalena Mts., Socorro Co., New Mexico.
9. E. c. cinereus, Mt. Withington, San Mateo Mts., Socorro Co., New Mexico.
10. E. c. cinereicollis, Willow Creek, Mogollon Mts., 10 mi. E Mogollon, Catron Co., New Mexico.
11. E. c. cinereicollis, Iron Canyon, Black Range, 15 mi. E and 6 mi. N Santa Rita, Grant Co., New Mexico.

? Organ Mountains, specimens not seen.

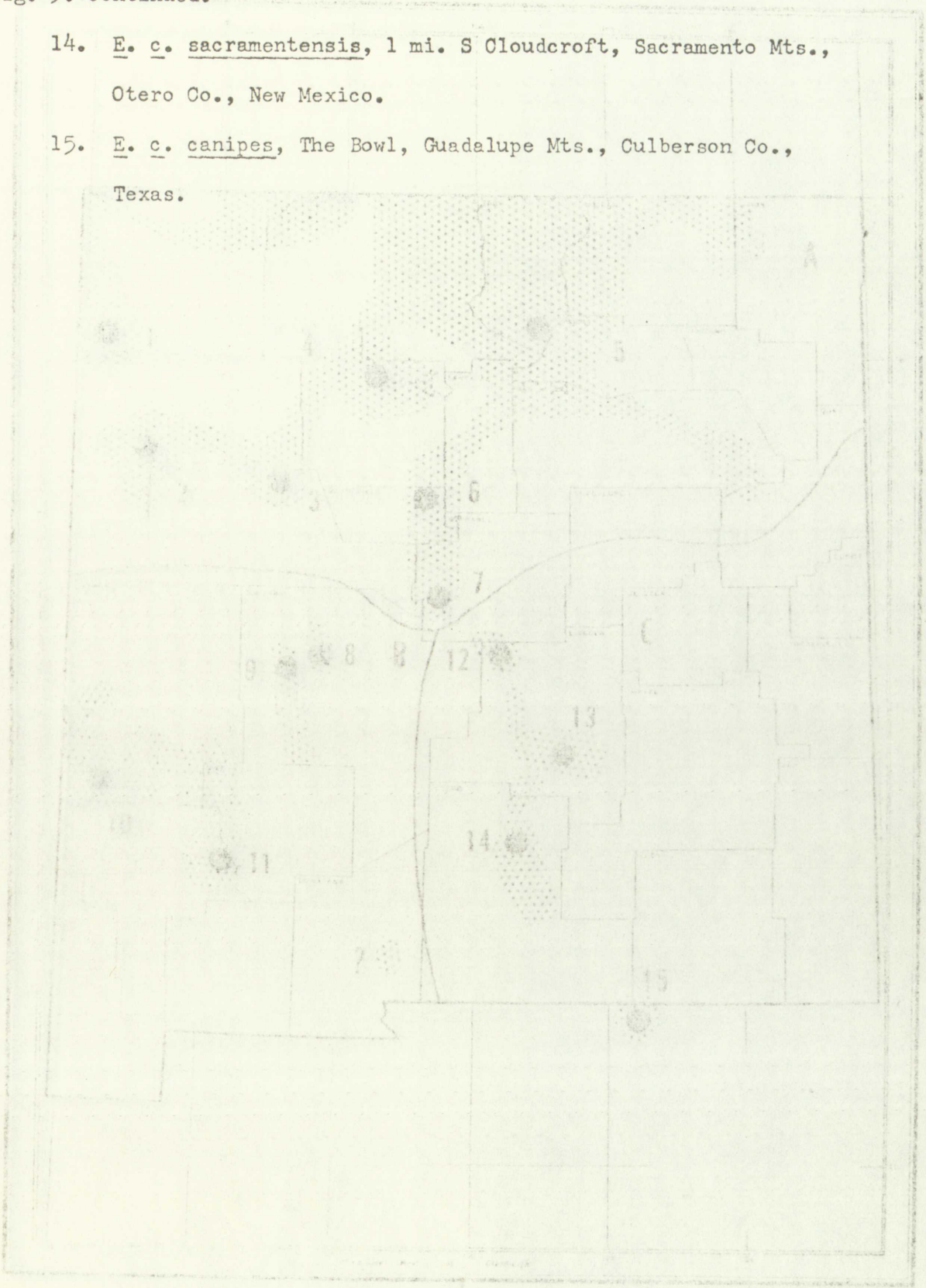
C. Eutamias canipes

12. E. c. ssp., 3 mi. S and 9 mi. W Corona, Gallinas Mts., Lincoln Co., New Mexico.
13. E. c. ssp., 5 mi. N and 9 mi. E Capitan, Capitan Mts., Lincoln Co., New Mexico.

Fig. 9. continued.

14. E. c. sacramentensis, 1 mi. S Cloudcroft, Sacramento Mts., Otero Co., New Mexico.

15. E. c. canipes, The Bowl, Guadalupe Mts., Culberson Co., Texas.



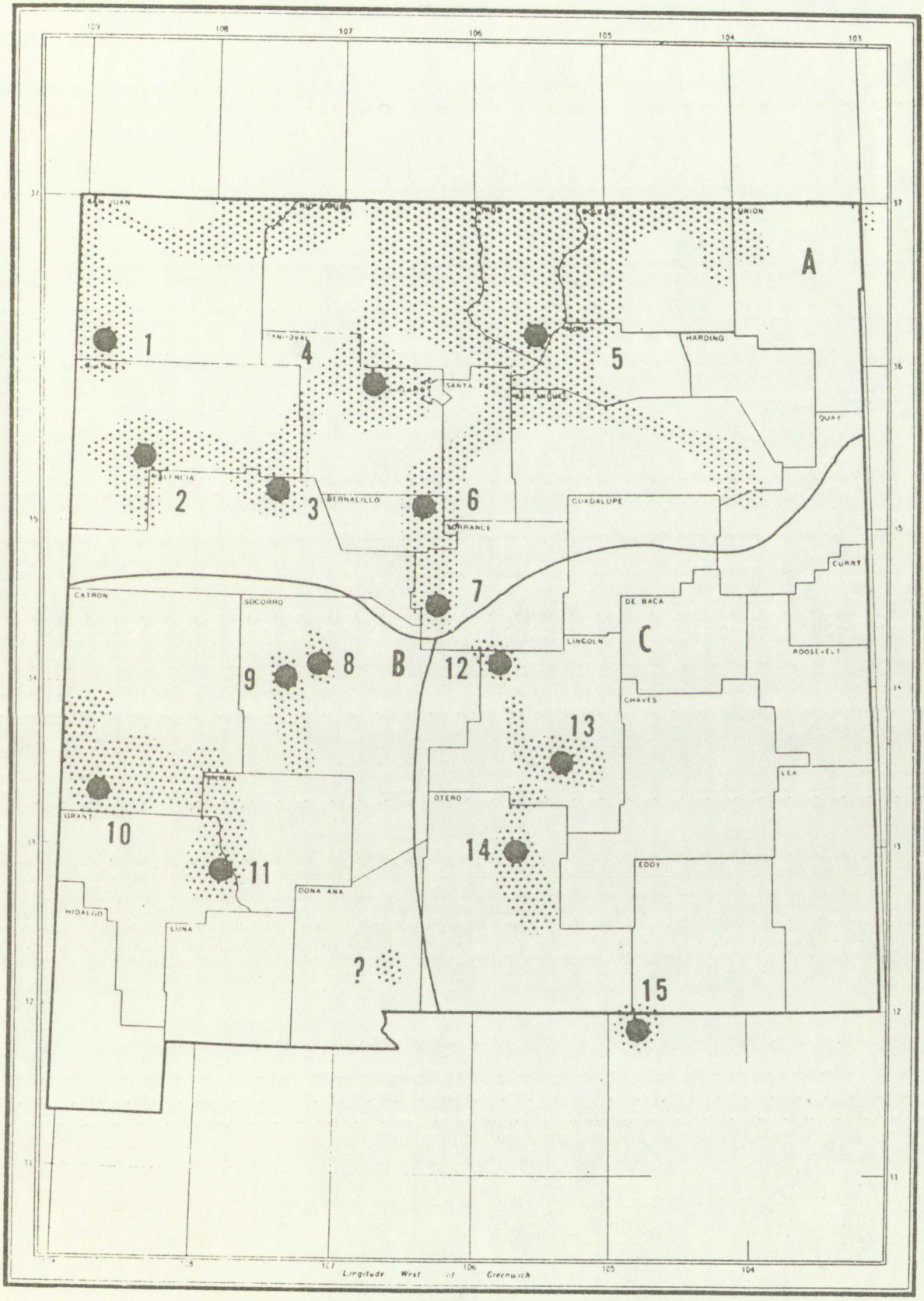
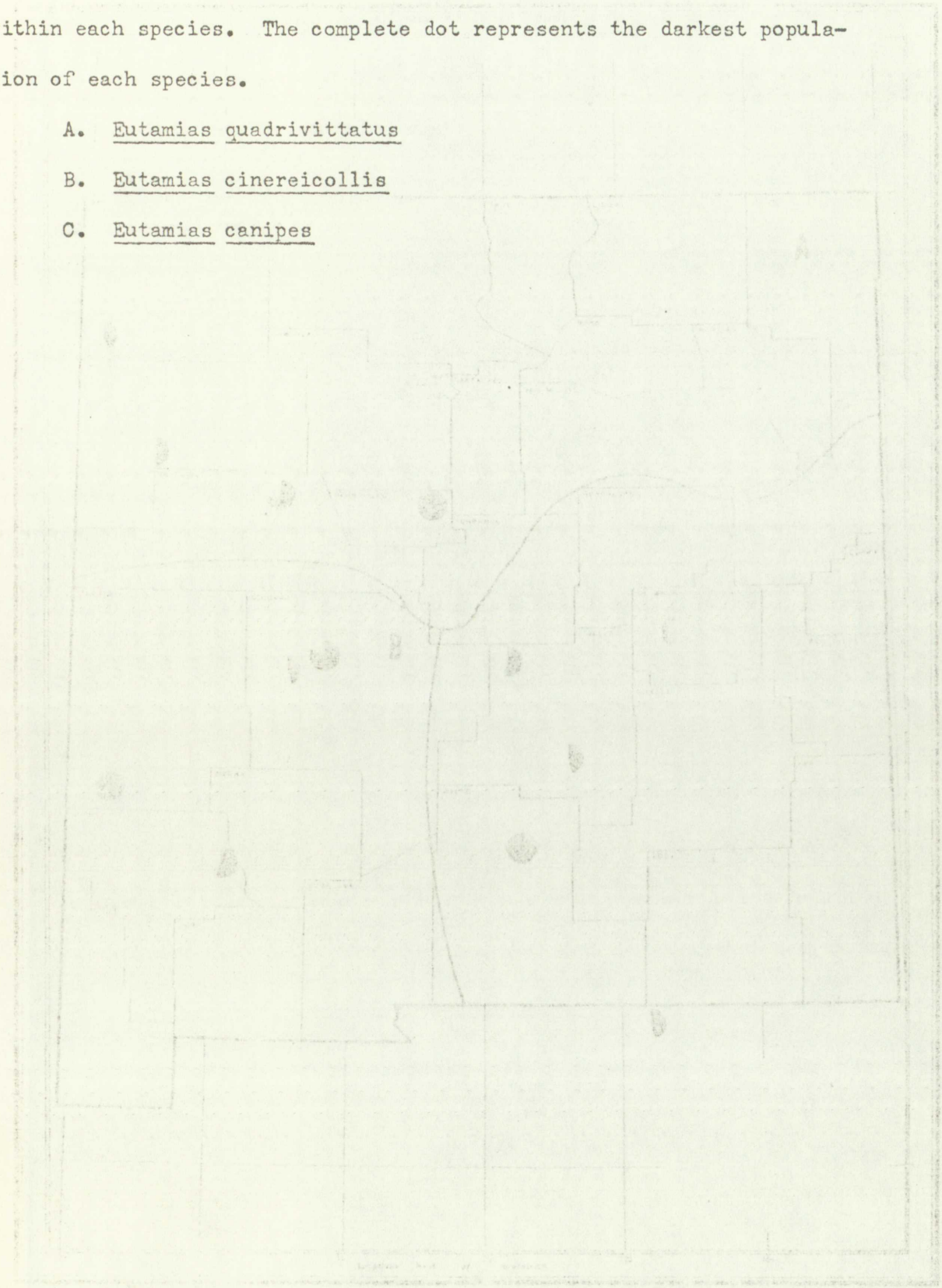

A
B
C
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
?
SAN JUAN
RIO ARRIBA
TAOS
COLFAX
UNION
HARDING
SANDOVAL
SANTA FE
SAN MIGUEL
QUAY
MCKINLEY
VALENCIA
BERNALILLO
TORRANCE
GUADALUPE
CURRY
CATRON
SOCORRO
DE BACA
LINCOLN
ROOSEVELT
CHAVES
SIERRA
OTERO
LEA
GRANT
EDDY
DONA ANA
HIDALGO
LUNA
103
104
105
106
107
108
109
Longitude West of Greenwich

Fig. 10. Map showing the relative darkness of certain populations within each species. The complete dot represents the darkest population of each species.

A. Eutamias quadrivittatus

B. Eutamias cinereicollis

C. Eutamias canipes



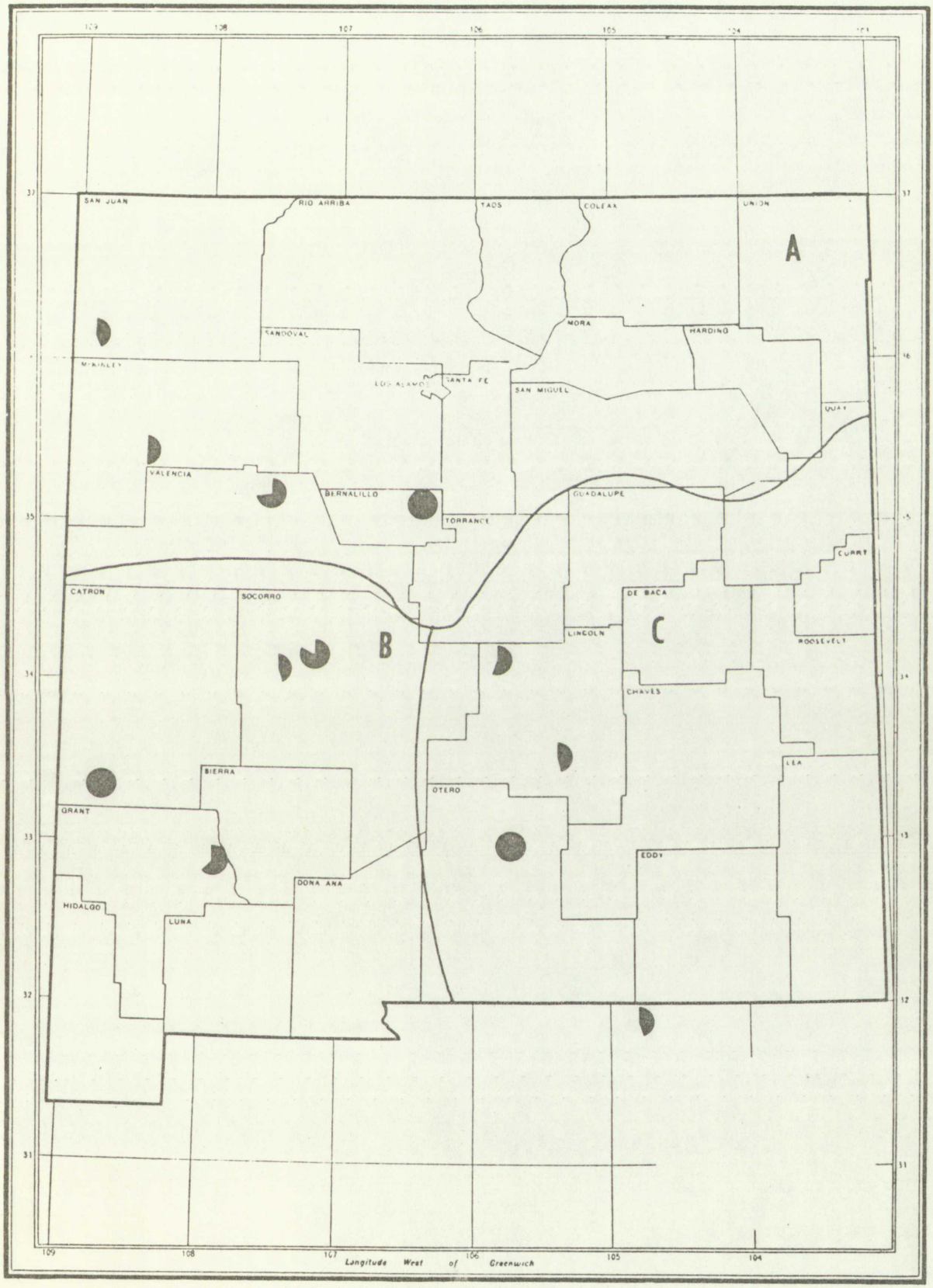

SAN JUAN
RIO ARRIBA
TAOS
COLFAX
UNION
A
SANDOVAL
MORA
HARDING
MCKINLEY
LOS ALAMOS
SANTA FE
SAN MIGUEL
QUAY
VALENCIA
BERNALILLO
TORRANCE
GUADALUPE
CURRY
CATRON
SOCORRO
B
DE BACA
C
LINCOLN
ROOSEVELT
CHAVES
LEA
SIERRA
OTERO
GRANT
EDDY
DONA ANA
HIDALGO
LUNA
109
108
107
106
105
104
37
36
35
34
33
32
31
Longitude West of Greenwich

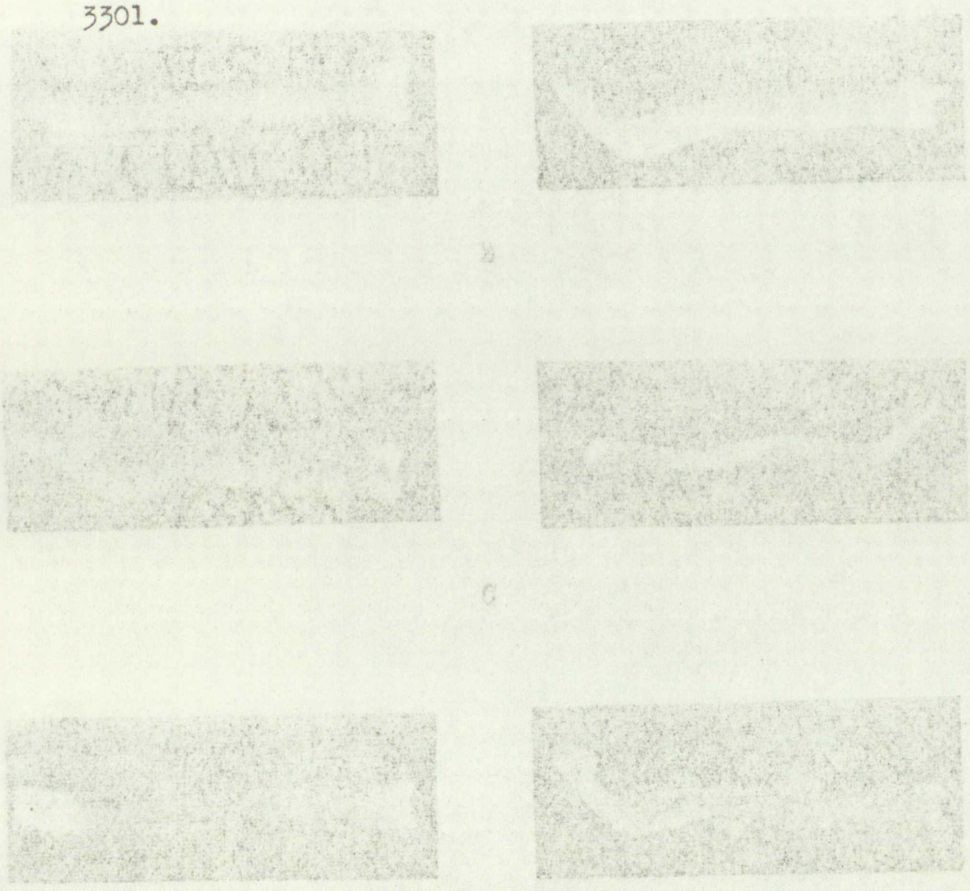
Fig. 11. Photographs (X10) of bacula from various populations of Eutamias quadrivittatus quadrivittatus. Dorsal view on the left, lateral view on the right.

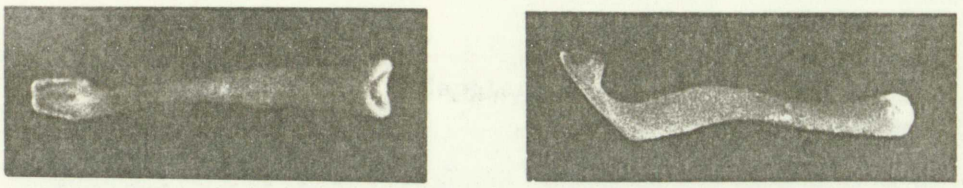
A. 1 mi. E McGaffey, Zuni Mts., McKinley Co., New Mexico, UNMCV 1685.

B. La Mosca Peak, Mt. Taylor, Valencia Co., New Mexico, UNMCV 1502.

C. Washington Pass, Chuska Mts., San Juan Co., New Mexico, UNMCV 1674.

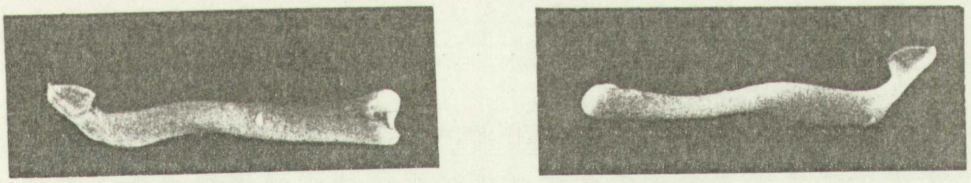
D. Sandia Crest, Sandia Mts., Bernalillo Co., New Mexico, UNMCV 3301.



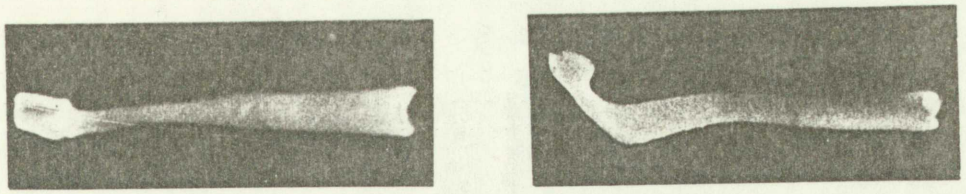


A

B



C



D

Fig. 12. Photographs (X10) of bacula from various populations of Eutamias canipes and Eutamias bulleri. Dorsal view on the left, lateral view on the right.

Eutamias canipes ssp.

A. 3 mi. S and 9 mi. W Corona, Gallinas Mts., Lincoln Co., New Mexico, UNMCV 3575.

B. 5 mi. N and 9 mi. E Capitan, Capitan Mts., Lincoln Co., New Mexico, UNMCV 3572.

Eutamias canipes sacramentensis

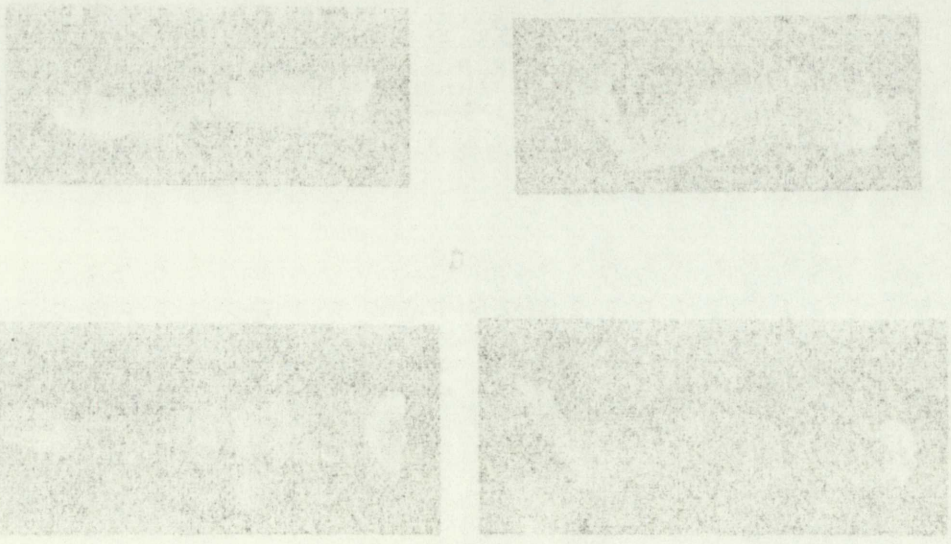
C. 1 mi. S Cloudcroft, Sacramento Mts., Otero Co., New Mexico, UNMCV 2988.

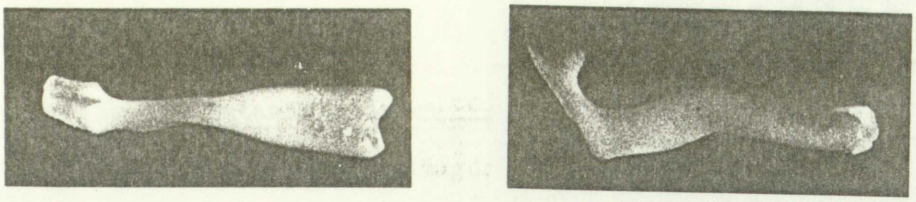
Eutamias canipes canipes

D. The Bowl, Guadalupe Mts., Culberson Co., Texas, UNMCV 3358.

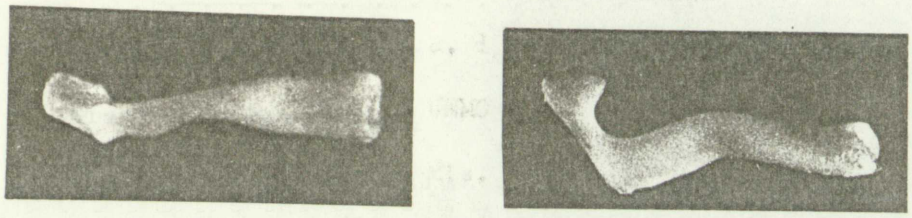
Eutamias bulleri durangae

E. 3 to 9 mi. SW Las Adjuntas, Durango, Mexico, KU 54,519.

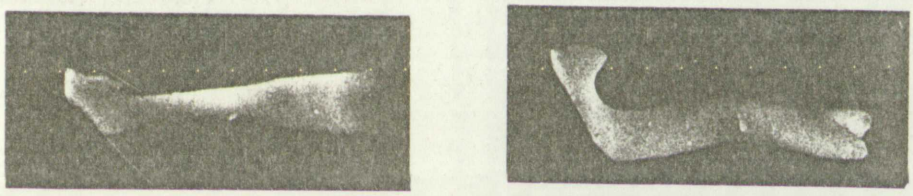




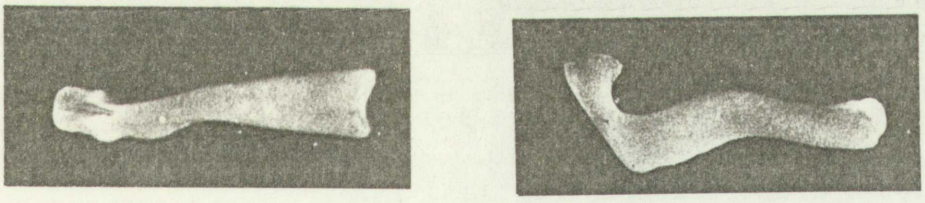
A



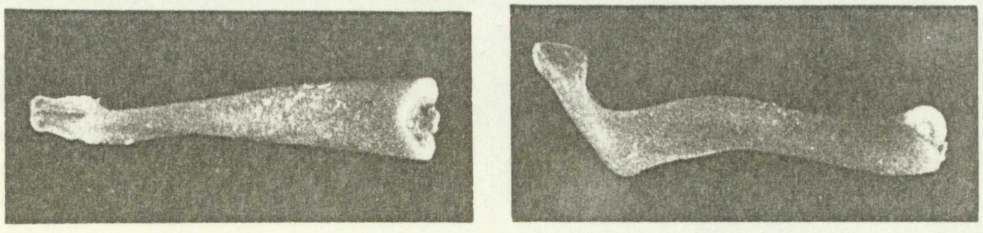
B



C



D



E

Fig. 13. Photographs (X10) of bacula from various populations of Eutamias cinereicollis. Dorsal view on the left, lateral view on the right.

Eutamias cinereicollis cinereus

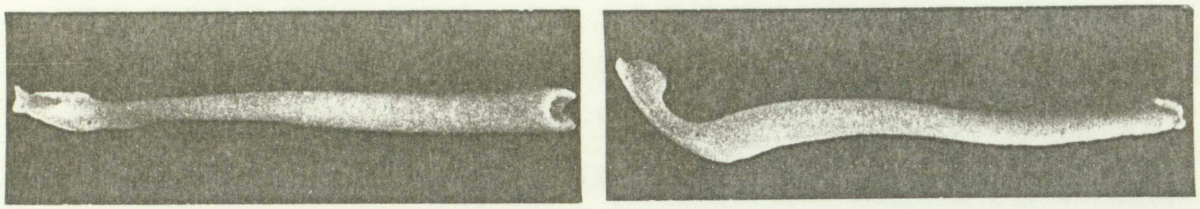
A. 11 mi. S and 3½ mi. E Magdalena, Magdalena Mts., Socorro Co., New Mexico, UNMCV 3041.

Eutamias cinereicollis cinereicollis

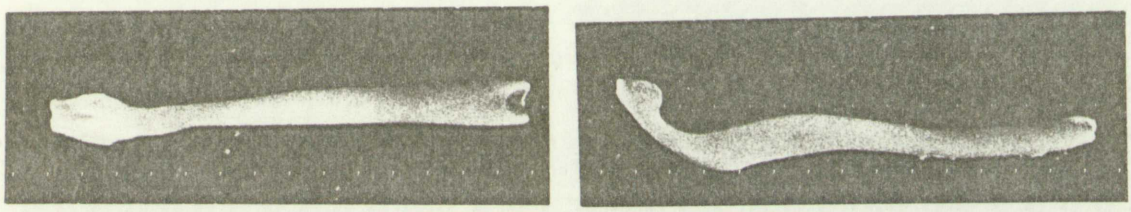
B. Iron Canyon, Black Range, 15 mi. E and 6 mi. N Santa Rita, Grant Co., New Mexico, UNMCV 3195.

C. Willow Creek, Mogollon Mts., 10 mi. E Mogollon, Catron Co., New Mexico, UNMCV 3121.

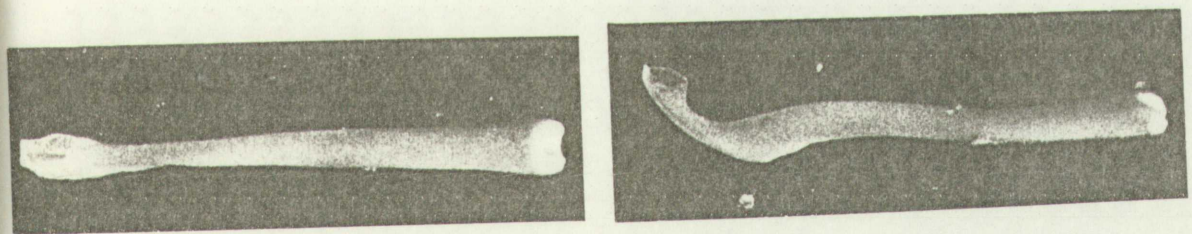
D. San Francisco Mts., 7 mi. N Flagstaff, Coconino Co., Arizona, UNMCV 3348.



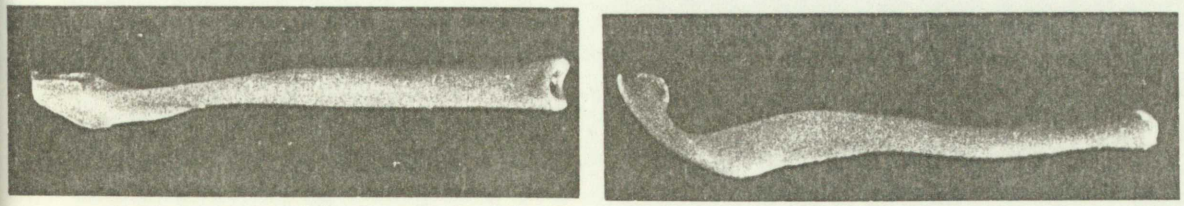
A



B



C



D