MISCELLANEOUS PUBLICATIONS
MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN, NO. 103

Life History and Ecology of the Chipmunk, *Eutamias amoenus*, in Eastern Washington

BY
HAROLD E. BROADBOOKS

ANN ARBOR
MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN
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CONTENTS

ILLUSTRATIONS

(Plates I-III follow page 43)

Plate

FIGURES IN THE TEXT

LIFE HISTORY AND ECOLOGY OF THE CHIPMUNK, *EUTAMIAS AMOENUS*, IN EASTERN WASHINGTON*

INTRODUCTION

IN the pine forests of eastern Washington, the chipmunk, *Eutamias amoenus*, is an ideal mammal for field study. It is easily captured, often abundant, and diurnal in habit. My primary goal was to learn something about the home ranges and populations of this species, a program which involved live-trapping over two field seasons in 1946 and 1947. In addition, however, I also investigated general behavior and ecology. The material on home ranges, territoriality, and populations will be treated elsewhere. The present paper is limited to other aspects of the chipmunk's behavior, life history, and ecology.

Acknowledgments

The stimulating field studies on small mammals by William H. Burt at the Edwin S. George Reserve of the University of Michigan probably had much to do with my choice of problem. I am especially grateful to him for his generous help and suggestions. The helpful criticisms of Lee R. Dice, William C. Steere, Alfred H. Stockard, the late Josselyn Van Tyne, Lewis E. Wehmeyer, Frederick H. Test, and the late Harold Wight were of great benefit. Thanks are also due Earl J. Larrison, who suggested the locality where I did my field work, and to H. G. Cooper, who helped in securing photographs, weather data, and historical information concerning the study area. I am indebted to Emmet T. Hooper for a critical reading of the manuscript and for ideas on dyeing chipmunks and to William D. Fitzwater and Francis C. Evans for useful hints on dyes. My wife has helped me in many ways, but particularly in typing and in the statistical work.

Assistance in identification of materials is gratefully acknowledged as follows: Alexander Martin and Paul G. Russell, seeds from chipmunk stores; Rogers McVaugh, plants; Keith Wagnon, grasses; Curtis W. Sabrosky and Herbert T. Dalmat, flies; Glen M. Kohls, ticks; William L. Jellison, fleas, lice, and ticks; Robert Traub, fleas; A. E. Woodhead, tapeworms. Theodore H. Hubbell gave me general advice dealing with entomological questions and identified insects from chipmunk dens.

Description of the Study Area

Most of the field work was done at Rocky Flat (also called Rocky Prairie), about 16 miles northwest of Naches, Yakima County, Washington. My

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headquarters were at Wenas Cattle Camp at the head of Benton Creek, about 4 miles from the Chinook Pass Highway (U. S. No. 410). The road from the highway to Bald Mountain takes one to Rocky Flat. Wenas Cattle Camp was located in the northwest corner of Section 11, 16 N, 15 E. The altitude at the camp is about 3800 feet.

Rocky Flat is appropriately named for there is an unusual amount of open ground, much of which is covered with volcanic rocks, and the soil is thin. The dominant tree in the area, the yellow pine *(Pinus ponderosa)*, is characteristic of the arid Transition Zone of the eastern slopes of the Cascades. This zone is usually bordered at lower altitudes by grassland and sagebrush. At higher elevations, above the arid Transition Zone, there are mixed forests of larch, hemlock, fir, and pine. All of these forests are part of the montane life belt of the Palusian Biotic Province of Dice (1943). Larrison (1946) subdivides the montane life belt into two sections: the yellow pine and the pine-larch-fir. His discussions of biotic areas and the ecology of the Cascade Mountains (Larrison, 1942, 1946) are particularly applicable to the Rocky Flat area.

The summers at Rocky Flat are dry and warm. Average maximum and minimum monthly temperatures (F.) for 1947 were as follows: July 26-31, 69.5, 44.8; August, 76.0, 43.2; September, 68.5, 41.0; October, 48.5, 33.7; November 1-14, 41.3, 28.2. Snow comes in late October or in November and stays as late as April.

The forest around Rocky Flat was logged in 1942. The selective cut was about 65 per cent of the stand. The woods around the edge of the flat were not as heavily logged as elsewhere and parts of the study area on the west side were undisturbed, while others had been thinned.

Typical vegetation of the area, in addition to the yellow pine, includes such herbs as yarrow, lupine, and pine grass *(Calamagrostis rubescens)*. In all 96 kinds of plants were collected. There were patches of open ground throughout the forest. Chipmunks traveled over these open spaces, but preferred the protection of logs and trees for leisurely foraging. The wide rocky flats to the east of the area served more or less as a barrier to movements of chipmunks in that direction.

A total of 1317 individuals of ten species entered the traps. In order of abundance they were: *Peromyscus maniculatus*, 620; *Eutamias amoenus*, 573; *Citellus lateralis*, 67; *Perognathus parvus*, 45; *Microtus longicaudus*, 7; *Tamiasciurus douglasi*, 1; *Eutamias townsendi*, 1; *Sorex vagrans*, 1; *Neotoma cinerea*, 1; *Thomomys talpoides*, 1. The record of captures does not give accurate estimates of the abundance of such species as pocket gophers *(Thomomys)*, common over the entire area, tree squirrels *(Tamiasciurus)*, usually too large to enter my traps, or shrews *(Sorex)*, which ordinarily would not have been attracted by the bait used.

Methods

Live traps were set in regular grids, each trap about 83 feet from the next one. The total area covered was about 42 acres. This was subdivided into 4 plots, which were trapped in sequence. I visited the traps in the

morning and again in late afternoon. Each chipmunk captured was toe-clipped for identification. Sunflower seeds served as bait in 1946 and corn in 1947; both were used with equal success. The movements and habits of chipmunks in the field were watched with 6-power binoculars. In addition, a few animals were held in cages for observation of molts and breeding. Black dye proved effective for field identification and also for the study of molts.

LIFE HISTORY AND ECOLOGY

Reproduction

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 next spring. There is only one litter each year.

Mating

None of the females examined was lactating or noticeably pregnant on May 1, 1947. Much of the mating, however, was presumed to have already taken place, since most births occurred by the end of May.

In the males, enlarged, descended testes were evident in one specimen taken on May 4. In some of the breeding males the hair was worn off exposing a small oval patch of black skin on the scrotum. The testes of most individuals examined were reduced in size and retracted into the abdomen between May 3 and 10. One animal, captured on May 11, 1947, had abdominal testes measuring 5 by 2 millimeters. By May 19 none had fully enlarged testes.

On May 11, 1947, a chipmunk which was chasing another over an open, rocky slope, was taken at Bald Mountain. This animal had large scrotal testes. Other males from this locality were also in breeding condition; hence, it appears that the breeding season on Bald Mountain is somewhat later than at Rocky Flat, which is 7 miles south and about 2000 feet lower.

Pregnancy

By the middle of May most females weighed more than males. Since females weighed between 65 and 70 grams just before parturition, any weights above 60 grams may indicate pregnancy. Weight changes of four breeding females in 1947 are given in Figure 1.

In the period from May 1 through June 30, 1947, there were 62 adult females captured in the study area whose breeding condition was definitely known. Of these, 52 (83.9%) were either pregnant or lactating. Five females, taken May 4-15, contained 5 to 7 embryos each. The 7 embryos of one, taken May 15, averaged 25 millimeters in crown-rump length; at birth they measure about 31 millimeters. The nose vibrissae were less than 1

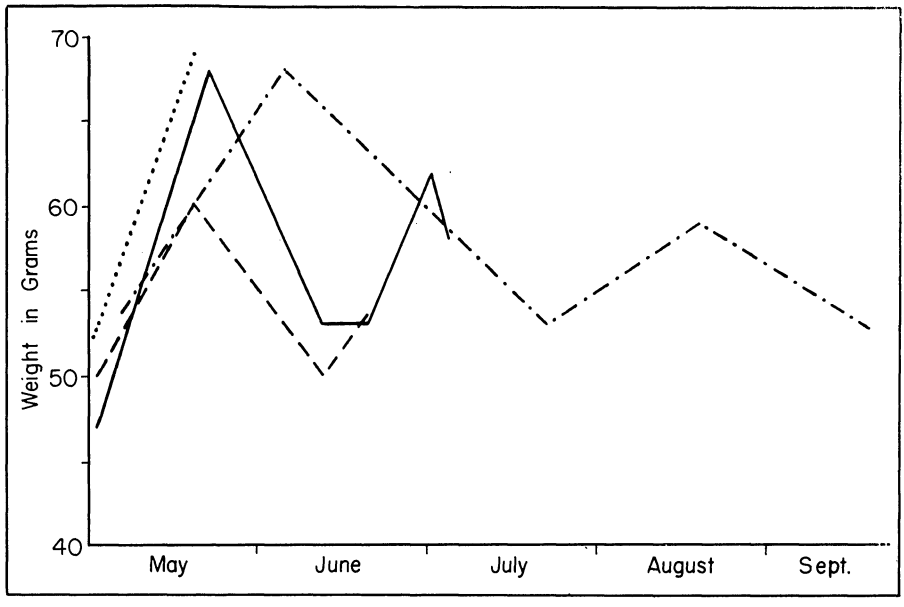

Fig. 1. Weight changes with age of four breeding females of *Eutamias amoenus* captured in 1947.

millimeter long. The placenta of a 25-millimeter embryo was 10 millimeters in greatest diameter.

Birth of Young

Most births occurred in May and early June. A female caged on May 19, 1947, gave birth to four of her six young on the following day. 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, was nervous, and moved rapidly about in the cotton nest in order to avoid my hand. By the succeeding morning her family had increased to six. This brood will be referred to as Litter 1.

Another captive female bore a litter of four (Litter 2) on May 26, 1947. For 11 days prior to parturition, and for about 2 days thereafter, she was in a cage with another adult female and a male. I saw no fighting among them. The two other adults were removed when the young were discovered in the nest box on May 27. Both mothers stayed inside their nest boxes most of the time for a few days after giving birth.

Lactation

There are four pairs of mammae in this species: one pectoral, two abdominal, and one inguinal. In lactating females the nipples are about 3 millimeters long. Many lactating females had developed large mammae

by early June. One unusually heavy female, whose total weight was 75.5 grams on June 11, had mammary glands that weighed 5.7 grams. About the third or fourth week of lactation the mammae reached their maximum size and by then the fur was usually worn off to such an extent that much of the belly was bare. Weaning is a gradual process and is completed when the young are about 6 weeks old.

Sex Ratio

The numbers of males and females live-trapped at Rocky Flat were about equal. In 1946 there were 147 males (53.1%) and 130 females (46.9%). In the following year 196 males (47.0%) and 221 females (53.0%) were captured.

The Young

Data on the growth and appearance of very young chipmunks were obtained from the litters of two captive mothers. I experienced some difficulties in raising these two litters, and this should be kept in mind when evaluating the growth data. Two young were lost from Litter 1. One was preserved as a specimen shortly after birth. A male from this same litter was sickly. His weight declined from 2.6 to 2.3 grams in 24 hours and was 2.2 grams at the time of his death on May 23. The mother made no attempt to remove the body from the nest.

It was fortunate that both litters were born at about the same time (May 20-21 and May 26, 1947) because the mother of the first brood (Litter 1) escaped on May 26 and was not recaptured. Her four remaining young went without food for a day, but with no ill results. The next day I put two of these orphans in with the other mother, thus increasing her family (Litter 2) to six. Two others were placed in a cage with a newly caught lactating female that had very large mammae, but she killed them by biting them in the head.

On June 19 a horse kicked over the cage containing the mother of the second litter and her augmented family of six. She apparently was unable to feed her brood for a day, as her young ones failed to gain weight the day after the accident. This same horse again knocked over her cage on June 24 and caused it to fall several feet to the ground. This time the mother died of fright and shock. In an attempt to provide foster mothers for the young chipmunks, two more lactating females were trapped. Both accepted the young and fed them, but one was considerably more nervous than the other and was released. The remaining female continued to care for the six babies.

Description of Newborn

Weights (gms.) of the six young of Litter 1, at approximately 20 hours after birth, all with milk in their stomachs, were 2.6, 2.6, 2.7, 2.7, 2.7, 2.8. Measurements (mm.) of the heaviest individual were: total length, 49; length of tail, 11; hind foot, 6.6. Weights (gms.) of the four young of

Litter 2, 24 hours after birth, were: 2.4 (milk in stomach); 2.5; 2.7 (milk in stomach); and 2.8. Measurements (mm.) of the four, in the same order as given above, were: total length, 48, 48, 48, 45; length of tail, 11, 10.5, 11, 10; hind foot, 6, 6, 6.5, 6. The white milk showed through the thin, semitransparent skin of those that had nursed just before being weighed.

In the newborn chipmunks the skin was pink or flesh-colored, loose, and wrinkled (Pl. I *A*). The posterior region of the body was darker than the anterior and the hind feet, in particular, were red and bloodshot. Under a binocular microscope the young appeared hairless except for a few areas on the head. Hairs on top of the head showed as dark spots under the skin. Individual hairs were visible with a 9X hand lens, but were not apparent to the unaided eye.

The numerous mystachial vibrissae on the side of the nose and on the upper lip were 1 millimeter or less in length and arranged in rows as much as 3 millimeters long. The longest of these hairs, the posterior ones, were barely visible to the naked eye. Some were darkly pigmented, others were colorless. This area of hair growth on the nose was colored a deep red by blood which showed through the skin.

There were two superciliary vibrissae above the anterior corner of each eye, three genal in the middle of the cheek 3 millimeters below the eye and 4 millimeters posterior to the corner of the mouth, and a tuft of three interramal vibrissae about 4 millimeters behind the point of the chin. All of these hairs appeared to be unpigmented, less than 0.5 millimeter long and were found with the aid of a 9X lens. The lower lip and chin were covered with hairs. Carpal vibrissae were not in evidence at birth.

Eyes of the newborn bulged slightly and looked dark through the translucent covering of skin. The united lids formed a shallow, horizontal groove 2.5 millimeters in length.

The pinnae of the ears were triangular and folded tightly against the sides of the head. Measured on a preserved specimen, they were 1.6 millimeters long.

Toes, although distinctly formed at birth, were united by membranes. The soft, unpigmented claws were 0.6 to 0.8 millimeters long.

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

A few hours after birth the 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 of Young

Development of the caged offspring may have been temporarily retarded by the change of mothers. Two of the surviving young were cared for by three mothers and four were fed at different times by two females. Eight nipples were available for the six animals and all of the young appeared well fed and healthy during their early life. There was no evidence that the two older members of the brood obtained a nutritional advantage because of their greater strength and size. Their weights were normal at maturity but none reached the size of wild adults in respect to hind-foot

and tail lengths. Possibly their diet 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 few days (Pl. I *A-D*). Specific aspects are discussed below.

Genitalia. — The distance between the genital organ and anus differed in male and female young, although the two sexes looked the same otherwise. In the males, this dimension was 4.5 to 5 millimeters on the third day after birth; in the females, 2.5 to 3. The penis was 2.0 to 2.5 millimeters long at five weeks. In adults it is about 3.

Claws. — The claws were soft at birth and bled when cut with a razor blade to mark them for identification purposes. The proximal end of the claw began to get black within a few days. In two weeks those of the front feet were entirely black, but only the bases of the hind ones were dark.

Ears. — At birth the pinnae were folded over the region of the future ear openings, but on the sixth or seventh day they became erect. One pinna may unfold a day before the other. The auditory meatus first opened in three animals when they were 28-days old.

Eyes. — The eyes became increasingly prominent and bulging. The lids opened 30 to 33 days after birth. When the lids first began to open, they formed short narrow slits which became fully separated within 24 hours.

Teeth. — The lower incisors were covered by the gums for 18 to 20 days. They continued to lengthen until, by the end of the second week, the buds of tissue protecting them projected about 2 millimeters. When the animals were 22 to 29 days old, the upper incisors appeared. The teeth remained white for at least 9 weeks before they acquired the brown color typical of adults.

Skin. — The skin of the head, back, and rump became somewhat dry and scaly at the age of 10 to 12 days and remained in this condition until about the twenty-first day. During this period all of the dorsal stripes became distinct.

Hair. — All hairs and vibrissae 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 3 days. No carpal vibrissae were detected in newborn animals, but a tuft of three emerged in 4 to 6 days. The longest of the mystachial vibrissae were about 1 millimeter at birth, 3 millimeters on the ninth day, 10 on the twenty-fifth day, and 29 at maturity.

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

Through a 9X lens one 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 and they were abundant, whereas those on the back were less numerous. On the sides of the body a few hairs emerged on the tenth day. A sparse growth of short hairs appeared on the belly and legs on the eleventh day. At that time the

tail was still bare, but on the twelfth day a few hairs showed on the proximal half and on the thirteenth they appeared on the terminal half. The tail was the last part of the body to acquire hair.

Two dorsolateral white stripes, each bordered by two faint black stripes, first appeared when the chipmunks were 10 days old. On the eleventh day the stripes were distinct and measured 24 millimeters long and 1 millimeter wide. The middorsal stripe was the last to appear. It was faintly visible on the fourteenth day and clearly marked by the twentieth.

By the end of the second week adult facial and dorsal body patterns were formed. The eyebrows were distinctly white and dark facial stripes evident. The sides were tawny and white postauricular patches well developed in animals 23 to 25 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 24 and 40 days; subsequently, black hairs became interspersed with the buff. During the buff stage the fur was smooth and closely appressed to the tail, and the tail lacked the hairy appearance that had developed by the forty-third day. At this stage 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 by the twenty-fifth day, while the posterior area was more sparsely furred. Underparts acquired a faint buff wash in three weeks time. The smooth, sleek appearance of the offspring was lost in about nine weeks; they then took on the appearance of young adults.

Toes. — The front toes started to separate at 11 days, and their division from one another was completed at about 25 days. In this process the hind feet lagged about 5 days behind the front feet.

Umbilical cord. — The blood clot at the navel disappeared in about 10 days.

Feces. — Fecal matter appeared as a brown, semiliquid stain at the anus for a week or more after birth.

Thermal control. — Young chipmunks at first were relatively cold-blooded. They presumably did not gain thermal control for a week or more. In any event they did not always feel warm to the touch for at least that long after birth.

Weight. — The weights of three young chipmunks are graphed in Figure 2. These animals gained at a fairly uniform rate for the first three months, the average daily increment being 0.47 grams, then their weights dropped abruptly and leveled off at a lower value. A momentum seems to carry the young chipmunk to this early maximum. Increased activity probably caused the subsequent loss of weight.

Behavior of Young

Under captivity. — The general activity of the young chipmunks of litters 1 and 2 increased noticeably during the first 24 hours. At the end of 2 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. Animals 16 days old could cling securely to my

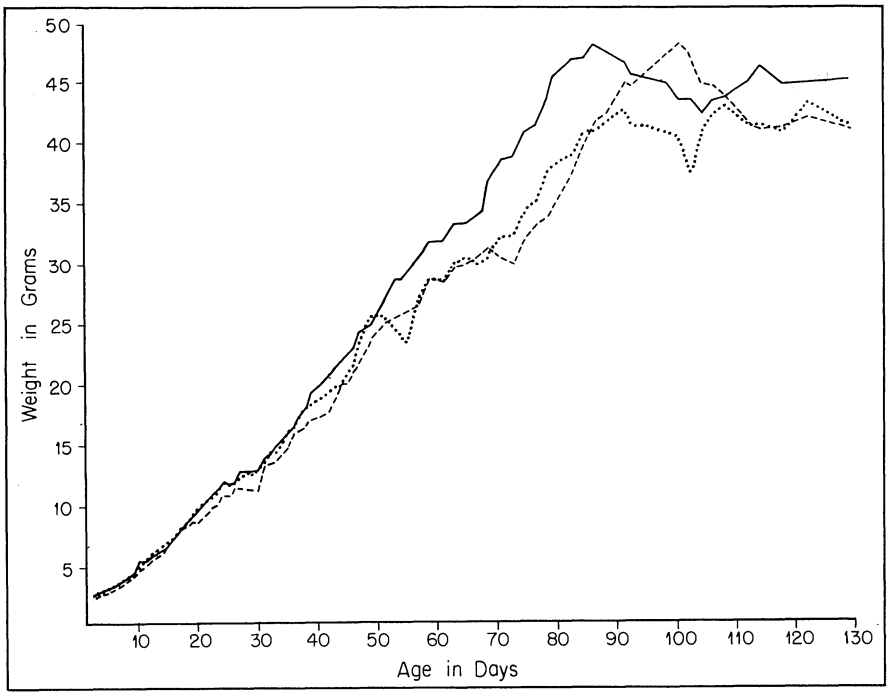

Fig. 2. Weight changes with age in three young chipmunks; solid line and dotted line represent females; dashed line, a male.

hand. By the seventeenth day they were able to hold their bodies off the ground.

Movements of the chipmunks when 3-weeks-old were jerky and spasmodic, but the young animals were already beginning to act in an adult way by scratching their ears with their hind feet.

Hearing was acute in 4-week-olds, which were quite sensitive to sharp, sudden sounds.

Voices of the young were quite strong within 48 hours after birth. Animals 2-weeks old were able to squeak loudly. One animal uttered an adult "pert" note as it came out from under the effects of ether. A chipmunk 72-days old, held in my hand, gave angry calls which sounded 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 resembled an adult alarm call.

By the time they were 5-weeks old the chipmunks showed a lively interest in their surroundings. They sniffed the scales on which they were weighed and were able to crawl well. A week later the young could climb the screen on the front of the cage. About this time, too, they learned to jump off the scales when I tried to weigh them. All were eating solid foods by 6 weeks. After eating they would sit on their haunches and wash their faces in an adult manner. When at rest or asleep the forepaws were held over the face, and the body and tail were curled up into a ball.

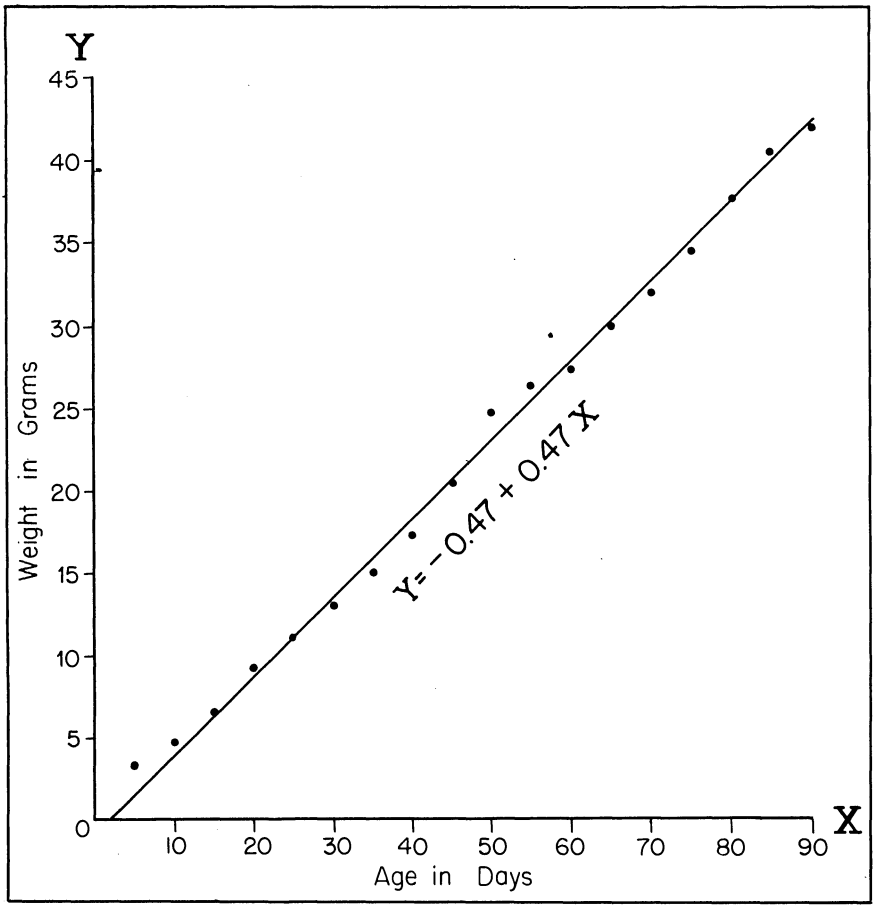

Fig. 3. Regression of weights of young captive chipmunks against age in days. Each dot represents the average of the original data.

Individual differences in temperament were marked in the six young by the end of the first month. One animal when cornered invariably tried to bite me and to ward off my hand with his forepaws while making angry, buzzing notes. Another was gentle and often climbed into my hand looking for food.

Sexual activity was first noticed in the young when a chipmunk 51-days old tried to mount one of the others.

Family breakup followed a feud that developed at 5 months. Two of the chipmunks (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 less aggressive pair lost weight between October 4 and November 14. One declined from 41 to 34 grams; the other from 44 to 34 grams.

A regression line computed from the weights of the six young chipmunks is shown in Figure 3.

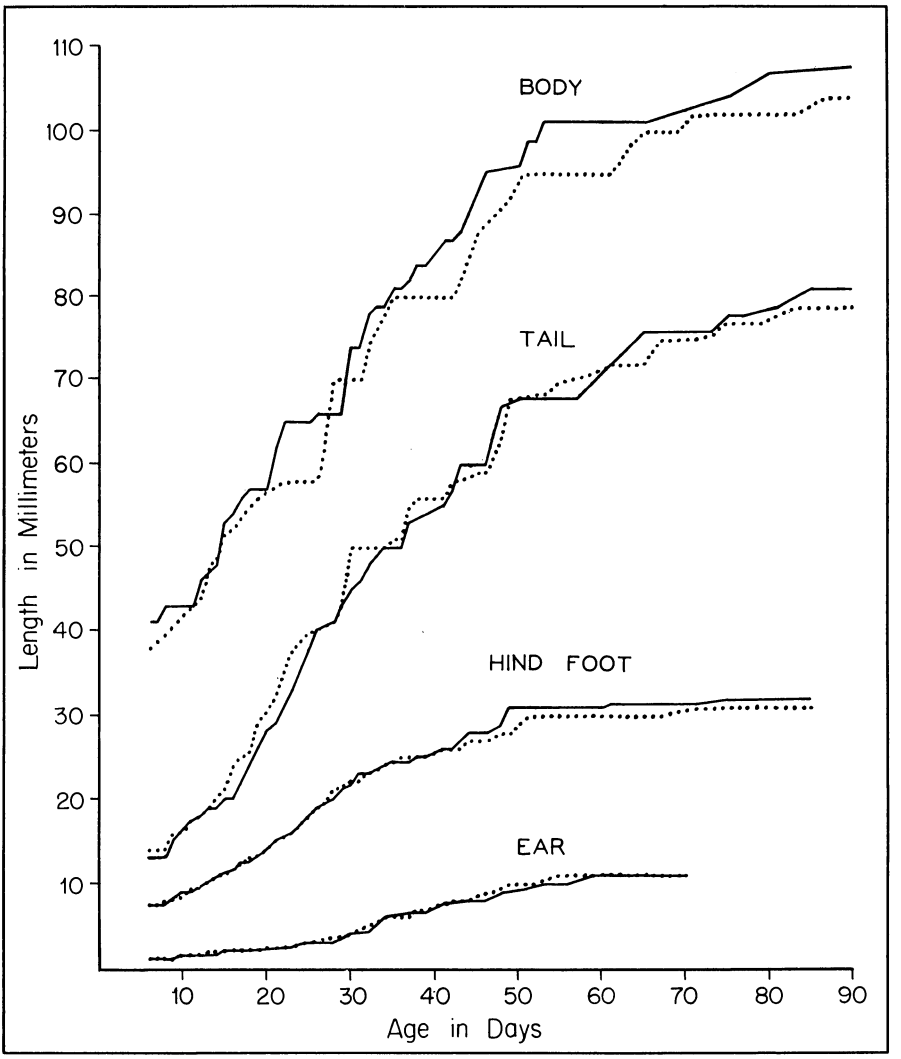

Fig. 4. Comparative growth of body parts of two young chipmunks of Litter 1. Solid line represents the male; dotted, the female.

Standard measurements of body (total length minus tail length), tail, hind foot, and ear for a male and female from Litter 1 are given in Figure 4. Body length increased (roughly in a straight line) for about 50 days but continued to rise (although more slowly) until the ninetieth day. Growth of the tail follows a rising curve for 3 months. The hind feet reached a length of about 30 millimeters in 50 days; they had grown only a few millimeters longer by the seventy-fifth day. The ears attained maximum length at an age of 55 to 58 days.

In the wild. — In 1946 field work was not begun until mid-July; in 1947 the first young chipmunks were seen above ground on June 9. During the last week of June of that year, many were observed that were about three-fourths the size of adults. The young ones were usually in family groups and probably near their home burrows as they were seen repeatedly in the same places. One family spent much of the time on and around a log, which projected from the pine woods of the trapping area onto a bare, rocky flat.

Young wild chipmunks showed great curiosity and boldness. One allowed me to approach within 6 feet, apparently disregarding alarm calls given by an adult about 40 feet away. Several others came within 3 feet of me to satisfy their curiosity. Some of the parents remained silent when I was near their young.

Description of Dens

The burrows of western chipmunks *(Eutamias)* have been described in a few published accounts. G. S. Miller (1897: 31) recorded an adult female, *E. minimus*, found in a nest of feathers and vegetable fibers on October 23 at Peninsula Harbor, Ontario. Her nest was at the end of a 2-foot tunnel in a chamber "about the size of a cocoanut [*sic.*]" and a foot or more beneath the surface of the ground. Shaw (1944: 274-84) discovered the breeding dens of two female chipmunks *(E. amoenus* and *E. townsendi)* in the Olympic Mountains. He mentioned no date, but I judge from the author's description of the young that he dug out the nests in June. The tunnel of the den of *E. amoenus* 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 for about 4 feet to the nest cavity, which was 7 inches high, $7\frac{1}{2}$ inches in diameter, and was 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. townsendi*, but its den was similar to that of *E. amoenus*. The tunnels of both species had turning points and were almost horizontal near the entrance. The nest of *E. townsendi* included sedge, lichen, and a few pieces of paper. Its weight was 95 grams.

At Rocky Prairie I located thirteen burrows, and at Bald Mountain, one. All but two were in bare, open ground with little or no cover. All of the dens were measured and photographed both before and after digging them out. A stick or piece of rubber tubing shoved down a tunnel usually helped to follow its course. Table I gives the dimensions of the fourteen dens.

Each burrow had only one entrance. The ten with nests averaged 28 inches from surface entrance to nest room. The tunnels were smoothly worn and circular in cross section. The simplest burrow was a straight 2-foot shaft with a terminal nest chamber; three others differed only in being curved. Four of the tunnels had short side branches $1\frac{1}{2}$ to 5 inches long that presumably were used as turn-around points (Pl. II *B*). The two dens with the longer 10-inch branches were winter homes. Three of the tunnels that chipmunks entered lacked nest rooms. One was only 15 inches

TABLE I

DESCRIPTION OF CHIPMUNK DENS

Measurements are in inches; angles in degrees.

No. of Den	Length of Tunnel	Depth of Nest Chamber	Average Angle of Slope	Tunnel Bore (Averages and Extremes)	Number of Branches	Length of Branches	Distance from Entrance to Branch
1	39	21	13	2	1	1.5	12
2	24	12	....	....	....	....	....
3	28	10	24	2 (1.5-2.5)	1	4	10
4	30	8	17	2.5 (1.5-2.5)	....	....	....
5	37	11	17	1.75 (1.5-2)	....	....	....
6	35	....	24	1.75 (1.5-2)	2	2.5, 2	3, 8
7	24	8	15	2 (1.5-2.5)	1	10	16
8	22	9	20	2	1	10	10
9	20	7	21	2 (1.75-2)	....	....	....
10	..	9	21	2.5	....	....	....
11	24	19	18	2.5 (1.5-3)	....	....	....
12	32	8	18	2.5 (1.5-2.5)	1	5	14
13	24	....	20	2	....	....	....
14	15	....	....	2	....	....	....
Average	27.2	11.1	18.3	2.1		5.0	10.1

long; the others were 24 and 35 inches, respectively. They needed only a terminal room to make them complete.

At least one burrow was occupied more than a year. A fresh winter nest and food store lay on top of the remains of an old nest and its cache. The other inhabited dens showed no sign of having been used previously. A few chipmunks used two old dens irregularly. Whether they made new dens and abandoned the old is uncertain, but the history of an adult female (No. 101) indicates that such may have been the case. She used two burrows at different times. One of them contained a nest and probably was her home during the spring and summer. The other den had no nest chamber.

The chipmunks apparently made their own burrows, but the manner in which they dispose of the dirt from the tunnel and nest chamber was undetermined. No loose soil was seen, either at the entrance or in the immediate vicinity of a den. Shaw (1944: 282), who examined the burrow of a *Eutamias amoenus* in the Olympic Mountains, found no dirt at the entrance. He suggested that a mound of loose earth that lay 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.

A few individuals were active even after snow covered the ground to a depth of 6 inches at Rocky Flat. They continued to use their dens by tunneling down through the snow (Pl. II *A*).

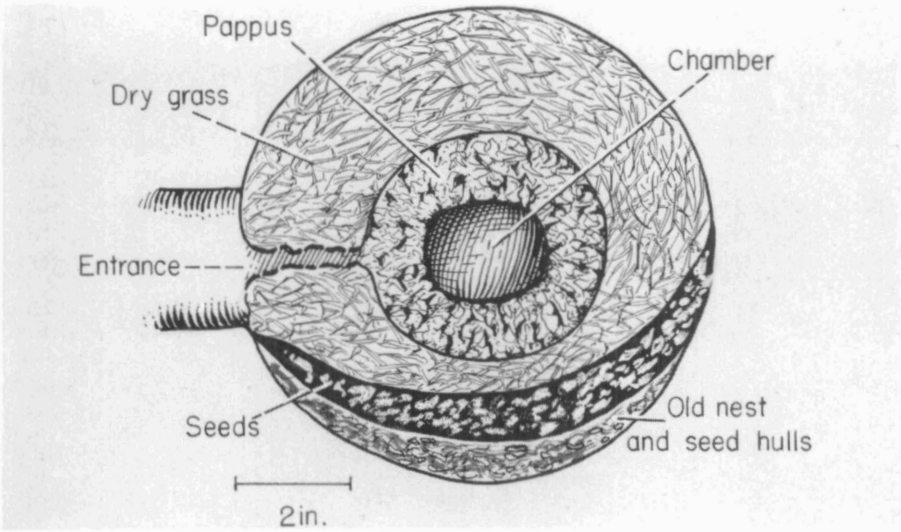

Fig. 5. Vertical diagrammatic section of chipmunk nest and food store from Den No. 11.

Description of Nests

All ten nests found in chipmunk burrows at Rocky Flat were nearly identical in size and shape. A vertical section of the nest from Den No. 11 is shown in Figure 5. Data concerning the nests is summarized in Table II. Three of those examined in November contained small flies, which Sabrosky (1949) identified as *Lutomyia aldrichi*, a new species, and *L. distincta*, formerly known only from the holotype. Some of the flies were crawling about on the surface of the nest and others emerged from the interstices. The wings of nearly all of them were peculiarly frayed and worn. Since their larvae are known to live on dung, perhaps they feed on the scats in chipmunk dens.

The chipmunks at Rocky Flat stored nest materials, such 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 *(Lepus)*. Often these caches were placed low in pine and fir trees, in grass, or on the ground. From June to September, I saw many pieces of cotton in seedling pines and on the lower limbs of older trees in the study area. Some of the trees near the traps were decorated with a dozen or more tufts, each of them about an inch in diameter, probably a single mouthful. Most were at heights of 3 to 10 feet. Once some cotton was noted in a clump of grass and on another occasion a chipmunk buried a mouthful in a small hole in the ground. Captive animals first stored cotton in the corners of their cages on September 6, 1947. On September 22 a chipmunk carried what appeared to be a mouthful of pappus 50 feet up in a pine tree. He descended without it. Several small pieces of common green lichen, along with a tuft of pappi, were cached among pine needles on September 10.

TABLE II

SUMMARY OF DATA ON TEN CHIPMUNK NESTS

No. of Den	Date Collected	Weight (grams)	Diameter (inches)	Nest Material	Food Cache	Insects in Nest	Scats in Nest
1	June 16, 1947	51	6.5	Lichen grass feathers paper	none	Fleas, ticks	37
2	June 24, 1947	50	....	Cotton pappus	none	....	....
3	July 4, 1947	70	6.75	Cotton grass pappus lupine leaves	none	Fleas, ticks	64
4	Sept. 8, 1947	47	6	Cotton grass paper	none	Lice, fleas, ticks	52
5	Nov. 6, 1947	56	6	Grass cotton rootlets	none	....	2
7	Nov. 11, 1947	52	6	Pappus	old	....	3
8	Nov. 13, 1947	50	6	Cotton pappus feathers grass lichen rootlets thread	new	Fleas, flies	0
9	Nov. 13, 1947	..	6	.....	none	....	....
11	Nov. 14, 1946	14	6.5	Grass pappus feathers	new and old	Fleas, flies, lice	0
12	Nov. 16, 1946	21	6	Pappus cotton rootlets	new	Fleas, flies	0

Beginning with the cold days of late October and continuing up to the middle of November, chipmunks carried food and nest materials down into their burrows in preparation for the winter months ahead. The earliest and latest records were October 25 and November 13. With commendable economy of effort, a chipmunk would gather both nest material and food during a single trip. 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.

Food

Feeding habits of chipmunks at Rocky Flat were determined (1) by direct observation through 6X binoculars, (2) from cheek-pouch contents, and (3) from winter caches. At least 47 different native plants were eaten. Sight records were obtained on 31 of these between May and November (Table III). Seeds of eight more species were found in the cheek pouches of ten chipmunks (Table IV), and evidence of still another eight in three winter caches (Table V). Probably, many others beside served as food, for 96 kinds of flowering plants were collected in the study area.

There seemed to be an abundance of food for chipmunks at Rocky Flat at all seasons. During the spring (May and June) some of the conspicuous

TABLE III

FOOD ITEMS EATEN BY CHIPMUNKS AT ROCKY FLAT IN 1947

Food Item	Date						
	May	June	July	August	September	October	November
Taraxacum officinale	27,30	....	....	14	5	....	....
Cacaliopsis nardosmia	30	....	....	....	5	....	....
Hydrophyllum sp.	30	....	....	....	....	....	....
Stipa lemmoni	31	....	....	....	....	....	....
Arnica cordifolia	....	9	30	....	....	....	....
Poa nevadensis	....	10	....	....	....	....	....
Bromus tectorum	....	10	....	....	....	....	....
Poa secunda	....	20	....	....	....	....	....
Bromus carinatus	....	30	....	....	....	....	....
Achillea millefolium	....	....	2,21,22,29	9	....	....	....
Sitanion hystrix	....	....	3	....	....	....	....
Penstemon sp.	....	....	9,29	....	....	....	....
Deschampsia elongata	....	....	10	....	3,18,22	....	....
Fungi (basidiomycetous tubers)	....	....	10,14,31	1,12	20	9,10,23	....
Poa juncifolia	....	....	14	....	....	....	....
Phacelia heterophylla	....	....	14,20,21,29	....	....	....	....
Arctostaphylos nevadensis	....	....	16	12	....	....	....
Erigeron sp.	....	....	29	....	....	....	....
Gilia gracilis	....	....	29,30	....	....	....	....
Symphoricarpos albus	....	....	....	1,12	....	22	....
Bark (probably *Pinus ponderosa*)	....	....	....	12	....	....	....
Holodiscus discolor	....	....	....	....	3	....	....
Polygonum sp.	....	....	....	....	3,5,6,21,22	9	....
Cirsium lanceolatum	....	....	....	....	5,6,16,21,29	10	6
Verbascum thapsus	....	....	....	....	6,21	10	....
Arceuthobium campylopodum	....	....	....	....	10	....	....
Pinus ponderosa	....	....	....	....	16,25,26,29	....	....
Grasshopper (*Trimeratropus suffusa*)	....	....	....		26	....	....

TABLE IV

CONTENTS OF CHEEK POUCHES OF TEN CHIPMUNKS IN 1947

Each column represents one animal.

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

and common plants were silver crown *(Cacaliopsis nardosmia)*, heart-leaved arnica *(Arnica cordifolia)*, penstemon *(Penstemon attenuatus)*, phacelia *(Phacelia heterophylla)*, dandelion *(Taraxacum officinale)*, and sedges and grasses. In the summer (July and August) some additional food plants were manzanita *(Arctostaphylos nevadensis)* and snowberry *(Symphoricarpos albus)*. During September and October the seeds from knotweed *(Polygonum* sp.*)*, thistles *(Cirsium lanceolatum)*, mullein *(Verbascum thapsus)*, ocean spray *(Holodiscus discolor)*, and yellow pine *(Pinus ponderosa)* were eaten in quantity in the study area.

Seeds. — The most important foods of the chipmunks at Rocky Flat were the seeds. Very few leaves and stems were eaten. During spring and summer they consumed the soft, immature seeds of various ripening flowers. Later, mature seeds were added to their diet and these constituted the main supply stored for the winter.

In the fall chipmunks climbed pine trees for the seeds as soon as the cone scales opened. Seeds of at least twenty species of flowering plants were gathered and stored in winter dens in October and November. The three caches analysed in Table V differed in the number of each kind stored. One store had 16840 *Carex* seeds; another, 1000; and the third, only 10. Chipmunks use what is available in the vicinity of their dens. Since many plants are not evenly distributed over the area, amounts accessible of each to different chipmunks will vary. There may also be variation among chipmunks in their preference for different plants.

TABLE V

COMPARISON OF CONTENTS OF THREE FOOD STORES FROM CHIPMUNK BURROWS

Starred figures represent actual counts; others were estimated from samples.

Food Item	Number of each Item stored			Total weight of all Items (in grams)		
	Nov. 14 1946 (1)	Nov. 16 1946 (2)	Nov. 13 1947 (3)	Nov. 14 1946 (1)	Nov. 16 1946 (2)	Nov. 13 1947 (3)
Seeds						
Amaranthus sp.	....	60	....	....	....	....
Arachis sp. (peanut)	....	2*	....	....	1.0*	....
Calandrinia 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. muricula	....	....	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 (pieces)	....	200	10000	....	1.4	80.0
Bumblebee (*Bremus* sp.) (2 legs, part of thorax)	....	....	1	....	....	....
Total	24360	13920	67970	70.0	170.0	190.1

Fungi. — Fungi (at least the more conspicuous kinds) seemed most abundant in the fall, but they were eaten from July to November. While they might well have been important in the chipmunk diet, they certainly were not eaten to the exclusion of other plants. There were no fungi in the three winter caches examined. Pine squirrels *(Tamiasciurus douglasi)*, in the area, on the other hand, did store mushrooms on logs and on low branches in trees in the fall.

Tevis (1953: 320) reported that hypogeous (subterranean) fungi are the most important food of chipmunks and mantled ground squirrels *(Citellus)* in the commercial timber belt of northeastern California. In mid-June

Eutamias townsendi and *E. quadrimaculatus* of certain habitats ate the fungi almost to the exclusion of everything else, but ".... *E. amoenus* showed less seasonal preference for fungi and ate relatively more seeds and insects than the other species."

Corms. — These underground plant parts apparently are relished by the chipmunks of Rocky Flat. In one of the winter caches (Table V) there were about 10000 small pieces of corm (species not identified). They also were carried in the cheek pouches of 2 out of 10 chipmunks.

Miscellaneous items. — Three scats (mouse or chipmunk size) and a small piece of bark were in the cheeks of one chipmunk (Table IV). In addition to these oddities, its pouches contained a cotyledon of some plant seedling, pieces of corm, a few pieces of pine needle, and 47 seeds of 8 species. No scats, bark, needles, or cotyledons were found in the cheek pouches of any of the others.

Animal food. — The bulk of the chipmunks' food was vegetable, but occasionally they did eat animals. One ate a grasshopper, and remnants of a bumblebee were found in a chipmunk nest. An adult lactating female ate one of the eyes and part of the neck of a deer mouse when the two were confined in the same live trap overnight.

Feeding Habits

Knotweed (*Polygonum* sp.), which carpeted much of the ground on the flat at the west side of the study area, apparently was a favorite food. Its tender fruits attracted large numbers of chipmunks. Often, as many as fifteen chipmunks were observed feeding on knotweeds within an area about 100 feet in diameter. While eating they frequently foraged only a few feet from one another without fighting. Later in the fall they stored the mature seeds in their burrows.

Yarrow *(Achillea millefolium)* was abundant throughout the area and chipmunks commonly ate the fruits in July and August. On several occasions I saw chipmunks leap up onto yarrow plants, climb the stems, and cut off 6-inch lengths of the flower-bearing stalks. Then they would drop back to the ground to eat the tiny fruits. One chipmunk ate three yarrow heads in 30 minutes. At times the stems were not completely severed and the flowers were left hanging. The fruits were eaten only when green and at a certain stage of development. Caged chipmunks would not eat yarrow heads which were either too young or too old, and wild chipmunks chose certain flowers and rejected others.

Thistles *(Cirsium lanceolatum)* were common in some places, and chipmunks frequently ate their fruits. They climbed the thorny plants with apparent ease and impunity. Sometimes they stayed up on the thistle to eat the seeds, but more often the flowers were severed from their stalks and allowed to fall to the ground or were carried down by mouth. Chipmunks ate the thistles on the spot or took them up to the vantage point of a nearby log or stump. They usually turned the prickly heads around several times with their forefeet and teeth until they located the least thorny part at the base of the flower head. Then they quickly dissected out the seeds. Conspicuous little piles of pappi from the seeds lay about on the ground or on logs until the wind blew them away.

Yellow pine seeds ripened in September. Chipmunks pulled out the seeds with their teeth as soon as the cone scales separated far enough. On September 26, 1946, two chipmunks were seen 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 two chipmunks were not marked with dyes, so their identity was not determined. Several individuals ate cones at heights of 60 to 70 feet, and some of them climbed the tallest trees, 100 feet or more. On September 22 an adult female (marked with black dye) stayed aloft for 30 minutes in a Douglas fir, a larch, and a yellow pine, crossing over from one tree to another. Occasionally she climbed to heights of 70 to 100 feet.

During late October most chipmunks foraged on the ground for seeds and corms to store in their winter dens. At the same time they gathered cotton and thistle pappi for their nests. In 1946, the first snow of the season fell to a depth of 2 to 4 inches on October 26. Chipmunks were still active; 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 in depth. The hulls of pine seeds lay scattered on the snow at one such digging.

On November 14, 1946, only two chipmunks were seen. They were busily gathering food from bare ground on south-facing slopes. There were no chipmunks above ground after snows fell to a depth of 10 inches on November 20. 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 it had dug through the snow for food.

Storage of food for winter. — 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. As late in the season as September 24 there were no caches in the two burrows belonging to female No. 101. She was seen to enter one of her dens on September 22, and caught for the last time in a live trap on September 24. When her two burrows were examined on November 6 there was no food in them, although one tunnel contained a new nest of dry grasses. The other, which she had entered on September 22, had no terminal nest chamber.

Various authors have noted that western chipmunks store food in shallow crevices or in holes at the surface of the ground. They have commented that caches are placed in burrows; but detailed information is lacking. A brief account by G. S. Miller (1897: 31) is the only one I have found that describes the exact location of a food store in the den of a *Eutamias*. He excavated a burrow of *E. minimus* in Ontario, Canada, on October 23; a small store of weed seeds and wild fruits was in the nest. *E. amoenus* stored food in a similar way at Rocky Flat.

Three newly gathered winter caches (Table V) were found in November, two in 1946 and one in 1947; also, the remains of a one-year-old store in 1947. In all of them the food was stored in spherical nest cavities. Each cache was in the bottom part of the nest itself rather than in a separate branch of the tunnel. Thus, a chipmunk could obtain a meal simply by reaching through the sides or floor of his nest.

The following are some of my observations on the behavior of four chipmunks in storing food for the winter. One, a male marked with black dye was watched for 47 minutes on October 25, 1947. He gathered food and cotton for his nest along a route that formed a circle approximately 250 feet in diameter. Most of the time he foraged on the ground, but once he climbed 15 feet up a Douglas fir; later he went up a yellow pine about 30 feet. In 20 minutes his cheek pouches were filled to bulging and he had circled back to within 50 feet of his burrow. He then paused a minute to pick up a large mouthful of cotton from the ground. Adjusting the load carefully with many little movements of his forepaws, he ran directly to his tunnel, which he entered immediately. In 3 minutes he reappeared and set out again.

This chipmunk finished collecting food during the first week of November, 1947. The entrance to his burrow, plugged and completely effaced on November 6, was relocated by probing the ground with a stick. A light snow that fell the day before had melted and the ground had thawed. A week later 2 inches of fresh snow covered the ground. The den was excavated and the chipmunk found curled up alone in his spherical 6-inch nest of cotton and pappus. He lay on top of his large food cache.

His store (Table V, Column 3) contained approximately 67970 items. These included 15 native species of seeds, corms, some corn obtained from live traps, and several legs and a part of the thorax of a bumblebee (*Bremus* sp.). The most abundant plant items were seeds of *Collinsia* sp. (31720) and of *Carex* sp. (16840) and corms (10000 pieces of various sizes averaging about 3 mm. in diameter). More than 86 per cent of the total weight of 190 grams was composed of the same three foods: pieces of corm (42%), collinsia seeds (24.5%), and sedge seeds (19.9%). The volume of this store was about 330 cubic centimeters (measured dry in a graduate cylinder). The bumblebee was a ground-dweller, so it may have entered the chipmunk's tunnel where it was captured and eaten. I found no other animal food in the four collections.

By the middle of November, 1946, few chipmunks were abroad at Rocky Flat. One, however, was seen on November 13. He carried conspicuous light-colored down in his mouth and disappeared into the ground near the bottom of a ravine, where his tunnel was located. After an interval he reappeared, went foraging again in the woods, and returned with cheeks and mouth filled with seeds and nest material. When he saw me he hesitated momentarily, then entered the den. Twenty minutes later he was still below ground. The next day (November 14) his nest and winter store were excavated.

In his cache (Table V, Column 1) were about 24360 seeds belonging to 12 species. They weighed about 70 grams and had a volume of 343 cubic centimeters. Douglas fir seeds formed the main bulk of the collection. They numbered about 5360 and weighed 40.3 grams (57.6% of the total weight). Many old hulls of Douglas fir seeds and the remains of an old nest were packed down on the floor of the chamber underneath the new nest and its store. It was obvious that this tunnel and room had been used as a winter home for at least two years.

A third chipmunk, whose storing activities led me straight to his

burrow on November 13, 1946, was a male marked with dye. While I was digging out his den 3 days later, he came within 10 feet of me and stayed nearby for some time. His cheeks were filled with food and he was carrying pappus in his mouth. Many seeds were stored in the sides and bottom of his thistledown nest (Plate III *A*). There were 15 native species, sunflower seeds, wheat kernels, and two hulled peanuts in this cache. The total number of food items in his store (Table V, Column 2) was approximately 13920. The three most abundant seeds were *Cirsium* sp. (6170), *Polygonum aviculare* (3400), and *Pinus ponderosa* (1080). The total weight was about 170 grams, 90.4 per cent of which was accounted for by four species: *Pinus ponderosa* (31%), *Hordeum vulgare* (29.1%), *Helianthus* sp. (18.8%), and *Cirsium* sp. (11.5%). The rough outer coverings had been taken off 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.

A fourth chipmunk, another marked male, was followed for 41 minutes on November 6, 1946, while he 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. Frequently, he 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 pappus. This took only 5 to 10 seconds. Then he went quickly to his burrow and he stayed inside for 3½ minutes.

On the next day he was again seen carrying food into his burrow, and this time he stayed underground for 7 minutes. His den was at the base of a north-facing slope where snow was about 2 inches deep. Many tracks radiated out from the entrance. Food-gathering was still feasible because some of the exposed slopes had thawed during the day. Foraging activities must have ended when snows fell to a depth of 4 inches on November 17 and 10 inches on November 20. I saw neither chipmunks nor their tracks after that.

During the summer of 1947, this last chipmunk's burrow was used only sporadically. When excavated on November 11, 1947, it contained 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, and 6 kinds of small seeds were all that remained of the cache. From a sample count of the store, an estimate of the total items in the original cache was made. Some foods may have been completely disposed of during the winter, so the following figures represent only the possible minimum numbers: *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.

Carriage of food in cheek pouches. — The cheek pouches of ten chipmunks were examined (Table IV) for the kinds of food collected. 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 the seeds, collinsia, was in the cheeks of three of the four animals. There were 184 seeds of this plant alone in the pouches of one chipmunk, and in those of another they formed the bulk (261) of the contents.

Eleven kinds of seeds, and also corms, were recovered from the pouches of 6 shipmunks in October, 1947. In most abundant supply were seeds of parsley (*Lomatium* sp.), stinking tarweed *(Madia glomerata)*, knotweed (*Polygonum* sp.), eriogonum (*Eriogonum* sp.), and stipa (*Stipa* sp.). There were also pieces of corms of unidentified plants. A chipmunk live-trapped on October 28 carried 85 seeds of one plant (*Lomatium* sp.) in its pouches; and another, on October 29, had 76 seeds of stinking tarweed *(Madia glomerata)* and four of a sedge (*Carex* sp.).

Chipmunks in live traps frequently had their cheeks filled with corn or sunflower seeds and, occasionally, with 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 before the last seed was expelled.

Hibernation

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

According to Taylor and Shaw (1927: 98), on Mount Ranier *Eutamias amoenus* hole up around November 1. These authors recorded observations of J. B. Flett 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 [*E. cooperi*]. 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, Evans, and Palmer (1944: 182) observed that most adult *Eutamias quadrimaculatus* in the Sierras of California evidently were inactive or in hibernation by November 1. Whether the animals resumed activity during favorable winter weather was not 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." They first saw chipmunks in the spring on March 17.

The Asiatic chipmunk, *Eutamias sibiricus*, is inactive in its burrows in winter and lays up a store of food for its occasional use during this period (G. M. Allen, 1940: 694). Allen quotes an observer named Anderson to the effect that *E. s. ordinalis* in northern Shensi, China, did not emerge from their holes until the latter part of April.

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

In 1946, the first light snow of the season fell on October 23, but it melted by noon. I caught 37 chipmunks (100 traps set) that day. A 3-inch snow fell on October 25 and there were light flurries on November 1 and 10. I caught only one chipmunk (in 100 traps on November 13, the day trapping was ended. Two chipmunks were seen in the trap area on November 13 and 16, but after heavy snows on November 17 and 20, neither the chipmunks nor their tracks were to be found.

In 1947, the first snow fell on October 19. It was about 2 inches deep, but in several days most of the ground was again bare. On October 30, the last day of trapping, I caught 34 chipmunks (100 traps set). Light snows fell on November 5, 8, 10, 13, and 14, but they melted to expose the ground in places. A few chipmunk tracks were in evidence as late as the 15th. One chipmunk was seen during a 4-mile hike to Yellowjacket Mountain (just north of the study area) on November 13. Altitude at the mountain is about 4800 feet and the snow was about 5 inches deep. Temperatures at my camp (3800 feet) ranged from 25° to 37° F. on 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 and had been running about on the snow.

Three live chipmunks were taken to Michigan, in 1947, where they spent the winter in rooms at a temperature of approximately 68° F. They did not hibernate, but were relatively inactive. During December and January they often remained in their nest boxes all day except for a short feeding period of from one-half hour to an hour. Their movements were not vigorous when they came out for food; sometimes they would shut their eyes and doze. These captives (like the chipmunks in the wild) stored food in their nests.

Weights

Chipmunks in the study area were trapped and weighed on the spot eight times each month on the average. The scales were considered accurate to within 2 or 3 grams under field conditions. Data on live weights of chipmunks at Rocky Flat for the periods of the study in 1946 and 1947 are summarized in Tables VI - VIII, and weight curves are presented in Figure 6. In 1947 the period from May to mid-October is included, but weights for 1946 were recorded only from July through September. The null hypothesis test was run on all the weights. The significant differences in weights noted between groups are commented on below.

Breeding *versus* nonbreeding females. — Weights of breeding females were significantly greater than those of nonbreeding females in all of the periods from early May to the middle of July (Table VI; Figure 6).

Adult males *versus* nonbreeding females. — The null hypothesis tests on these two groups did not yield clear-cut results, but in 1947 the females were significantly heavier in two periods, the first half of May and during the entire month of July (Tables VI - VII; Figure 6).

TABLE VI

COMPARISON OF LIVE WEIGHTS OF BREEDING AND NONBREEDING FEMALES, 1946-1947

Weights of nonbreeding females in parentheses.

Period	Number of Individuals	Average Weight (in grams)	Standard Error	Range
1946				
July				
Second half	9	49.7	2.53	40-62
	(18)	(41.6)	(1.04)	(30-48)
August				
First half	8	46.2	1.95	40-54
	(17)	(44.6)	(1.42)	(35-57)
Second half	15	48.0	1.19	41-56
	(63)	(46.4)	(0.43)	(40-52)
1947				
May				
First half	53	51.6	0.92	41-67
	(19)	(47.4)	(1.28)	(38-61)
Second half	22	55.4	1.67	42-69
	(9)	(49.3)	(1.18)	(44-57)
June				
First half	37	61.7	0.93	47-73
	(6)	(50.3)	(1.30)	(46-55)
Second half	37	54.8	0.82	45-65
	(3)	(47.3)	(1.87)	(45-51)
July				
First half	35	55.4	0.71	48-67
	(15)	(51.8)	(1.00)	(45-58)
Second half	38	51.6	0.74	42-59
	(9)	(51.0)	(1.14)	(45-56)
August				
First half	6	51.0	1.13	47-54
	(8)	(51.6)	(2.01)	(43-60)
Second half	26	52.8	0.75	47-60
	(18)	(48.3)	(0.68)	(41-52)
September				
First half	6	50.0	1.16	46-53
	(14)	(48.4)	(0.96)	(44-55)
Second half	11	51.4	0.93	45-56
	(24)	(49.0)	(0.81)	(39-59)
October				
First half	9	50.2	1.38	42-54
	(25)	(48.0)	(0.82)	(38-55)

Male young *versus* female young. — In 1947, the average weight of young females was greater than that of young males from June to October, but differences were statistically significant only for the second half of July and the second half of August (Table VIII; Figure 6).

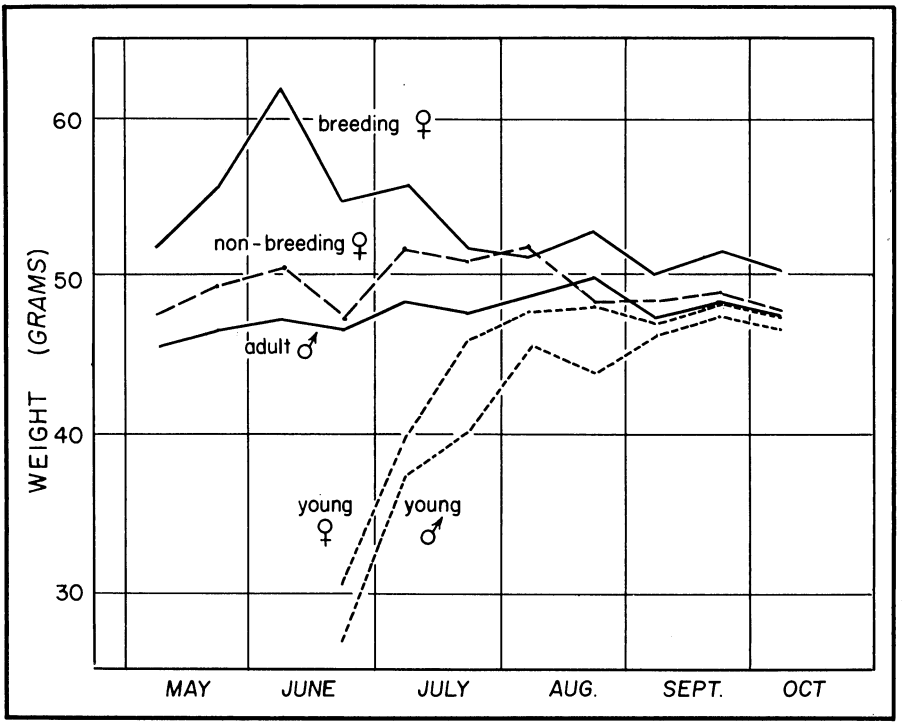

Fig. 6. Comparison of live weights of chipmunks at Rocky Flat in 1947. Data from Tables VI to VIII.

1946 *versus* 1947 weights. — In practically every period and for each sex and age group, the weights were significantly greater in 1947 than in 1946. Comparative data for the two years are available only from July through October. This result was unexpected because the populations were about equal both years and the food supply apparently similar. Perhaps the weather had something to do with the lesser weights in 1946. The snowfall was exceptionally heavy during the winter of 1945-1946, according to records from the two nearest mountain weather stations, Bumping Lake and Rimrock. Hence, the chipmunks probably emerged from hibernation dens later in 1946 than in 1947. Also, heavier snows may have changed both quantity and quality of food. Possibly, too, botfly infestation of the chipmunk population at Rocky Flat, which was greater in 1946 than in 1947, may have influenced weights. It is also interesting to note that the fall molt began nearly a month later in 1946 than in 1947.

Scats

Scats of these chipmunks are varied in size and shape. They are 2 to 7 mm. long, averaging about 4.5 mm., the shape is round to oblong and the surface is rough.

TABLE VII

LIVE WEIGHTS OF ADULT MALES, 1946 AND 1947

Period	Number of Individuals	Average Weight (in grams)	Standard Error	Range
1946				
July				
Second half	22	44.3	1.74	30-54
August				
First half	29	43.7	1.75	36-52
Second half	106	45.4	0.72	37-53
September				
Second half	3	55.3	2.74	50-59
1947				
May				
First half	142	45.5	0.30	36-57
Second half	43	46.6	1.26	36-55
June				
First half	69	47.3	0.47	37-58
Second half	52	46.7	0.62	35-56
July				
First half	22	48.5	0.81	40-55
Second half	41	47.8	0.66	42-58
August				
First half	32	48.9	0.76	41-56
Second half	34	50.0	0.73	40-60
September				
First half	28	47.5	0.65	39-56
Second half	37	48.5	0.65	42-54
October				
First half	34	47.7	0.77	42-56

Animal Parasites

Botflies. — Botflies of the genus *Cuterebra* parasitized chipmunks at Rocky Flat. Unfortunately, their specific identity is still in question. C. W. Sabrosky kindly examined three adult flies which I reared from larvae; pending further study he would call them *Cuterebra fasciata* Swenk.

The number of chipmunks infested with botfly larvae has varied considerably from year to year. Larrison (1947: 25) found larvae in more than 50 per cent of the chipmunks *(Eutamias amoenus)* he collected at Rocky Flat in August, 1941. I found larvae in about 14 per cent of those trapped in 1946 during August, the peak month of infestation. Only 6 per cent had larvae in August of 1947. Warbles were first noticed on chipmunks in July, but most of them appeared in the latter half of August (Table IX). In 1946 I found 58 per cent of the larvae in August; in 1947,

TABLE VIII

COMPARISON OF LIVE WEIGHTS OF YOUNG FEMALES AND YOUNG MALES, 1946-1947

Data on young males in parentheses.

Period	Number of Individuals	Average Weight (in grams)	Standard Error	Range
1946				
July				
Second half	3	38.7	2.98	33-43
	(7)	(34.1)	(2.32)	(26-43)
August				
First half	3	40.0	4.62	32-48
	(4)	(39.0)	(1.80)	(34-42)
Second half	16	41.9	1.02	35-49
	(11)	(42.7)	(1.26)	(35-49)
October				
First half	6	45.7	2.02	39-51
	. . .	. . . .	. . . .	. . . .
1947				
June				
Second half	6	30.2	2.21	25-39
	(3)	(27.0)	(1.16)	(25-29)
July				
First half	10	39.7	2.19	22-46
	(8)	(37.2)	(2.00)	(28-44)
Second half	28	45.9	0.58	38-53
	(13)	(40.1)	(1.11)	(34-46)
August				
First half	17	47.9	1.07	43-59
	(18)	(45.6)	(1.64)	(41-52)
Second half	37	48.2	0.60	41-54
	(16)	(43.9)	(0.93)	(38-51)
September				
First half	15	47.1	0.96	38-52
	(10)	(46.2)	(1.12)	(40-53)
Second half	32	48.3	0.40	44-56
	(9)	(47.6)	(1.62)	(41-54)
October				
First half	18	47.7	0.47	44-51
	(12)	(46.8)	(0.98)	(42-54)

68 per cent appeared in that month. Many larvae or their scars were still to be seen on chipmunks in September. Botfly numbers dropped abruptly in October. My latest record of a chipmunk botfly was November 2, 1946.

Of the 74 chipmunks parasitized by botflies, in 1946 and 1947, 82.4 per cent bore one larva each; 12.2 per cent, two; and 5.4 per cent, three. Three was the largest number carried by a single chipmunk at any one time.

TABLE IX

SEASONAL OCCURRENCE OF BOTFLY LARVAE IN CHIPMUNKS

Month	Number of Larvae		
	1946	1947	Total
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
Total	66	25	91

Larrison *(loc. cit.)* observed a greater number (four or five) per chipmunk in 1941.

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 20 days before they emerged. Most of the bots were on the side of the body (34), but others were located on the belly (23), back (14), neck (11), shoulders (7), and rump (1). There were none in the scrotum and genitals or on the head.

The bot larva grows under the skin in a pocket or cyst communicating to the outside through a single hole (Plate III *B*). Full-grown larvae protrude from the body of the chipmunk as large, oval lumps (20 by 5 mm.). The muscles are not penetrated to any great extent. The skin that covers the warbles changes from a normal pink to a shiny black and is smooth and devoid of hair. Four or five days after the larva begins to enlarge the breathing hole, it gradually works out of the cyst and drops to the ground. The gaping cavity in the chipmunk is a rather good cast of the larva. The newly emptied cyst has a round, flaring mouth about 10 mm. in diameter and is lined with pink, healthy tissue (Plate III *C*). Some of the wounds remain fairly clean and dry until they heal over; 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; they neither ate nor destroyed them. I have seen chipmunks lick and scratch their skin around an encysted bot. The larvae probably are somewhat irritating. The larva changes color from white to dark brown or black during its development. When it falls to the ground, it burrows into the soil to a depth of an inch or less within about 24 hours; it pupates within a day or two.

Fleas. — Four kinds of fleas lived on the chipmunks and in their nests: *Oropsylla idahoensis* (also taken from *Citellus lateralis* at Rocky Flat), *Opisodasys keeni*, *Catallagia decipiens*, and *Monopsyllus eumolpi cyrturns*. Heaviest infestation by fleas occurred in May, when they were found on approximately one-half of the trapped animals. Less than 5 per cent had fleas from June to November. Underground nests harbored a good many fleas in June and November. Thirteen per cent of the chipmunks had fleas in 1947; no tabulations were made for 1946. These parasites had no harmful effects on their hosts, as far as one could tell, and they never occurred in large numbers on any one individual.

Ticks. — Several engorged ticks, *Dermacentor andersoni*, were found attached to the ears of chipmunks.

Mites. — Thirty-three chipmunks (26%) had small, reddish mites during May of 1947. They burrowed into the skin of the belly causing small lumps. I have seen as many as a dozen or more on one animal. Scabs eventually formed over the wounds caused by these mites.

Lice. — At least fourteen chipmunks (5%) had lice *(Hoplopleura erratica arboricola)* in 1946; two (0.7%) in 1947.

Tapeworms. — Thirteen live-trapped chipmunks voided proglottids of small tapeworms from August 29 to October 28, 1947. The proglottids appeared in the feces of individual chipmunks for an average of 5 consecutive days. One animal voided them on September 26 and again for the period from October 22 to 30, 1947.

One chipmunk was taken to camp for observation on August 30, 1947. His weights taken on August 30, September 9, and September 20, were: 43, 29, and 25.1 grams. Death occurred on the last date. His intestines were filled with 62 tapeworms, the largest 40 millimeters long. Another chipmunk had an intestinal population of 26 of these parasites, some as long as 110 millimeters. The tapeworms were of two species: *Hymenolepis nana* and *H. diminuta*.

Skin Diseases

Only a few chipmunks had diseases of the skin. The foot of one animal was swollen and covered with scabs on August 20, 1947. New hair appeared on it on September 6. Five days later the foot looked almost normal. Five other chipmunks had toes without hair and five more had hairless patches on the side of the nose. One of the chipmunks whose nose was bare on August 19 had grown new hair by August 22. The lower jaw and chin of another chipmunk were 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.

Longevity

In order to obtain data on length of life, part of the area was retrapped four years after the original marking program at Rocky Flat. For 5 days (August 10-15, 1950) 90 live traps were placed in Plot 1. I caught 83 different chipmunks *(E. amoenus)*, 11 of which (13%) had clipped toes. Two adults, first marked in 1946, were at least 5 years and 2 months old. The others had been toe-clipped in 1947. Since four were adults then, they were at least 4 years 2 months old in 1950. Five were born in 1947; they were about 3 years and 2 months old in August, 1950.

Manville (1949) caught 31 *Eutamias minimus jacksoni* in three successive years in northern Michigan. Only two of these were retaken in different years. Their ages were at least 12 and 13 months at last capture.

Mortality

Winter turnover. — A detailed analysis of my data on chipmunk mortality throughout the year remains to be done. Of 130 chipmunks caught on Plots 1 and 2 between October 1 and November 13, 1946, 84 (64.6%) were recaptured during the 1947 season, May 1 to October 31. Nearly all the chipmunks caught in live traps appeared to be healthy and active. Only one dead chipmunk was found on the study area during the two seasons of field work. He lay on the ground a few feet from one of the live traps, but the cause of death was not determined.

One chipmunk had lost his right hind leg below the femur; otherwise he was healthy and vigorous. Another animal apparently had a broken left hind leg, but survived the handicap for at least another month.

Predation. — The long-tailed weasels *(Mustela frenata)*, coyotes *(Canis latrans)*, badgers *(Taxidea taxus)*, bobcats *(Lynx rufus)*, and goshawks *(Accipiter gentilis)* are probably the main enemies of chipmunks at Rocky Flat. An adult weasel entered one of the live traps, July 29, 1946, and ate a chipmunk; several other times weasels tried to get into occupied traps. One bobcat was seen on the area. There were tracks and diggings of a few coyotes and badgers. Goshawks lived in the vicinity. Chipmunks always were vociferous in sounding the alarm when one of these hawks flew over. Rattlesnakes *(Crotalus viridis)* may account for a few deaths at Rocky Flat. I saw three rattlers during the two seasons of field work.

General Behavior

Movements. — When climbing a tree, these chipmunks will run up the trunk in spurts of 5 or 6 feet, resting for a moment between each effort. In comparison, pine squirrels *(Tamiasciurus douglasi)* are more agile and can run from the bottom to the top of a fairly tall pine with scarcely a pause. On the ground, movements of the chipmunks are almost always nervous and jerky. Even when they are foraging they advance by spasmodic motions and short rushes, rather than by walking. The tail is an expressive part of the chipmunk. Its various uses reflect the nervous energy of the animal. While sitting still and eating, he waves his tail from

side to side, seeming to show the pleasure of the moment. A calling chipmunk nearly always waves his tail with each note, either from one side to the other or forward and backward. The tail is held anywhere from horizontal to vertical when the chipmunk runs any considerable distance. The position depends on the speed of travel and the roughness of the terrain. When standing still, the tail is frequently held vertically or bowed somewhat forward.

Daily cycle. — Chipmunks are more in evidence at certain times of the day than at others. At Rocky Flat they usually were out shortly before sunrise and were active for several hours until the heat became oppressive. From about nine in the morning until three or four in the afternoon, on hot days, relatively few were seen. Later in the afternoon on such days they again came out in numbers. My data show that one was out at 4:50 A.M. on May 27; another at 4:43 A.M. on July 17. Later in the season (October 8) caged chipmunks came out at 6:35 A.M. Two minutes later, just before sunrise, wild chipmunks also were active around camp.

Most of the chipmunks disappeared when the sun went down, but a few stayed out as late as half an hour after sunset. On August 9, 1946, the last chipmunk of the day was heard at 7:32 P.M. On September 24, 1947, one was seen at 6:18 P.M., about 30 minutes after sundown. On November 12, 1946, the latest observation for that year, a chipmunk chirped steadily for about 8 minutes, then entered his den at 4:56 P.M., 15 or 20 minutes after sunset.

Influence of weather. — When cloudy, the usual rhythmic cycle of activity is not so apparent. While chipmunks may be seen at any hour, even during a drizzle or light rain, heavy rains drive them to cover. They are quite active during the calm overcast period just before a rainstorm, and following a shower they usually appear in large numbers. For example, after one thundershower, at 11:00 A.M. on August 26, there were many chipmunks feeding on the flat at camp; several of them chirped steadily.

On windy days at Rocky Flat usually only a few chipmunks were in sight, but there was no reduction in the number caught in live traps. It seemed that the chipmunks stayed under cover to feed and avoided strong wind as much as possible.

Dust bathing. — Chipmunks frequently bathe in dust. They do this by rubbing along on outstretched belly and by rolling over on their sides and back. Dust helps keep their fur in good shape by removing excess oil. The fur of caged chipmunks becomes oily and matted in a few days if there is no dust to roll in.

Temperament. — Almost all of the chipmunks were nervous and frightened when handled. One exception was a male that was caught frequently. He sometimes stayed on my hand to eat a seed when I released him. Around camp certain chipmunks were bold enough to come within a few feet of me to steal food from my table or to raid a sack of corn, but at the least movement they usually scampered away.

Reaction to sound and movement. — Chipmunks have keen hearing. At distances of 100 yards they would react to my squeaks by calling excitedly and climbing onto some observation point to investigate the source of the strange sound. Even "harmless" noises and calls will startle them. One

"froze" at the sound of a robin and another, that was feeding on a dandelion at the edge of a clearing, ran to a log 10 feet away when a robin gave alarm notes.

Chipmunks also have good sight. On one occasion, as a goshawk flew swiftly along at a height of about 10 feet, first one and then another chipmunk along his route called in alarm. One of the chipmunks that had ducked under cover at sight of the hawk, came out onto a log within a few seconds. A ground squirrel also alerted stayed out of sight for a minute or two. When mildly alarmed, chipmunks often assume a picket-pin posture.

Manner of greeting. — When chipmunks meet each other, they first touch noses with outstretched necks, then they smell the sides of the face and shoulders and finally the anal region. The whole procedure may take about 5 or 6 seconds.

Communication

The voices of chipmunks are spirited and varied in keeping with their lively natures. Although difficult to represent, a general idea of their calls may be conveyed by phonetic symbols and a description of the notes and situations in which they are used. The voices of various species of *Eutamias* have been described by Grinnell and Storer (1924: 177-96), Gordon (1943: 58-59), A. H. Miller (1944: 87-89), and Larrison (1947: 23-30).

Among the chipmunks of Rocky Flat I could distinguish at least ten different calls. One of the commonest was a sharp, accented note, usually recorded as *kwst* (also as *kst*, *kwist*, *kss*). This call expressed mild alarm or excitement and may have served as a warning to other chipmunks. It was uttered in traps, when jays flew overhead, and when I approached or gave them peanuts.

Another call frequently used was a low, mellow note that sounded like a robin, and which I described as *pert* (also as *pwert*, *pyert*, or *whirt*). Chipmunks were able to make this sound with full cheek pouches. Individuals, after release and when 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 utterance his tail waved forward or backward. There was usually one note per second, but occasionally two in rapid succession. The calls sometimes were repeated for several minutes at a time.

One single note heard sounded like *peer*. At late dusk one evening a chipmunk monotonously repeated this call at the rate of one per second for about 8 minutes.

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.

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. Most chipmunks were vocal when handled, some expressed fear and others put up a fight. They often gave a kind of growl or throaty,

gutteral sound that seemed to express anger, recorded as *ugheeee*, *rrgh*, *ghr*, and *rrrr*. Males fighting in a cage also made such 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*, *geik*, and *eeuk*. One note was a high, thin *eee* sound that ended with a sharp *ik*.

Frightened chipmunks sometimes uttered a long quavering or trilled note, *ker-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 recordings for this sound were *tsr-r-r-r*, *sr-r-r-r*, *tseeerr*, *pseeerr*, and *pr-r-r-r*.

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 the lower jaw moved with each note.

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, the latter gave a series of thin, high notes that sounded somewhat like *tsee tsee tsee*.

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 is almost explosive, while the others usually diminish in volume and vigor. When birds of prey, 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 cry, and I often heard it when Steller's jays flew over. It seems strange that jays should frighten chipmunks. The element of surprise, however, 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 TO GROUND SQUIRREL

One rarely finds two forms which occupy so nearly the same niche as do the chipmunk *(Eutamias amoenus)* and the golden mantled ground squirrel *(Citellus lateralis)* in Washington. According to Grinnel (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." Johnson (1943) observed in California that "each species [of chipmunk] has a characteristic habitat which differs from those of other species. Where two or more species occur together in a general locality they are usually mutually exclusive in their choice of foraging and nesting sites and in time of breeding."

Notwithstanding the general truth of the above assertions, the habitat requirements of the chipmunk and golden mantled ground squirrel at Rocky Flat appeared to be almost identical and their behavior similar. 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, 40 or 50 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 the study area; this was a strip of forest no more than a few hundred feet wide that was bounded by the more open pine woods which seemed preferred.

Food choices of the two species are also similar. The many items upon which these animals feed in other parts of the western United States have been listed by Gordon (1943: 25-28) and Howell (1929: 4-11; 1938: 31-33). At Rocky Flat some plants they ate in common were dandelion heads, corms, fungi, and seeds of pine trees and lupines. Probably, there were a good many others. As a rule the ground squirrels selected the leaves and stems, the chipmunks, the seeds (Tevis, 1953).

Both animals forage and spend most of their time on the ground, but the two differ in 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. Although on several occasions the ground squirrels were seen at heights of 10 or 15 feet in bushes and conifers, they are not nearly so agile or apt to climb as the chipmunks. Thus, in respect to arboreal habits at least, ground squirrels have a more restricted habitat.

A list of the foods eaten by each species does not necessarily give any indication of the amount of competition for them. The same food may be eaten, but at different times and places and in different amounts, by the two animals. For instance, while both will eat conifer seeds, the chipmunk climbs 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.

The breeding seasons of both occur at the same time. Young ground squirrels first appeared in the area on June 4, 1947, and young chipmunks 5 days later. In each species there is only one litter a year, the offspring numbering about four to six on the average.

Chipmunks were certainly more abundant than ground squirrels at Rocky Flat, but my data on the numbers of the squirrels may be inadequate because the traps were somewhat small for them. The total catch of each species, 573 chipmunks and 67 ground squirrels, however, gives a rough

idea of their relative abundance. Gordon (1943: 43-44) gave populations for the two species at one camp in Colorado and at two in Oregon. His estimates of numbers per acre of *Eutamias* and *Citellus* at the three localities were, respectively, 6 and $2\frac{1}{2}$, 1 and 5, and 5 and 5.

Apparently there is little direct conflict between the two species. I have seen chipmunks, seemingly without fear, approach to within an inch or two of ground squirrels. Even breeding females of both species are tolerant of one another. Two of them raised families in dens only 30 feet apart. Their burrows were in nearly identical situations except for the fact that the chipmunk den was hidden beneath a log, while that of the ground squirrel was in the open.

In temperament there is a noticeable difference between the two species. The chipmunk seldom makes a slow movement; his actions are almost always quick and nervous. The ground squirrel moves more deliberately and in general is more phlegmatic; often he will remain motionless on a stump or some other lookout point for a considerable length of time. In May of 1947 a goshawk flew over the area, frightening all chipmunks and ground squirrels and causing them to take to cover. While the chipmunks reappeared a few seconds later, the ground squirrels did not come out for several minutes.

In the fall chipmunks remain active several weeks longer than the ground squirrels. They disappear in late October or early November. The ground squirrel, after acquiring a large amount of fat, goes into hibernation by the middle of October. The chipmunk accumulates no fat and apparently relies on stored food for sustenance during the winter months.

SUMMARY

This study of the chipmunk, *Eutamias amoenus*, is based on eleven months of field work in the Cascade Mountains in Yakima County, Washington, in 1946 and 1947. Most of the data were obtained by live-trapping and observation of about 600 chipmunks at Rocky Flat. The study plot (42 acres) was in open, yellow pine forest at an altitude of about 3800 feet.

This chipmunk proved to be a fine animal for field study because of its abundance, diurnal habits, and the ease with which it is trapped.

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 reach breeding age until the following spring. There is only one litter per year. Two litters born in captivity consisted of four and six young. Seven females averaged 5.8 embryos each. About 84 per cent of the adult females live-trapped in the spring of 1947 were pregnant or lactating. The sex ratio was 50-50.

Average weight at birth was 2.65 grams. The daily increase in weight was 0.47 grams. A peak was reached in about 90 days. The ears unfolded from the side of the head in 6 or 7 days. The eyes opened 30 to 33 days following birth. Upper incisors appeared in 22 to 29 days. The dorsolateral black and white stripes appeared in 10 days; the black center stripe first showed in 14 days.

Fourteen dens, all tunnels in the ground, were examined. None of them had loose dirt piled around the entrance. The average length of a burrow was 27 inches. The nest was at the end of the tunnel in a room about $6\frac{1}{2}$ inches in diameter. Favorite nest materials were grasses, pappi, and cotton from traps, and occasionally lichens and feathers.

November nests contained fleas and two species of flies, *Lutomyia aldrichi* and *L. distincta.*

Winter food stores consisted mostly of seeds placed in the bottom of the nest. At least twenty kinds of native plants were in three caches examined. Some of the commonest seeds were *Carex, Collinsia, Phacelia,* and *Pseudotsuga taxifolia.* Corms also were stored. The average number of seeds in these three winter caches was 35400; their weight averaged 143 grams.

Chipmunks ate the following foods most often: seeds of *Achillea millefolium, Cirsium lanceolatum, Deschampsia elongata, Gilia gracilis, Penstemon, Phacelia heterophylla, Pinus ponderosa,* and *Polygonum*; also, *fungi* (basidiomycetous tubers).

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

Individual weights of 60 grams or more usually indicated pregnancy. By July the weights of breeding and nonbreeding adult females were not significantly different, nor were those of adult males and nonbreeding adult females. Similarly, young males and females weighed about the same. In 1947, average weights of all age and sex groups were greater than in 1946.

Thirteen per cent of the chipmunks caught in a retrapping check, in 1950 were individuals marked in 1946 or 1947. Several of them were at least 5 years and 2 months old.

Twenty-three per cent of the chipmunks were parasitized in 1946 by the botfly, *Cuterebra.* Only about 9 per cent were similarly afflicted in 1947. Other parasites were fleas, ticks, mites, lice, and tapeworms.

These chipmunks have at least ten different calls.

The chipmunk, *Eutamias amoenus*, and the ground squirrel, *Citellus lateralis*, are alike in geographic boundaries of their ranges, habitat, food, and den requirements. They differ in temperament, and the chipmunks are more arboreal. Both hibernate, but the ground squirrels store up fat for the winter, while chipmunks do not.

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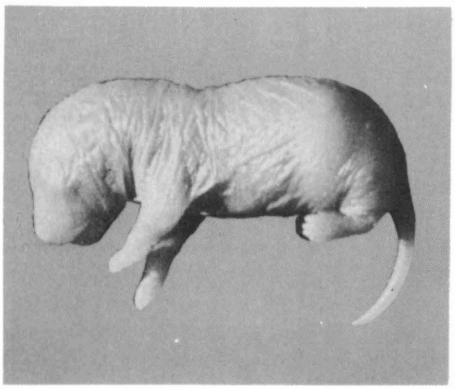
PLATES

William L. Brudon, Artist, Museum of Zoology, University of Michigan, has been most helpful in improving the quality of the illustrations.

PLATE I

Growth stages of young chipmunks (head and body length given) at: *A* (upper left), 20 hours, 35 mm.; *B* (upper right), 14 days, 50 mm.; *C* (lower left), 26 days, 70 mm.; *D* (lower right), 43 days, 90 mm.

PLATE I



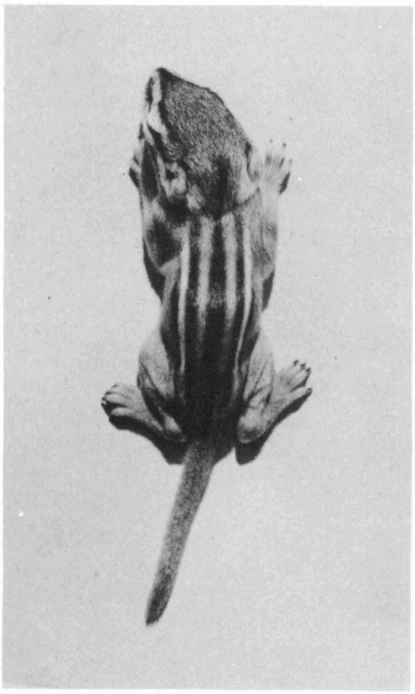


PLATE II

Chipmunk dens: *A* (upper), winter view of opening of den; *B* (lower), den excavated.

PLATE II

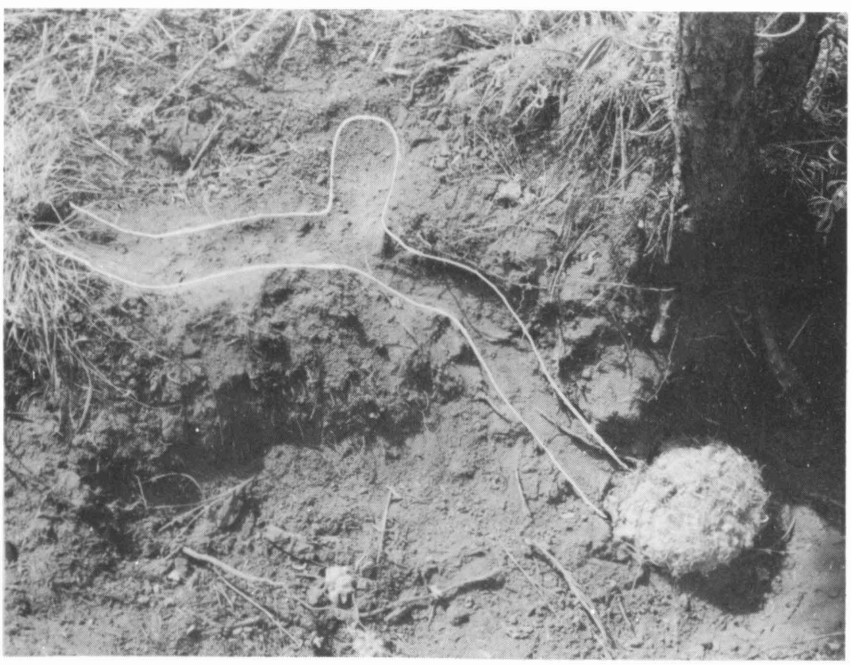
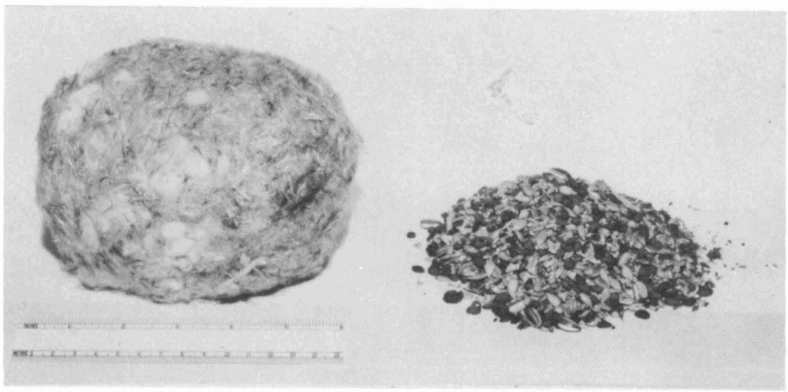
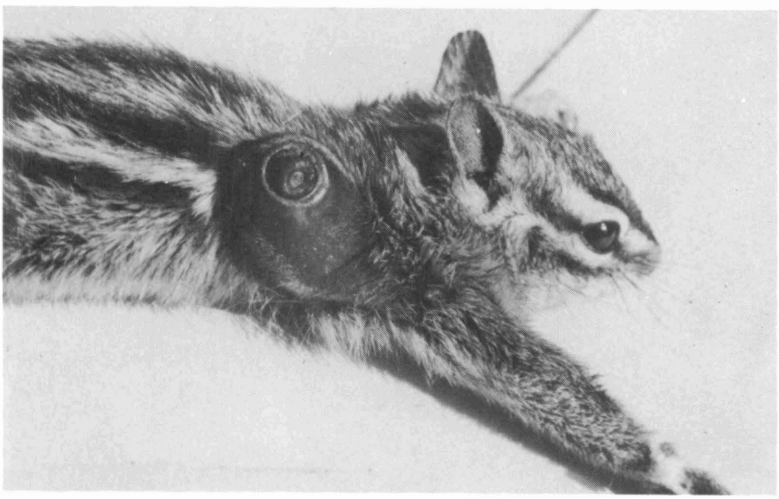


PLATE III

A (upper), Chipmunk nest and food contents from Den No. 12, collected November 16, 1946. Parasitized chipmunk: *B* (center), mature botfly larva (*Cuterebra* sp.) beginning to emerge, August 26, 1947; *C* (lower), fresh wound left after emergence of larva, August 29, 1947.

PLATE III





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