THE GOLDEN-MANTLED GROUND SQUIRREL CITELLUS LATERALIS CHRYSODEIRUS (MERRIAM) ITS SOCIAL AND COMMUNITY INTERACTIONS

by

JOHN HAROLD WIRTZ

A THESIS

submitted to

OREGON STATE UNIVERSITY

in partial fulfillment of
the requirements for the
degree of

DOCTOR OF PHILOSOPHY

June 1961

APPROVED:

Redacted for Privacy

Professor Zoology

In Charge of Major

Redacted for Privacy

Chairman of Department of Zoology

Redacted for Privacy

Chairman of School Graduate Committee

Redacted for Privacy

Dean of Graduate School

Date thesis is presented May 12, 1961

Typed by May Sono

ACKNOWLEDGEMENTS

This study was undertaken at the suggestion and under the direction of Dr. Kenneth L. Gordon, Professor of Zoology, Department of Zoology, Oregon State University. I am especially grateful to Dr. Gordon for his invaluable aid in the field and for his generosity in sharing with me his knowledge of interpreting natural history phenomena.

I am most graciously indebted to my wife without whose aid my graduate study would have been impossible. I am especially indebted to her for her encouragement when progress seemed to be at a standstill.

For their aid in the preparation of the manuscript, for helpful hints and suggestions, and for the use of materials, I am most grateful to Mrs. Eleanor Rigdon and Mrs. May Sono.

I am indebted to the National Park Service personnel at Crater Lake National Park. I especially wish to acknowledge the assistance given by Chief Ranger, Jack Broadbent, and Assistant Chief Ranger, Jack Raftery in keeping the study area intact. I am also grateful to Park Naturalist, Bruce Black, and Assistant Park Naturalist, Richard Brown, for the use of equipment and laboratory space.

A special note of thanks is also due Mrs. Shirley Malcolm for critically reading the manuscript and for helpful criticism.

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

LIST OF FIGURES

LIST OF FIGURES
(Continued)

LIST OF TABLES

INTRODUCTION

The golden-mantled ground squirrel, Citellus lateralis chrysodeirus, is an ideal mammal for field study. Diurnal in habit, it is easily captured and quite abundant in some areas. My primary goal was to learn more about the community interactions of this species, a program which involved live trapping over two seasons in 1959 and 1960. In addition to investigations of community structure and social hierarchy, observations were also made on the maturation behavior of young ground squirrels. The daily round of activity was noted, and attitudes assumed by mantled ground squirrels were photographed.

Preliminary research was also begun in the area of color discrimination and the distances this species will travel when removed from its home territory.

Crater Lake National Park was considered as an ideal location for these studies, for a variety of reasons. One of the main reasons was that, inasmuch as, all of our National Parks are wildlife sanctuaries, there would be no danger of a sudden destruction of a ground squirrel population because of vandalism or control

measures. Also, there are areas which are off limits to the public, and investigations can be conducted without interference from curious onlookers.

A study of this type seems desirable, not only from an academic point of view, but also from an economic standpoint. Any animal can be a destructive nuisance if the population is sufficiently large, and the more that is known of their life habits the easier it becomes to apply control measures.

THE GOLDEN-MANTLED GROUND SQUIRREL CITELLUS LATERALIS CHRYSODEIRUS (MERRIAM) ITS SOCIAL AND COMMUNITY INTERACTIONS

REVIEW OF THE LITERATURE

Mantled ground squirrels are a group of rodents which belong to the family Sciuridae. According to Hall and Kelson (20, Vol. 1, p. 292-410), North American sciurids, including Marmota, Citellus, Cynomys, Tamias, Eutamias, Tamiasciurus, Sciurus, and Glaucomys, in general extend southward from above the Arctic Circle to the Panama Canal, and eastward from the Pacific Ocean to the Atlantic seaboard.

Citellus lateralis ranges over almost the entire western half of the United States. Its range extends eastward from the Pacific Coast to approximately the eastern edge of the Rocky Mountains, and from the Cascade Mountains of southern British Columbia south to the Mexican border. A disjunct population has been reported from near Guadalupe y Calvo, Chihuahua. Citellus lateralis chrysodeirus in Oregon ranges from the Columbia River in the north to the Oregon-California border in the south, and from the Cascade Mountains eastward to approximately the 118th meridian (Figure 1).

Samuel Parker collected the type specimen of Citellus lateralis chrysodeirus in 1888 in the mountains near Fort Klamath,

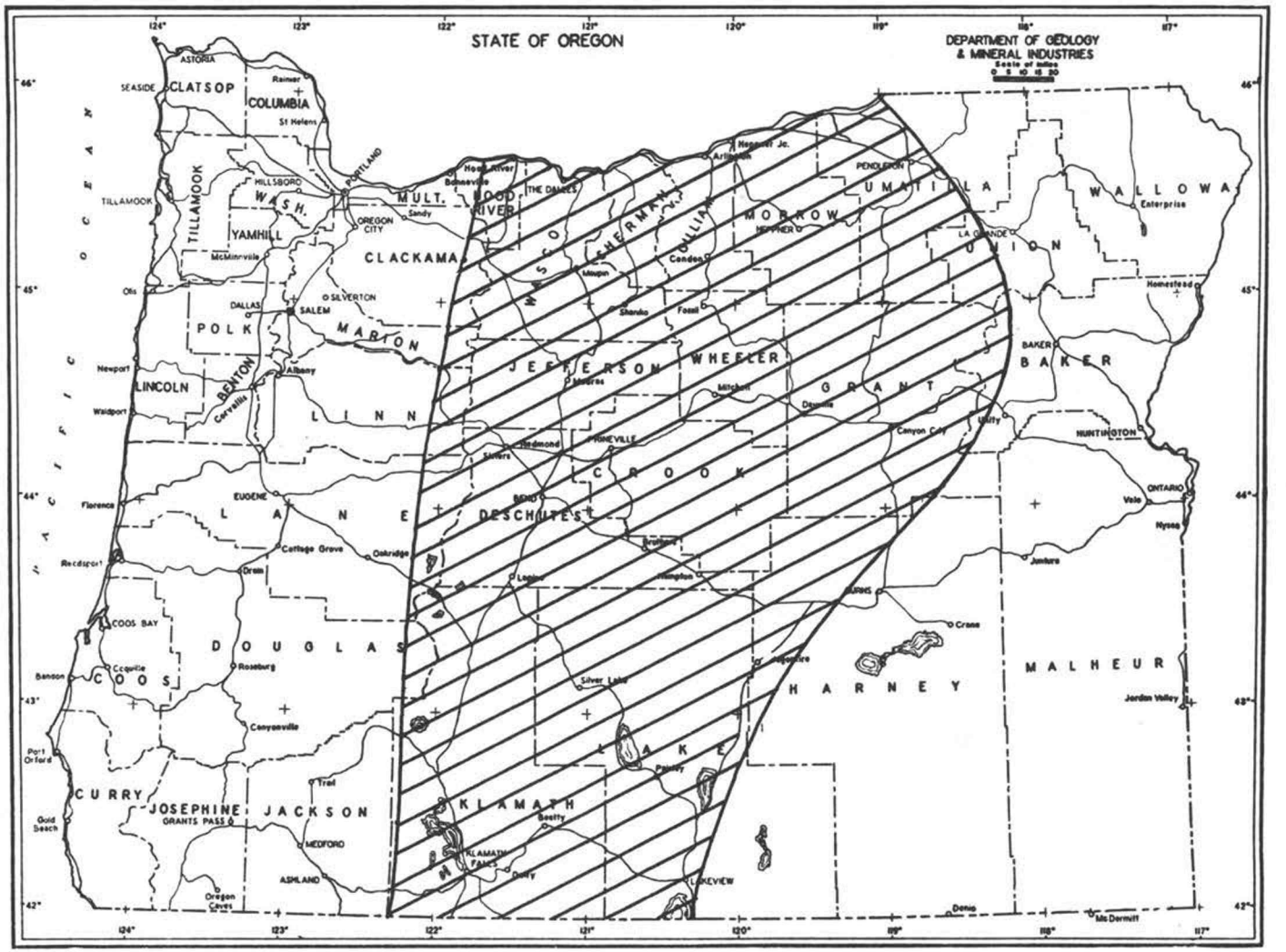


Figure 1 The range of Citellus lateralis chrysodeirus in Oregon.

Oregon (5, p. 139). In 1890, the name Tamias chrysodeirus was applied to this form of ground squirrel (30, p. 60) Merriam (31, p. 189-212) placed this group in the genus Callospermophilus, and Howell (22, p. 256) reduced this genus to subgeneric rank and placed the group in the genus Citellus. Although Hall and Kelson (20, Vol. 1, p. 362) use the generic name Spermophilus of F. Cuvier, the uncertain status of Spermophilus encourages the retention of the name Citellus.

In areas of heavy population the mantled ground squirrel is accused of causing damage to grain crops by carrying away the heads of wheat, oats and barley. However, the damage is of little consequence and control is easily accomplished by shooting, trapping and poisoning. In camping areas, these little rodents soon lose their fear of humans, and often become a nuisance by getting into food boxes.

Because the mantled ground squirrel is closely associated with forested areas, Wahlenburg (51, p. 637-641), and Taylor and Gorsuch (42, p. 218-223) considered them to be an important consumer of conifer seeds. Smith and Aldous (41, p. 361-369) discussed the large quantities of seeds eaten by red squirrels (Tamiasciurus hudsonicus), and various species of Eutamias, but only mentioned that the mantled ground squirrel is responsible for

seed consumption. Mullaly (33, p. 65-73) listed pine seeds as a food item as did Gordon (19, p. 27). Taylor and Gorsuch (42, p. 218-223) obtained data from carefully controlled plots, and reported that the Arizona mantled ground squirrel was the animal responsible for complete depredation of yellow pine seedlings in the Flagstaff area. Tevis (46, p. 291-292) also stated that mantled ground squirrels are a threat to reforestation because of their seed-eating habits. On the other hand, after analyzing the contents of 314 stomachs, Tevis (43, p. 198-205) concluded that Eutamias townsendii is more detrimental than are other kinds of chipmunks, and that the mantled ground squirrel, at least in the Sierra Nevadas, did not gather or eat pine seeds even at places where E. townsendii found them.

Tevis (44, p. 316-324) further reported that hypogeous fungi are most important in the diet of chipmunks and ground squirrels, and where there is an abundance of fungi, the mantled ground squirrel eats relatively few conifer seeds. From a series of 71 stomach analyses, Tevis (43, p. 198-205) cited a percentage volume of 67%, and a percentage frequency of 82% for subterranean fungi. No conifer seeds were found. Tevis stated that an economic rating cannot be assigned, for a species may be harmful in one area and beneficial in another; thus, he suggested every area should

be studied and managed as a unit.

Although the economic importance of the mantled ground squirrel may be somewhat tenuous, much has been done in regard to behavior. During the past 40 years a vast amount of literature has accumulated which is concerned with various aspects of behavior. The social structure of animal groups has been given particular attention. The principle investigators in this area of study are J. B. Calhoun (10, p. 139-157, and 11, p. 287-301), Konrad Lorenz (27, p. 221-268 and 28, p. 67-78), J. P. Scott (38, p. 1001-1122; 39, p. 213-220, and 40, p. 281) and Niko Tinbergen (47, p. 281; 48, p. 1-150, and 49, p. 1-289). Most of the behavioral work, however, has been carried out in the laboratory, or at best, in semi-natural conditions. In all this wealth of literature, Gordon (19, p. 104) with his classical approach to behavioral studies, is one of the few who has done any work on the social structure of the mantled ground squirrel.

Investigations in the area of sensory physiology have contributed much to our understanding not only of perceptual processes, but also of evolutionary trends which become more evident when a comparative approach is employed. Again, most of the work has been done on animals in the laboratory. Gordon (19, p. 49-53), working on smell and form discrimination in the mantled ground

squirrel, is one of the few investigators to go into the field and work with animals in their natural habitat.

Of all visual processes investigated, color vision has received the most attention. According to Walls (52, p. 514), all scuirids, with the exception of the flying squirrel, have pure cone retinae; yet there is little work reported on color vision in this group. Kolosvary (25, p. 473-477) found when the West European ground squirrel, Citellus citellus was offered variously colored bits of paper for nesting material, certain colors were selected more readily than others. From these data he concluded that this form possessed color vision. Walls (52, p. 515), in comparing this data with color preference in the tree-squirrel, indicated some doubt as to the validity of Kolosvary's interpretation. Reimov (36, p. 585-587), working with the dwarf souslik Citellus pygmaeus in the field, indicated that this animal exhibited a differential brightness discrimination rather than a response to color.

MATERIALS AND METHODS

Location and Description of the Study Area

The areas where this investigation was carried out are all within the boundaries of Crater Lake National Park, Klamath County, Oregon. The area most extensively trapped and where the main observations were made is located near the south entrance to the park, T32S., R. 6E., Section 25. This site was being used by the Park Service as a storage place for scrap wood (Fig. 2). The nine large, dome-shaped piles formed excellent places of refuge, and as a consequence, there was a fairly large population with which to work. The area in which color perception tests were conducted was near the Headquarters region where cabins for the seasonal staff are located.

The area at the south entrance at an altitude of 4, 500 feet is considered to be in the Transition Zone. The prevalent plant species are as follows: (Plant names and authorities are according to Peck's Manual of the Higher Plants of Oregon.)

Trees

Pinus ponderosa	Pseudostuga menziesii
Pinus monticola	Populus trèmuloides
Pinus lambertiana	Populus trichocarpa

Figure 2. A view of the south entrance study area.

Trees (Continued)

Pinus contorta

Abies concolor

Prunus emarginata

Shrubs

Ceonothus velutina

Amelanchier florida

Ribes cereum

Ribes viscossisemum

Purshia tridentata

Herbaceous forms

Cynoglossum occidentale

Castilleja pinetorum

Gilia aggregata

Delphinium depauperatum

Phacelia heterophylla

Lomatium triternatum

Phlox diffusa

Collomia tinctoria

Antennaria rosea

Fragaria sp.

Spraguea umbellata

Corallorhiza maculata

Penstemon hesperius

Pterospora andromeda

Gayophytum diffusum

Lupinus andersoni

The headquarters region at an altitude of 6,000 feet is in the Canadian Zone. The prevalent plant species for this region are as follows:

Trees

Abies magnifica var. shastensis

Abies lasiocarpa

Tsuga mertensiana

Alnus sinuata

Alnus tenuifolia

Shrubs

Arctostaphylos patula

Arctostaphylos nevadensis

Sorbus sitchensis

Ribes erythrocarpum

Penstemon davidsoni

Amelanchier florida

Sambucus callicarpa

Herbaceous species

Dicentra formosa

Senecio integerrimus

Viola glabella

Similacina amplexicaulis var. glabra

Scirpus microcarpus

Microseris nutans

Hieracium albiflorum

Gilia aggregata

Corallorhiza maculata

Valerian sitchensis

Lonicera conjugialis

Senecio triangularis

Epilobium angustifolium

Phlox diffusa

Fragaria sp.

Polygonum bistertoides

Aster cascadensis

Weather

The summers at Crater Lake are warm and dry. The maximum daily temperatures were reached between 2:00 and 3:00 p. m. The means and ranges of daily maximum and minimum temperatures recorded at the south entrance area are summarized in Table 1.

Out of a total of 83 days in which sky conditions were recorded, 22 days were cloudy. However, there were only five days in which the cloud cover was 0. 5 or more. On the other days, the clouds were of the fair weather cumulus type and constituted a sky covering of 0. 3 to 0. 4.

In general, humidity was low, ranging from a high of 50% early mornings (6:00 - 8:00 a. m.) to a low of one or two percent during the hottest part of the day.

Temperatures within burrows varied little throughout the day, ranging from a low of 56 degrees at 6:50 a. m. on July 28, to a high of 79 degrees at 12:15 p. m. on July 22. Temperatures taken six inches below the surface were similar to those recorded for the burrows.

Temperatures taken from thermometers laid on the ground ranged from a low of 58 degrees at 6:50 a. m. to a high of 147 degrees at 2:00 p. m. One inch above the surface, the temperature ranged from a low of 46 degrees at 6:50 a. m. to a high of 112 at

TABLE I

The Means and Ranges of Maximum and Minimum Temperatures at the South Entrance Study Area 1959-1960

Temperatures in Degrees Fahrenheit

	Shade				Open			
	Maximum		Minimum		Maximum		Minimum	
	Average	Range	Average	Range	Average	Range	Average	Range
1959								
July								
Second half	82.1	72-89	44.3	30-58	99.7	94-105	34	18-55
August								
First half	82.1	73-87	45.8	31-47	101.6	97-107	27.7	20-37
Second half	74.6	72-80	37	33-40	91.6	86- 98	27	23-33
1960								
June								
Second half	75.3	70-78	30.4	26-32	83	70- 90	26	18-33
July								
First half	77.8	72-85	39.5	34-42	92.1	89- 99	34.5	27-40
Second half	84.4	80-86	44.2	40-48	99.6	94-106	38.4	34-43
August								
First half	81.2	68-86	40.6	35-48	97.2	84-102	36.4	29-42
Second half	76	64-83	32.6	30-37	92.6	80-102	28	25-32

2:00 p. m. One foot above the surface the low temperature was 54 degrees at 6:50 a. m. ranging to a high of 114 degrees at 1:30 p. m.

Snow comes in late August. During the summer of 1959 the first snow fell August 19. On August 22, 1960, two inches of snow were recorded at 9:00 a. m. However, the early snows rarely last more than a day or two.

Trapping and Marking

All animals were live-trapped with Sherman traps constructed of sheet metal. Because of the high temperatures in the south entrance area, the traps were covered with boards and inspected hourly. Traps were baited with oats and placed under wood piles and other likely spots known to be inhabited by ground squirrels. To facilitate handling for marking and weighing, animals were released from the trap into a cloth sack. For permanent marking, certain toes of the hind feet and forepaws were amputated. The hind toes were numbered one through nine, starting with the outermost toe of the left hind leg when the animal is viewed from the ventral surface (Figs. 3 and 4, Table 2). The tenth toe on the right hind foot was number 90. The toes of the front feet were numbered 10 through 80, starting with the outermost toe of the left forepaw when the animal is viewed from the ventral side. With this method, 215 animals could be marked, and no more than one toe need be

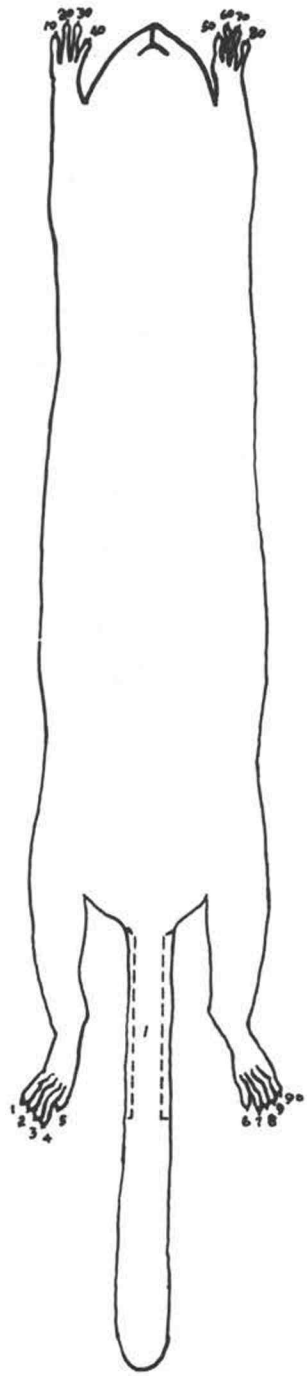


Figure 3 The numbering system used in amputating toes for permanent marking.

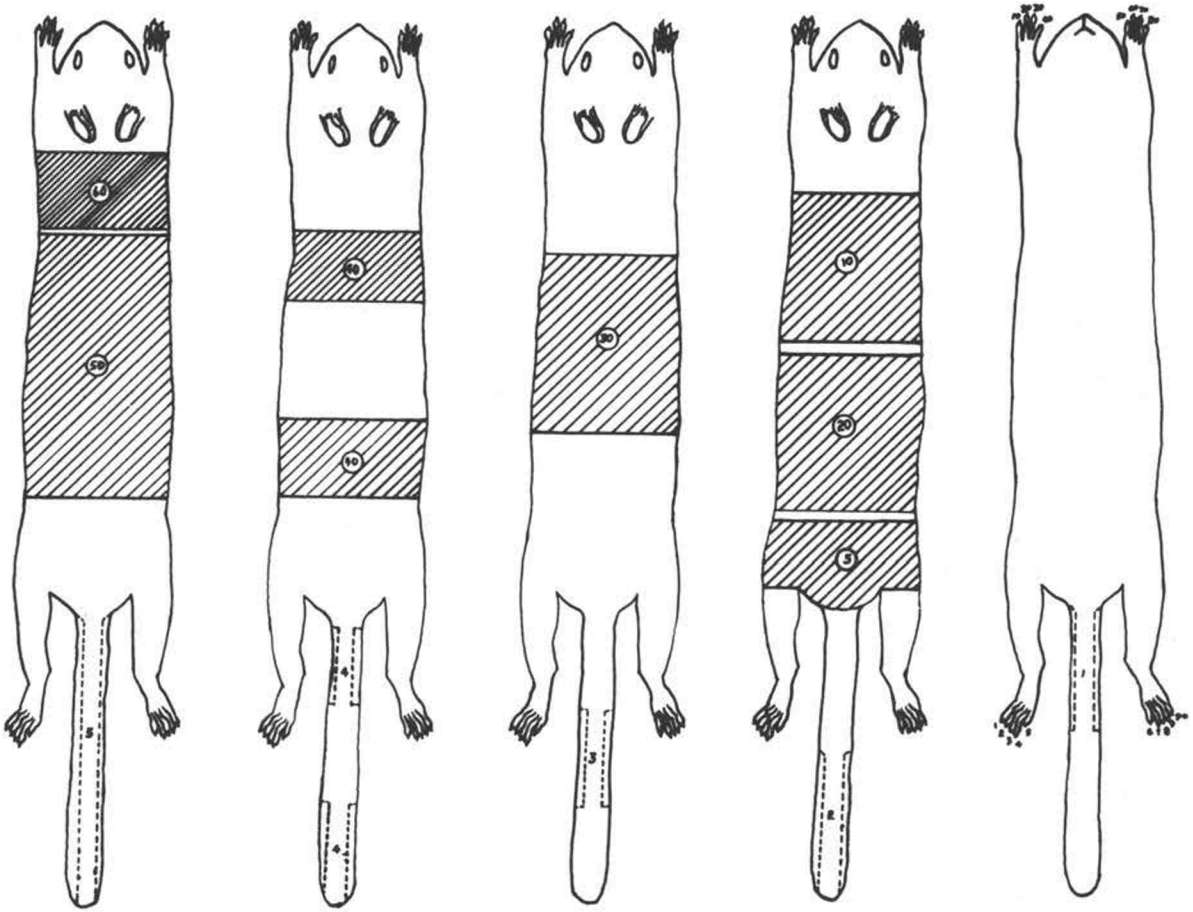


Figure 4 A diagrammatic representation of the visual marking system.

TABLE II

Summary of Coding System for Permanent and Visual Marking of Golden-Mantled Ground Squirrels

Number	Permanent Mark	Visual Mark
1	1 toe of left hind foot amputated	Basal third of tail hairs clipped
2	2nd toes " " " "	Apical " " " "
3	3rd " " " " "	Middle " " " "
4	4th " " " " "	Basal & Apical " " "
5	5th " " " " "	Entire tail clipped
6	1st toe of right hind foot amputated	Rump dyed + Basal third of tail hairs clipped
7	2nd " " " " "	" " + apical 3rd " " "
8	3rd " " " " "	" " + middle 3rd " " "
9	4th " " " " "	" " + basal and apical 3rd clipped
10	1st toe of left front foot amputated	Anterior third of back dyed
20	2nd " " " " "	Posterior half of back dyed
30	3rd " " " " "	Middle half of back dyed
40	4th " " " " "	Anterior and Posterior third of back dyed
50	1st toe of right front foot amputated	Entire back dyed
60	2nd " " " " "	Shoulders dyed
70	combination of toe amputation	Combinations of shoulder stain plus any of the above

removed from any one foot. The toes were amputated with side-cutting pedicure clippers. The animals showed no distress with this procedure, and generally there was little bleeding. No animals re-trapped showed any indication of infection, and the wound was well healed within a few days.

The animals were also marked with a dye substance to enable individual to be identified at a distance. Prior to the field work, a number of dyes were tried out in the laboratory on white rats in order to determine how long these would last. Methyl blue, coralin yellow, eosine, erythrosin, methyl red and methyl green were made up in various strengths, using alcohol, formalin and water as solvents. None of these dyes lasted more than 10 days on the caged animals. On the basis of these results, none of these dyes were used on animals in the field. The use of a 10 per cent silver nitrate solution proved to be most satisfactory. The animals were stained a deep reddish color which was permanent enough to last from one moult to the next.

The coding for visual purpose is as follows: For units one through five tail hairs were clipped as shown in Figure 4. The broken lines indicated the area where the hair were clipped. Thus, for example, 1/2 of the basal portion of the tail was clipped for animal number one. For animal number four, the basal one third

and 1/3 of the apical portion of the tail were clipped, thus leaving a tuft of hairs in the middle third of the tail. The next unit set of numbers, six through nine, were indicated by painting the rump with $AgNO_3$ plus the clipping of tail hairs. Units of ten were indicated by staining the shoulders with $AgNO_3$. Units of 20 were indicated by dyeing the posterior half of the back with $AgNO_3$; units of 30, by dyeing the middle third; units of 40, the anterior and posterior third of the back; and 50, the entire back. Numbers 60 to 100 were indicated by staining the shoulder with $AgNO_3$ plus combinations of the patterns for units 10 through 50; thus, for example, number 63 would have the entire back plus the shoulder dyed, and the middle third of the tail would be clipped. For numbers beyond 100, other dye substances could be substituted, such as picric acid; however, the stain is light and difficult to observe. Hair dye (Miss Clairol #33, bright red red was tried with success, but is not as expedient to use in the field because of application methods.

Color Discrimination Testing

Three approaches were used in an attempt to ascertain whether or not mantled ground squirrels would indicate a color preference. In the first attempt at color discrimination, ground squirrels were conditioned to coming to a particular area to obtain unshelled peanuts (Fig. 5). After the conditioning period, unshelled

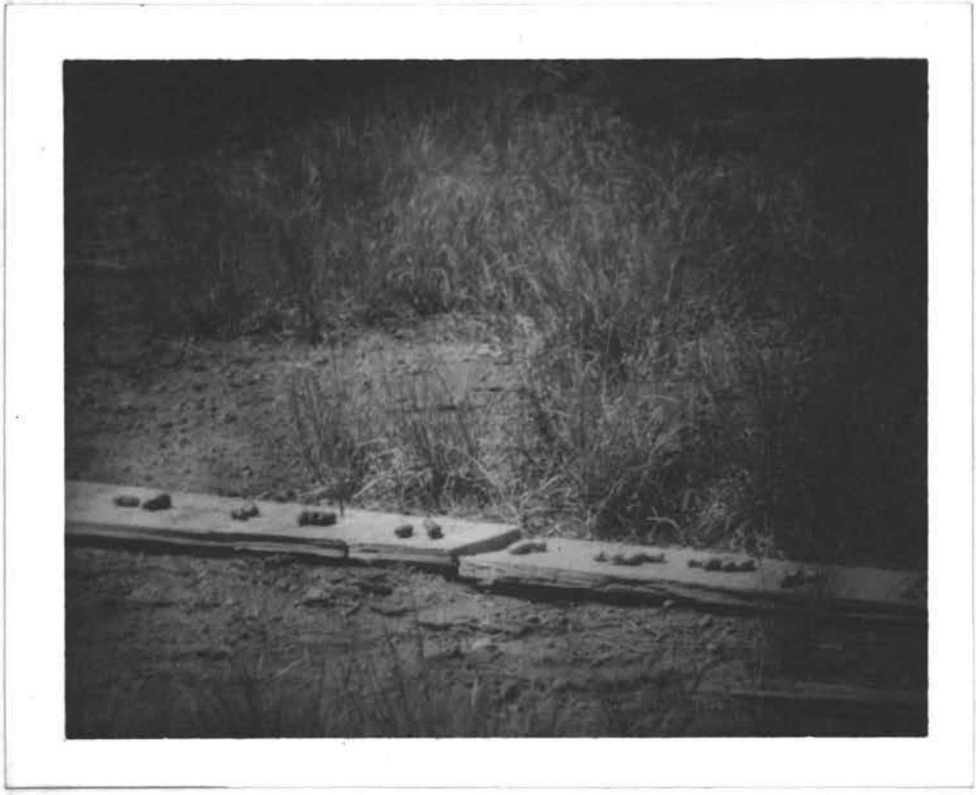


Figure 5. The method of displaying variously colored peanuts during the preliminary period of color discrimination experiments.

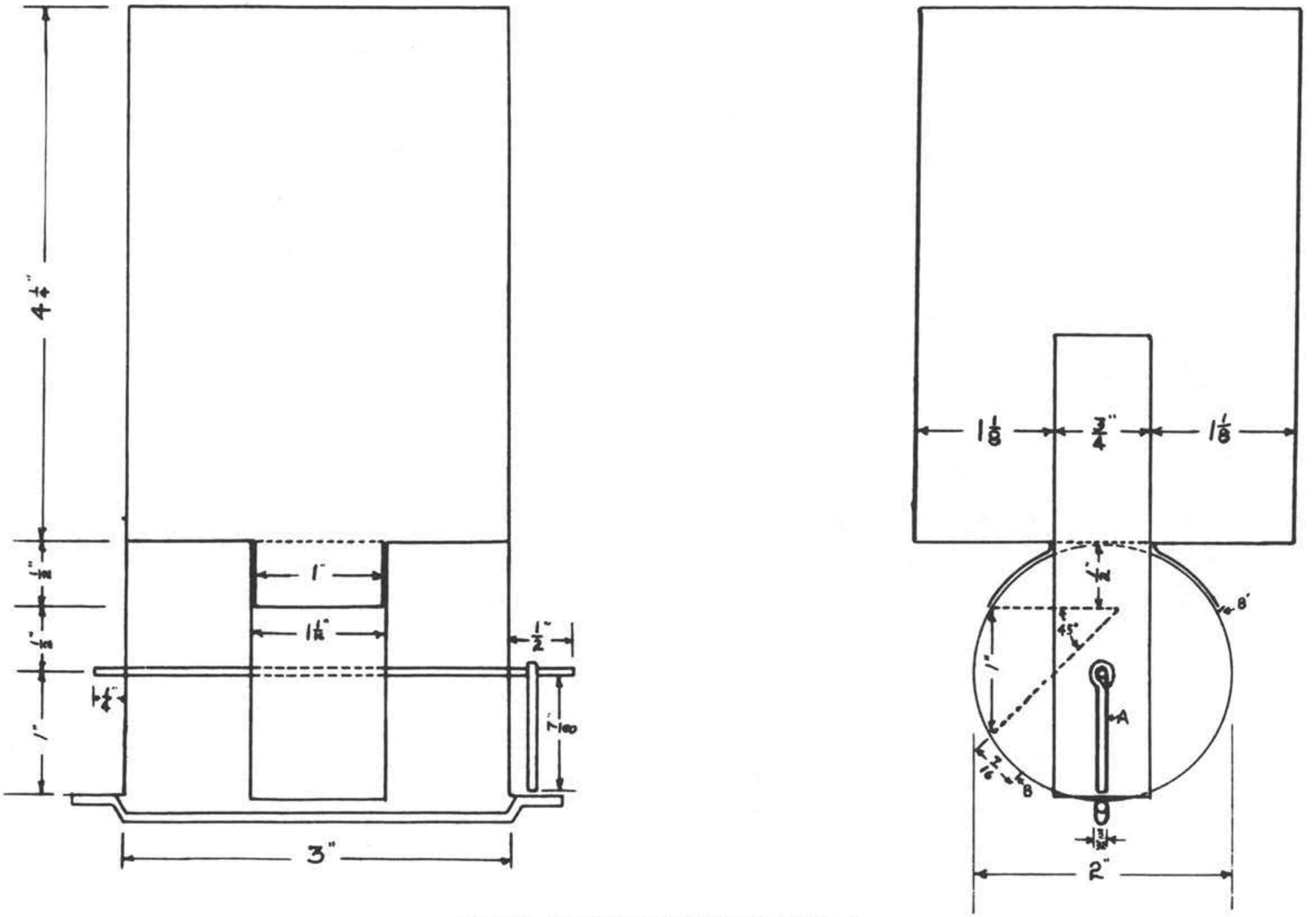
peanuts stained blue, red, yellow, and green with Rit dyes were substituted for natural colored peanuts. Colored and uncolored peanuts were also soaked in gasoline, pine pitch, alcohol, formalin, creosote oil stain, and pine oil disinfectant, in order to eliminate the possibility of these animals responding to odor. In another experiment, colored and uncolored peanuts were placed in No. 11 veterinary capsules and suspended from strings. This eliminated not only odor, but also prevented the animals from "recognizing" peanuts by feel and/or texture.

In the third experimental set-up, three plywood boxes were constructed, each with a door through which ground squirrels could enter (Fig. 6). Once the animals were conditioned to go into the boxes for food, colored construction paper was placed over each door. At first, red, yellow, and blue colors were used. Later, other colors plus various shades of gray and finally no colors at all were employed. To test for color discrimination, only one box, the reward stimulus, had food in it which was available to the animal. The non-reward stimuli had food in the box, but it was not available to the ground squirrels. After each trial, whether successful or not, the positions of the boxes were changed, thus avoiding the possibility of position-learning.

When the boxes were first set out, generous amounts of the

Figure 6. An illustration of two of the experimental units and the manner in which they were arranged when testing for color vision.

food, peanuts and oats mixed, were placed on the floor of the box. This soon proved to be impractical; for once an animal entered the box, it would stay there until its cheek pouches were full. To overcome this difficulty, a food dispensing device was invented (Figs. 7 and 8). This consisted of a tin can as a reservoir with a one inch by one inch opening cut into the bottom. Beneath this opening, a wheel two inches in diameter, and one inch wide, with a pocket in it large enough to hold five peanut kernels was suspended on an axle between brackets. A short lever was soldered to the axle, and a cord was attached to the inside of the door and the lever. Thus, when the door was opened, five peanuts were dropped to the floor of the box. When the device was first set up, the operation was entirely automatic, i. e., the bucket would trip on opening the door and be reset when the door closed. This proved to be disadvantageous, for the animals soon learned to respond to the sound of dropping peanuts as they opened the door to leave the box. They would then turn around and continue to fill their pouches. This problem was overcome by attaching a length of string to the lever ("A" Fig. 7) and by manually operating the closing of the door and resetting of the bucket.



FOOD DISPENSING DEVICE

Figure 7 Construction details of the food dispensing device used in color vision experiments.

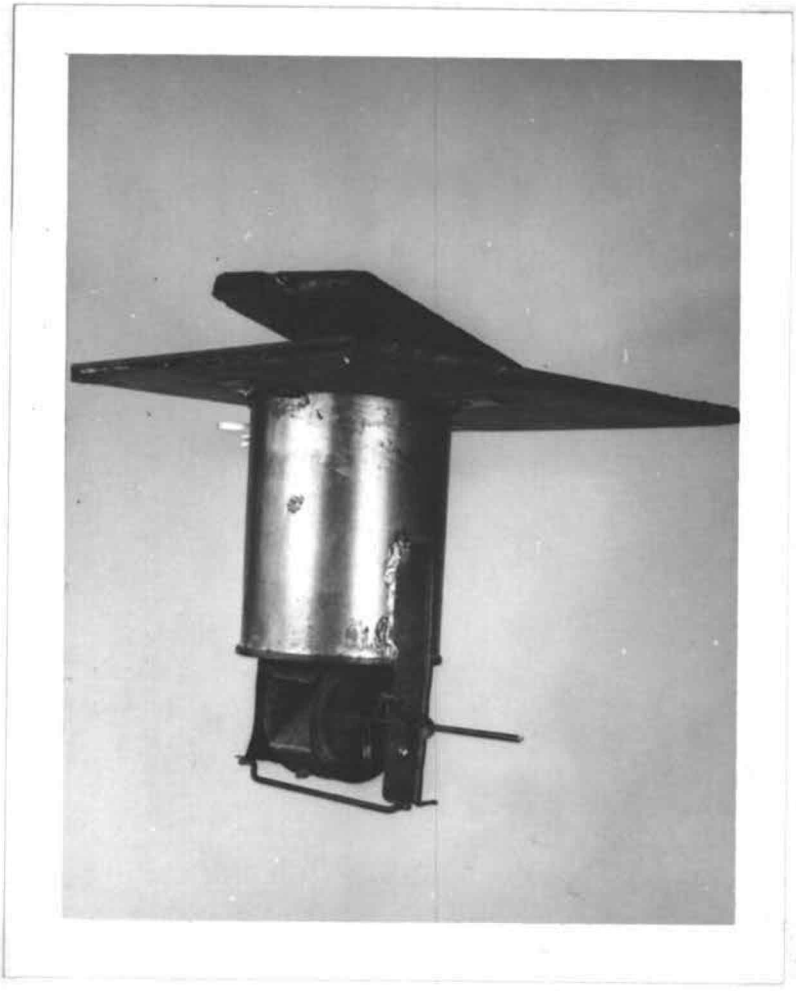


Figure 8. Photograph of the food dispensing mechanism. Food was put into the container through an opening at the top.

Animal Movements

In order to obtain data on distances travelled by ground squirrels removed from their home territory, squirrels were live-trapped, marked in the usual fashion, returned to the trap and then transported various distances and directions. To avoid taking nursing females, or unweaned young ground squirrels, trapping for removal was delayed until the first week of August at which time mammary glands were reduced and the young of the season were foraging for themselves. Over short distances the animals were transported by foot, the distances being measured by using a 100 foot length of rope. Animals transported more than 1/2 mile were carried to the release site by automobile.

Burrows

A number of burrows were opened, and diagrams and measurements made of the course. The soil is mainly pumice and pine duff, and as a consequence is quite soft. In order to facilitate following the course of the burrow, a flexible branch was used as a guide while opening the burrow.

Observations and Records

Where necessary, observations were made with a pair of 7 x 40 binoculars. Notes were recorded in the usual fashion the

first season. However, the second summer, a battery-operated, transistorized tape recorder was used for note-taking in the field. This proved to be especially helpful since there was no need to stop observing to write notes. Photographs were made with a Kine-Exakta, using normal and telephoto lenses. The first summer Kodachrome film was used. The second season High-Speed Ektachrome (ASA160) was used with superior results. For purposes of thesis illustration, black and white negatives were made from the color transparencies and printed in the usual manner.

Tranquilizers

As an aid in following mantled ground squirrels over the course of their activity, some preliminary experiments were conducted using Promazine Hydrochloride (Gamma-dimethylamino-n-propyl phenothiazine hydrochloride) as a tranquilizing agent. The biggest difficulty encountered was in arriving at a satisfactory dosage. Interpolating from the dosages used on dogs and cats was unsatisfactory, and while some idea of the dosage required for ground squirrels was obtained, there still remains more work to be done.

Weights

The animals were weighed on a dietary scale each time they were trapped. The weights were recorded to the nearest gram.

Climatological Data

Two areas were set up; one, in an area of a dense grove of trees, and the other, in an open area. A maximum-minimum thermometer was used to keep a record of the daily range of temperatures in both areas. In the shaded area, humidity readings were obtained by use of a bulb psychrometer; in the open area, a hygrometer was used. In addition to recording ambient temperatures in the open area, soil temperatures at a depth of six inches below the surface, as well as temperature at the surface one inch and one foot above the surface were also taken. Wind direction and velocity, and degree of cloudiness were recorded. Using a standard photographic exposure meter, readings were taken from a standard gray card in sunny as well as in shaded areas. Weather readings were generally made at 10:00 AM, 12:00 noon, and 2:00 PM. Temperatures were recorded in degrees Fahrenheit.

Histological Preparations

Eyes for histological preparation were obtained by placing the animal in a state of surgical anesthesia by intraperitoneal

administration of sodium pentathol. The eyes were excised, and the oculor fluid was replaced with Bouin's fixative, and preserved in the same. The tissue, after fixation, was embedded, sectioned at 7μ, and stained with hematoxylin and eosin.

RESULTS AND DISCUSSION

Activity of Young Mantled Ground Squirrels

There is little reported on the activity of young mantled ground squirrels. Jaeger (24, p. 168) described some of the activities of young chipmunks, and Gordon (19, p. 56) described briefly some of the behavior of young ground squirrels.

When young ground squirrels first left the nest, they were rather docile. They remained near the burrow opening, and unless called by the female, remained there allowing the investigator to approach to within a few feet. As Gordon pointed out, for the first two or three days, one can approach closely enough to touch them. However, as time passed, the young began to explore the immediate area around the nest site, gradually moving farther and farther away. At first, investigative behavior carried the young a distance of only two or three feet from the nest site. After each of these short excursions, the young dashed back and assumed a position of alertness, sometimes for as long as two minutes. By the second day, the extent of movement was considerably increased. During the early morning hours, the young moved four to six feet from the nest site; however, by midmorning this distance was increased to about 15 feet; some of the more aggressive individuals moved as

much as 50 feet in their quartering activity. At the end of the third day, some of the young were moving 75 to 100 feet from the burrow. Although the distance covered by most of the young were still quite short, ranging from 10 to 20 feet.

When the young first came out of the burrow, a large part of the time was spent sitting in an erect position near the burrow entrance. The female appeared to spend little time with the young. Outside of the nest, she sat in an erect position near the burrow opening, preferably on a stump or some other elevated structure which gave the animal full view of the surrounding area. She appeared to pay no attention to noises in the immediate vicinity. The young, however, sitting near the female, turned their heads in the direction from which the sound originated, such as the call notes of a solitary vireo, the churring of a chickaree or the chattering of a chipmunk. If the sounds were of a particular quality, young ground squirrels quickly sought cover.

For example, a chickaree in a near by tree made a "thumping" noise, and suddenly gave forth with a series of scolding notes; the young ground squirrels scampered behind the female, sat up and looked about, and then disappeared into the burrow. The female sat quietly until the chickaree gave forth with a staccato "uu-uu-uu" call; the adult ground squirrel then moved to a vantage point, looked

about for a moment and disappeared. After about five minutes the young reappeared, sat erect and looked about for a moment, and then made short exploratory movements. After an interval of 15 minutes the female returned, looked about for a few seconds and disappeared again.

At times when the female returned to the nest site, she had some nesting material which she carried into the burrow; after an absence of about five to ten minutes she reappeared. At no time was a female seen to carry old nest material from the burrow.

After the young left the nest, there were only brief epimeletic encounters. When the female returned from her foraging and the young were at the nest site, the female stopped, sat erect, and the young approached the female and attempted to suckle. It appeared, however, that these attempts were unsuccessful, for the female seldom stayed still long enough for the young to obtain any milk. On several occasions, a type of behavior that appeared to be a display of "affection" was noted. A female returned to the nest site, and when a young ground squirrel approached her, she held the face of the young in her forepaws and bumped noses. The young responded in kind, followed by the female gently tapping the young on the head with her forepaws. Sometimes when the female started to leave the nest site, the young would follow; the female would stop,

and the young would nuzzle the female. The female would then push the young to one side and dash away; the young would quarter about for a brief period, return to the nest site, and assume an erect position.

While the young in many respects resembled the adults, there were differences other than size which made them quite distinctive. The young, first of all, were brighter in color than adults, and in general had a fuzzy rather than a sleek appearance. Young ground squirrels were also quite clumsy, showing little of the agility of the mature animal. Even when sitting on a flat surface in an erect position, they lost their balance and topple over. On several occasions they were seen to topple off a log which was about three feet above the ground. At other times they were observed attempting to climb into a Ceonothus bush, only to lose their grip and tumble to the ground. They would, however, continue trying until they reached the particular spot for which they started.

The young played among themselves, sometimes wrestling, at other times indulging in sexual play, one mounting the other and making copulatory movements; at other times, there were short chases lasting only a few seconds. (Fig. 9) At no time was it possible to establish any chase order amongst the young.

Figure 9. Sexual play of juvenile mantled ground squirrels.

The manipulative ability appeared to be quite well developed. Several young were observed gathering seeds of Carex inops by pulling down the fruiting head with hand-over-hand movements (Fig. 10).

When the young were not engaged in playful activity, foraging, or investigating, they would either sit or lie in the sun, much in the manner of the adult. Like adults, when the young ate, they would first pick up the food with the teeth, then take a sitting position and handle the food with the forepaws (Fig. 11).

A pair of juvenile male mantled ground squirrels were kept in a cage with an exercise wheel for a two week period for observation. The wheel was operated about five minutes after the pair were introduced into the cage. At times they would operate the wheel in unison; sometimes side by side; at other times in tandem fashion.

There was frequent fighting, manifested by clawing, biting, and rolling about. This activity lasted from two to 30 seconds and was always accompanied by churring sounds. The loser frequently dashed to the wheel and ran vigorously for a short period of time, an activity which was considered to be displacement behavior, a type of behavior comparable to an angry person throwing something, or when frightened running away. The winner would feed for a while

Figure 10. Juvenile mantled ground squirrel pulling down fruiting head of Carex inops.

Figure 11. Feeding position of juvenile mantled ground squirrel.

and then go to sleep. If the subdominant animal was sleeping, the dominant one would start nipping at the flanks of the resting ground squirrel. This was generally followed by a short fight.

When the animals were released, the dominant one left the cage four minutes after the door was opened. During this interval the animal would climb to the opening, look about, drop to the floor of the cage, run in the exercise wheel, and go back to the open cage door. Finally, the animal jumped to the top of the cage, leaped to the ground, quartered about for a brief time and disappeared. The subdominant squirrel left the cage about 12 minutes after the door was opened. There was a direct move from the floor of the cage to the opening. After a short period of looking about, the animal jumped to the ground and scampered away. Both animals were observed in the area for a few days, and after that were not seen again.

A few observations were made possible on a young male nesting ground squirrel when Dr. Gordon fortunately saw a female drop the young animal as she was carrying it to a new burrow. There was no fear indicated. When the animal was picked up, no attempts to escape were made. It would take diluted milk from a medicine dropper readily, lapping the milk from the tip. When the dropper was empty, it would feebly gnaw on the tip for a short time, and then curl up and go to sleep. The animal would go to sleep

readily when held in the hand, provided it was held snugly. Thus held, even when awake, the animal could be turned in any direction, except head down. If held this way it would struggle to obtain a normal position. Within a day, the animal was more difficult to hold and struggled to free itself.

Social Dominance

From about 1920 there has been an enthusiastic study of behavior of infrahuman species with the idea in mind of laying the foundation for a basic science of general sociology, thus providing a frame of reference for human behavior studies from a social and ecological background (39, p. 213-220). There is still a great need for social behavior studies, of a comparative nature, in order to provide an adequate basis for general theories. Howard (21, p. 1-308) wrote on the significant relationships between song and territory in 1920. But not until Schjelderup-Ebbe (37, p. 225-252) discovered the social hierarchy of the domestic chicken was the full significance of territory establishment and maintenance realized. According to Collias (13, p. 83-123), this is an undeveloped field of study, and any suggestions are to be regarded as a framework for continued research rather than as well developed rules.

The social hierarchy or chase order of mantled ground squirrels was worked out at the south entrance area and at the

headquarters study site. In order to get the animals into a contact situation, large quantities of food were put into an open area.

The work of Schjelderup-Ebbe (37, p. 225-252) Allee (1, p. 129-146) and others working with hens, pullets and cockerels reported that the organization is quite well developed; that is, there is a straight-line relationship: "a" pecks "b," "b" pecks "c," and so on. In mantled ground squirrels, as Gordon (19, p. 63) pointed out, the social structure is loosely developed.

Although 103 animals were trapped and marked, only 23 animals came to the oat pile; and of these, only eight were consistent visitors. Animal number four, an adult male, was the dominant. It was observed to make 50 chases, and at no time during the period of observation was it seen to be chased (Figure 12). The animal with the next highest number of chases was number 16, an adult male with 19 chases. However, it was chased 21 times; approximately as many chases as the number of times it was chased. Table 3 is a summary of the weight, sex and age, the number of chases made by each animal, as well as the number of times it was chased. Although number four was the dominant, it was not the first animal to come to the oatpile. Numbers six, eight and 20 were the first to visit the food. These three animals were at the oats early in the morning. Number six showed its dominance immediately

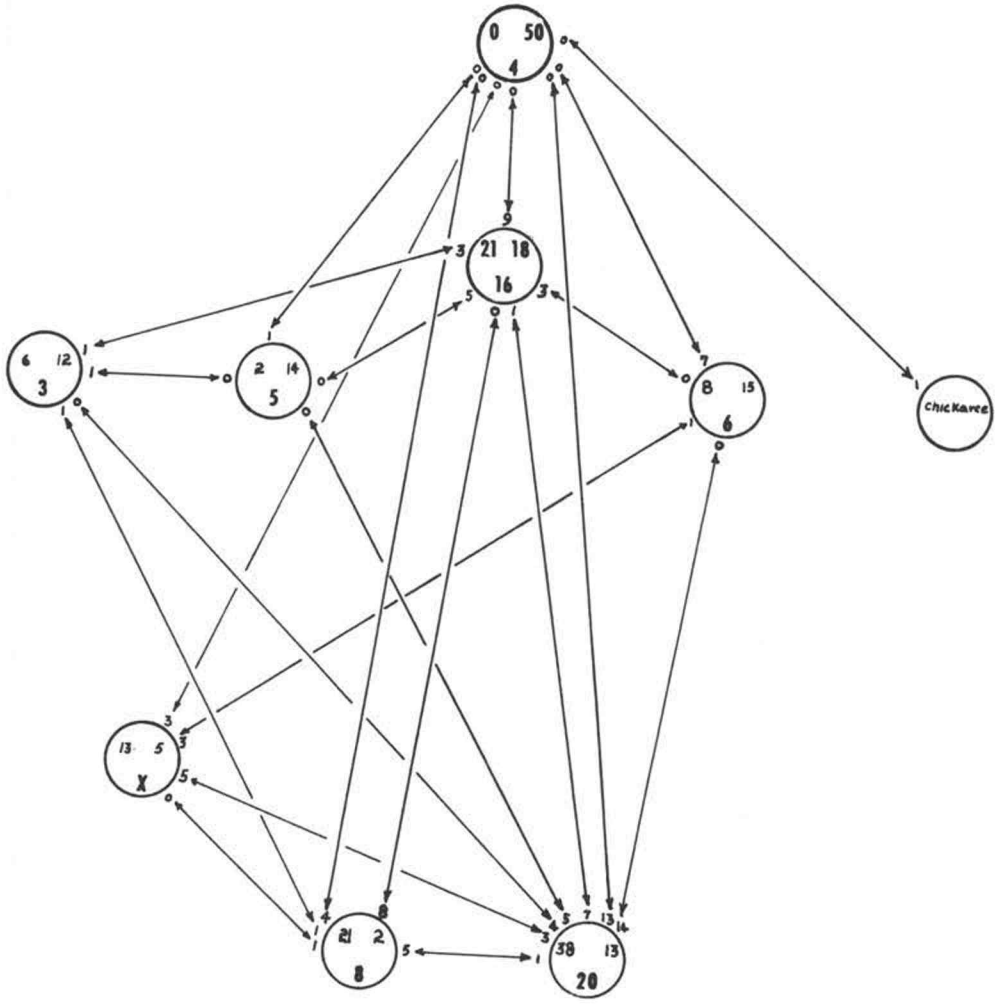


Figure 12 The social hierarchy structure at the south entrance area. The lower number identifies the individual. The number to the right indicates the number of chases it made and the number to the left the number of times it was chased. The numbers at the ends of the arrows indicate the number of times the animal was chased by the animal at the opposite end of the arrow.

by chasing both number eight and 20. By midmorning, number four was on the scene, and immediately showed its superiority by chasing all other ground squirrels away from the oats.

In referring to Fig. 12 it can be seen quite readily that the social hierarchy is a group structure rather than a straight-line system. The lower figure within the circle is the number of the animal. The number to the right is the number of chases made by the animal, and the number to the left is the number of times it was chased. The arrows indicate the animals that came into contact with each other. The number at the end of the arrow indicates the number of times the animal was chased by the animal at the other end of the arrow. Thus, for instance, number 6 chased x three times, and x chased six once. Although number 16 was chased a trifle more than it chased other ground squirrels, it was deemed to be slightly higher in the social scale because of the severity of its chases; and many times when it was chased, it had just finished filling its cheek pouches and appeared ready to leave the area anyway.

There was only one instance noted when a ground squirrel chased a chickaree, but the observation seems worthy of mention since the chase was quite long, ending only when the chickaree took refuge in a tree. After the chase, number four returned to the oats and quietly resumed filling its pouches.

At the headquarters area, the hierarchy was even less well established. Number six was undoubtedly the dominant, but on occasion was chased by a fourth order animal, number one (Fig. 13).

The social structure appeared to be very complex. While the dominants in the two areas retained their social status for the length of time they were observed, the immediate subordinates would often lose their standing; and then at some later time, regain their position of social status.

Not all of the encounters resulted in chases. On occasion, as many as seven animals congregated at the oat pile, all feeding peacefully. Then for some reason, one or more would appear to be startled, and suddenly they would dash off for cover. After an absence of a few minutes, they would return and resume feeding. Animal number four engaged in 11 encounters during which no aggression was shown, including number 38, the animal chased most often. Occasionally juveniles would come to the oats. In most cases, they were ignored by the adults, but every once in a while they would be sent scurrying. The chases, in general, were shorter when juveniles were involved; the chaser pursuing only a few feet. At times when a number of animals were together, a very short movement, often only a step or two, would be sufficient for the dominant to drive away the subordinate animals.

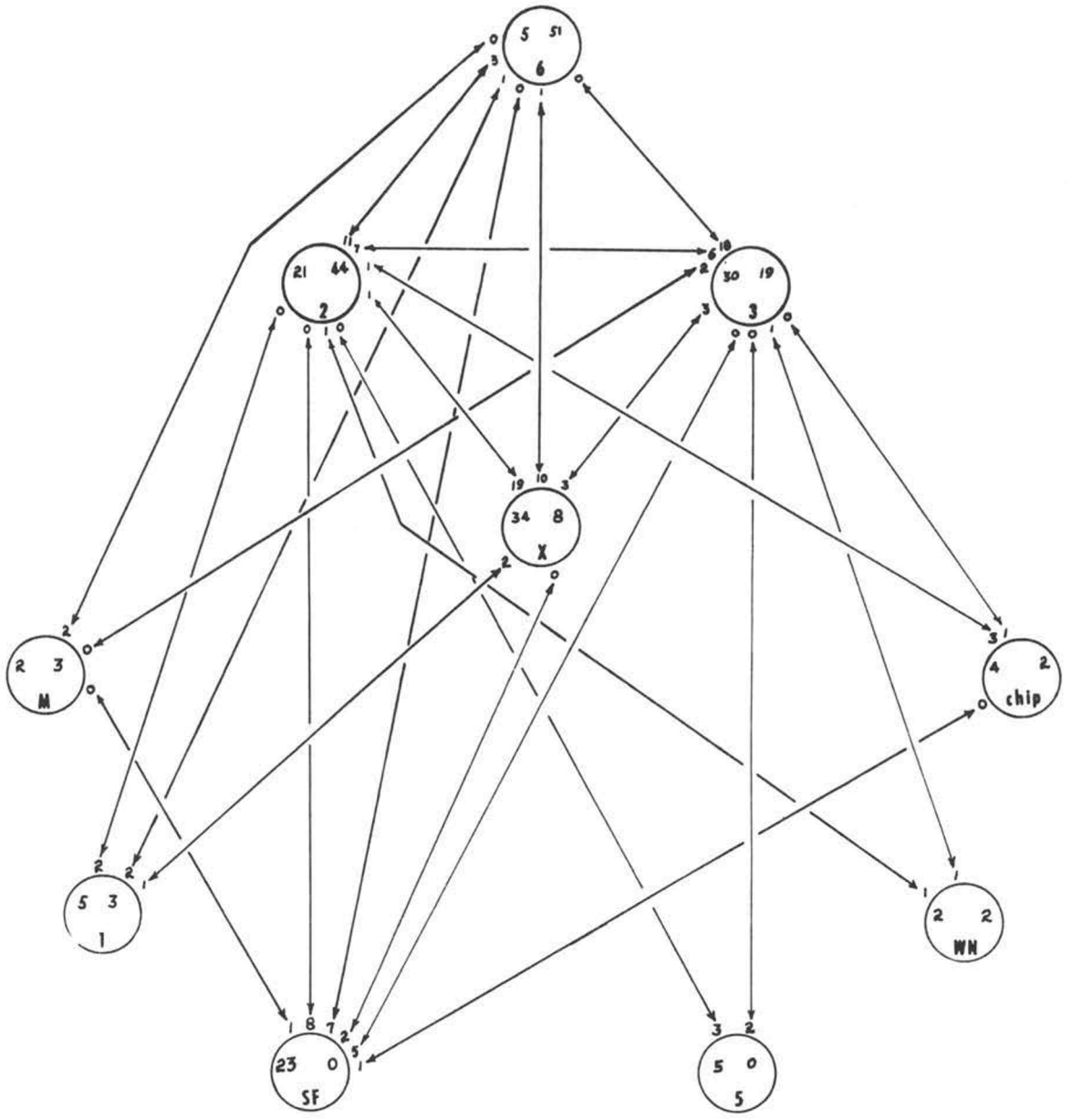


Figure 13 Social structure at the headquarters area.
Refer to Figure 12 for explanation of numbers.

TABLE III

Weight, Sex, Age and Chase Order

South Entrance Area

Animal No.	Age	Sex	Weight (grams)	No. of Chases	No. Times Chased
4	adult	male	190	50	0
16	adult	male	164	18	21
6	adult	male	157	15	8
5	adult	male	180	14	2
20	adult	male	180	13	38
3	adult	female	148	12	6
X	adult	-	-	5	13
2	adult	female	140	2	4
8	adult	female	175	2	21
9	adult	female	153	1	1
10	adult	female	142	1	0
12	adult	male	168	1	0
30	adult	female	154	1	4
40	adult	male	165	1	1
		Sleepy Hollow			
6	adult	male	168	51	5
2	adult	female	190	44	21
3	adult	male	168	19	30
X	adult	-	-	8	34
M	adult	-	-	3	2
WN	adult	-	-	2	2
1	adult	female	200	1	5
5	subadult	male	132	0	5
S. F.	adult	-	-	0	23
S. T.	adult	-	-	0	1

Occasionally the encounters would result in a brief but fierce fight. The fight would commence with an arching of the back, followed by the animals jumping at each other and then rolling end over end. The vanquished squirrel would dash off with the victor in close pursuit. The fighting is accompanied by considerable vocalization in the form of growls, squeeks and chortling sounds. At no time during the period of observation was any ground squirrel seen to be injured by the fighting, although one of the permanent personnel reported that he had seen one mantled ground squirrel bite off about two inches of tail of another squirrel during a fight.

On a number of occasions, it was observed that when a dominant began chasing an animal lower in the hierarchy, the subdominant, instead of running away, would stop suddenly and no further agonistic behavior was displayed. Further observation showed that this stopping by the chasee was accompanied by one of two characteristic postures. In the first case, the chasee would lie down in a prone position, flattening itself as much as possible, placing both chin and tail against the ground. In the second situation, the animal would likewise stop after moving a short distance. But instead of assuming the prone position, the chin was placed on the ground, the rump was raised, and the tail became erect. In this second instance, the chaser would then approach the chasee and

sniff the anus much in the manner of a male dog approaching a bitch in heat. All signs of aggressiveness disappeared. After a brief period of sniffing, the chaser would return to the food and the chasee would leave the area.

Tinbergen (48, p. 1-150) reported that when a particular stance, which he calls "head-flagging" is assumed by black headed gulls, aggression ceases. This type of appeasement behavior has also been observed in other birds, in fish such as stickle backs, River Bullheads, Guppies, and Cicklids. According to Tinbergen, hostility plays an important part in the spacing-out of breeding pairs and the species is unable to give it up. The stimulus for this hostility is provided by intruders, and inasmuch as females are very similar to males in coloration, the first impulse is to drive away the female. If mating is to take place, there must be some gesture on the part of the female which will appease the agonistic behavior of the male. And through the long course of evolution, the head flagging ceremony finally arose to combat this situation. Inasmuch as mantled ground squirrels maintain territories (19, p. 62-63) and show aggressive behavior toward one another, it appears that the appeasement ceremony displayed by these animals has a similar function. The display is not necessarily confined to the breeding period, for the observations were made during August

and September, a time when the young are leaving the nest. Tinbergen likewise noticed that kittiwakes show the appeasement ceremony at times other than during courtship. It is a moot question if the significance of this behavior in ground squirrels is the same as Tinbergen suggested it was for gulls. However, the fact that aggression ceases would strongly suggest that it is. There are no references to this type of behavior for mantled ground squirrels, and further investigations would certainly seem to be worthwhile.

Mantled ground squirrels were also seen to go through a series of motions, such as "stamping" the forepaws on the ground, or rubbing their chins in the dirt. This type of activity was seen whenever the animal was in a stress situation, such as, when meeting another ground squirrel. At first, the movements appeared to have no relationship to the animals' immediate activity and was almost overlooked. However, after repeated observations, it occurred to me that this was probably a display of displacement behavior or a redirected attack. Tinbergen (48, p. 1-150) reported that a similar situation occurring in black head gulls is manifested by pecking at the ground, and comes about when a bird is provoked by another but is inhibited from attacking it. What effect this behavior has on other animals in the community, or what survival

value it may have, is not known; like the appeasement ceremony it needs further investigation.

The picture that emerges is one of a community in which there is a social hierarchy, but one in which dominance appears to be a group arrangement rather than a straight-line relationship. In the long run, one becomes fairly sure which mantled ground squirrel will dominate in the larger number of its contacts, but the results of the next contact between two individuals cannot be predicted with any certainty. Reversals may take place within a matter of minutes without any observable unusual circumstances.

The qualities responsible for an animal becoming dominant over another are largely unknown. To be sure, there is no one single factor responsible, and in the summarization which follows not all of the factors discussed are of equal importance.

Allee (1, p. 141) stated that weight seems to be of little consequence among chickens insofar as social status is concerned. This also appeared to be the case for mantled ground squirrels. While animal number four at the south entrance site weighed 190 grams, 10 grams more than the next heaviest animal, number 16 weighed 164 grams and held sway over animals weighing as much as 16 grams more. Number 20, weighing 180 grams was chased more than any other animal, and as a consequence was lower in the

social hierarchy than any of the other animals. At the headquarters area, number six was the dominant, weighing 168 grams. Number one, weighing 200 grams, was in the seventh position of the chase order. These data, of course, are not conclusive, but they do appear to agree with the findings of Allee.

Territory undoubtedly is an important factor, and animals which are ordinarily dominated by another, more than likely, show less timidity as they approach the area of their dens. Gordon (19, p. 62) described the activities of a female valiantly chasing any intruder which came near her den. Allee (1, p. 129-147) reported similar situations for chickens, as does Alverdes (3, p. 1-1195) for seals, and Darling (15, p. 1215) for red deer stags.

At the headquarters area there were a number of incidents which appeared to substantiate these findings. Number three had his den approximately 50 feet from the site where the color experiments were situated. When he came into contact with a dominant, he would run toward his burrow opening. The chase was ended abruptly when the two were within 15-20 feet of number three's den. Frequently number three would then become the chaser; however, the chase was short and did not have the vigor and enthusiasm of the original situation. Likewise, an unmarked ground squirrel which did not participate in the color experiments but came up on my lap

for peanuts, soon established an area around me from which all other animals were chased if they approached too closely. If this animal was chased by another, the chase would stop once the chase was within approximately 6-10 feet of where I was seated. A brief movement toward the chaser was then made. Occasionally a fight followed, but in most cases the chaser returned to its previous activities.

In the south entrance area, similar situations were observed. Some of the animals had their dens in wood piles and would chase any intruder away. If one of these would leave the wood pile and come to the oats and subsequently was chased, the chase if a vigorous one would last until the chasee reached its wood pile. Again the chase would stop, and occasionally the chaser would become the chasee. Hunger appears to be an important factor in dominant-subordinate interactions. Maslow (29, p. 161-198) working with monkeys, Nowlis (35, p. 91-116) with chimpanzees, and Bruce (8, p. 395-412) with cats in the laboratory all reported that aggressiveness increased as the animals became hungrier. Collias (13, p. 83-123) stated that the frequency of pecking in chickens increased several fold when they are placed on short rations. Errington (16, p. 168-186) observing muskrats in the field, reported that during periods of drought animals crowded together into small

water holes without serious conflict; but if there was also a shortage of food, aggressive behavior became severe and often lethal. Gordon (19, p. 62), in describing territorial defense, reported that the defending female was unable to keep other mantled ground squirrels away from the food pile which was placed close to the den.

When the quantity of oats was large and spread over a large area, there was considerably less chasing than when the food pile was small and concentrated into a small area. In the south utility area, number four would pay little attention to other ground squirrels at the oat pile if there were large amounts. However, when the food pile was reduced, number four would chase every other animal until his own cheek pouches were full. At the headquarters area a similar situation was noted. On several occasions, animal S. F. (scar flank, a natural mark), entered a color discriminating box even though one of the dominant animals was in the area. It appeared to have little fear of the other animals, and left the area only after it had fed for a period of time. At times when it didn't appear to be hungry, it approached the area gingerly, and if another squirrel were seen it would leave.

Another factor which may influence the social standing is the physical well-being of an animal. An animal was introduced into the headquarters community which was trapped at the south

entrance site. At first the animal quartered around, investigating the area thoroughly. It then disappeared for several days, and when observed again it appeared quite aggressive, chasing all other ground squirrels except number six. Later this transferred animal was retrapped and given an injection of a tranquilizer (Promazine). The animal lost all aggressiveness and was immediately chased by all squirrels with which it came into contact.

Injured animals are likewise set upon by the other animals in the area. On a number of occasions I was fortunate enough to observe ground squirrels which had been injured by various means. None of the injured forms chased other squirrels although they themselves were chased. The nature of the injury in each case was not so severe as to disable the animal sufficiently to prevent it from moving about freely.

Age also apparently has some significance in determining dominance. Generally, adults chase juveniles. In one or two instances, juveniles appeared to chase adults, but the situation was not clear. It was difficult to tell whether the adult was ready to leave the area anyway and the chase was mere coincidence, or if the adult failed to recognize the animal as a juvenile. At the headquarters area, number five was classed as a subadult (132 grams),

and at no time was it seen to chase any other animal, although it was chased by other ground squirrels in the area.

In some animals, such as canaries, intensity of fighting varies with different phases of the reproductive cycle (2, p. 139-161). For mantled ground squirrels this is a difficult question to answer because practically nothing of the nature of the breeding pattern is known.

Social rank is frequently, perhaps in most cases, decided by fighting, displaying or submission at the initial encounter of a pair of individuals. Schjelderup-Ebbe, (37, p. 225-252) and Collias (12, p. 519-538) reported that this followed almost diagramatically for domestic fowl. Uhrich (50, p. 373-413) and Ginsburg and Allee (18, p. 485-506) found similar results for mice studied in captivity. Parallel results were observed for macaques by Maslow (32, p. 313-324), for chimpanzees by Crawford (14, p. 259-266), and for the chameleon, Anolis, (17, p. 88-111).

There is no reason to doubt that fighting is an important factor in establishing dominance in mantled ground squirrels. However, to what degree fighting is significant is difficult to ascertain from observations made in the field. The fights observed were brief, and neither animal appeared to be injured. More often than not, the two animals which were fighting would be feeding peaceably

side by side a few moments later and showing no antagonism toward one another. Like fighting, there is little doubt that dominance is established when animals meet for the first time. However, when working with animals in the field there is no way of identifying first encounters.

Certainly, the factors discussed, play a role in determining dominant-subordinate relationships among mantled ground squirrels. Which one is more important than the other has not been determined. Perhaps at different times throughout the year, or perhaps during the course of daily activities one factor may assume more importance than others.

Color Vision

Description of the eye

The eye of the golden mantled ground squirrels is a black, nearly spherical structure, measuring four millimeters along the vertical axis and six millimeters along the horizontal axis. The lens is a crystalline structure, strongly yellow in color.

Microscopic examination of the photic layer revealed the retina to be of the pure-cone type. These findings concur with the general statement of Walls (52, p. 514) that ground squirrels have a more certainly pure-cone retina than tree squirrels. Although his

reference is to the marmotines, (ground squirrels, prairie dogs), no mention is made of the genus Citellus, and he states furthermore, "all others except the flying-squirrels are probably pure-cone."

Because of the diurnal habit and the fact that ground squirrels have photopic retinal mechanisms, it would be reasonable to suspect that they would demonstrate color vision. Arden and Tansley (4, p. 592-602) by means of electroretinograms worked out the spectral sensitivity of the pure-cone retina of the grey squirrel, Sciurus carolinensis leucotis, and found that there was good color sensitivity. And yet, when tests for responses to color are conducted, there is little if any indication that squirrels actually see color, at least as color is interpreted by man.

Perhaps reactions to color depend upon certain releasing mechanisms which are present in nature, but are not present in experimental situations. Tinbergen (47, p. 1-228), working with the butterfly, Pieris brassicae, showed that for oviposition the female selects green objects, but for feeding selects yellow, blue, and red flowers. Certainly, one cannot readily compare reactive behavior between arthropods and vertebrates. However, in the light of such findings, it may well be that if the experimental approach were changed, and color perception tests were conducted under more natural conditions, one might obtain entirely different results.

Experimental Results and Discussion

I. Dyed peanuts

(a) Training period: At the beginning of the color discrimination experiments, unshelled, non-colored peanuts were put on a board in an open area and left there until a number of animals were conditioned to coming to the area.

(b) Peanuts dyed with methyl green: After the animals were assumed to be conditioned, the uncolored peanuts were exchanged for some which had been dyed with methyl green.

(c) Varicolored peanuts in individual piles: After several animals habitually visited the area and were conditioned to green peanuts, peanuts dyed purple with gentian violet, red with methyl red, and black with India ink were also placed on the board. The variously colored peanuts were place in individual piles to see if the animals showed any preference for the different colors. This technique did not work well, for the animals would come in from the same direction, and stop at the first group of peanuts, regardless of color.

(d) Varicolored peanuts in one pile: The peanuts were then put in one pile and mixed. However, the animals still indicated no color preference, taking the first peanut they came to.

II. Deodorized peanuts

It was then suspected that odor was a more important factor than sight in detecting the food. To observe if this were the case, uncolored and colored peanuts were soaked in either gasoline, formalin, 95 percent alcohol, or rubbed with pine pitch. The assumption was that these odoriferous substances would mask the scent of the peanuts, and if color perception were present, only green peanuts would be taken. The results were entirely unexpected. The treated peanuts were taken just as readily as untreated peanuts.

III. Discrimination boxes

Because the animals display a considerable manipulative ability, it was decided that if there were some device in which doors must be opened, and if on these doors there were colored cards, perhaps the animals would demonstrate color discrimination by consistently choosing the box with the colored door to which they had been conditioned, and thus be rewarded with food.

Three boxes, nine inches on a side, were constructed. At first food was just placed inside the experimental box. This proved inefficient since the animals would sit inside and fill their cheek pouches. It was then that the food dispensing device was constructed. Figure 12 is a graph showing the number of right responses to the

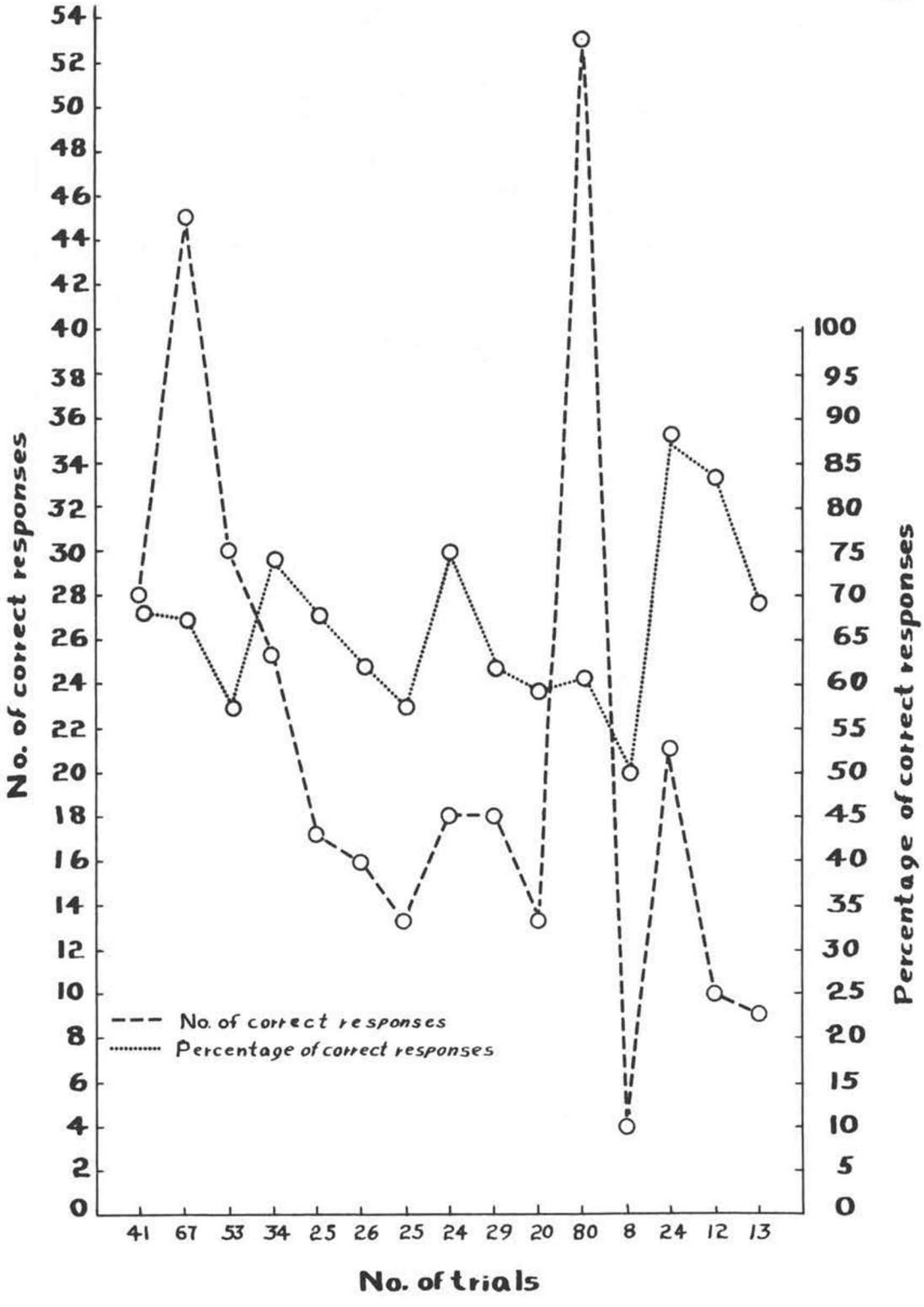


Figure 14 A graph showing the number of correct responses to the experimental unit, and the percentages of right choices.

experimental box, as well as the percentage of correct choices. The graph was plotted for the total of the 481 trials conducted over a 15 day period. There were 320 correct responses and 161 wrong choices. Of the wrong responses, 78 were made to the right of the experimental unit, and 81 to the left of it. The average percentage for all of the trials is 66.5 percent.

(a) Training period: On the first day of the trials, the boxes were set out loaded with peanuts and the doors tied open, thus getting the animals conditioned to going into the boxes for food. Three hours later the doors were closed, but each box still had food in it. At first the ground squirrels quartered around the base of each box investigating until they learned to open the door. Once they learned to open the doors, the animals were trained to a blue color.

(b) Blue card: With a blue card on the reward stimulus and no colored cards on the non-reward stimuli, there were 11 correct responses and four wrong ones.

(c) Blue versus red and yellow cards: Next, red and yellow cards were placed on the non-reward stimuli. For the six days that this combination of colors was used the number of correct responses was greater than wrong choices, of the 227 trials run, 150 were to blue, 25 to red and 52 to yellow (Table IV). To avoid the

TABLE IV

The Number of Responses to Colored Cards on the Experimental Unit

Day	No Colors	Blue* (only)	Blue* Red Yellow	Yellow* (only)	Green* (only)	Pink (only)	Gray (only)	All Gray	Green* Gray Pink	Pink* Gray Green	Gray* Green Pink
1		11 r 4 w	17 r 9 w								
2			45 r 19 w								
3			30 r 21 w								
4			25 r 10 W								
5			17 r 8 w								
6			16 r 10 w								
7		13 r 13 w									
8		18 r 6 w									
9		14 r 12 w		4 r 2 w							
10				1 r 0 w	2 r 0 w	2 r 1 r	5 r 6 w	3 r 6 r			
11	11 r 7 w						28 r 17 w	11 r 4 w	7 r 2 w		
12									4 r 4 w		
13									7 r 3 w	8 r 0 w	6 r 0 w
14	10 r 2 w										
15					9 r 4 w						

The colors across the top of the chart are those used on the doors of the boxes. The asterisk after the color indicates the reward stimulus. The other two colors were on the non-reward stimuli. The word "only" beneath the color indicates there were no colors on the controls. The letter "r" after the numbers in the columns indicates the number of correct responses; the letter "w," the number of wrong responses.

possibility of position learning, the boxes were shifted at random after each trial.

(d) Blue cards on all boxes: After the sixth day and for the next three days, blue cards were substituted for red and yellow cards on the non-reward stimuli. The first day's results netted 13 right and 13 wrong responses. However, on the second day, there were 18 right and six wrong choices, indicating that the animals were responding to some stimulus other than color. Results of the third day were similar to those of the first with 14 right and 12 wrong responses.

(e) Yellow card: Next, a yellow card was substituted for the blue card on the reward stimulus. Immediately after the change of cards, two correct responses were made to the yellow.

(f) Pink card: A pink card was exchanged for the yellow one following the responses to the yellow card. There were two correct choices and one wrong response.

(g) Gray card: After exchanging the pink card for a gray one, there were five right and six wrong responses.

(h) All gray: After these 11 trials, gray cards were also placed on the non-reward stimuli. Of the nine trials run, three were correct and six were wrong.

(i) Gray card only: The following day the gray cards were removed from the non-reward stimuli. Of the 45 trials conducted, 28 responses were correct and 17 were wrong.

(j) All gray: The gray cards were then replaced on the non-reward stimuli. The results from the 15 trials were 11 right and four wrong.

(k) No color: After these 15 trials, the cards were removed from all units. Following this there were 11 right and seven wrong choices.

(l) Green versus gray and pink: Following the trials with no colored cards on the units, a green card was placed on the reward stimulus, and gray and pink cards on the non-reward stimuli. Of the 27 trials run over a three day period, there were 18 right choices and nine wrong ones.

(m) Pink versus gray and green: With a pink card on the experimental unit, there were eight correct responses and no wrong choices.

(o) No colors: Again after removing all cards, there were 10 right responses and two wrong choices.

(p) Green card only: Finally, a green card was put on the reward stimulus and no cards on the other two units. The results obtained were nine right and four wrong responses.

The data of this experiment were subjected to the chi-square test, and at the five percent level with one degree of freedom, the results were significant. The significance cannot be interpreted to mean golden-mantled ground squirrels have color discrimination. It does mean, however, that some stimulus other than color vision was responsible for the animals making the right choices to the experimental unit.

Like many other animals, mantled ground squirrels have anal scent glands, and thus, mark an area for identification. Several attempts were made to destroy any odor the boxes might have had from animals being in contact with them. The boxes were "painted" with pine oil disinfectant, and later sprayed with air freshener (the type used in homes). In either case there was no change noted in the facility with which the animals found the experimental unit. Finally, the boxes were painted with creosote oil stain. At first, the animals, except number six, appeared confused. Number six went immediately to the experimental unit, but the others sniffed around the three boxes and did not open the doors. After number six returned to the experimental unit several times, other animals began to enter the box and help themselves to food.

Observations of the activity of the animals would tend to indicate that smell is important. In general, there was considerable

investigative behavior by all participants. Even after becoming conditioned to finding food inside the box, the animals would sniff around the base of the boxes before opening the door. At times, individuals would go directly to one non-rewarding unit and then to the other, back to the first unit, run away a short distance, stop and rest, and then proceed to the reward stimulus.

Animal number six, the dominant, behaved differently than the other mantled ground squirrels. He soon learned to operate the tripping mechanism of the dispensing device. When the animal opened the door of the reward stimulus, the vendor would spill a certain quantity of food on the floor, number six would begin to fill his cheek pouches, if there was room for more he would pull on the string which tripped the dispensing bucket, pick up the food dispensed, and continue this until his pouches were full; then and only then would he leave.

Oats were also tried as a food item, thinking that there was less odor and therefore not as readily detectable, however, there was no difference in the results.

IV. Peanuts on strings

In another series of experiments, animals were conditioned to reaching for peanuts suspended from strings. After the initial training, peanuts colored blue with Rit dye were used to replace

the natural colored peanuts. In either case all peanuts were taken readily. After having been subjected to taking blue peanuts, some peanuts colored red and others yellow, also colored with Rit dyes, were likewise suspended from strings. At first the peanuts were all suspended at the same level above the ground. Later some red, some yellow and some of the blue peanuts were suspended high enough so that the animals had to "work" to get them. The nuts closest to the ground were taken first, and then those that were hung slightly out of reach. In either situation no color preference was indicated.

V. Peanuts in gelatin capsules

The final series of experiments were somewhat similar to those just described. The animals were again given blue colored peanuts. At the end of the training period, peanuts colored blue, red, or yellow and non-colored nuts were put into number 11 gelatin veterinary capsules, being careful to leave no peanut aroma on them. Some of the enclosed peanuts were then suspended above the ground within easy reach of the animals. Other capsules were placed in a pile on the ground.

The animals approached the suspended peanuts, sniffed briefly, and then either scurried off or began quartering about. Similarly, the capsules were sniffed, and then abandoned. Only

one capsule was taken and opened up, and it contained a yellow peanut. Some of the capsules were later smeared with peanut butter. Immediately animals tried to pick these up and carry them off, but because of the smoothness and size of the capsule this was impossible. After several attempts to carry the capsule away, the animals paid no further attention to them. These observations indicate that smell, rather than color, is more important in finding food.

Conclusions

Although there were a statistically significant number of correct responses to the reward stimulus, it cannot be concluded positively that there is a color discriminatory capacity in golden-mantled ground squirrels. On the other hand, there is no proof that color vision is entirely lacking in these animals. Locher (26, p. 1-56) concluded that there is a very weak capacity for discriminating color in Sciurus vulgaris, but so very weak that, within limits of normal individual variation, it may be lacking in a particular individual. It may be that this is the case in mantled ground squirrels.

Suggestions as to methodology

One factor that appears to be responsible for the high number of correct responses is that the animals approached the experimental site from the same direction. Even though the boxes were shifted at random, over a long period of time the number of correct choices would be greater than wrong ones through choice alone. Suppose that at one trial the order would be: non-reward, non-reward, reward stimulus; the animal coming from the left could make the two wrong choices before a right response. On the other hand the animal coming from the right would make no wrong choices. If the position were changed to non-reward, reward, non-reward stimulus, both animals would each make a wrong choice and then a right one. Also, there would be a number of chance responses to the reward stimulus. Thus in no case are the animals responding to color but rather are "finding" the reward stimulus through the normal course of their behavior. A more satisfactory arrangement would be to control the direction of approach to the experimental units. This could be accomplished by elevating the boxes, and have runways, originating from a common point, leading to each of the units.

Odor appeared to be an important factor in finding the reward stimulus. Although attempts were made to mask the smell of peanuts, there was no assurance that this was done. A more

satisfactory method of eliminating smell as a factor, would be to destroy the sensory structures of olfaction.

There is also the problem of color versus brightness discrimination. Prior to further field work it is suggested that all color cards be carefully matched for brightness value. In addition to color cards matched for brightness, a series of gray cards, not only matched with the color cards for brightness, but also an intermediate series should be used. The use of gray cards is a convenient method for eliminating the possibility of brightness discrimination. If the animal is trained to a color versus medium gray, and then other grays are substituted from a finely-graded series, color is qualitatively seen if no confusion arises between these grays and the positive stimulus.

Perhaps the best way to test for color vision would to bring the animals into the laboratory, and use monochromatic light, the intensities of which can be carefully regulated.

The experimental units can also be used to test for pattern and form discrimination, and success or failure, might serve as a check on the validity of color experiments.

Reproduction

Sex ratios

The numbers of males and females live-trapped at the south entrance area were about equal if adults and juveniles are both considered. In 1959, there were 33 (53.2%) males and 29 (46.8%) females. Of these, 12 (40%) were adult males and 18 (60%) were adult females. In the following year, 26 (57.7%) males and 19 (42.3%) females were captured. According to age groups, there were 10 (55.6%) adult males, eight (44.4%) adult females, 16 (59.3%) juvenile males and 11 (40.7%) juvenile females.

Because some animals are trap shy, and therefore never caught, it is difficult to ascertain actual differences in numbers between the sexes of a population. On the other hand, some animals enter traps readily, thus further complicating the obtaining of sex ratios.

Weights of juveniles

Mantled ground squirrels in the study area were weighed on the spot each time they were trapped. Weights were obtained for 21 juvenile females and 34 juvenile males. The data on live weights are summarized in Tables V and VII.

During the second half of July, 1959, the males were on a average, 5.2 grams heavier than females (Table V). During the

TABLE V

Comparison of Live Weights of Male and Female
Juvenile Mantled Ground Squirrels
1959-1960

(Weights of females in parentheses.)

Period	Number of Individuals	Average Weight (in grams)	Range
1959			
July			
First half	1	70	-
Second half	6	88.7	80-105
	(2)	(83.5)	(82- 85)
August			
First half	13	107.2	83-130
	(5)	(117.4)	(104-130)
Second half	0	0	0
	(4)	(121)	(112-132)
1960			
August			
First half	9	91.4	78-110
	(7)	(98.6)	(80-113)
Second half	7	101.9	84-120
	(4)	(95.8)	(85-105)

first half of August there was a marked change. The females gained weight more rapidly, and by the middle of the month they were on an average, 10.2 grams heavier than the males. No comparison is possible for the second half of August since no males were trapped. During this time the average increase in weight for the females was 3.7 grams. During the first half of August, 1960, the average weight of the males was 15.6 grams less than the average weight of the males during the same period one year previous. Females, on an average, weighed 18.8 grams less than females did last year at the same period of time. During the second half of August, 1960, males on an average weighed 101.9 grams, as compared to 95.8 grams for females. Juvenile females averaged 25.2 grams heavier during the 1959 period.

There is no apparent reason for this overall decrease in weight. Food was equally abundant both years, and weather and temperature were essentially the same.

Weight of adults

The average weights of 21 adult males captured during the 1959-1960 trapping period was 163.8 grams, and for adult females the average weight was 157.0 grams. The averages and the ranges of weights for adult males and females are summarized in Table VI.

TABLE VI

Comparison of live Weights of Adult
Male and Female Mantled Ground Squirrels
1959-1960

(Weights of females in parentheses.)

Period	Number of Individuals	Average Weight (in grams)	Range
1959			
June			
Second half	3	175.7	157-190
	(2)	(144)	(140-148)
July			
First half	0	-	-
	(2)	(164)	(153-175)
Second half	6	170.3	158-180
	(5)	(158.8)	(142-177)
August			
First half	3	170	165-180
	(5)	(160.8)	(142-170)
Second half	0	-	-
	(2)	(149)	(140-158)
1960			
June			
Second half	4	141.3	120-178
	(2)	(181.5)	(170-193)
July			
First half	2	153	140-166
	(2)	(140.5)	(131-150)
Second half	2	176	174-178
	(2)	(162)	(156-168)
August			
First half	1	160	-
	(0)	(-)	(-)
Second half	0	-	-
	(2)	(152.5)	(139.166)

There was a considerable amount of variation of body weight between the individual males and females. These variations could be due to various factors, such as age differences, more restricted activity of females caring for young, or the increased size of the mammary glands of lactating females.

Weights were recorded to the nearest gram. A greater degree of accuracy was felt to be unjustified, because in many cases the animals would defecate or empty their cheek pouches immediately after the weighing. In one instance, the weight of droppings and cheek pouch contents was a total of 10 grams. In those cases when the animal emptied its pouches or eliminated in the sack in which it was weighed, the sack with its contents was reweighed after the animal was released, and this weight was then subtracted from the original weight.

Due to such discrepancies, the writer feels that often times too much stress is placed on the accuracy of weight measurements. Animal number 42 was trap prone and would often be recaptured an hour after being released, and upon reweighing a variation of as much as 5 grams was often noted. Thus, recording weights to the nearest tenth of a gram, as many investigators do, seems unnecessary.

The range of weights and weight increases for adult and juvenile ground squirrels is summarized in Table VII. The rate of weight increase varied considerably between individuals. During its first year of growth, a juvenile animal, number 26, gained 45 grams in only eight days. In comparison to other animals, this is an amazingly rapid increase. The following year the same animal gained only 18 grams in 19 days. Another animal, number 43, gained only 29 grams during a nine-day period, an increase of a little more than three grams per day. Most juvenile animals appear to gain weight at the rate of two to three grams per day.

Adults present quite a different picture. Weight gains are not only considerably slower, but many animals lost weight. Animal number 10 gained 14 grams in 20 days the first year. The second year she lost 49 grams in 47 days. This was the most drastic weight loss recorded. The range of weight loss for other animals was five to nine grams during an interval ranging from 12 to 24 days.

One animal represented a rather interesting case of the rapidity with which animals lose or gain weight. Number 63, an adult, was used in an experiment to determine how far displaced animals will travel to return to their home sites. On June 24, number 63 weighed 120 grams. There was no increase in weight

TABLE VII

Weight Increase and Range of Weights of
Adult and Juvenile Mantled Ground Squirrels

Animal Number	Sex	Number of Times Weighed		Range of Weights		Period of Time in Days		Weight Increase in Grams	
				Adults					
		1959	1960	1959	1960	1959	1960	1959	1960
4	M	1	2	-	191-220	-	46	-	29
10	F	2	3	142-156	213-164	20	47	14	-49
18	F	1	3	-	200-228	-	34	-	28
30	F	1	3	154-???	178-190	-	37	-	8
35	M	3	2	165-175	180-171	14	24	10	- 9
38	F	2	2	142-169	156-148	10	13	27	- 8
54	F	2	1	130-118	152-???	4	-	-12	-
62	M	2	2	-	178-191	-	31	-	13
65	F	-	3	-	170-161	-	43	-	- 9
66	F	-	3	-	131-126	-	12	-	- 5
67	M	-	3	-	140-164	-	40	-	24
92	F	-	2	-	139-144	-	7	-	5
				Juveniles					
22	M	2	-	90-123	-	11	-	33	-
23	M	2	-	90-113	-	14	-	23	-
24	M	2	-	105-117	-	4	-	12	-
25	F	3	-	82-114	-	17	-	32	-
26	F	2	2	85-130	162-180	8	19	45	18
31	M	4	-	95-136	-	20	-	41	-
42	F	3	6	105-118	170-200	10	54	13	30
43	M	2	-	108-137	-	9	-	29	-
57	F	2	-	112-118	-	5	-	6	-
59	F	1	2	117-???	144-167	-	20	-	23
74	F	-	2	-	80-119	-	15	-	39
83	F	-	3	-	84-120	-	15	-	36
88	M	-	2	-	92-107	-	8	-	15
93	F	-	2	-	85-101	-	3	-	16

when it was reweighed July 1, but by August 8, it had gained 32 grams. From August 8 to August 15, this animal was transported various distances, and its weight rapidly dropped to 114 grams, a weight loss of 38 grams in 15 days. The major portion of this weight loss was during the four day period from August 19 to August 23, when it lost 22 grams. This animal either ate very little on the way back to its home area, or the rigors of travel, or a combination of these two factors are perhaps responsible for the drop in body weight. The animal appeared to be in good health judging from the strength with which it struggled when held, and the alertness it showed when released.

The weight loss for number 10 is understandable, inasmuch as she was a lactating female. For the others, however, there is no explanation, for there was not only an abundance of natural food, but oats, as well, were put out each evening.

Description of Burrows

The burrows of mantled ground squirrels have been previously described in a few published accounts. Huestis (23, p. 15) recorded an adult male, found in a burrow in August, at Crater Lake National Park. No nest or food caches were found.

At the south entrance site, four tunnels were located, and at the headquarters area, one. All of the dens were measured and drawn to scale.

The number of entrances varied and appeared to have no relationship to the length of the tunnel. The longest burrows excavated was 71 feet 4 inches long; while the shortest was seven feet long (Fig. 15). The entrances are not necessarily hidden, although in one case the burrow opening was located by observing an animal enter the tunnel through an opening which was in the base of a large snow bush, (Ceonothus velutina). The tunnel diameter varied from 2.5 to five inches. In depth the tunnels ranged from two to seven inches below the surface, although the chambers may be deeper than this. In only one burrow was there a chamber with nesting material, and this consisted of shredded wood and a few pieces of lichen, (Evernia vulpina).

The pattern of the burrows was quite variable. If, during the course of digging, an animal would encounter a large stone or heavy root, it would either turn sharply to the left or right, or the animal would dig under the obstruction and continue in a more or less straight line. The tunnels were not necessarily confined to soil. In one case a burrow ran the length of a decaying ponderosa pine log, the upper portion of the tunnel actually dug out of the soft

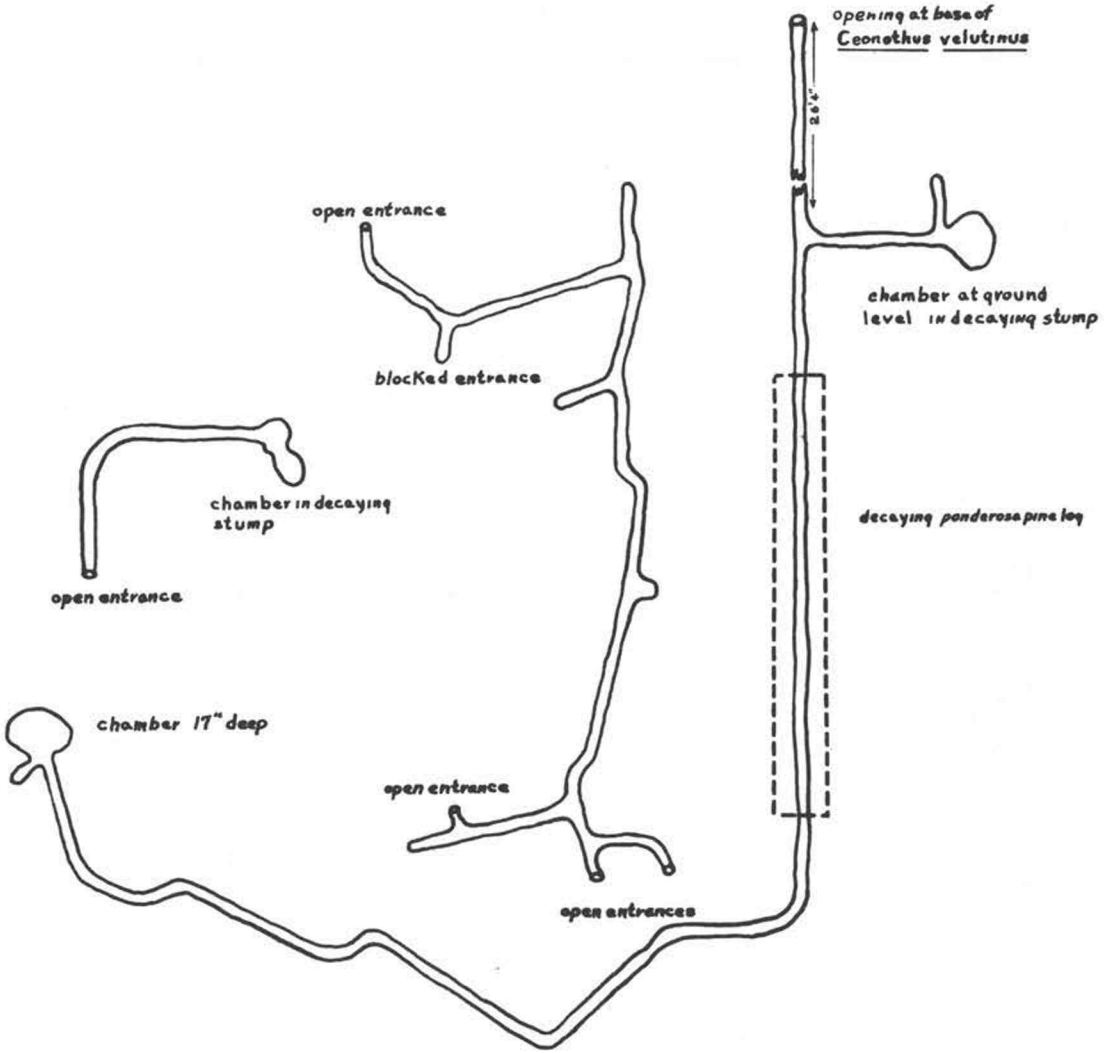


Figure 15 **Burrow Plans of Golden Mantled Ground Squirrels**

wood (Fig. 15). At no time was there any evidence of fresh dirt around the opening. The manner in which dirt is disposed of is undetermined.

At least two tunnels were used more than a year. Two females each occupied a stump and had their litters there both during 1959 and 1960. An attempt to excavate one of the stumps was abandoned after digging to a depth of 4 feet. The internal portion of the stump was quite punky, and many cross connections were found. However, no nest was found.

There is some evidence that more than one tunnel may be occupied at a time. An unmarked female with a litter at the Annie Springs Entrance Station was observed to attend her young at one burrow, and after attending to her duties she was seen to enter another burrow with full cheek pouches, which were empty when she came out again some time later. To make certain that there were two distinct burrows, the one which contained the young was dug up after they had left the area.

Hibernation

Tevis (45, p. 71-78) gave a good account of hibernation for mantled ground squirrels. Little, however, is known of the factors responsible for inducing the animals to enter hibernation. That

weather is not a factor, according to Tevis (45, p. 71-78) and Mullaly (33, p. 65-73) is evident from the fact that the animals entered hibernation when temperatures are still quite high. Although the ground was seldom frozen, and there were numerous sunny days, Tevis saw no ground squirrels throughout the entire winter.

Observations on a captive animal kept in the house offer further evidence that weather is not a factor. This animal went into hibernation about the latter part of October. Prior to entering the hibernating state, the animal was busy throughout the day, running in the wheel, feeding, and moving nesting material from one corner of the cage to the other. Finally the nest was left undisturbed, and the animal slowly became inactive. At first it would come out in the morning, and play for an hour or two, and then go back into the nest. Later in the day, usually early evening, he would emerge for a short period and then retire for the night. By mid-November the animal was seen only on occasion. He would leave the nest once a week, or sometimes only once every two weeks. Several times while the animal was sleeping, the nest was opened, and it was found in the typical hibernating attitude, that is, curled into a ball with the nose between the hind legs, and the tail curled over the head.

Emergence from hibernation, according to Tevis (1955) varies with locality. The animals at lower elevations emerge first. At Crater Lake the mantled ground squirrel is frequently seen as early as the first week in April, especially if the weather is warm and sunny.

The state of hibernation apparently is not as deep in mantled ground squirrels as in some other animals. Park personnel have reported seeing ground squirrels scrambling over snow banks at various times throughout December.

Food Habits

Food habits of mantled ground squirrels are described in a number of published accounts. The most extensive work is that of Tevis (44, p. 316-324), who analyzed the contents of 273 ground squirrel stomaches.

At Crater Lake, as well as elsewhere, ground squirrels eat a variety of foods. Seeds of conifers are gathered quite readily, and if not eaten, they are stored. The remains of cones from Pinus contorta were found at a number of stumps known to be inhabited by ground squirrels. There is no direct evidence, however, of the quantity of coniferous seeds destroyed when the supply is plentiful. Seeds from grasses and shrubs are gathered readily.

When available, mantled ground squirrels take subterranean mushrooms in preference to other foods (Fig. 16). In areas where oats were available, animals busy quartering about would occasionally stop, dig and finally pick up a mushroom and run to the top of a woodpile or stump and busily eat, having paid no attention to the oats.

The animal's diet is not strictly vegetarian. Insects, and the flesh of rodents when available, are taken readily. When meat, either fresh or cooked is offered to captive animals, other food in the cage is abandoned in preference to the meat.

Golden-mantled ground squirrels are considered to be a serious threat to reforestation. The degree with which quantities of seeds or seedlings are destroyed varies, not only seasonally, but from locality to locality. Tevis (44, p. 316-324) suggests that wherever hypogeous fungi are plentiful, mantled squirrels consume relatively few conifer seeds. Thus, in some areas, ground squirrels could conceivably be influential in retarding reforestation. There is little evidence that ground squirrels played an important role in reforestation at Crater Lake. Seedlings were examined for evidence of gnawing, and none was found. And while ground squirrels were observed gathering seeds from conifers, there was a good cone crop both seasons, and the numbers of seeds taken probably wouldn't be significant.

Figure 16. A photograph of a subterranean mushroom of the type commonly eaten by golden-mantled ground squirrels.

On July 8, 1960, 50 random samples of Shasta Red Fir seedlings were taken with a foot square frame in an area known to be inhabited by ground squirrels. In an area approximately an acre in size, 182 seedlings were counted. On August 11, another 50 random samples were taken. Only five seedlings were observed. There was no evidence that the seedlings had been gnawed. Close observation of the ground showed many wilted seedlings, and it is suspected that a lack of moisture was largely responsible for the seedling loss.

In opposition to forest depredation, the mantled ground squirrel is credited with burying large quantities of seeds which are never recovered. Thus they are considered more of a help than a hinderance in reforestation (9, p. 368).

Evidence of a forgotten cache is readily observable. The trees grow in tight groups, as contrasted to the more dispersed pattern when seeds are disseminated under natural conditions. Giving credit to the ground squirrel for such activity without observation hardly seems justified. It is true that these animals bury food items, but so do many other rodents. In an area in which ground squirrels were observed digging pits and burying food, I ran 10 transects, each 50 feet long. In none of the 100 pits examined was a single coniferous seed found. In several scattered

areas, the top two or three inches of soil were removed, and while buried oats and peanuts were found, no other kinds of food were revealed.

Water does not appear to be a necessary part of the mantled ground squirrels' diet. The nearest source of water to ground squirrels at the south entrance area was a little over a mile away. An animal kept in captivity has been given no water for nine months and appears to be in good health. Bartholomew and Hudson (6, p. 354-360) studying the effects of sodium chloride on weight and drinking in the antelope ground squirrel (Citellus leucurus) show that these animals can extract water from a 1.0 molar salt solution. They suggest that a tolerance of moderate hyperthermia, production of hypertonic urine, avoidance of heat stress, and obtaining moisture from food as well as utilizing metabolic water are means of preventing dehydration. Although not required, ground squirrels will drink quite freely when water is available. Bartholomew and Hudson recorded a mean water consumption of 12% of body weight for laboratory confined antelope ground squirrels.

Mobility

In general, very little is known of the movements made by mantled ground squirrels. Nelson (34, p. 446) reported that

mantled ground squirrels travel approximately 600 feet to available food, and Gordon (19, p. 29) has followed an animal 900 feet.

During the past two seasons, a number of animals were followed from a supply of food to their burrows. Several ground squirrels had their burrows 400 feet from the oat pile, and made frequent trips to the food stock. The length of time for a round trip varied. Sometimes the animal would be gone for as long as four or five minutes; at other times, as much as 15 minutes would elapse before it reappeared on the scene.

The farthest any animal was trailed was 1, 200 feet. Unlike those ground squirrels that had their burrows closer to the food pile, this animal made frequent stops along the way. It would climb up some vantage point, sit at attention briefly, and then scamper off. The rate of movement was always faster across an open area. The pathway taken by this animal was pretty much the same. The deviations from its course seemed to correlate with the closeness to which I approached it, especially when we were quite close to the burrow. On one occasion I waited about 15 feet from the burrow entrance. When the animal returned, it first went to the left of the opening and then to the right, each time climbing up on a stump and looking about. After approximately 10 minutes, I moved out of "sight" and the animal immediately entered the burrow.

The deliberateness with which these animals moved from one area to another suggested the transporting of juvenile and adult ground squirrels various distances and directions from the trapping site. Removing the animals from the home territory was delayed until there was no evidence that the young were still being cared for by the female.

The distances and directions transferred, as well as recapture dates at the home sites of 35 animals, are summarized in Table VIII. Of all the animals transferred, number 63 was the only one to consistently return. The greatest distance from which the animal returned was 2.5 miles. Whether other ground squirrels would return after having been transported over such a distance is a matter of conjecture. Perhaps more amazing is the return of number 83, a juvenile female, which weighed only 84 grams when released 1.1 miles north of the trapping area. She not only returned after four days, but gained 12 grams in the process. When recaptured on August 27, 11 days after having been transferred 0.5 miles north, she weighed 120 grams.

This gain in weight is in sharp contrast to the weight changes of number 63. When he was transferred on August 8, he weighed 152 grams, on August 9, a 5 gram loss was recorded. There was a weight loss after each return trip, and when recaptured for the

TABLE VIII

Distances, Directions and Recapture Dates of 35
Golden Mantled Ground Squirrels
Transferred From Their Home Territory

DDT = Distance and Direction Transferred
R = Recapture Date T = Transfer m = miles

Animal No.	Sex	Age	Date 1960	DDT	R	T	R	T	R	T	R	T	R
74	F	J	8- 8	300 ft N	8-23								
80	F	J	8- 9	400 ft N									
75	M	J	8- 8	600 ft N									
18	F	A	8- 9	1000 ft S	8-15	14 m N							
79	M	J	8- 9	1000 ft S									
67	M	A	8- 9	1000 ft S									
73	M	A	8- 8	2280 ft E									
76	M	J	8- 8	2280 ft E									
77	F	J	8- 8	2280 ft E									
4	M	A	8- 9	2280 ft E									
81	M	J	8- 9	2280 ft E									
65	F	A	8- 9	2280 ft E									
84	F	J	8-14	2280 ft E									
85	M	J	8-14	2280 ft E									
59	F	J	8-14	2280 ft E									
42	F	A	8-14	2280 ft E	8-23								
10	F	A	8-14	2280 ft E	8-16	1/2 m N	8-27						
86	M	J	8-15	2280 ft E									
87	F	J	8-15	2280 ft E									
88	M	J	8-15	2280 ft E	8-23								
89	F	J	8-15	2280 ft E									
90	M	J	8-15	2280 ft E									
91	M	J	8-16	1/2 m N									
92	F	A	8-16	1/2 m N	8-23								
93	F	J	8-16	1/2 m N	8-19	1 m N							
94	F	J	8-16	1/2 m N									
95	M	J	8-16	1/2 m N									
96	M	J	8-16	1/2 m N									
54	F	A	8-12	1.1 m N									
30	F	A	8-12	1.1 m N	8-23	1.1 m N							
82	M	A	8-12	1.1 m N									
83	F	J	8-12	1.1 m N	8-16	1/2 m N							
63	M	A	8- 8	2280 ft E	8- 4	2280 ft E	8-12	1.1 m N	8-15	1.5 m N	8-19	2.5 m N	8-23
78	M	J	8- 8	14 m N									
17	F	A	8-15	14 m N									

last time on August 23, his weight was recorded at 114 grams, a loss of 38 grams in 15 days. This seems to suggest that when traveling over long distances, the adult animals spend little time in feeding, depending entirely on reserve food. Juveniles, however, have little stored fat, and thus, have to stop and feed. Number 30, released 1.1 miles north, returned after an absence of 11 days. Reweighing showed a four gram loss, which is not at all significant. It may be that there are individual differences; some animals stopping to feed and others, not.

The behavior of the animals when first released regardless of distance transferred, varied from individual to individual. Some would immediately dash in the direction of the trapping site. Others appeared confused. They would move a short distance out of the trap, stop, look about and then quarter right and left, finally moving off toward home. A number of the young headed toward a shrub or stump which they climbed, and after surveying the area for a while, they, too, scampered back to home territory. Only three animals, headed away in a direction opposite to the trapping site, and were not seen again.

The intriguing problem that presents itself is, how do the animals find their way back? All animals were transported in closed metal traps. It does not seem reasonable that the animals

used land marks, considering that some of them, at least, were moving in new territory.

Orientation to the sun is a suggested answer to the problem; however, there is no experimental evidence for this. The problem is a challenging one, and certainly is worth further investigation.

Use of Tranquilizing Agents

In order to overcome some of the difficulties encountered when attempting to follow ground squirrels for long distances, intramuscular injections of Promazine were given to 15 mantled ground squirrels. The most difficult task was determining the proper dosage. At first, the Promazine was diluted on a weight basis, interpolating from recommended dosages for cats and dogs. This was unsuccessful, and as a consequence, a number of animals died.

One cubic centimeter per 100 grams of body weight of a nine-to-one dilution was found to work satisfactorily. If given more than this amount, the animal would just sit in one place. If given a lighter dosage, the animal would move too quickly to follow easily.

It took about 20 minutes for the drug to take effect. When first released, the animals sat quietly, moved slowly and only for short distances when prodded. Sudden movements, or loud noises

did not startle the animals into running away. The only reaction noted was a slight body contraction.

After a lapse of 30 minutes from the time they were released, the animals moved about freely, but they were still very approachable and could be picked up readily.

Approximately 1 1/2 hours after the injection, ground squirrels began foraging actively; and after their cheek pouches were full, they returned to their burrows. They moved in a leisurely fashion and therefore were more easily followed.

It was interesting to note that these animals given an optimum dosage of Promazine sought cover as readily as untreated animals. The main difference in their behavior was that they didn't make the customary hurried dash for protection when I approached them.

When tranquilized animals were placed on a limb several feet above the ground, they had no difficulty in staying there; but whenever they tried moving, they invariably lost their balance and fell to the ground. Ordinarily, when an untranquilized ground squirrel slips while above ground, it will struggle to regain its balance. Tranquilized animals, however, did not. It appeared as if their coordination was lost, or else the fear of falling was totally suppressed. And yet, when these same animals were put on the

ground, they moved about with ease and with no evidence of loss of coordination.

From these preliminary results it appears that a tranquilizer can be used effectively when attempting to learn more about the mobility of animals which are difficult to follow because of size and the speed with which they move.

Daily Cycle

Golden-mantled ground squirrels are more in evidence at certain times of the day than at others. At the south entrance site the area was shaded by the surrounding trees until about 7:30 A. M. Up to this time only a few ground squirrels were noted sunning themselves in patches of sunlight. As the shadows disappeared, activity increased. From noon until 4:00 P. M. (the warmest part of the day), activity decreased, and then as it became cooler, activity increased once again and lasted until about six o'clock. Most of the animals disappear by the time the sun sets, but a few individuals were observed foraging as much as an hour after sunset.

When cloudy, the usual cycle of activity is not so apparent. In the event of a light drizzle, animals may be seen at any time but heavy rains keep them under cover. During one early snowfall a few individuals were foraging, but most of the animals remained

in their burrows. Examination of the area around the burrow opening revealed that the animals emerged momentarily, for tracks led away from the opening about two feet, and then led right back to the burrow. Further observations showed that the animal remained in the burrow the rest of the day.

When mantled ground squirrels first appeared in the morning, many were seen either sitting or lying in the sun, generally on top of a stump or some other vantage point. The length of time spent in sunning varied, sometimes lasting only five minutes and at other times as long as 15 or 20 minutes. Occasionally during the sunning period, the animal would stretch, and yawn, shift position and then settle down again.

When not resting, mantled ground squirrels are busy foraging. Food is first picked up with the teeth and then manipulated with the forepaws after the animal assumes a sitting position. Besides sunning and foraging, the animals spend a great deal of time in investigative behavior. Strange objects are approached cautiously with short, jerky movements accompanied with a nervous flicking of the tail. When the object is reached, the animal sniffs every part of it, and occasionally the animal will bite or gnaw it. All the while the animals are either foraging, investigating or sunning, they are constantly on the alert. A strange noise or the

sudden appearance of a shadow in their vicinity sends the animal scurrying for cover. A moment later the animal reappears and generally assumes an alert position before continuing its activities.

When the animals are not gathering food, resting or quartering about in investigative behavior they are busy gathering nesting material, an activity that takes place any time during the summer. Nesting material observed being gathered consisted of shredded newspaper, grass stems, rags, and kleenex. Items too large to handle, such as a newspaper or long grass stems are cut to shorter lengths. The material is picked up with the teeth and positioned in the mouth with the aid of the forepaws. The ends of long pieces are patted down so that nothing projects beyond the width of the body. Occasionally animals stop whatever they are doing and take a dust bath. They do this by stretching, rolling over on their sides and rubbing their chins and sides of their faces in the dust. They also spend much time in preening, especially after the animal had vigorously scratched at fleas.

Attitudes

The mantled ground squirrel assumes a variety of attitudes, some of which give the animal a comical appearance. The most common position observed is one of alertness which is manifested

in a variety of ways. Gordon (19, p. 22) stated that these poses represent various degrees of alarm. If much concern is exhibited, the animal stands up on its hind feet (Figs. 17 and 18). This position is taken when the animal enters an area for the first time or if a strange object is suddenly present in its territory. The raucous calls of Steller's Jay or Clark's Nutcracker, or the warning calls of chickarees, chipmunks or other ground squirrels also cause the animal to take the picket-pin stance. When only mild concern is aroused, the animal merely stops what it is doing and looks about (Figs. 19 and 20).

If the animal is on the ground and surrounded by tall objects, it will climb up on a log or rocks and then "freeze" (Figs. 21 and 22). When sufficiently frightened, and if the animals are near their burrows, they take cover. When they emerge, they slowly stick their heads out of the burrow just far enough to see if it is safe. If the danger is sufficiently distant, they come out far enough so that the head and shoulders are exposed, but no farther (Figs. 23 and 24).

Feeding positions are also quite varied. In some instances the animal stretches out full length and rapidly fills its pouches (Fig. 25); in others, it assumes a sitting position (Figs. 26 and 27). Attitudes of dusting (Fig. 28) and flea chasing are illustrated in

Figure 17. Alert position assumed when a mantled ground squirrel is much concerned

Figure 18. Alert position assumed when a mantled ground squirrel is much concerned.

Figure 19. Alert position assumed when a mantled ground squirrel is only mildly concerned.

Figure 20. Alert position assumed when a mantled ground squirrel is only mildly concerned.

Figure 21. "Freezing" attitude.

Figure 22. "Freezing" attitude.

Figure 23. Attitude assumed when surveying the area for near by danger.

Figure 24. Position taken if danger is sufficiently distant.

Figure 25. One of the many feeding positions assumed. The animals stretch out full length and rapidly fill their pouches.

Figure 26. Sitting position of a feeding adult.

Figure 27. Sitting position of a feeding adult.

Figure 28. Dust bathing attitude assumed by mantled ground squirrels.

Figures 29 and 30, and some of the positions of stretching and yawning are represented in Figures 31 and 32; while Figures 33 and 34 illustrate the use of the forepaws in gathering nesting material.

Mantled ground squirrels which were given Promazine exhibit none of the alertness demonstrated by non-treated animals. In general, they appear sleepy and seem to show little interest in their surroundings (Figs. 35, 36 and 37).

Mantled ground squirrels are exceptionally fond of peanuts and will go through a variety of antics, such as climbing into shirt pockets, squeezing through narrow openings, or gnawing through cloth or paper bags to get them. The following account is illustrative of some of the maneuvers of ground squirrels in obtaining their favorite food. A quart jar approximately one fourth full of peanuts was placed on a window sill after several animals were conditioned to coming to the area for food. One evening when no scraps were put out, a ground squirrel which habitually came to feed, entered through the open window, and after a brief investigatory period found the peanuts. The animal jumped to the top of the jar, stopped and looked about and then dropped in head first hanging on to the top of the jar with its hind feet (Figs. 38 and 39). The animal filled its cheek pouches and left, only to return with empty pouches. This process continued until the jar was emptied.

Figure 29. Flea chasing.

Figure 30. Flea chasing.

Figure 31. Stretching attitude.

Figure 32. Stretching and yawning attitude.

Figure 33. The use of forepaws in positioning nesting material in the mouth.

Figure 34. Another illustration of gathering nest material showing the use of the forepaws.

Figure 35. A mantled ground squirrel under the influence of Promazine. No attention is given to any type of stimuli.

Figure 36. A tranquilized ground squirrel slightly more aware of its surroundings than the animal in Figure 35.

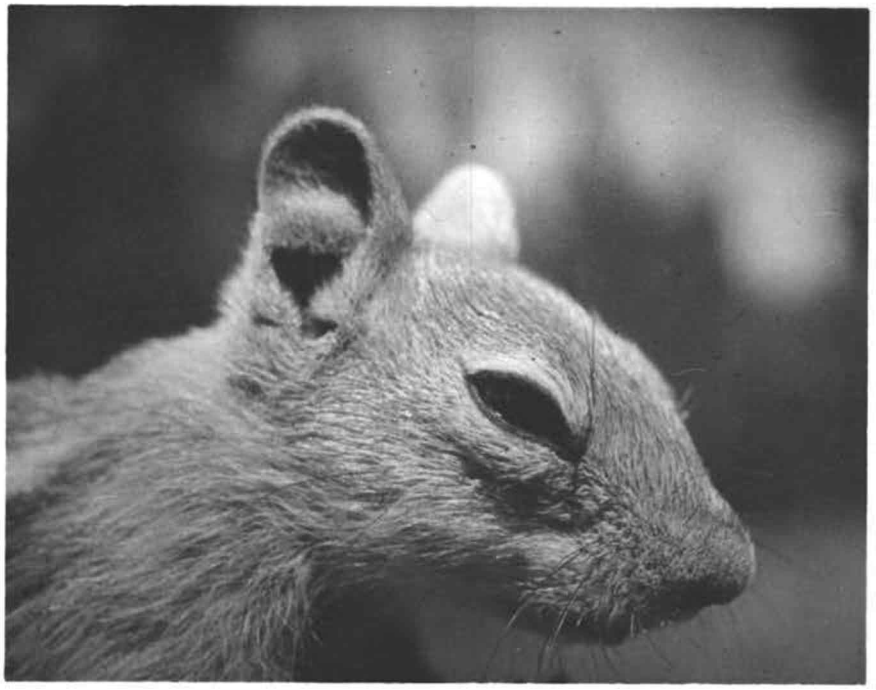


Figure 37. Portrait of a tranquilized ground squirrel. Note the drowsy appearance, and general lack of alertness.

Figure 38. Mantled ground squirrel on top the jar after finding the peanuts.

Figure 39. The head first position assumed when an animal gathers food from a container.

Relationship to the Chipmunk

The golden-mantled ground squirrel, and the two species of chipmunk, Eutamias amoenus and Eutamias townsendii, so nearly occupy the same ecological niche at Crater Lake, that one would almost assume that there was a great deal of competition between these species. However, there is little direct evidence to warrant such an assumption. Broadbrooks (7, p. 1-42), working with the chipmunk, Eutamias amoenus, in Washington, stated that there is little direct conflict between the chipmunk and the ground squirrel.

Furthermore, the habits of the two animals are quite different. The chipmunk is quite arboreal and frequently climbs to the tops of tall pine trees to gather cones. Ground squirrels on the other hand, are not as agile as the chipmunks, and while several were observed up in a tree about 20 feet, most of them stay nearer to the ground.

The choice of food of the two species is also similar, and the items on which these animals feed have been listed by Gordon (19, p. 27) and Tevis (43, p. 198-205 and 44, p. 316-324). At Crater Lake both species were observed eating fungi, the fruits of Ribes cereum, Arctostaphylos patula, Carex inops and the flowers of Ceonothus velutina. Undoubtedly, there were many others.

In areas where oats were supplied, ground squirrels and chipmunks came together to feed with little or no conflict. There were only a few chases, and in general they were very brief. Often a chipmunk would approach a ground squirrel, sniff the face and proceed to feed.

Even though both species have similar food preferences, there is no indication that they compete with one another for it, at least as long as there are sufficient amounts. On the other hand, there is also no evidence of cooperation between the species, thus, one is led to the conclusion that the relationship between the two species is one of coexistence.

SUMMARY

This study of the golden-mantled ground squirrel, Citellus lateralis chrysodeirus, is based on six months of field work at Crater Lake National Park, Klamath County, Oregon. Data were obtained by live-trapping, experimental procedures and observation in two widely separated study plots. One area was in the Transition Zone at the south entrance to the park, and the other was in the Canadian Zone near Park Headquarters.

The mantled ground squirrel is an excellent animal for field study because of its diurnal habits, relatively large numbers and the ease with which it is trapped.

For permanent marking, certain toes of the hind feet and forepaws were amputated, according to a previously established code. Animals were also marked for visual observation, using a combination of staining with $AgNO_3$ and a patterned clipping of tail hairs. A number of other dye substances, such as eosin, corallin yellow and methyl green were tested as marking agents; none of these, however, proved satisfactory since the colors faded within five to ten days. Silver nitrate, on the other hand, is a permanent stain, and needs to be reapplied only after an animal has moulted. Several animals that were marked during the summer of 1959 were

still marked sufficiently well the following spring to make identification possible at a distance.

When the young first left the nest they stayed quite close to the burrow opening. During their first excursions, they moved only two to three feet from the nest site. The distance covered while the young investigated their surroundings increased rapidly. Some of the more precocious animals were observed approximately 50 feet from the burrow by mid-morning of the next day. The young were easily approached for the first few days after they left the nest. However, after two or three days they were quite wary and quickly disappeared when anyone approached within 10 to 15 feet.

Noises that appeared to arouse no response in adults were given full attention by the young. They sat erect and turned their heads in the direction of the sound, and after a brief period of alertness they would resume their quartering activity.

Young mantled ground squirrels were observed to be brighter in color and fuzzier in appearance than the adults. The young were also quite clumsy and were frequently seen toppling over while sitting on their haunches or falling from an object they were attempting to climb. When they were not foraging for food or quartering about investigating, the young indulged in a variety of activities, such as wrestling, chasing and sexual play. At no time,

however, was the existence of a social hierachy detected among immature mantled ground squirrels.

Social dominance was well established in adult ground squirrels. The chase order, however, was a group arrangement rather than a straight-line relationship. During the period of observation only one animal was noted which was not chased by any other animal in the community. That this animal was the most aggressive one was evidenced by the fact that it gave chase to a chickaree, an incident that was observed only once during the period of investigation. Social encounters, in general, were brief and resulted in short chases. Occasionally there were fights, but they were brief and not of a serious nature. Two types of behavior were noted, neither of which had been previously reported. Occasionally during a chase, the chasee would stop and place its chin on the ground and either raise its rump, or lie down in a prone position. In either case all agonistic behavior ceased. This display was interpreted as an appeasement attitude. At other times when one animal approached another, or if one came into an area where some foreign object was encountered, the animal would stop, rub its chin on the ground or stamp the forefeet. The underlying motivation for this type of posturing was interpreted as a form of displacement behavior.

The factors responsible for establishing dominance are not clear. An animal dominant in one situation may very well be the subordinate in another. Weight did not appear to be important in determining social status. However, there is some evidence that territorial defense, physical well being, and hunger are important.

Histological examination of the eyes of golden-mantled ground squirrels revealed the retina to be of the pure-cone type. Because these animals have photopic retinal mechanisms, experiments were conducted to determine the presence or absence of color vision. The results and methods used are presented only as a progress report. Although there were 66.5 percent correct responses to the reward stimulus, it cannot be concluded positively that there is a color discriminatory capacity in golden-mantled ground squirrels. It may be that before further field work is done, ground squirrels should be brought into the laboratory and tested for color vision with light which is controlled both for color and intensity.

One of the major difficulties encountered in doing experimental work in the field is that there is little control over the activities of animals in the area. If there is an abundance of natural food, attracting animals to the experimental device becomes problematical. On the other hand, if animals congregate readily

at a given site, predators are attracted. Such was the situation at Crater Lake. A young fox that had been cared for by humans as a pup was eventually released. However, rather than deserting the area, it remained in the nearby vicinity and on several occasions was seen with a dead ground squirrel in its jaws. Because peanuts were used to attract the animals to the experimental devices, bears were a nuisance. Several days after the experimental unit was put into operation, an adult black bear tore the boxes apart to get at the peanuts, a rather disconcerting situation which was repeated on several occasions.

In field experiments where little or no previous work has been done, the investigator quite frequently has to spend a good deal of time in working out the methodology to be employed. The use of laboratory equipment in the field is not always feasible, especially in such cases where the apparatus is large and heavy, or requires controlled voltages or delicate handling. Also, equipment that can be used successfully in one situation cannot always be used in another. Thus, without the benefit of previous experience of other investigators, one frequently constructs a number of devices, none of which are satisfactory, and as a consequence, much time is lost.

Approximately equal numbers of males and females were trapped and marked during the two seasons of field work. There were slightly more males taken, both among the adults (55. 6 per cent).

Juvenile males during the second half of July were on an average 5. 2 grams heavier than females. However, by the middle of August females on an average were 10. 2 grams heavier than males. The average weight for adult males captured during the 1959-1960 trapping was 163. 8 grams, and for adult females the average weight was 157. 0 grams. The rate at which animals gained weight varied considerably, ranging from a low of 10 grams in 24 days for an adult male, to a high of 45 grams in eight days for a juvenile female.

Five burrows were examined. The shortest was seven feet long. The longest burrow measured was 71 feet 4 inches. No food caches were found, and only one nest was discovered.

Mantled ground squirrels hibernate during the winter. The state of hibernation doesn't appear to be as deep as it is in some other animals, for they were frequently seen moving over snow banks on sunny days in December.

Golden-mantled ground squirrels eat a variety of foods. Foods observed to be eaten were subterranean mushrooms, Pinus

contorta seeds, leaves and stems of Aster ledophyllus, and the fruits of Arctostaphylos patula, Ceanothus velutina and Carex inops. There was no evidence that mantled ground squirrels were responsible for the destruction of conifer seedlings. Neither was there evidence that they buried conifer seeds in pits, thereby aiding in seedling establishment.

Ground squirrels were observed to travel as much as 1,200 feet between their burrows and a readily available food supply. From August 8th to August 16th, 35 animals, trapped at the south utility area, were transported various distances and directions, from their home site. The greatest distance from which an animal returned was 2.5 miles. That the means by which these animals orient themselves are unknown suggests a number of interesting problems for future investigation.

Preliminary investigations were begun in the use of Promazine as an aid in following ground squirrels. The most satisfactory dosage was found to be one cubic centimeter per 100 grams of body weight of a nine to one dilution. Approximately 1.5 hours after an intramuscular injection of the tranquilizing agent, the animals appeared to resume their normal activity, except that they moved in a more leisurely manner.

Although the golden-mantled ground squirrel, C. l. chrysodeirus and the chipmunks, Eutamias amoenus and E. townsendii have similar food and habitat requirements, there was no evidence of competition between these animals. That there was no apparent competition may have been due to the abundance of natural foods in the area. In the event of a food shortage it is suspected that the ground squirrel would survive longer, in part because of larger size and greater aggressiveness.

BIBLIOGRAPHY

1. Allee, W. C. The social life of the animals. Boston, Beacon Press, 1938. 233p.

2. _____ Levels of integration in biological and social systems. In: R. Redfield's (ed.) Biological symposia, vol. 3. Lancaster, Cattell, 1942. p. 139-161.

3. Alverdes, F. The behavior of mammalian herds and packs. In: C. Murchison's Handbook of social psychology. Worcester, Clark University Press, 1935. 1195 p.

4. Arden, G. B. and K. Tansley. The spectral sensitivity of the pure-cone retina of the grey squirrel(Sciurus carolinensis leucotis). Journal of Physiology 127:592-602. 1955.

5. Bailey, Vernon. The mammals and life zones of Oregon. North American fauna 55:1-416. 1936.

6. Bartholomew, George A., and J. W. Hudson. Effects of sodium chloride on weight and drinking in the antelope ground squirrel. Journal of Mammalogy 40(3):354-360. 1959.

7. Broadbooks, Harold E. Life history and ecology of the chipmunk, Eutamias amoenus, in Eastern Washington. Ann Arbor, University of Michigan, 1958. 42 p. (Michigan University. Museum of Zoology. Miscellaneous publications 103)

8. Bruce, R. H. An experimental analysis of social factors affecting the performance of white rats. Journal of Comparative Psychology 31:395-412. 1941.

9. Cahalane, Victor H. Mammals of North America. New York, Macmillan, 1947. 682 p.

10. Calhoun, John B. The social aspects of population dynamics. Journal of Mammalogy 33(2):139-157. 1952.

11. _____ Behavior of house mice with reference to fixed points of orientation. Ecology 37:287-301. 1956.

12. Collias, N. E. Statistical analysis of factors which make for success in initial encounters between hens. American Naturalist 77:519-538. 1943.

13. _____ Aggressive behavior among vertebrate animals. Physiological Zoology 17(1):83-123. 1944.

14. Crawford, M. P. Dominance and the behavior of pairs of female chimpanzees when they meet after varying intervals of separation. Journal of Comparative Psychology 33:259-266. 1942.

15. Darling, F. F. A herd of red deer. London, Oxford University Press, 1937. 215 p.

16. Errington, P. L. Reactions of muskrats to drought. Ecology 20:168-186. 1939.

17. Evans, H. M. A study of a social hierarchy in the lizard, Anolis carolinensis. Journal of Genetic Psychology 48:88-111. 1936.

18. Ginsburg, B. and W. C. Allee. Some effects of conditioning on social dominance and subordination in inbred strains of mice. Physiological Zoology 15:485-506. 1942.

19. Gordon, Kenneth L. The natural history and behavior of the western chipmunk and the mantled ground squirrel. Corvallis, 1943. 104 p. (Oregon State Monographs: Studies in Zoology No. 5)

20. Hall, E. Raymond, and Keith R. Kelson. The mammals of North America. vol. 1. New York, Ronald Press, 1959. 546 p.

21. Howard, H. E. Territory and bird life. London, Murray, 1920. 308 p.

22. Howell, A. H. Revision of the North American ground squirrels. North American Fauna 56:1-256. 1938.

23. Huestis, Ralph R. The golden-mantled ground squirrel. Crater Lake National Park, Crater Lake Natural History Association, 1951. 22 p. (Crater Lake Nature Notes)

24. Jaeger, Edmund C. Denizens of the mountains. Baltimore, Thomas, 1929. 168 p.

25. Kolosvary, C. A study of color vision in the mouse (Mus musculus) and the souslik (Citellus citellus L.) Journal of Genetic Psychology 44:473:477. 1934.

26. Locher, Charlotte J. S. Untersuchungen über den Farbensinn von Eichhörnchen. Leiden, Brill, 1933. 56 p.

27. Lorenz, Konrad Z. The comparative method in studying innate behaviour patterns. In: Physiological mechanisms in animal behaviour, Symposium No. 4 Society for the study of experimental biology, New York, Academic Press, 1952. p. 221-268.

28. _____ The evolution of behavior, Scientific American 199(6):67-78. 1958.

29. Maslow, A. H. The role of dominance in the social and sexual behavior of infra-human primates, the determination of hierarchy in pairs and in a group. Journal of Genetic Psychology 49:161-198. 1936.

30. _____ Dominance quality and social behavior in infra-human primates. Journal of Social Psychology 11:313-324. 1940.

31. Merriam, C. Hart. Description of twenty-six new species of North American mammals. North American Fauna 4:60. 1890.

32. _____ Notes on the chipmunk of the genus Eutamias occuring west of the east base of the Cascade-Sierra system, with descriptions of new forms. Proceedings of the Biological Society of Washington 11:189-212. 1897.

33. Mullally, Don P. Hibernation in the golden-mantled ground squirrel, Citellus lateralis bernardinus. Journal of Mammalogy 34:65-73. 1953.

34. Nelson, Edward W. Smaller North American mammals. The National Geographic Magazine 33(5):371-493. 1918.

35. Nowlis, V. The relation of degree of hunger to competitive interaction of chimpanzees. Journal of Comparative Psychology 32:91-116. 1941.

36. Reimov, R. An experimental study of the color vision of the dwarf souslik (Citellus pygmaeus Peall) in the field. Academy of Sciences, USSR, Proceedings, Biological Science Section 114:585-587. May-June 1957. (Trans. by American Institute of Biological Sciences)

37. Schjelderup-Ebbe, T. Beitrage zur Sozialpsychologie des Haushuhns. Zeitschrift für Psychologie 88:225-252. 1922.

38. Scott, John P. (ed.) Methodology and techniques for the study of animal societies. Annals of the New York Academy of Science 51:1001-1122. 1950.

39. Scott, John P. The analysis of social organization in animals. Ecology 37:213-220. 1956.

40. _____ Animal behavior. Chicago, University of Chicago Press, 1958. 281 p.

41. Smith, C. F. and S. E. Aldous. The influence of mammals and birds in retarding artificial and natural reseeding of coniferous forests in the United States. Journal of Forestry 45:361-369. 1947.

42. Taylor, Walter P. and D. M. Gorsuch. A test of some rodent and bird influences on western yellow pine reproduction at Fort Valley, Flagstaff, Arizona. Journal of Mammalogy 13:218-223. 1932.

43. Tevis, Lloyd Jr. Autumn foods of chipmunks and golden-mantled ground squirrels in the northern Sierra Nevada. Journal of Mammalogy 33:198-205. 1952.

44. _____ Stomach contents of chipmunks and mantled ground squirrels in northeastern California. Journal of Mammalogy 34:316-324. 1953.

45. _____ Observations on chipmunks and mantled ground squirrels in northern California. American Midland Naturalist 53:71-78. 1955.

46. _____ Invasion of a logged area by golden-mantled ground squirrels. Journal of Mammalogy 37:291-292. 1956.

47. Tinbergen, Niko. The study of instinct. Oxford, Clarendon Press, 1951. 228 p.

48. _____ Social behavior in animals. London, Methuen, 1953. 150 p.

49. _____ Curious naturalists. New York, Basic Books, 1958. 280 p.

50. Uhrich, J. The social hierarchy in albino mice. Journal of Comparative Psychology 25:373-413. 1938.

51. Wahlenberg, W. G. Reforestation by seed sowing in the northern Rocky Mountains. Journal of Agricultural Research 30:637-641. 1925.

52. Walls G. L. The vertebrate eye and its adaptive radiation. Bloomfield Hills, Cranbrook Press, 1942. 785 p. (Cranbrook Institute of Science Bulletin No. 19)