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1950

LIFE HISTORY, BEHAVIOR, AND POPULATIONS OF THE WESTERN CHIPMUNK, *EUTAMIAS AMOENUS AFFINIS* (ALLEN)

by
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of the requirements for the degree of
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1949

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INTRODUCTION

The chipmunk, Eutamias amoenus affinis (Allen), was chosen for the present study because of its abundant numbers and its diurnal nature. Through direct observation of its movements and general habits, it seemed that a study of these features might test live-trapping data and techniques. There is much that we do not know about the home ranges, numbers, and behavior of this species as well as of other small mammals associated with it in the Northwest. Also, the relationship of the chipmunk to the golden-mantled ground squirrel promised to be of particular interest because of the similarity of their behavior and their occurrence in the same habitats.

Description of area:

The small area in which most of the field work was carried out is called Rocky Flat or Rocky Prairie. It is located in Yakima County, Washington, on the east slope of the Cascade Mountains about thirty miles northwest of the city of Yakima. My headquarters was Wenas Cattle Camp at the head of Benton Creek, approximately four miles from U.S. Highway 410, and was reached on the Bald Mountain Road. Its exact location was the northwest corner of Section 11 in Township 16 North and Range 15 East at Lat. 46° 53' 36" N. and Long. 120° 55' 12" W.

The study area was in the yellow pine belt at an altitude of about 3800 feet. This zone is usually bounded by grassland and sagebrush at lower altitudes (except where local topography and exposure

alter the zonation) and by mixed forests of larches, hemlocks, firs, and pines higher up in the mountains. The area was logged in 1944. This, of course, reduced the overhead cover, but increased the number of logs and brush piles, which made conditions even more favorable for chipmunks. The woods around the edge of Rocky Flat were not as heavily logged as elsewhere. Consequently, Plot 3 was changed very little from its original condition, but sections of the other plots were altered by clearing.

The summers at Rocky Flat are dry and warm. Rains occur mainly in September and October, and snow begins in late October or November, continuing until April of the following spring. Daily weather observations for 1947 can be found in Appendix A.

An aerial view (Fig. 1) reveals certain features of the country. Most of the trees are widely spaced in open, parklike stands except on barren, rocky ground and shaded northern slopes. There is ordinarily little undergrowth outside of scattered buckbrush, willows, and kinnikinnick. The unusual extent of open, rocky terrain surrounded by forests makes the name Rocky Flat an appropriate one for this locality.

The location of my camp is indicated by letter "A" in Figure 1, and the other letters indicate points where I released chipmunks in homing experiments. The area outlined in white was trapped for about eleven months—from July to November, 1946, and May to November, 1947. The total area trapped was 42.0 acres, and its greatest widths from east to west and from north to south were about 1600 feet.

In 1946 only Plots 1 and 2 were trapped. Each was 750 feet square with an area of 12.8 acres. The combined area, including the intervening

strip, was 750 by 1580 feet, or 27 acres. Two more plots were added in 1947. Plot 3 extended from the east side of the trapping area out to the edge of the prairie. On the west side Plot 4 was laid out to include a steep northern slope with a rather dense cover of firs and pines and a few larches. Most of the study area was fairly level, but the west side of Plot 1 and all of Plot 4 sloped down into Benton Creek ravine.

A fairly typical view (Fig. 3) of most of the study area includes open pine forest, logs, and plants such as yarrow, lupines, and pine grass. Shade and cover were densest in Plot 4 (Fig. 4). In all of the other plots there were patches of open rocky ground (Fig. 5). These small open areas in the woods were traversed by chipmunks, although they preferred the protection of logs and trees (Fig. 6) for leisurely foraging. I regarded the wide rocky flats to the east of the area as natural barriers to the movements of chipmunks in that direction. There the boundary line between forest and barren flat is usually very sharp (Fig. 7).

Species trapped:

Many mammals other than chipmunks were captured. In all, 1321 individuals belonging to ten species of small mammals were live-trapped at Rocky Flat. They were as follows:

Sorex vagrans monticola	1
Eutamias amoenus affinis	577
Eutamias townsendii cooperi	1
Citellus lateralis saturatus	67
Tamiasciurus douglasii	1
Perognathus parvus	45

Thomomys talpoides yakimensis	1
Peromyscus maniculatus gambelii	620
Neotoma cinerea occidentalis	1
Microtus mordax halli	7
Total.....	1321

Description of traps:

I designed and built about two hundred live traps for chipmunks. One of the traps is shown in Figure 8. It is 10 inches long, 2½ inches wide, and 3 inches high with sides and bottom of ¼-inch hardware cloth and the top and rear door of thin sheet metal. The working mechanism is similar to that of the pressed wood trap used by Blair (1943). The front door is hinged at the top and drops down into place when an animal walks over the treadle and moves the trigger wire. The front door is bent so as to form an apron that lies flat against the floor when the door is closed. I presumed that the trapped animal would step on the apron while attempting to escape and thus prevent the door from opening. However, some animals were able to escape. Consequently, near the end of the 1946 season I installed wire locks. These locks drop with the door and hold it in place, precluding both escape and most double captures.

A larger and particularly a longer trap than mine is needed for ground squirrels and pine squirrels. These animals often held up the door with their tails or hind quarters while they picked up the bait. Instead of turning around in the trap, they would simply back out, and the door would fall after they had escaped.

Trapping procedures:

Traps were evenly spaced about eighty-three feet apart in a grid

pattern. This method of distributing traps has been employed by most workers who have studied small mammal populations in recent years. I trapped each plot for from four to six consecutive days. It was necessary to visit the traps twice a day, once in the morning and again in the afternoon, in order to prevent deaths from over-exposure.

One hundred traps were used in Plot 1, 100 in Plot 2, 56 in Plot 3, and 48 in Plot 4. (See Appendix B for diagram showing the layout of these traps.) Plot 1 was trapped for thirty-seven days in 1946 and thirty-three days in 1947. Plot 2 was trapped twenty-five days in 1946 and twenty-nine days in 1947. The other two plots were each trapped eighteen days in 1947.

Fourteen animals died in the traps during the first few weeks of trapping in 1946, but very few were lost in this manner after I covered the traps with pieces of bark to protect captured animals from the direct rays of the sun.

Most of my time in the field was spent in live-trapping and keeping records of the animals captured. Consequently, I would say that under conditions similar to those that prevailed during my work, one should not try to handle more than about seventy traps at one time.

Bait:

Sunflower seeds served as bait in 1946, but corn, which was considerably cheaper, was used with equal success the following season.

Marking methods:

I marked individual chipmunks by clipping off certain toes, no more than one being taken from a foot. The wounds healed within a few days and the loss of toes apparently did not affect the activity of the animals. I also tried notching the ears around the edges,

but the notches often became frayed. Holes punched in the center were sometimes torn, making identification difficult. Nevertheless, single holes in the ear were useful in allowing me to increase the series of numbers. In my daily records individuals were identified by the toes that were missing, a method also used by Holdenried (1940). However, when one has a large number of animals, it would be much simpler to assign numbers to individuals, rather than to record the missing toes.

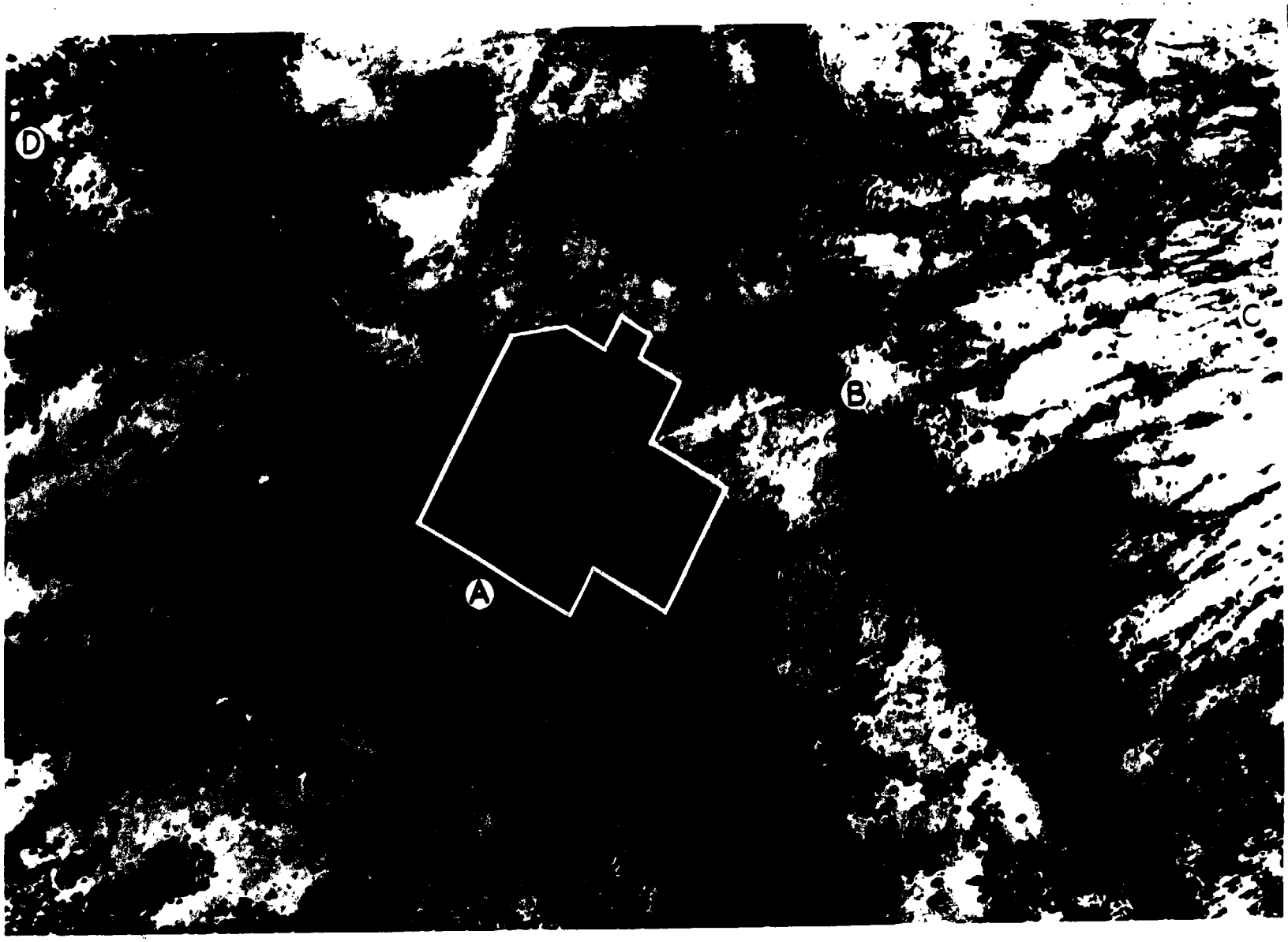


Fig. 1. Aerial view of Rocky Flat; A, location of camp; B, C, and D, points of release in homing experiments

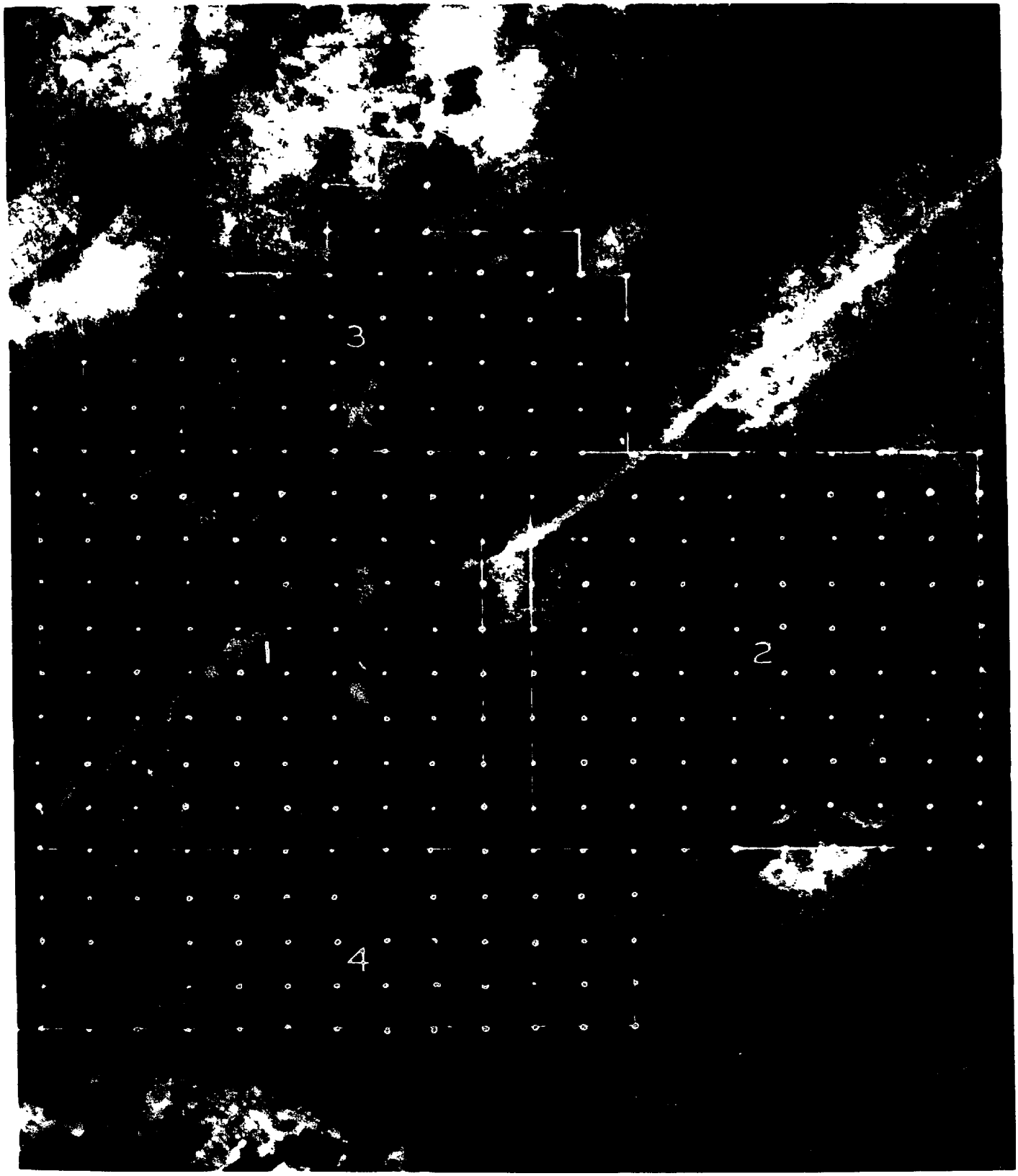


Fig. 2. Aerial view of the study area, showing trap locations and division into plots



Fig. 3. Typical view of the study area, center of Plot 1

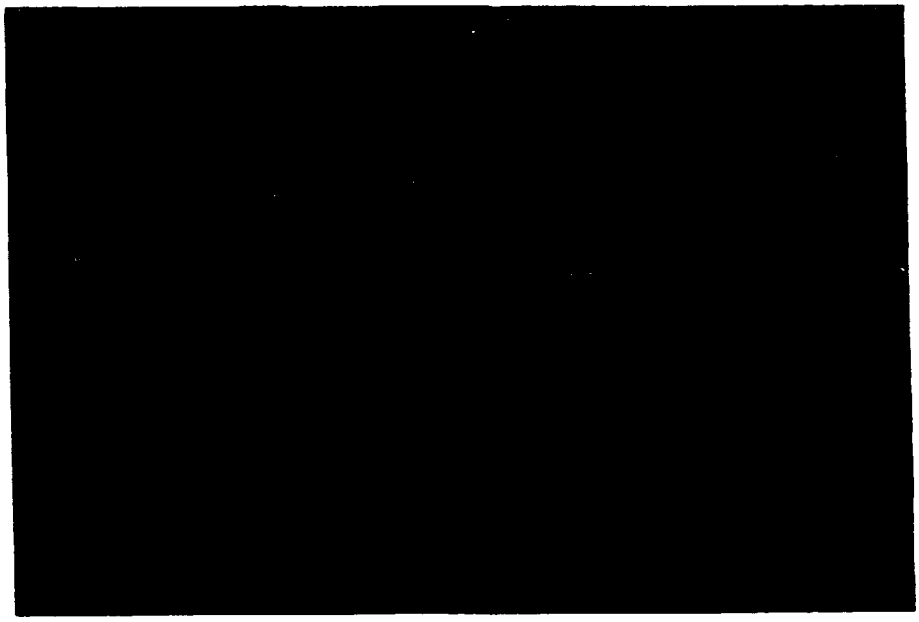


Fig. 4. Densely wooded slope, Plot 4



Fig. 5. Rocky ground, Plot 1



Fig. 6. Favorite log pile of ♀ 101

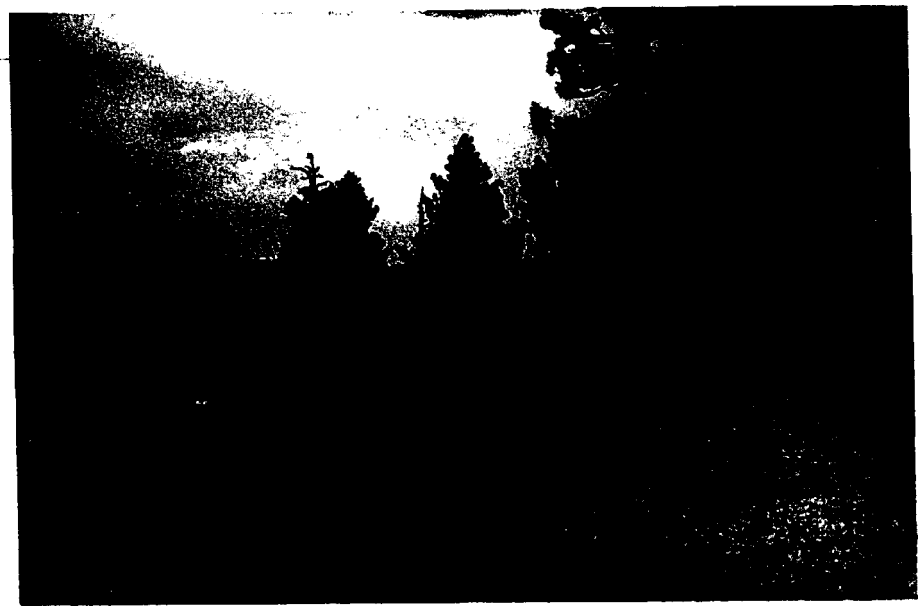


Fig. 7. Eastern boundary of study area

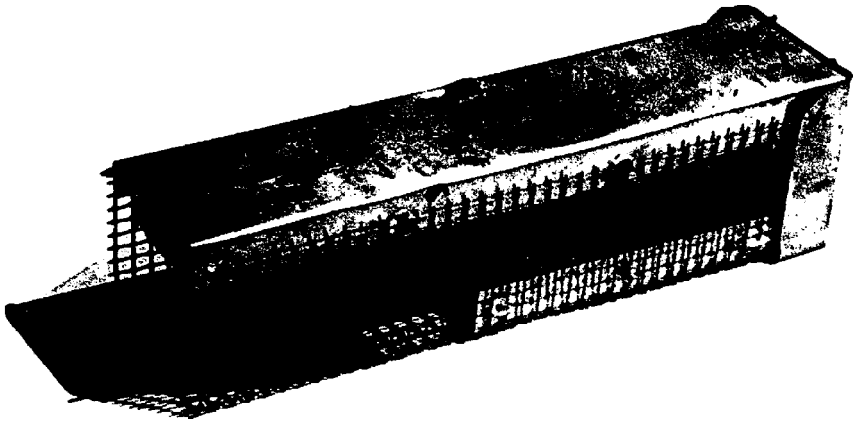


Fig. 8. Live trap used in this study

HOME RANGES

One of the main purposes of my work was to determine home ranges and territories of individual chipmunks. The term "home range" has usually been defined as that area visited by an individual in its normal activities (Burt, Blair, Dice, Noble, Seton, etc.). This does not include permanent range shifts and migration. "Territory" is the defended part of the home range.

Method:

Home ranges may be studied by direct observation of the animals themselves, or by live-trapping. Seton (1929) contributed a great deal to our knowledge of this phase of the natural history of many mammals by observation of individuals. Trapping methods have been developed in recent years, since the early experiments of M. S. Johnson (1926) and B. W. Johnson (1927) with marked mice. One of the advantages of using traps is that they produce quantitative data, but the information gained from trapping must be interpreted with care because various factors, such as mortality and the presence of transients, complicate the picture of ranges obtained in this way. Furthermore, there is still no standard method of delimiting the boundaries and calculating the sizes of ranges. Mohr (1947) has pointed out the difficulty of comparing the results of one worker with those of another when different systems have been used.

An excellent summary and analysis of methods used in calculating home ranges is given by Hayne (1949), who emphasizes the importance

of differing degrees of intensity of use of the various parts of the home range in the determination of its absolute size. He outlines a method for calculating the hypothetical center of activity and points out that trapping results may be stated in terms of the distribution of captures about this center. The mathematical probabilities of capture at various distances from the center of the range are discussed.

Hayne states (p. 16) that "The phenomenon of the trap-revealed home range area increasing rapidly for the first few captures and apparently 'leveling off' with further captures has previously been explained solely on the assumption that the animal has reached the absolute limits of its home range. However, a similar tendency might result from the mechanics of trapping, and therefore observation of this phenomenon is not in itself proof that such absolute limits have been revealed." According to Hayne (p. 15), the "home range, as revealed by trapping, may be described as an area over which the animal enters traps with greater or lesser frequency according to the location of the traps." He further states that the relationship between true home range and trap-revealed range is especially in need of experimental analysis.

The chipmunk was made the special subject of my work because I believed that the validity of the trapping method in determining ranges might be checked fairly easily by direct observations of this species.

Burt (1940) delimited home ranges by drawing boundary lines halfway between the traps in which an individual was captured and those in which it was not, so as to encompass as small an area as possible. Haugen (1942) used a similar method, but his ranges were outlined more geometrically.

Blair (1942) connected the outlying grids by straight lines in such a way that ranges which might be "U-shaped" would be unduly large. If the assumption that most ranges are approximately circular is correct, this method possibly would not exaggerate their size.

Dalke (1942) used what has been called the "minimum home range" system (Mohr, 1947), in which the out-lying points of capture and not grids are connected by straight lines. The disadvantage of this system is that a row of captures would be represented by a straight line rather than a certain area.

Mohr (1947) concluded that spacing of traps is an important factor in calculating size of range and held that the small grid system is more likely to give a correct estimate than is a large one. This assumption is one that is open to question and needs support by experimental evidence (Hayne, 1949).

Although the area of range may vary somewhat with the distance between traps when the grid system is used, it seems to me that this method has theoretical and practical advantages over the minimum home range method. Of course, if traps are too close together the normal movements of the animal may be restricted too much. The spacing should probably be such that the different points of capture will reveal the approximate shape of the range. The distance of eighty feet between traps seemed quite satisfactory for chipmunks.

Number of captures needed:

It is important to know the smallest number of captures which will show the complete range of an individual. Haugen (1942), working with cottontails, plotted the number of captures against the size of range and found that the curve levelled off at about ten captures.

He assumed that the range of a cottontail would be adequately recorded with that number of captures. His traps were spaced 110 yards apart. Blair (1942) used only those chipmunks (Tamias striatus) which had been caught ten or more times in calculating the sizes of their home ranges.

The element of time must also be considered because the range may shift.

In order to form an idea of the approximate number of captures which should reveal the range for any given period, I chose those ranges that appeared to be complete (i.e., had reached a point at which the increase in size slowed down). Then I sorted these ranges into four or five size groups by sex and age and plotted curves for each group to show how much of the complete range was revealed by different numbers of captures. The curves begin with five captures. At that point a certain fraction of the range is shown, and with more captures an increasing percentage of the range is obtained. I found that the smaller the range, the fewer were the number of captures needed to show that range. For example, it took only 7.5 captures to obtain three quarters of the area of adult female ranges in the smallest size group. Just on the basis of probability this is to be expected (Hayne, 1949). Average curves for males and females appear in Figure 9.

It seems reasonable to me to assume that ranges at the 75 per cent point or higher should be used in calculating the sizes of ranges. Thus, twelve or thirteen captures should on the average give most of the range of a female, and twenty captures, the range of a male. This difference between the sexes is to be expected because males have larger ranges than females.

Fig. 9a, Number of captures needed to reveal home ranges of adult female chipmunks. Ordinates are per cent of the complete range; abscissas, the number of captures

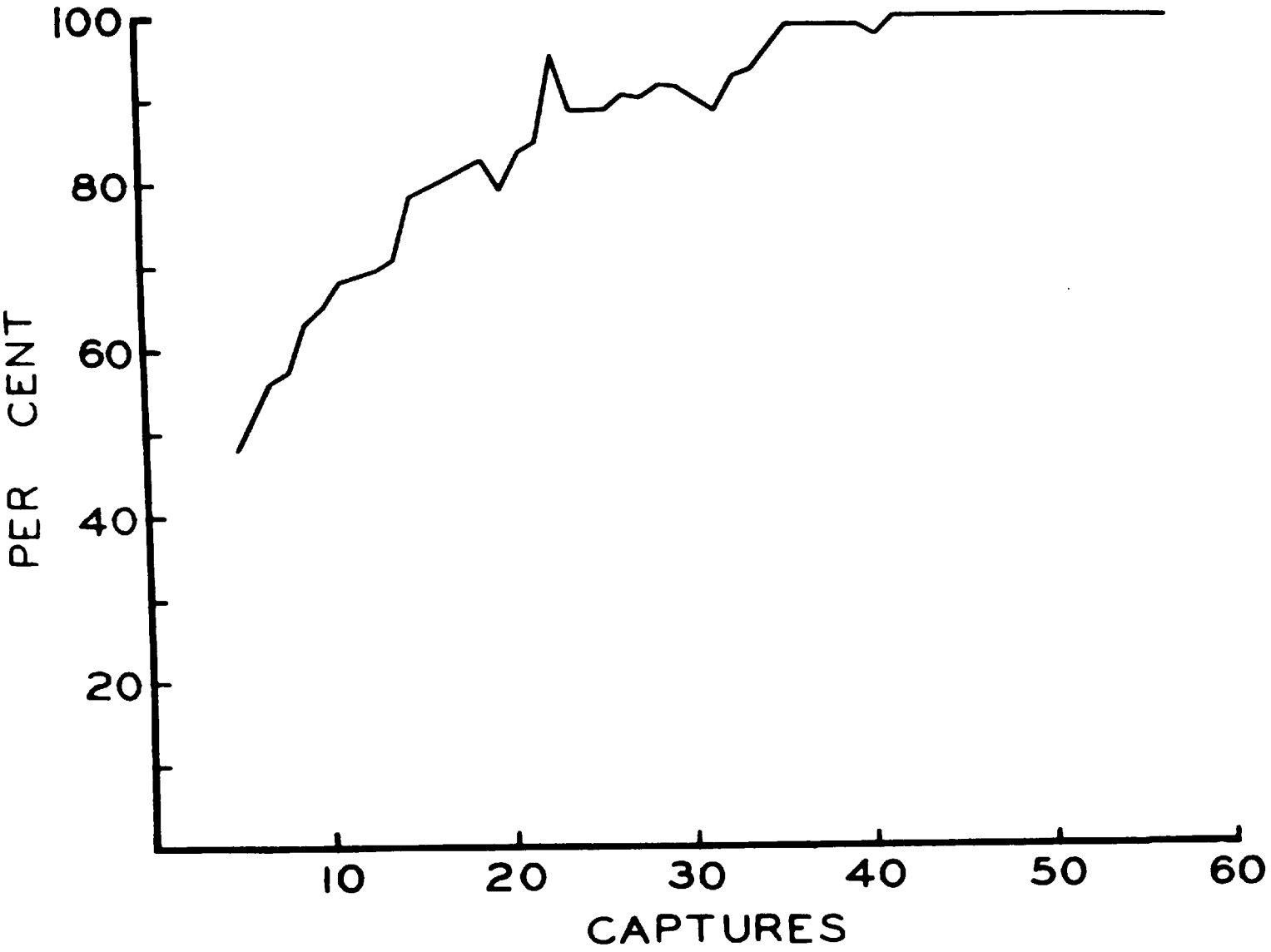
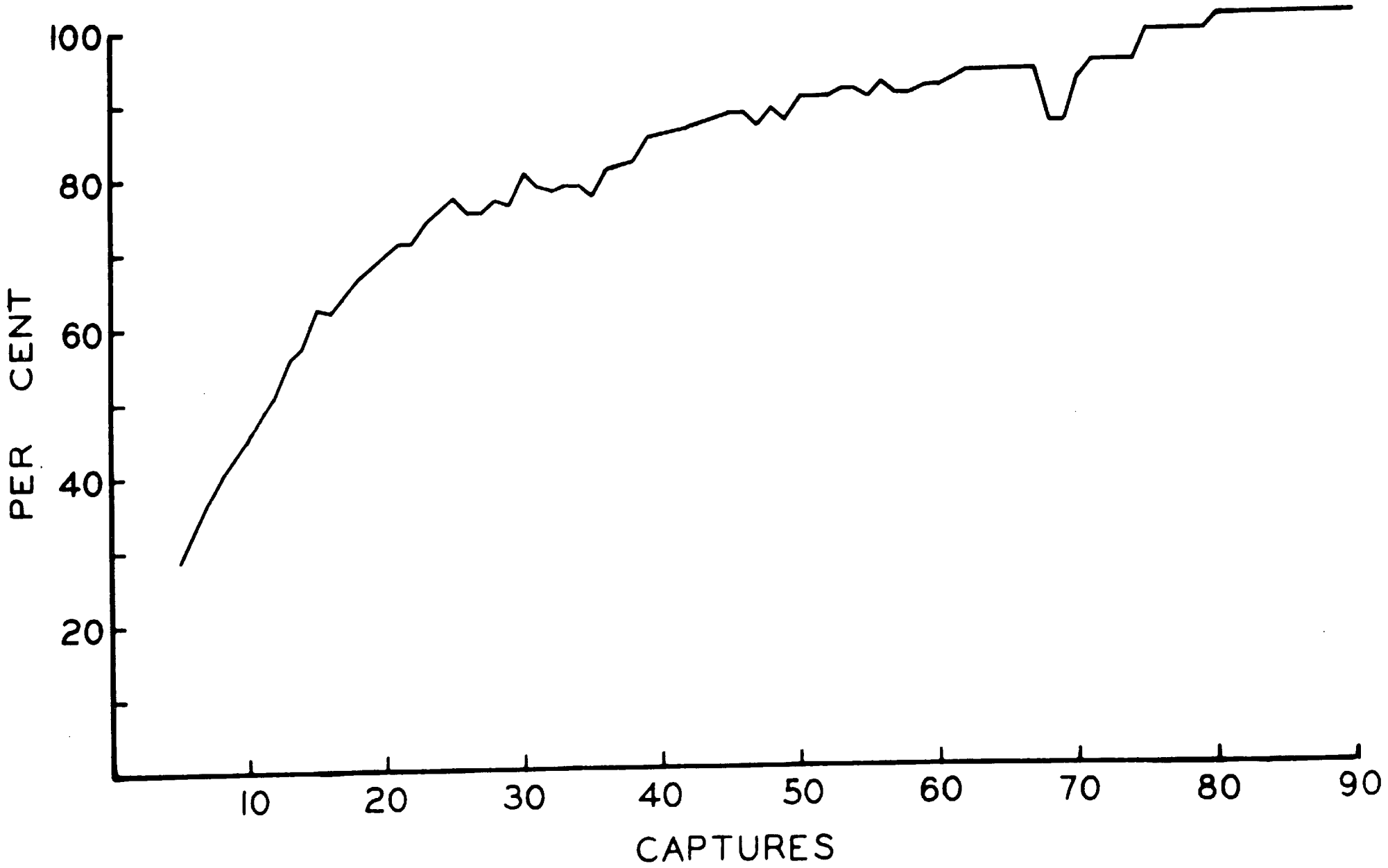

100
80
60
40
20
PER CENT
10
20
30
40
50
60
CAPTURES

Fig. 9b. Number of captures needed to reveal home ranges of adult male chipmunks. Ordinates are per cent of the complete range; abscissas, the number of captures


100
80
60
40
20
PER CENT
10
20
30
40
50
60
70
80
90
CAPTURES

Theoretically, as the trap-revealed range increases in size, the chances that the animal will be caught at greater distances from the center of activity will decrease. Evidence from observed animals which bears on this matter of intensity of use of different parts of the range will be discussed later.

Shapes of ranges:

The shapes of chipmunk ranges are quite variable. Many of them have an irregular amoeboid form with irregular "pseudopodia" projecting out in different directions, but a few are nearly circular and some are elongate. In a strictly uniform habitat, possibly the ranges would be circular if there were no territorial defense. The habitat is not uniform, however. Some of the environmental factors which vary within the area occupied by individual chipmunks are: (1) protective cover, such as trees, logs, bushes; (2) location of plants which provide food at the time; and (3) desirable routes of travel, such as logs, which may appeal psychologically, as well as protect the animals from predators.

Sizes of ranges:

I have used essentially the same method as Burt (1940) in calculating the areas of individual ranges; i.e., I added together the trap units included within the boundary line of each range. (One unit is an area eighty-three feet square, or 6889 square feet.) Burt does not include within the home range occasional sallies away from the usual home area. However, I have included all points where an individual was captured in the home range, even if this meant adding a long strip of ground in order to connect a distant point to the main part of the range. This plan was adopted because of the frequency of such records

in the case of chipmunks. The strips connecting distant captures to the range were eighty-three feet wide. A clear piece of cellophane marked off in a grid the same size as that of the home range map was of help in calculating the areas of strips which lay diagonally across trap rows. The areas were calculated to the nearest half unit.

The average range for all females was 2.25 acres in 1946 and 2.36 in 1947 (Table 1). Males averaged 3.80 in 1947. I have not given the figures on 1946 male ranges because I believe that the trap area at that time was not quite large enough for them.

There was no significant difference between the ranges of adults and young. The average for the young females was slightly greater than that for adult females, while young males averaged slightly less than adult males.

Seasonal ranges:

The sizes of ranges vary from season to season (Tables 2, 3, and 4). When I calculated the spring, summer, and fall ranges separately, the number of individuals with enough captures (twelve or more) in each period was small, but the averages seem to indicate that the ranges in summer are larger than they are in either the spring or fall (Fig. 15).

Diameters:

The maximum diameters of the ranges were measured to give an idea of the greatest distances traveled by individuals and to provide a check on seasonal variations in range size. The data is summarized in Table 5. In all cases, the diameters were greater in the summer than in the spring or fall. It seems evident from trap records that the season of greatest movement is in the summer.

Fig. 10. Home range of an adult female. The size of her range (2.15 acres) is approximately the average size of range for all adult females in 1947

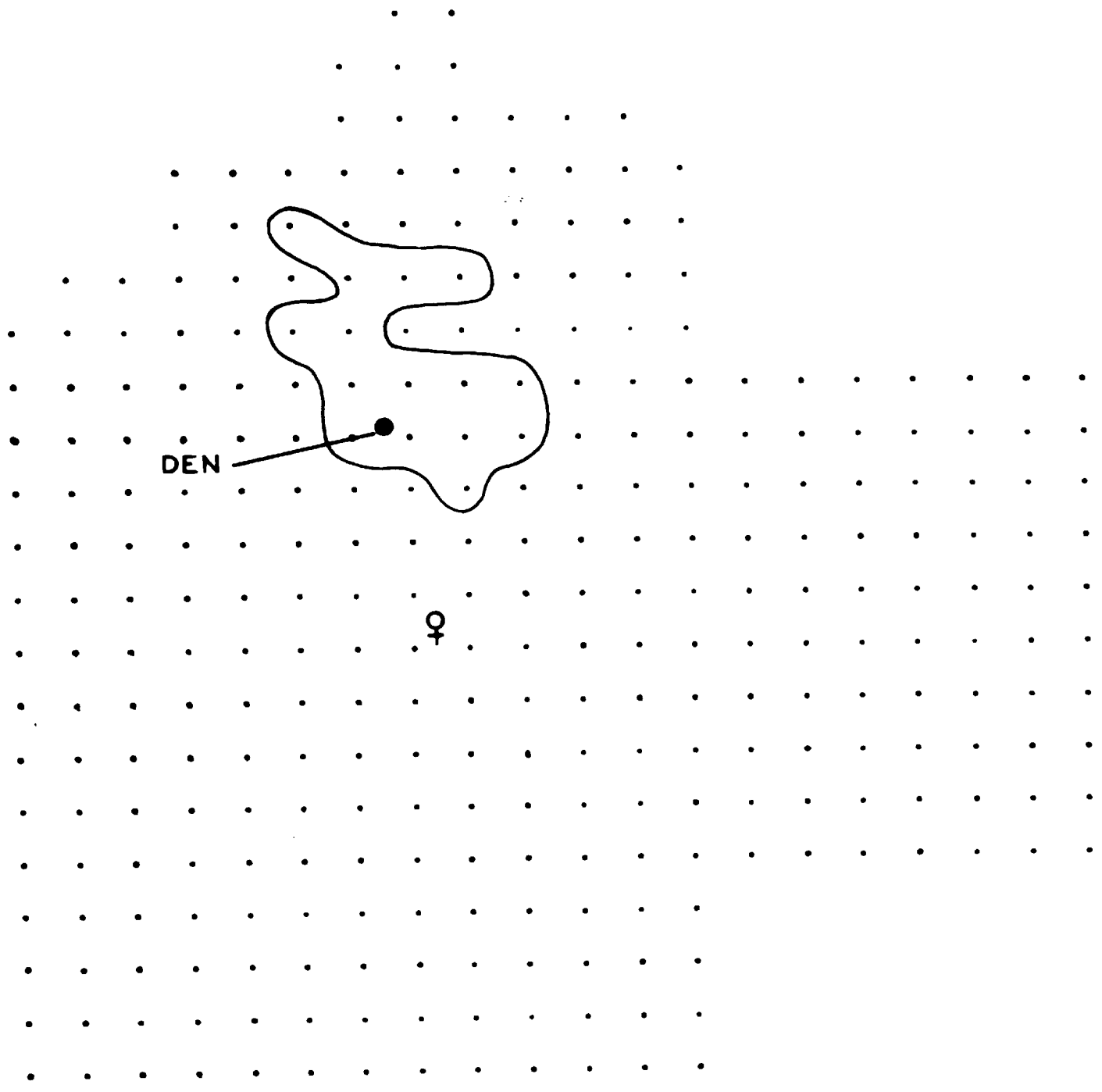

DEN
♀

Fig. 11. Home range of an adult male. The size of his range (4.05 acres) is approximately the average size of range for all adult males in 1947

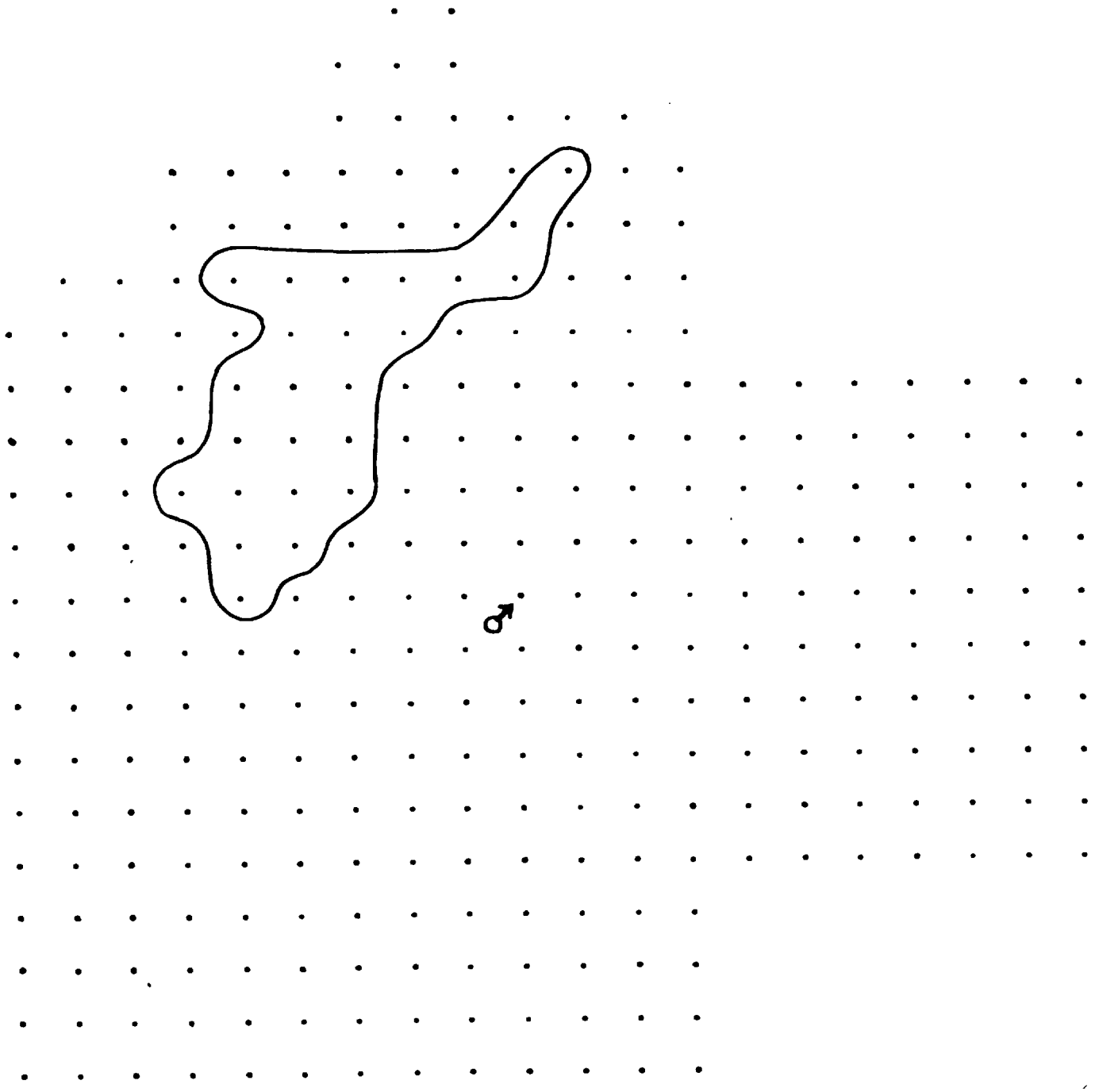


Fig. 12. The 1947 home ranges of two adult females showing their dens and calculated centers of activity. Numbers represent captures in each trap

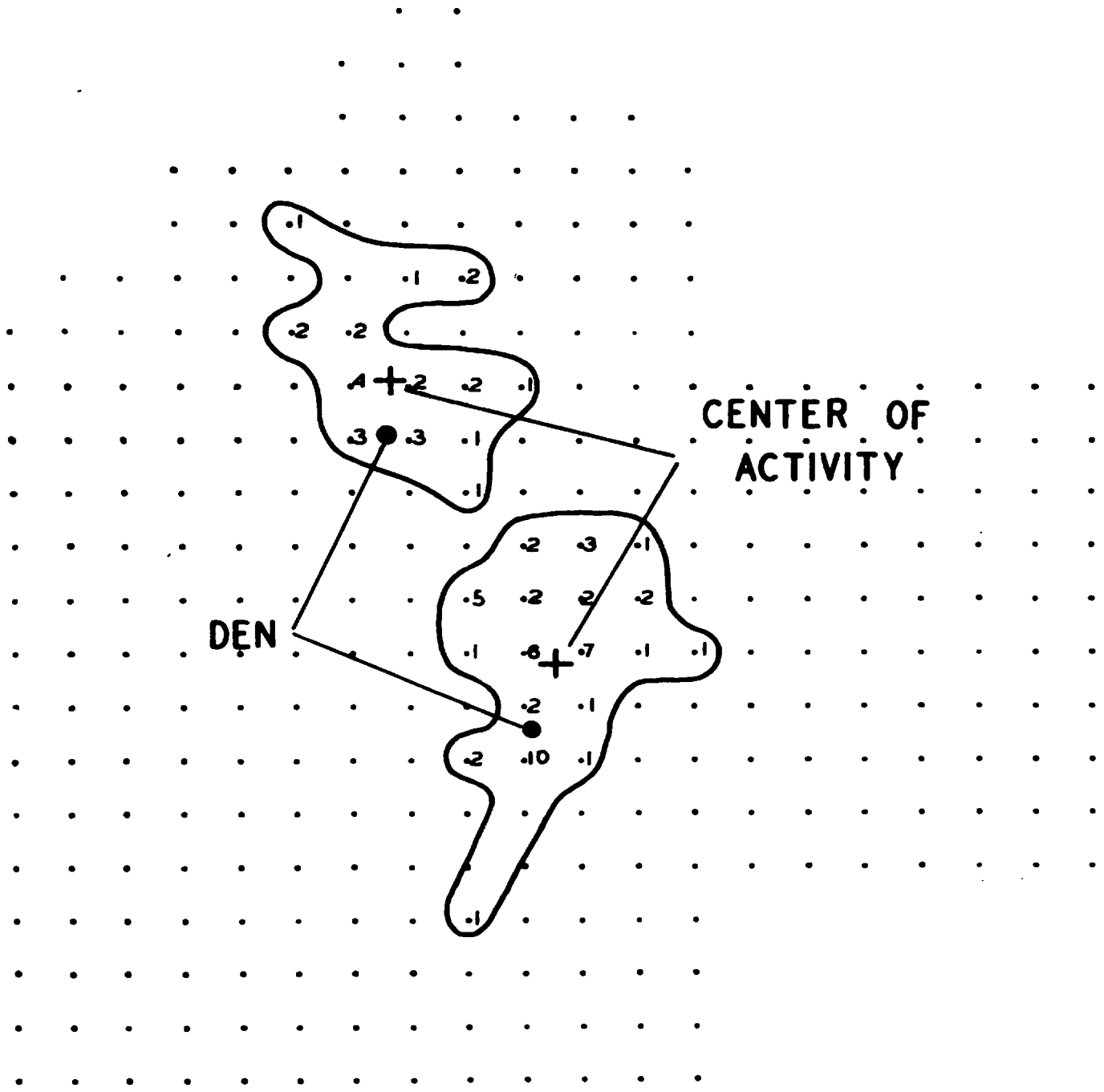

CENTER OF ACTIVITY
DEN

Fig. 13. The 1947 home range of an adult male showing his den and calculated center of activity. Numbers represent captures in each trap

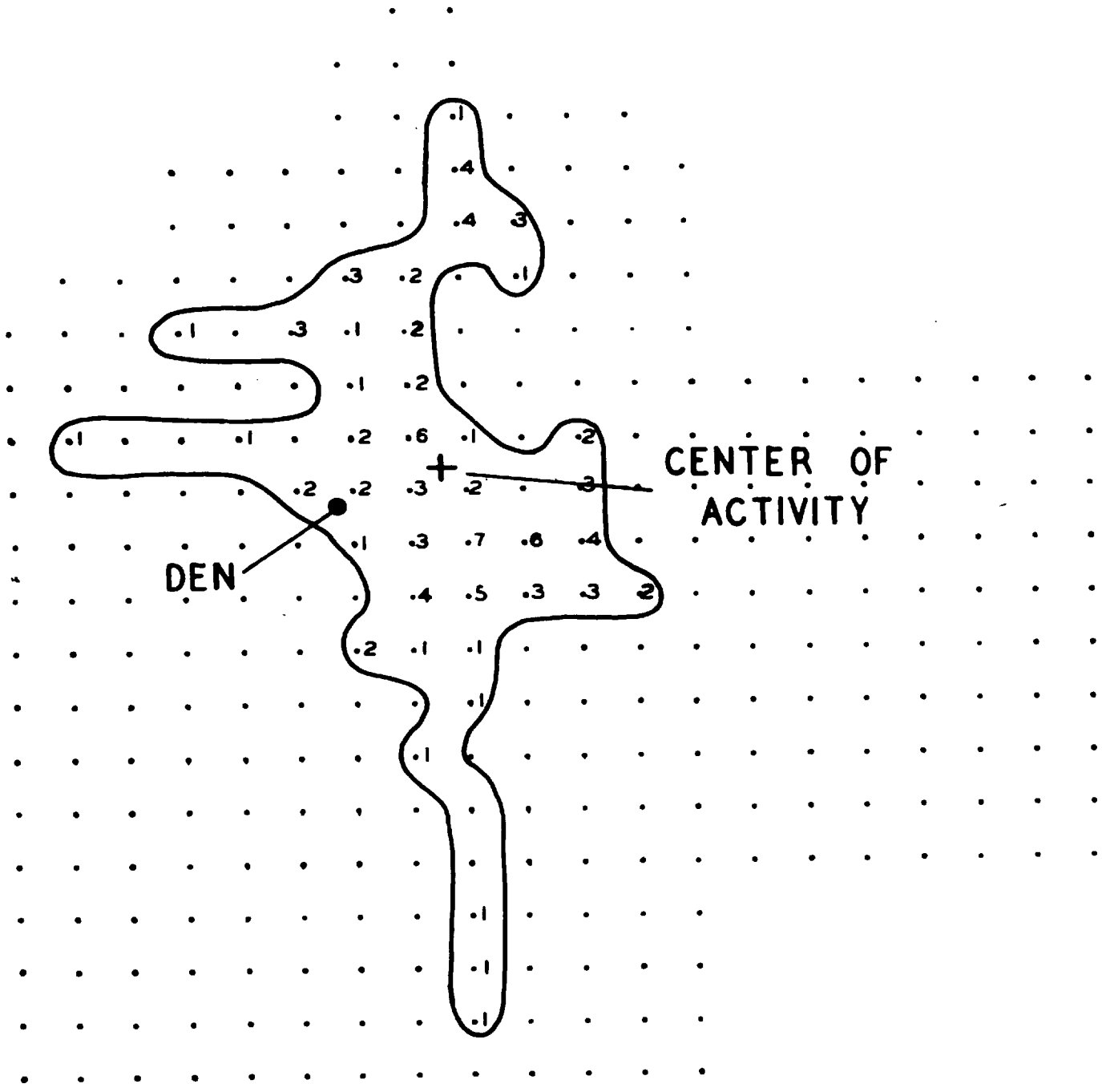

CENTER OF
ACTIVITY
DEN

Fig. 14. The 1946 and 1947 home ranges of an adult female. Broken line for 1946 and solid line for 1947

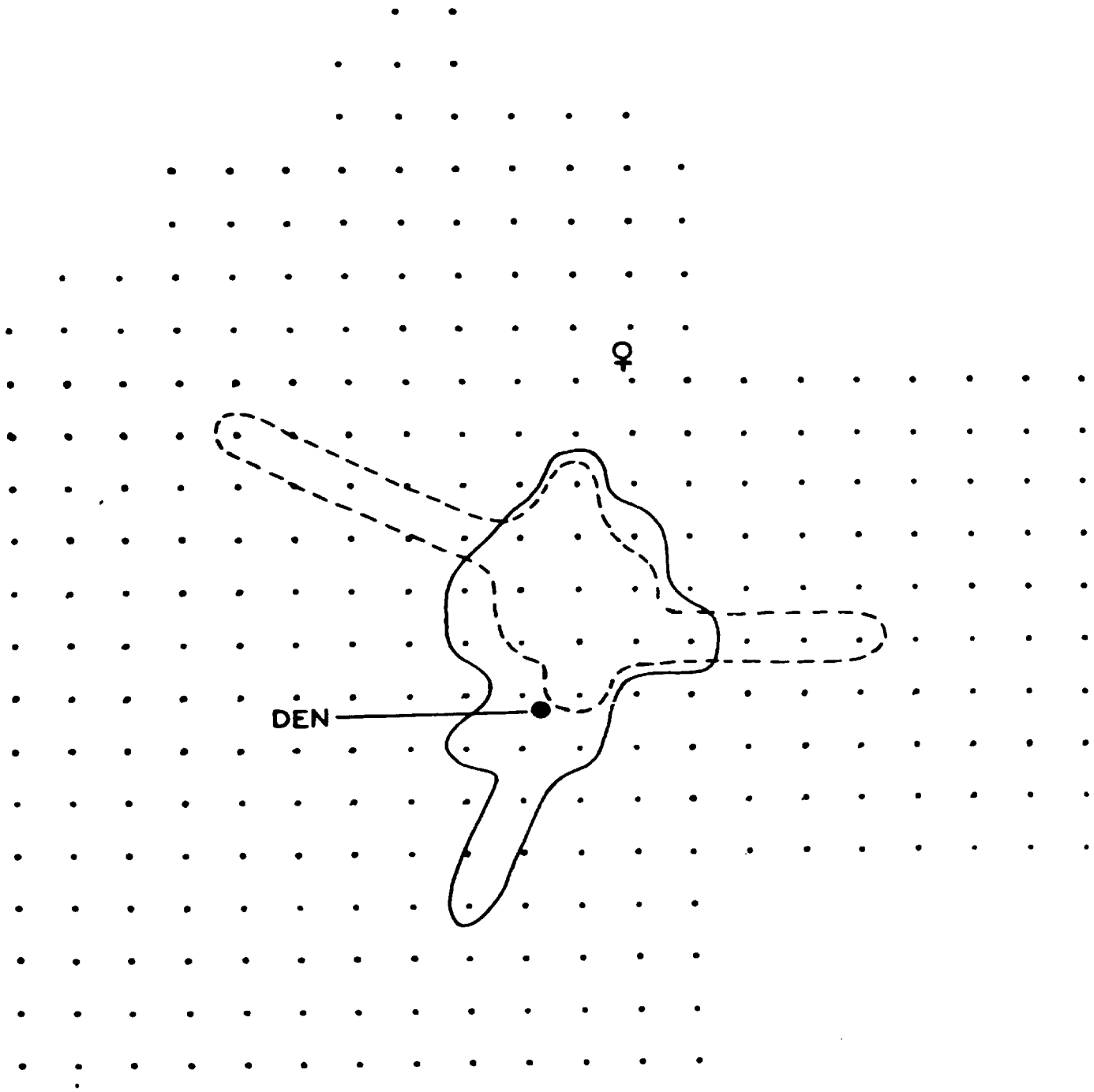

♀
DEN

Table 1

Home ranges of chipmunks for the period July 15 to November 13, 1946 and May 1 to October 30, 1947

Sex and age	Number of individuals	Average number of captures	Average sizes (acres)	Standard deviations (acres)	Extreme sizes (acres)
1946					
Adult and Young ♀♀	18	24.0	2.25	0.77	1.27 - 3.63
1947					
Adults					
♀	25	26.2	2.15	0.76	1.11 - 4.03
♂	23	42.0	4.05	1.91	1.74 - 8.07
Young					
♀	21	28.1	2.51	1.01	1.27 - 5.61
♂	10	27.3	3.19	1.19	1.58 - 5.53
All ♀♀	46		2.36		
All ♂♂	33		3.80		

Table 2

Home ranges of female chipmunks in 1946 by seasons. Number of captures per individual is 13 or more; adults and young are grouped together

Trapping period	Number of individuals	Average number of captures	Average sizes (acres)	Extreme sizes (acres)
July 15 - Sept. 6	8	17.1	2.04	1.42 - 4.11
Sept. 10 - Oct. 30	8	20.0	1.95	1.27 - 3.63

Table 3

Home ranges of female chipmunks by seasons in 1947

Trapping period	Number of individuals	Average number of captures	Average sizes (acres)	Extreme sizes (acres)
Adults				
May 1 - July 12	13	18.4	1.91	1.11 - 5.38
July 15 - Sept. 6	9	17.3	1.57	0.95 - 2.37
Sept. 10 - Oct. 30	....	....	....	....
Young				
May 1 - July 12	....	....	....	....
July 15 - Sept. 6	9	21.9	2.67	1.11 - 5.38
Sept. 10 - Oct. 30	13	18.9	1.84	0.79 - 3.24

Table 4

Home ranges of male chipmunks by seasons in 1947. Number of captures per individual is twenty or more

Trapping period	Number of individuals	Average number of captures	Average sizes (acres)	Extreme sizes (acres)
Adults				
May 1 - July 12	6	28.8	3.45	1.27 - 6.01
July 15 - Sept. 6	8	28.1	4.55	4.11 - 6.80
Sept. 10 - Oct. 30	4	22.5	3.46	2.14 - 4.74
Young				
May 1 - July 12	....	....	....	....
July 15 - Sept. 6	3	20	3.64	3.19 - 4.41
Sept. 10 - Oct. 30	4	20	2.97	4.11 - 3.95

Fig. 15. Graph showing seasonal home range sizes for 1947; bars with diagonal lines represent adults; the clear bars, young

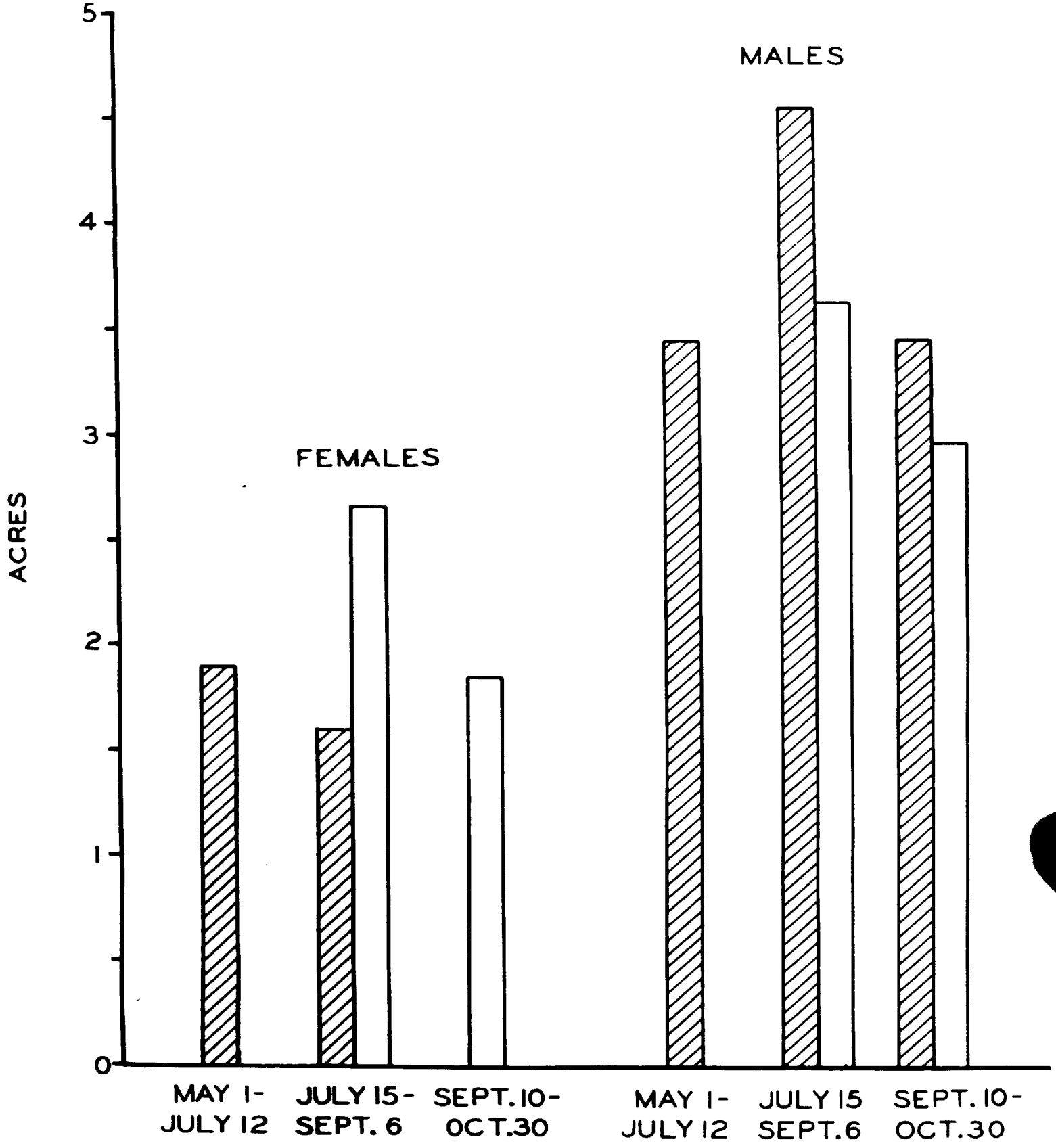

5
4
3
2
1
0
ACRES
FEMALES
MALES
MAY 1-
JULY 12
JULY 15-
SEPT. 6
SEPT. 10-
OCT. 30
MAY 1-
JULY 12
JULY 15
SEPT. 6
SEPT. 10-
OCT. 30

Table 5

Greatest diameters of female home ranges in 1946; number of captures per individual, twelve or more; two of the ranges touched the border of the trap area

Trapping period	Number of individuals	Average number of captures per individual	Average of greatest diameters (feet)	Extremes (feet)
July 15 - Aug. 30	8	17.1	504	264 - 683
Sept. 9 - Nov. 13	8	20.0	450	264 - 839

Table 6

Greatest diameters of female home ranges in 1947; number of captures per individual, twelve or more

Trapping period	Number of individuals	Average number of captures per individual	Average of greatest diameters (feet)	Extremes (feet)
Adults				
May 1 - July 12	14	18.4	453	268 - 839
July 15 - Sept. 6	9	17.3	418	268 - 683
Sept. 10 - Oct. 30	....	....	....	....
Young				
May 1 - July 12	....	....	....	....
July 15 - Sept. 6	10	19.5	719	234 - 1571
Sept. 10 - Oct. 30	13	19.1	408	254 - 996

Table 7

Greatest diameters of male home ranges in 1947: number of captures per individual, twenty or more

Trapping period	Number of individuals	Average number of captures per individual	Average of greatest diameters (feet)	Extremes (feet)
Adult				
May 1 - July 12	6	28.8	740	273 - 1249
July 15 - Sept. 6	8	28.1	1024	536 - 1337
Sept. 10 - Oct. 30	4	22.5	844	488 - 1279
Young				
May 1 - July 12	....	....	....	....
July 15 - Sept. 6	3	20.4	1178	1074 - 1337
Sept. 10 - Oct. 30	4	20.0	740	449 - 966

Shifts:

Most of the animals were repeatedly caught in rather clearly defined areas, but a few individuals apparently shifted their ranges during the study period. Of sixty-four females captured in both 1946 and 1947, five (7.8 per cent) were taken in new areas in the second year. Seven (11.86 per cent) of the fifty-nine males caught in both years shifted ranges from 1946 to 1947.

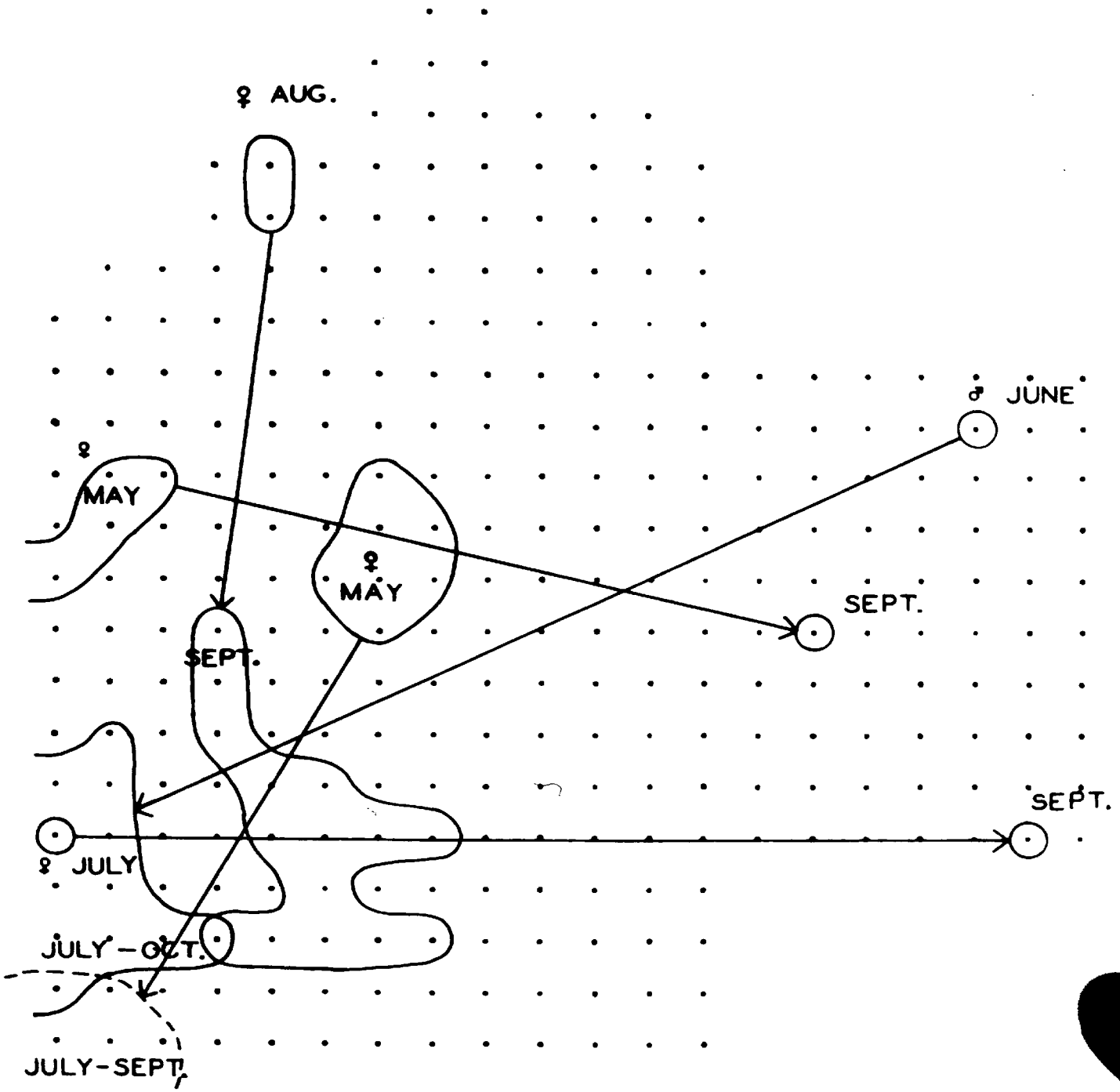
Observed ranges:

In order to check on the validity of trap ranges and trapping technique in general, I marked individual chipmunks and followed them about. Their movements were plotted on maps with the trap locations marked on them, in order that observed ranges could be compared with trap-revealed ranges.

There are several good ways by which one can mark chipmunks to enable identification of individuals at a distance. Clipping of the hair on the sides and rump is a fairly good method because the black underfur exposed by shearing stands out well against the surrounding colors, but these marks are limited to a rather small number.

Dyes are easily applied and are more practicable than clipping, both from the standpoint of visibility and because a larger number of individuals may be marked. I had the most success with a black dye, Nyanzol A, obtained from the Nyanza Color and Chemical Company, 215 Water St., New York 7, New York. This dye was suggested to me by W. D. Fitzwater, Jr., who has used it with success in experiments on the red squirrel (1943). In my experience with chipmunks and ground squirrels, it was very satisfactory because of ease of application, visibility, and permanence. A stock solution may be prepared easily by dissolving

Fig. 16. Diagram showing shifts of ranges of adult chipmunks in 1947


♀ AUG.
♂ JUNE
♀
MAY
♀
MAY
SEPT.
SEPT.
SEPT.
♀ JULY
JULY – OCT.
JULY-SEPT.

about twenty grams of the dye in a quart of warm water. The dye may be mixed with peroxide in the ratio of two to one just before it is used, or the two can be applied separately. The mixed solutions weaken rapidly with oxidation, so I discarded them when they were one-half hour old.

When running my live trap lines, I usually carried one vial with dye and another with peroxide and mixed them in a third vial when the desired individuals were captured.

The simplest way to handle a chipmunk or ground squirrel is to grasp the animal firmly around the body with one hand and brush on the dye with the other. Gloves should be worn as protection against teeth as well as dye. If the back is to be colored, it is convenient to grasp the animal by the base of the tail and allow him to pull away from you on a log or on the ground, while applying the dye. He usually tries to escape rather than bite the hand that holds him.

Only black dye was used and with the one color several dozen patterns could be distinguished. Considerable care was necessary in applying the dye to prevent smearing unwanted parts. I wanted to be able to identify the sex of any dyed animal at a glance, so I marked the noses of males and the cheeks of females.

The lasting quality of this dye is good. The fur of a chipmunk colored on November 13, 1946, and recaptured five months later on April 30, 1947, was still black. The fall molt of this animal was complete before he was marked. Thus, the persistence of the dye proved that no molt occurred during the winter.

The occurrence of two molts in the summer and fall caused some difficulty in keeping chipmunks marked properly. They had to be re-dyed

several times when they were molting. There is a definite molt sequence from front to rear in the summer and the reverse direction in the fall; with this knowledge one could place the identifying marks on areas that would not change in the near future and thus save the time and trouble of an extra application of the dye.

Even though the black marks are conspicuous at a considerable distance, it is surprising how easily a chipmunk can elude an observer and disappear, even in an open woods.

I watched three dyed females and three males repeatedly from May to November, 1947. Table 8 lists twenty-four observations. Ten of the periods were over an hour long, and the longest was four hours.

Only one chipmunk (♀ No. 101) traveled outside its trap range during these observations. I saw her eighty feet beyond her range on July 28, 540 feet beyond on August 1, and 615 feet beyond on August 2, 1947. The fact that she was outside her normal range at that particular time indicates a greater tendency to wander in the summer. This evidence confirms trapping data which show larger ranges and greater movements (diameters of ranges) in the summer than in spring or fall.

In view of the fact that I saw a chipmunk go beyond the boundaries of its trap-revealed range in only three out of twenty-four observations, it seems to me that trap data give a fairly accurate picture of the actual range sizes. Observed movements or ranges superimposed on the trap ranges conform very well (Figs. 17 and 18).

Foraging often is done in a fairly systematic way. Frequently the route leads out from the den or favored refuge in what approximates the arc of a circle the size of the range. In the short period of an hour a chipmunk may visit a large part of its home range. For example,

in one instance an animal reached the eastern, western, and southern boundaries of its range during the course of a single two-hour trip. Thus, the theory that the probability of capture is least at the edge of a range may not be true.

From my records of distances traveled by chipmunks in certain lengths of time, I was able to calculate the approximate speed of normal travel in such activities as foraging. There appears to be considerable difference between males and females. Males traveled more than twice the distance that females did in the same length of time. The average distance that an individual moved in one hour, calculated from all animals observed, was 634 feet. Data on rate of travel are summarized in Table 9.

Table 8

Data on the travels of observed chipmunks

Animal observed	When observed Date	When observed Hours	Time of observation Hours	Time of observation Minutes	Approximate distance traveled (feet)	Remarks
♀ 41	July 2	1000-1044		44	250	Within trap range
♀ 41	July 3	1005-1052		49	...	Within trap range
♀ 61	May 28	535-715 pm	1	40	640	Within trap range
♀ 61	May 29	810-1100	2	50	1500	Within trap range
♀ 61	July 21	851-930		39	840	Within trap range
♀ 61	Sept. 18	915-950		35	250	Within trap range
♀ 61	Sept. 18	115-130		15	490	
♀ 101	May 31	744-920	1	36	690	Within trap range
♀ 101	June 9	922-122	4	00	930	Within trap range
♀ 101	June 21	855-1020	1	15	820	Within trap range
♀ 101	June 30	1000-1130	1	30	?	Within trap range on favorite log pile
♀ 101	July 3	1040-1045		05	...	Within trap range
♀ 101	July 28	914-1145	2	31	1170	80 ft. southeast of range when lost

Table 8 (continued)

Data on the travels of observed chipmunks

Animal observed	When observed Date	Hours	Time of observation Hours	Minutes	Approximate distance traveled (feet)	Remarks
♀ 101	Aug. 1	700-705 pm		05	...	600 ft. east of range
♀ 101	Aug. 2	evening		05	...	550 ft. east of range
♀ 101	Aug. 11	924-1157	2	33	930	Within trap range
♀ 101	Sept. 18	1240-156	1	16	100	Within trap range
♀ 101	Sept. 22	1140-1210		30	40	Within trap range
♂ 223	Nov. 13	1058-1115		17	280	Range unknown
♂ 250	July 21	1005-1130	1	25	1760	Within trap range
♂ 250	Oct. 25	1150-1237		47	930	Within trap range
♂ 530	Nov. 6	1135-1216		41	840	Range unknown
♂ 530	Nov. 6	1220-114		54	1170	Range unknown, traveled 250 ft. from den
♂ 530	Nov. 9	1050-1145		55	440	Range unknown, traveled 120 ft. from den

Fig. 17. Diagrams of the observed movements of an adult female plotted against her trap range: A, 7:44–9:20 A.M., May 31; B, 9:22 A.M.–1:22 P.M., June 9; C, 8:55–10:20 A.M., June 21; D, 9:14–11:45 A.M., July 28; E, 9:24–11:57 A.M., August 11; F, 12:40–1:56 P.M., September 15 and 11:40 A.M.–12:10 P.M., September 22. Heavy black dot indicates location of den

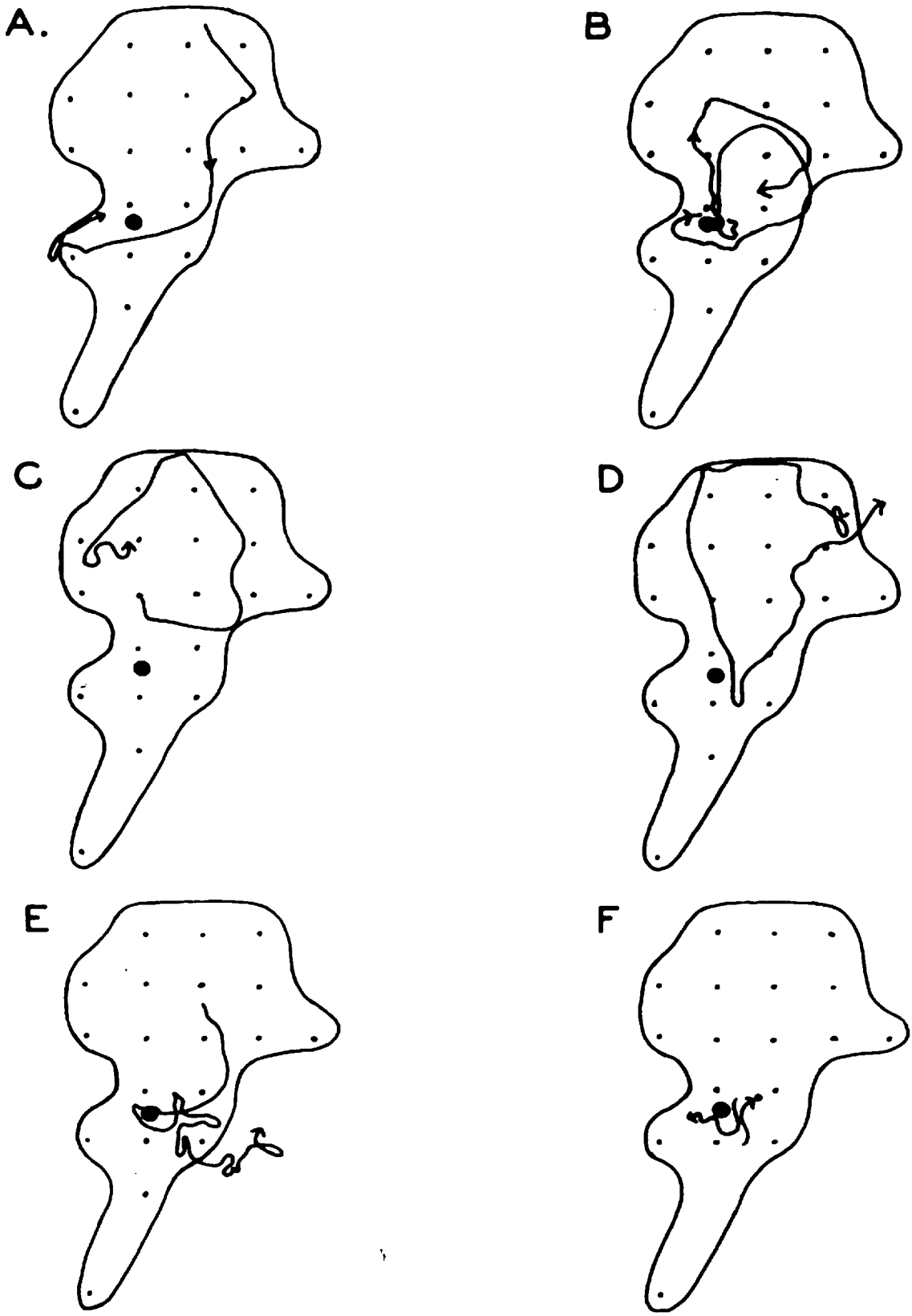

A.
B
C
D
E
F

Fig. 18. Diagrams of the observed movements of an adult male plotted against his trap range; A, 10:05-11:30 A.M., July 21; B, 10:50 A.M.-12:37 P.M., October 25. Heavy black dot indicates location of den

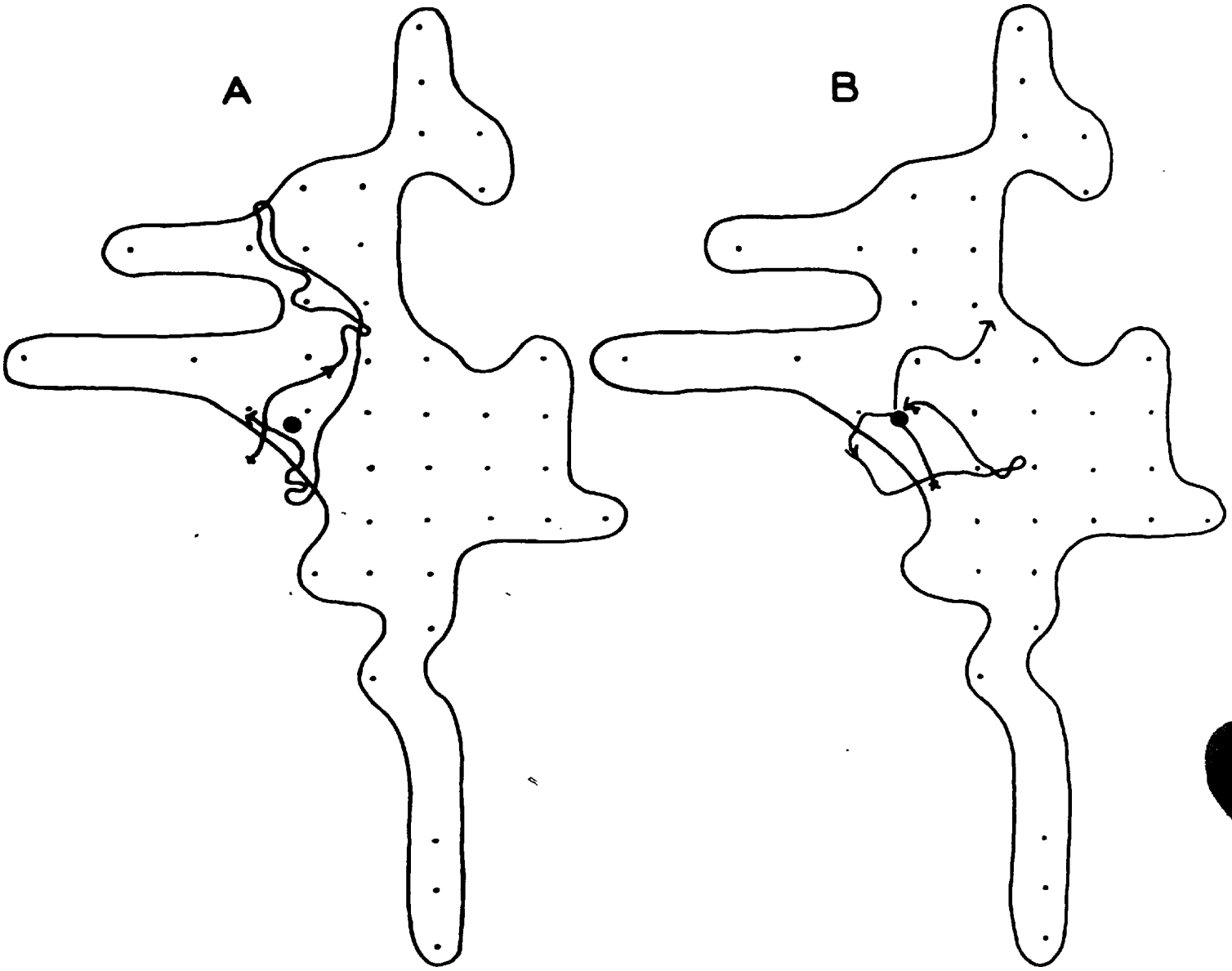

A
B

Table 9

Rate of travel in normal activities; figures based on observation of dyed chipmunks

Sex	Number of observations	Time observed (minutes)	Distance traveled (feet)	Distance traveled per minute	Distance traveled per hour
♀♀	13	1224	8650	7.07	424
♂♂	6	299	5420	18.13	1088

TERRITORY

That territorial behavior is a basic and widespread attribute of many kinds of animals (insects, fishes, reptiles, birds, and mammals) has been pointed out by a number of biologists (Burt, 1940, 1943, 1949; Elton, 1927; Evans, 1938; Heape, 1931; Howard, 1920; Nice, 1933, 1941). A study of this phenomenon in small mammals has been neglected until fairly recently when the development of live-trapping techniques opened up the possibilities for critical work on all kinds, including the nocturnal species.

In some kinds of animals territoriality is strongly marked and in others it appears to be little developed. The behavior of the two sexes also may differ considerably.

In most live-trapping studies the criterion of defended territory has been established on the assumption that ranges which do not greatly overlap are defended against intruders. This conclusion may be a valid one, but there is considerable room for differences of interpretation of trap records. For example, the method of calculating individual ranges (Burt, 1940; Blair, 1942) may give rise to divergent opinions on the matter of territory. The only way one can be certain of territoriality, as Burt (1943: 351) has said, is by direct observation.

Ornithologists have gone well beyond mammalogists in detailed studies of territorial behavior. Six different kinds of bird territory have been listed by Nice (1933, 1941) in her comprehensive

reviews of this subject. Nesting sites and food stores are commonly defended by small mammals, but we know little about the relationship of territory to home range, seasonal changes in behavior, and other details which have been worked out for a good many birds. Concerning these matters, we have no information whatsoever on many species of mammals.

Defense of territory is a conspicuous trait of some of the sciurids, but seems to be little developed in others. Gordon (1943: 62-63) observed one clear case of territorial defense in ground squirrels (Citellus lateralis chrysodeirus) during a three-year study of their behavior in Colorado and Oregon. A female that evidently was nursing at the time had her nest under a log pile and she did her best to drive away the dozen or so ground squirrels attracted by food that was placed there for the experiment. "She drove them off from any part of the pile where she met them, not alone from the food. Some of the chases were short; others were long and tortuous....She seldom followed them more than 20 or 30 feet from the logs. One day I counted 58 chases in 5 hours and 40 minutes. The same day she made 7 of the chases in 10 minutes. It was all vain effort. The lure of food was greater than fear of her. The area to which she thus laid particular claim was only a small one immediately around the log pile."

There is also good evidence that the eastern chipmunk (Tamias striatus) defends territory. Burt (1940: 44-45) watched an old breeding female and saw that "Although other chipmunks often invaded her territory, she invariably drove them away. Her protected area was about fifty yards in radius; beyond this fifty-yard limit around her nesting site she was not concerned. Her foraging range (i.e., home

range) was considerably greater than the protected area (territory) and occasionally extended 100 or more yards from her nest site. The territories held by members of this species apparently are smaller than the normal home ranges of the animals. The areas in which home ranges overlap are neutral and are not protected by any one individual."

The home ranges of all but the suckling adult females live-trapped by Blair (1942: 34) overlapped broadly. He concluded that it was possible that breeding females occupy home ranges from which other breeding females are excluded, but did not confirm his trap data with direct observation of the animals themselves.

There seems to be no really conclusive evidence that western chipmunks (Eutamias) defend part of their range. Storer, Evans, and Palmer (1944: 183) found that female Eutamias quadrimaculatus apparently had separate ranges with slight overlapping, while male ranges overlapped extensively and showed little sign of territoriality. However, they observed that males had cuts on their faces in the breeding season. Gordon (1943) does not mention territoriality in his study of the behavior of Eutamias quadrivittatus, minimus, and amoenus in Colorado and Oregon, but he describes social dominance among individuals which he marked and observed. He found that an elaborate kind of chase order with one individual on top of the pyramid was established among the dozen or so chipmunks competing for food at each camp. This type of competition is different from defense of territory, he explained. The latter kind of behavior involves protection of a certain area of the individual's range.

I obtained the best evidence of territoriality among chipmunks at Rocky Flat by observing a lactating female. Her den was at the base of a small pine tree about fifty feet from my tent, so I frequently watched her activities. On June 6, 1947, I saw her chase another chipmunk up the tree by her den, across one of its limbs into a larger pine, and then down to the ground. Loud chipping notes were uttered during the chase, which was a vigorous one that led the two animals about thirty feet away from the burrow. I knew something of the history of this female because she previously had been marked with black dye. She had a family at this time, but unfortunately a few weeks later her burrow was destroyed by some dogs and the young ones were killed.

I found evidence of territorialism in another lactating female (No. 101), whose trap- and observed-ranges were well known to me. She chased other chipmunks five times in a total of about fifteen hours of observation. All five of the pursuits took place at or near her favorite log pile (Fig. 6) about forty feet from her den. I first saw her chase another chipmunk (sex unknown) on June 9; the pursuit was a short and mild one. On June 21 she met a male at the same place. They sniffed each other on both cheeks for a few seconds, and then she gave a sharp call, "kwit kwit," and chased him off the logs. On August 12 she was feeding at the log pile when I saw her chase another chipmunk twice within two minutes for distances of five to ten feet. The stranger then voluntarily continued to move away from the spot. About forty minutes later she chased another animal away from the logs, uttering two "pert pert" calls. The other chipmunk gave a "tchip." I was too far away to determine the sexes of the unmarked

animals. All of the pursuits by female No. 101 were short and seemingly did not indicate any great excitement on her part.

On several other occasions female No. 101 met chipmunks on the opposite side of her range from the den and log pile, on ground that appeared to be neutral because the other animals were not pursued. Thus, on July 21 she met a lactating female (No. 41), and they foraged near one another for about ten minutes. Another breeding female was seen near her at the same place on June 30, and she met a third chipmunk on the east side of her range on July 28.

My impression from observations of the female at camp and female No. 101 was that defense of territory was probably limited to the area in the immediate vicinity of the den. But despite the fact that I watched these two animals (particularly female No. 101) closely for a number of hours, there is still a great deal that I do not know about their territorial behavior. For example, I was unable to define with any exactness the limits of the territory and neutral area within the home range. Perhaps it is not possible to do so, for territorial boundaries may not be rigid and precise. It seems more likely that they vary seasonally and with different individuals. It is quite possible that territorial habits might be modified by my presence, although chipmunks seemed to ignore me when I watched them quietly. If one were to observe them carefully for a considerable time from blinds or from such a distance that the animals would be undisturbed, more conclusive information on this matter should be gained.

The evidence for territorial behavior was negative in other marked animals that were observed. However, I watched them less often than female No. 101.

One of the chipmunks whose range slightly overlapped female No. 101's range on the north side was an adult breeding female (No. 41). She had been dyed and also had a deformed tail that enabled me to identify her at sight. I came to know her trap range from twenty-seven captures in 1947 and I discovered the burrow in which she successfully raised a family that year. On the two occasions that I watched her carefully for any length of time, she did not appear to defend territory in her range, even the area near her den.

On July 21 I saw female No. 41 with her neighbor, female No. 101, at a log about thirty feet from her burrow, and the next day during a one-hour period I again saw these two animals, in addition to a third lactating female, near one another at the same log. No fighting occurred on these two occasions. Actually, only a part of their ranges overlapped, and female No. 41's den, which was located at the very edge of her own range, happened also to be in the small area overlapping female No. 101's range. The fact that both female No. 101 and female No. 41 were captured twice in special traps set at the latter's den and twice at a distance of only thirty feet from the den during the period from July 1 to 5, also points to considerable trespassing on the home area of female No. 41.

The burrow of an adult female ground squirrel was only thirty feet from the chipmunk den, but apparently neither animal molested the other. In any event, both of them were successful in raising their young, all of which appeared above ground at about the same time in early June.

Several other dyed chipmunks met "strangers" in a peaceable manner. During two observation periods I saw a certain non-breeding

female meet four other chipmunks, three of them at the edge of her range and one in the center. A mutual sniffing of faces took place on two occasions. Once I saw an adult male meet a young chipmunk at the edge of his range, but he continued with his feeding without giving chase. The conclusions we may draw concerning territorial behavior are limited, since there were comparatively few observations.

The picture one gets from a map of the spring ranges of breeding females (Fig. 19) shows a great deal of overlapping of individual ranges and would lead one to believe that no territories are maintained. However, such a conclusion may not be true, as I discovered after examining one of the ranges. I selected female No. 101 for detailed analysis (Table 10) because her trap range was in the center of the study area, and she was known from a large number of captures (thirty-three in 1946 and forty-nine in 1947). I also observed her more often than any other chipmunk. All but four of the nineteen traps within her range caught other adult females, so it was evident that the total area overlapped by this sex and age group alone was considerable. However, when the ranges of each of the neighboring females was compared with that of female No. 101, it became apparent that none of the others completely overlapped her's.

In order to obtain a quantitative measure of the overlapping of individuals, I calculated the ratio of the overlapped area of each animal to the total area of its range. The average of these ratios for seven adult females was 0.22. Thus, we find that 22 per cent of the area of their ranges overlaps that of female No. 101.

To carry the weighting principle further, one should reckon not only with the areas, but also with the number of captures involved in the overlapping parts. The amount or intensity of use of the range

Fig. 19. Ranges of 65 breeding females for the period May 1 to July 31, 1947

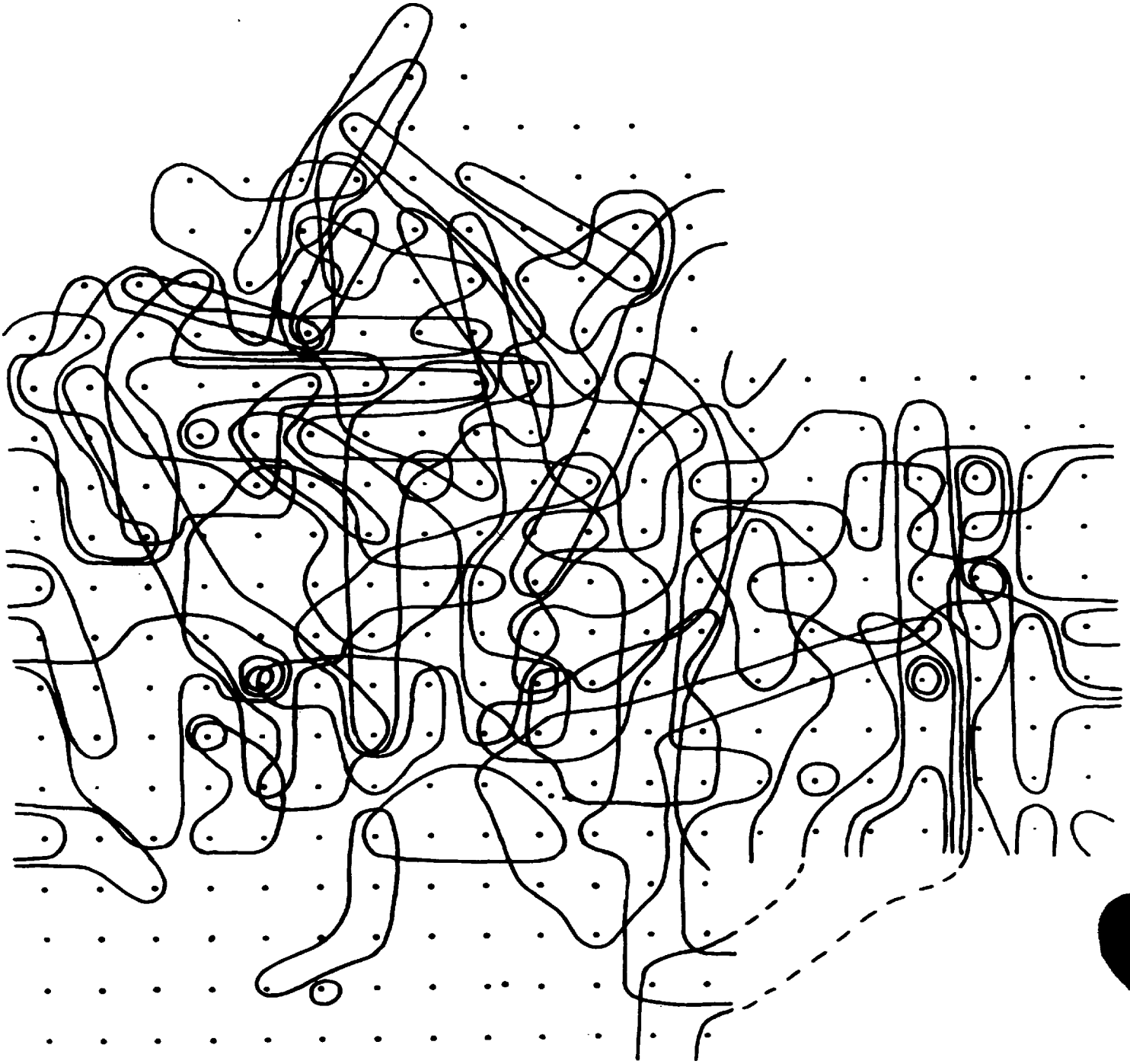


Table 10

Data on the ranges of ♀ 101 and the adult ♀♀ that overlapped her range

Number of each trap in range of ♀ 101	101	Breeding Females (Number of captures)							Non-breeding Females (number of captures)		
		41	504	262	520	562	140	119	123	560	412
70	2		2		1						
61	3		1								
62	1	1									
52	1	1	3								
51	2		2	1							
60	2									1	1
59	2										
49	1	1									
50	6	2				1					
41	7										1
42	1										
43	1										
31	1		1			1		2			
40	1									1	
29	2	1							3		
30	9						1	1			
21	1						1	4			1
11	1						3		3		
59	1								1		

Table 10 (continued)

Data on the ranges of ♀ 101 and the adult ♀♀ that overlapped her range

	101	Breeding Females							Non-breeding Females		
		41	504	262	520	562	140	119	123	560	412
Numbers of captures:											
a) Captures inside range of ♀ 101	45	6	9	1	1	2	5	7	7	2	3
b) Total captures in each range	45	23	16	27	16	9	40	18	28	11	4
c) % overlap, equals a/b	...	26.1	56.3	3.7	6.2	...*	12.5	38.8	25.0	...*	...*
Areas:											
d) Number of overlapping trap squares in range of ♀ 101	...	6	6	2	3	2	3	3	3	2	3
e) Number of trap squares in each range	...	25.5	19	14	23	11	15	10.5	13	14	6
f) % overlap, equals d/e	...	23.5	31.6	14.3	13.0	...*	20.0	28.6	23.1	...*	...*

* Too few captures to show the complete range

by neighboring females should be given due consideration. If one were to consider only the area of the overlap zone and not the number of captures in it, one capture in a certain trap would be considered equally as important as five or ten captures in another trap.

A figure for each female that will represent her use of the zone of overlap may be obtained by calculating the ratio of captures within each overlap area to the total number of captures in the respective range. The average for the seven adult females was 24.1 per cent.

By the same method as that used for the whole overlap zone, we could arrive at a figure which would represent the use of each one of the overlapping traps (or the square area represented by each trap) by calculating the ratio of captures in each trap to the total number of captures for the entire range of each female. From these figures we may calculate an average use of each trap. Then female No. 101 may be compared with all the other females with respect to the use of individual traps in her range.

For example, let us take trap 30 in the range of female No. 101. She was caught more often in this trap than in any other (nine times in a total of forty-five for the whole range). This represented 20 per cent of the total number of captures. Only two other females were caught in this trap—one of them 2.5 per cent of the time (one in forty captures), and the other 5.5 per cent of the time (one in eighteen captures).

If the other females were captured only a few times in those parts of the range in which female No. 101 was caught most often, then it seems to me that she probably excluded the others from that area most of the time.

POPULATIONS

Literature:

The populations of chipmunks have been reported in the literature by various authors, but only a few of these studies have been based on detailed investigations.

Grinnell and Storer (1924: 179) estimated the populations of Eutamias sonomae frater in Yosemite Park, California, at about two per acre in the Canadian Zone and one per acre in the Hudsonian Zone, on the basis of observation and snap-trapping. Much larger numbers were noted by Seton (1929: 173, 175). He estimated that there were a thousand or more in one acre at a mill in Manitoba, and in Yellowstone Park (in 1897) he saw hundreds to the mile. Along a road they were seen in groups of nine, ten, eight, eleven, twenty, twenty-eight, and thirty, feeding together on grain.

After a detailed study of the animal communities of the Kaibab Plateau, Rasmussen (1941: 257) estimated the populations of Eutamias minimus consobrinus and E. adsitus at three to five per acre, with greater concentrations in camp areas. His figures were based on trapping and observations.

Several live-trapping studies in recent years have added to our knowledge of the numbers of western chipmunks (Eutamias), although none was planned as a population study of this animal.

In a paper on the movements of Eutamias quadrimaculatus in California, Holdenried (1940: 407) tabulates the numbers of individuals

caught each month in an area that was gradually increased during the study to a total of thirty acres. The author does not give the numbers per unit area, but his data indicate a density of less than two per acre. The number of chipmunks captured in November dropped significantly. The suggested reasons for this were lessened activity, hibernation, and restriction of range, which would limit movement and prevent other individuals from wandering into the trap area.

In an experiment designed to test the relative merits of live and snap traps, Gray (1943) obtained information on the numbers of Eutamias minimus in the Yakima Valley. He trapped pairs of quadrats (one member with live, the other with snap traps) in three different localities in the desert. Members of each pair were 300 to 500 yards apart and the individual plots were 150 feet on a side. He estimated that the average number of chipmunks for the three quadrats, based on three-day periods, was 2.4 per acre. Undoubtedly this figure is too high because of the small size of each plot.

Gordon (1943: 42-45) marked chipmunks at various camps in Colorado and Oregon and estimated the populations from the number of marked and unmarked individuals observed. There were six Eutamias minimus and E. quadrivittatus per acre in lodge-pole pine country in Colorado; in the yellow pine country of Oregon there was one E. amoenus per acre in the Blue Mountains, five per acre at one camp in the Cascades, and at another, 6.25 in 1940 and 3.0 in 1941.

Storer, Evans, and Palmer (1944: 183) calculated the numbers of Eutamias quadrimaculatus in the Sierras of California from live-trapping data on an eleven-acre plot, the area within an encircling line of traps rather than the grid alone. The populations per acre were 0.5 in

April, 2.5 in June, 0.5 in September, and 0.1 in early November, a seasonal cycle similar to that of the chipmunks at Rocky Flat. An August snap trap census of a plot 0.78 acres in extent gave very high figures—20.5 per acre for Eutamias quadrivittatus and 21.8 for E. amoenus. The small size of the plot and drift into the depopulated area would account for these numbers.

Burt (1940: 45-47) found that in southern Michigan the May populations of the eastern chipmunk (Tamias striatus) ranged from 1.63 in 1935 to 0.8 per acre in 1937. In June the appearance of young caused an increase to 3.62 animals per acre in 1935 and 2.42 per acre in 1937. There was a gradual decrease to September when the second litters arrived, but the author had no data on numbers for the fall period. The live-trapping was done in isolated woodlots up to 5.52 acres in extent.

Blair (1942: 35) found an average of 3.4 chipmunks per acre in northern Michigan. The area that he live-trapped was 18.18 acres of virgin hardwood forest.

Using snap traps on small quadrats up to 150 feet on a side (0.516 acres), Bole (1939: 67) got populations of Tamias striatus in Ohio of 8.7 in 1935, 1.14 in 1937, and 0.8 per acre in 1938. His figures were based on three-day trapping periods. He thought that the basic factor regulating changes in chipmunk populations was the cyclical nature of seed production of beech and sugar maple trees.

I live-trapped a total of 577 chipmunks on forty-two acres at Rocky Flat. In order to arrive at the population per unit area two problems were considered: (1) the number of trapping days needed in which to catch all the resident animals; and (2) the size of the area needed in calculating the number per acre.

Days needed:

Most authors who have done live-trapping studies of small mammals in recent years have based their figures on four- to seven-day periods in the belief that most of the residents were captured in that length of time. Burt (1940), Blair (1941), and Stickel (1946) used periods of one week for getting populations of Peromyscus. Evans (1942) based his figures for Apodemus on four nights of trapping, but he thought that all individuals were not captured in that time. Hamilton (1937) used a seven-day trap period in population work on Microtus.

Most investigators who have censused small mammal populations with snap traps have used a three-day period on which to base their figures, on the assumption that all or most of the animals are caught in that length of time. In estimating populations of deer mice in the Black Hills of South Dakota, Dice (1938) thought that usually all Peromyscus were caught in three to five days of trapping. Bole (1939) censused small mammals in Ohio with snap traps and concluded that three days of trapping were sufficient. Townsend (1935) also used three-day censuses, while Hanson (1944) used four nights. Gray (1943) made a comparative study of snap and live traps in which he, too, employed the three-day period.

In general, it is probably true that four to seven days of live-trapping will suffice to catch most small mammals of mouse size, but a longer or shorter time may be required, depending on the species. For example, Haugen (1942) found that only after ten days were all cottontails captured in quadrats with traps that were spaced 110 yards apart.

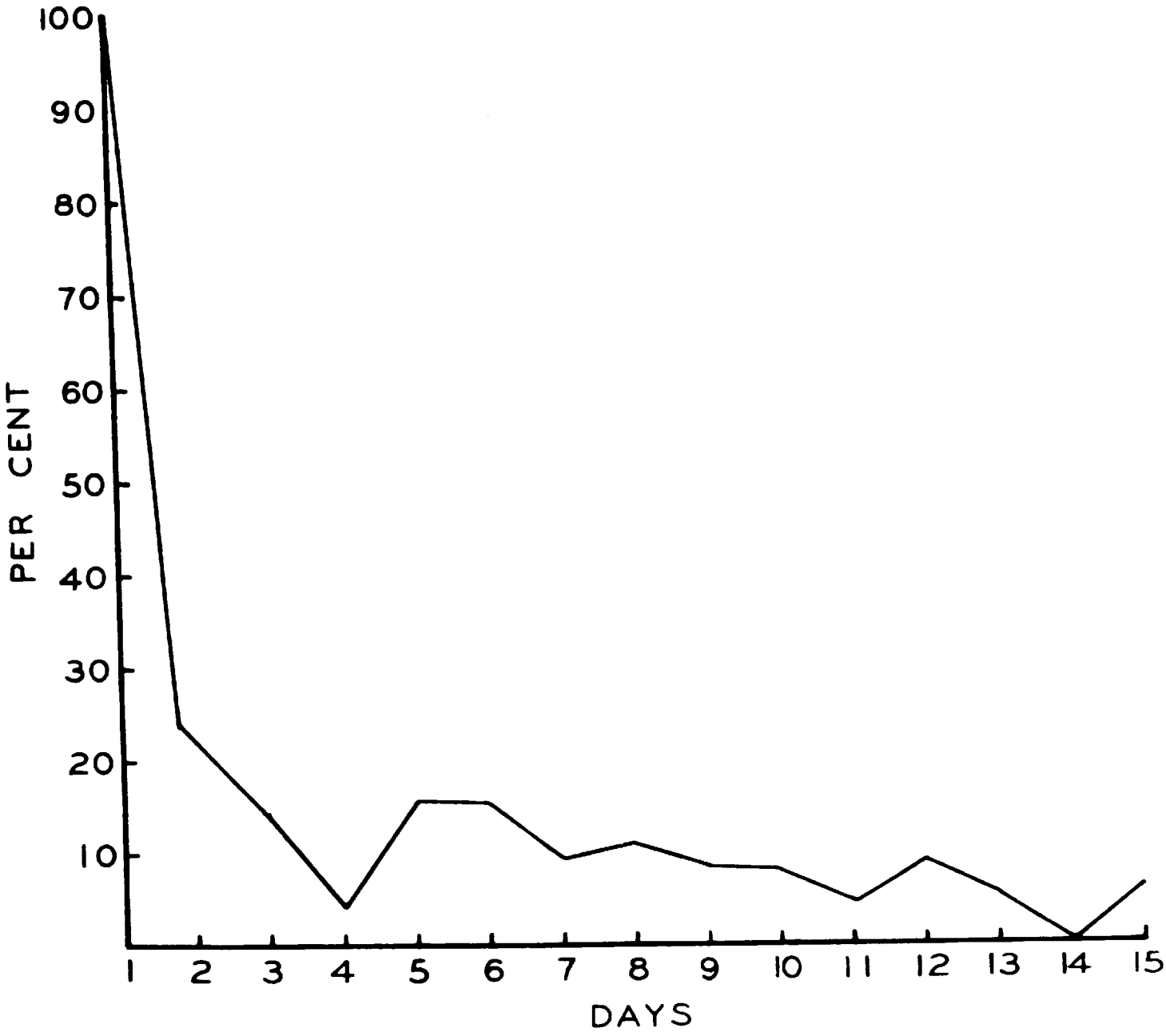
In an attempt to find out how many days of trapping would be needed for a census of chipmunks, I analyzed a period in the spring when the population was presumably fairly stable. The percentage of new individuals caught on each day in fifteen days of trapping is shown in Figure 20. A sharp decline in the number of new animals occurred in the first three days; then the curve leveled off and on each of the succeeding twelve days an average of 8 per cent of the catch was new, i.e., had not previously been taken in that period.

Just where to draw the line and say that all the residents have been caught is difficult to determine. The decision must be an arbitrary one at best. Ten days might be a good compromise. However, I shall also use data for periods of only four or five days, in order to show the seasonal fluctuations. The shortest feasible number of days should be used because the longer the time involved, the more confusing will be the changes in the community. If trapping periods are too long, undue increases in the population result when new animals come in from surrounding areas, either as transients or to become permanent residents. At the same time the original population is continually being decreased by mortality and occasional shifts of range.

Size of area needed:

An area to be censused for small mammals should be at least several times larger than the range of one individual (Dice, 1938, 1941; Burt, 1940; and Haugen, 1942). If the area is too small, the population estimate will be unduly large. This fact has been proved by experiments of Bole (1939) and Stickel (1946).

Fig. 20. Percentage of new individuals (not previously captured in the period) caught each day during a live-trapping period of fifteen days, May 1-3, May 19-24, June 11-12, and June 17-20


100
90
80
70
60
50
40
30
20
10
PER CENT
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
DAYS

I first used two adjacent plots, each 757 feet on a side, to study chipmunk ranges at Rocky Flat. These quadrats were about the minimum size that could be used.

Table 11

Numbers of chipmunks trapped on Plot 1 (12.8 acres) from July 15 to November 13, 1946; sexes are pooled

Date	Trapping Days	Number of chipmunks	Number that died	Number per acre
July 15-20	5	89	14	3.02
July 29-Aug. 3	6	80		2.24
Aug. 19-23	5	51	4	1.73
Sept. 9-12	4	78		2.51
Sept. 30-Oct. 5	6	87		2.95
Oct. 22-26	5	37		1.25
Nov. 1-2, and Nov. 11-13	5	12		0.41
Average				2.49

Area of Plot 1 plus a border zone used in calculation of numbers per acre is 29.5 acres.

The number of animals which died in traps due to exposure in any one period was added to the following period.

Table 12

Numbers of chipmunks trapped on Plot 1 (12.5 acres) from May 1 to October 17, 1947; sexes calculated separately

Date	Trapping Days	Number of chipmunks ♂	Number of chipmunks ♀	Number per acre ♂	Number per acre ♀	Total number per acre
May 1-3	3	28	20	0.84	0.85	1.69
May 19-24	6	37	23	1.11	0.98	2.09
June 11-12	2	24	17	....	....	....
June 17-20	4	30	32	0.90	1.36	2.26
July 15-19	5	44	52	1.32	2.21	3.53
Aug. 12-15	4	43	37	1.29	1.57	2.86
Sept. 10-13	4	38	35	1.14	1.49	2.63
Oct. 14-17	4	29	22	0.87	0.94	1.81
Average						2.55

Sexes cannot be calculated separately for 1946, since the area was too small at that time to obtain accurate figures on the sizes of male home ranges.

Area of Plot 1 plus a border zone used in calculation of numbers per acre is 33.3 for males and 23.5 for females.

Table 13

Numbers of chipmunks trapped on Plot 1 (12.8 acres) from July 15 to November 13, 1946; populations based on combined trap periods of ten to fifteen days; sexes pooled

Date	Trapping days	Number of chipmunks	Number that died	Number per acre
July 15-20, July 29-Aug. 3	11	122	14	4.14
Aug. 19-23, Sept. 9-12, Sept. 30-Oct. 5	15	142	4	4.81
Average				4.48
Oct. 22-26, Nov. 1-2, Nov. 11-13	10	50		1.69

Total area used in calculation of numbers is 29.5 acres.

The number of animals which died in traps due to exposure in any one period was added to the following period.

Figures for the last period were not included in the average because some chipmunks may have begun hibernation at that time.

Table 14

Numbers of chipmunks trapped on Plot 1 (12.8 acres) from May 1 to October 17, 1947; populations based on combined trap periods of nine to twelve days; sexes calculated separately

Date	Trapping days	Number of chipmunks ♂	Number of chipmunks ♀	Number per acre ♂	Number per acre ♀	Total number per acre
May 1-3, May 19-24, June 11-12	11	46	32	1.38	1.36	2.74
June 17-20, July 15-19	9	55	63	1.65	2.68	4.33
Aug. 12-16, Sept. 10-13, Oct. 14-17	12	57	47	1.71	2.00	3.71
Average						3.93

Area of Plot 1 plus a border zone used in calculation of numbers per acre is 33.3 for males and 23.5 for females.

Table 15

Numbers of chipmunks trapped in Plot 2 (12.8 acres) from August 6 to October 12, 1946; populations based on trapping periods of five and six days; sexes pooled

Date	Trapping days	Number of chipmunks	Number per acre
Aug. 6-10	5	75	2.90
Aug. 27-31	6	47	1.81
Sept. 16-21	6	58	2.24
Oct. 8-12	5	61	2.36
Average			2.33

Total area used in calculation of numbers is 25.9 acres.

Table 16

Numbers of chipmunks trapped in Plot 2 (12.8 acres) from May 6 to October 30, 1947; populations are based on trapping periods of four and five days; sexes calculated separately

Date	Trapping days	Number of chipmunks ♂	Number of chipmunks ♀	Number per acre ♂	Number per acre ♀	Total number per acre
May 6-7, May 9-10	4	34	11	1.02	0.47	1.49
June 3-7	5	33	25	0.99	1.06	2.05
June 25-28	4	39	35	1.17	1.48	2.65
July 22-25	4	39	48	1.17	2.04	3.21
Aug. 19-23	5	46	58	1.38	2.47	3.85
Sept. 23-26	4	36	46	1.08	1.96	3.04
Average						2.72
Oct. 22, Oct. 28-30	4	15	28	0.45	1.19	1.64

Area of Plot 2 plus a border zone used in calculation of numbers per acre is 33.3 for males and 23.5 for females.

Figures for the last pefiod were not included in the average because some chipmunks may have begun hibernation at that time.

Table 17

Numbers of chipmunks trapped in Plot 2 (12.8 acres) from August 6 to October 12, 1946; populations based on trapping periods of ten and eleven days; sexes pooled

Date	Trapping days	Number of chipmunks	Number per acre
Aug. 6-10, Aug. 26-30	10	90	3.47
Sept. 16-21, Oct. 8-12	11	78	3.01
Average			3.24

Total area used in calculation of numbers is 25.9 acres.

Table 18

Numbers of chipmunks trapped in Plot 2 (12.8 acres) from May 6 to October 30, 1947; populations are based on trapping periods of seven to eleven days; sexes are calculated separately

Date	Trapping days	Number of chipmunks ♂	Number of chipmunks ♀	Number per acre ♂	Number per acre ♀	Total number per acre
May 6-7, May 9-10, June 3-7	9	40	30	1.20	1.28	2.48
June 25-28, July 22-25	7	59	62	1.77	2.64	4.41
Aug. 19-23, Sept. 23-26, Oct. 22, 28-30	11	61	72	1.83	3.06	4.89
Average						3.93

Area of Plot 2 plus a border zone used in calculation of numbers per acre is 33.3 for males and 23.5 for females.

Table 19

Numbers of chipmunks trapped in Plots 1 and 2 combined (27.04 acres); populations are based on trapping periods of five to sixteen and ten to seventeen days; sexes pooled

Date	Trapping days 1	2	Total	Number of chipmunks	Number per acre
1946					
July 15–Aug. 10	12	9	21	176	3.61
Aug. 19–Sept. 21	9	11	20	162	3.33
Sept. 30–Nov. 13	16	5	21	155	3.18
Average					3.37
1946					
July 15–Aug. 30	17	10	27	201	4.13
Sept. 9–Nov. 13	14	11	25	179	3.68
Average					3.90

Total area used in calculation of numbers is 48.7 acres.

Table 20

Numbers of chipmunks trapped in Plots 1 and 2 combined (27.04 acres); populations based on trapping periods of eight to eleven days; sexes calculated separately

Date	Trapping days 1	2	Total	Number of chipmunks ♂	♀	Number per acre ♂	♀	Total number per acre
1947								
May 1–June 7	9	9	18	72	54	1.28	1.26	2.54
June 11–July 12 (omitted)								
July 15–Aug. 23	10	9	19	98	114	1.74	2.66	4.40
Sept. 10–Oct. 30	8	8	16	69	81	1.22	1.89	3.11
Average								3.35
1947								
May 1–June 7	9	9	18	72	54	1.28	1.26	2.54
June 11–July 25	11	7	18	103	108	1.83	2.52	4.35
Aug. 12–Sept. 26	9	9	18	88	101	1.56	2.36	3.92
Oct. 14–30 (omitted)								
Average								3.60

Area of Plots 1 and 2 plus a border zone used in calculation of numbers per acre is 56.3 for males and 42.8 for females.

Table 21

Numbers of chipmunks trapped in Plot 3 (6.01 acres); populations based on trapping periods of four to eleven days; sexes calculated separately

Date	Trapping days	Number of chipmunks ♂	Number of chipmunks ♀	Number per acre ♂	Number per acre ♀	Total number per acre
1947						
July 1-5	6	24	40	1.53	3.15	4.68
July 29-Aug. 2	5	25	42	1.59	3.31	4.90
Aug. 27-30	4	27	38	1.72	2.99	4.71
Oct. 1-4	5	22	27	1.40	2.13	3.53
Average						4.46
1947						
July 1-5, July 29-Aug. 2	11	39	58	2.48	4.57	7.05
Aug. 27-30, Oct. 1-4	9	33	44	2.10	3.46	5.56
Average						6.31

Area of Plot 3 plus a border zone used in calculation of numbers per acre is 13.3 for males and 10.4 for females.

Table 22

Numbers of chipmunks trapped in Plots 1-4 combined (42.38 acres); populations based on trapping periods of three to six days; sexes calculated separately

Date	Trapping days 1	2	3	4	Total	Number of chipmunks ♂	♀	Number per acre ♂	♀	Total number per acre
1947										
June 17-July 12	6	3	5	4	18	88	106	1.37	1.97	3.34
July 15-Aug. 9	5	4	5	5	19	94	116	1.46	2.16	3.62
Aug. 12-Sept. 6	5	5	4	4	18	88	115	1.37	2.14	3.51
Sept. 10-Oct. 10	4	4	4	5	17	72	98	1.12	1.82	2.94
Average										3.35

Area of Plots 1-4 plus a border zone used in calculations of numbers per acre is 64.17 for males and 53.72 for females.

Border area:

A certain number of animals caught in border traps may live partly within and partly outside of the area actually covered by the traps, and allowance should be made for this in calculating the density of the population. Dice (1938) suggested extending the trapped area by an average distance of half the mean width of an individual range. This method has been followed by most authors and is the system I used in arriving at the populations per acre in the preceding tables. I have calculated the numbers per acre in order that my data may be compared with the findings of others who have employed these same units.

A modification of this method of determining the border area was proposed by Stickel (1946). She thought that "the width of this rim should not be one-half the width of a range, because this practice would produce progressively greater areal inaccuracies with increase in size of the area studied. The result would be to yield rapidly decreasing per-acre figures with increase in size of the area considered." "It would be better to divide the mean range (or movement) diameter between a width inside the trapped area and a width outside the trapped area in such a way that the two rims would have equal areas." (p. 156) She then presented a formula by which these two areas could be calculated. The population figures she derived by this method were very close to the figures obtained by the method in which the buffer zone equals one-half the width of the average range.

I used the average size of all complete ranges in figuring the width of the border zone. The average of thirty-seven females was 14.9 trap squares; the average of thirty-three males was 24.0 trap

squares. The weighted average for both sexes was 19.2 trap squares. The diameter of a circular range with an area of 19.2 trap squares is 410 feet. One half of this is about 200 feet, the width of the border strip. Extensive treeless flats, which bordered one side of Plot 3 and Plot 2, were probably rather effective natural boundaries, and no border strips were added in those places.

I also calculated the 1947 population figures, separating the sexes. The mean diameter of female ranges was 262 feet and of males was 460 feet. Table 23 gives a summary of the results.

In using this method one assumes that the ranges are circular in shape. The average area of a home range is taken as the area of a circle, and then the diameter of this circle is computed. However, as pointed out on page 13, the shapes of chipmunk ranges are not circular. On the contrary, a large percentage of them are elongate. The average of the greatest widths of female ranges is 298 feet, while the average of the greatest lengths is 458 feet. Likewise, these figures for males are 507 feet and 984 feet. (These measurements were taken horizontally and vertically--horizontally for the width and vertically for the length--on the range diagrams.) If ranges were to be measured at several points on both the horizontal and vertical axes and these measurements were then averaged, a better dimension for the border strip might be obtained.

Other methods of calculating populations:

The method described above is based on the idea that it is necessary to add a border area (calculated from home range size) before one can obtain a true population density figure for mammals in a uniform area, but no one has tested this method to see if it really gives

Table 23

Summary of population figures for 1946 and 1947

Year	Plot	Trapping days	Average per acre (sexes calculated separately)	Average per acre (Sexes pooled)
1946	1	4-6	....*	2.49
	1	10-15	....	4.48
	2	5-6	....	2.33
	2	10-11	....	3.24
	1 and 2	9-16	....	3.37
	1 and 2	14-17	....	3.90
1947	1	3-6	2.55	2.51
	1	9-12	3.93	3.77
	2	4-5	2.56	2.72
	2	7-11	3.93	4.12
	1 and 2	8-10	3.35	3.37
	1 and 2	9-11	3.60	3.60
	3	4-6	4.46	4.93
	3	9-11	6.31	7.00
	1-4	17-19	3.35	3.09

* Sexes cannot be calculated separately for 1946, since the size of the trap area was too small to give accurate figures on the sizes of male home ranges.

a close approximation to the numbers actually present. This method assumes that all of the area used for calculations is occupied, but this state of affairs probably does not exist very often. Some method that would avoid this source of error may be preferable.

There are several ways in which one can determine the approximate population, using only the actual trap area and numbers of animals caught. If only the trapped area is used for computing population, then we must in some way find out the numbers for that area only. But it is obvious that some border animals have ranges almost entirely outside the trap area, and this fact must be given due consideration. In order to do this without adding a border strip, I have calculated the population of the area included in the trap grid by two methods, one using the area of the range and the other, the number of captures. (Plot 1 is used for these calculations.)

Area method:

A. Animals whose ranges are wholly within Plot 1:

(1) If the animal had been captured the necessary number of times to reveal its range (twelve for females, twenty for males; see page 15), then its fraction for computation was taken as 1.00.

(2) If the animal had not been captured the necessary number of times to reveal its range, then the area of as much of its range as was known was divided by the area of the average home range for its sex. The result of this division was its fraction for computation. (Of course, this procedure assumes that all subsequent captures will occur outside of Plot 1, but until some

method of predicting the probabilities of capture at various points adjacent to the known range is worked out, this is probably the best one can do with this method.)

B. Animals whose ranges were partly within Plot 1 and partly within other plots of the trap area:

(3) If the animal had been captured the required number of times, the area of its range that lay within Plot 1 was divided by the total area of its range to obtain the fraction for computation.

(4) If the animal had not been captured the required number of times, then the area of its range that lay within Plot 1 was divided by the area of the average home range for its sex. In a few cases the area of the known home range turned out to be larger than that of the average home range, even though there were comparatively few captures. In this situation the known area was used for the divisor. This was done in order to stick as closely to the known facts as possible.

C. Animals whose ranges were within Plot 1, but bordered on territory not in the trap area:

(5) The ranges of all these animals were considered incomplete regardless of the number of captures. (The great majority of them did not have the necessary number anyhow.) For these animals, the area of as much of its range as was known was divided by the area of the average home range for its sex to obtain the fraction for

computation. In the one or two cases where it occurred, the same exception to this procedure as noted in (4) was applied.

After all of the fractions for computation had been obtained, they were totaled. This sum was then divided by the actual area of Plot 1 (12.8 acres) to obtain the number per acre.

Capture method:

This method is similar to the area method, except that the number of captures, instead of the area, is used. It is based upon the assumption that the number of times an animal is captured in one particular trap indicates about how much of its time it spends in the vicinity of that trap.

A. Animals whose ranges are wholly within Plot 1:

(1) If the animal had been captured the required number of times, then its fraction for computation was 1.00.

(2) If it had not been captured the necessary number of times, then the number of times that it had been captured was divided by the average number of captures for its sex (27.3 for females, 35.3 for males). It might be well to point out that this average number of captures should not be confused with the number of captures necessary to show a home range. The figures for the average number of captures were obtained from only those animals whose ranges were considered complete, i.e., were captured twelve times or more if a female, and twenty times or more if a male.

B. Animals whose ranges were partly within Plot 1 and partly within other plots of the trap area:

(3) If the animal had been captured the necessary number of times, then the number of captures in Plot 1 was divided by the total number of captures for that animal.

(4) If the animal had not been captured the required number of times, then the number of captures in Plot 1 was divided by the average number of captures for its sex. If the total number of captures exceeded this figure, then the total number was used for the divisor.

C. Animals whose ranges were within Plot 1, but bordered on territory not in the trap area:

(5) As in the area method, the ranges of all these animals were considered incomplete. The total number of captures was divided by the average for its sex to obtain the fraction for computation.

The fractions for computation were totaled, and then this sum was divided by the actual area of Plot 1 (12.8 acres) to obtain the number of animals per acre.

Conclusions on population methods:

All three methods give us population figures that are very similar (Table 24), so it seems likely that the border zone system which has been used in the past is as good a method as any that has been devised. However, all of these methods are open to the objection that animals with inadequate records may not be given proper treatment.

Table 24

Comparison of population methods
(Number per acre in Plot 1)

Date	Trapping days	Border zone method	Area method	Capture method
1947				
May 1-3	3	1.63	1.76	1.79
May 19-24	6	2.03	2.09	2.22
June 17-20	4	2.10	2.07	2.27
July 15-19	5	3.25	2.86	2.99
Aug. 12-15	4	2.71	2.91	2.84
Sept. 10-13	4	2.47	2.57	2.59
Oct. 14-17	4	1.73	1.66	1.60
Averages		2.38	2.27	2.33

Why do some animals have only a very small number of captures? There are several possibilities. During the census period, they may die, move to another area, be trap shy, or may only visit briefly from an outlying area. Some method should be devised by which as many of these factors as possible would be considered. Such a system would have to consider each animal individually and would likely be involved with the theory of probability.

Seasonal populations:

Two examples of seasonal changes in populations may be seen in Figure 21. The curves are based on data obtained from May 1 to October 30, 1947, in Plots 1 and 2. The trapping periods on which the numbers per acre are based are four to six days each.

The seasonal cycle begins with a low spring population made up of adults which have survived the winter. Then in early or mid-June the young begin to appear and cause the population to rise sharply to a peak in late July and August. The numbers then drop off rapidly and reach zero in early November when the chipmunks go into their burrows for the winter.

Yearly averages:

The numbers caught in the entire area (Plots 1-4) from June 17 to October 10 are given in Table 22. The seasonal fluctuations are not revealed in these data because the time required to trap all four plots was about one to one and one-half months. However, it may be of some value to have data for the entire area of forty-two acres.

The potential increase in numbers from the spring level of population is about 200 per cent, as usually at least four young are born

Fig. 21a. 1947 populations in Plot 1, showing seasonal fluctuations

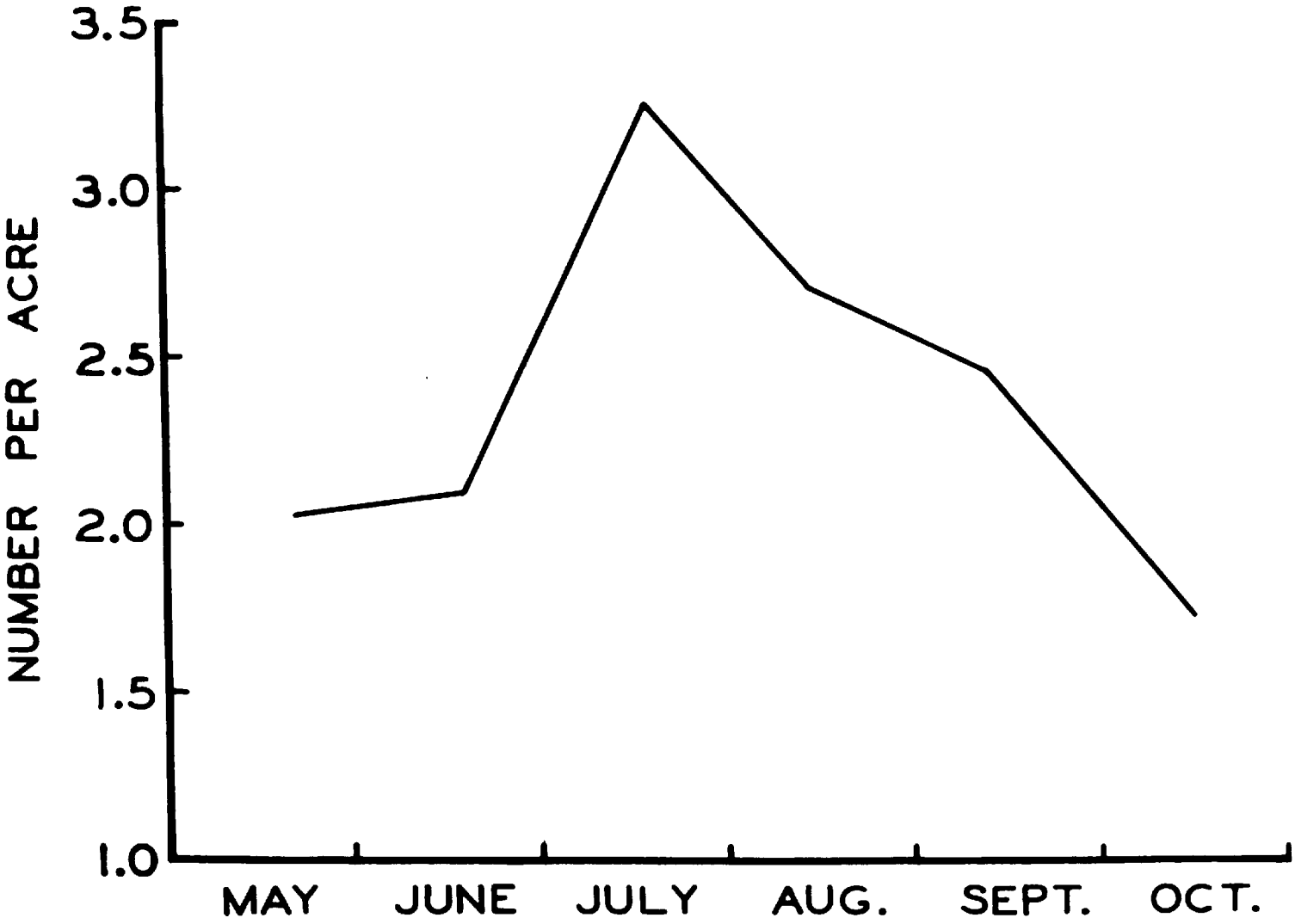
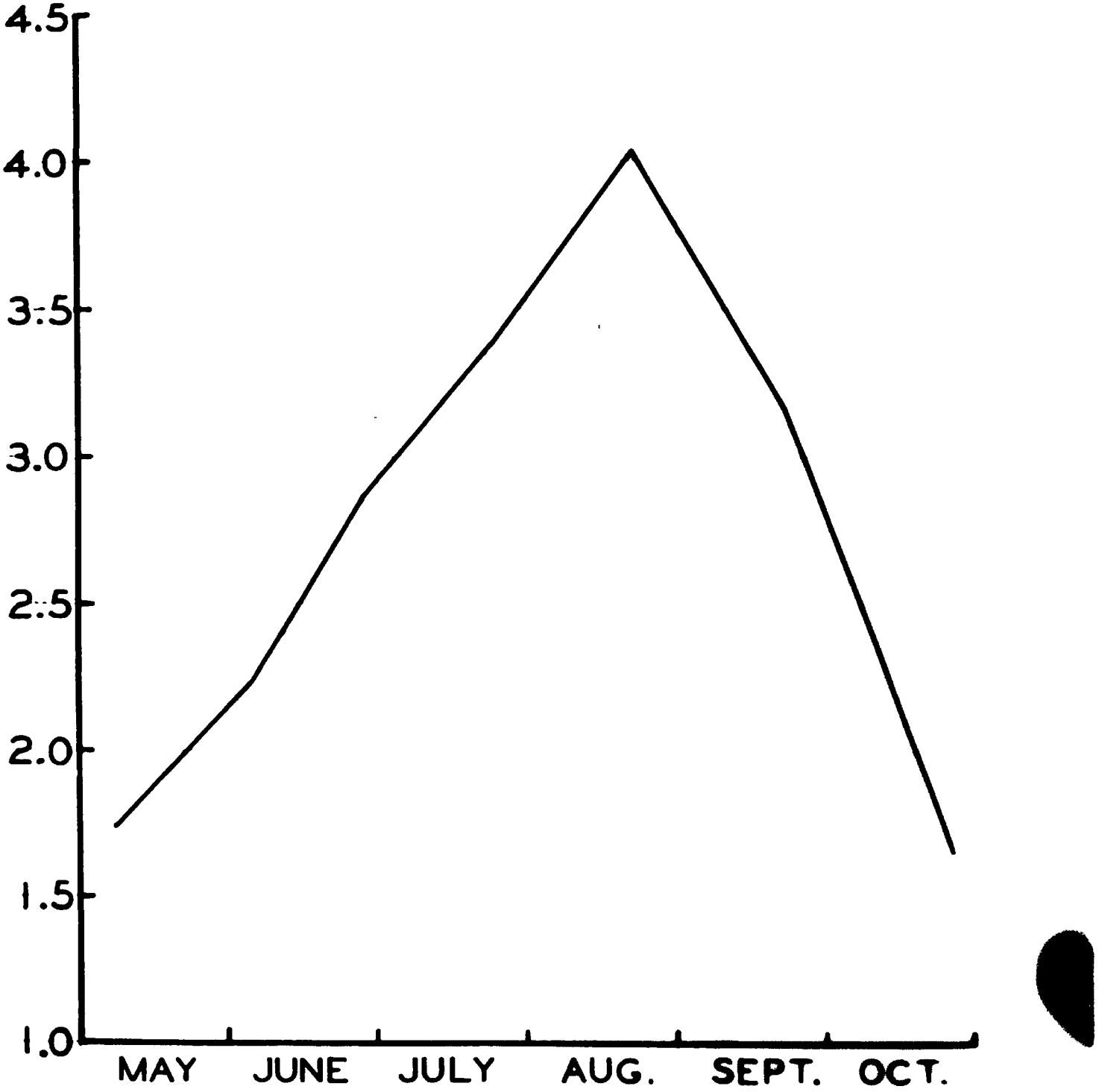

NUMBER PER ACRE
3.5
3.0
2.5
2.0
1.5
1.0
MAY
JUNE
JULY
AUG.
SEPT.
OCT.

Fig. 21b. 1947 populations in Plot 2, showing seasonal fluctuations; ordinate figures are the numbers per acre


4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
MAY
JUNE
JULY
AUG.
SEPT.
OCT.

in each litter. However, instead of being tripled, the population is only doubled. There are several reasons why the increase is not as great as might be expected.

(1) In the first place, not all adult females have young; only about 80 per cent bred in 1947.

(2) Mortality is another factor which probably applies particularly to young animals in the first few weeks after they come out of their dens in June and July. They are curious and bold and may be easy prey to hawks, coyotes, bobcats, and badgers. I once saw two dogs catch a young chipmunk and it seems likely that coyotes might take a fairly large number. Goshawks were present in the area, and I have seen them dive for ground squirrels. I also saw a large Buteo try to catch a chipmunk or ground squirrel on one occasion. Sparrow hawks (Falco sparverius) were common at Rocky Flat and they, too, very likely catch chipmunks.

J. and F. Craighead (doctoral dissertation, University of Michigan) have kindly given me data on Sparrow Hawk predation at Moose, Wyoming. They found that chipmunks formed 1.8 per cent (four out of 220 individuals) of the diet of these hawks as indicated by pellet and non-pellet materials.

(3) I know very little about the role of disease in regulating numbers of this species. Almost all of the animals that I handled seemed to be in good health.

(4) The most conspicuous parasite, the botfly (Cuterebra), may cause the death of chipmunks in certain years, but the amount of infestation during the period of my study was not great enough to have any lethal effect. Individuals with as many as three large bot larvae

were apparently as healthy as those without any of these parasites. Still it is possible that the movements of the animals are somewhat impeded for mechanical, if not physiological, reasons.

(5) Tapeworms probably caused the death of one young adult chipmunk. Heavy infestations of tapeworms may possibly weaken affected chipmunks so that they are more readily caught by predators, and may even cause a certain number of deaths.

(6) About 50 per cent of the young captured in June and July (when they could be easily identified as to age) were not recaptured after the middle of August, presumably because of death and dispersal. When the ranges of the young were mapped (Figs. 22-25), it could be seen that they frequently established themselves at various distances from the point of their first capture. The early captures probably were made when they were still using the home dens, and the family groups had not yet broken up. The arrows in the maps indicate the distance from the first capture (in June) to the home range established later on in the season. It would be interesting to know the dispersal beyond the study plot, but limitations of time prevented me from carrying out spot censuses in surrounding areas at various distances.

There is considerable room for speculation as to why the young disperse, as usually there are very few direct facts to go on. The reasons may be largely psychological. It is also quite possible that the young are forced out by the adults. On two occasions I observed a lactating female within thirty feet of her den chase young animals for short distances (six to ten feet).

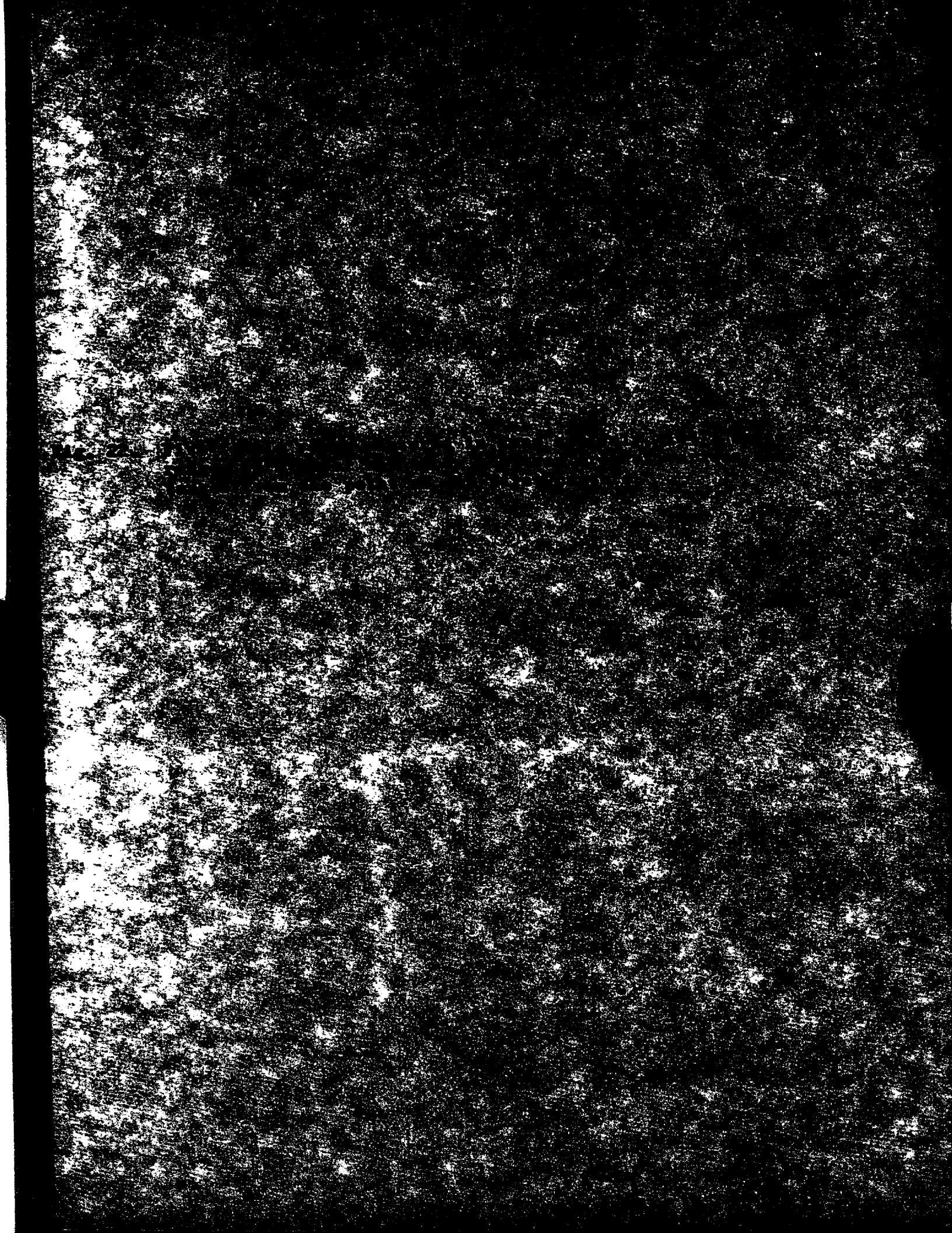
Conclusions on methods of calculating populations:

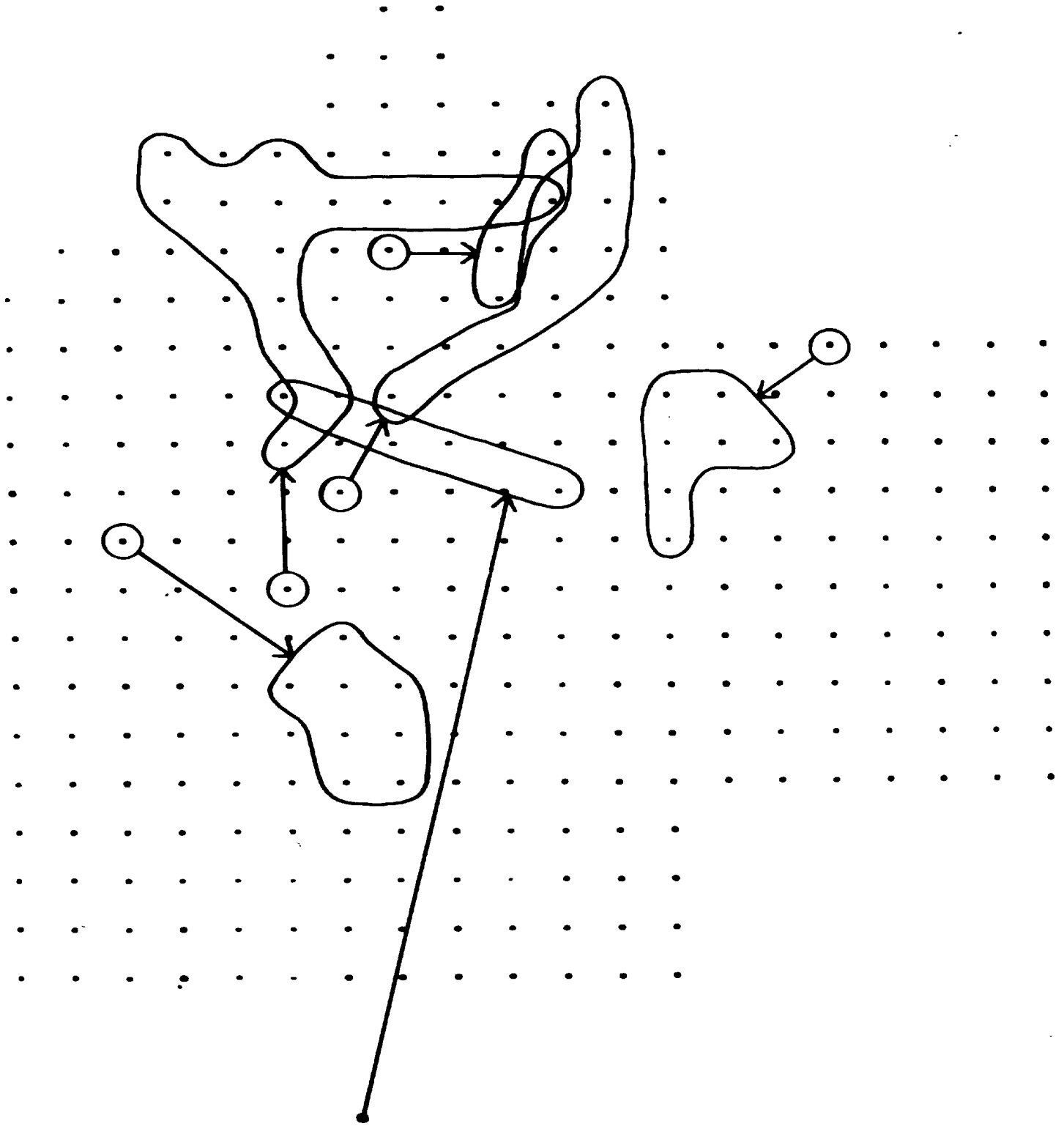
Since new animals are continually being taken, the number of days one should trap in one place to obtain a census must be decided more or less arbitrarily. With traps spaced 83 feet apart as in my experiments it may take about 8 or 10 days to catch most resident chipmunks.

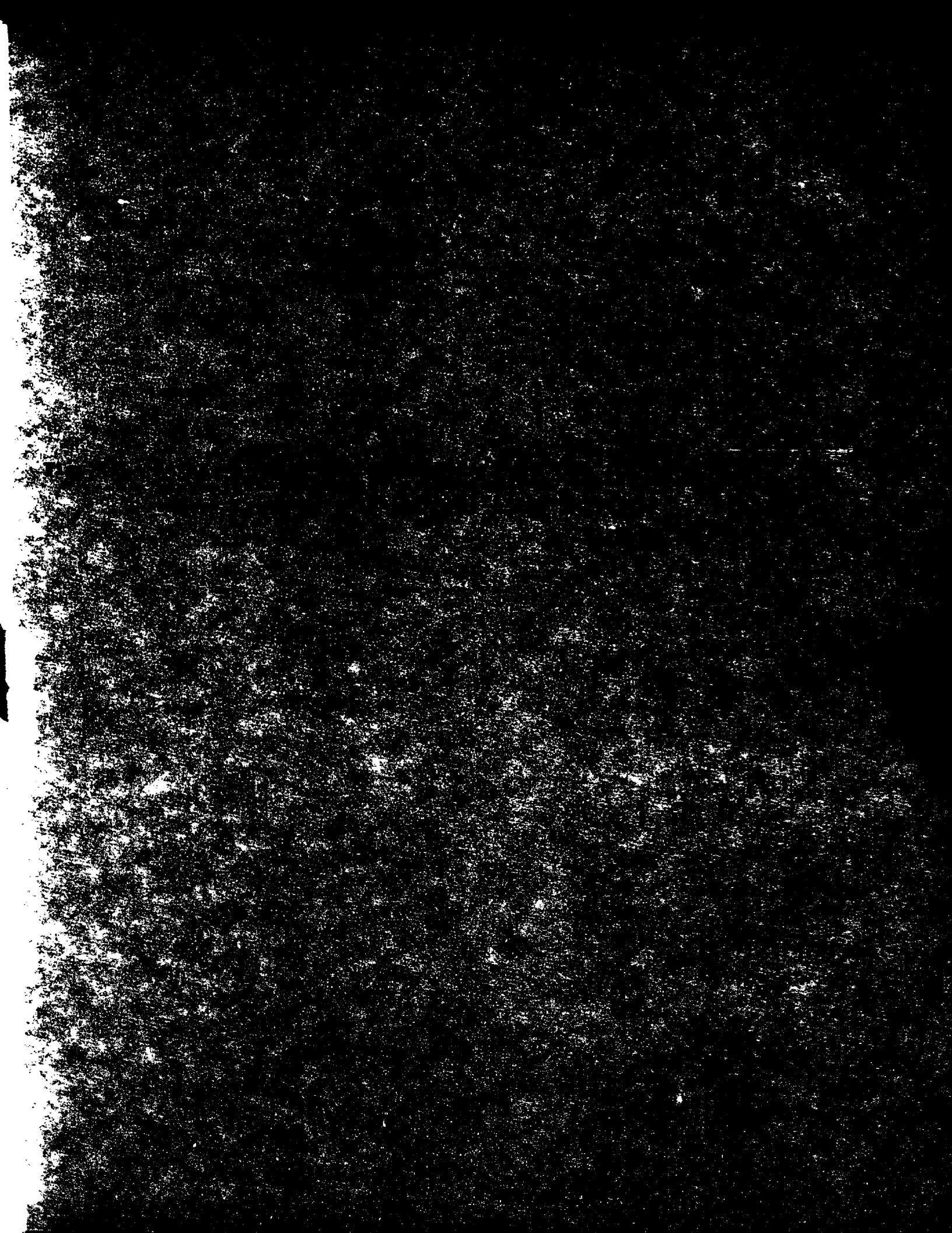
I have grouped my trapping days into both short (about 5 days) and long (about 10 days) periods. The population figures produced by the long periods were larger by an average of 1.31 per acre. The longer the trapping period, the higher will be the figure. A period of one week might be adequate.

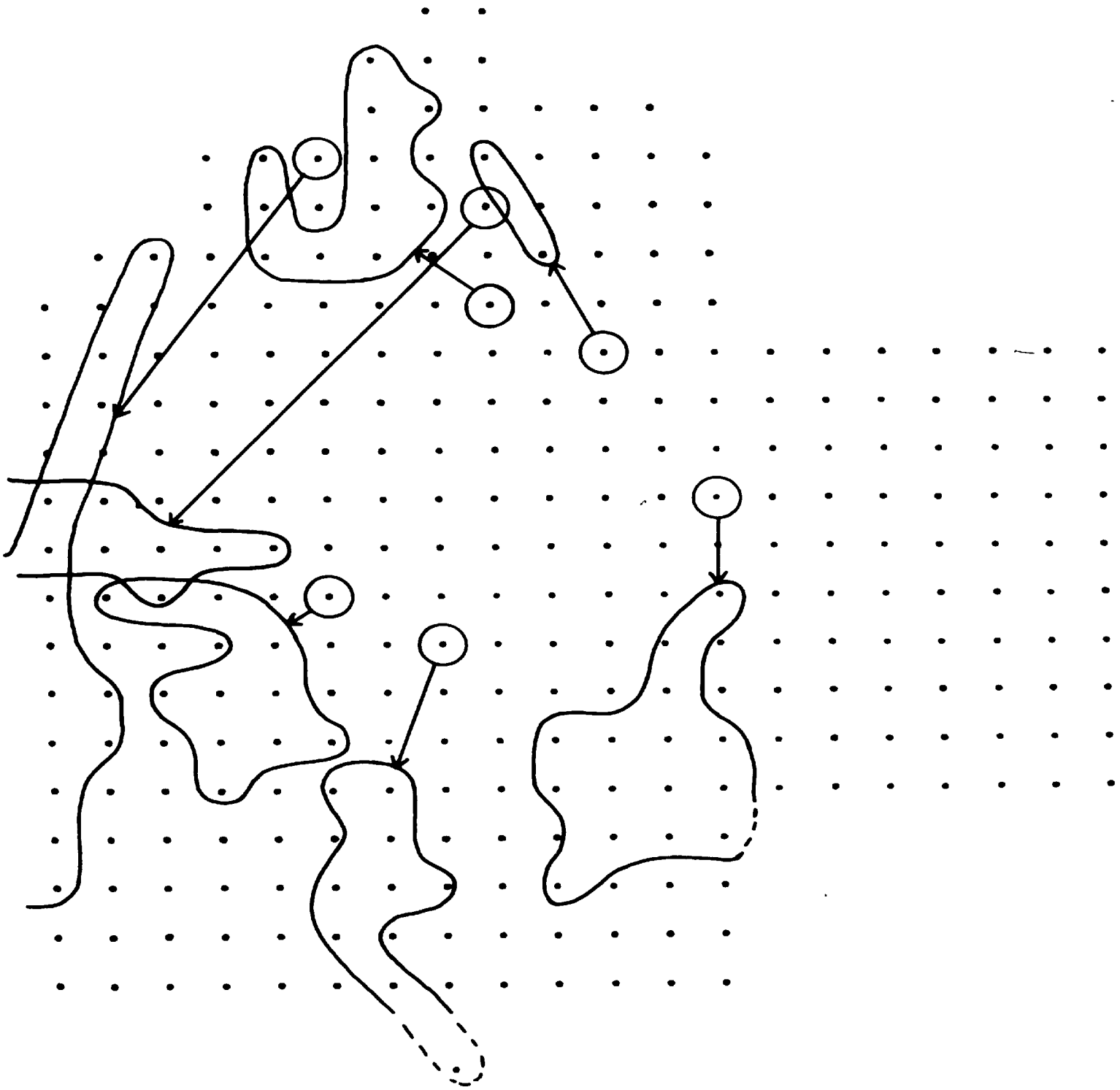
Populations also were calculated on small, medium and large areas. The figures yielded by the smallest area (Plot 3) were larger than those yielded by the largest area (Plots 1-4 combined). I would suggest trapping an area roughly 1400 feet square in a detailed study of ranges and populations of chipmunks. This suggestion is based on my figures for diameters of ranges. The greatest diameter was 1337 feet.

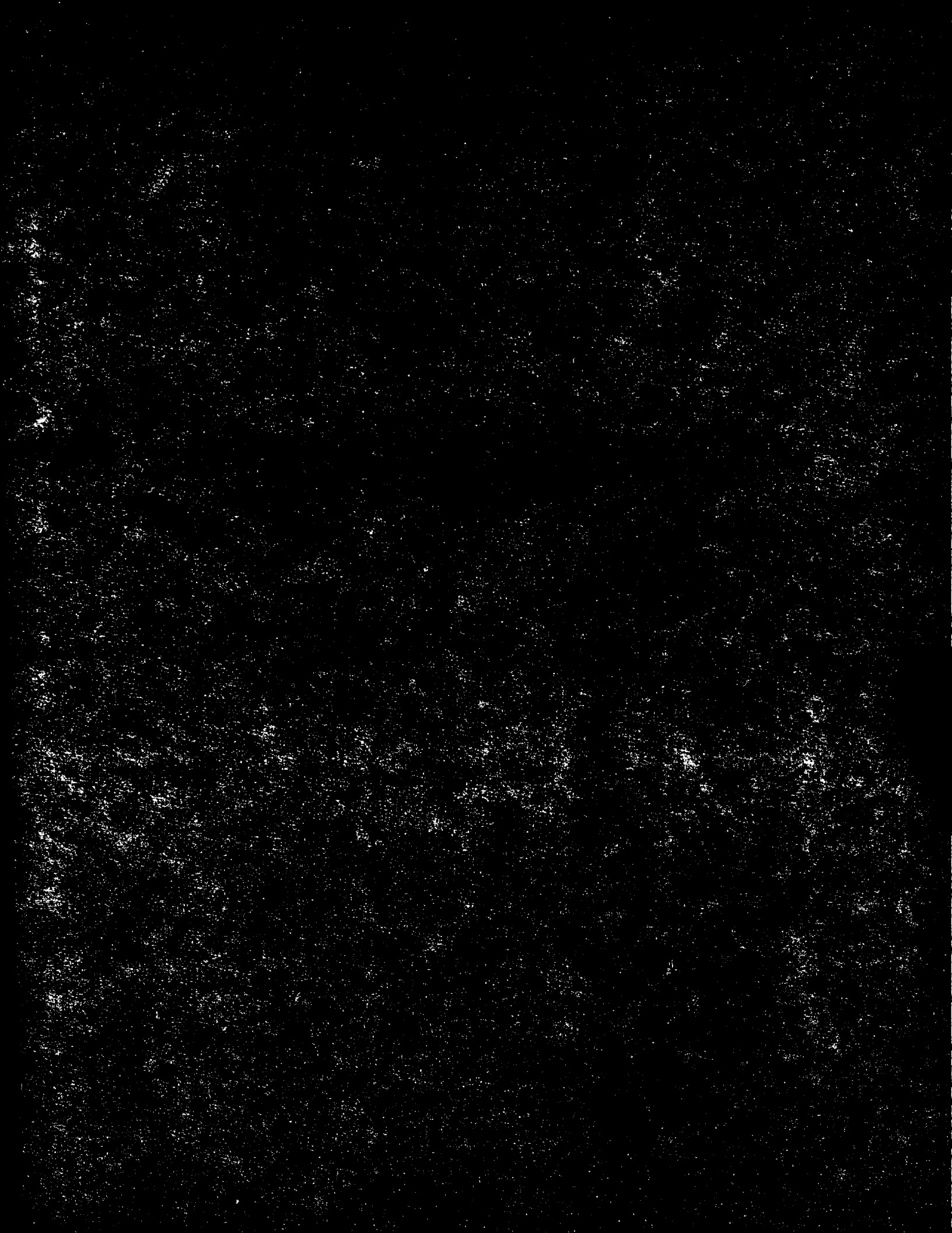
When sexes were pooled or calculated separately there was no significant difference, the method of pooling the sexes giving figures that were larger by an average of only 0.12 per acre. Therefore, one might as well use the simpler method—calculating numbers for the whole population at once rather than for each sex.











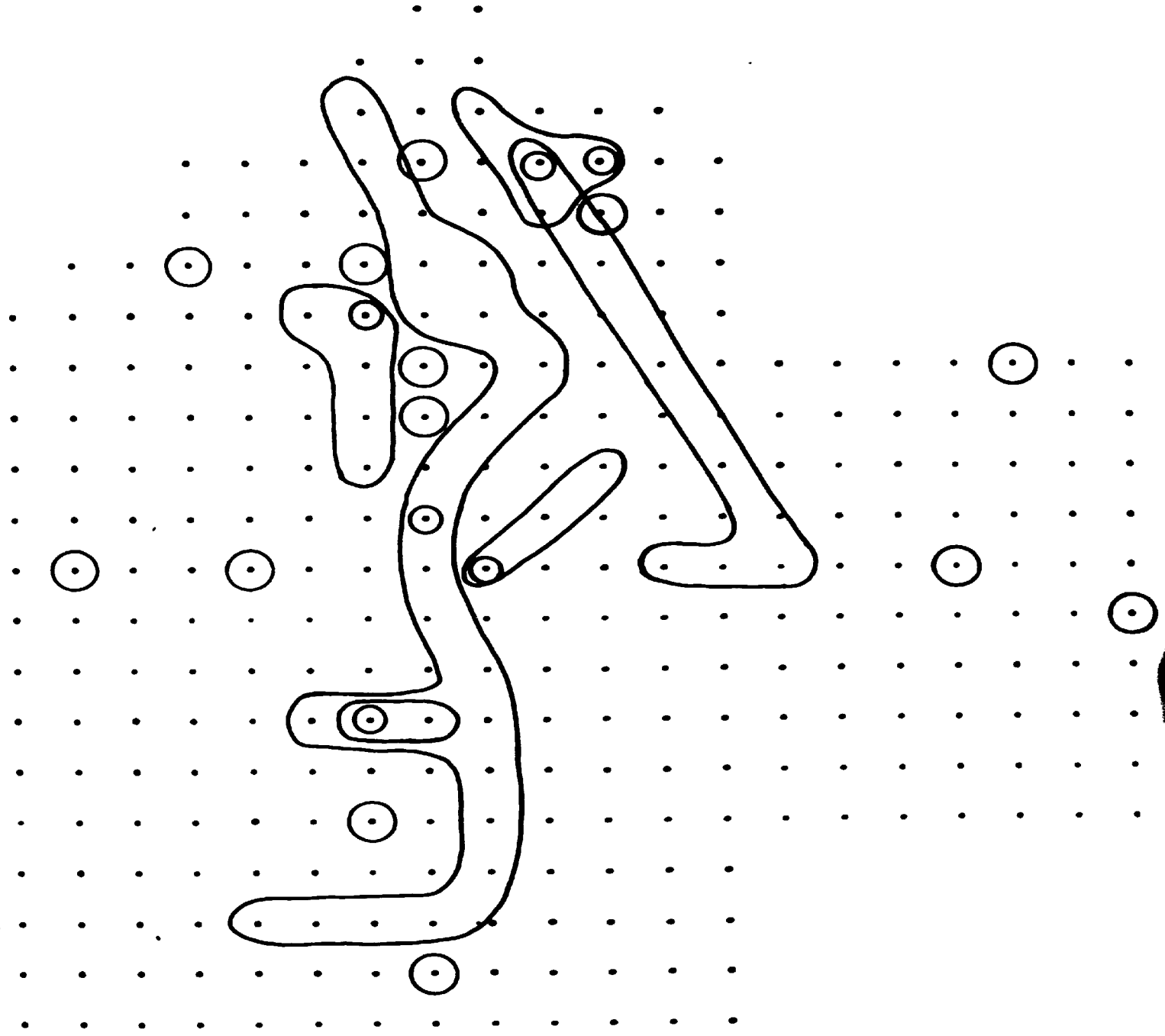
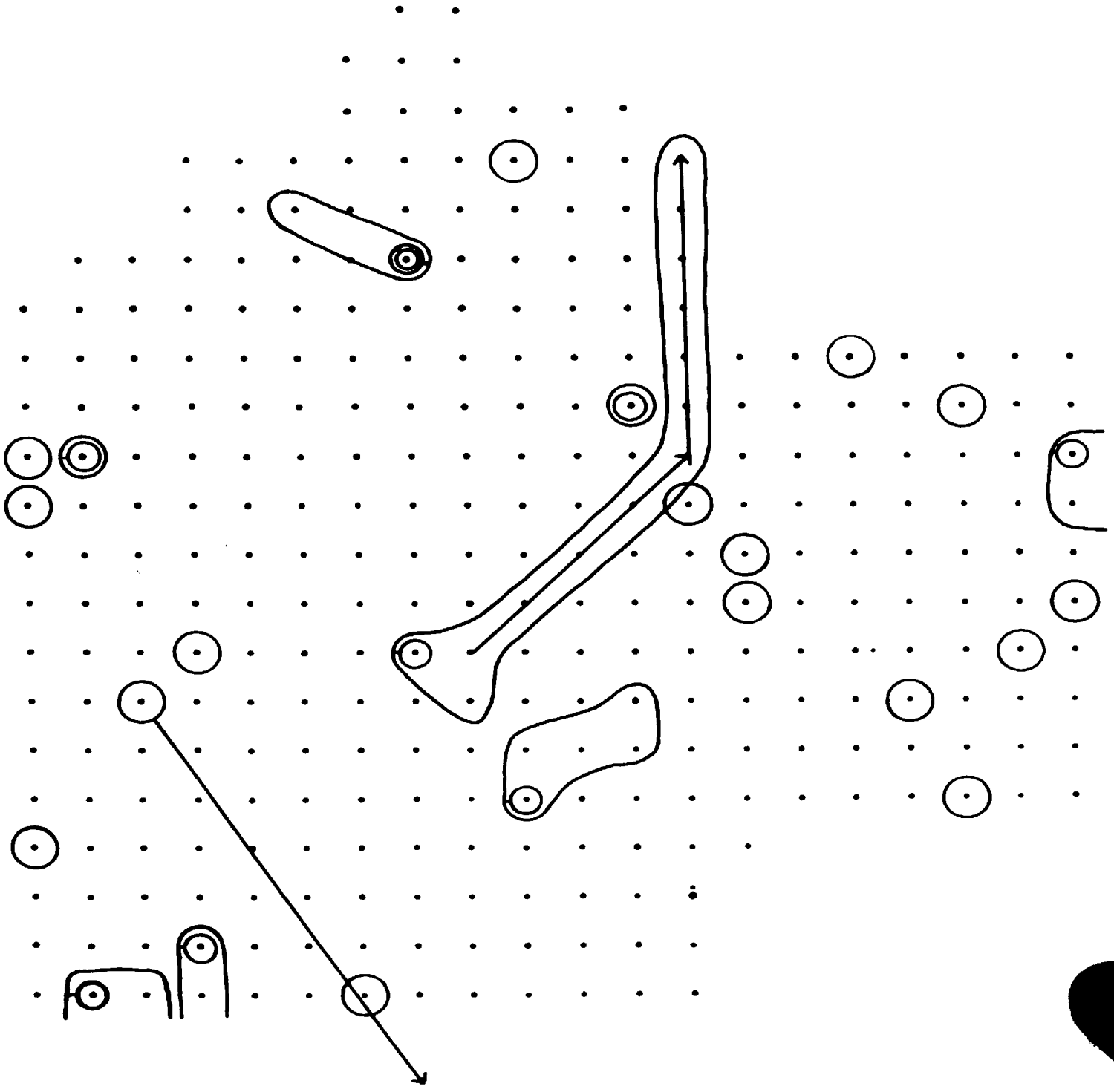


Fig. 25. Twenty-seven male young captured in June and July, 1947, that left the trap area by August 16, 1947; circles represent points of first capture



HOMING

Homing instinct has been shown in various small mammals (Johnson, 1926; Marie and Marie, 1931-32; Hamilton, 1939; Burt, 1940; Hungerford and Wilder, 1941), but apparently no one has experimented with Eutamias amoenus. In the course of my study I released chipmunks thirty-nine times at distances varying from 680 feet to one mile from the original point of capture. I captured most of the animals for the first time at camp (letter A in Fig. 1), where I had traps set more or less continuously, and then carried them to the point of release in my car. A few of the experimental animals were dyed in order that they might be identified by sight when they returned.

The results of these experiments are summarized in Table 25. Ninety-two per cent (twelve out of thirteen) of the animals released at distances of 680 feet to 1370 feet (0.26 mile) were recaptured in the original area, and 55 per cent (eleven out of twenty) returned from a point (letter B in Fig. 1) one-half mile away. Considering all distances, 66 per cent (twenty-five out of thirty-eight) of all individuals returned home.

It was interesting to note that 75 per cent (nine out of twelve) of the males, but only 25 per cent (two out of eight) of the females in the half-mile experiments were recaptured.

I released three chipmunks at a distance of one mile. A male and a female transported one mile southwest of camp down Benton Creek failed to return, but a male released one mile south was recaptured

Table 25

Summary of homing experiments with chipmunks

Distance returned	Number released					Number recaptured					Per cent returned
	Female		Male			Female		Male			
	ad.	yg.	ad.	yg.	Total	ad.	yg.	ad.	yg.	Total	
1 mile	1		2		3			1		1	33
.9 mile			1		1			1		1	100
.7 mile			1		1						0
.5 mile	3	5	10	2	20	1	1	8	1	11	55
1370 ft. (.26 mile)	1	3	1	2	7	1	2	1	2	6	86
1330 ft. (.25 mile)	1				1	1				1	100
1250 ft.			1	1	2			1	1	2	100
1170 ft.			1		1			1		1	100
700 ft.			1		1			1		1	100
680 ft.			1		1			1		1	100
Totals	6	8	19	5	38	3	3	15	4	25	

at camp on the third day after his release. A few days later this same animal was taken to a point 0.9 mile north of camp, and he returned within twenty-four hours.

I think one may conclude from these tests that chipmunks do have a homing instinct. However, one question that occurs to me is, why do more males than females return? Perhaps this is because males have a greater innate wandering tendency than females. Evidence that males do wander more than females is indicated by their larger trap ranges and their greater rate of travel as shown by observation.

Chipmunks possibly don't travel over every square foot of the area within the arbitrary outlines of the home ranges as I have mapped them, but it seems to me very likely that a high percentage of that area is eventually gone over in the constant search for food.

Certain routes of travel are favored, but it is also my observation that chipmunks often forage about on the ground in various directions in a more or less haphazard fashion. By virtue of their diurnal habits and keen vision, chipmunks undoubtedly are more or less familiar with a considerably larger area than that actually visited.

My homing experiments have shown what seems evident from trapping and direct observation of individuals--that chipmunks have a strong attachment for their home ranges, the areas most familiar to them.

Table 26

Data on females used in homing experiments

No.	Where captured before release	Where released	Date released	Date returned	Where first recaptured or seen	Distance of return (feet)	Time of return to original point or home range (days)
Adults							
167	Camp (A)	Plot 1, 94	9/26/46	9/28/46	Camp (A)	1220	2
301	Camp (A)	½ mi. S (B)	7/25/46	No return	....	....	....
399	Camp (A)	Plot 2, 71	8/20/47	8/21/47	Camp (A)	1372	1
399	Camp (A)	½ mi. S (B)	8/25/47	8/28/47	Plot 3, 92	1464	3
497	Camp (A)	Plot 3, 57	9/26/46	10/3/46	Plot 1, 12	752	7
584	Camp (A)	½ mi. S (B)	9/6/47	No return	....	....	....

Table 26 (continued)

Data on females used in homing experiments

No.	Where captured before release	Where released	Date released	Date returned	Where first recaptured or seen	Distance of return (feet)	Time of return to original point or home range (days)
Young							
168	Camp (A)	½ mi. S (B)	9/24/46	No return	....	....	....
320	Camp (A)	Plot 2, 71	8/19/47	No return	....	....	....
382	Camp (A)	½ mi. S (B)	7/25/47	No return	....	....	....
395	Camp (A)	½ mi. S (B)	8/6/47	No return	....	....	....
402	Camp (A)	½ mi. S (B)	8/4/47	No return	....	....	....
403	Camp (A)	Plot 2, 71	8/20/47	8/25/47	Camp (A)	1220	5
403	Camp (A)	½ mi. S (B)	8/25/47	9/3/47	Camp (A)	2440	9
404	Camp (A)	Plot 2, 71	8/20/47	8/26/47	Camp (A)	1172	6

Table 27

Data on males used in homing experiments

No.	Where captured before release	Where released	Date released	Date returned	Where first recaptured or seen	Distance of return (feet)	Time of return to original point or home range (days)
Adults							
70	Plot 2, 33	Camp (A)	10/10/46	11/2/46	Plot 2, 89	1420	24
70	Plot 2, 89	Camp (A)	11/10/46	6/4/47	Plot 2, 22	720	207
120	Plot 2, 59	Camp (A)	9/26/46	10/8/46	Plot 2, 22	710	12
221	Camp (A)	½ mi. S (B)	9/26/46	9/49/46	Camp (A)	2020	3
221	Camp (A)	1 mi. SW	10/10/46	No return	....	....	....
290	Plot 1, 23	½ mi. S (B)	8/4/47	No return	....	....	....
400	Camp (A)	Plot 2, 100	8/4/47	8/5/47	Plot 4, 93	830	1
419	Camp (A)	½ mi. S (B)	9/6/47	9/11/47	Camp (A)	2610	5
502	Camp (A)	½ mi. S (B)	9/26/46	5/6/47	Camp (A)	2610	222

Table 27 (continued)

Data on males used in homing experiments

No.	Where captured before release	Where released	Date released	Date returned	Where first recaptured or seen	Distance of return (feet)	Time of return to original point or home range (days)
Adults							
506	Camp (A)	½ mi. S (B)	8/4/46	8/12/46	Plot 1, 17	2270	8
529	Plot 1, 10	Camp (A)	11/13/46	5/1/47	Plot 1, 12	590	167
530	Camp (A)	½ mi. S (B)	8/8/46	8/13/46	Camp (A)	2220	5
534	Plot 1, 28	Plot 1, 1	5/20/47	5/23/47	Plot 1, 28	480	3
569	Plot 2, 11	Camp (A)	6/5/47	6/7/47	Plot 2, 12	1170	2
118	Camp (A)	½ mi. S (B)	8/8/47	8/19/47	Camp (A)	2610	11
118	Camp (A)	Plot 2, 71	8/20/47	8/21/47	Camp (A)	1420	1
118	Camp (A)	½ mi. S (B)	8/25/47	8/26/47	Camp (A)	2610	1

Table 27 (concluded)

Data on males used in homing experiments

No.	Where captured before release	Where released	Date released	Date returned	Where first recaptured or seen	Distance of return (feet)	Time of return to original point or home range (days)
Adults							
118	Camp (A)	1 mi. S (C)	8/27/47	8/30/47	Camp (A)	1 mi.	3
118	Camp (A)	.9 mi. NE (D)	9/4/47	9/5/47	Camp (A)	.9 mi.	1
118	Camp (A)	½ mi. S (B)	9/6/47	No return	....	....	....
Young							
317	Camp (A)	½ mi. S (B)	7/25/47	10/22/47	Plot 2, 20	1980	89
321	Camp (A)	½ mi. S (B)	8/4/47	No return	....	....	....
401	Camp (A)	Plot 2, 100	8/4/47	8/6/47	Camp (A)	1260	2
406	Camp (A)	Plot 2, 71	8/20/47	9/3/47	Plot 4, 82	1370	14
406½	Camp (A)	Plot 2, 71	8/20/47	8/26/47	Camp (A)	1420	6

BREEDING

The breeding cycle of Eutamias amoenus at Rocky Flat has the following general sequence. Mating probably occurs in April. The young are born in May and are first seen above ground in June. They mature by fall, but do not reproduce until the following spring. I obtained my data on their breeding habits from embryos, by observing the birth of young in captivity, and from the appearance of the genitalia of males and the mammae of females.

When I began live-trapping at Rocky Flat on May 1, 1947, none of the females was lactating or visibly pregnant. The males, however, had enlarged, descended testes. In one specimen, collected on May 4, these measured 11 x 7 millimeters. The skin of the scrotum of breeding males was black and in some of them the hair was worn off, exposing a small oval patch of black skin (Fig. 27). The testes of the majority of males diminished in size and retracted into the abdomen from about May 3 to 10. An individual collected on May 11, 1947, had abdominal testes which measured 5 x 2 millimeters. By May 19 none of the males had fully enlarged testes.

The evidence from weights and the average sizes of breeding females indicated that their young were born in May. By the middle of the month, most females weighed more than males. Weights of 60 grams or more were a sure sign of pregnancy (Fig. 26 and Table 38) because none of the males and non-breeding females were that heavy.

On May 11, 1947, I traveled seven miles north to Bald Mountain and checked on the breeding of chipmunks there. One chipmunk was seen chasing another over an open, rocky slope and one of them was shot. The specimen was a male with large, scrotal testes, but whether he was the pursuer or pursued was not known. Other males from this locality also had large testes. Thus it appears that the breeding season here was somewhat later than at Rocky Flat. This may be due to the fact that Bald Mountain is two thousand feet higher.

Of fifty-four adult females live-trapped during the period from May 16 to June 15, 1947, 77.1 per cent were in breeding condition. Because observations were not begun until July, 1946, I obtained little information on breeding conditions that year.

Many lactating females develop large mammae by early June. For example, a female whose total weight was 75.5 grams on June 11 had mammary glands that weighed 5.7 grams. At about the third or fourth week of lactation the mammae reach their maximum size, and by then the fur is usually worn off to such an extent that much of the belly is left bare (Fig. 29).

There are eight mammae and the arrangement is by pairs--one pectoral, two abdominal, and one inguinal. In lactating females the nipples are about 3 millimeters long, but in non-breeding females they are much less conspicuous. In one individual some of the mammae may be pink while others are darkly pigmented.

My experience with captive animals showed that weaning is a gradual process and is completed when the young are about six weeks old.

Data on number and size of embryos and young of seven females are given in Table 28. A female that I shot at Rocky Flat on May 4 furnished my earliest record of pregnancy. The uterine swellings caused

Table 28

Number and size of embryos and young in 1947
(weights are in grams, measurements in millimeters)

Date	Weight of mother	Numbers of embryos: Right horn	Left horn	Total	Sizes of embryos: Crown-rump length	Diameter uterine swellings
May 4	....	3	3	6	....	6
May 11	62	3	2	5	....	....
May 11	51	2	3	5	....	3
May 15	73	5	2	7	25 (23-26)	....
May 15	62	4	2	6	10.3 (9-11)	....
May 20	....	....	....	6	31	....
May 26	....	....	....	4	....	....

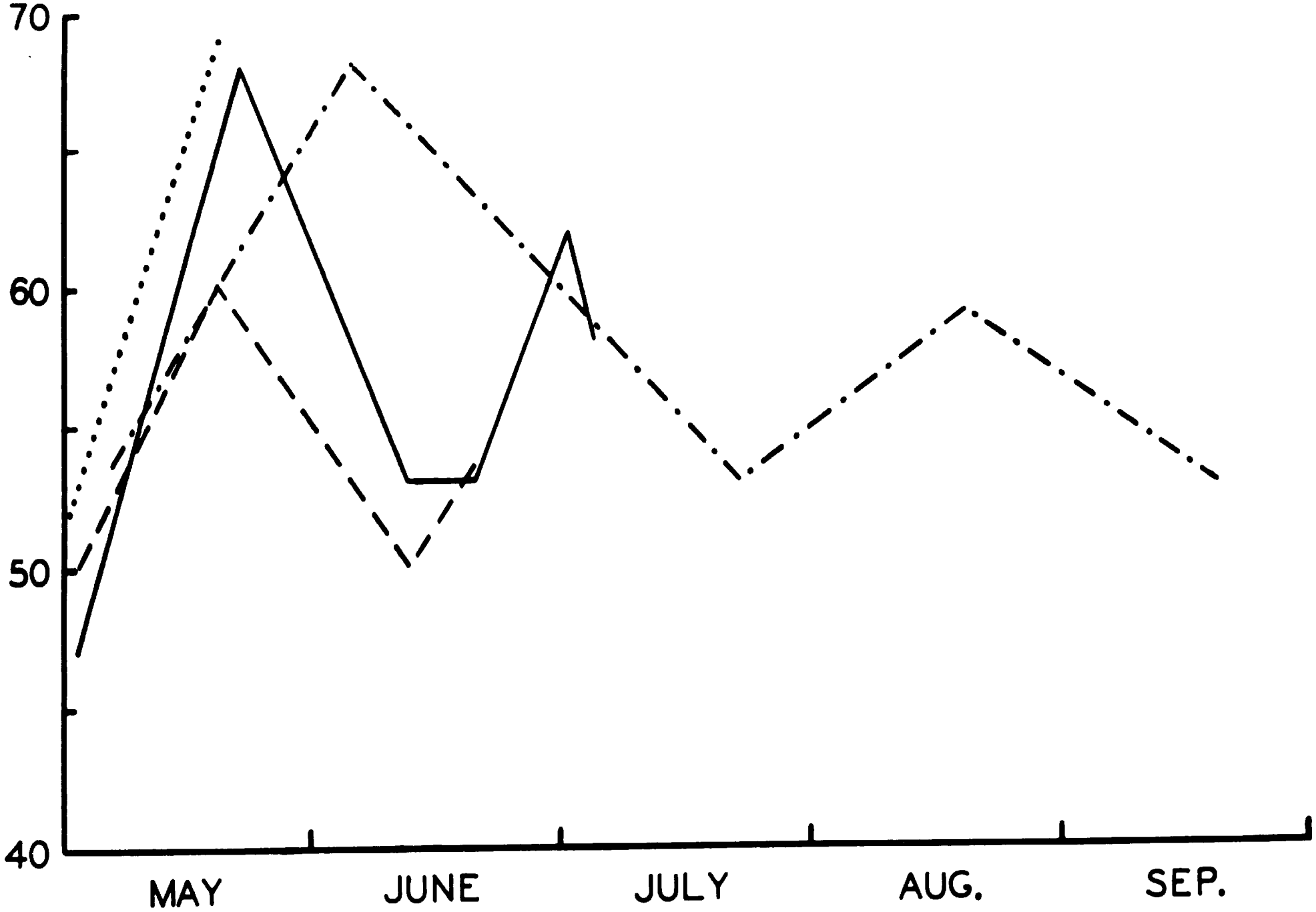
by her embryos were 6 millimeters in diameter. Another female collected on May 15 was in advanced pregnancy. Her seven embryos averaged 26 millimeters in crown-rump length--a length which is about 31 millimeters at birth. They had vibrissae less than 1 millimeter long on their noses. The placenta of a 25-millimeter embryo was 10 millimeters in diameter.

Most pregnant females just prior to parturition weighed between 65 and 70 grams, and during the subsequent period of lactation weighed 50 to 63 grams. One lactating female weighed 75.5 grams on June 11. Figure 26 shows the weight changes of four breeding females. In May their weights rose sharply. The figures for one female were 47 grams on May 2, 68 grams on May 20 when she was pregnant, and 52 grams on June 12 when she was lactating. Another female weighed 65 grams on May 20, 58 grams on May 27 (one day after the birth of four young), and 51 grams on June 25, when her young still suckled occasionally, but were practically weaned.

Each breeding female bears only one litter a year. The majority of births occur in May and early June. I examined five pregnant females for embryos and raised two families of young chipmunks in captivity. The embryos were 6 to 26 millimeters in crown-rump length. The number of embryos and young ranged from four to seven and averaged 5.6 in the case of the seven females (Table 28). It should be borne in mind that the actual numbers of young that are born may be less than the numbers of embryos found in the uterus.

In the spring of 1947 I observed the first young chipmunks on June 9. During the last week of June I saw many that were about three-fourths the size of adults. The young usually were in family

Fig. 26. Weight changes of four breeding females in 1947 (weights are in grams)


70
60
50
40
MAY
JUNE
JULY
AUG.
SEP.

groups and probably were not far from their home burrows. They were repeatedly seen in the same places. One family spent much of its time on and around a log, which projected onto a bare, rocky flat from the pine woods of Plot 3 (Fig. 30).

Young chipmunks showed great curiosity and boldness. One animal, accompanied by its mother, who repeatedly gave alarm calls from a distance of about 40 feet, seemed to pay no attention to her excited warnings and allowed me to approach within about six feet. Several other young ones came within three feet of me, probably to satisfy their curiosity. Some mothers remained silent when I was near their young.

The numbers of each sex for the years 1946 and 1947 are shown in Table 29. Slightly more males than females were captured in 1946, while the reverse was true in 1947. For the two years combined the sexes were nearly equal in number, males forming 51 per cent and females, 49 per cent of the total of 577 chipmunks.

Table 29

Sex ratios of chipmunks

Year	Total numbers	Number of males	Percentage males	Number of females	Percentage females
1946	285	151	52.8	135	47.2
1947	292	129	44.2	163	55.8

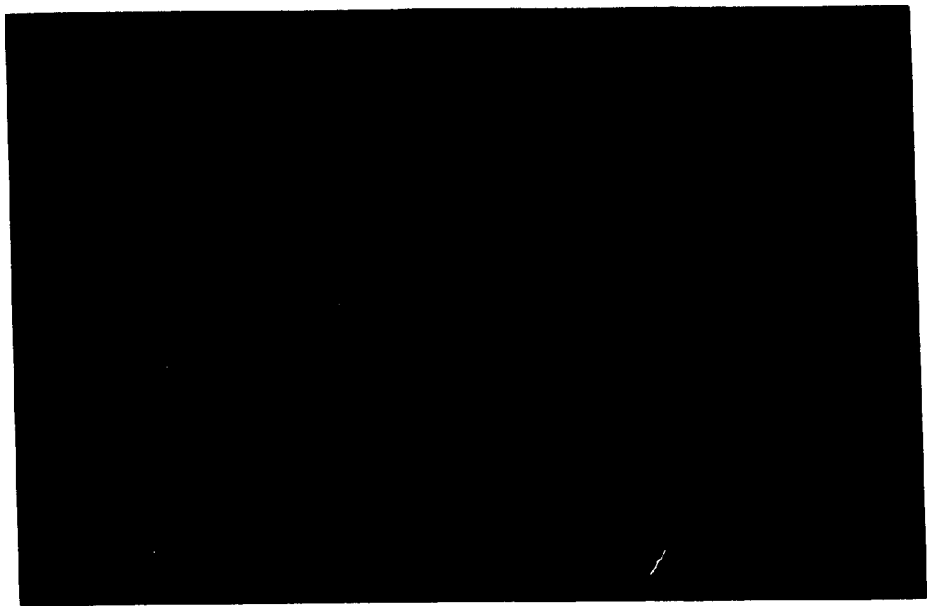


Fig. 27. Male chipmunks with enlarged testes
May 15, 1947

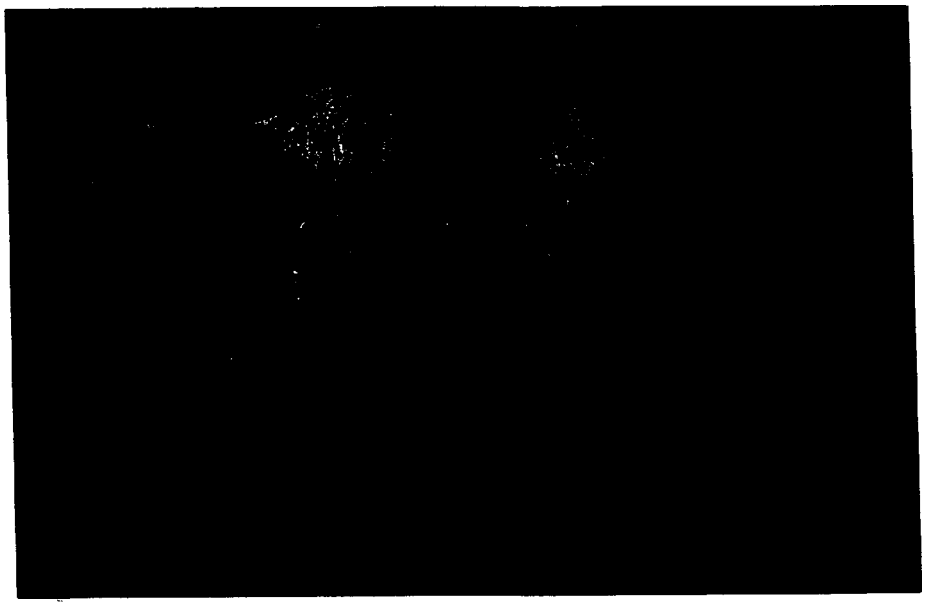


Fig. 28. A pregnant female chipmunk on the left and a non-breeding female on the right
May 15, 1947



Fig. 29. A lactating female with fur worn off the mammae
July 11, 1947



Fig. 30. Log at edge of woods frequented by a family of young chipmunks in the spring

YOUNG

Two captive chipmunks gave birth to young in the spring of 1947. One of the mothers was obviously pregnant on May 19 since her weight had increased from 52 grams on May 1 to 68 grams, and her abdomen was greatly distended. She was caged for observation and the following day, May 20, gave birth to six young in her cigar-box nest. Two of her offspring were born between 4:00 and 6:00 P.M. and two between 6:00 and 7:15 P.M. At that hour she still appeared to be carrying more young, and was nervous and moved rapidly about in her cotton nest in order to avoid my hand. By the following morning her family had been increased to six. Presumably the last two were born between 7:00 and 9:00 P.M. on May 20. One animal from this litter was preserved in alcohol soon after it was born.

On May 26 a litter of four was born to another captive chipmunk, a female caught at Bald Mountain on May 15. For eleven days prior to the delivery of her brood, and for about two days thereafter, she was in a cage with two other adults, another female and a male. I observed no fighting between the three. As soon as I discovered the young in the nest box on May 27, about one day after their birth, the two other adults were removed from the cage. I failed to witness the birth of these four chipmunks, but their age could be closely approximated by comparing them with the young ones whose ages were known.

Both mothers remained out of sight in their nest boxes most of the time during the first few days after parturition.

It was fortunate that the two litters were produced at about the same time because the mother of the first brood escaped on May 26 and was not recaptured. Her five young went without food for a day, but with no ill results. Two members of litter one were removed, and a newly-caught lactating female was then placed in the cage with them. She killed the seven-day-old chipmunks by biting each one in the head. This female had very large mammae and had apparently been lactating for some time, since the hair surrounding her nipples had been worn off and the skin was bare. Probably her own offspring differed considerably in age and appearance from the two she destroyed.

Meanwhile I noticed that one of the males from this same litter was sickly. His weight declined from 2.6 to 2.3 grams in twenty-four hours and was 2.2 grams at the time of his death on May 23. The mother made no effort to remove the body from the nest.

On June 19 a horse kicked over the cage containing the mother of the second litter and her augmented family of six. This frightened the mother so badly that she apparently was unable to feed her brood for a day. Consequently, the weights of her young ones failed to increase on the day following the accident. The same horse again knocked over her cage on June 24, causing it to fall several feet to the ground. This time the mother died of fright and shock.

I trapped two more lactating females in an attempt to solve the food problem of my young chipmunks. At different times each mother was put into the cage with the orphaned chipmunks and, fortunately, both of them accepted the young and fed them. One of the females was

considerably more nervous than the other, so I released the wild one and kept the more tractable animal.

This foster mother usually hid her head in the nest, but did nothing more than that to avoid my hand when I opened the top of her nest box to pick up the young. She allowed them to suckle and remained quiet when I separated them from her nipples. She successfully cared for her new family until July 18, 1947, when she died for some unknown reason, possibly a dietary deficiency. The young were still suckling her occasionally at the time of her death, but they were sufficiently weaned to live entirely on solid food thereafter.

Description of newborn young:

One of the chipmunks born on May 20 was examined within three hours after birth. It weighed 2.8 grams and had the following dimensions (in millimeters): total length, 49; crown-rump length, 32; tail, 11; hind foot, 6.6.

The weights and measurements of two litters of chipmunks less than twenty-four hours old are given in Table 30. The average weight of the ten animals was 2.64 grams, and the average measurements (in millimeters) of five were: total length, 47.6; tail, 10.7; and hind foot, 6.1. Seven of the ten had nursed before they were weighed, and the white milk could easily be seen through the thin, semitransparent skin.

In the newly-born chipmunk the skin is pink or flesh-colored, loose, and wrinkled (Fig. 36). The posterior region of the body is darker than the anterior region, the hind feet in particular appearing red and bloodshot.

Table 30

Weights and measurements of ten young chipmunks less than twenty-four hours old

Litter	Weight (grams)	Total length (mm.)	Tail (mm.)	Hind foot (mm.)	Approximate age in hours	Remarks
Litter 1						
	2.8	49	11.0	6.6	3	
	2.7	....	....	....	20	Milk in stomach
	2.7	....	....	....	20	Milk in stomach
	2.7	....	....	....	20	Milk in stomach
	2.6	....	....	....	20	Milk in stomach
	2.6	....	....	....	20	Milk in stomach
Litter 2						
	2.8	45	10.0	6.0	24	
	2.7	48	11.0	6.5	24	Milk in stomach
	2.4	48	11.0	6.0	24	Milk in stomach
	2.5	48	10.5	6.0	24	
Averages	2.65	47.6	10.7	6.1		

Under 10X binoculars the body appeared hairless except for a few areas of the head (Fig. 35). The numerous mystachial vibrissae on the side of the nose and on the upper lips were 1 millimeter or less in length and were arranged in rows as much as 3 millimeters in length. The longest of these hairs, the posterior ones, were barely visible to the naked eye. Some of the mystachial vibrissae were darkly pigmented, while others were colorless. This area of hair growth on the nose was colored a deep red by blood which showed through the skin.

Two superciliary vibrissae were located above the anterior corner of each eye. Three genal hairs grew in the middle of the cheek, 3 millimeters below the eye and 4 millimeters posterior to the corner of the mouth. There was a tuft of three interramal vibrissae about 4 millimeters behind the point of the chin. All of these hairs were unpigmented, less than 0.5 millimeters long, and were found with the aid of a lens. The lower lips and chin were well covered with hairs. Carpal vibrissae were not in evidence at birth.

The location of developing hairs on top of the head was indicated by the presence of dark spots under the skin. Each spot was visible with a 9X lens, but was not apparent to the unaided eye.

The eyes bulged slightly and appeared dark through the translucent skin which covered them. The united lids formed a shallow, horizontal groove 2.6 millimeters in length.

The pinnae of the ears were triangular in shape and were folded down tightly against the sides of the head. They were 1.6 millimeters long in a preserved specimen.

The toes were distinctly formed at birth, though united by membranes. The soft, unpigmented nails of each toe were 0.6 to 0.8 millimeters in length.

The umbilical cord, which was marked conspicuously by a dark blood clot, persisted for a time as a short stump 1.7 millimeters in length.

A few hours after birth young chipmunks uttered faint squeaks and squirmed vigorously when separated from their mother. They reacted with sucking or swallowing motions when their mouths were touched.

Growth and behavior of young in captivity:

The development of the young chipmunks in captivity may have been temporarily disturbed or retarded to some extent by a change of mothers. Two of the young were cared for by three females, and four were fed at different times by two mothers. There were eight nipples for the six animals, and all of the young appeared well fed and healthy during their early development. I have no evidence that the two older members of the brood obtained a nutritional advantage because of their greater strength and size. None of these chipmunks reached the size of wild adults in respect to hind foot and tail lengths, but their weights were normal. Possibly the diet of my captives lacked certain elements necessary for fullest growth.

Photographs taken at regular intervals showed that conspicuous changes in the appearance of the young often took place within a matter of a few days.

Both male and female newly-born chipmunks looked alike, except that the distance between the genital organ and the anus differed in the two sexes. In the males this distance was 4.5 to 5 millimeters

on the third day after birth; in females, 2.5 to 3 millimeters. The same measurements for two specimens preserved in alcohol when they were seven days old were 4 millimeters for the male and 2 millimeters for the female. The penis is 2 to 2.5 millimeters long when chipmunks are five weeks old. In preserved adults the organ is 3 millimeters in length.

The nails were soft at birth and bled when they were cut with a razor blade for identification purposes. The proximal end of the claw began to acquire black pigment within a few days, and by the eleventh day this area had become very dark. The claws of the front feet were entirely black in two weeks, while only the bases of the hind claws were dark at that time.

At first the pinnae are folded down over the region of the future meatus, but on the sixth or seventh day they become erect. One pinna may unfold a day sooner than the other. The auditory meatus first opened in three animals when they were twenty-eight days old.

The eyes became increasingly prominent and bulging in the course of their development, and the lids opened thirty to thirty-three days after birth. The eyes of one of the six young opened on the thirtieth day, another on the thirty-first, two on the thirty-second, and two on the thirty-third day. When the lids first began to open, they formed short, narrow slits which became fully separated within twenty-four hours.

The lower incisors were covered with gum tissue for eighteen to twenty days. The incisors continued to lengthen until the buds of tissue protecting them were about 2 millimeters long at the end of the second week. In five young these teeth emerged on the following days: eighteenth, nineteenth, twentieth, twentieth, and

twentieth. When the chipmunks were twenty-two to twenty-nine days old, the upper incisors appeared.

The teeth remain white and unpigmented for at least nine weeks before acquiring the brown color which is typical in adults.

The skin of the head, back, and rump became somewhat dry and scaly (Fig. 42) at the age of ten to twelve days and remained in this condition until about the twenty-first day. It was during this period that all of the dorsal stripes became distinct.

The hairs that showed on the young chipmunks at birth grew rapidly. Hairs on the chin and lower lip, although very short at birth, were fairly conspicuous after three days. No carpal vibrissae were detected in newborn animals, but a tuft of three of these hairs emerged in four to six days. The longest of the mystachial vibrissae measured about 1 millimeter at birth, then grew to 3 millimeters on the ninth day, 10 millimeters on the twenty-fifth day, and 29 millimeters at maturity.

At the end of one week the only hairs that were visible without the aid of a lens were the vibrissae of the head and carpal areas. It was not until about the twentieth day that individual hairs could easily be distinguished by the naked eye.

Through a 9X lens I could see a few hairs on top of the head on the second day, and by the fourth day they were fairly conspicuous there. On the third and fourth days I found a few scattered hairs along the back. At the end of a week the hairs of the head and back were less than 1 millimeter long, and those on the tip of the nose had become noticeably darker than any of the others. Hairs on the head were also dark in color and quite abundant, while those on the

back were fewer in number. On the sides a few hairs emerged on the tenth day.

Two dorso-lateral white stripes, each bordered by two faint black stripes, were first noticed when the chipmunks were ten days old. The color of the stripes was caused by hairs which had not yet broken through the semitransparent skin membrane. These stripes measured 24 millimeters in length and 1 millimeter in width on the eleventh day (Fig. 41) and were quite distinct then.

A sparse growth of short hairs appeared on the belly and legs at eleven days of age. The tail was still bare at that time, but on the twelfth day a few hairs showed on the proximal half and one day later they appeared on the distal half.

The adult facial and dorsal body patterns (Fig. 43) were found by the end of the second week. The eyes bulged out greatly and the white stripes on the body were particularly noticeable at that age. The eyebrows were distinctly white, and dark facial stripes were evident. The mid-dorsal stripe was the last to develop. It extended along the back, neck, and posterior part of the head. It was faintly visible on the fourteenth day and quite clearly marked by the twentieth.

The sides appeared tawny, and white post-auricular patches were well developed in animals twenty-three to twenty-five days old. The outer sides of the legs and the bottoms of the hind feet had become noticeably dark at the end of a month.

The tail was well haired and buff in color in chipmunks between the ages of twenty-four and forty days; then black hairs became interspersed with the buff. During the buff stage the fur was smooth and closely appressed to the tail. It lacked the hairy appearance that

developed by the forty-third day. At this stage of development the four younger chipmunks could be distinguished from the older two by the appearance of their tails.

The anterior half of the belly was closely covered with white hair on the twenty-fifth day, while the posterior area was more sparsely furred. The underparts acquired a faint buff wash in three weeks time.

The smooth, sleek appearance of the young animals disappeared in about nine weeks, and they began to look like young adults.

The front toes began to separate when the chipmunks were eleven days old, and completed division from one another in about twenty-five days. In this process the hind feet lagged about five days behind the front feet.

The blood clot at the navel disappeared in about ten days. Fecal matter appeared as a brown, semi-liquid anal stain for one week or more after birth.

Young chipmunks were relatively cold-blooded in early life, although I did not record any definite time at which they appeared to have gained thermal control. The process was a gradual one that may have taken a week or longer.

Within forty-eight hours after birth, the voices and actions of the young were noticeably stronger, and animals two weeks old were able to squeak loudly. One animal uttered an adult "pert" note as it came out from under the effects of ether. When a chipmunk seventy-two days old was held in my hand, it gave angry calls which sounded to me like a kind of growl and which I described in my notes as a "throaty, buzzing rattle." He also gave a sharp "kwist" note that was similar to an adult alarm call.

Chipmunks fifteen days old had acquired a snub-nosed appearance, which was due to the bulging frontal area of the head. The general development of the animal at the end of the third week was striking, and the hind legs appeared disproportionately large in comparison with the rest of the body (Fig. 46).

The young were so active by July 3 that I began anesthetizing them before taking their weights and measurements. Two animals died from the ether on July 24 and August 19, despite the fact that I watched them closely while administering it, so the use of an anesthetic was eventually discontinued.

The general activity of young chipmunks increased noticeably during the first twenty-four hours, and at the end of two weeks they could drag themselves around on their bellies. The front legs were much stronger than the hind legs and served as the principal means of locomotion. When the animals were sixteen days old, they could cling securely to my hand. They were able to support their bodies off the ground on the seventeenth day.

The motions of chipmunks three weeks old were jerky and spasmodic, but the young animals were then beginning to act in a typical adult way by scratching their ears with their hind feet. The four younger chipmunks then were noticeably less coordinated than the older two when the latter were five weeks old.

Animals which were four weeks old were quite sensitive to sharp, sudden sounds, and one animal would defend itself from my hand by pawing the air with rapid, jerky movements of all four of its feet.

Young chipmunks sniffed the scales on which they were weighed and showed a lively interest in their surroundings by the time they

were five weeks old. They were able to crawl well then, and a week later they could climb the screen on the front of the cage. About this time they began the annoying practice of jumping off the scales when I tried to weigh them. All of them were eating solid foods when six weeks old, and they would sit on their haunches and wash their faces just like an adult.

When at rest or asleep the forepaws were held over the face, and the body and tail were curled up into a ball (Fig. 44).

The six young showed rather marked differences in temperament by the end of the first month. One of them invariably tried to bite me when cornered. He would try to ward off my hand with his forepaws while making angry, buzzing notes. Another one was quite tame and usually climbed into my hand looking for food.

Sexual activity was noticed for the first time when a chipmunk fifty-one days old tried to mount one of the others.

Family feuds began when they were about five months old. Two of them (a male and a female) fought the other two and often forced them to retreat to the nest box. This fighting may have been the reason why the two underdogs dropped in weight from October 4 to November 14. One declined from 41 to 34 grams and the other from 44 to 34 grams in this period.

The weights of the young chipmunks, two of whom died before reaching maturity, are summarized in Table 31. Weights increased at a fairly uniform rate for the first three months, the average daily increment for this period being 0.49 grams. The growth curves approximate a straight line (Figs. 31 and 32). The probable weights of young chipmunks at various ages may be read from the regression line (Fig. 33 and Table 32).

The standard measurements of total length, tail, hind foot, and ear for a male and female of litter one have been plotted (Fig. 34). The curves for linear growth in litter two, while not shown here, follow a similar pattern.

Fig. 31. Weight changes of two young chipmunks of litter one; the solid line represents the male and the dotted line, the female

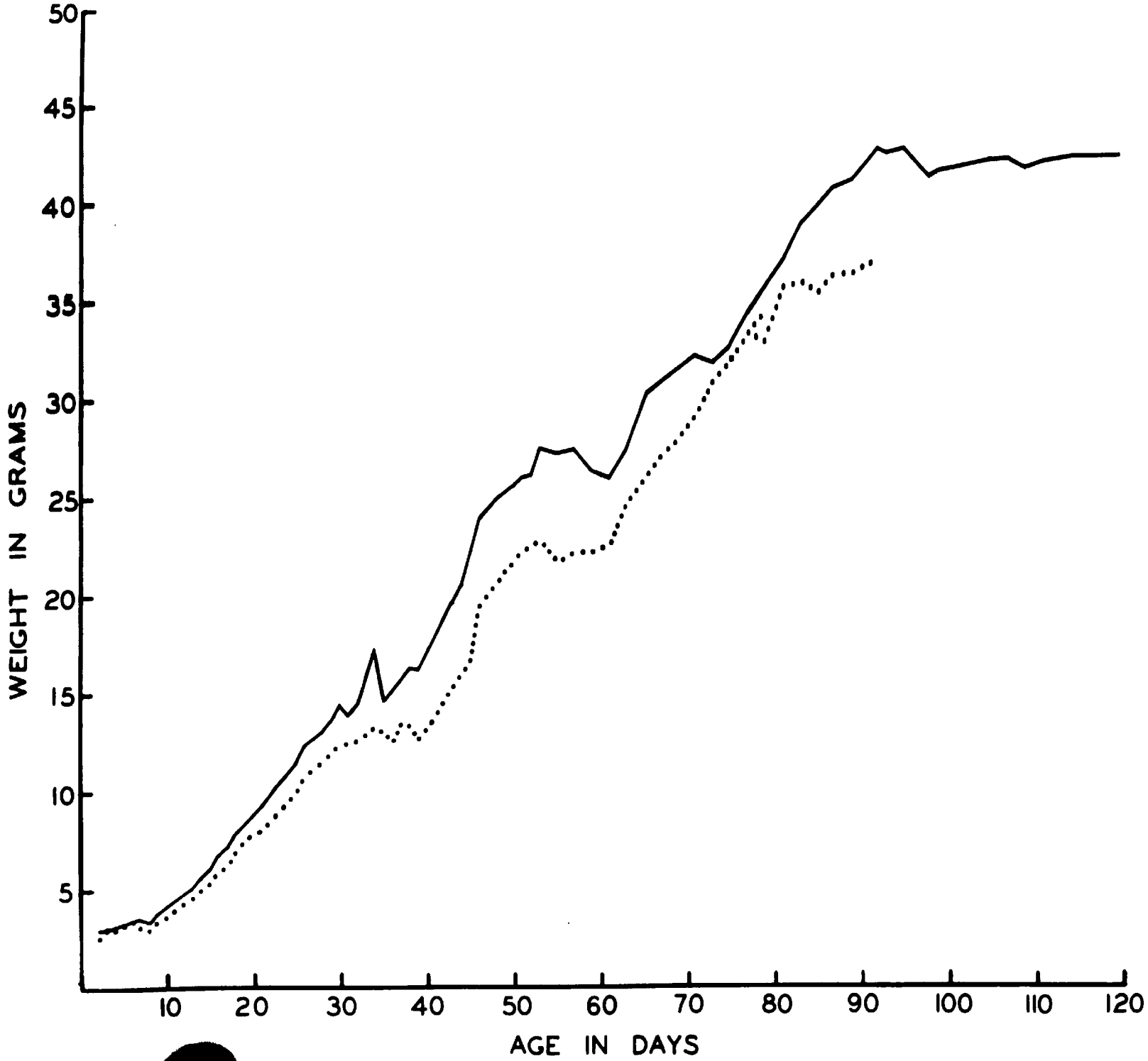

50
45
40
35
30
25
20
15
10
5
WEIGHT IN GRAMS
10
20
30
40
50
60
70
80
90
100
110
120
AGE IN DAYS

Fig. 32. Weight changes of three young chipmunks of litter two; the solid line and the dotted line represent females and the dashed line, a male

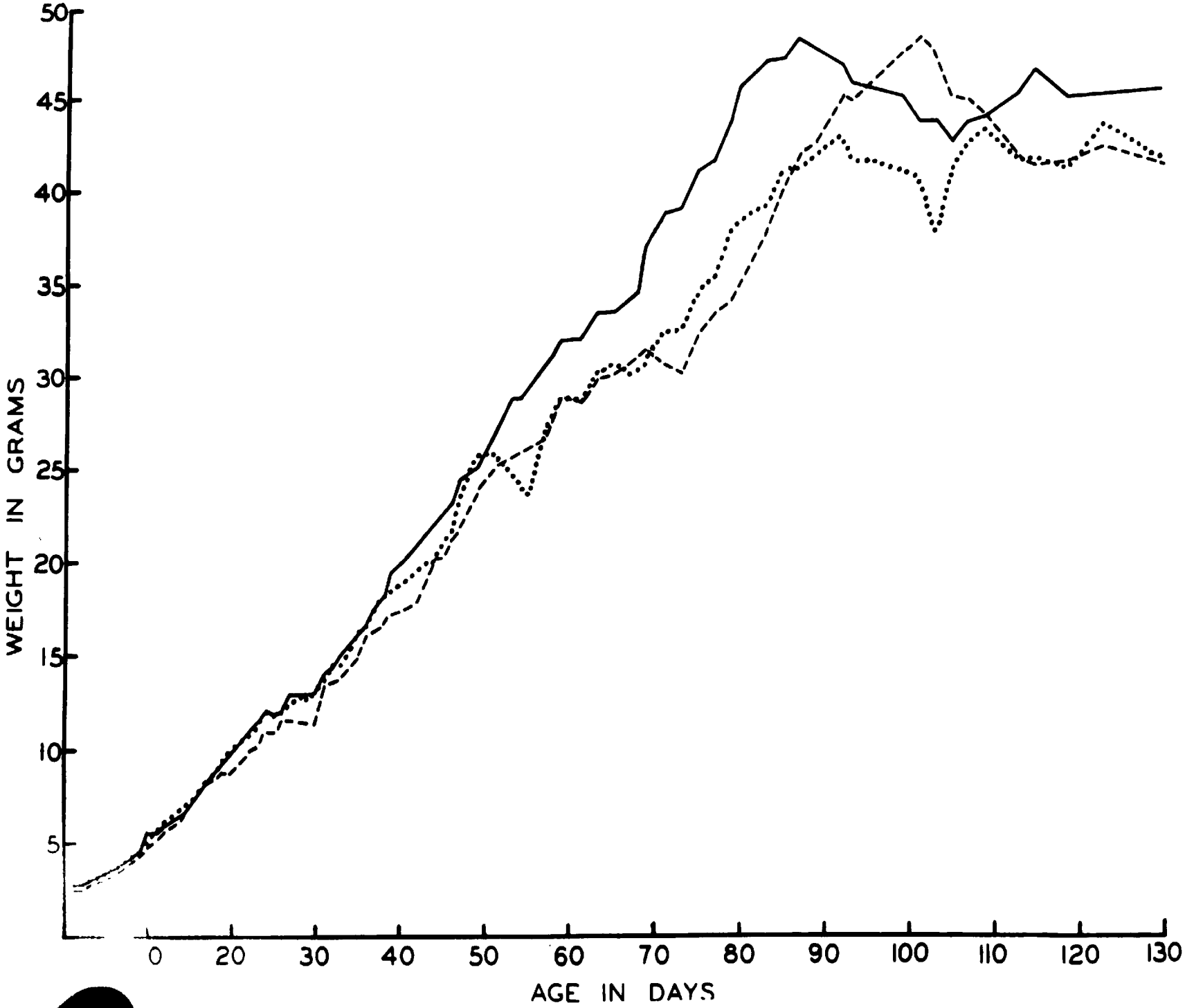

WEIGHT IN GRAMS
50
45
40
35
30
25
20
15
10
5
0
20
30
40
50
60
70
80
90
100
110
120
130
AGE IN DAYS

Table 31

Changes in weights of young chipmunks in 1947

Age in days	Weight in grams: Litter 1 ♂	Litter 1 ♀	Litter 2 ♀	Litter 2 ♀	Litter 2 ♂	Litter 2 ♂
1	....	....	2.8	2.7	2.4	2.5
2	3.0	2.6	2.8	2.8	2.5	2.5
3	3.0	3.0	3.0	3.0	2.7	2.7
4	3.2	3.0	3.2	3.2	2.9	2.8
5	....	....	3.4	3.4	3.2	3.1
6	3.5	3.4	3.7	3.7	3.5	3.3
7	3.7	3.3	3.9	3.9	3.8	3.6
8	3.4	3.0	4.6	4.1	4.2	4.0
9	3.8	3.6	4.7	4.5	4.4	4.3
10	4.2	3.8	5.1	5.5	5.0	4.8
15	6.2	5.4	7.2	7.0	7.1	6.8
20	8.8	8.0	9.9	9.8	10.0	8.8
25	11.5	10.2	11.7	11.8	11.7	10.8
30	14.5	12.5	13.1	13.3	13.0	11.7
35	14.6	13.0	16.2	16.1	15.4	14.9
40	17.1	13.5	18.8	19.8	18.3	17.3
45	22.2	16.6	21.1	22.6	21.2	20.2
50	25.5	21.6	25.6	25.9	25.0	24.8
55	27.2	21.6	23.4	28.8	26.7	26.0
60	26.0	22.4	28.2	31.9	29.0	28.6
65	30.0	25.9	30.5	33.3	....	30.0
70	31.7	28.5	31.4	37.7	....	30.9
75	32.6	31.8	34.4	41.0	....	32.2
80	36.2	34.1	38.2	44.6	....	34.8
85	39.5	35.2	40.9	47.1	....	39.9
90	41.7	36.4	42.2	46.7	....	43.3
95	42.5	....	41.6	45.4	....	45.2
100	41.5	....	41.0	44.3	....	47.7
105	41.6	....	41.0	42.5	....	45.1
110	41.7	....	42.3	44.2	....	43.5
115	42.0	....	41.6	46.4	....	41.1
120	42.0	....	41.5	44.4	....	41.6
125	43.3	....	43.1	43.5	....	....
130	43.0	....	41.5	45.0	....	41.0
137	43.9	....	39.3	....	....	....
172	....	....	....	44.2	....	33.6
178	33.8	....	....	....	....	....

Fig. 33. Regression line for chipmunk weights: $Y = -0.47 + 0.47\ X$
Each dot represents the average of the original data

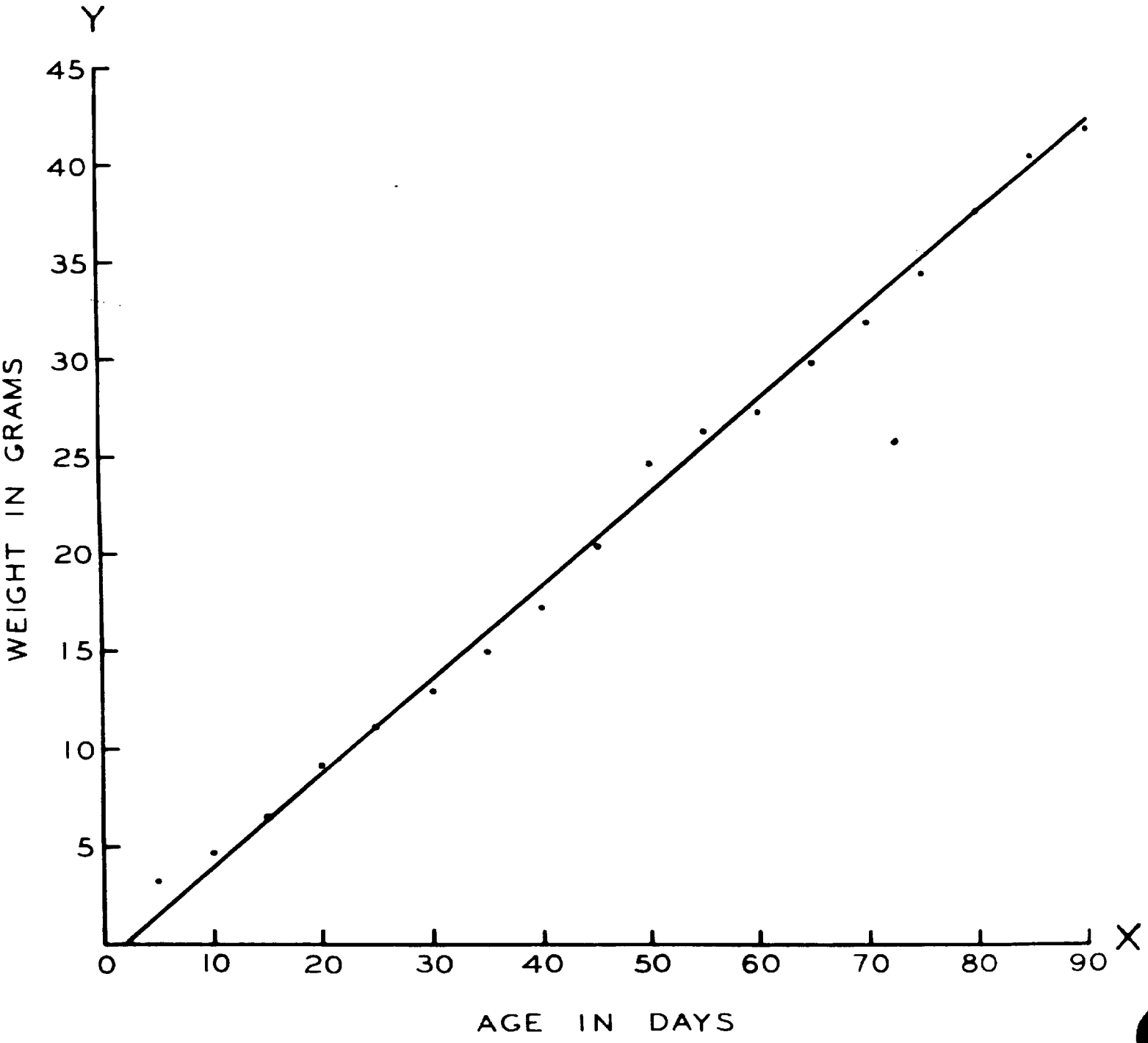

Y
45
40
35
30
25
20
15
10
5
WEIGHT IN GRAMS
0
10
20
30
40
50
60
70
80
90
X
AGE IN DAYS

Table 32

Probable weights of young chipmunks at various ages; linear regression equation: $Y = -0.47 + 0.47\ X$
(actual weights used for the first nine days)

Age in days	Probable weight in grams	Age in days	Probable weight in grams	Age in days	Probable weight in grams
1	2.60	31	14.10	61	28.20
2	2.70	32	14.57	62	28.67
3	2.90	33	15.04	63	29.14
4	3.05	34	15.51	64	29.61
5	3.28	35	15.98	65	30.08
6	3.51	36	16.45	66	30.55
7	3.68	37	16.92	67	31.02
8	3.88	38	17.39	68	31.49
9	4.21	39	17.86	69	31.96
10	4.23	40	18.33	70	32.43
11	4.70	41	18.80	71	32.90
12	5.17	42	19.27	72	33.37
13	5.64	43	19.74	73	33.84
14	6.11	44	20.21	74	34.31
15	6.58	45	20.68	75	34.78
16	7.05	46	21.15	76	35.25
17	7.52	47	21.62	77	35.72
18	7.99	48	22.09	78	36.19
19	8.46	49	22.56	79	36.66
20	8.93	50	23.03	80	37.13
21	9.40	51	23.50	81	37.60
22	9.87	52	23.97	82	38.07
23	10.34	53	24.44	83	38.54
24	10.81	54	24.91	84	39.01
25	11.28	55	25.38	85	39.48
26	11.75	56	25.85	86	39.95
27	12.22	57	26.32	87	40.42
28	12.69	58	26.79	88	40.89
29	13.16	59	27.26	89	41.36
30	13.63	60	27.73	90	41.83

Fig. 34. Growth of two young chipmunks of litter one from the age of six days to maturity; the solid line represents the male and the dotted, the female

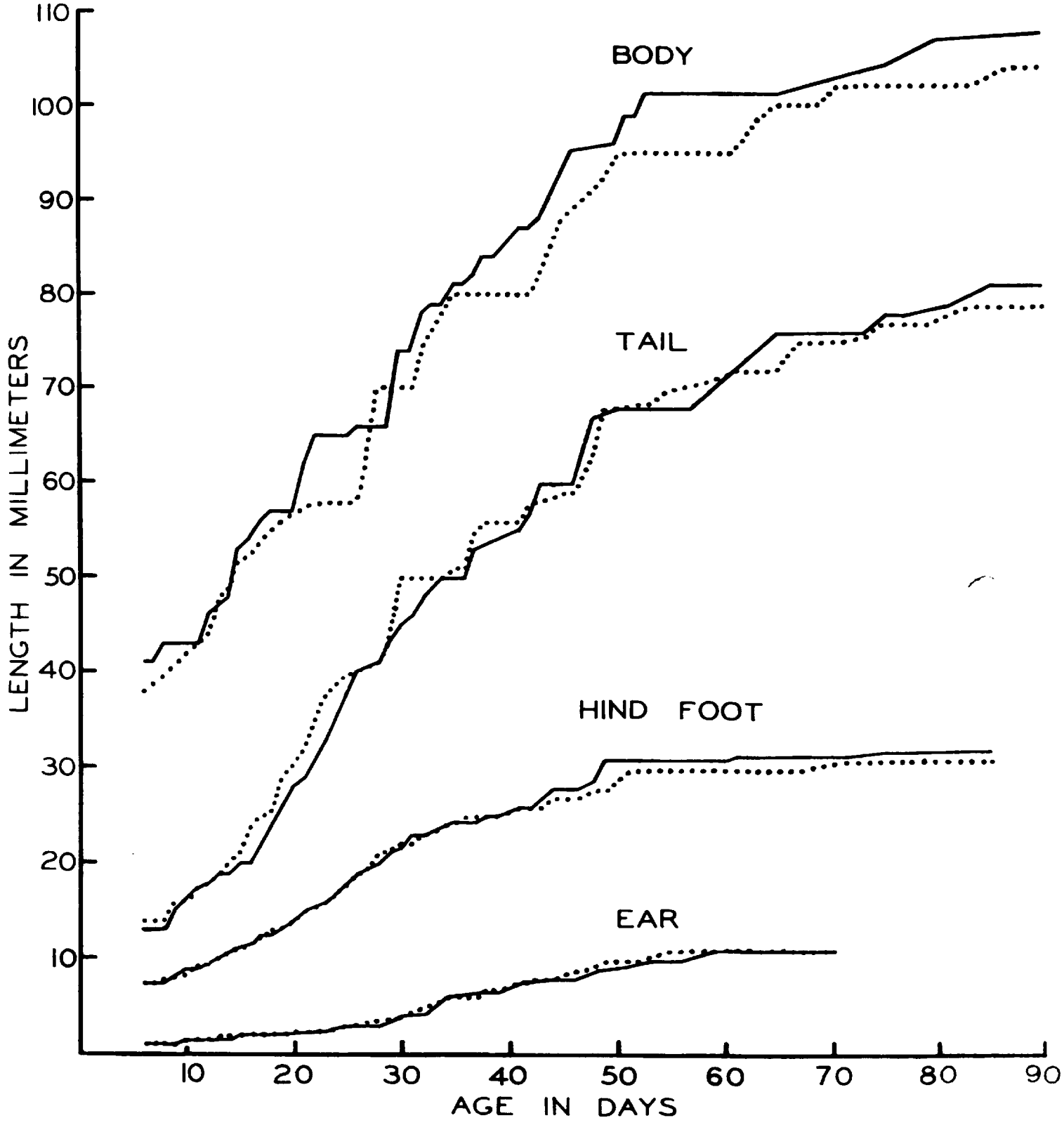

110
100
90
80
70
60
50
40
30
20
10
LENGTH IN MILLIMETERS
BODY
TAIL
HIND FOOT
EAR
10
20
30
40
50
60
70
80
90
AGE IN DAYS

Fig. 35. Facial vibrissae of chipmunk at birth; lengths are exaggerated





Fig. 36. Age, 20 hours; note loose, wrinkled skin, united toes, eyes closed, pinnae folded against the head

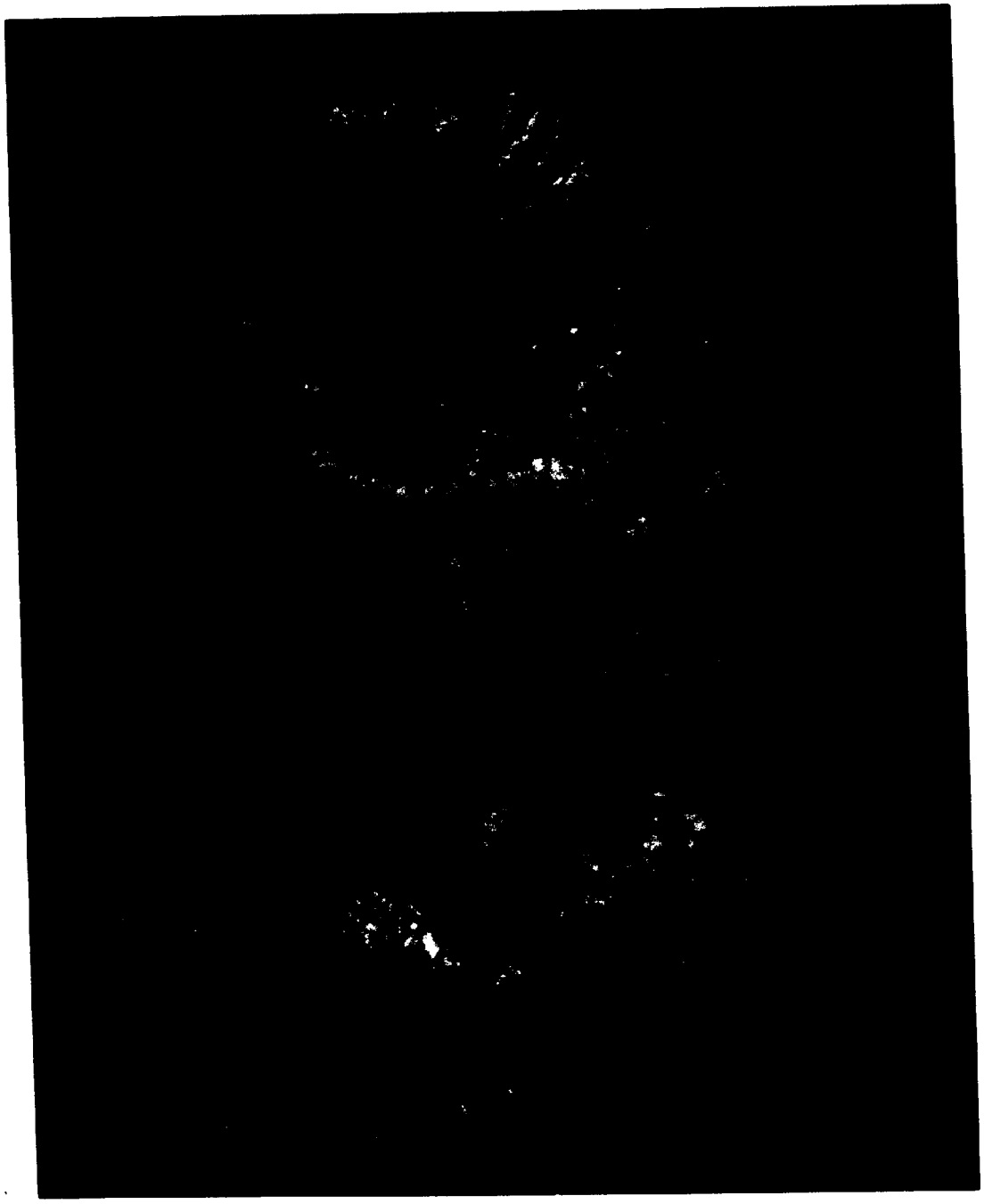


Fig. 37. Age, 4 days; the eyes are bulging and dark

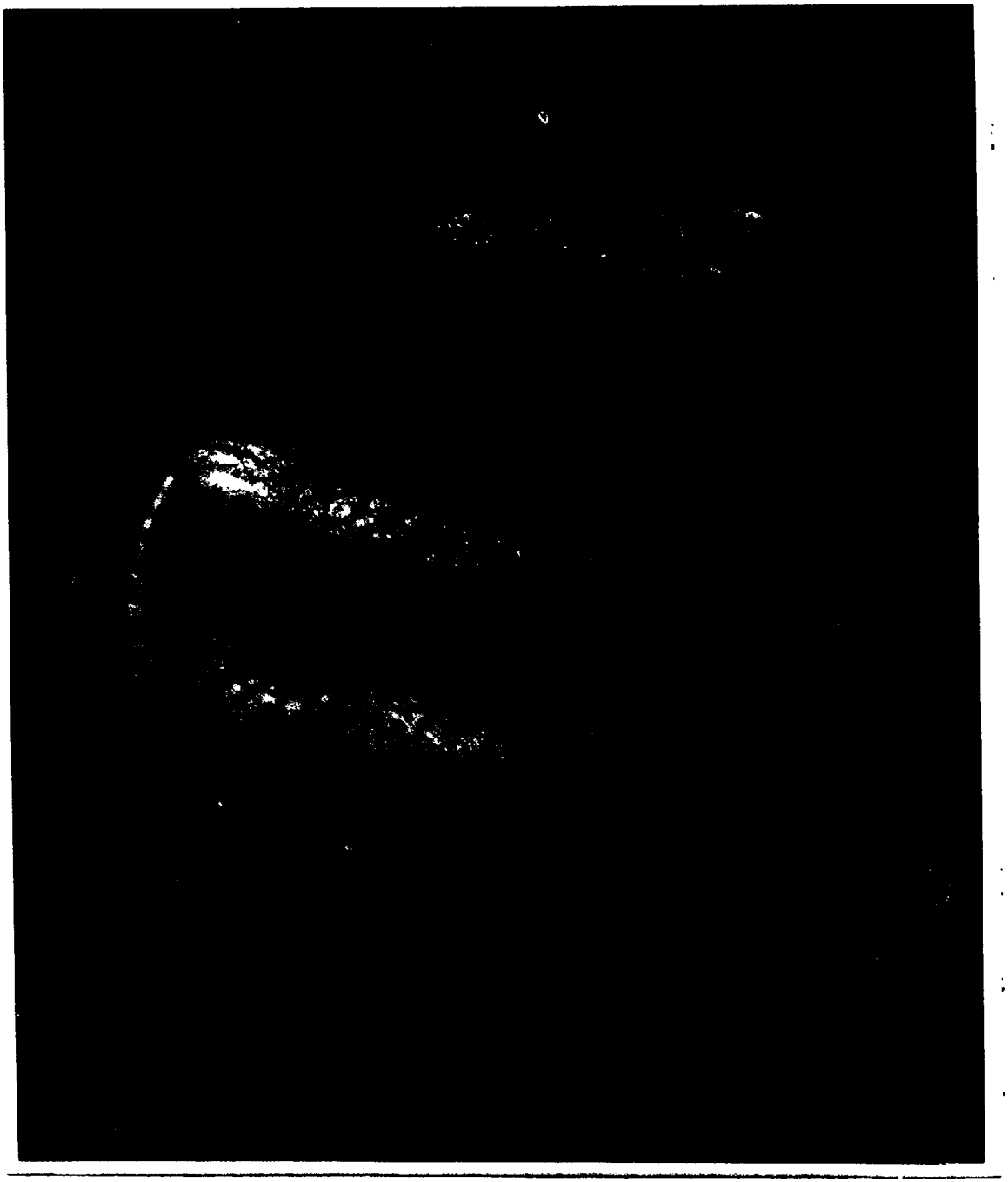


Fig. 38. Age, 6 days; note the hair on nose and head, erect pinna, and white and black stripes on back



Fig. 39. Age, 14 days, note loose skin, black toe nails



Fig. 40. Age, 15 days



Fig. 41. Ages, 14 and 20 days; note development of black mid-dorsal stripe in the older animal; toenails black



Fig. 42. Age, 19 days; note white, flaky scales on back

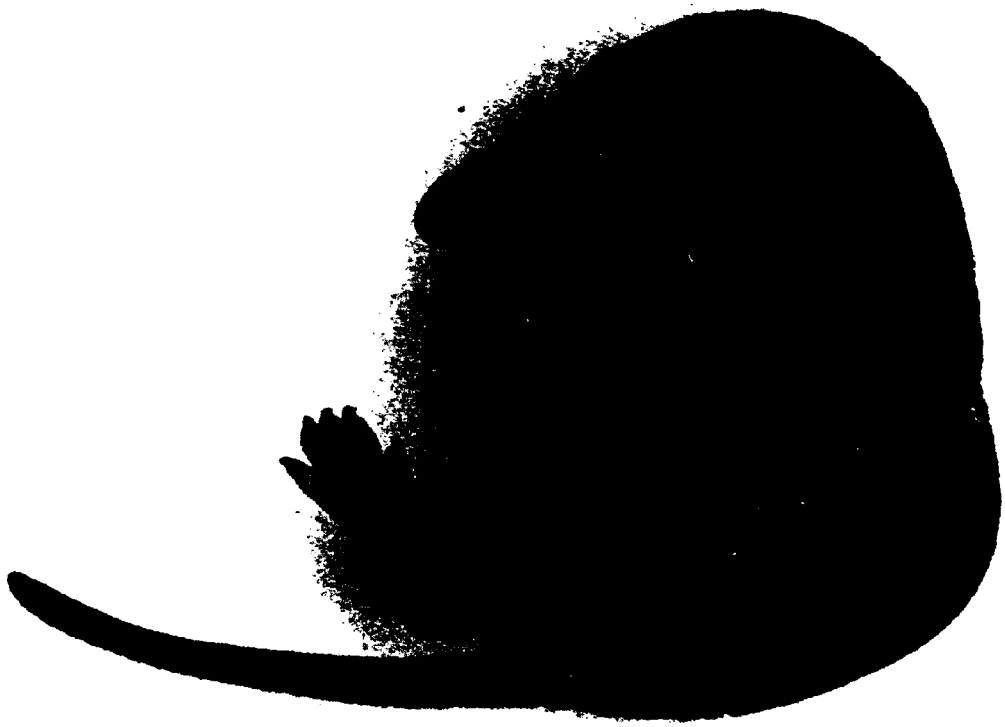


Fig. 43. Age, 20 days; note distinct dorsal and facial stripes

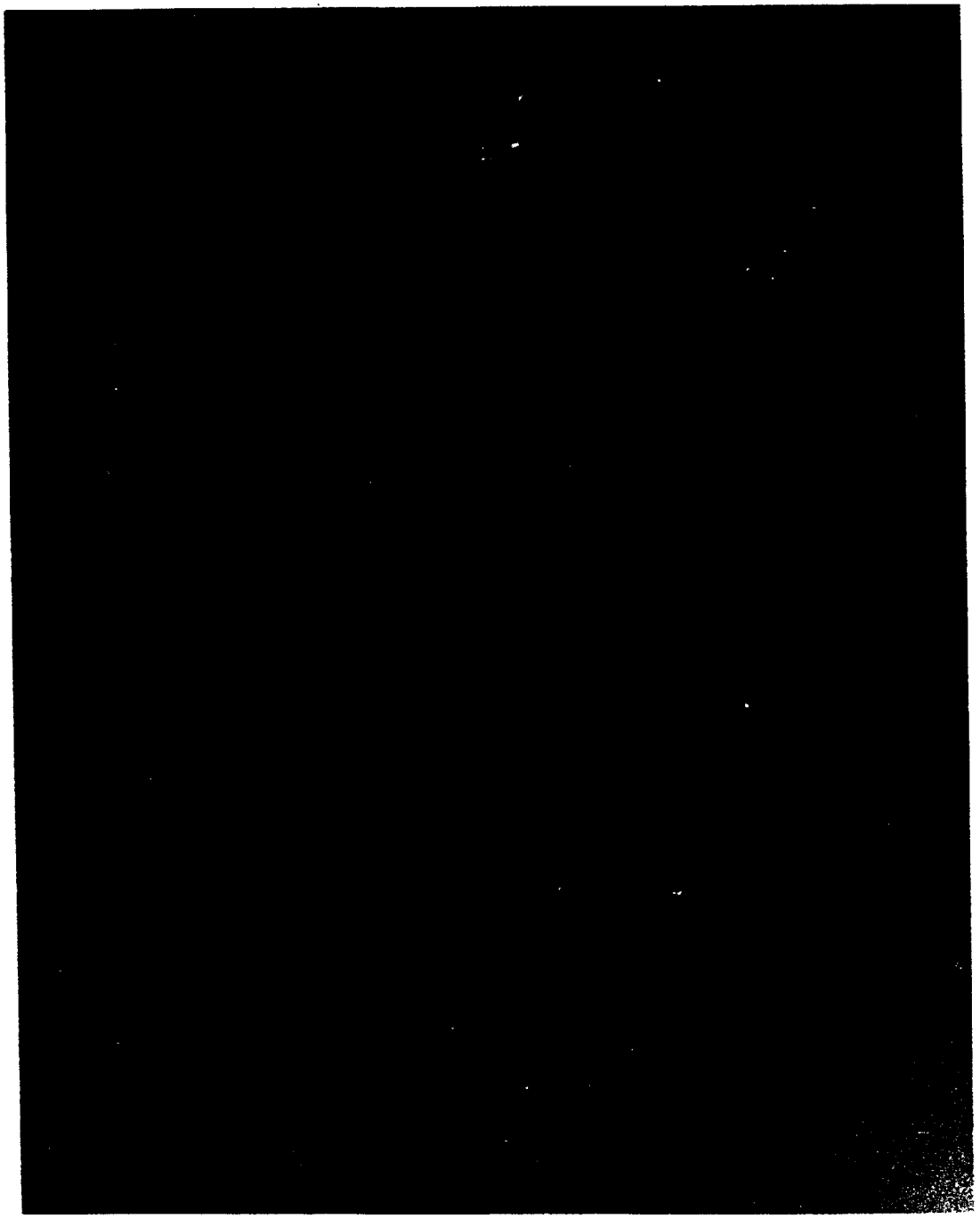


Fig. 44. Age, 26 days; post-auricular patches distinct

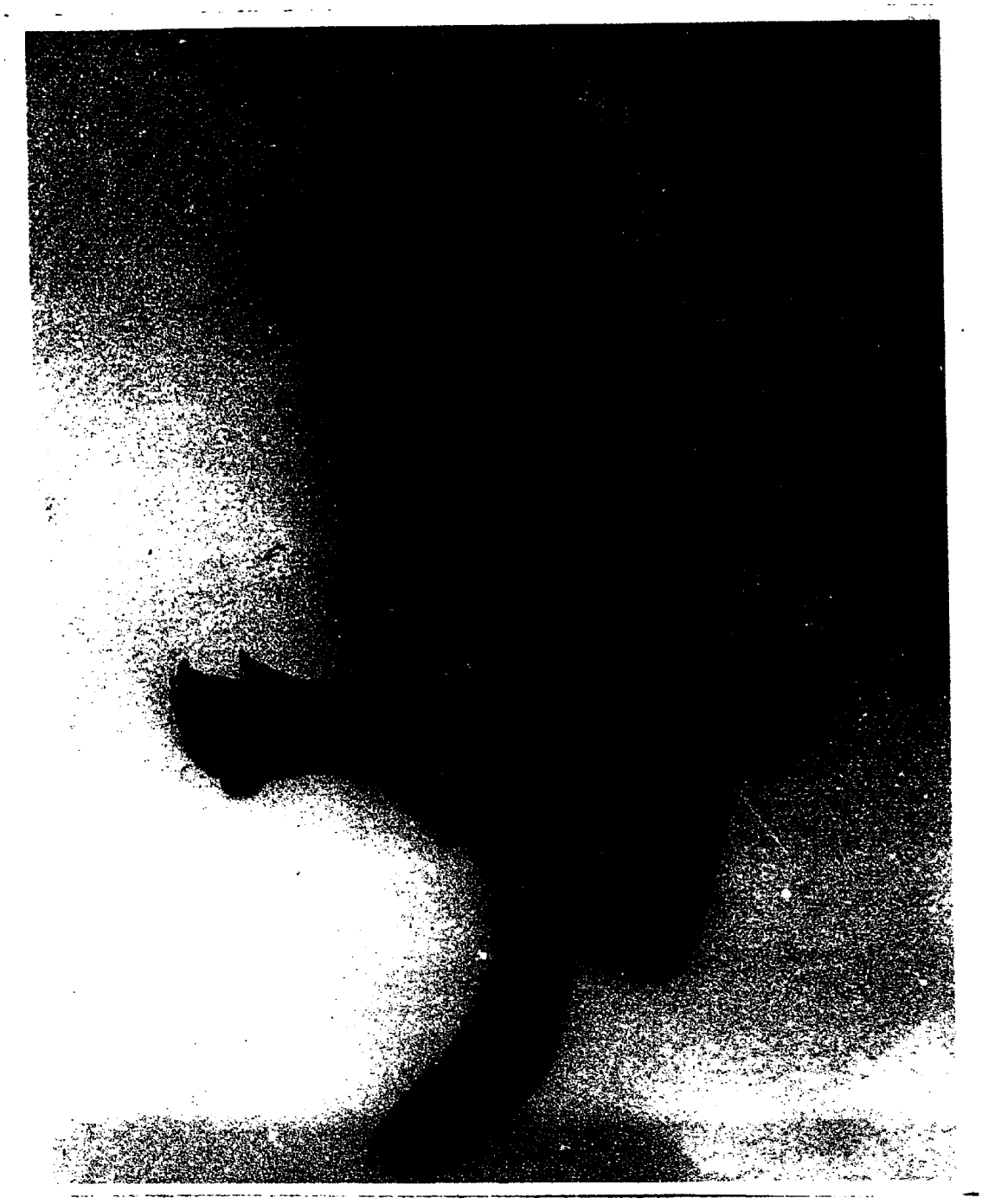


Fig. 45. Age, 26 days; outer toes of hind foot separate, inner toes half united, tail well haired



Fig. 46. Age, 32 days; toes separate, hair of body and tail smooth and appressed



Fig. 47. Age, 43 days; general appearance that of an adult

DENS

Details of the burrows of the western chipmunk (Eutamias) have been described in a few published accounts. Miller (1897: 31), on October 23 at Peninsula Harbor, Ontario, found an adult female Eutamias minimus borealis in a nest of feathers and vegetable fibers at the end of a two-foot tunnel in a chamber "about the size of a cocoanut" and a foot or more beneath the surface of the ground. The chamber was filled by the nest, which contained a small store of seeds of various weeds and wild fruits.

Shaw (1944: 274-284) found the breeding den of a female Olympic chipmunk (Eutamias amoenus caurinus) and that of a female Cooper's chipmunk (E. townsendii cooperi) in the Olympic Mountains. No date was mentioned, but I would judge from the author's description of the young that he dug out the nests in June. The tunnel of the Olympic chipmunk had a small pocket or turning point 2 inches in diameter, located 9 inches from the entrance. From here it ran almost on a level just beneath the surface of the ground for a distance of about 4 feet to the nest cavity, which was 7 inches high, 7½ inches in diameter, and shaped like a "round-bottomed flask." This chamber was filled with a nest built of sedges and a few scattered contour feathers; the sedge blades lining the inside of the nest were more finely shredded than those on the outside. The whole structure weighed 124 grams. Measurements were not given for the den of E. amoenus, but its den was similar to that of E. townsendii. The tunnels of

both species had turning points and were almost horizontal near the entrance. The nest of Eutamias amoenus included sedge, lichen, and a few pieces of paper. The weight was 98 grams.

My own data on dens of Eutamias amoenus affinis was obtained from fourteen burrows, all of which were rather simple tunnels with terminal nest cavities 6 to 7 inches in diameter. I shall describe each of these dens in the following account.

Den one:

On May 11, 1947, I discovered the burrow of a chipmunk about seven miles north of Rocky Flat and one-half mile south of Bald Mountain fire lookout. The entrance to the den (Figs. 49 and 50) was in a bank on the uphill side of the Bald Mountain road. My attention was first attracted to the owner when I saw him carrying nest material in his mouth. He was about forty feet downhill from the burrow in a grove of trees, but he soon crossed the road and disappeared into the bank. In a few minutes he made a second trip to gather lichens from a douglas fir. Although I stood in full view, only fifteen feet from his burrow, the chipmunk watched me quietly for several minutes and then ran across the road in front of me and disappeared into his den.

The entrance was an inconspicuous round hole under a small clump of grass. No pile of dirt marked the opening nor was any scattered near the den. The tunnel extended into the road-bank horizontally for 12 inches, rose abruptly for 3 inches, and then sloped down gradually at an angle of approximately 20° to the nest. The general route of the shaft is shown by a vertical photograph (Fig. 51). First the burrow curved slightly to the left for twelve inches, then

turned right, and after passing under several roots reached its greatest depth at the nest. The latter was about 39 inches from the entrance by way of the tunnel, but only 30 inches in a straight line. The nest filled a round chamber 6½ inches in diameter; its roof was 21 inches below the surface of the ground. This was the greatest depth of any den, probably because the burrow was in a bank. The top of the nest was only about six inches below the level of the burrow entrance. The nest weighed 51 grams. It was largely composed of a dark lichen, but also contained small scraps of paper, a few dry grasses, several pieces of green lichen, and about one hundred down and contour feathers, some of which had been chewed into small sections. The living room inside the nest was 2¼ inches in diameter, and in it were a few green fir needles and a bumblebee wing. Thirty-seven pellets were found in the bottom of the nest. The soil in which the tunnel was located was compact and contained many small rocks 2 to 4 inches in diameter.

Den two:

I found another chipmunk den about 40 feet east of the cabin at Wenas Cattle Camp on June 5, 1947. The tunnel was beside a snowberry bush (Figs. 53 and 54) and 2 feet from the base of a small yellow pine. There was no loose dirt on the surface of the ground to mark the entrance, an inconspicuous hole only 1½ inches in diameter in a surface litter of old pine needles.

On June 24 two dogs dug into the burrow and destroyed the nest and at least part of the litter being raised there. In the scattered nest material I found one dry and nearly mummified young chipmunk that appeared to be about three weeks old. The destruction of the

den precluded my obtaining a detailed description of its construction, but it was obvious that the passage had been about 2 feet long, leading down among the roots of the pine to a depth of about one foot (Fig. 55).

The nest had been made from equal parts of cotton and pappi and weighed 50 grams.

Den three:

I found a burrow on June 20, 1947, when two half-grown young, released from live traps, ran directly to their home (Fig. 56). A minute after the first one entered the burrow, the mother came out. On July 4 I dug out this den.

The entrance (Fig. 57) was a smooth, round hole in a clump of pine grass on level ground where there was no cover, except for lupines and yarrows. First the burrow curved slightly to the left, running horizontally beneath a one-inch layer of soil for a distance of 10 inches; then it turned a little to the right and sloped down to the nest at an angle of 35°. The passageway was 28 inches long and its only branch was a short turning space 4 inches long and 2 inches wide, 10 inches from the entrance. Again I found no clue as to what chipmunks do with the dirt from the tunnel.

The diameter of the shaft measured 1¾ inches at the entrance, but at a distance of 18 inches it had increased to about 2¼ inches and remained that size as far as the nest chamber. The tunnel was round for most of its length, but at one of the curves it was flattened to an ellipse 2⅓ inches wide and 2 inches high. At the end of the burrow a spherical ball of cotton and dry grasses filled a

room 6¼ to 7 inches in diameter. The ceiling of this room was 10 inches from the surface of the ground.

The nest weighed 70 grams, and cotton that had been discarded from my traps formed about 60 per cent of its volume. Most of the remaining material was dry grasses, which were cut into short lengths, as they had been in some of the other nests. I also found a small amount of pappi, several dry lupine leaves, and a few segments of a pine needle. The entrance to the ball was about an inch in diameter, and the space inside was 2½ inches wide by 4 inches long. This was a comparatively large room because a family of three or more chipmunks used it. There were sixty-four scats on the floor of the nest. Beneath the thin surface layer of pine needles, the soil was hard and contained a few small rocks.

Den four:

I suspected that female No. 41 (a dyed animal) had a den nearby when I saw her appear suddenly at a log near trap 52 in Plot 1 on June 16, 1947. Later I found the entrance to the den hidden beneath the log (Fig. 60). In the vicinity there were a few scattered trees, and the ground was covered with a sparse growth of lupines, pine grass, and the debris of fallen needles. The soil beneath the surface litter, a thin layer of sandy loam, changed to hard clay at greater depths. There were few rocks.

The young chipmunks which I saw around this den in the latter part of June and in July probably were born about May 21. The lactating mother was trapped regularly from May 22 to July 5, but then she disappeared from the area and was not captured again. I exposed the entrance of the tunnel (Figs. 61 and 62) by moving the log to one side, and within two hours a chipmunk had plugged the hole with dirt.

The simplicity of the thirty-inch shaft is shown in a vertical view (Fig. 64). There were no branches of any kind although there was a gradual curvature to the left. The burrow was almost horizontal for the first 12 inches of its length; then it sloped down at an 18° angle for a distance of 10 inches, and finally at a steeper angle of 35° to within a few inches of the nest where it leveled off (Fig. 65).

I dug out the nest and found fleas in it on September 8, so the den probably was still in use. It seems likely that one or more of the young lived in it at that time. Had the mother been around, I probably would have caught her.

The diameter of the shaft averaged 2 3/8 inches, measuring 1½, 2¼, 2½, and 2¾ inches at distances of 3, 12, 24, and 30 inches, respectively, from the entrance. The burrow was 30 inches long and its greatest depth was 14 inches. The nest chamber was 8 inches below the surface of the ground and was filled by a nest that weighed 47 grams. The nest material was mainly cotton, but there also were a few dry grasses and pieces of paper. The room inside the nest was 3½ inches long and 2 inches wide, and there were 52 dry scats on the floor.

Den five:

I saw female No. 101 enter a burrow in the ground near trap 30, Plot 1, on June 9, 1947, after I had followed her around for an hour and a half. On July 18, 1946, she had entered one of my traps for the first time. I marked her with a dye on May 19, 1947, and trapped and observed her many times thereafter. On September 18, 1947, I saw her enter a second den about 50 feet south of the first one, so

she apparently had two burrows that fall. I excavated both dens on November 6.

Although I never actually saw young chipmunks enter or leave either burrow, I believe that a litter was born in the first one. The entrance was on level ground which was bare except for grasses and lupines (Fig. 67), and was partly hidden beneath the end of a small, dead pine branch. There was an open stand of pines and douglas firs in the area, the nearest tree being 20 feet from the den. There was no loose dirt either at the entrance or in the general vicinity of the den to betray its location. The tunnel was a simple one without branches (Fig. 70), 37 inches long, and had walls that were worn smooth and hard. In the first 15 inches from the entrance there were several slight curves, but the remainder of the shaft was a straight passageway 22 inches long. The bore was 1½ inches near the entrance and in the second half of the tunnel it was a uniform two inches. The burrow was nearly level for the first 12 inches, then descended at a 24° angle to a spherical room filled with a six-inch nest of dry grasses and cotton (Fig. 69). The top of the chamber was 11 inches below the surface of the ground.

The nest weighed 56 grams and was composed of cotton (60%), dry grasses which had been cut into short lengths, and fine, stiff rootlets. Most of the latter were in the roof, but others occurred throughout the nest and served as a good binder. There was no food store, and I found only two scats on the floor. September rains soaked down 14 inches and caused the ground around the nest to become wet.

Den six:

The second den of female No. 101 had its entrance in a litter of old pine needles (Figs. 71 and 72) and was located in a grove of pine

seedlings. The shape of the tunnel resembled rather closely that of a fish hook. The bent part of the hook was formed by a sharp left curve (Fig. 73); two small enlargements or turning points in the shaft (2½ and 1 inches in length at distances of 3 and 8 inches, respectively, from the entrance) might be compared to the barbs. The 35-inch tunnel was almost level for a distance of about 12 inches from the entrance, then descended at a nearly uniform angle of about 18° to a blind end 9 inches below the surface of the ground. The burrow apparently had not been completed since it lacked a nest chamber.

The owner remained in the second den at least an hour on the 18th, but I was unable to learn whether she was working on the tunnel at this time. The other den had no food stores, so possibly this burrow was to have been her winter home. On October 25 I discovered that the ground at the entrance to this den had been disturbed. Possibly a predator had caught her there. In any event this was the only clue to the disappearance of female No. 101 from the study area.

Den seven:

I found the den of a male chipmunk on November 6, 1946, at the bottom of a wooded slope at the edge of Plot 4, when I saw him carry thistledown and seeds into the burrow. The entrance hole (Fig. 76) was 1½ inches in diameter at that time. It is probable that the burrow was used irregularly during the summer of 1947 because lichens were sometimes left undisturbed in the entrance-way for several days at a time.

It was not until November 11, 1947, that I excavated this den. The nest probably had not been occupied recently because the materials were not new. At the bottom of the nest cavity lay old seed

hulls, probably from the store of the previous fall. The nest was six inches in diameter, weighed 52 grams, and was composed mainly of pappi. I found only three scats in the floor material.

The main shaft was 24 inches long and appeared nearly straight when viewed from above (Figs. 77 and 78). The tunnel first descended steeply at approximately a 65° angle for 6 inches, then leveled off in a 5° slope almost to the nest, where it dipped abruptly for several inches. The tunnel was 1½ inches in diameter near the entrance, but widened to 1¾ inches and 2½ inches at distances of 15 and 24 inches, respectively, from the opening. There was one branch in this tunnel that sloped down to the left at a 30° angle to a depth of 16 inches. At the end of the main burrow there was a smooth, round, six-inch chamber that was 8 inches below the surface of the ground. The room was 6 inches in diameter, round, and with smooth sides.

Den eight:

The appearance of the area around den eight is shown in Figure 79. On October 25, 1947, I saw a chipmunk take cotton and food into the burrow. Its entrance (Figs. 80 and 81) was completely exposed on bare ground about 12 inches from a pine stump. At that time there was no sign of the dirt that had been carried out of the tunnel. When I excavated the burrow on November 13, 3 inches of snow covered the ground. The chipmunk had plugged up the first 10 inches of his tunnel with dirt, and lay curled up in his nest on top of his winter store of seeds and corn. He was by no means torpid, but was normally active at that time.

When viewed from above, the den resembled a T (Figs. 83 and 84). The left-hand branch 12 inches in length led to the nest, and the

right-hand branch formed a cul-de-sac 10 inches long. It is probable that the branch was made when the chipmunk plugged the tunnel entrance because the length of this arm and that of the dirt plug were about equal. The nest was an inch or two from the side of the stump and filled a room 6 inches in diameter. The tunnel was nearly horizontal until it forked. Then the left-hand passage led downward almost vertically 4 inches and recurved in such a way that part of the nest lay 2 inches under the middle of the tunnel (Fig. 84) and only 10 inches from the burrow entrance. The other branch descended an inch or two from the horizontal. The ground sloped up to the base of the stump, resulting in tunnel depths of 3, 5, and 9 inches at distances of 6 and 10 inches from the entrance and at the nest. The nest weighed 50 grams and was composed largely of cotton that had been discarded from traps. In addition, there were about three dozen small contour feathers, small amounts of pappi, a few threads, a piece of green lichen, dry grasses, and a few rootlets. There were no scats in the nest, but fleas and six small flies of two species (Lutomyia distincta Garrett and L. aldrichi Sabrosky) were collected from it. The main shaft of the tunnel was 22 inches long, smooth-walled, and averaged about $2\frac{1}{4}$ inches in diameter. The soil was a rock-free sandy loam.

Den nine:

Tracks in the snow led me to a chipmunk den on Yellowjacket Mountain about one mile north of Rocky Flat on November 12, 1947. This den was near the top of a ridge on open ground (Fig. 85). Despite cold weather this chipmunk was still active and obtained food by digging down to the ground through 4 inches of snow.

His burrow was simpler than any of the others; it was a straight shaft 20 inches long that ended in a round nest chamber 6 inches in diameter and 7 inches below the ground surface (Fig. 87). The tunnel sloped at about a 20° angle and was 1¾ inches wide and 12 inches in diameter near the nest. The burrow evidently was in a state of disrepair, as its walls were not worn, the nest was old and collapsed, and there was no stored food. However, the tracks in the snow proved that a chipmunk had entered the den several times on November 13. There must have been another refuge nearby with a winter cache. Refuse from an elk hunter's camp near the burrow may have provided a good source of food.

Den ten:

By chance I discovered an old chipmunk tunnel a few feet from the end of a ground squirrel burrow when I dug out the latter on November 14, 1947. The chipmunk den was twenty feet from an inhabited chipmunk burrow. The nest chamber and a part of the old tunnel are shown in Figure 88. The tunnel was 2½ inches in diameter and sloped at a 25° angle about 8 inches from the nest. The nest room was spherical, 6 inches in diameter, and 9 inches below the surface of the ground.

Den eleven:

This den was located about 15 feet from the bottom of a ravine on a grassy, south slope (Fig. 89). The hole was 5 feet from the base of a large yellow pine and 4 feet down-slope from a group of pine and fir seedlings. The entrance, which was well hidden in a growth of pine grass and lupines, had no excavated soil in the immediate vicinity to reveal its location.

I discovered the den on November 13, 1946 by watching a chipmunk carrying "down." When I excavated the tunnel the next day, I found that it ran into the hillside at a downward angle of 18° for a distance of 24 inches, then widened abruptly to form a 6½ inch spherical cavity filled with a nest of grasses and pappi. The top of the nest was 19 inches below the surface of the ground due to the upward slope of the hill, but the burrow descended only 7 inches from the level of the entrance. The first part of the tunnel was nearly straight, but then it descended gradually for 12 inches, turned abruptly to the left for 6 inches, and finally curved right for another 6 inches to the nest. The diameter of the entrance was 1½ inches, but the width of the tunnel increased to 3 inches at a distance of a foot from the entrance, and then back to 2¾ inches at the nest. The last bend in the tunnel, which may have served as a turning place, was 4 inches wide. The nest was a round ball with a central room 2 inches in diameter lined entirely with pappi; on the outside were dry grasses, which formed 75 per cent of the bulk of the nest. A single down feather was the only other material. The total weight of the structure was 14 grams.

In the bottom of the nest there was a store mainly composed of douglas fir seeds. There were also the remains of an old nest and hulls from an old cache of douglas fir seeds packed down in the floor of the chamber.

Den twelve:

This den was on a bare rocky slope (Fig. 90). I saw a male carry nest material into the burrow on November 16, 1946, and dug it out two days later. The tunnel was 32 inches long and averaged 2½ inches

in diameter. The chipmunk had deposited no dirt at the entrance (Fig. 91), a smooth, round hole in a clump of Phacelia heterophylla. The first 14 inches of the tunnel extended downhill parallel to the surface of the ground and was roofed over with a thin crust of soil 1½ inches thick. Then the passage divided into a short downhill branch 5 inches long and 2½ inches in diameter, which formed a convenient turning space. The main branch sloped at an angle of 5° to 10° into the hillside to the nest cavity. The round chamber was 6 inches in diameter 8 inches below the surface of the ground. Thistledown and a little cotton had been used in the nest, which weighed only 21 grams. I found a varied cache of seeds in the floor. Fleas and nine flies (Lutomyia distincta Garrett), some of whose wings appeared to be almost completely worn off, were in the nest.

Den thirteen:

Chipmunk tracks in the snow led me to this tunnel on October 29, 1946. It proved to be a straight, simple shaft without branches, 2 inches in diameter and 24 inches long, ending in a space 4 inches in width. The angle of descent was about 20°. Since this den had no nest, it probably was uninhabited and served only as a refuge.

Den fourteen:

The shortest tunnel that I found was located on open ground at the edge of Rocky Prairie (Figs. 93, 94 and 95). It was only 15 inches long—a simple, horizontal passage 2 inches in diameter overlain by a thin crust of earth. Possibly the chipmunk that dug this tunnel would eventually have lengthened it to make a regular den with living quarters.

Summary and discussion of dens:

During the course of my chipmunk study I located fourteen burrows, thirteen of them at Rocky Prairie and one at Bald Mountain. In addition to these, two incomplete dens or refuges were examined. I measured and photographed all of the dens and later examined their nests and food stores in some detail. Table 33 summarizes the dimensions of these burrows. A stick or piece of rubber tubing shoved down a tunnel usually helped me in following its course while digging with a shovel and trowel.

Chipmunks apparently made all of their dens themselves. Each burrow had but one entrance and was 27 inches long on the average. A typical den would end in a spherical nest chamber 6 to 7 inches in diameter that was 12 inches below the surface of the ground. The tunnels were $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in diameter, smoothly worn and circular in cross section. The average slope from entrance to nest was 20°.

The simplest burrow (Fig. 87) was a straight two-foot shaft with a terminal nest chamber, while three other tunnels differed from this plan only in being curved. Four burrows had short side branches, probably used as turning points by the chipmunk, located 10 to 14 inches from the entrances.

Each of two winter dens (Figs. 77 and 83) had 10-inch branches, which I believe were made when the chipmunk plugged the entrance from within for the winter.

All but two burrows were located in bare, open ground with little or no cover. The manner in which a chipmunk disposes of dirt from its tunnel and nest chamber is a mystery to me because I have never found this soil at the entrance or in the immediate vicinity of the den.

Unfortunately, I have never seen a chipmunk dig his burrow. Shaw (1944: 282) examined a burrow of Eutamias amoenus caurinus in the Olympic Mountains and found no dirt at the entrance. He suggested that a mound of loose earth lying above the tunnel may have been shoved up from below by the chipmunk when it constructed its den, and that the final entrance was then made from the inside. However, it appears to me that moles might have been responsible for this pile of dirt.

Three tunnels entered by chipmunks appeared to be incomplete; one was only 15 inches long, and the other two lacked nest chambers.

It was evident that one burrow was used more than one year. A fresh winter nest and food store lay on top of the remains of an old nest and its cache in den eleven, but the other inhabited burrows showed no sign of having been used the previous season.

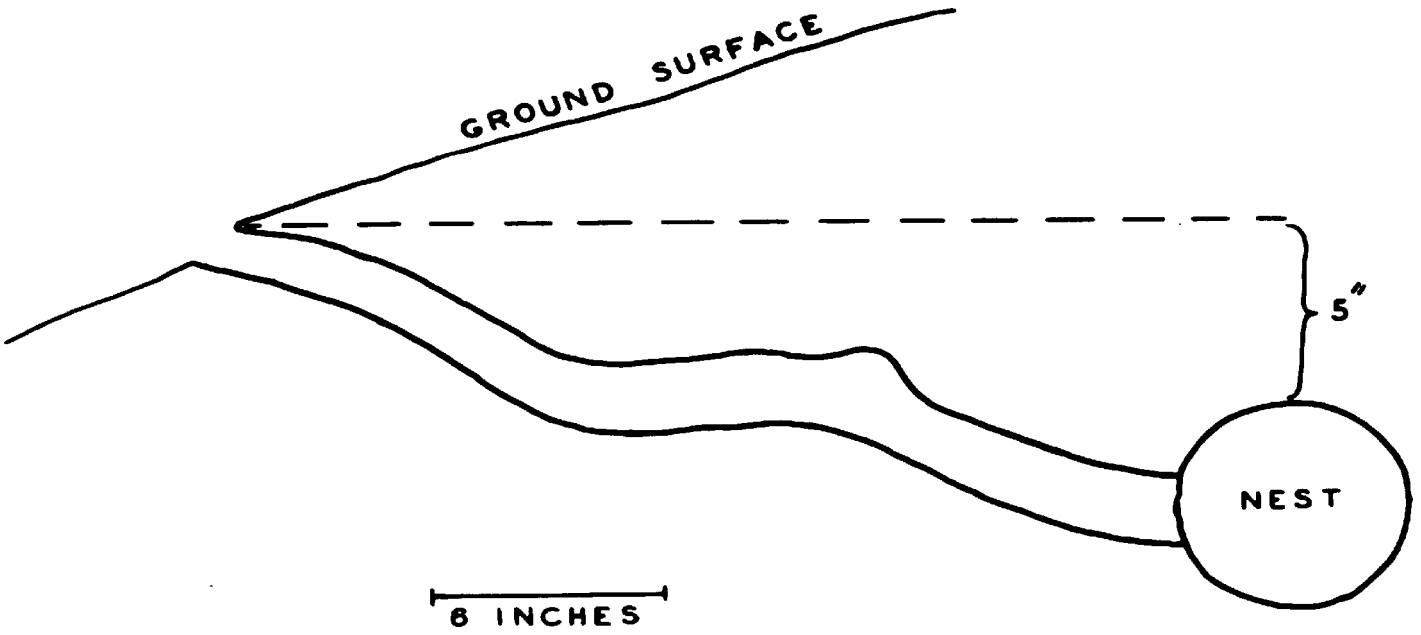
Chipmunks used two old dens (numbers seven and nine) irregularly. Whether they made new dens and abandoned the old I am unable to say, but the history of adult female No. 101 indicates that such may have been true. I saw her use two burrows. She probably lived in the one which contained a nest during the spring and summer. The other, which I saw her enter on September 18, lacked a nest chamber.

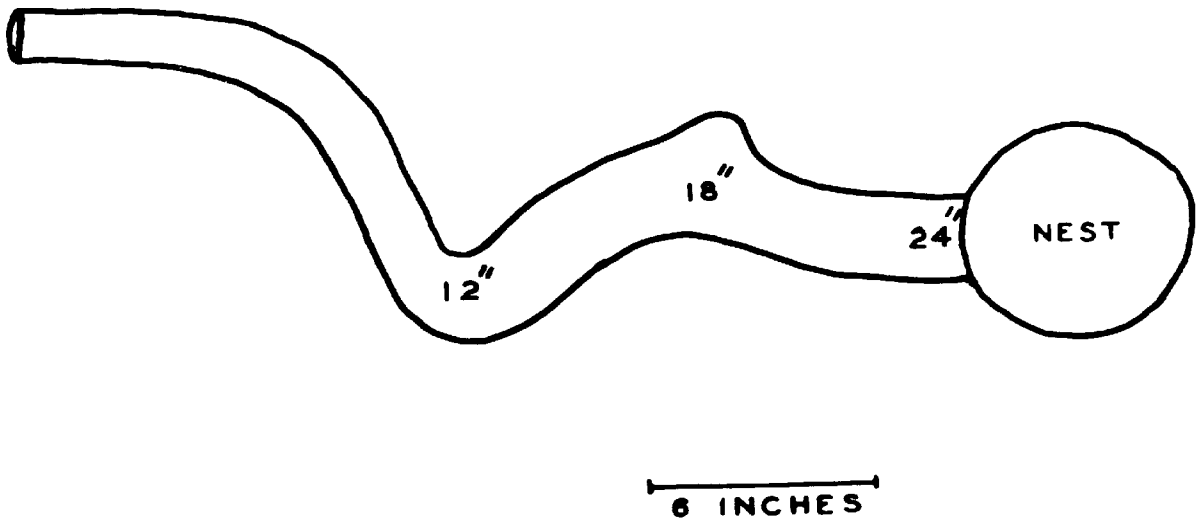
Table 33

Dimensions of fourteen dens
(measurements are in inches)

Den	Length of tunnel	Depth of nest chamber	Average angle of slope	Averages and extremes of tunnel bore	Number of branches or turn-arounds	Length of branches	Distance from entrance to branch
1	39	21	13°	2	1	1½	12
2	24	12	....	....	....	....	....
3	28	10	24°	2 (1¾-2½)	1	4	10
4	30	8	17°	2½ (1½-2¾)	0	....	....
5	37	11	17°	1¾ (1½-2)	0	....	....
6	35	....	24°	1¾ (1½-2)	2	2½, 2	3, 8
7	24	8	15°	2 (1½-2½)	1	10	16
8	22	9	20°	2	1	10	10
9	20	7	21°	2 (1¾-2)	0	....	....
10	....	9	21°	2½	?	?	?
11	24	19	18°	2½ (1½-3)	0	....	....
12	32	8	18°	2½ (1½-2½)	1	5	14
13	24	....	20°	2	....	....	....
14	15	....	....	2	0	....	....

Fig. 48. Diagram of den twelve; side view above; vertical view below


GROUND SURFACE
5"
NEST
6 INCHES


18"
24"
12"
NEST
6 INCHES

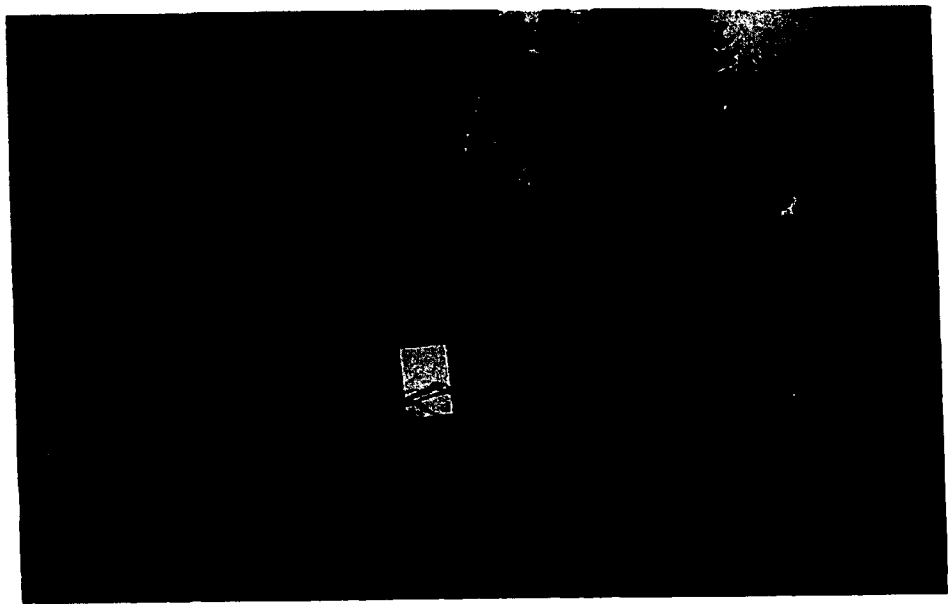


Fig. 49. Den one in road bank on slope one-half mile south of Bald Mountain at about 5500 feet: May 11, 1947



Fig. 50. Den one; the entrance is marked by the arrow

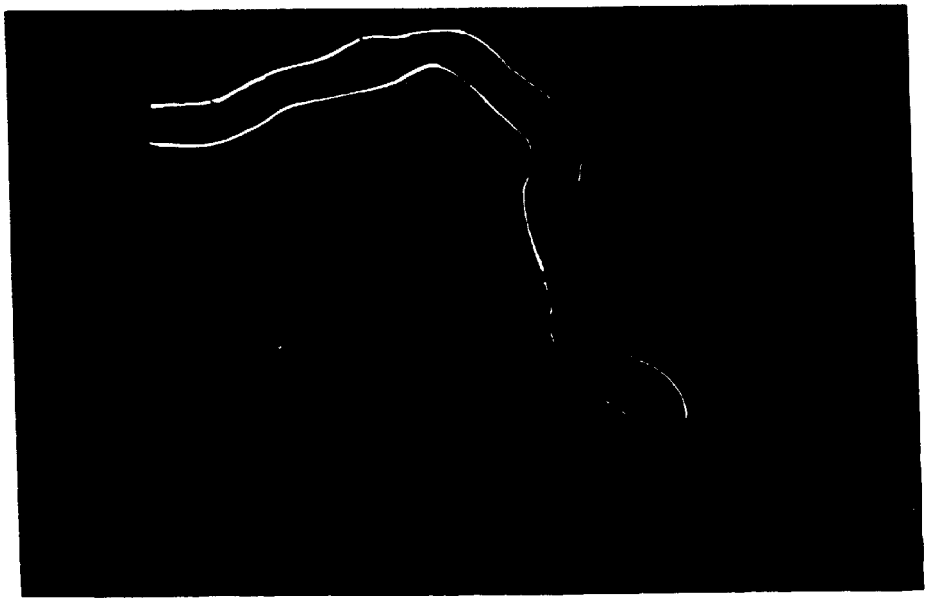


Fig. 51. Vertical view of den one



Fig. 52. Front view of den one from a 45° angle

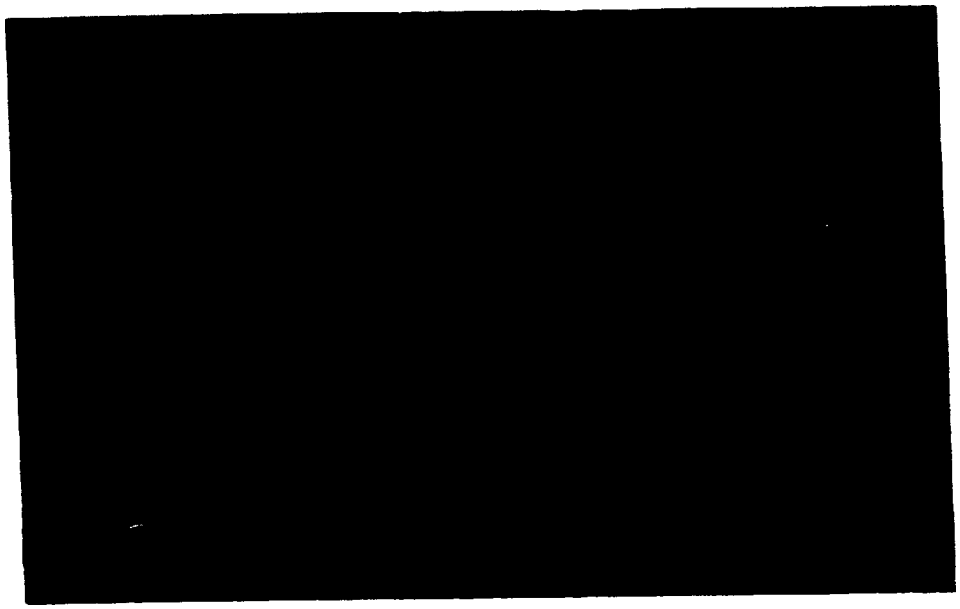


Fig. 53. Location of den two; June 15, 1947

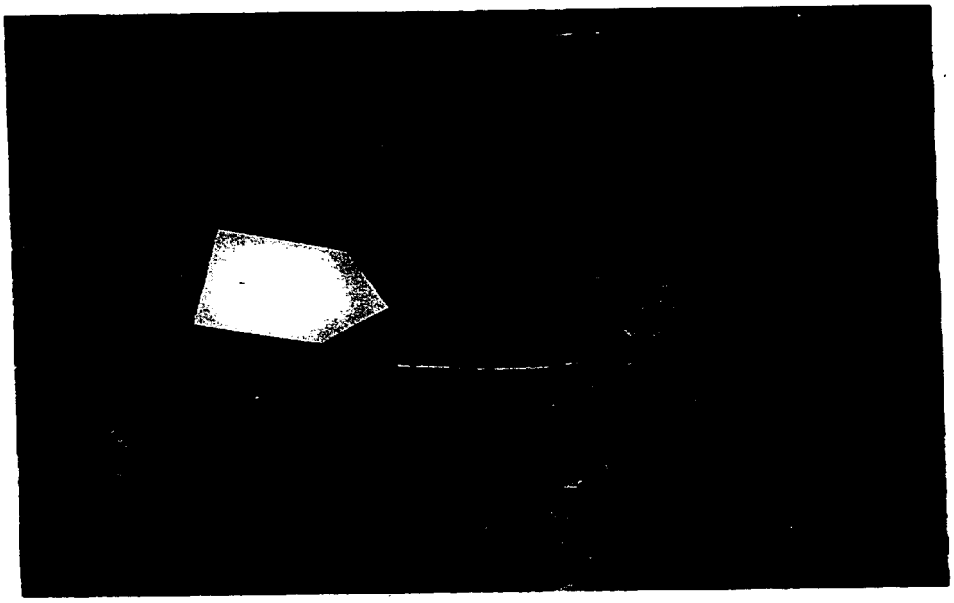


Fig. 54. Entrance of den two in litter of pine needles beside a snowberry bush

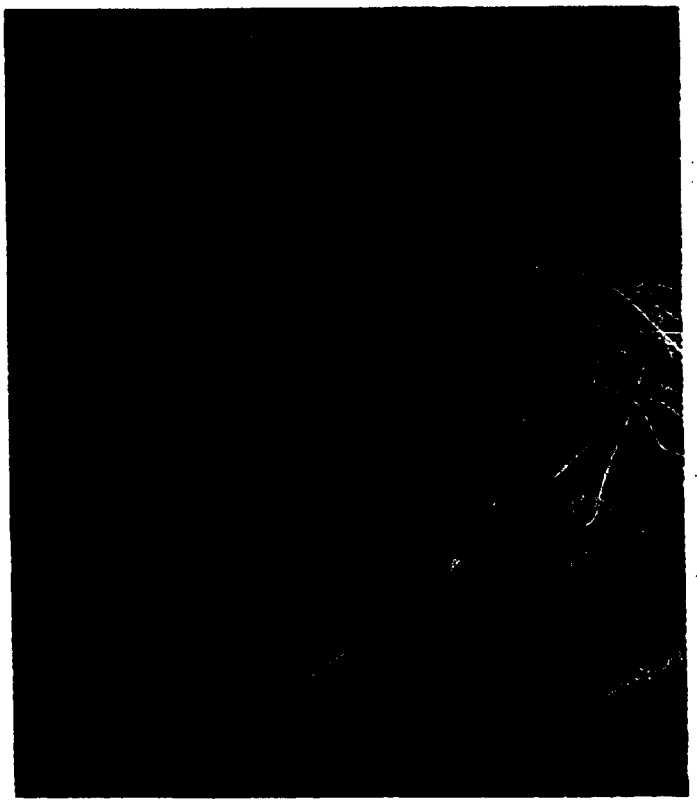


Fig. 55. Den two after being excavated by dogs on June 24, 1947; the nest chamber was among the roots of the pine

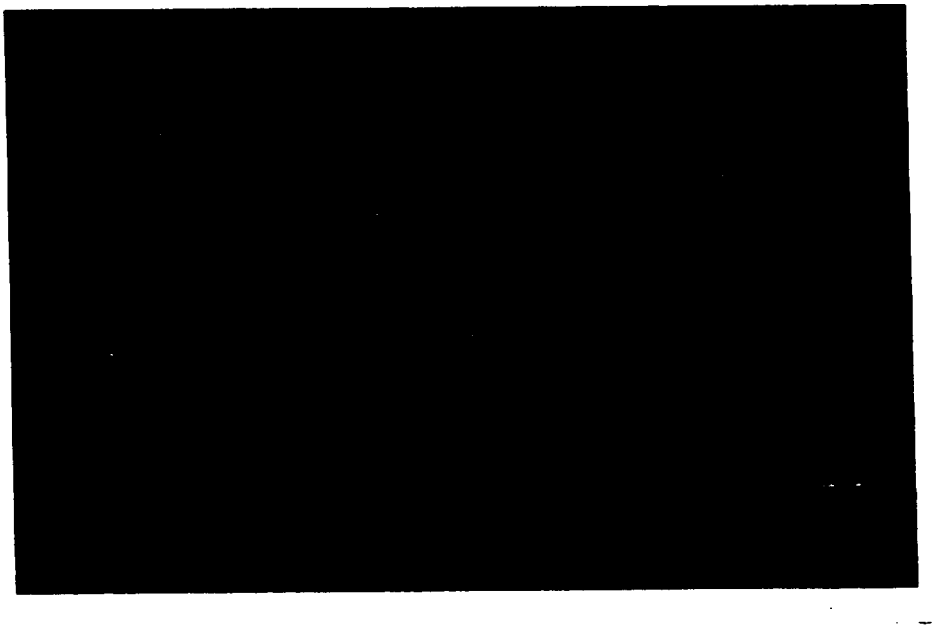


Fig. 56. Location of den three; the white card is above the entrance; the trees are yellow pines, and other plants are lupines, yarrows, and pine grass; July 4, 1947



Fig. 57. Entrance to den three in a clump of pine grass; lupines can also be seen

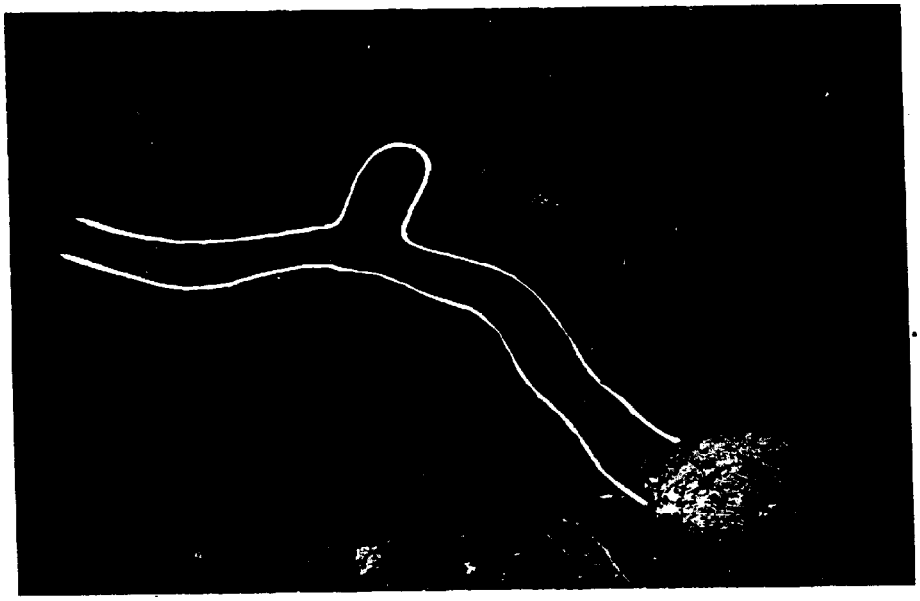


Fig. 58. Den three viewed from above and to one side at an angle of 45°

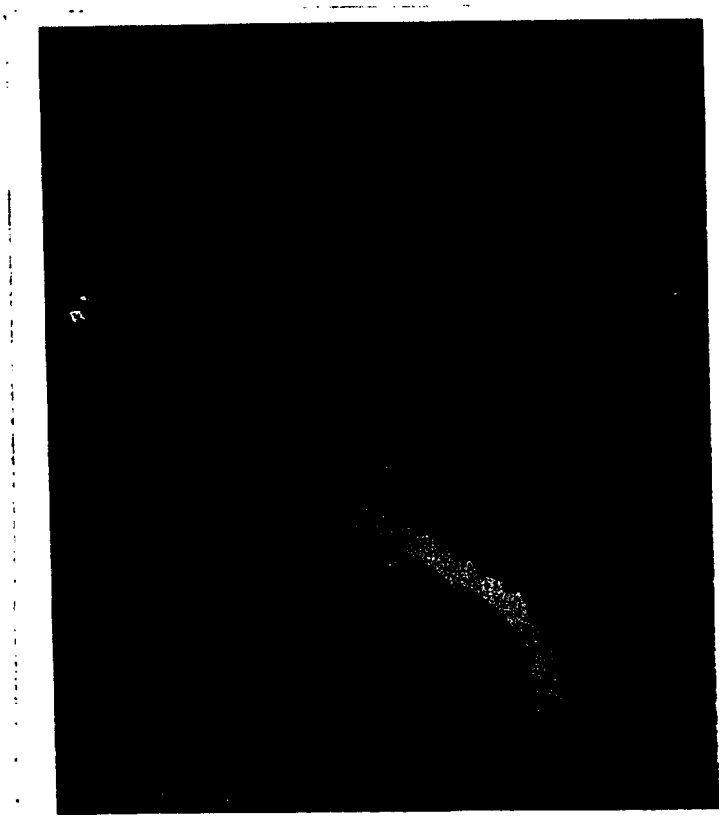


Fig. 59. Front view of den three looking down from a 45° angle; the tunnel was marked with borax

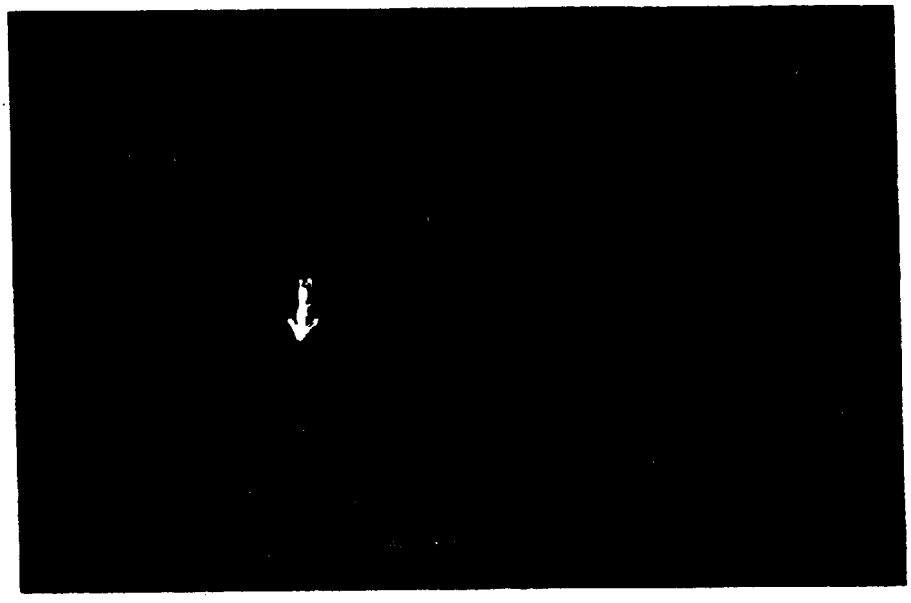


Fig. 60. Location of den four beneath the log

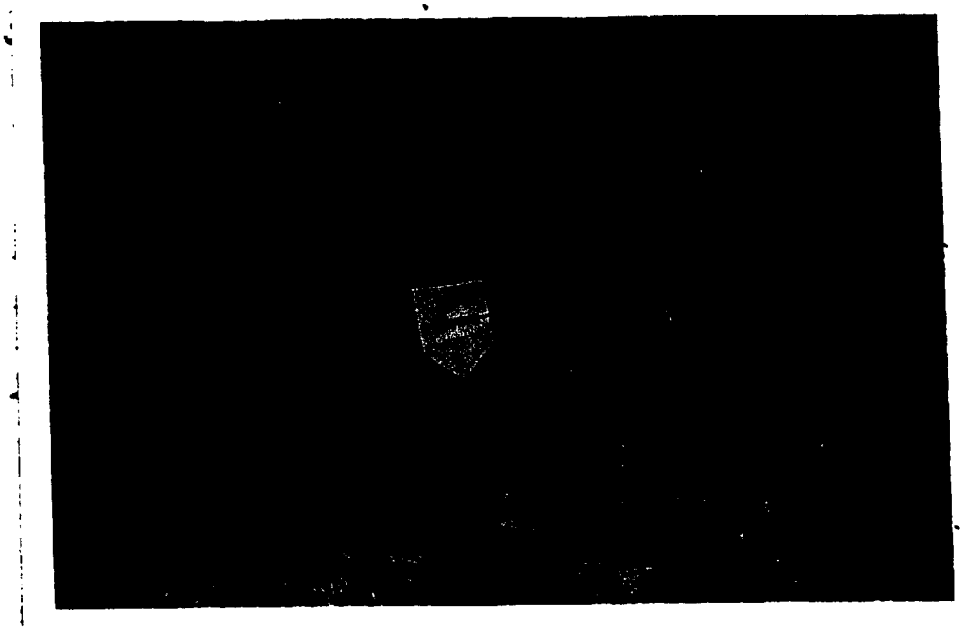


Fig. 61. Entrance to den four which was plugged up by a chipmunk when the log shown in Fig. 60 was moved

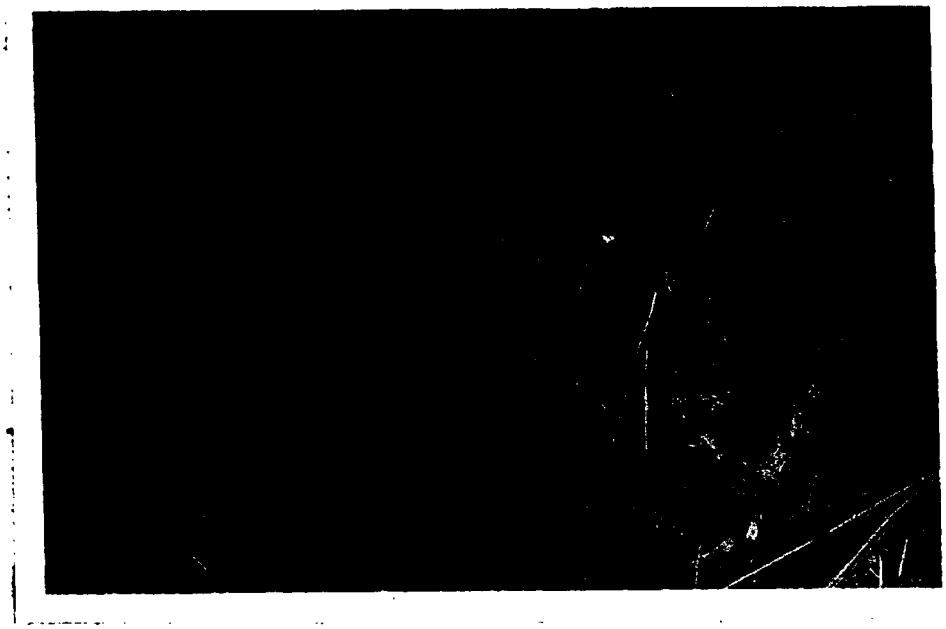


Fig. 62. Closeup from above of the entrance to den four after the dirt plug had been removed

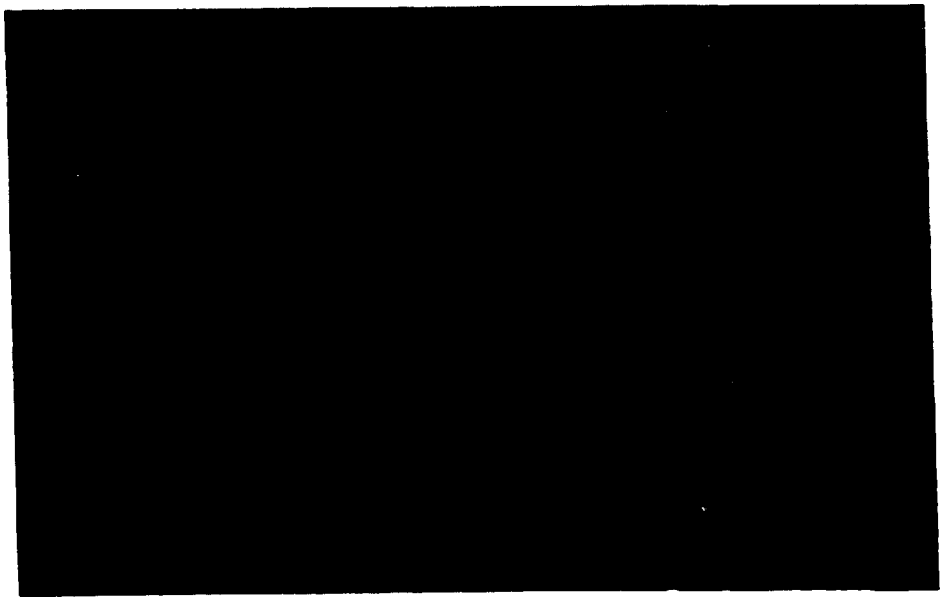


Fig. 63. Another closeup of the entrance to den four looking straight in

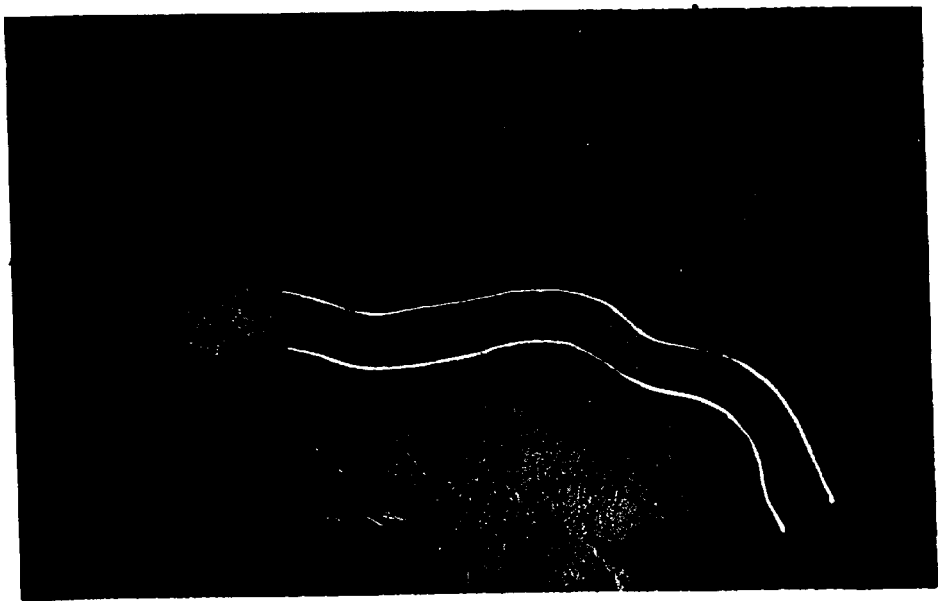


Fig. 64. Vertical view of den four

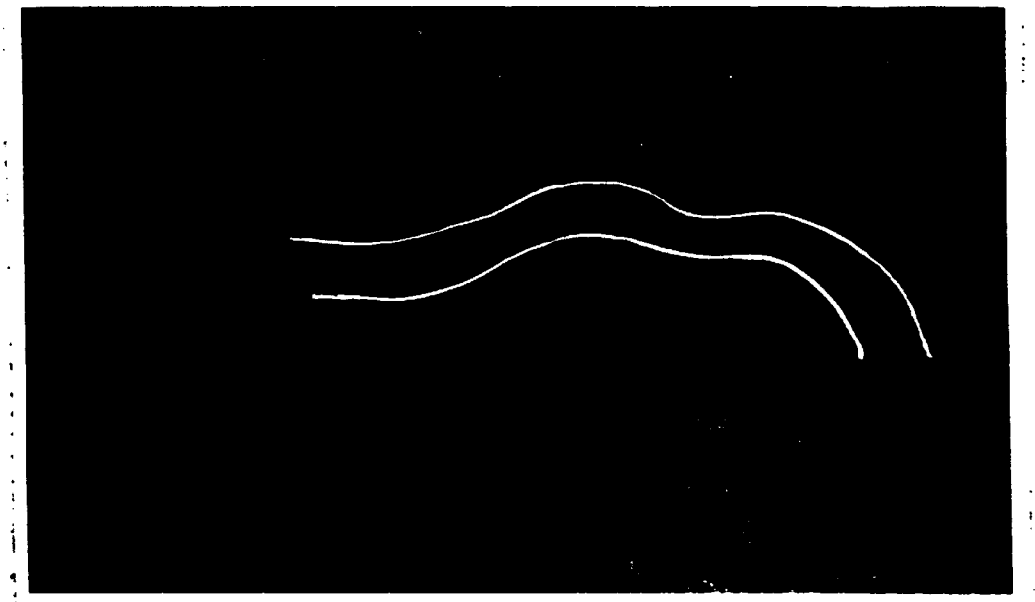


Fig. 65. Den four viewed from above and to one side at a 45° angle

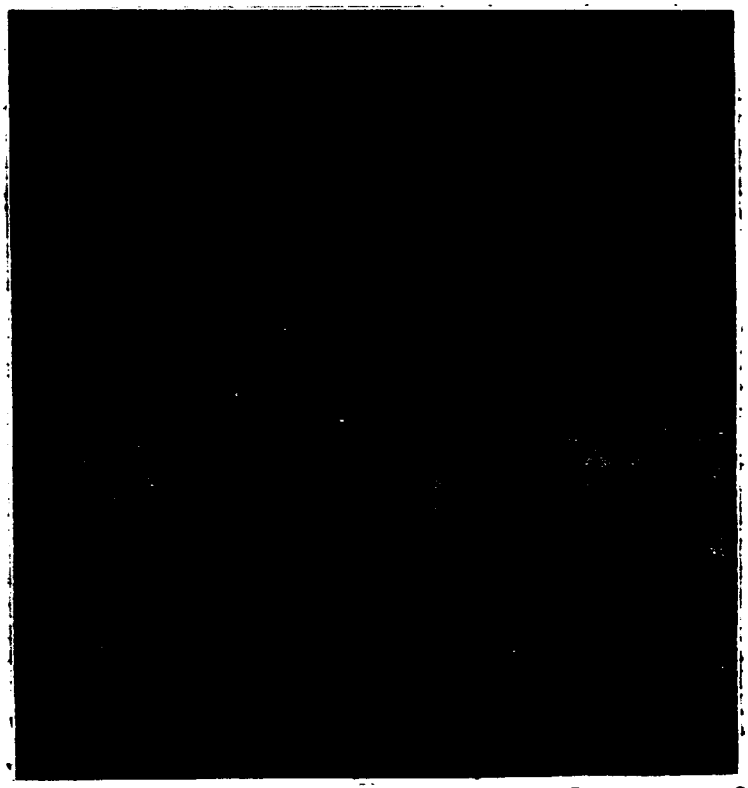


Fig. 66. Den four viewed from the front and above at a 45° angle



Fig. 67. Den five (near trap 30, Plot 1) marked by the white card

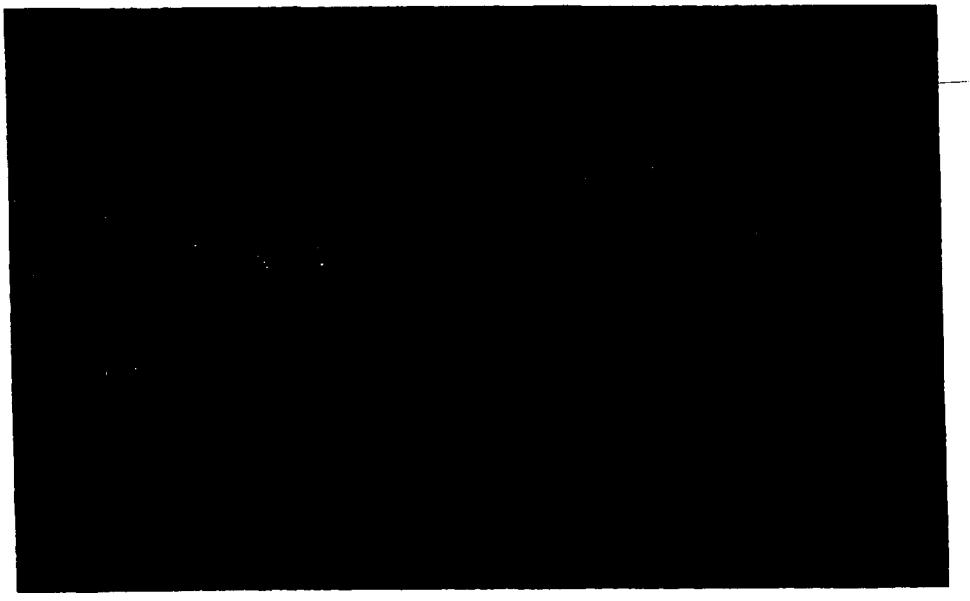


Fig. 68. Entrance to den five; the limb was originally above the hole

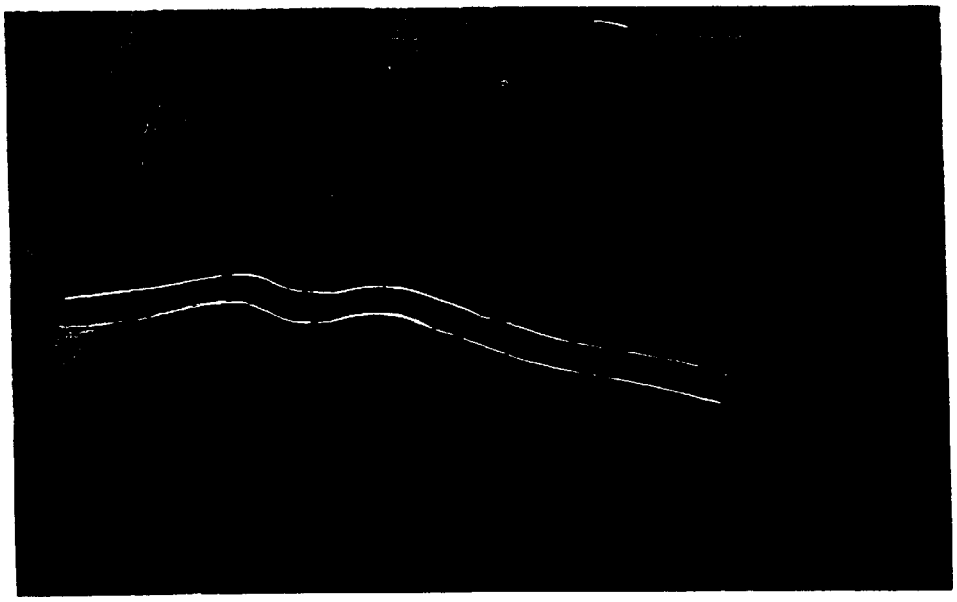


Fig. 69. Vertical view of the exposed tunnel and nest of den five

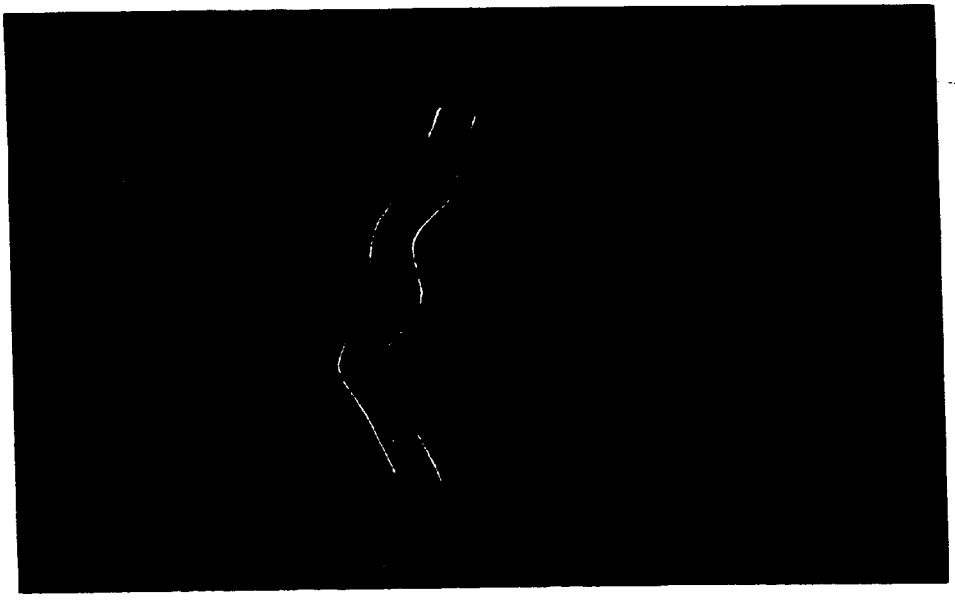


Fig. 70. Den five viewed from the front at a 45° angle

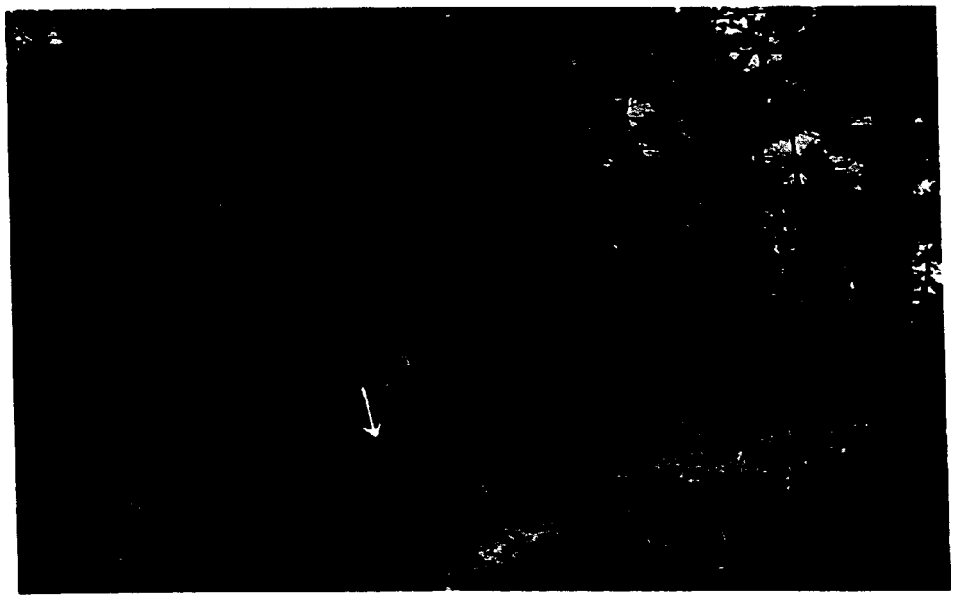


Fig. 71. Location of den six in a grove of pine seedlings near trap 40, Plot 2; white arrow marks site of den



Fig. 72. Entrance to den six in litter of pine needles



Fig. 73. Vertical view of den six; entrance is on the left

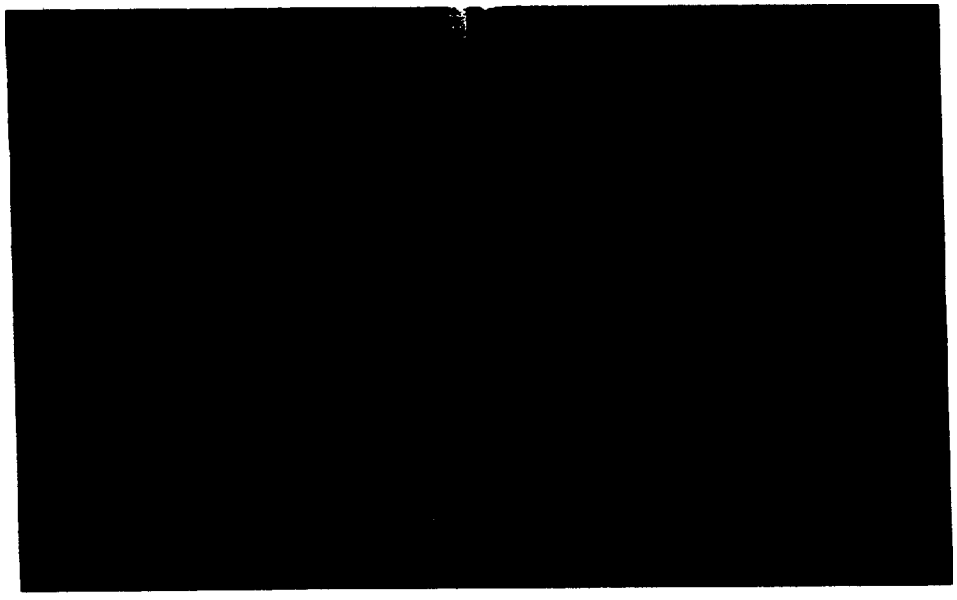


Fig. 74. Den seven, marked by the white card

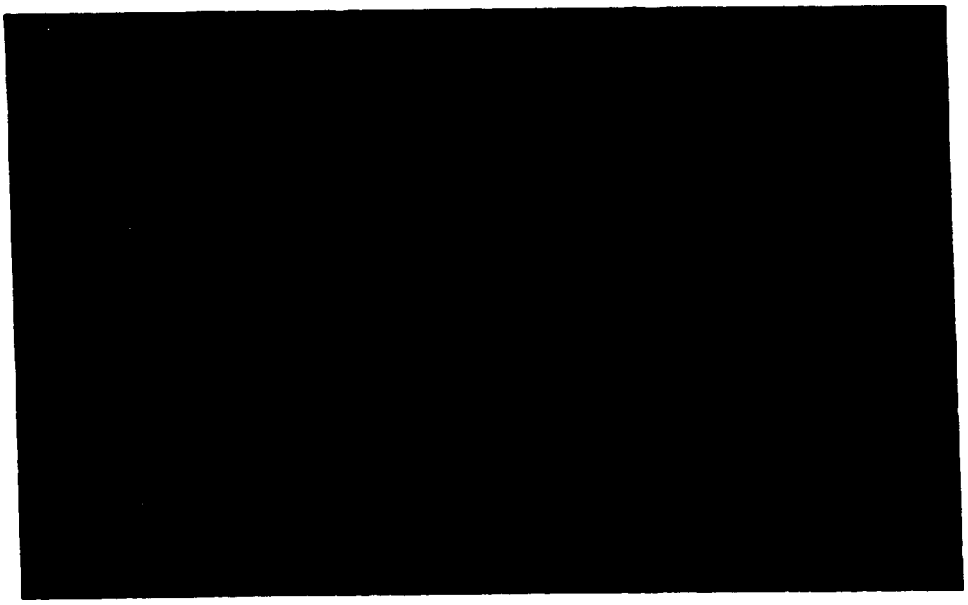


Fig. 75. Entrance to den seven in pine needles

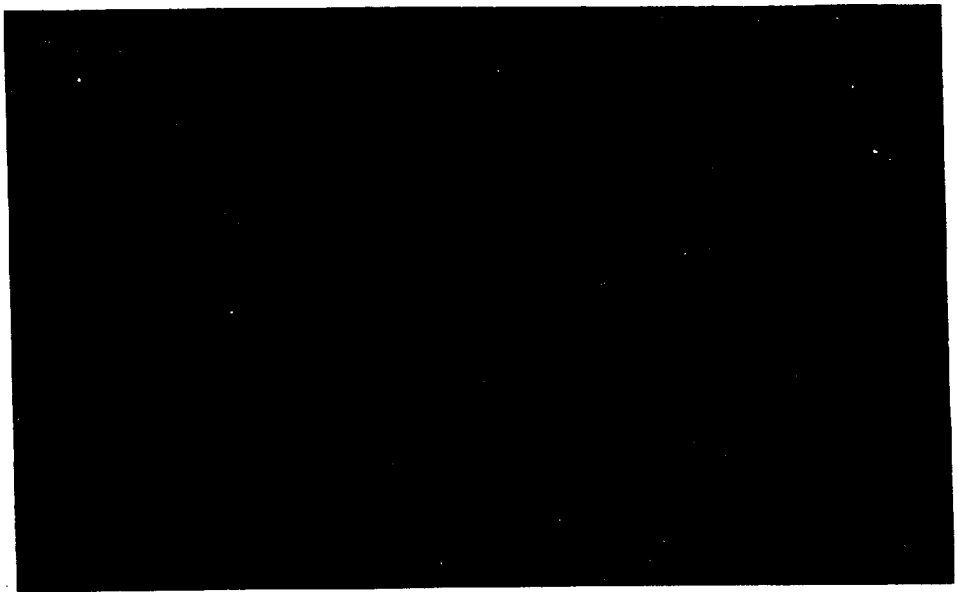


Fig. 76. Entrance to den seven on November 7, 1947

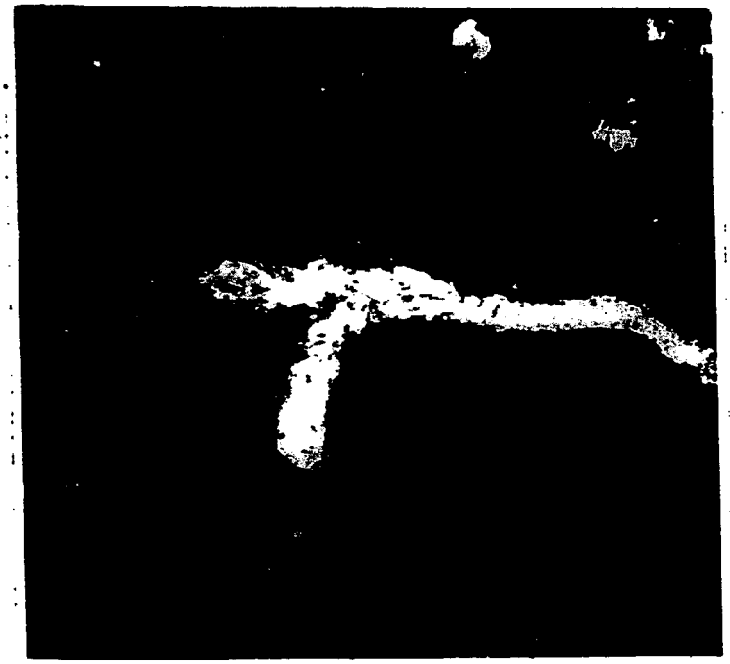


Fig. 77. Vertical view of den seven



Fig. 78. Den seven viewed from above and to one side



Fig. 79. Den eight is marked by the arrow; yellow pine woods near trap 74, Plot 1; September 3, 1946

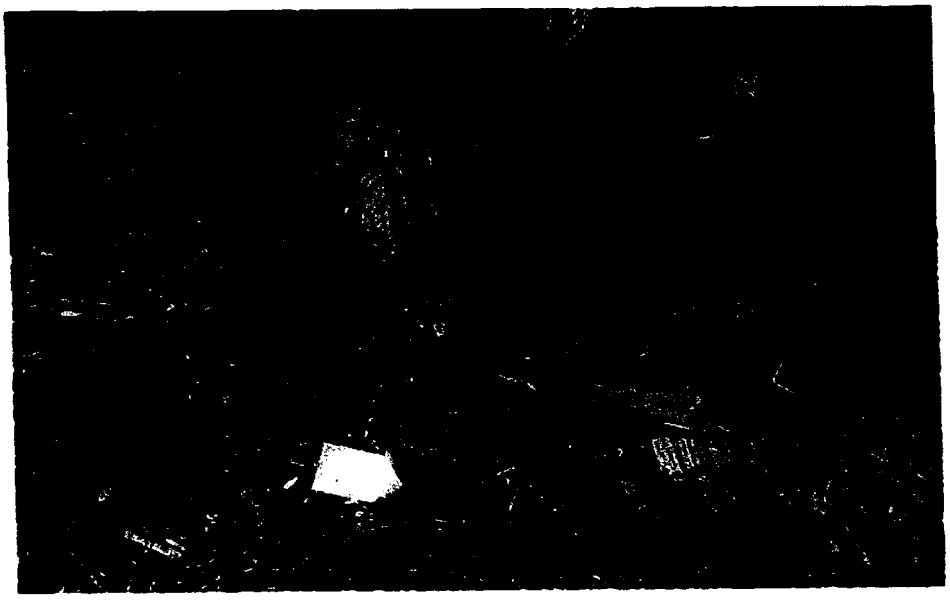


Fig. 80. Entrance to den eight

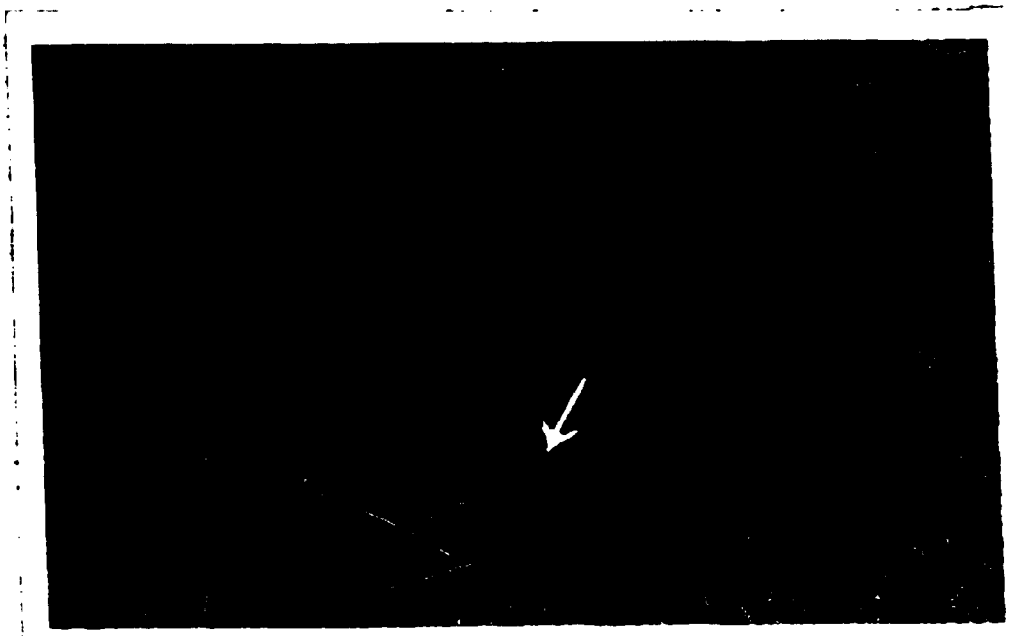


Fig. 81. Entrance to den eight before it was plugged by a chipmunk



Fig. 82. Den eight and exposed nest at base of yellow pine stump

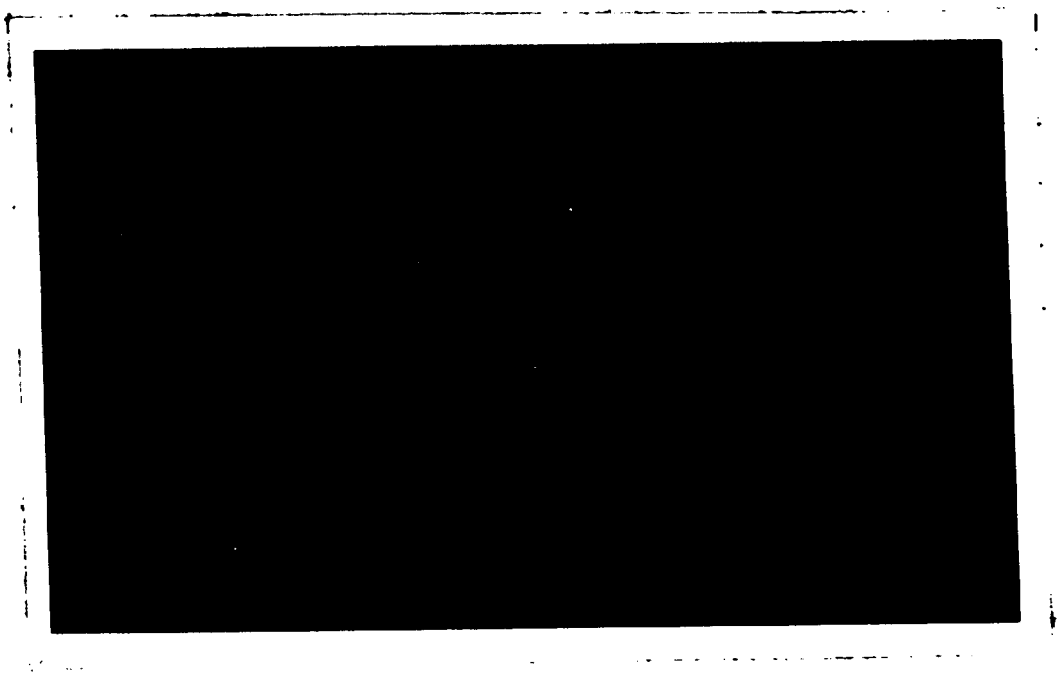


Fig. 83. Vertical view of den eight; the nest contains a food store



Fig. 84. View of den eight from the side at a 45° angle



Fig. 85. Entrance to den nine in snow

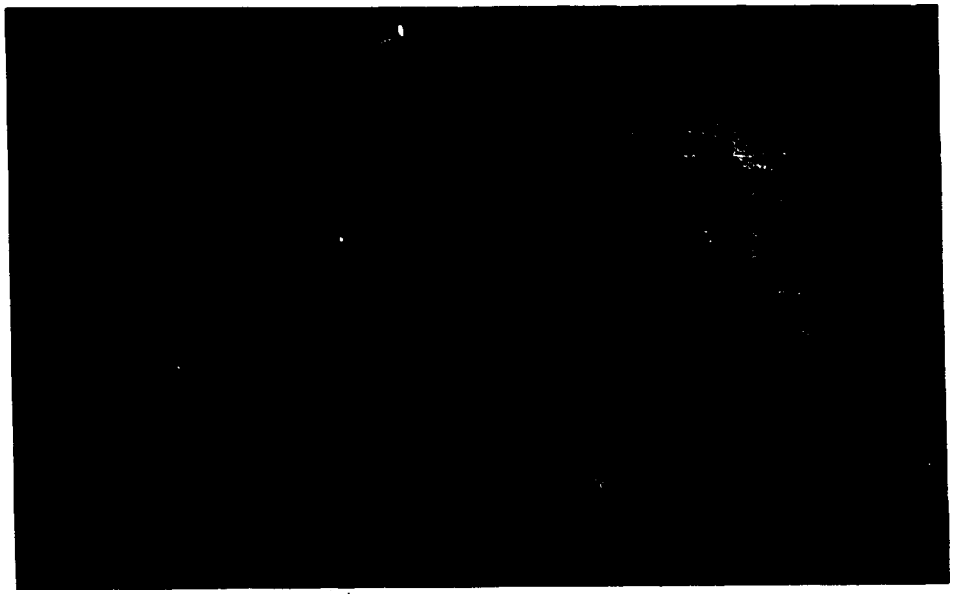


Fig. 86. Closeup of entrance to den nine

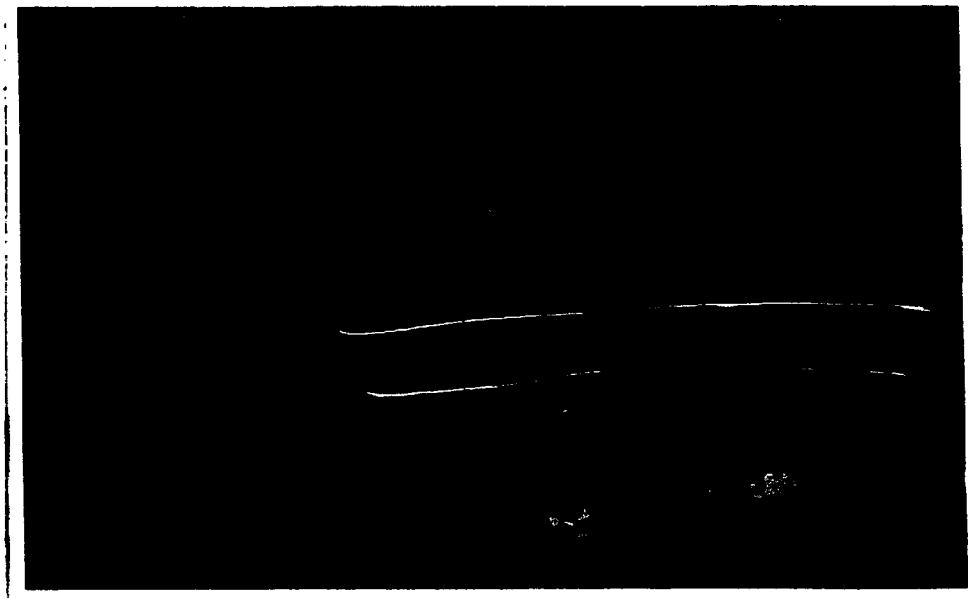


Fig. 87. Vertical view of den nine; the nest was an old one

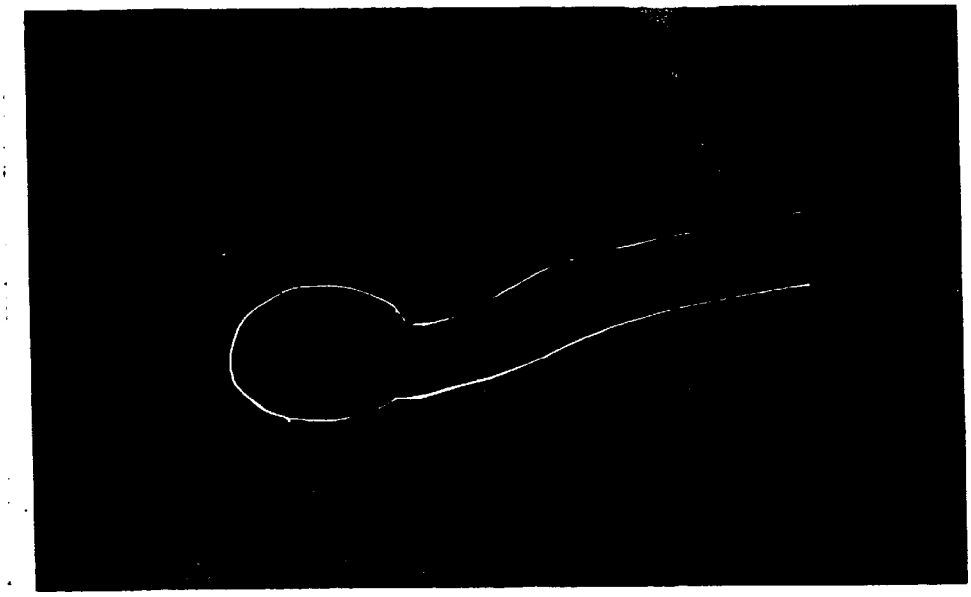


Fig. 88. Den ten viewed from the side at a 45° angle



Fig. 89. Den eleven marked by the arrow



Fig. 90. Den twelve marked by the arrow



Fig. 91. Entrance to den twelve in Phacelia heterophylla



Fig. 92. Den twelve viewed from the side



Fig. 93. Den fourteen marked by the white card



Fig. 94. Entrance to den fourteen



Fig. 95. Den fourteen, a 15-inch tunnel probably used as a refuge

NESTS

The ten nests that I found in burrows of Eutamias amoenus affinis were nearly identical in size and shape. (See Table 34 and Figs. 96-104) They varied from 6 to 7 inches in diameter, were round, and filled the smooth chambers in which they lay. Chipmunks made their nests from pappi, dry grasses, lichens, cotton, and relatively small numbers of feathers, rootlets, paper, and leaves. These materials were usually distributed evenly, but one nest was lined inside with pappi and outside with grass. The nest entrance, except in burrows occupied by several animals, was self-sealing and could not be distinguished by sight. Fresh winter nests inhabited by single individuals had walls 2 inches thick and rooms 2 inches in diameter (Figs. 97 and 104) and contained food stores in the floor and sides. There were no scats in three nests, but in the others the following numbers were found: 2, 3, 37, 52, and 64.

All of the nests being used contained fleas, and three of those examined in November contained small flies also. C. W. Sabrosky of the U. S. National Museum has identified these flies as Lutomyia aldrichi, a new species, and L. distincta, formerly known only from the holotype. Some of them were crawling about on the surface of the nest and others emerged from the interstices. The wings of nearly all of the specimens were peculiarly frayed and worn. The larvae of these flies are known to

Table 34

Summary of data on ten chipmunk nests

Den	Date collected	Weight (grams)	Diameter (inches)	Nest materials	Store	Insects in nests	Number of scats
1	June 16, 1947	51	6½	lichen, grass, feathers, and paper	none	fleas, ticks	37
2	June 24, 1947	40	?	pappi	none	?	?
3	July 4, 1947	70	6¾	cotton, grass, pappi, and lupine leaves	none	fleas, ticks	64
4	Sept. 8, 1947	47	6	cotton, grass, and paper	none	fleas, ticks	52
5	Nov. 6, 1947	56	6	grass, cotton, rootlets	none	?	2
7	Nov. 11, 1947	52	6	pappi	old hulls	?	3
8	Nov. 13, 1947	50	6	cotton, pappi, feathers, grass, lichen, rootlets, and thread	new	fleas, flies	0
9	Nov. 13, 1947	....	6	?	none	?	?
11	Nov. 14, 1946	14	6	grass, pappi, feathers	new and old	flies	0
12	Nov. 16, 1946	21	6	pappi, cotton, rootlets	new	fleas, flies	0

live on dung and thus may use the scats in chipmunk dens. One nest had some lice, but in another there were neither parasites nor flies.

Chipmunks at Rocky Flat stored such nest materials as cotton discarded from traps, pappi from the flowers of thistles and other composites, lichens, and in one instance the white belly fur of a snowshoe hare.

From June to September I found many pieces of cotton in seedling pines and on the lower limbs of older trees in the study area. Some of the trees near my traps were "decorated" with a dozen or more tufts, each of them about an inch in diameter and probably a single mouthful. Most were at heights of 3 to 10 feet. Once I found cotton in a clump of grass and on another occasion I saw a chipmunk bury a mouthful in a small hole which he dug in the ground. Captive animals first stored cotton in the corners of their cages on September 6, 1947.

Tufts of pappi discovered on September 2, 10, and 22, 1947, again appeared to be single mouthfuls. One of these bunches of pappi (Fig. 105) was stuck into a crevice in the bark of an old pine, 21 inches from the ground, and others were wedged among the needles of seedling pines (Fig. 106) at heights of 20 inches to 5 feet. On September 22 I watched a chipmunk carry what appeared to be a mouthful of pappus 50 feet up a pine and presumably store the material there because he descended without it.

Several small pieces of a common green lichen along with a tuft of pappi were cached among pine needles on September 10, 1947.

Beginning with the cold days of late October and up to the middle of November, chipmunks carried food and nest materials into their burrows in preparation for the winter months ahead. This activity began in late

October and lasted until mid-November, when nearly all chipmunks had disappeared. My earliest and latest records were, respectively, October 25 and November 13, 1947.

Showing commendable economy of effort, a chipmunk would gather both nest material and food during a single trip from his den. First he would forage about on the ground until his cheeks were crammed with seeds, then pick up a piece of cotton or bunch of pappi in his teeth, sit on his haunches to smooth and adjust the projecting ends with rapid movements of his forepaws, and finally carry the load into his tunnel.

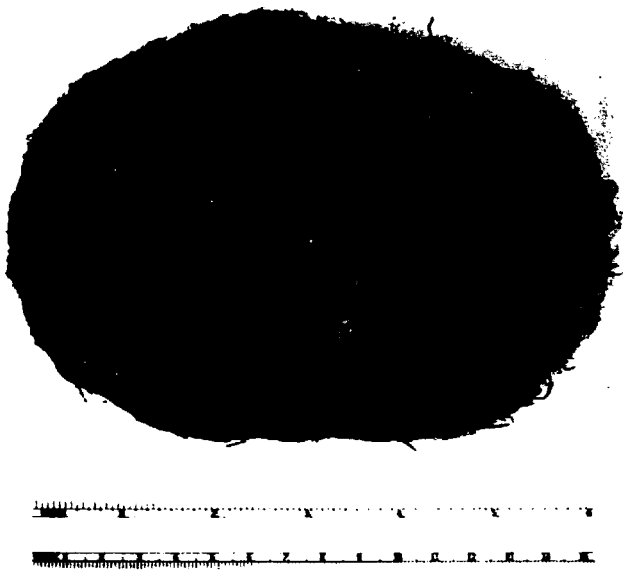


Fig. 96. Nest from den twelve, composed of thistle pappi, cotton and small rootlets

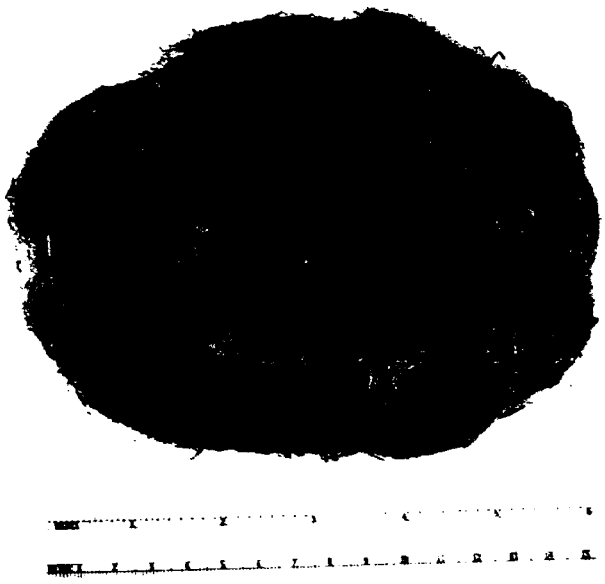


Fig. 97. Nest from den twelve dissected to show the 2-inch room in the center

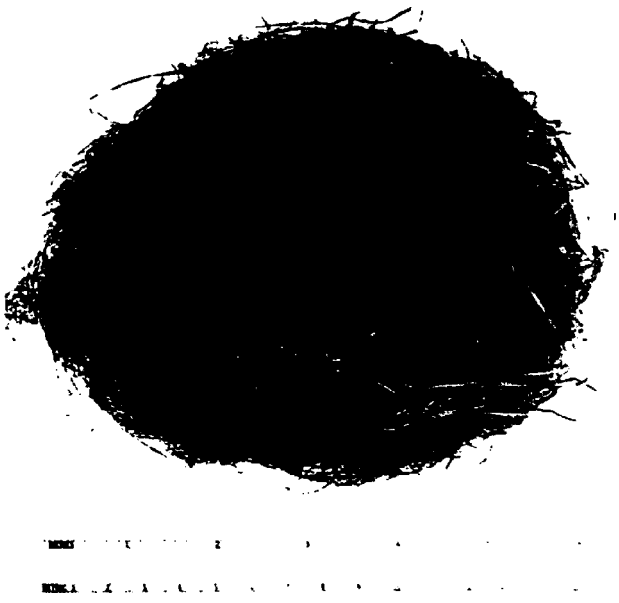


Fig. 98. Nest from den eleven, composed of dry grasses on the outside and pappi within

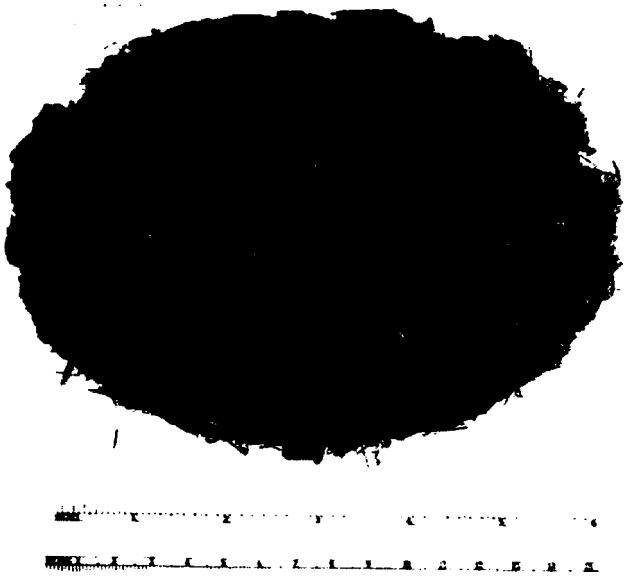


Fig. 99. Nest from den five, composed of dry grasses cut into short lengths, cotton, and rootlets

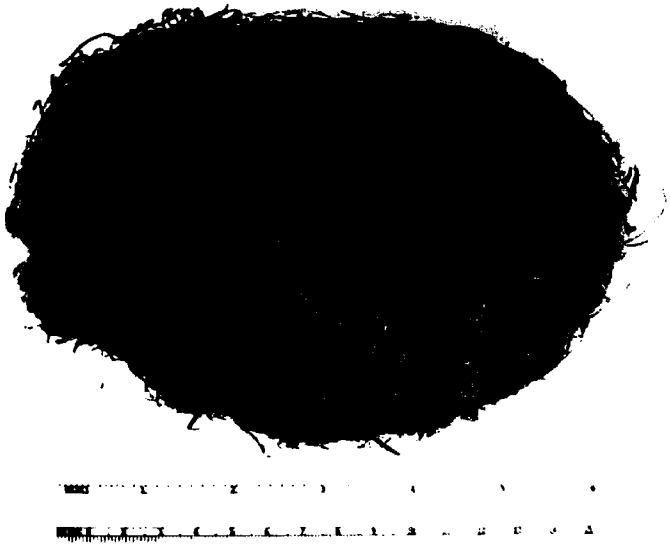


Fig. 100. Nest from den three, composed of dry grasses and cotton

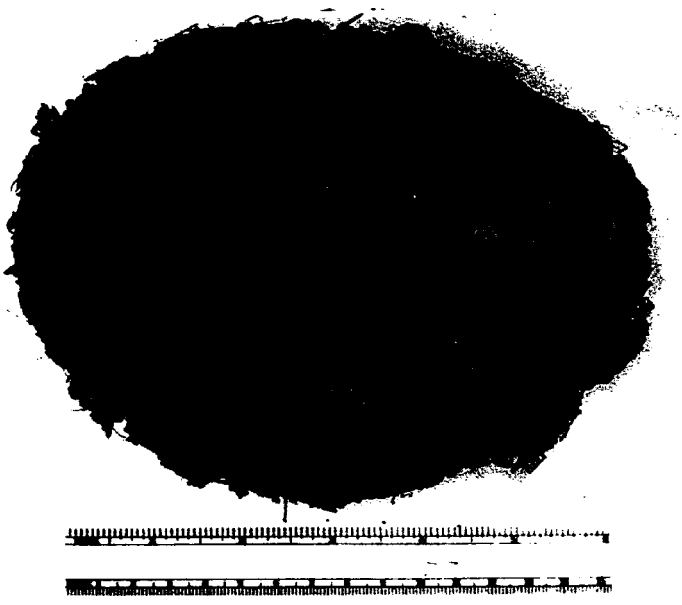


Fig. 101. Nest from den four, composed of cotton and dry grasses

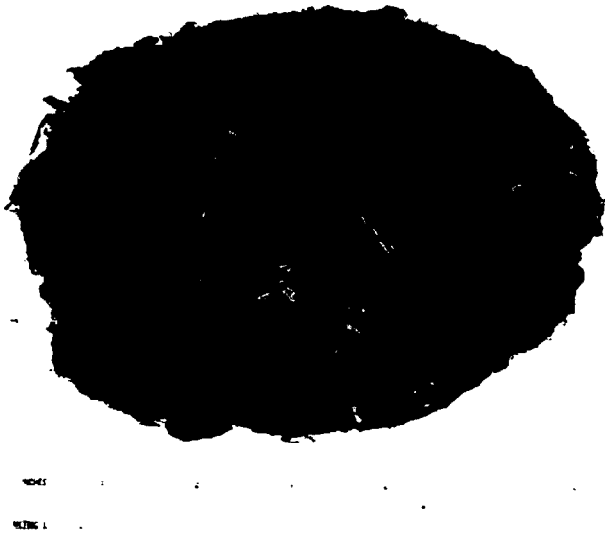


Fig. 102. Nest from den one, composed of lichens and scraps of paper

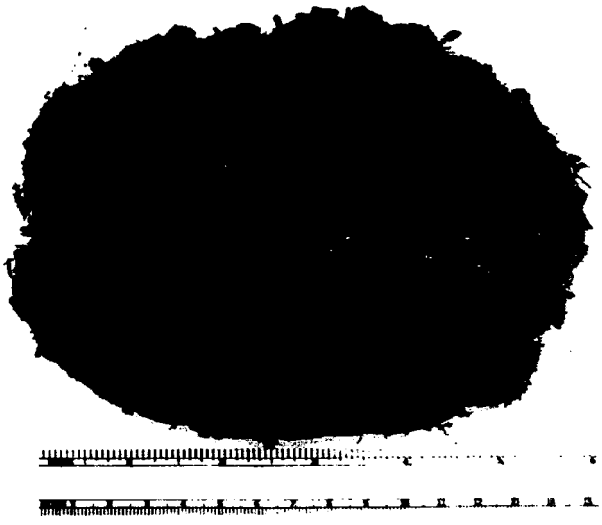
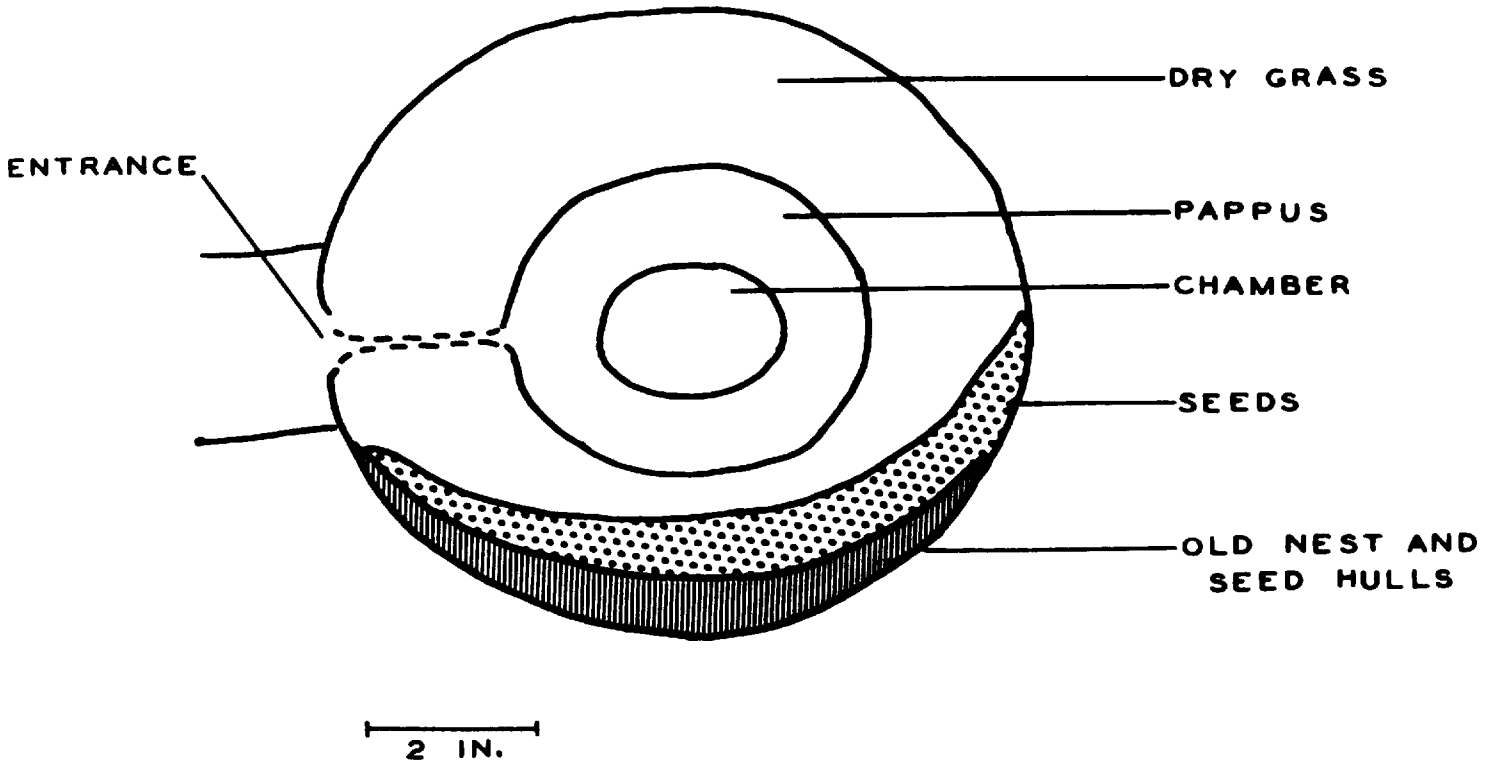


Fig. 103. Old nest from den seven, composed mainly of pappi

Fig. 104. Diagram of nest and food store from den eleven; vertical section


DRY GRASS
ENTRANCE
PAPPUS
CHAMBER
SEEDS
OLD NEST AND
SEED HULLS
2 IN.

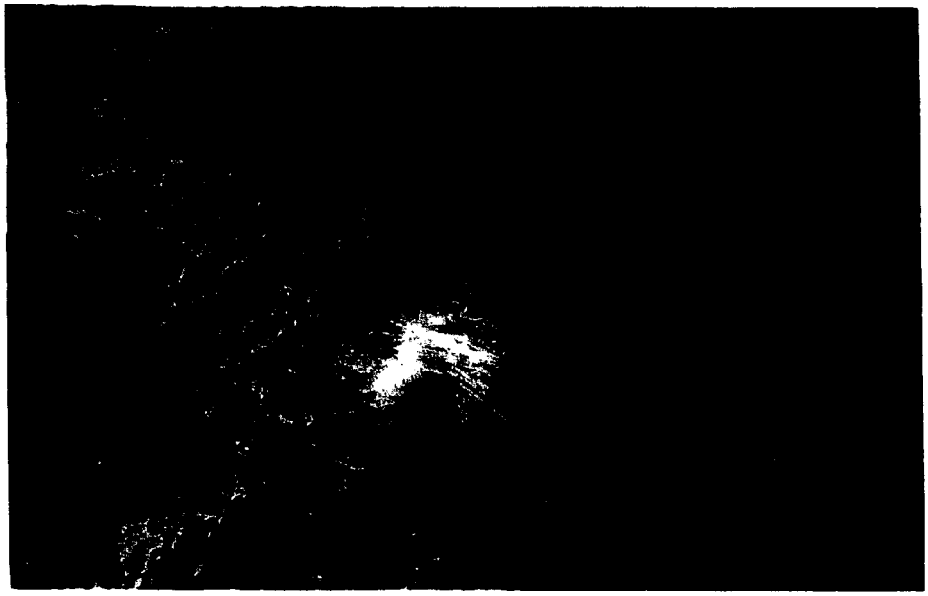


Fig. 105. Mouthful of pappi stored by a chipmunk on the trunk of a yellow pine; September 2, 1947



Fig. 106. Mouthful of pappi and piece of green lichen stored among the needles of a seedling pine

FOOD

Observed foods:

I learned about the feeding habits of Eutamias amoenus affinis at Rocky Flat by direct observation and from winter caches and cheek pouch contents. For example, when I followed marked animals in order to study their home ranges, I also was able to observe their feeding activities. With the aid of six-power binoculars I usually could identify the plants being eaten. Sight records of thirty-six different food items noted from May to November are summarized in Table 35. The list of plants which I collected at Rocky Flat (Appendix C) probably includes still other species that were used for food.

My earliest observations were in May, 1947. At that time I saw chipmunks eat green fruits of the flowers of silver crown (Cacaliopsis Nardosmia, Fig. 107), dandelions (Taraxacum officionale), a grass (Stipa lemmoni), and a petiole of Hydrophyllum sp.

On June 9, 1947, a dyed female that I followed for three and a half hours fed mainly on grass spikes and heart-leaved arnica (Arnica cordifolia) heads. Chipmunks ate at least three species of grasses (Bromus carinatus, Poa nevadensis, and P. secunda, Fig. 108) during the month of June. I watched a female for three and a half hours on July 29 and again on July 30 and saw her feed on the flowers of yarrow (Achillea millefolium, Figs. 109 and 110), an aster (probably Erigeron linearis), heart-leaved arnica (A. cordifolia), Penstemon sp. and Gilia (?) sp. She consumed three yarrow heads during a thirty-minute period. Two other dyed animals that I followed for two hours on July 21 foraged on the ground, presumably for small fungi and seeds. In one instance I definitely recognized a fungus.

Table 35

Foods observed being eaten by chipmunks

Food item	Dates of observation						
	May	June	July	August	September	October	November
Abies grandis						9	
Achillea millefolium			2,21,22,29	9			
Arctostaphylos nevadensis			16	12			
Arcuthobium campylopodum					10		
Arnica cordifolia		9	30				
Bromus carinatus		30					
B. tectorum		10					
Cacaliopsis Nardosmia	30				5		
Cirsium lanceolatum					5,6,16,21,29	10	6
Deschampsia elongata			10		3,18,22		
Erigeron sp.			29				
Gilia gracilis			29,30				
Holodiscus discolor					3		
Hydrophyllum sp.	30						
Penstemon sp.			9,29				

Table 35 (continued)

Foods observed being eaten by chipmunks

Food item	Dates of observation						
	May	June	July	August	September	October	November
Phacelia heterophylla			14,20,21,29				
Pinus ponderosa					25,26,29,16	2,9	
Poa juncifolia			14				
P. nevadensis		10					
P. secunda		20					
Polygonum sp.					3,5,5,6,6,21,22	9	
Pseudotsuga taxifolia						9	
Sitanion hystrix			3				
Stipa lemmoni	31						
Symphoricarpos albus				5	22		
Taraxacum officionale	27,30			14	5		
Verbascum Thapsus					6,21	10	
Fungi: unidentified				1,12	20	9,23	
Basidiomycetous tubers			10,14,31		20	10	
Hygrophoris eburneus						10	
Hysterangiaceae						10	
Grasshopper: Trimeratropis suffusa					26		
Bark				12			

Sight records for July included three grasses (Deschampsia elongata, Poa juncifolia, and Sitanion hystrix), varied-leaved phacelia (Phacelia heterophylla, Fig. 113), manzanita fruit (Arctostaphylos nevadensis, Fig. 111), and small fungi (basidiomycetous tubers, order Hysterangiales).

Fungi, yarrows, dandelions, grasses, and manzanitas continued to serve as food in August. I first saw fruits of the snowberry (Symphoricarpos albus) eaten on August 5, 1947. On that date I watched a chipmunk feed for five minutes on the green, half-grown berries of this shrub (Fig. 112). For a period of two hours and forty-eight minutes on August 12, female No. 101 ate manzanita fruits and a small fungus (probably the tuber of a basidiomycete) and searched for food on the ground.

In September the fruits of six new plants were fed upon: knotweed (Polygonum sp.), mullein (Verbascum Thapsus, Fig. 115), yellow pine (Pinus ponderosa), Douglas fir (Pseudotsuga taxifolia), thistle (Cirsium lanceolatum), and ocean spray (Holodiscus discolor). The knotweeds which carpeted much of the ground on the flat at the west side of Plot 4 apparently were a favorite food, as the tender fruits in its flowers attracted large numbers of chipmunks. I often saw as many as fifteen animals feeding on this species at one time within an area no more than 100 feet in diameter. They frequently foraged only a few feet from one another, but I observed no fighting or competition. Later in the fall chipmunks stored mature knotweed seeds in their burrows.

Yarrows were particularly abundant throughout my study area, and chipmunks commonly ate their fruits in July and August. On various occasions I saw them leap up onto these plants and climb the stems to cut off

6-inch lengths of the flower-bearing stalks, drop to the ground, and there eat the tiny fruits. At times the stems were incompletely severed, and the flowers were left hanging (Fig. 110). The fruits in yarrow flowers were eaten only when green and at a particular stage in their development. Caged animals would not accept heads which were too young or too old, and chipmunks in the wild chose certain flowers and rejected others.

Thistles (Fig. 116, 117, and 118) also were common in some places, and their fruits frequently were eaten. Surprisingly enough, chipmunks climbed these thorny plants with apparent ease and impunity. Sometimes they remained up in the plants to eat there. However, the flowers often were severed from their stalks and allowed to fall or were carried to the ground by mouth. Chipmunks ate the thistles on the ground or took them to the vantage point of a nearby log or stump. They usually turned the prickly heads around several times with fore feet and teeth until the least thorny area at the base of the flower was located and then quickly dissected out the seeds. Until dispersed by the wind, white pappi lay about on the ground or on logs in conspicuous little piles wherever thistle flowers had been eaten (Fig. 117). Later this downy material was gathered for winter nests.

Yellow pine seeds ripened in September, and chipmunks fed on them as soon as the cone scales separated enough for the fruits to be extracted. On September 25, 1946, I saw two chipmunks feeding on pine cones at a height of about 50 feet. In the course of their foraging both animals climbed out to the end of a limb and onto a single cone where, side by side, they busily pulled out seeds. The discarded papery seed "wings" fluttered to the ground. These individuals were unmarked, so I do not

know whether they were members of one family. I saw a number of animals eat cones at heights of 60 to 70 feet, and some of them ascended the tallest trees, 100 feet or more. The female mentioned above (No. 101) also foraged for cones at this season. On September 22 I watched her while she remained aloft for thirty minutes in a Douglas fir, a larch, and a yellow pine; she occasionally climbed to heights of 70 to 100 feet.

Dandelions, fungi, and snowberries continued to be eaten in September. I believe that chipmunks may eat the fruits of the mistletoe (Arcuthobium campylopodum), a common parasite on yellow pines, although I failed to observe them do so. Certain remains of this plant which I discovered on September 10 appeared to have been used as food. I saw a chipmunk eat a grasshopper (Trimeratropis suffusa) on September 26, 1946. My only other record of animal food was that of a bumblebee found in a winter food store.

In early October yellow pine seeds, as well as those of Douglas and grand firs, continued to be taken from cones remaining in the trees. Thistles were abundant and commonly used. Other food plants were knotweed and fungi(Hygrophoris eburneus and basidiomycetous tubers of the order Hysterangiales).

During late October it appeared that most chipmunks foraged on the ground for seeds and corms to store in their winter dens, and at the same time they gathered nest materials such as cotton and thistle pappus.

The first snow of the season fell to a depth of 2 to 4 inches on October 26, 1946, but chipmunks remained active, and their tracks were everywhere. In many places they dug down through the snow in search of food, making holes 3 to 6 inches in diameter and an inch or two deep in the ground (Fig. 119). I found the hulls of pine seeds scattered on the snow at one such digging.

On November 14, 1946, I saw but two animals in the study area, and they were busily engaged in gathering food from bare south slopes. But there were no chipmunk signs after snows fell on November 17 and 20, covering the ground to a depth of 10 inches. My latest record of chipmunk activity in 1947 was on November 13, when the snow at Rocky Prairie was 4 to 5 inches deep. Tracks of the one animal abroad on that date revealed that he obtained food by digging through the snow.

Storage of food:

Chipmunks at Rocky Flat stored food in their burrows in October and November. Dens examined on May 11, June 24, and July 4, 1947, contained no food, and as late as September 24 there were no caches in two burrows known to have been used by female No. 101. I saw her enter one of her dens on September 22, and she was last caught in a live trap on September 24. Then she unaccountably disappeared. When I dug out these two burrows on November 6, 1947, there was no food in them. One of her tunnels contained a new nest of dry grasses, but the other one which she entered on September 22 was apparently incomplete, as it lacked a terminal nest cavity.

Various authors have noted that western chipmunks store food in shallow crevices or holes at the surface of the ground, and they have made general comments to the effect that caches are made in burrows, but detailed information is lacking. Miller (1897: 31) excavated a den of Eutamias minimus borealis at Peninsula Harbor, Ontario, on October 23 and found a small store of weed seeds and of wild fruits within a nest which filled a chamber about the size of a cocoanut. This brief description is the only one I have found regarding the exact location of a food store in the den of a western chipmunk (Eutamias). The stores of E. amoenus affinis which I studied were similar to the one noted by Miller.

I found three newly-gathered winter food caches (Table 36) and the remains of a year-old store in November of 1946 and 1947. All of the stored food was in the spherical nest chambers, and each cache was within the bottom part of the nest itself (Fig. 104) rather than in a separate branch of the tunnel. A chipmunk in his winter home thus would lie directly on top of his food supply and could obtain a meal by simply reaching through the sides or floor of his nest. Following is an account of the storing activities of four individuals.

On October 25, 1947, I watched a dyed male forty-seven minutes while he gathered food and cotton for his nest along a route that approximated a circle about 250 feet in diameter. Most of the time he foraged on the ground, but once he climbed 15 feet up a Douglas fir and later he went up a yellow pine to a height of 30 feet. In twenty minutes his cheek pouches were filled to bulging and he was back within 50 feet of his burrow. Then he paused a minute to pick up a large mouthful of cotton from the ground, adjusted the load carefully with many little movements of his fore paws, and ran directly to his den, which he immediately entered. In three minutes he reappeared and set out again.

This chipmunk finished collecting food during the first week of November, 1947. The entrance to his burrow was plugged and completely effaced on November 6, but I was able to relocate it by probing the ground with a stick. The light snow of the previous day had thawed, and the ground around the den was bare at this time. One week later, when 2 inches of fresh snow covered the ground, I excavated the den and found the occupant curled up alone on top of his food cache in a spherical, 6-inch nest of cotton and pappus.

Table 36

Contents of three food stores from chipmunk burrows
(Starred figures represent actual counts; the rest were calculated from samples)

Food Items	Numbers			Weight in grams		
	Nov. 14 1946	Nov. 16 1946	Nov. 13 1947	Nov. 14 1946	Nov. 16 1946	Nov. 13 1947
Seeds						
Amaranthus sp.	....	60	....	....	....	....
Arachis sp. (peanut)	....	2*	....	....	1.0*	....
Callandrinia caulescens	....	....	20	....	....	....
Carex sp.	1000	10	16840	2.9	....	37.8
Cirsium sp.	20	6170	660	0.1	19.6	1.9
Collinsia sp.	2030	410	31720	2.0	0.7	46.3
Cryptantha ambigua	2230	520	240	0.7	0.4	0.1
C. muriculata	....	....	50	....	....	....
Eriogonum sp.	20	140	10	....	0.1	....
Helianthus sp.(sunflower)	....	430	....	....	32.0	....
Hordeum vulgare	....	650	....	....	49.4	....
Lomatium (?) sp.	....	....	120	....	....	0.2
Lupinus sp.	20	....	....	....	....	....
Madia sp.	....	20	2650	....	....	6.6
Phacelia sp.	7890	230	370	8.0	0.2	0.2
Pinus ponderosa	260	1080	17*	8.1	52.4	0.9*
Polygonum aviculare	....	3400	1600	....	5.8	2.6
P. punctatum	3230	10	260	4.4	....	0.2
Pseudotsuga taxifolia	5360	450	....	40.3	5.2	....
Ribes sp.	1430	....	970	1.3	....	0.7
Stipa sp.	870	....	2520	2.2	....	7.6
Symphoricarpos albus	....	30	....	....	....	....
Triticum sp. (wheat)	....	90	....	....	1.8	....
Zea sp. (corn)	....	....	20	....	....	5.0
Corms	....	200	10000	....	1.4	80.0
Bumblebee (*Bremus* sp.) (2 legs, part of thorax)			1			
Totals	24360	13920	67970	70.0	170.0	190.0

His store (Fig. 123) contained approximately 67,970 items, including fifteen native species of seeds, corms of unidentified plants, some corn obtained from traps, and several legs and part of the thorax of a bumblebee (Bremus sp.). The most abundant items were Collinsia sp. (31,720), Carex sp. (16,840), and corms (10,000 pieces of various sizes averaging about 3 mm. in diameter). Eighty-five per cent of the total weight of 190 grams was composed of three foods: corms (42%), Collinsia seeds (24%), and sedge seeds (19%). Other species were Stipa sp. (4.0%), Madia sp. (3.5%), Zea sp. (2.6%), Polygonum aviculare (1.4%), Cirsium sp. (1.0%), Pinus ponderosa (0.5%), and Ribes sp. (0.4%). Also there were Lomatium sp., Phacelia sp., Polygonum punctatum, Cryptantha ambigua, Callandria caulescens, Cryptantha muriculata, and Eriogonum sp., each weighing less than 0.1 per cent of the total. The volume of this store was about 330 cc. The bumblebee is a ground-dwelling form, so it may have entered the tunnel to be captured and eaten there. I found no other animal food in the four collections.

By the middle of November, 1946, there were very few chipmunks abroad. However, I did see one on November 13. He carried conspicuous light-colored down in his mouth when I first saw him, so I watched closely in the hope that he would lead me to his burrow. In a short while he disappeared into the ground near the bottom of a ravine, and I soon found the tunnel when he reappeared. He went foraging again in the woods, and when he returned, his cheeks and mouth were filled with seeds and nest material. He hesitated to approach me for a few minutes, but then overcame his fear and entered the den. Twenty minutes later he was still below ground. The next day I returned with a shovel and dug out his nest and winter store.

In his cache (Fig. 122) were about 24,360 seeds of twelve species. These weighed approximately 70 grams and had a volume of 343 cc. Douglas fir seeds, forming the bulk of the collection, numbered about 5360 and weighed 40 grams (57.5% of the total). The following species also were represented in the store: Pinus ponderosa (1.2%), Phacelia sp. (1.1%), Polygonum punctatum (0.6%), Carex sp. (0.4%), Stipa sp. (0.3%), Ribes sp. (0.2%), and Cryptantha ambigua (0.1%). Others were Cirsium sp., Eriogonum sp., and Lupinus sp. in amounts less than 0.1 per cent of the total weight.

Many old hulls of Douglas fir seeds and the remains of an old grass nest lay packed down on the floor of the chamber underneath the new nest and its store.

On November 13, 1946, a dyed male led me straight to his burrow. While I was digging out the den three days later, he came within 10 feet of me and remained in the vicinity for some time. His cheeks were filled with food and he was carrying pappus in his mouth at the time. Many seeds were stored in the sides and bottom of his thistledown nest.

The items found in this cache (Fig. 121) were the seeds of fifteen native species, sunflower seeds, wheat kernels, and two hulled peanuts. The total number of food items was approximately 13,920. The three most abundant seeds were those of Cirsium sp. (6170), Polygonum aviculare (3400), and Pinus ponderosa (1080). The total weight was approximately 170 grams, 91 per cent of which was due to four species: Pinus ponderosa (31%), Hordeum vulgare (29%), Helianthus sp. (19%), and Cirsium sp. (12%). Other plants in descending order of frequency were Polygonum aviculare (3.4%), Pseudotsuga taxifolia (3.1%), Triticum sp. (1.0%), corms (0.8%), Arachis sp. (0.6%), Phacelia sp. (0.1%). There were also small numbers of

Eriogonum sp., Amaranthus sp., Carex sp., Madia sp., Polygonum punctatum, and Symphoricarpos albus.

The rough outer coverings were found on only about half of the Polygonum seeds. The tough shells of pine and fir seeds were intact, but their "wings" had been removed. Sunflower seeds were stored either with or without their shells.

Another marked male, which I followed forty-one minutes on November 6, 1946, also was busy gathering food and thistle pappus. After emerging from his tunnel he ranged in a course that approximated a circle 250 feet in diameter and frequently stopped to dig in the ground and surface litter for seeds. His last act before returning to his home was to gather a mouthful of thistle pappus. This took only five to ten seconds and then he went quickly to his burrow and entered it, remaining inside for three and a half minutes.

The next round-trip took an hour and thirteen minutes and covered about the same ground as before. He foraged most of the time on the bare southern slope of a ridge about 200 feet north of the den. In twenty minutes his cheeks bulged conspicuously, but not for another twenty-seven minutes did he unload his pouches. On this trip he again picked up a mouthful of down just before entering his tunnel. This time seven minutes passed before he reappeared and set out to gather more food and nest material.

On the following day I saw him carrying food into his burrow, and again he stayed underground for seven minutes. His den was located at the base of a northern slope where snow was about 2 inches deep at this time. Many tracks radiated out from the entrance. Food-gathering was quite feasible because exposed slopes thawed during the day. Foraging

activities must have been stopped when snows fell to a depth of 4 inches on November 17 and 10 inches on November 20 because thereafter I saw neither chipmunks nor tracks.

During the summer of 1947 this burrow was used only sporadically. Excavation on November 11, 1947, revealed an old nest of pappus beneath which lay the remains of seeds that had been stored the previous fall. Debris of yellow pine hulls and thistle seeds was about all that remained of the cache, but in these remains were five kinds of small seeds, probably overlooked by the occupant of the burrow. I sorted and counted a sample from the store and then estimated the total numbers in the original store. The following figures represent only the possible minimum numbers, and some foods may not be included in the list if they were completely disposed of during the winter: Pinus ponderosa (120), Cirsium sp. (5350), Polygonum sp. (1660), Cryptantha ambigua (30), and a few seeds of Pseudotsuga taxifolia, Polygonum aviculare, Madia sp., and Amaranthus sp.

I obtained additional information on foods from cheek pouches of ten individuals (Table 37). Four specimens shot in early June, 1947, carried seeds of collinsia (Collinsia parviflora), sedge (Carex sp.), and two species of knotweed (Polygonum sp.). The most abundant of these, collinsia, was in three of the four animals. There were 184 seeds of this plant alone in the pouches of one chipmunk, and in another they formed the bulk (261) of the contents.

Chipmunks in live-traps frequently had their cheeks filled with corn or sunflower seeds and occasionally those of native plants. They often emptied their pouches by movements of the tongue and mouth when I handled them. Usually it took several minutes to expel the contents of the cheeks in this manner.

Table 37

Contents of cheek-pouches
(Each date represents a single animal)

Items	June 1	June 4	June 4	June 12	Oct. 23	Oct. 28	Oct. 28	Oct. 29	Oct. 29	Oct. 29
Amaranthus sp.					2					
Bromus sp.					3					
Carex sp.		4		94					17	4
Collinsia parviflora	184	261	20							
Corms					42			2		
Cotyledon of seedling					1					
Eriogonum sp.					1	10				
Glyceria sp.					2					
Lomatium sp.					12	9	85			
Madia glomerata								10		76
Phacelia sp.					1	7				
Pinus ponderosa needles (10-12 mm. long)					2					
Polygonum sp.		1		19	26	2			24	
Stipa sp.										
Bark fragment					1					
Chipmunk (?) scats					3					
Totals	184	266	20	113	96	28	85	12	41	80

There were seventeen kinds of seeds in six pouches examined in October. The items present in greatest numbers were seeds of parsley (Lomatium sp.), stinking tarweed (Madia glomerata), knotweed (Polygonum sp.), eriogonum (Eriogonum sp.), stipa (Stipa sp.), and corms of unidentified plants. One individual had collected the following varied items: corms, nine species of seeds, a cotyledon of a seedling, two short segments of a dry yellow pine needle, a small piece of bark, and three chipmunk (?) scats. This animal apparently had been collecting corms and seeds of knotweed principally. A chipmunk live-trapped on October 28 had eighty-five seeds of only one plant (Lomatium sp.) in its pouches, and on October 29 another carried seventy-six seeds of stinking tarweed (Madia glomerata) and four of a sedge (Carex sp.).



Fig. 107. Silver crown (Cacaliopsis Nardosmia), a spring food

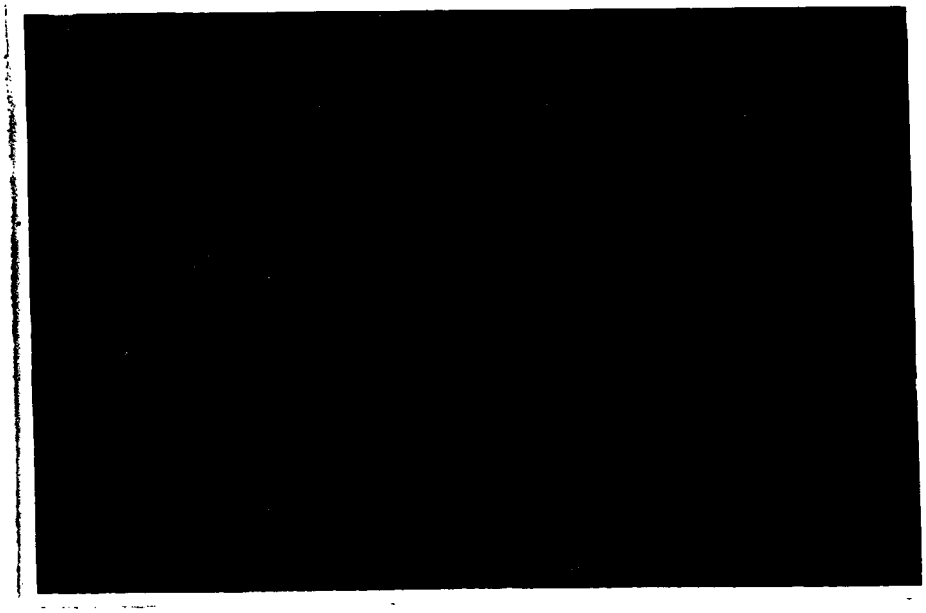


Fig. 108. A grass whose spikes were eaten by chipmunks

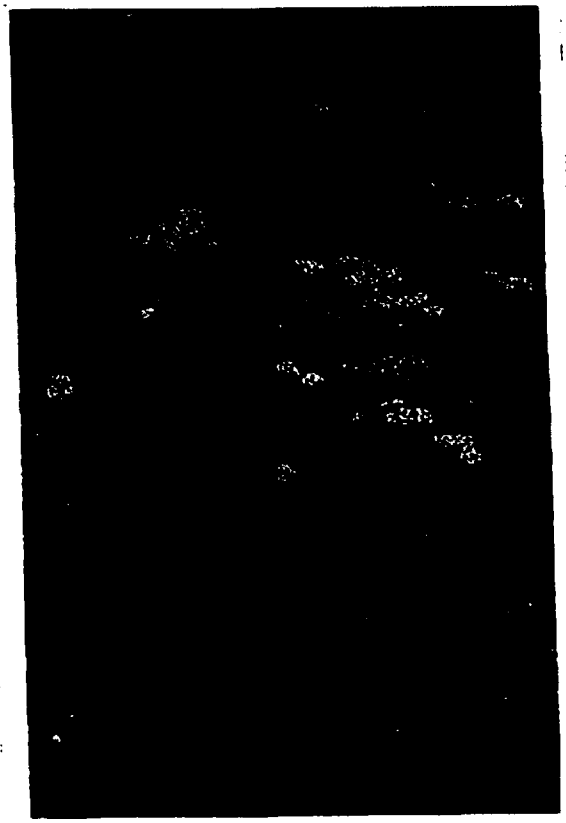


Fig. 109. Yarrow (Achillea millefolium), a chipmunk food in July and August



Fig. 110. Flower stalks of yarrow cut by chipmunks

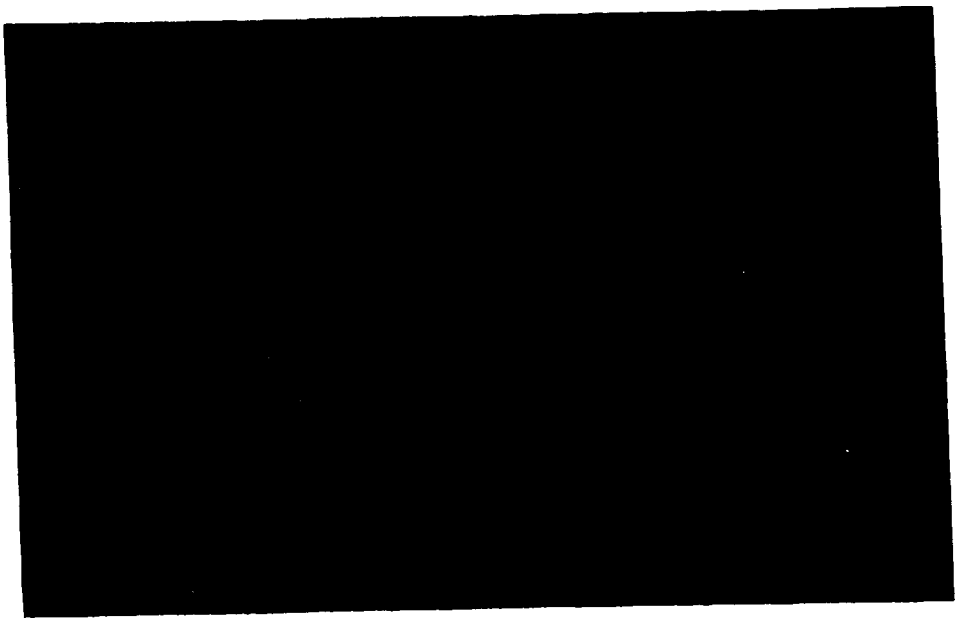


Fig. 111. Manzanita (Arctostaphylos nevadensis), berries eaten by chipmunks in July and August

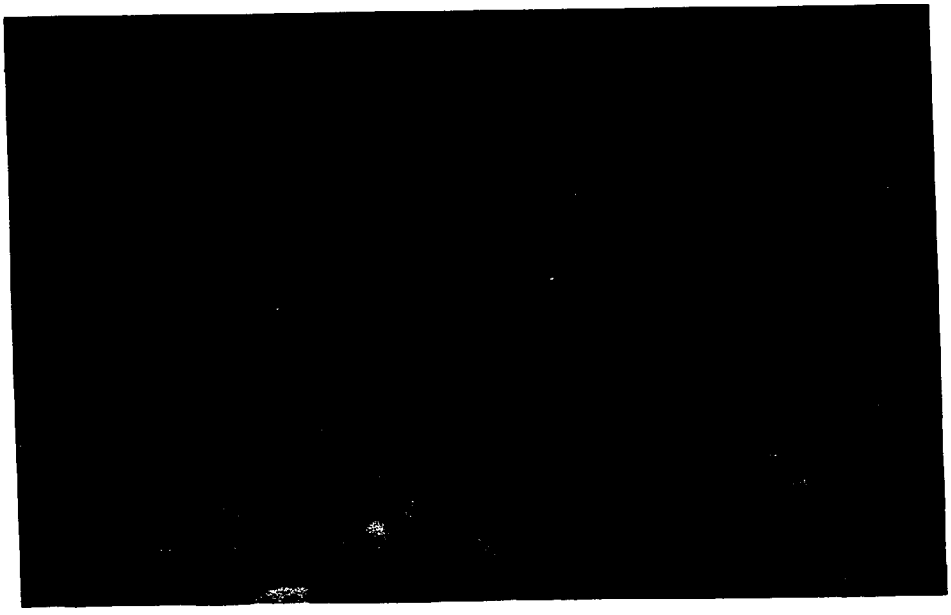


Fig. 112. Snowberry (Symphoricarpos albus), an August and September food



Fig. 113. Phacelia heterophylla, a July food

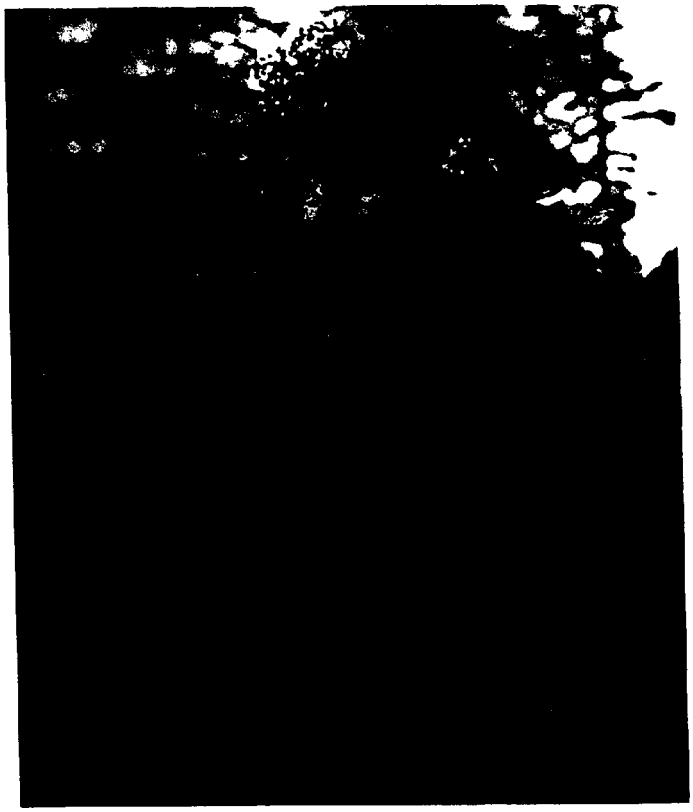


Fig. 114. Ocean spray (Holodiscus discolor), green fruits eaten in September

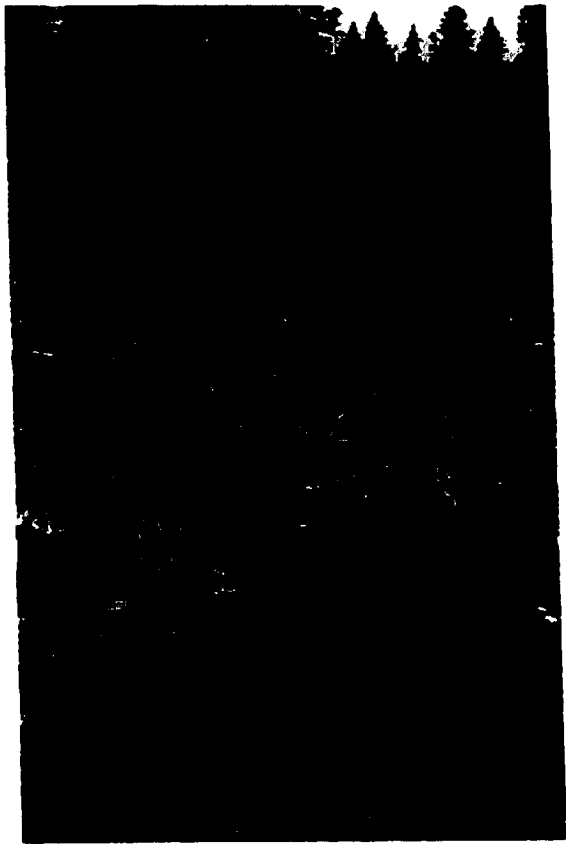


Fig. 115. Mullein (Verbascum Thapsus), a September food



Fig. 116. Thistle (Cirsium lanceolatum), eaten during September, October, and November



Fig. 117. Thistledown on a log where a chipmunk had torn the head apart for its fruits; Sept. 8, 1946



Fig. 118. Patch of thistles at west edge of Plot 4; the flowers were a source of food and nest material



Fig. 119. Hole in snow made by a foraging chipmunk



Fig. 120. Same as above

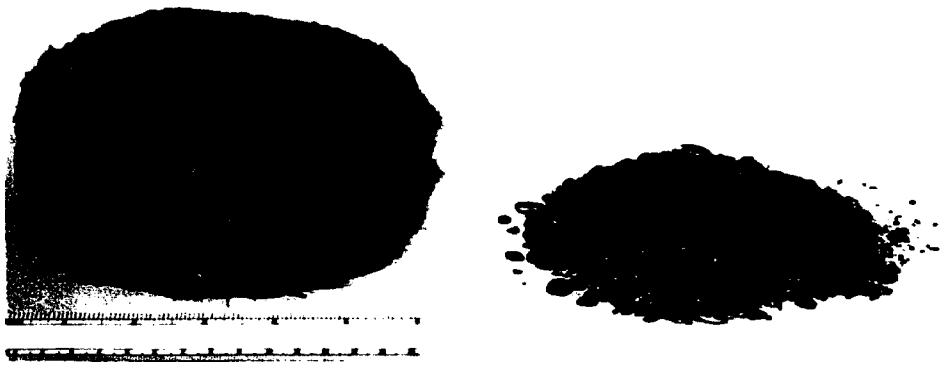


Fig. 121. Nest and cache from den twelve; collected November 16, 1946



Fig. 122. Nest and cache from den eleven; collected November 13, 1946

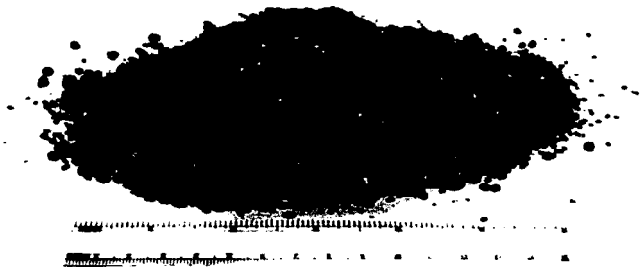


Fig. 123. Cache from den eight; collected November 13, 1947



Fig. 124. Year-old nest and hulls from den seven; collected November 11, 1947

HIBERNATION

There are a few records of hibernation in several species of Eutamias. On January 2 on the coast of Oregon, Walker (1923: 257) found a dormant animal (E. townsendii) that was cold and stiff. It was in a nest located in a stump 5 feet above the ground. The chipmunk remained inactive for several hours before it was placed in a warm room. Eight miles east of Portland, Oregon, in late winter Anthony (1924: 76) discovered several individuals of this species in nests that were underneath stumps; these animals were stiff and cold, "the flesh almost as if it might be frozen." Svihla (1936: 289-90) observed captive E. amoenus canicaudus in outdoor cages at Pullman, Washington, and noted that during the months of December and January periods of torpor alternated with periods of activity during which the animals ate the food stored in their nests.

On Mount Rainier Eutamias amoenus caurinus hole up around November 1, according to Taylor and Shaw (1927: 98). They record observations of J. B. Flett to the effect that "on February 14, 1920, there being little snow on the ground at Longmire, a little chipmunk appeared, being followed two days later by a Cooper chipmunk. With the return of cold weather about a week later both disappeared, and neither was seen until March 31, when the little chipmunk appeared in the worst snowstorm of the season....the chipmunk ate until his little cheeks were puffed out. He then went back to sleep and came out the third time on April 13."

Storer, Palmer, and Evans (1944: 182) observed that most adult Eutamias quadrimaculatus in the Sierras of California evidently were inactive or in hibernation by November 1. Whether they resumed activity during favorable winter weather could not be determined. "We neither saw nor heard chipmunks from November 4 to January 5, when winter really set in with heavy snow, but they might then well go unnoticed unless 'chipping'; they were seen rarely even when very active." The first chipmunk of the spring was seen on March 17.

My observations at Rocky Flat were not continued beyond November 20, but two facts suggest that deep hibernation of long duration does not occur: (1) the failure of chipmunks to accumulate fat or increase in weight, and (2) the storage of food in winter dens.

I saw a few fully active chipmunks in mid-November when the temperatures were freezing, and snow was 5 inches deep in places. Chipmunks probably remain in their burrows most of the winter because little food is available when the snow is deep.

At Rocky Flat chipmunks were abundant in late October, but rapidly diminished in numbers with increasing cold and snow and disappeared by mid-November. A few animals were active in severe weather, but most of them retreated to their burrows before permanent winter snows covered the ground. The first light snow of the season fell on October 23, 1946, but it thawed by noon. I caught thirty-seven animals with one hundred traps that day. There followed a 3-inch snow on October 25 and light flurries on November 1 and 10. As late as November 17 much of the ground remained free from snow because south slopes thawed during the day. I caught only one chipmunk in one hundred traps on November 13, when trapping was ended. I saw two chipmunks outside

the trap area on November 13 and 16, respectively, but after heavy snows came on November 17 and 20 and laid down a blanket 10 inches deep, neither the animals nor their tracks were to be found.

The following year (1947) the first snow of the winter season fell on October 19. The depth was about 2 inches, but within several days most of the ground was bare again. On October 30 I captured thirty-four chipmunks with one hundred traps in Plot 2. I discontinued the trapping on that date, but made general observations until November 15. A 1-inch snow fell at Rocky Prairie, but thawing caused most of the ground to be exposed again by noon. I saw only a few chipmunk tracks that day and recorded only one individual from November 9 to 15. I saw him during a 4-mile hike to Yellowjacket Mountain on November 13. The altitude there was about 4800 feet, and the snow was 5 inches deep. Temperatures at camp (3800 feet) ranged from 17° to 35° F. that day. When I discovered this chipmunk, he was watching me quietly from a vantage point 20 feet up in a pine tree, but tracks showed plainly that he had dug for food (Figs. 119 and 120) and had been running about on the snow.

During the winter three captive chipmunks living in rooms at a temperature of approximately 68° F. were relatively inactive, but did not hibernate. During December and January they often remained in their nest boxes all day except for a short feeding period of about half an hour to an hour. Their movements were not vigorous when they came out for food, and sometimes they dozed with eyes shut. These captives, as well as chipmunks in the wild, stored food in their nests.

Professor A. D. Moore of the University of Michigan has been interested in the field of animal energy for some time, and after I

had discussed the question of hibernation with him, he kindly agreed to take my data and apply it to certain laws of metabolism and an original formula on the basal metabolic rate for mammals. His analysis of food stores and hibernation in Eutamias amoenus is quoted here in full.

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From collections made by Broadbooks, Yakima County, Washington, it appears that in preparing for hibernation, this chipmunk does not get fat; rather, that it depends on food stores to be resorted to from time to time during waking intervals in the hibernating sleep.

A food store of 180 gm. of seeds appears to be typical. A typical weight for the animal is 45 gm., or 0.045 kg. The question is, could the animal be expected to survive, in good condition, on this store for a four-month hibernating period?

We first look into the question of burrow temperature. Mean air temperature data are available in "Climate and Man, 1941 Yearbook of Agriculture", United States Department of Agriculture. Data from a number of weather stations in Yakima County are given (p. 1173). The month of January average temperature ranges, for these stations, from 24.4° to 30.0° F.; and July averages, from 58.4° to 73.7° F. The Broadbooks research was done at an altitude above most or all of these stations, and his air temperature means for January and July would therefore be expected to be as low as 24° and 58°. Taking the average of 24 and 58, we get 41; and this, as is known from long experience, would be a very good estimate of the annual mean air temperature.

From geophysics, we also know that ground temperature taken at a level (perhaps 20 feet) far enough down to get below annual fluctuations, is nearly always within a few degrees of the mean annual air temperature. Deep ground temperature at the location would then be about 41°. The burrow, located above this steady ground temperature and below the fluctuating ground surface temperature, would fluctuate between the two. Ground surface temperature, taken among the top particles, can show great daily variations. However, at a depth of a foot or two, the temperature at any one time would tend to approximate to the mean air temperature of the preceding two or three weeks. All this serves to indicate that by mid-November, when the hibernation began, burrow temperature should at least have been as low as 58°, the July mean, and was probably several degrees below that.

The point of this is to show that when hibernation began, and the chipmunk's body temperature dropped to that of the burrow, it dropped at least to 58°, which is more than 40° below its optimum body temperature. Such a body temperature is amply low to permit hibernation; in fact, estivation is successfully carried on in some species at much higher body temperatures.

Something about normal metabolic rates must now be estimated. From a correlation I have made between weight and basal metabolism for mammals, the basal rate can be taken as

$$\text{Basal C/KD} = 65.5\ W^{-0.228}$$

where C/KD is Cal. per kg. per day (Cal. means large calories), and W is the animal's weight in kg. Using W equals 0.045, basal C/KD comes out to be 134. Multiply this by W to get Cal/day for the whole animal, or C/D; we get C/D equals 6.0 for the basal state.

No accurate data are available, on a broad scale, for the metabolic rates of animals in the hibernating state. However, from such data as are available, plus the known fact that respiration and heart rates are extremely low, it is safe to assume that the hibernating rate would not be more than 5 per cent of the basal rate, or C/D equals 0.3. This is probably considerably above the actual level.

Four months, or 120 days, at this rate, would use up 120 x 0.3, or 36 Cal.

To use up the food stores, the animal must at times awaken and have some activity. It thus becomes necessary to have an estimate of the metabolic rate during such periods. From studies that are too lengthy to include here, I am proposing that among the warm-bloods, the average daily maximum metabolic rate, continued over a period of more than a few days, is no higher than five times basal. For the chipmunk, we could hardly expect this level to be achieved during the waking intervals by muscular activity alone; however, owing to winter temperatures, the heat loss might be considerable. Assuming the proposed top factor of five to obtain, the C/D during waking periods would be 5 x 6.0, or 30. If we allow ten days of such activity (twenty-four-hour days, or twenty half-days, if you like), the Cal. needed would be 10 x 30, or 300 Cal.

The total calorific requirement would then be 36 for hibernation and 300 for waking periods, or 336 in all.

Dice (1922) determined that whole wheat grain had a calorific value of 3.33 Cal/gm. Using the rounded value of 3 for "seeds", 180 gm. of seeds would yield 3 x 180, or 540 Cal.

The chipmunk should survive.

* * * * * * * * * * * * * * *

WEIGHTS

By means of a spring scales calibrated in one gram units, I weighed the chipmunks in my study area about eight days of each month, on the average. I carried the scales around with me while live-trapping and weighed the captured animals on the spot. First I would note the weight of both trap and chipmunk, then put the animal in a bag and weigh the trap alone; the difference in readings was the weight of the chipmunk.

I tested the scales several times with a balance and considered them to be accurate to within 2 or 3 grams under field conditions. It is well to place the scales on level ground, but that is difficult in some places. Also, the accuracy of the scales was poor in a wind, so I would usually not weigh on windy days.

Tables 38-42 summarize the live weights of chipmunks at Rocky Flat by fifteen-day periods from May to October, 1947.

My records show a difference in weight between males and females. The null hypothesis test indicated that this difference was significant. Sixty-six records of non-breeding adult females (chosen because their weights are not confused by young and lactation) averaged 50.0 grams, while 395 records of adult males averaged only 47.4 grams. In eight out of nine periods the females were heavier than males, so the difference is a fairly constant one.

There is a difference in average weights of young, as well as adult, males and females. Young females weighed more than young males

in eight out of nine periods from July 15 to the end of October. As we would expect, breeding females weighed more than non-breeding females from May to the end of July. The highest average weight of breeding females was during the first half of June, so this was probably the period in which most of the young were born.

Table 38

Weights of breeding females from May to October, 1947
(Weights are in grams)

Period	Number of weights	Average	Standard deviation	Extremes
May				
First half	37	52.4	6.23	41-67
Second half	23	55.4	7.41	42-69
June				
First half	28	57.1	5.83	47-73
Second half	36	55.3	4.61	47-65
July				
First half	38	55.2	4.02	48-67
Second half	38	52.0	4.20	42-59
August				
First half	5	50.6	2.93	47-54
Second half	24	52.6	3.59	47-59
September				
First half	6	50.0	2.83	46-53
Second half	10	50.7	3.13	45-54
October				
First half	6	51.7	3.44	46-54
	Total	Weighted average	S.D. of weighted average	Extremes
	251	53.8	2.39	41-73

Table 39

Weights of non-breeding females from May to September, 1947
(Weights are in grams)

Period	Number of weights	Average	Standard deviation	Extremes
May				
First half	17	46.7	5.00	38-55
Second half	7	49.7	5.84	44-58
June				
First half	7	51.1	2.62	49-55
Second half	7	51.9	4.53	45-59
July				
First half	7	51.7	4.11	45-58
Second half	7	49.4	3.18	45-53
August				
First half	4	55.6	4.14	52-60
Second half	6	50.3	2.08	48-53
September				
First half	4	51.8	4.09	46-55
	Total	Weighted average	S.D. of weighted average	Extremes
	66	50.0	2.59	38-60

Table 40

Weights of adult males from May to October, 1947
(Weights are in grams)

Period	Number of weights	Average	Standard deviation	Extremes
May				
First half	108	45.6	3.85	37-57
Second half	39	46.5	4.48	36-56
June				
First half	54	47.2	3.35	42-58
Second half	47	46.5	4.58	35-56
July				
First half	16	49.3	3.11	43-54
Second half	39	47.9	4.16	42-58
August				
First half	28	49.3	3.90	41-56
Second half	23	50.9	4.11	40-60
September				
First half	20	48.3	3.20	41-60
Second half	18	50.4	3.38	44-54
October				
First half	3	51.7	3.11	49-55
	Total	Weighted average	S.D. of weighted average	Extremes
	395	47.4	2.30	35-60

Table 41

Weights of young females from June to October, 1947
(Weights are in grams)

Period	Number of weights	Average	Standard deviation	Extremes
June				
Second half	5	31.0	5.61	25-39
July				
First half	10	39.7	6.96	22-46
Second half	31	45.6	3.15	38-53
August				
First half	17	47.8	4.47	43-59
Second half	36	48.0	3.60	41-54
September				
First half	13	46.7	3.79	38-52
Second half	26	48.6	2.98	44-56
October				
First half	8	47.3	2.44	44-51
Second half	9	48.1	1.69	46-50
	Total	Weighted average	S.D. of weighted average	Extremes
	155	46.4	6.08	22-59

Table 42

Weights of young males from June to October, 1947
(Weights are in grams)

Period	Number of weights	Average	Standard deviation	Extremes
June				
Second half	3	27.0	2.00	25-29
July				
First half	7	36.7	5.92	28-44
Second half	12	39.9	3.92	34-46
August				
First half	18	45.6	3.70	41-52
Second half	15	44.6	3.86	38-51
September				
First half	10	46.5	3.72	40-53
Second half	8	47.9	4.93	41-54
October				
First half	4	45.0	2.00	42-47
Second half	5	48.2	3.36	46-54
	Total	Weighted average	S.D. of weighted average	Extremes
	82	43.6	7.00	25-54

PARASITES

Botflies:

The botfly, Cuterebra, parasitized chipmunks at Rocky Flat. I found larvae in sixty-six (23.1%) of 286 chipmunks trapped in 1946. Only 8.6 per cent (twenty-five out of 292 individuals) were afflicted in 1947. It appears that there is considerable variation in the amount of infestation from year to year, and 1947 may have been a low period. Larrison (1947: 25) found botflies in more than half of the specimens he collected at Rocky Flat in August, 1941.

In July I first noticed warbles, but most of them appeared in the latter half of August (Table 43). During that month I found 60.4 per cent (ninety-one) of the larvae. My latest record of a botfly was on November 2, 1946.

Three larvae was the greatest number carried by a single chipmunk at any one time (Table 44). Seventy-four animals had parasites and of these, 82.4 per cent bore one; 12.2 per cent, two; and 5.4 per cent, three of the larvae. Larrison (loc. cit.) observed a greater number (four or five) per chipmunk, as well as higher frequency of occurrence in the population.

As far as I was aware, the larvae caused no deaths and did not seriously affect the general vigor and activity of chipmunks. Wounds made by the larvae quickly healed within a few days to a week.

Larvae made noticeable swellings about twenty days before they emerged from a chipmunk. Most of the bots were on the sides of the

Table 43

Occurrence of botfly larvae in the chipmunk

Month	Number of larvae 1946	Number of larvae 1947	Total number of larvae
July			
First half	....	2	2
Second half	3	....	3
August			
First half	15	6	21
Second half	23	11	34
September			
First half	7	2	9
Second half	12	2	14
October			
First half	5	2	7
Second half	....	....	....
November			
First half	1	....	1
Totals	66	25	91

Table 44

Numbers of botfly larvae on individual chipmunks

Number of larvae per chipmunk	Number of chipmunks	Percentage of infested chipmunks
1	61	82.4
2	9	12.2
3	4	5.4
4	....	....
Total	74	

body, but others were located on the belly, back, neck, shoulders, and rump in decreasing order of abundance (Table 45). None was found in the scrotum and genitals or on the head. The general appearance of the larvae and their position on the host may be seen in Figures 125-137.

The bot larva grows under the skin in a pocket or cyst communicating to the outside through a single hole and does not penetrate into the muscles. Full-grown larvae protrude from the body of the chipmunk as large (20 x 5 mm.), oval lumps (Fig. 128). The skin that covers the warbles changes from a normal pink to a shiny black, smooth and devoid of hair. The larva gradually works out of the cyst and drops to the ground four or five days after it begins to enlarge the breathing hole. The gaping cavity is a rather good cast of the larva. The newly emptied cyst has a round, flaring mouth about 10 millimeters in diameter (Fig. 129) and is lined with pink, healthy tissue. Some of the wounds remain fairly clean and dry until they heal over, while others fill with pustulent material in a day or two. Recovery is rapid in most cases, the hole closing up and developing scabs within a few days. Hair grows back over the wound in time, and there is little or no trace of the spot by late fall.

It seems strange that chipmunks do not kill the larvae when they emerge from accessible parts of the body. I once found an adult larva in the bottom of a live trap with a chipmunk and have secured a dozen or more from captive animals by waiting until the bots fell to the floor of their cage. Possibly chipmunks find the larvae distasteful, as they neither ate nor destroyed them. However, the larvae probably are somewhat irritating. I have seen chipmunks lick and scratch their skin around an encysted bot.

Table 45

Location of botfly larvae on chipmunks

Part of body	Numbers of larvae	Percentage
Sides	34	37.8
Belly	23	25.6
Back	14	15.5
Neck	11	12.2
Shoulders	7	7.8
Rump	1	1.1
Totals	90	100.0

The larva changes color from white to dark brown or black during its development (Fig. 137). When it falls to the ground, it burrows into the soil to a depth of an inch or less within about twenty-four hours and pupates there within a day or two.

The larval stages of Cuterebra are difficult to identify, so I made an attempt to raise adult flies. Immediately after they were collected, the experimental larvae were placed in three-pound coffee cans containing 3 to 4 inches of loose surface soil and litter. They pupated and some of them developed into mature flies by the following spring. I kept the larvae at Rocky Flat until the middle of November, 1947 (when temperatures went down to 15° F.), and then took them to the University of Michigan where they were kept in rooms at about 68° F. Occasionally the soil became quite dry and shrank from the sides of the containers, although water was added to the cans at irregular intervals of a week or two.

Four of the seven larvae I had placed in cans in 1947 developed into adult flies. They closely resemble a bumblebee in size and general appearance (Figs. 139 and 140). The main color patterns are black and buffy white; the head and body are covered with long, dense hairs. The total length is about 17 millimeters.

I found the first fly in one of the cans on April 19, 1948. It was still sufficiently alive to move its legs freely, but could neither fly nor walk, so it probably had emerged several days previously. The larva pupated on August 31, 1947, so the emergence was approximately 232 days later.

The second fly was very much alive when found on April 24, 1948, clinging to the cheesecloth cover on one of the cans. It had been a pupa since September 24, 1947, a period of 213 days.

A third fly remained a pupa for 273 days (August 23 or 24, 1947 to May 23, 1948). The fourth botfly appeared on June 16, 1948, 297 days after pupation.

The average pupation period was 254 days.

Other parasites:

Four kinds of fleas lived on chipmunks and in their nests. These were Oropsylla idahoensis (also taken from Citellus lateralis saturatus), Opisodasys keeni, Catallagia decipiens, and Monopsyllus eumolpi cyrturns.

The heaviest infestation by fleas occurred in May, when they were found on approximately one-half of the trapped animals. Less than five per cent had fleas in the subsequent months from June to November. Underground nests harbored a good many fleas in June and November. However, thirteen per cent of the total number of chipmunks had fleas in 1947. These had no harmful effects on their hosts, as far as I could tell, and never occurred in large numbers on any one individual.

I found several engorged ticks, Dermacentor andersoni, attached to the ears of chipmunks.

Thirty-three chipmunks had small, reddish mites during May of 1947. They burrowed into the skin of the belly causing small lumps. As many as a dozen or more were counted on one animal. Scabs eventually formed over the wounds caused by these mites.

At least fourteen chipmunks (5%) had lice in 1946 and two (0.7%) in 1947.

Skin diseases troubled only a few chipmunks. The foot of one individual was somewhat swollen and covered with scabs on August 20, 1947 (Fig. 142), but new hair began to appear on September 6 and by September 11 the foot was almost normal in appearance. Five other chipmunks had

toes without hair, and there were hairless patches on the sides of the noses of five other animals (Fig. 143). One individual whose nose was bare on August 19 had grown new hair by August 22. The lower jaw and chin of another chipmunk was bare on August 20, 1947. A large patch of skin on the rump of another animal was smooth, hairless and black on August 6, 1946; new hair began to appear three days later.

Two specimens had tapeworms on September 21 and November 6, 1947. The host chipmunks looked healthy, despite the fact that their intestines were crammed full of these parasites. They belonged to two species: Hymenolepsis nana and H. diminuta. I have records of thirteen chipmunks which voided small tapeworms in their feces in the period from August 29 to October 28, 1947. These cestodes were nearly round and about 2 millimeters in diameter. They would appear in the feces of individual chipmunks for an average of five consecutive days. One animal voided tapeworms on September 26 and again during the period from October 22 to 30, 1947. I took another chipmunk to camp for observation on August 30, 1947, after I had found these parasites in its feces. His weights on August 30, September 9, and September 20 were, respectively, 43, 29, and 25.1 grams. Death occurred on the last date. An autopsy revealed that his intestines were filled with a large number of tapeworms.



Fig. 125. A mature Cuterebra larva beginning to emerge from a chipmunk; August 13, 1947

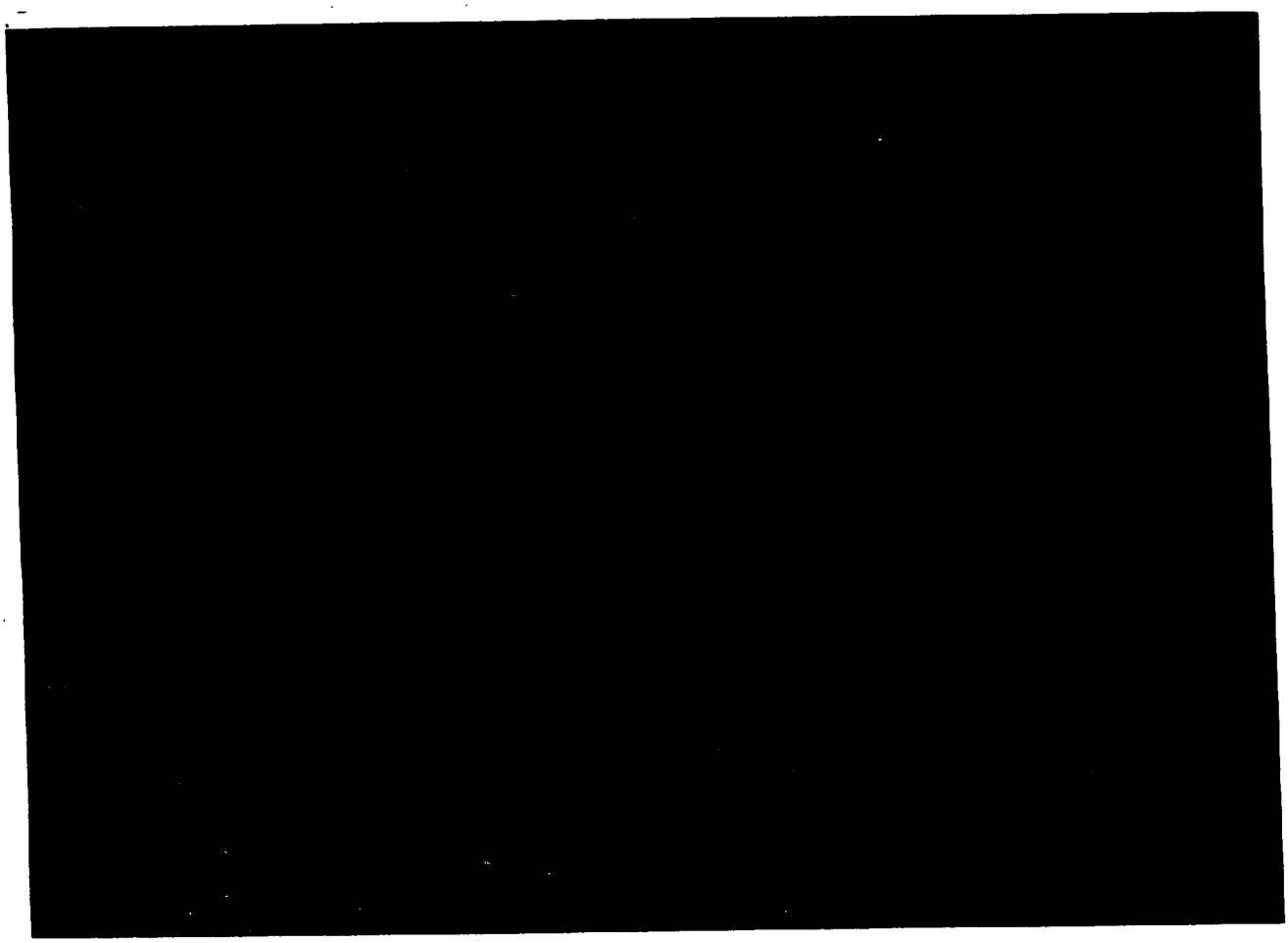


Fig. 126. The same larva four days later; August 17, 1947



Fig. 127. The wound healing; August 24, 1947



Fig. 128. Mature larva beginning to emerge; August 29, 1947



Fig. 129. Fresh wound left by larva; August 26, 1947

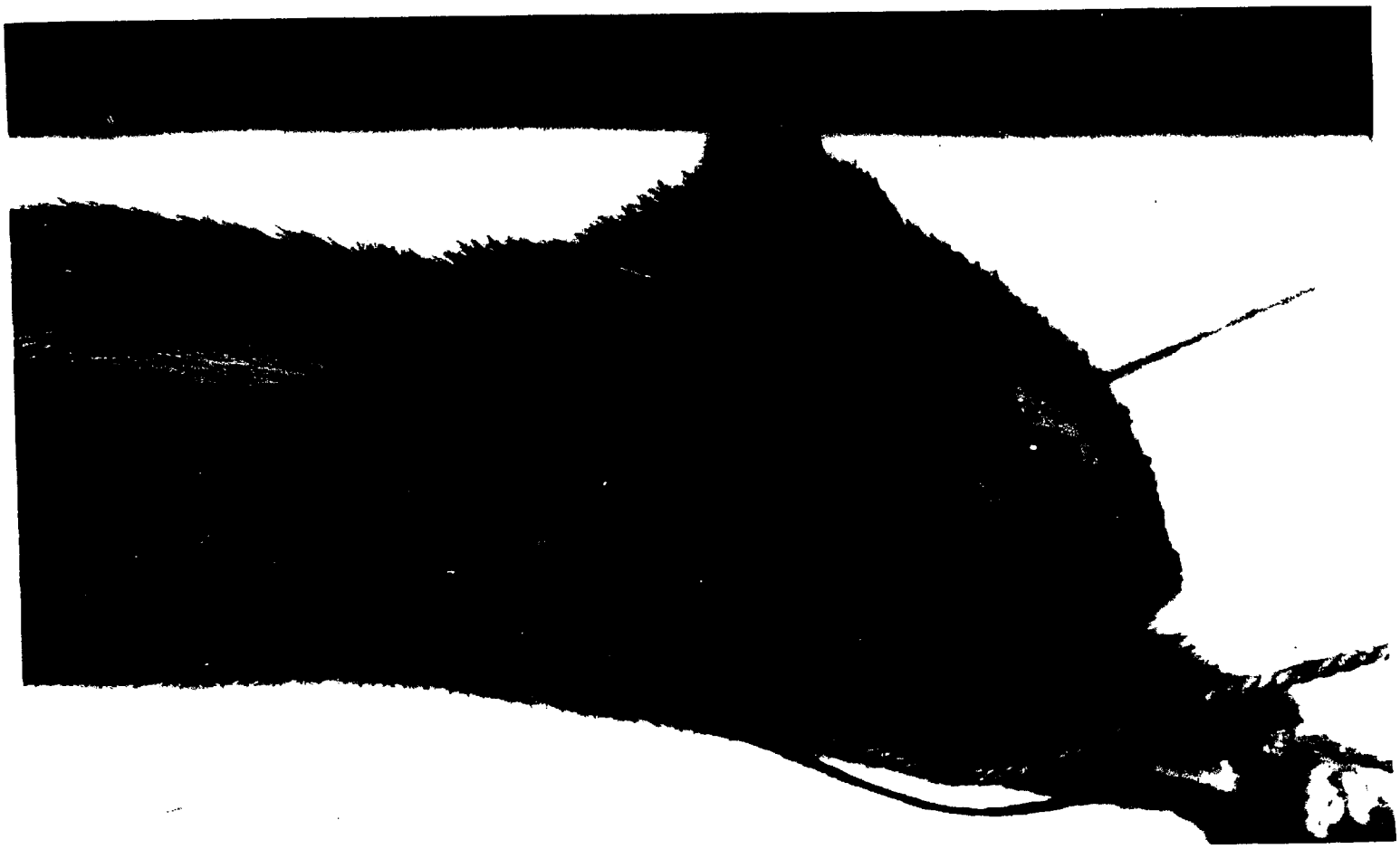


Fig. 130. Healed wound; September 12, 1947



Fig. 131. Dorsal view of chipmunk with mature Cuterebra larvae; August 21, 1947

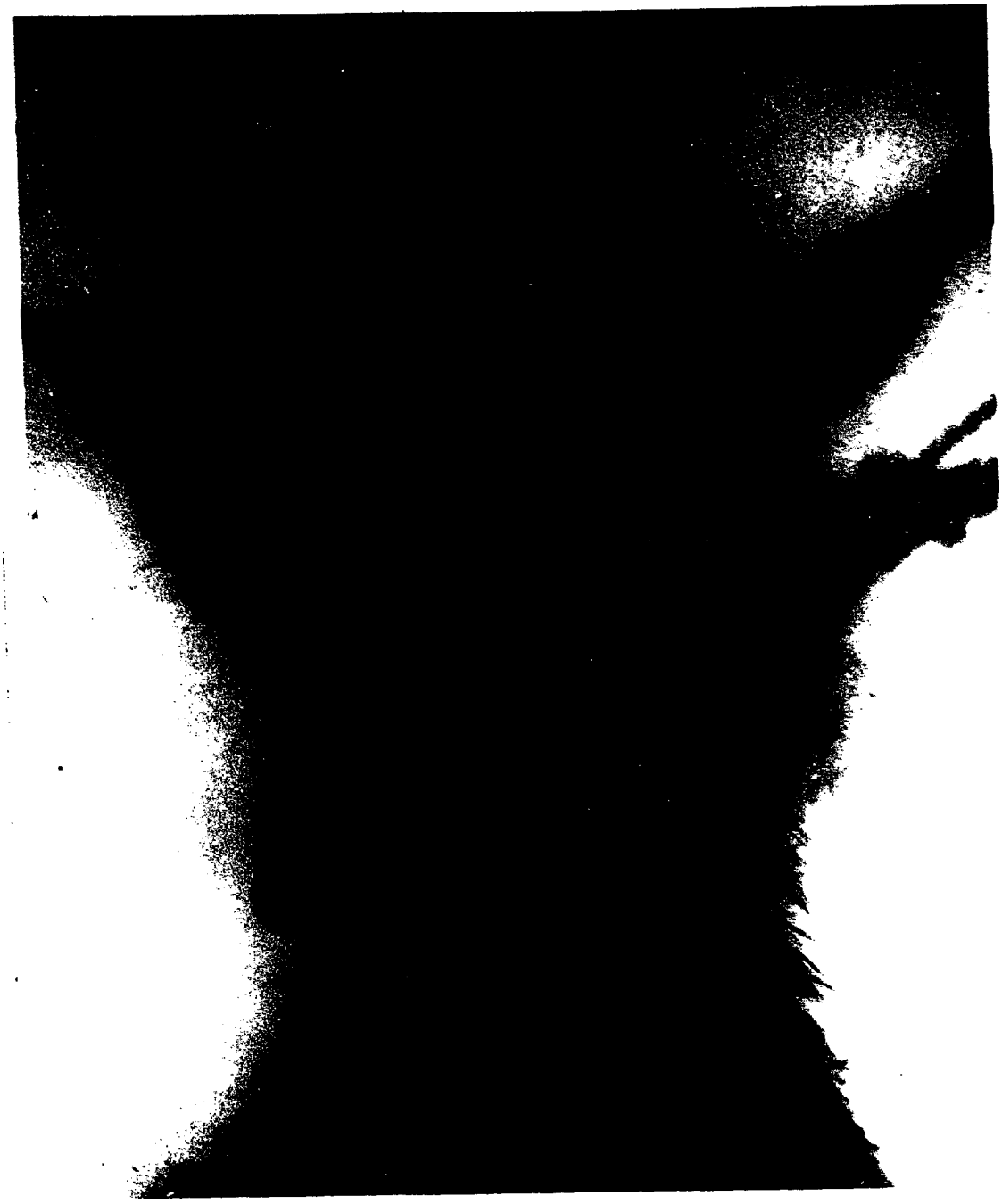


Fig. 132. Ventral view of the same individual; the larvae have enlarged the breathing hole and begun to emerge



Fig. 133. Two mature larvae beginning to emerge; the skin of the chipmunk is smooth and black; August 21, 1947

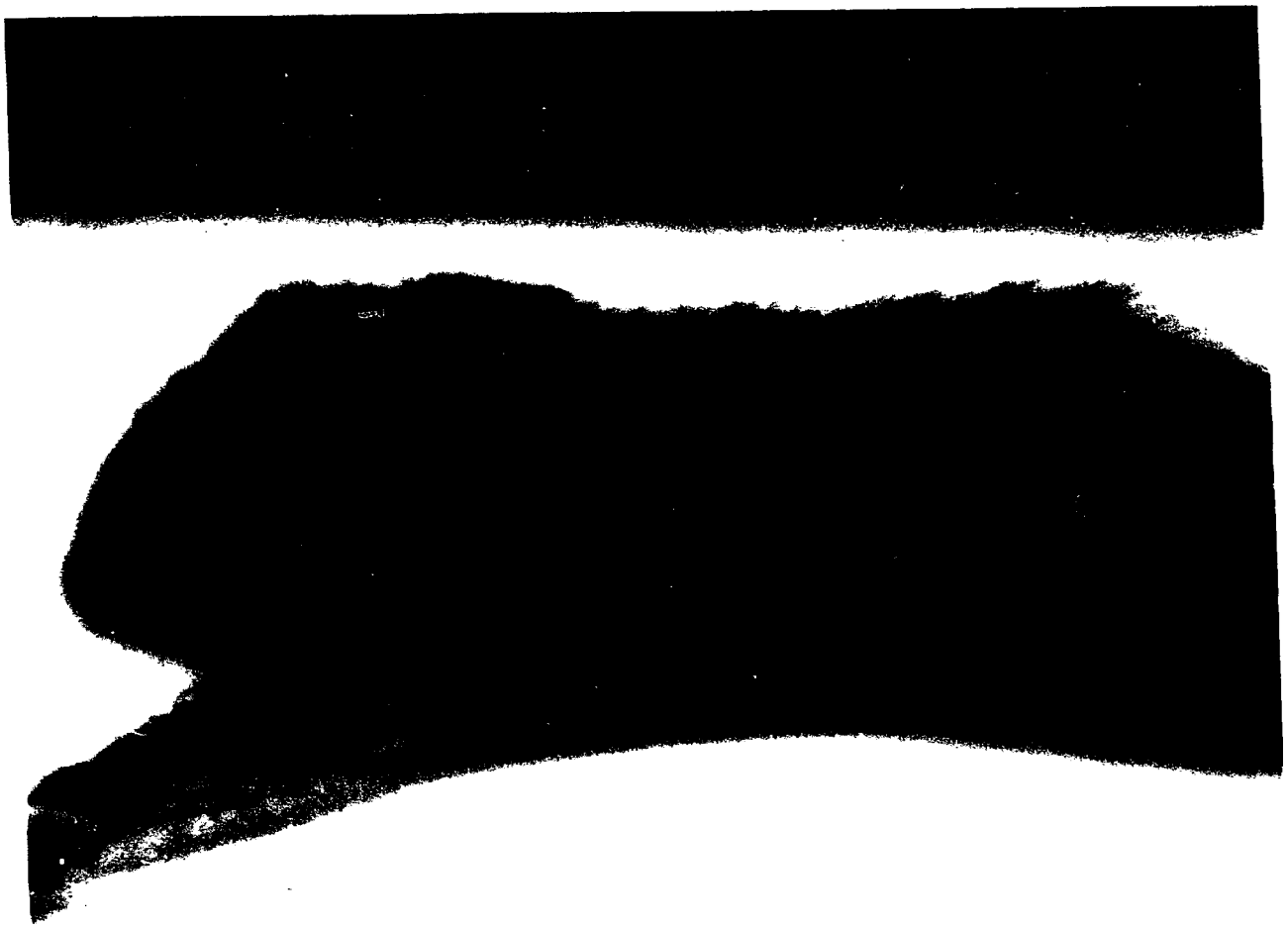


Fig. 134. The same individual three days later, after the larvae had left; August 24, 1947

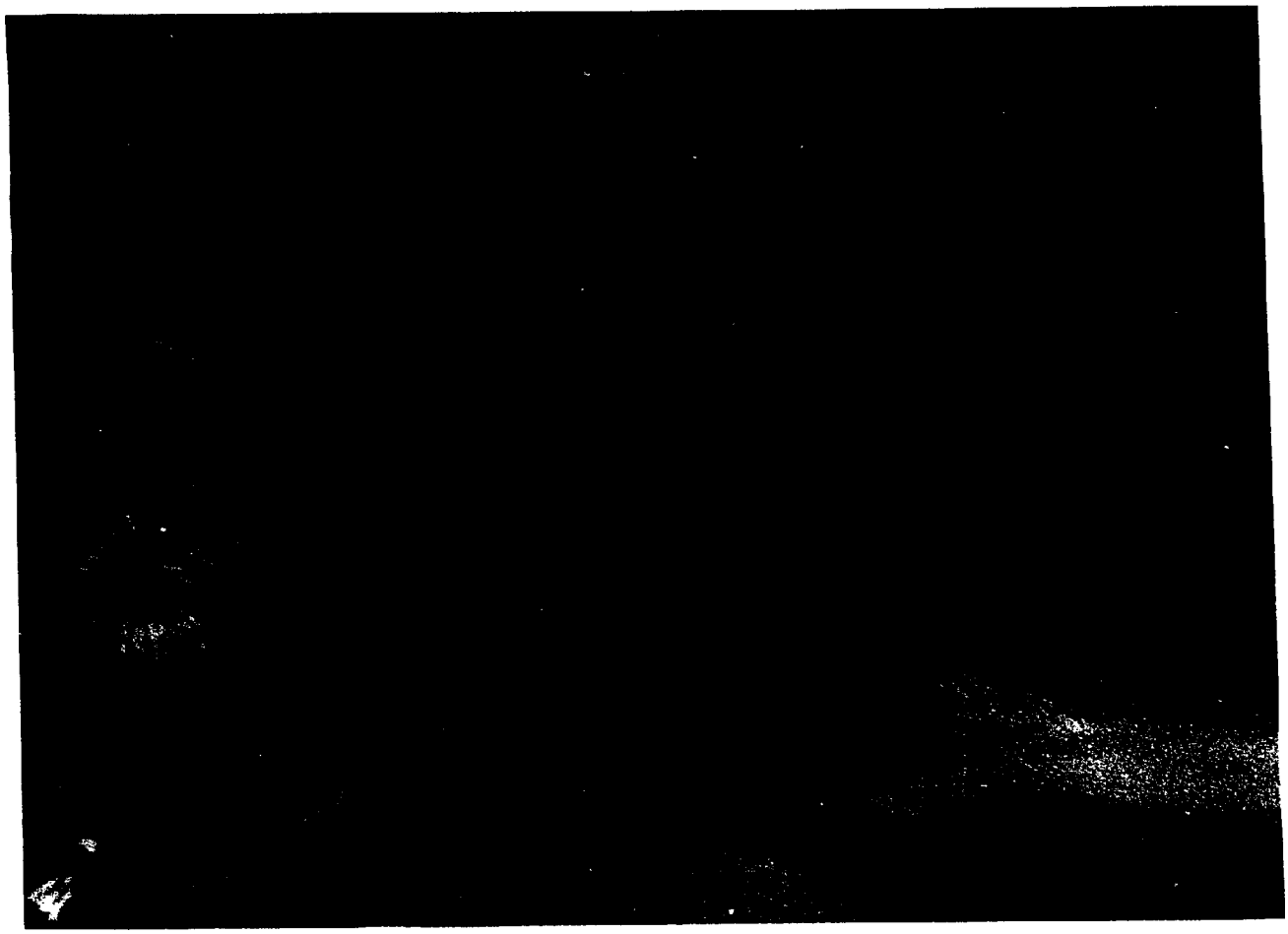


Fig. 135. Chipmunk with partly healed bot wound on left side; August 26, 1947

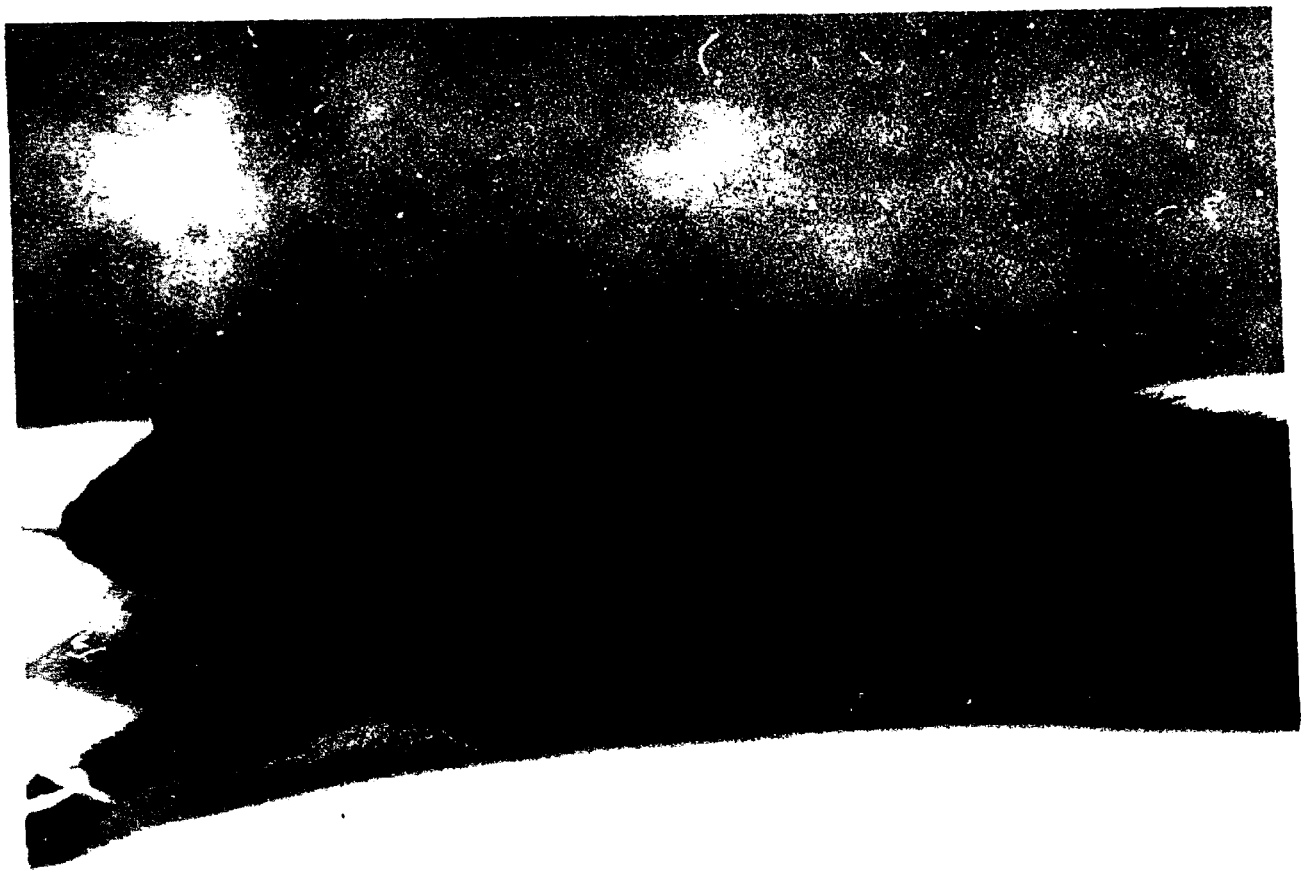


Fig. 136. The same individual with healed wound; September 12, 1947



Fig. 137. Pupa and three immature larvae of Cuterebra from chipmunks

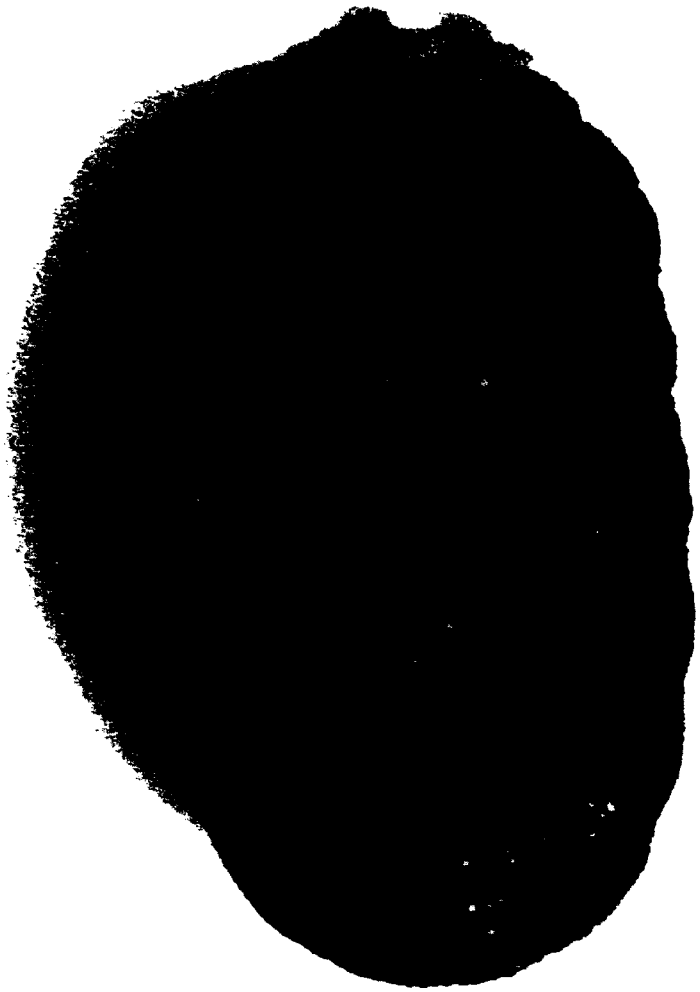


Fig. 138. Dorsal view of the pupa case of botfly



Fig. 139. A botfly, Cuterebra, and its puparium; dorsal views



METRIC

Fig. 140. Botfly, whose larvae parasitize chipmunks



Fig. 141. Puparium of a botfly; lateral view



Fig. 142. Chipmunk with the skin of one foot in a diseased condition



Fig. 143. Chipmunk with bare patch on side of its nose



Fig. 144. Three-legged chipmunk

VOICE

The voices of chipmunks are spirited and varied, in keeping with their lively natures. It is difficult to represent these calls, but a general idea of them may be conveyed by phonetic symbols and by a description of the notes and the situations in which they are used. Attempts to describe the voices of various species of Eutamias have been made by Grinnell and Storer (1924: 177-196), Gordon (1943: 58-59), Miller (1944: 87-89), and Larrison (1946: 23-30).

I could distinguish at least ten different calls:

(1) One of the commonest was a sharp, accented note which I usually recorded as kwst. (Several other notations were kst, kwist, kss). This call expressed mild alarm or excitement and may have served as a warning to other chipmunks. They uttered this sound in traps when jays flew overhead and when I approached or gave them peanuts.

(2) Another call which they frequently used was a low, mellow note which sounded like a robin and which I described as pert (and as pwert, pyert, or whirt). A chipmunk is able to make this sound with full cheek pouches. Individuals which had just been released and were running away gave this call. It was occasionally uttered after a hawk or jay had passed over. One chipmunk expressed his excitement with this call when he found a melon rind. His chirps were recorded as pert pert pert-pert pert, and as kwst pert kwst. With each note his tail waved forward or backward. There was usually one

note per second, but occasionally two in rapid succession. The calls may be repeated for several minutes at a time.

(3) One of the single notes sounded like peer. At late dusk one evening a chipmunk monotonously repeated this call at the rate of one per second for about eight minutes.

(4) Another single note sounded like kyuk or pyuk. It apparently expressed mild excitement and was uttered once by a chipmunk exploring the inside of my cabin.

(5) I have heard chipmunks reply to distress notes of an individual held in my hand with a sharp whit. The note was repeated at the rate of two per second.

(6) Most chipmunks were vocal when handled, some expressing fear and others putting up a fight. I often heard them give a kind of growl, a throaty, gutteral sound that seemed to express anger. My field notations were: ugheeee, rrgh, ghr, and rrrr. Males fighting in a cage also made these buzzing sounds, as did a female repulsing a male that was apparently trying to copulate with her. Animals held in my hand uttered various sounds, some of them like gheek, guik, eeik, gsik, and eeuk. One of them was a high, thin eee sound that ended with a sharp ik.

(7) Frightened chipmunks sometimes uttered a long quavered or trilled note, ksr-r-r-r-r, that faded out in pitch and volume. After the first strong accent the sound was often preceded or followed by a sharp kwst alarm note. Other spellings for this sound were tsr-r-r-r, sr-r-r-r, tseeerr, pseeerr, and pr-r-r-r-r.

(8) Great fear or distress was expressed by a series of five or six descending notes which sounded like tseeeoo seeoo seeoo seeoo seeoo.

The first note was the highest and loudest, and each of the others was lower in pitch and volume. Chipmunks made these sounds, which were answered occasionally by other animals in the vicinity, in my hand, in traps, and in a handling bag. The mouth was held open during the call, and a movement of the lower jaw accompanied each note.

(9) A plaintive, descending e-e-e-e-e also expressed fear. Various other notes, which I called squeals for lack of a better word, were eeuh, ueee, eeeukeee, and eee. Once when a ground squirrel chased a chipmunk I heard the latter give a series of thin, high notes that sounded somewhat like tsee tsee tsee.

(10) One of the commonest alarms was a series of four to six accented notes, ks ks ks ks ks. Other representations were ksee ksee ksee ksee and kus kus kus kus kus. The first note of the group was almost explosive, while the others usually diminished in volume and vigor. When birds of prey such as the goshawk, Cooper's hawk, sharp-shinned hawk, and western red-tailed hawk appeared on the scene, chipmunks in the vicinity invariably gave warning. A vulture and a sooty grouse also evoked this alarm and I often heard it when Steller's jays flew over. It seems strange that jays should frighten chipmunks. However, the element of surprise as well as the shape and manner of flight of these birds, may be important.

Excited chipmunks running for cover sometimes uttered a rapid series of notes which, instead of dying out, ended on the loudest and most sharply accented sound of the group. At times their chitterings were highly variable in pitch, volume, and tempo.

RELATIONSHIP OF THE CHIPMUNK AND GROUND SQUIRREL

One rarely finds two animals which so nearly occupy the same niche as do the chipmunk (Eutamias amoenus affinis) and the golden mantled ground squirrel (Citellus lateralis saturatus) in Washington. According to Grinnell (1928), "No two species in the same general territory can occupy for long identically the same ecologic niche. If, by chance, the vagaries of distributional movement result in introducing into a new territory the ecologic homologue of a species already endemic in that territory, competitive displacement of one of the species by the other is bound to take place. Perfect balance is inconceivable." There are differences between the chipmunk and ground squirrel, to be sure, but their habitat requirements appear to be almost identical and their behavior similar. Therefore, a comparison of the two species may be of some interest.

In the first place, the geographic boundaries of their ranges on the eastern slopes of the Cascade Mountains are practically the same. At Rocky Flat these animals were common in open pine woods and seldom ventured far from the cover of trees and logs. Although they usually avoided barren, rocky ground and treeless areas, they occasionally ranged out into the sagebrush forty or fifty feet from the edge of the forest. Both chipmunks and ground squirrels frequented a thickly wooded northern slope (Plot 4), which bordered one side of my study area; this strip of forest was no more than a few hundred feet wide and was bounded by the more open pine woods which seemed to be preferred.

The foods of the two are also similar. The many items mentioned in the literature on these same animals found in other parts of western United States have been summarized by Gordon (1943: 25-28) and Howell (1929: 4-11 and 1938: 31-33). At Rocky Flat they had dandelion heads, corms, fungi, the seeds of pine trees and lupines, and probably a good many other foods in common.

Both animals forage and spend most of their time on the ground, but the two species differ in the amount of arboreal activity. Particularly in the fall, chipmunks climb trees fairly often, ascending even the tallest of pines and firs for seeds. Instead of obtaining the seeds by climbing trees, the ground squirrels find them in cones dropped to the earth by pine squirrels. On several occasions I have seen the ground squirrels at heights of 10 or 15 feet in bushes and conifers, but they are not nearly as agile or prone to climb as chipmunks. Thus, in respect to arboreal habits the former has a more restricted habitat.

It is obvious that a mere list of foods eaten by each species does not necessarily give us an indication of the amount of competition for them. While both animals will eat conifer seeds, the chipmunk has the ability not shared by the ground squirrel of climbing to obtain them. Thus, the chipmunk probably has access to seeds before they are available to the ground squirrel and he has them in greater abundance. It may be that there are other differences in feeding habits which I have not observed.

The breeding seasons of both species occur at the same time. Young ground squirrels first appeared on June 4, 1947, and young chipmunks, only four days later. Females have only one litter each year numbering about four to six on the average.

Chipmunks were more abundant than ground squirrels at Rocky Flat, but my data on the numbers of the latter may be inadequate because my traps were somewhat small for them. The total catch of each species, 577 chipmunks and sixty-seven ground squirrels, gives a rough idea of their relative abundance in that locality.

Gordon (1943: 43-44) gives populations for the two species at one camp in Colorado and two in Oregon. His estimates of numbers of Eutamias and Citellus lateralis were, respectively, six and two and a half, one and five, and five and five.

The home ranges of the two are about equal in size, but here again we need more information on the ground squirrels.

Apparently there is little conflict between the two species. I have seen chipmunks approach to within an inch or two of ground squirrels, seemingly without fear. Even breeding females of both species are quite tolerant of one another. For example, two of them raised families in dens only 30 feet apart. Their burrows were in identical situations except for the fact that the chipmunk den was beneath a log, while that of the ground squirrel was in the open. Thirteen other chipmunk burrows, as well as many ground squirrel dens, were on open ground, unprotected by logs, rocks, or bushes.

There is a noticeable difference between the two species in respect to temperament. It would seem that the chipmunk seldom makes a slow movement; his actions are almost always quick and nervous. The ground squirrel, on the other hand, moves more deliberately and in general is more phlegmatic. Often he will remain motionless on a stump or some other look-out point for a considerable length of time.

In May, 1947, I witnessed an incident that may illustrate this difference in temperament between the two animals. A goshawk flew over, frightening all chipmunks and ground squirrels to cover. The chipmunks reappeared a few seconds later, but ground squirrels did not come out for several minutes.

In the fall chipmunks remain active several weeks longer than the ground squirrels, disappearing in late October or early November. The ground squirrel goes into hibernation by the middle of October after he acquires a large amount of fat, but the chipmunk accumulates none and apparently relies on stored food for sustenance during the winter months.

SUMMARY

This investigation was carried out in the yellow pine belt of the Cascade Mountains in Yakima County, Washington, during the summers of 1946 and 1947. The total area trapped was 42.3 acres. The traps were evenly spaced about eighty-three feet apart. I marked chipmunks by clipping off certain toes and by punching holes in the center of the ears.

I used Burt's (1940) method of delimiting home ranges. Using only those ranges which appeared to be complete, I plotted curves showing how much of the complete range was revealed by different numbers of captures. Twelve or thirteen captures were required for females, while twenty captures were needed to show the complete ranges of males.

The average range for all females was 2.25 acres in 1946 and 2.36 in 1947. Males averaged 3.80 in 1947. By calculating areas and greatest diameters of seasonal ranges, I found that the period of greatest movement is in the summer, as contrasted with the spring and fall.

By the use of dyes, I marked certain animals for observation and plotted their movements against their trap-revealed home ranges. In only three out of twenty-four observations did a chipmunk travel outside of its trap range.

Defense of territory, at least by breeding females, seems to be confined to the area immediately surrounding the den, but may vary from one individual to another.

I live-trapped a total of 577 chipmunks in the two years. Populations per acre were calculated in several ways. Using Dice's (1938) border zone method, various combinations were tried. The trapping days were grouped into both short and long periods. In every case the longer periods produced figures which were larger by an average of 1.31 per acre. The data was also calculated using small, medium, and large areas. The only significant difference found was that between the figures yielded by the small area compared with those yielded by the large area. The former population figure was decidedly larger than the latter. When sexes were pooled or calculated separately, there was no significant difference, the method of pooling the sexes giving figures that were larger by an average of only 0.12 per acre.

In order to test homing instinct, I released chipmunks a total of thirty-nine times. Considering all distances, 66 per cent returned home. One out of three returned from the greatest distance, one mile. A much greater percentage of the males returned than females.

The breeding cycle is as follows: mating probably occurs in April, the young are born in late May and early June, first appear above ground in June, but do not breed until the following spring. There is only one litter per year. The average number of young per litter is between four and six.

Two litters of young were raised in captivity. Average weight at birth was 2.64 grams. Their average daily weight increment was 0.47 grams. The general appearance of an adult was attained at about six weeks.

I excavated fourteen dens during the course of the study. The average length of a burrow was 27 inches and it had only one entrance. Winter dens had branches that were probably made when the chipmunk plugged the entrance from within for winter.

The favorite nest materials were grasses, pappi, feathers, lichens, and cotton from my traps.

Winter stores consisted mostly of seeds of the following plants: Carex, Collinsia, Phacelia, and Pseudotsuga taxifolia, but there was considerable variety.

I observed chipmunks eating the following foods most often: Achillea millefolium, Cirsium lanceolatum, Deschampsia elongata, Gilia gracilis, Penstemon, Phacelia heterophylla, Pinus ponderosa, Polygonum, and Basidiomycetous tubers.

During the winter chipmunks probably alternate between sleeping and feeding from their food stores. By the middle of November most chipmunks are underground.

Weights of 60 grams or more usually indicated pregnancy. Adult, non-breeding females averaged about 50.0 grams, while adult males averaged 47.4 grams. In both young and adults the females had significantly greater weights than the males.

In 1946, twenty-three per cent of the chipmunks were parasitized by the botfly, Cuterebra. Only about nine per cent were afflicted in 1947. Other parasites were fleas, ticks, mites, lice, and tapeworms.

Chipmunks can make quite a number of different calls. Mild alarm or excitement was expressed by kwst or pert. Fear or distress was indicated by ksr-r-r-r-r or tseeeoo seeoo seeoo seeoo seeoo. Many other notes were used under various circumstances.

The chipmunk, Eutamias amoenus affinis, and the ground squirrel, Citellus lateralis saturatus, are very similar in many ways--geographic boundaries of their ranges, habitat, food, breeding habits, and size of home ranges. The main differences are in temperament and the fact that chipmunks are more arboreal. Also, ground squirrels store up fat for the winter, while chipmunks do not.

APPENDIX A

WEATHER DATA TAKEN AT ROCKY FLAT, YAKIMA COUNTY, WASH.

(July 26–Nov. 14, 1947)

Date	Temperatures 0700	1200	1800	Min.	Max.	Remarks
July 26	45 (730)	56	...	45	59	Fog, light rain, AM
" 27	58 (800)	62	53 (800)	46	65	
" 28	50 (700)	63	57	47	65	
" 29	50	67	65	36	77	Clear
" 30	46 (600)	75	72	43	78	Partly overcast
" 31	...	63	60	52	73	Cloudy in AM; clear PM
Averages				44.8	69.5	
Aug. 1	...	78	70 (700)	41	82	
" 2	45	85	82 (500)	44	88	
" 3	67 (730)	81	60 (800)	52	85	Rain. Partly cloudy PM
" 4	57 (800)	71	51 (1000)	50	75	Clear, breeze in AM
" 5	46 (730)	77 (100)	66	36	78	
" 6	52 (730)	76	...	38	79	
" 7	55	...	...	50	80	
" 8	50	66	57	46	70	Partly cloudy, strong wind
" 9	51	66	60	42	68	Clear. Strong winds
" 10	55 (830)	70	...	33	76	
" 11	59 (800)	68	56 (630)	53	71	
" 12	50	67	68	42	79	
" 13	50	78	72	40	84	
" 14	52	83	69 (630)	40	84	
" 15	60	78 (300)	58	53	75	
" 16	52	...	67 (500)	50	71	
" 17	65 (900)	78 (100)	53 (1000)	45	81	
" 18	51	...	59	44	75	
" 19	42 (800)	65	57 (700)	30	73	
" 20	44	59	...	40	70	
" 21	51 (800)	65	53 (700)	39	69	
" 22	49	...	52 (700)	46	62	Partly overcast
" 23	48	66	66	44	70	
" 24	60 (800)	68	67	38	72	
" 25	52 (800)	78	...	40	80	Clear
" 26	61 (900)	77	62 (730)	40	84	Overcast AM, clear PM
" 27	43	80 (145)	63	41	82	Clear, hot
" 28	63 (845)	75 (230)	53 (1000)	48	78	Overcast, calm AM
" 29	49	76	...	42	76	Partly cloudy AM, clear PM
" 30	55 (900)	60	56	56	65	
" 31	47 (830)	72 (100)	...	36	73	
Averages				43.2	76.0	

Date	Temperatures 0700	1200	1900	Min.	Max.	Remarks
Sept. 1	50	74	71	43	79	
" 2	59	75	64	59	78	Cloudy AM, clear PM
" 3	45 (830)	75	62	45	77	Clear, calm
" 4	51	70	...	23	70	
" 5	50 (930)	63	55	50	71	Clear, calm
" 6	43	53 (230)	48	33	71	Cloudy AM, light rain PM
" 7	48 (815)	57	53	33	71	Rain all day
" 8	45	...	...	36	59	Cloudy, showers
" 9	45	54	46	45	57	Clear AM, showers PM
" 10	50 (930)	...	53	36	67	Clear, calm
" 11	39	69	...	36	67	
" 12	40	75	62	40		Clear, wind in PM
" 13	45	59	51	44	68	Clear, breeze
" 14	53 (900)	66	...	33	72	
" 15	45	71	...	33	75	
" 16	45 (745)	53	44	...	56	
" 17	40 (730)	45	41	35	49	Rain
" 18	36	...	46	32	52	Cloudy
" 19	35 (615)	...	...	...	...	
" 20	...	...	...	...	...	
" 21	...	...	63	...	77	
" 22	53 (800)	76	67	49	79	
" 23	49	74	60	49	81	
" 24	49	75	57 (800)	45	77	
" 25	...	57	54 (600)	50	62	Cloudy, light rain
" 26	...	...	59 (600)	48	73	
" 27	54 (800)	...	...	...	70	
" 28	...	...	...	...	...	
" 29	...	68	50 (900)	...	72	Clear, warm
" 30	45	59	55	42	70	Clear, warm
				41.0	68.5	

Averages

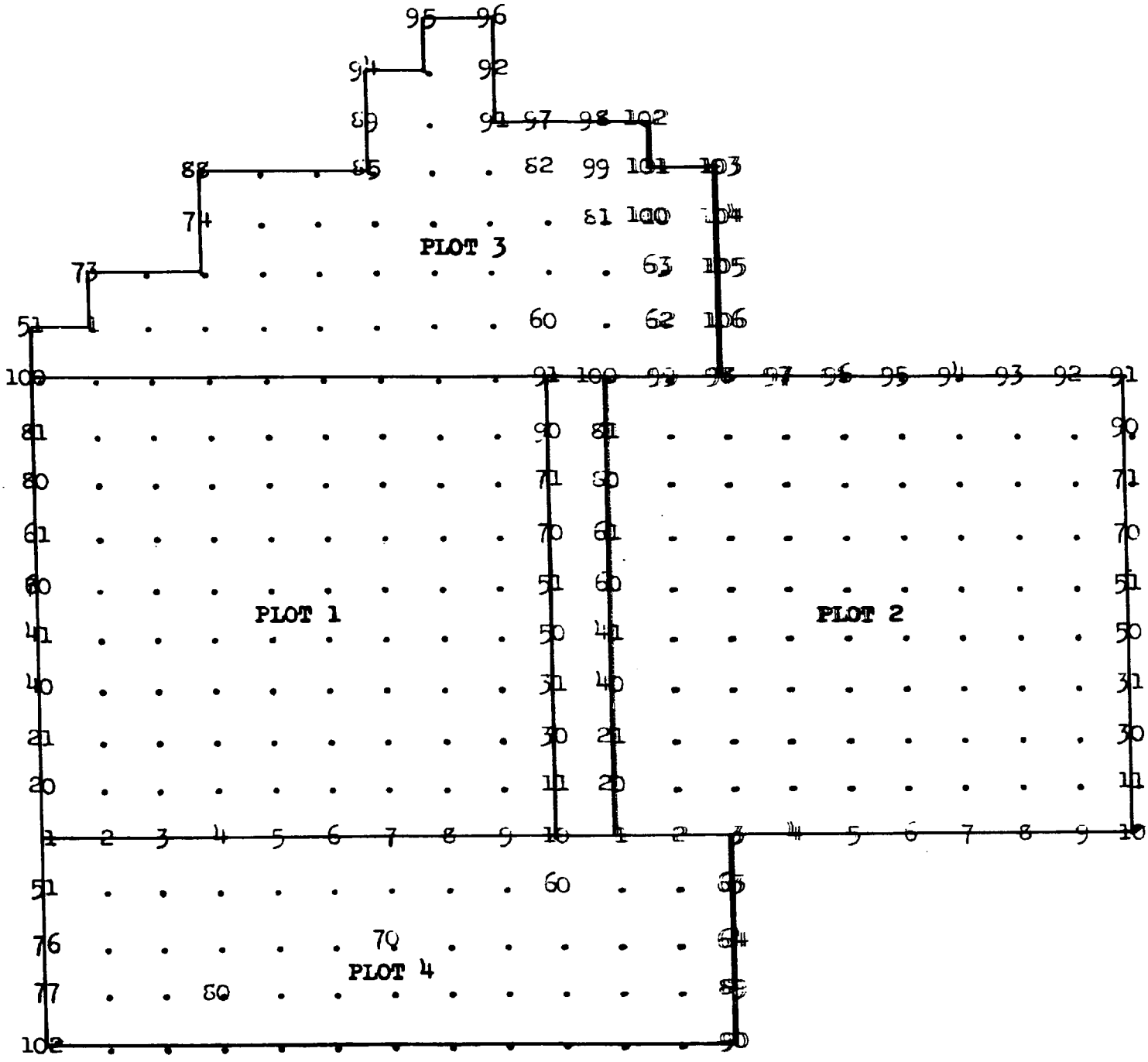
Oct. 1	50 (730)	62 (130)	52	47	53	Cloudy, showers 6 PM
" 2	47 (500)	61 (200)	56 (730)	46	52	Cloudy
" 3	50	65	48 (1000)	48	67	
" 4	47	52	45	43	67	
" 5	34	53 (200)	44	32	53	
" 6	29	...	43 (650)	23	54	High overcast, calm
" 7	40	...	40	34	47	Cloudy AM, rain PM
" 8	35	47	47	32	50	Cloudy AM, rain in eve.
" 9	43	47	44	40	47	Light rain all day
" 10	32	43	40	30	44	Intermittent showers
" 11	32	...	...	31	63	
" 12	...	...	...	...	...	
" 13	...	55	46	...	...	
" 14	33	49	44	29	50	
" 15	43	49	43	40	49	Light rain AM

Date	Temperatures 0700	1200	1900	Min.	Max.	Remarks
Oct. 16	39	45	37	35	47	Rain, intermittent
" 17	32	40	38	30	43	Rain AM, rain and fog PM
" 18	...	...	...	...	...	Rain in AM
" 19	...	...	...	...	...	
" 20	...	...	...	...	...	
" 21	...	43	...	28	44	Clear
" 22	33	...	33	27	39	Clouds, showers
" 23	32	...	35	32	46	Fog, then clear
" 24	...	45 (230)	37	30	45	
" 25	32	47 (200)	46 (300)	31	48	Clear
" 26	...	...	...	...	...	
" 27	...	...	37	30	49	Clear, partly cloudy
" 28	35 (830)	44	34	31	45	Cloudy, then clear
" 29	36 (800)	...	36	30	38	Rain and fog all day
" 30	32 (730)	40	38	29	42	Fog, drizzle
" 31	37 (745)	45	43	35	45	Rain and clouds AM
Averages				33.7	48.5	
Nov. 1	38	...	...	37	...	Partly cloudy
" 2	...	...	...	...	...	
" 3	...	...	...	...	...	
" 4	...	...	...	...	...	
" 5	...	...	31	...	...	Snow, clouds
" 6	...	41	37	28	47	Clear and cold
" 7	39 (800)	46	32	35	49	Chinook wind, partly cloudy
" 8	34 (730)	...	33	32	44	Snow, clearing PM
" 9	33 (800)	35	34	28	37	Cloudy, wind
" 10	40 (845)	...	32	30	49	Snow, 2" in eve.
" 11	31 (900)	32 (330)	28 (800)	27	37	
" 12	33 (800)	...	32	23	37	Cloudy
" 13	31 (830)	34	25 (900)	25	37	Snow at noon
" 14	20 (730)	34	29 (300)	17	35	Snow
" 15	...	30	...	...	...	
Averages				28.2	41.3	

APPENDIX B

DIAGRAM OF STUDY AREA SHOWING TRAP NUMBERS IN EACH PLOT

(DISTANCE BETWEEN TRAPS IS 83 FT.)



APPENDIX C

LIST OF PLANTS COLLECTED AT ROCKY FLAT, 1947

Trees

Pinus ponderosa Dougl. Western yellow pine.

Larix occidentalis Nutt. Western larch.

Pseudotsuga taxifolia (Poir.) Britt. Douglas fir.

Abies grandis Lindl. Grand fir.

Populus tremuloides Michx. Aspen.

Salix sp. Willow.

Shrubs

Spirea lucida Dougl. Spirea.

Ceanothus sanguineus Pursh. Buckbrush.

Arctostaphylos nevadensis Gray. Manzanita.

Apocynum pumilum (Gray) Greene. Dwarf dogbane.

Symphoricarpos albus (L.) Blake. Snowberry.

Herbs

Bromus carinatus H. & A. California brome-grass.

B. tectorum L. Downy brome-grass.

Poa fendleriana (Stend.) Vasey. (?) Bluegrass.

P. secunda Presl. Sandberg's bluegrass.

P. nevadensis Vasey. Nevada bluegrass.

P. juncifolia Scribn. Alkali bluegrass.

Sitanion Hystrix (Nutt.) J. G. Sm. Bottle-brush squirrel-tail.

Deschampsia elongata (Hook.) Munro. Slender hair-grass.

Calamagrostis sp. Pine grass.

Stipa Lemmoni (Vas.) Scribn. Lemmon's stipa.

Carex sp. Sedge.

Allium Nevii Wats. Nevin's onion.

Camassia Quamash (Pursh.) Wats. Common Camas.

Fritillaria pudica (Pursh.) Spreng. Yellow-bells.

Erythronium grandiflorum Pursh. Yellow adder's tongue.

Sisyrinchum Douglasii Dietr. Purple-eyed grass.

Corallorihiza sp. Coral-root.

Arceuthobium campylopodum Engelm. Yellow leafless mistletoe.

Polygonum ramosissimum Michx. (?)

P. Douglasii Greene. Douglas' knotweed.

P. aviculare L. Common knotweed.

Eriogonum Thymoides Benth. Thyme-leaved eriogonum.

E. compositum Dougl. Heart-leaved eriogonum.

E. Douglasii Benth. Douglas' eriogonum.

Chenopodium album L. Pigweed.

Montia perfoliata (Donn.) How. Miner's lettuce.

Arenaria macrophylla Hook. Large-leaved sandwort.

Stellaria Jamesiana Torr. Sticky chickweed.

Silene oregana Wats. Oregon campion.

Ranunculus glaberrimus Hook. Sagebrush larkspur.

Delphinium megacarpum Nels. & Macbr. Sagebrush larkspur.

Aconitum columbianum Nutt. Monkshood.

Berberis Aquifolium Pursh. Oregon grape.

Arabis Holboellii Hornem. Holboell's rock cress.

Sedum Douglasii Hook. Douglas' stonecrop.

Lithophragma bulbiforum Rydb. Slender fringe-cup.

Holodiscus discolor (Pursh.) Maxim. Ocean spray.

Potentilla flabelliformis Lehm. Slender-toothed cinquefoil.

Rosa sp. Rose.

Lupinus sericeus Pursh. Silky lupine.

Trifolium macrocephalum (Pursh.) Poir. Big-headed clover.

Lathyrus pauciflorus Fern. Few-flowered pea.

Viola Beckwithii T. & G. Sagebrush violet.

Epilobium paniculatum Nutt. Tall annual willow-herb.

Gayophytum diffusum T. & G. Spreading gayophytum.

Lomatium triternatum (Pursh.) C. & R. Narrow-leaved desert parsley.

Perideridia Gairdneri (H. & A.) Math. Western false caraway.

Dodecatheon conjugens Greene. Desert shooting star.

Phlox whitedi E. Nelson.

Gilia aggregata (Pursh.) Spreng. Scarlet gilia.

G. gracilis (Dougl.) Hook.

Collomia linearis Nutt. Narrow-leaved collomia.

Hydrophyllum capitatum Dougl. Dwarf waterleaf.

Phacelia heterophylla Pursh. Varied-leaved phacelia.

P. procera Gray. Tall phacelia.

Hesperochiron pumilis (Dougl.) Porter. Dwarf hesperochiron.

Hackelia floribunda (Lehm.) Johnst. Many-flowered tickweed.

Mertensia umbratillus Greenm. Shade lungwort.

Agastache urticifolia (Benth.) Rydb. Nettle-leaved giant hyssop.

Verbascum Thapsus L. Mullein.

Collinsia parviflora Dougl. Small-flowered collinsia.

Penstemon attenuatus Dougl. Taper-leaved penstemon.

Galium Aparine L. Cleavers.

Aplopappus stenophyllus Gray. Narrow-leaved aplopappus.

Erigeron poliospermus Gray. Cushion erigeron.

E. linearis (Hook.) Piper. Linear-leaved erigeron.

Erigeron peucephyllus Gray. Yellow erigeron.

Gnaphalium sp.

Antennaria rosea Greene. Rosy everlasting.

Balsamorhiza sagittata (Pursh.) Nutt. Arrow-leaved balsamroot.

Wyethia amplexicaulis Nutt. Smooth dwarf sunflower.

Madia glomerata Hook. Stinking tarweed.

Eriophyllum lanatum Var. integrifolium (Hook.) Smiley. Woolly sunflower.

Achillea millefolium sens. lat (A. Lanulosa Nutt.). Yarrow.

Artemisia tridentata Nutt. Sagebrush.

Cacaliopsis Nardosmia Gray. Silver crown.

Arnica cordifolia Hook. Heart-leaved arnica.

A. fulgens Pursh. Shining arnica.

Senecio integerrimus Nutt. Tall western senecio.

Cirsium lanceolatum (L.) Scop. Common Thistle.

Taraxacum officionale (L.) Weber. Dandelion.

Hieracium albiflorum Hook. White-leaved hawksweed.

H. cynoglossoides Arv.-Touv. Houndstongue hawkweed.

H. glomerata Hook.

Crepis barbigera Leib. Bearded Hawksbeard.

(Peck's A Manual of the Higher Plants of Oregon has been followed in most cases.)

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