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NOTES ON THE GROUND-SQUIRREL,  
CALLOSPERMOPHILUSBY ROBERT T. HATT<sup>1</sup>

The notes upon which this paper is founded were made principally upon the species *Callospermophilus lateralis lateralis* and its sub-species *C. l. arizonensis*. A single note is included on the sub-species *C. l. saturatus*. Unless specifically stated to the contrary, the notes refer to the first form mentioned. Field studies were made of *C. l. lateralis* in the foothills and along the front range of the Rocky Mountains of Colorado from Pike's Peak north to the vicinity of Nederland, Boulder County. The notes on *C. l. arizonensis* were made at its type locality, the San Francisco Mountains of Arizona. *C. l. saturatus* was observed near the type locality at Lake Keechelus, Washington.

The original notes were made during field observation of free animals; from observations on captives secured in the Pike's Peak region, later transported to the Atlantic seaboard; and from dead specimens which had been shot or trapped.

The author wishes to acknowledge his indebtedness to those persons and institutions which contributed materially to the

<sup>1</sup> Contribution from the Biological Laboratory, New York University.

study. To Lee R. Dice, whose many courtesies and helpful suggestions were so freely extended, the writer expresses his gratitude. G. W. Goldsmith, of the Carnegie Institution of Washington, has generously permitted the publication of some of his notes on hibernation dates. Harriet L. Smith aided considerably by analyzing the vocal expressions of captives. Nathan Banks, of the Museum of Comparative Zoology, has most kindly determined ticks from the squirrels, while H. E. Ewing, of the United States Department of Agriculture, courteously made identifications of fleas. Seeds removed from cheek pouches have been taxonomically placed by members of the staff of the United States Department of Agriculture.

The expeditions upon which the field work was done were the University of Michigan-Bryant Walker Pacific Coast Expedition of 1922 and the University of Michigan-Carnegie Institution Expedition to the Southwest in 1924. New York University had cages constructed for captives and supplied food for these captives for the two years they were held. W. K. Hatt generously contributed materially to the investigation at various times.

In the various parts of its range *Callospermophilus* is known locally as "big chipmunk," "rock-squirrel," "copper-head," "copper chipmunk," "two-bar chipmunk," etc., while in literature it has received many "book" names, such as, "golden-mantled ground squirrel," "gilded-squirrel," "gray ground squirrel" and other cumbersome titles. It is in need of a brief descriptive name that will be exclusive to its own use. Closer contact with civilization will no doubt establish such a name.

#### GENERAL CHARACTER

*Callospermophilus* is a medium sized ground-squirrel of stocky build, living in the mountains of the western United States, Canada and Mexico. Its pelage bears lateral stripes similar to those of a chipmunk, but these do not extend

through the eye as they do in those animals, nor is there the median dark stripe of the chipmunk. The head and shoulders usually show a conspicuous mantle of ferruginous-chestnut or ochraceous, though many specimens of some species have a mantle of gray.

*Weight.* The weights of ten adult *C. l. lateralis* taken in the Colorado foothills between August 3 and September 5 averaged 231.3 grams. The heaviest of these was a male taken September 1 which weighed 275 grams. This was a very fat individual. The lightest of the specimens was a female taken August 3 that weighed 167 grams. Five females averaged 220.2 grams, with extremes of 264 and 167 grams. Five males averaged 242.4 grams, with 275 as high and 212 lowest. An immature female taken on August 6 weighed 131 grams; another on August 23, 97 grams; and one on August 25, 137 grams.

Ten adult *C. l. arizonensis* collected in the San Francisco Mountains between July 3 and July 6 averaged 225.9 grams, with extremes at 177 grams and 270 grams, both females. Of the series two were males, one weighing 200 grams, the other 220 grams; the average is 210 grams. The eight females average 229.8 grams; the extremes were noted above. A juvenile female secured July 4 weighed 103 grams. It may be inferred from this small series that there is no significant weight difference between *C. l. lateralis* and *C. l. arizonensis*.

*Fat.* These ground squirrels become very fat as autumn approaches. The fat is deposited in large quantities under the skin, between the shoulders, about the kidneys, and in many other places through the body.

*Incisors.* The color of the enamel on the anterior surfaces of the incisors varies greatly within the species. Individuals of one sex, of the same age, taken at the same time in one locality, have shown variation from a uniform deep chrome yellow to a light sulphur yellow, faded towards the tips.

*Scent Glands.* The transmission of messages by the use of secretions from sudoriparous glands, so often resorted to among the mammals, has led to a specialization of two areas

in *Callospermophilus*. One of these is a spatulate area in the skin of the back in which the sweat glands are enlarged. The other consists of a set of three anal glands similar to those of *Citellus*, *Marmota*, and other rodents.

Externally, the dorsal glandular area is, in living individuals, quite inconspicuous, since the fur is kept well groomed. In freshly killed animals the area may frequently be exhibited by smoothing out the fur of the back. When a dead animal is allowed to lie for some hours the glandular secretion will often definitely mat the hairs. Such a condition is common in dried museum skins. The area is then marked by a diamond shaped depression in the fur of the back between the lateral stripes. From a point between the scapulae the matting extends caudally one centimeter or more. This depression is always longer than wide. In skins of individuals which have the glandular area well developed, but which have been thoroughly cleaned, the area will usually be defined by a fine break in the level of the hairs of the back—not always obvious, but visible to a discerning eye. If such skins are blown on from behind, the hairs of the glandular area lie undisturbed while the others fluff up. This is due to the relative shortness of the shield hairs among the glands and the usual absence of fur hairs.

The glands, themselves, have been described<sup>2</sup> as modified and enlarged sudoriparous glands consisting of a fundus, which is the tightly coiled and lightly branched end piece, a sinus with secretory walls; and a narrow duct leading to the surface. These glands are found best developed in the males and in them are most prominent in the spring and summer.

The secretion is a light clear fluid bearing a distinct though evasive odor. It has been variously described as resembling a slightly rancid oil, decomposing fish entrails, and musk. Excitement appears to stimulate the glands to secretion.

No observations on these animals bear on the use of the

<sup>2</sup> Hatt, Robert T. 1926. A new dorsal gland in the ground squirrel, *Callospermophilus*, with a note on its anal gland. *Jour. Morph. and Physiol.* v. 42, no. 2, pp. 441-451.

glands, and one is forced to speculation if an explanation of their function is to be given. A glandular area in such a position would from time to time come in contact with such features of the animal's environment as rocks, logs, burrows, and the overhanging herbs and shrubs of the habitat. Such contact might be consciously made, or purely accidental. There is no reason to believe that the messages left on the air and the solid features of the animal's environment must at all times be constant. They might convey such classes of intelligence as the age, the sex, the nest community, the personal identity and even the mental state of the individual. Since they are best developed in the males, and since they are best developed in the period which appears to include the breeding season it is possible that the glands serve too as sex stimulators. Their role probably is one which tends to hold the family or the species together.

The anal glands may have similar functions or a function peculiar to themselves. While the squirrels are seen to protrude the nipples of these glands from the anal aperture during times of extreme fear and extrude a milky substance from them, the secretion is not sufficiently repellant to serve in defense. The function of its use is as much an enigma as is that of the dorsal glands.

#### ALTITUDINAL DISTRIBUTION

*Callospermophilus l. lateralis* is found in practically every sunny habitat from the base of the foothills to the grassy areas above timberline. It was taken on Pike's Peak at altitudes from 6,500 to 13,000 feet. Timberline nearest this high record was at 11,800 feet. The squirrels were most abundant from 7,000 to 11,500 feet.

*Callospermophilus l. arizonensis* was recorded from 6,800 to 8,600 feet. It was most abundant at about 8,000 feet, though this may be only because of a great artificial difference in habitats.

## HABITS AND HABITATS

*Principal Habitats.* Callospermophilus, like the chipmunks, is associated with habitats where it may receive direct sunlight for at least part of the day. In very dense stands of spruce or fir the squirrel will either be absent altogether or will only forage through the area. An open situation favors the presence of ground squirrels because of the greater food supply close to the ground, and probably too because of the pleasure or necessity of sunning.

The natural areas which support the heaviest population of Callospermophilus are the dry, open, gravelly hillsides with a light oak chaparral or seedling growth, whose surface bears in abundance the kinnikinnik (*Arctostáphylos úva-úrsi*), Oregon grape (*Odostemon fremontii*), grasses and other herbs and shrubs. Except for high alpine meadows, open grass areas that are well grazed also carry a considerable population. Alpine meadows are scantily populated because of the brevity of the summer season and the scarcity of suitable food in these habitats. On rock slides Callospermophilus is frequently found, though usually near the margin, for there is little to sustain life in the center of an extensive slide.

About camps and buildings where these animals are fed, or, at least, unmolested, they reach their peak of concentration, for here food is abundant and enemies scarce. Villages, however, do not attract them, for food scraps are not so readily available and the presence of numerous cats, dogs, and boys make it an inhospitable neighborhood.

Pure stands of yellow pine (*Pinus ponderosa*), limber pine (*P. flexilis*), lodgepole pine (*P. contorta* var. *murrayana*), Engleman spruce (*Picea englemanni*), Douglas fir (*Pseudotsuga mucronata*), and aspen (*Populus tremuloïdes*), as well as mixed stands all support populations of Callospermophilus, provided the stand is not too dense. Open stands of Engleman spruce and Douglas fir frequently show an abundance of squirrels.

In the part of the range of *C. l. arizonensis* which was examined, there was not a diversity of suitable habitat, though

those habitats which the animal did occupy were extensive. Slashings in the yellow-pine forest were heavily populated. Here the numerous stumps, rotten logs, and brush heaps furnished abundant shelter and the food supply seemed practically identical to that in the forest. In the open pine forests the squirrels were common but not abundant. The presence of logs and stumps, of abundant grass and other very low plants here make the forest a suitable environment. It is a common roadside animal in the cultivated areas of the San Francisco Mountain region.

*The Burrow.* A *Callospermophilus* begins life in a burrow and spends a large proportion of the remainder of its life there, for not only does it stay inside at night, but it seeks shelter and protection when the weather is unfavorable and when enemies pursue. Here, too, are spent practically all the

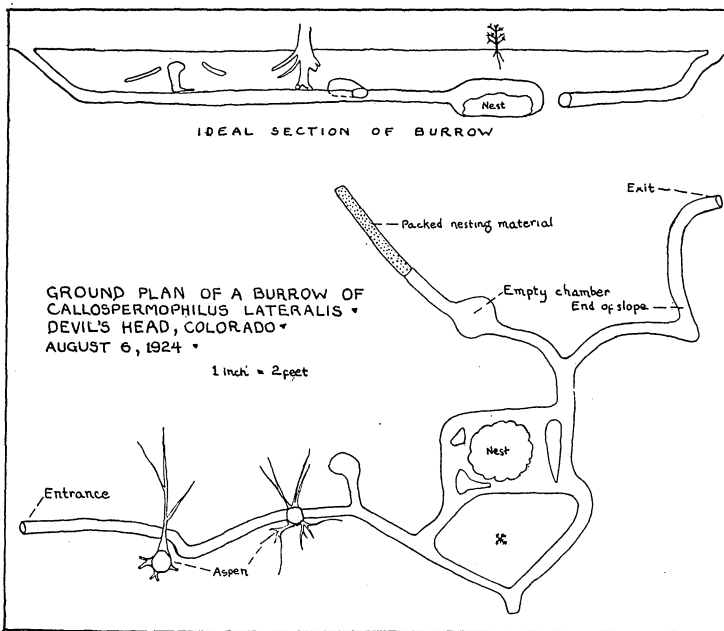


FIG. 1

months in which snow lies on the ground, in the mountains a good portion of the year.

Over the greater part of the range of *C. l. lateralis* the soil is composed of a well weathered granite of a nearly gravel-like character, and the digging of deep burrows is difficult or impossible. This is typical of the front range of the Rocky Mountains of Colorado. At best the excavation of one of these burrows is probably a heavy task and a time consuming occupation.

In Douglas County, Colorado, ten miles southwest of Castle Rock, on the crest of a long ridge over which leads the road to Devil's Head Peak, there was found a burrow which offered an opportunity for excavation and which seemed typical of the burrows of this region.

The ridge at this point supported a good stand of mature yellow pine. In this was a little-used tourist camp site, established by the Forest Service. On the slopes of the ridge were dense stands of quaking aspens alternating with closely grazed open spaces. On the border between the cleared pine stand and an open area were a few small aspens, three to four inches in diameter. In this group was located the den which was excavated. The entrance lay within eight feet of the roadway and the long axis was parallel to it.

Kinnikinnik (*Artostaphylós uva-úrssi*) carpeted the ground thickly at the entrance to the burrow. Since there was no debris here, the entrance was quite inconspicuous, and if two squirrels had not been seen to enter, the discovery might not have been made.

The diameter of the burrow (Figure 1) at the entrance was three inches. For the distance of a foot there was a 45 degree angle and then the course flattened out to a depth uniformly eight inches under the surface, except at the opposite end and in one of the pockets. A few inches past the entrance the tunnel narrowed down to a uniform two inch bore. At one place in its course the roof was crossed by the root of an aspen. Farther on the tunnel passed directly under the base of a tree and beneath its roots.



The first pocket leading from the main passage contained no debris of any sort, and at the time of the excavation, could not have been in use unless it was a passing place or unlined nesting site.

Six feet in from the entrance the passage forked, one lead passing directly to the nest, the other passing to it by a semi-circular arc. A runway surrounded the nest on three sides from which there were four passages leading in. This nest cavity was four inches deep, the nest not filling the space available, but occurring more as a mat in the bottom of the cup.

A passage led away from the nest in the direction opposite from that of the other main passage. Six inches from the cavity this forked, one branch leading from an empty chamber five and one half inches in diameter, beyond which was a blind lead filled for a distance of about twelve inches with old nesting material, firmly packed. The other branch led by an angular path and a sharp grade to another entrance completely obscured by kinnikinnik and hidden by a mat of leaves.

The two squirrels which had been seen to enter the nest just before excavation was started could only have gotten out through this opening, though the covering seemed undisturbed by a hasty exit. It is of interest to note here that a captive *Callospermophilus* was found to stop up the entrance to its burrow each night with a half-inch plug of soil.

In the valley below the excavated burrow where the ground was more loamy, there were other burrows of this species. Several individuals had works around the foundations of fallen log houses. In each place where burrows were seen the soil was rocky near the surface.

The burrows of *C. l. arizonensis*, in the San Francisco Mountains of Arizona, were essentially the same in external appearance though soil conditions were much different. In the greater number of cases burrows were near or under a fallen log or stump. Occasionally, however, they would be ten feet or more from any such protection. No refuse or

excavated material was found near the burrows. Neither did the openings go straight down, at least not for more than two or three inches, but they sloped at a very steep angle for perhaps a foot.

*Nest.* The nest of the burrow of *C. l. lateralis* figured proved an interesting mixture. Not only did it furnish a long list of components which could have hardly been typical because of the several elements contributed by the camp dump, but the faunal components proved many and unusual. The number of species obtained was large, and the nest fairly swarmed with the individuals present. It was composed of the following materials: fine fragments of paper (abundant); dry aspen leaves (abundant); dry *Arctostaphylos* leaves (abundant), freshly cut *Arctostaphylos* leaves (few); shredded grasses (abundant); dry stems of other plants (abundant); dead yellow pine needles (few); dead Douglas spruce needles (few); small rootlets, three to seven inches long (many); fragmented cotton cloth (abundant); and shredded bark (abundant). In with this material were a few berries of *Arctostaphylos* and a few feces of *Callospermophilus* which bore a fruiting fungus.

The invertebrate animals saved from the nest were lost before they were accurately determined, though the field notes carry the following list: camel crickets (*Ceuthophilus* sp.), several in burrow; millipede (Order Chilognatha); mites (Acarina), thousands in nest; very large fleas, fairly common; small fleas (*Ceratophyllus*) abundant; book scorpions (Order Pseudoscorpionida) few; small yellow ants, fairly common.

Several interesting facts are evident from the description; the animals drop feces in the nest; the nest supports a large number and variety of insects and arachnids and furnishes a good medium for the transmission of parasites; no food is stored at that time of year; the animals use almost any available fine nesting material; two animals may use the same nest; burrows are essentially shallow; the declivity near the entrance is great but short and not perpendicular; there may be a second hidden opening for escape; debris is not promiscuously scattered around the entrance.

But one observation was made which bore on the time of nest building. At 11,500 feet on Pike's Peak, August 1, a *Callospermophilus* was seen carrying in its mouth dry grass which looked like the withered leaves around the base of a bunch of grass rather than the longer leaves cut and dried.

Captive ground squirrels of this genus, kept in nesting boxes where there was no place to dig, were furnished with cotton. They built a globular fluffy nest with an indistinct and temporary entrance at the side. When the weather was warm, the cage small, and two animals were in the cage together, the nest was practically always kept quite open at the top. At least two animals will live peacefully together in a nest such as this.

An adult female, fourteen months in captivity, with no place to dig, was furnished a box of earth (clay soil) six feet long, four feet wide and three feet deep, with concrete side walls and a screen bottom. When the animal was placed in this cage on December 4, the temperature was but a few degrees above freezing and within three hours the squirrel had constructed burrows the extent of which was not determined. Three days after this the writer excavated the burrow and found the following conditions.

From the entrance, which was in a corner of the cage, the tunnel flattened out almost immediately to a uniform tube an inch and a half below the surface, which coursed for three feet along the side of the concrete wall. The path then descended abruptly to the nest cavity which was in another corner, the roof eight inches below the surface. The cavity was globular and but six inches in diameter. In this was a hollow sphere of dry oak leaves and dry grass, the only nesting material provided. Functionally composing part of the bottom of the nest was the corpse of one *Callospermophilus* while the other was terrifiedly cringing in the remaining space.

Three days later, with the return of bright sun, the construction of a new burrow was commenced and completed. Its entrance was in the same spot as before. The first night

the entrance was plugged up with earth from the inside, but early the next morning the squirrel removed the plug.

The art of nest building apparently had to be learned by each individual, for when an animal was first placed in captivity it would usually be two or three days before it would construct a nest of the material supplied. They soon learned to handle cotton batting well and learned to make from it a globular fluffy nest with a single entrance on the side.

Two animals would nest together amicably in captivity whether they were of the same or of different sexes. Individuals which were caged separately for long periods would occupy a single nest, incorporating the material of one nest into that of the other.

Deserted nests of captive animals were demolished and their material incorporated into the nest of others having access to the old nest.

Some caged individuals attempted to bury their nests, if one may judge from the amount of debris that was placed under them and heaped about the sides. The open wire walls of the cages made the completion of such a process impossible.

*Trails.* These animals, in localities where they were abundant, kept open a series of trails in their feeding grounds and in the vegetation close to their burrows. At Minnehaha, on Pike's Peak, such trails were found under cut banks and through herbaceous growth in the feeding ground. While the trails were kept free of vegetation their presence was in all probability the result of frequent repetition of course more than a consciously constructed passageway, for in their habitats herbaceous growth is never so luxuriant as to require any such labor.

*Food.* Rodents chew their food so thoroughly that little can be gained from examining stomach contents. Information on their food habits must be obtained by closely observing feeding animals in the field, by examination of cheek pouches, and by experimental feeding.

An individual of *C. l. lateralis* was observed feeding on the fruits of *Menzelia multiflora*, on August 24, on Pike's Peak.

A small green caterpillar, 19 seeds of *Trifolium repens*, and three of *Capsella (Bursa)bursa-pastoris*, were removed from the cheek pouches of an individual near Cascade, Teller County, Colorado, on August 3. Another individual carried in its cheek pouches eight seeds of *Capsella (Bursa) bursa-pastoris* and three seeds of *Verbascum* sp. A berry of either kinnikinnik (*Arctostaphylós uva-úrsi*) or Oregon grape (*Odostemon fremontii*) was found in the cheek pouch of an individual on Devil's Head Peak, Colorado, August 6. There were leaves of a freshly cut mullein near the burrow of a *Callospermophilus* two miles north of Devil's Head Peak, Colorado. Some of these were dragged partly down the hole. Near here an individual was seen standing on top of an old pine log and feeding, apparently on the flowers, on the top of a mullein growing beside the log.

Near timberline on Pike's Peak, the animals nibbled off the tops of grasses and other low herbs (probably the seeds) and seemed to bite off the ends of young Engleman spruce needles close to the ground. Near public automobile camps and buildings in the mountains a great deal of waste food is made available to the animals of the region. In such places the ground squirrels congregate. Here they were seen feeding on dry bread crusts, pancakes, bran bread, soda crackers, apples, cabbage stumps, prunes (though not prune seeds), and cantelope.

*Feeding.* These animals feed throughout the day between sunrise and sunset, though they seem to be more active in the early morning than later in the day. Captive *C. l. lateralis* did the major part of their feeding before 9:00 A. M.

The cheek pouches of two out of eight individuals of *C. l. arizonensis* shot before nine in the morning contained seeds.

That these animals will go to some little trouble to store food was indicated by an adult *C. l. lateralis* observed on Pike's Peak. The animal had found a full sized slice of bread which it held in its mouth by the edge. The animal's head was held high and the bread hung perpendicularly. On level ground the animal rose on its toes to keep the crust from

dragging. While on the level this squirrel could make some progress but on a steep rock surface toppled over backwards. Three times this was tried, but each time it fell. A fourth attempt was successful and the animal disappeared in a crevice in the rocks carrying its booty.

*Breeding.* No embryos were found in female *C. l. lateralis* collected on the eastern slope of the Rockies of Colorado between August 3 and 25. A female secured on August 27 had apparently been nursing recently though none were found lactating between August 3 and 25. An immature female secured August 6 weighed 131 grams. Another taken August 25 weighed 137 grams. Adult weights averaged 240 grams in August. No specimens bred in captivity. Specimens in the American Museum of Natural History have mammae varying in different individuals and present formulæ 1-1-1, 1-1-2 and 2-0-2. The most common distribution is 1 pair pectoral, 1 pair abdominal, 2 pairs inguinal.

Testes of three adult males, *C. l. arizonensis*, taken at San Francisco Peak July 4 and 6, were small. Two of seven females taken July 3 to 6 were in milk. The others had apparently been nursing recently. None of them contained embryos, though in the uterus of one female were found black patches, probably the remnants of placenta. Of these, five were in the right horn and one in the left. In another female were similar patches, four in the right horn, three in the left. The young were about half grown on July 6. One individual weighed 103 grams in contrast to an average weight of 240 grams for the adults. The mammae are 2-1-1 or 2-1-2. One individual had 2-1-1 left and 2-1-2 right.

*Enemies and Parasites.* At Glen Cove, Pike's Peak, at an elevation of 11,500 feet, Clark's nutcrackers were twice seen to pursue Callospermophilæ. Once, for no obvious reason, one of these birds was seen to dive down from the air towards an adult squirrel which was sitting at one end of a log. The rodent scampered away along the trunk to its burrow some fifteen feet distant. The nutcracker flew a few inches behind the fleeing animal but did not strike.

A young *Callospermophilus* feeding at a garbage heap was chased some five feet away by a nutcracker which then proceeded to feed where the squirrel had been before.

Fleas are common on this species of ground-squirrel. Specimens taken from *C. l. lateralis* have been determined as belonging to the genus *Ceratophyllus*, probably of the species *C. poeantis* Roth. Ticks collected from *C. l. lateralis* were immature, possibly of the genus *Dermacentor*.

Cannibalism is not an uncommon accompaniment of overcrowding of captives. Both sexes have been found to kill individuals of their own and of the opposite sex. Little is eaten from the conquered animal. One individual so killed was severely bitten about the head. Large gashes occurred between nose and eye, and one zygomatic arch was broken. Another individual had half the head eaten away.

A paralysis, common in captive squirrels and chipmunks, killed three caged specimens. This disease is apparently due to a vitamin deficiency since the animals respond to a feeding of Scott's emulsion. One individual was completely cured by this treatment. The two others were not treated early enough and eventually succumbed. The paralysis first appears in the hind limbs. The animal is loath to leave its nest, and when it does so the hind legs are dragged or at best thrown forward and back in an uncontrolled spasmodic hop. Slowly the paralysis creeps forward to fore limbs and is then soon accompanied by death.

Mange occurred in one captive. The hair became almost totally absent on one side of the head. Eventually the trouble disappeared without treatment.

*Voice.* *Callospermophilus* is ordinarily a silent animal and the species *lateralis* is rarely heard to make a sound. Under the nervous strain of captivity they use a few notes which are recorded below.

The vocal sound which is heard most frequently is one of fear. It is a querulous high pitched call having something of the quality of a whimper. The notes, which are liquid and musical, decrease both in volume and pitch from the first.

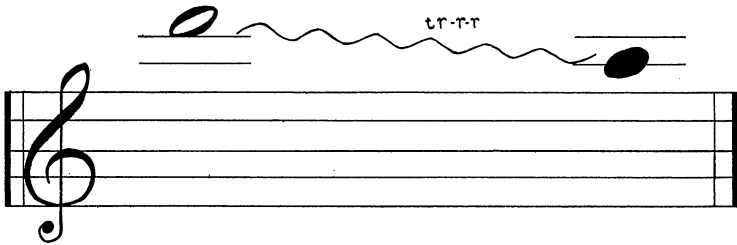


FIG. 2

Each successive note drops below its predecessor less than would be represented by a single bar on the musical staff, yet each component of the whole is lower in tone than the note before it. With the inflexible standards of musical symbols it seems best represented by a series of short trilled steps between the first and the last note, as is indicated in the accompanying figure. The whole series occupies about four seconds. This call may be repeated as many as five or six times if the stimulation of fear is kept up. This cry was used when a person annoyed them by cleaning the cage, by introducing food into the cage, or merely by approaching them suddenly. Some individuals used the call every time they were disturbed, while others were never heard to use it. Apparently it is a matter of individual nervous temperament. When first caught in box traps two individuals, one adult and one juvenile, made neither noise nor produced glandular odor, but crouched quietly in a corner of the cage. Two others, both adult, when first trapped jumped about excitedly, bit the wire end of the trap, smelled strongly musky and sounded frequently their querulous cry. Other individuals displayed intermediate temperaments.

Of four captives under observation in the summer of 1925, one male used the call frequently, the other male rarely, the females probably never. Observation of other individuals, however, shows that females also will use this call.

Another note has been heard only from males when their mates were fighting them. This was a rasping choked cry of rage or pain, a throttled squealing protest.



The only other note which has been heard is a single sharp bird-like chirp of alarm issued when an intruder is first seen to be approaching the cage.

An individual disturbed in hibernation issued a few sounds which are described under the heading of hibernation.

*Pugnacity and Sociability.* A captive female placed in a large open cage with a pair of red squirrels showed remarkable pugnacity. The squirrels had a nest in a box on the side of the cage five feet above the ground, which was reached by climbing up the wire mesh of the cage wall. One day shortly after the ground squirrel had been placed in the inclosure, its burrow was destroyed and this misfortune accompanied by a heavy rainfall forced the animal to find better quarters. There were two alternatives. One was to remain on a barren concrete floor in that portion of the cage which was within a heated building. The other was to dispossess the red squirrels. To my astonishment it chose the latter course and not only climbed to the nest but drove out the squirrels. For the three days of ensuing rain the *Callospermophilus* retained possession of the nest and forced the red squirrels to seek shelter in the building. With the return of fair weather the conqueror returned to the earth and constructed a new burrow.

Pairs of captives occupied nests amicably though there was usually some squabbling when they first came together. The first occupant always took the offensive in such cases.

One pair in my possession fought as a daily diversion. The female, considerably the larger of the two, completely dominated her consort and made his life one of misery. The male frequently uttered the rasping choked cries previously referred to. Once they were seen sitting on their haunches and boxing as well as nipping at each other. The male as usual did not seem to relish the contest.

*Hours of Activity.* In their native habitat these squirrels are seen only between sunrise and sunset. On a warm sunny day there is a tendency towards taking a midday siesta as then the animals are either in their burrows or quietly resting on some rock or other open space. Cloudy days in the

Pike's Peak region kept them pretty well to their burrows. A rain storm invariably sent them to shelter.

Under the changed conditions of captivity these animals were found out of their nests and moving about during the winter months as late as 1 A. M.

*Sanitation.* Much of the day, at least in the summer, is spent in resting in the sun on a rock, a log, or an open space on the ground. Such a practice is in effect, if not in purpose, a sun bath. Usually the sunning place is within a few feet of the burrow. The position that the animal assumes is in general sphinx-like. The head is held erect, the fore feet thrust anteriorly, while both hind legs and tail are stretched to the rear. The author has not seen them asleep or totally recumbent during these sunnings. Such a practice would be far too dangerous.

Dust baths are frequently taken. The animals were seen to scratch a depression in the gravel (see Plate I, fig. 4), roll over and around in it several times, and then lie in a position half on their sides, but with head erect. An apparent difference in pelage color in individuals of one locality was found to disappear when skins were washed in gasoline. This difference was probably correlated with the time elapsing since the last dust bath.

One of a pair of captives was drowned in its underground nest during a heavy rain storm. The corpse of this individual was left in place by its mate, the body forming an integral part of the nest during the three days in which the nest was not disturbed.

*Climbing.* A captive climbed five feet up the wire mesh of its cage to reach a nest box. Other individuals in gnawing at the sides of their cage invariably clung to the vertical front.

In the Cascade Mountains individuals of *C. l. saturatus* were seen several feet up in the bushes of an old burn. Here they were feeding on berries.

*Hibernation.* *Callospermophilus* starts laying on fat in the summer and by the middle of September is exceedingly

plump. The mean July weight of about 225 grams for adults is increased to as much as 275 grams by mid-September.

G. W. Goldsmith, of Colorado Springs, furnishes the following records of time of hibernation on Pike's Peak:

1922. Last seen November 2. 8,000 feet.

1923. Last seen October 2. 7,000-7,500 feet.

1924. Last seen October 27. 7,500 feet.

Four individuals were kept in New York City the entire length of the winter of 1925. One of these remained active the entire winter; a second hibernated for but three days, a third for forty-two days, and the fourth for forty-three days. The longest period of continuous hibernation was the twenty-two days during which two of the animals were dormant.

That in the wild state hibernation is not continuous is corroborated by Warren<sup>3</sup> and by a photograph reproduced in Stone and Cram<sup>4</sup> showing a "Say's Spermophile" with his head above a snow bank.

During winter days of activity my captives took both food and water.

The first cold period which the captives were subjected to, came in the middle of November. The mercury registered temperatures as low as 34°, though the mean temperature for these two days, in which but one animal was torpid, was 45°. The other individuals remained active. The last of November and the first four days of December were days in which the thermometer registered from 39° to 59°. During this period three of the animals hibernated. The advent of temperatures above 60°, however, brought the squirrels out of their sleep. Two individuals hibernated again in the middle of December and remained in this condition until January 3. During this time there were no temperatures in excess of 65°, while the mean remained about 50°.

The following two weeks the daily temperatures averaged with one exception above 60° and all animals remained active.

<sup>3</sup> Warren, E. R. *The mammals of Colorado*. Putnam. 1910, p. 168.

<sup>4</sup> Stone, W. and Cram, W. E. *American animals*. Doubleday, Page and Company. 1903, opp. p. 164.

From then until the first of February the thermometer was constantly below 60°, dropping to 12° at the coldest period. Two individuals hibernated until the arrival of a 70° temperature while the others remained active. One animal remained very sensitive to temperatures below 60°, and went to sleep for two other short periods in February in which the thermometer hovered between 50° and 60°.

When in hibernation *Callospermophilus* assumes a position in which the least possible surface is exposed to the air. The fore limbs are folded over the chest and the hind feet half curled up under the body. The nose is drawn down to the base of the tail, which is curled over the body slightly to one side of the median plane. In this way the animal's body approaches a sphere. All animals under the author's observation remained in an upright position (Plate I, fig. 6) supported in part by the material of the nest.

Within six hours after being active the animal would sometimes be in a state of complete dormancy. The degree of insensibility varies greatly from time to time, but when an animal is completely dormant, one may handle it, place it on its side, and even clip its ears for purposes of identification without obtaining the slightest response. If the animal is gently unrolled for measuring the body when released will return to its normal hibernating position. Breathing is practically stopped when the animal is completely torpid. On the other hand, individuals show all transitional degrees of dormancy. Handling may provoke faint protesting squeaking or slow limited body movements. If the animal is placed on its side it may even right itself again and shake violently.

One individual which was completely insensible in its nest was removed to a position in direct and brilliant sunlight where there was an air temperature of 71°. Its nest was partly removed and the animal photographed (Plate I, fig. 6). In five minutes it evidenced signs of returning activity by shaking slightly from side to side and somewhat lessening the tension of the flexor muscles of the back. In ten minutes the head was shaking violently both in median and lateral planes.

The eyes remained closed. At this stage a slight touch on the side of the head caused the animal to move it toward the pressure but there was no movement of eyelids or mandible. At twelve minutes the fore-limbs shook violently. The eyelids parted and though it did not seem to see, it closed the eyelids very slowly if an object was brought near them. The head showed a slight dodging reaction. At fifteen minutes the hind limb showed movement and handling provoked vigorous kicking. At seventeen minutes the animal scrambled under the cotton of its nest. Back in the shade and cold of the animal room the squirrel quickly became groggy and finally curled up for another sleep of about eight hours.

#### ADAPTATION TO CIVILIZATION

Throughout those portions of the range of *Callospermophilus* which were visited, the members of the genus were found in a half tame state where they are closely associated with man. Especially did this seem true of *C. l. lateralis*. At many camps in the foothills and front range of the Colorado Rockies they had become tame enough to take scraps thrown to them. In places where they were not commonly exposed to the luxuries of camp life the animals would rarely come into camp if anyone was in sight.

At Minnehaha, along the Pike's Peak Cog Road, a half dozen or more copperheads as well as a number of chipmunks became tame enough to feed from the hands of a few people at the section house there. These shy little creatures were fed every morning of the summer on flap-jacks and other scraps and thus learned to trust the people who fed them. They would not, however, take food from the hand of a stranger.

Around camps and ranches in the Pike's Peak region where there were no dogs or cats, the ground squirrels seemed to be far more abundant than in any other habitat. Here they obtained grain scattered near the stables, as well as the scraps thrown to them. It seemed that automobile roads passing through *Callospermophilus* territory and the Pike's Peak Cog

Road bore more than the usual quota of squirrels for equal areas off such highways. Perhaps the scraps left by tourists contributed to this, but more than likely the determining factor was the presence of a greater number of plant species to furnish food to these rodents than would be found in a natural habitat. Too, the cuts and embankments along such routes furnished a splendid place for burrowing and sunning, and thus simplified life. As a third factor it is presumed that their natural enemies would shun the highways to some extent and life would in consequence be less hazardous.



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PLATE I

- Fig. 1. Callospermophilus searching for food.
- Fig. 2. Eating. Pike's Peak.
- Fig. 3. Portrait on Pike's Peak.
- Fig. 4. Preparing dust bath at foot of a gravel slope along Pike's Peak Cog Road.
- Fig. 5. Juvenile on lookout. Pike's Peak.
- Fig. 6. Hibernating *C. l. lateralis* in nest box, New York City.



