

*Spermophilus tridecemlineatus*. By Donald P. Streubel and James P. Fitzgerald

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*Spermophilus tridecemlineatus*  
Mitchill, 1821

Thirteen-lined Ground Squirrel

*Sciurus tridecem-lineatus* Mitchill, 1821:248. Holotype not designated; type locality fixed in "central Minnesota" by J. A. Allen, 1895:338.

*Arctomys hoodii* Sabine, 1822:590. Type locality Carlton House, Saskatchewan.

*Spermophilus tridecemlineatus* Audubon and Bachman, 1849:294, first use of current name.

**CONTEXT AND CONTENT.** Order Rodentia, Family Sciuridae, Genus *Spermophilus*, Subgenus *Ictidomys*. *Spermophilus tridecemlineatus* is divided into nine Recent subspecies (Howell, 1938; Armstrong, 1971) as follows:

*S. t. tridecemlineatus* Mitchill, 1821:248, see above (*hoodii* Sabine a synonym).

*S. t. pallidus* J. A. Allen, 1877:872. Holotype not designated; lectotype and type locality, "mouth of the Yellowstone River, Montana," designated by Howell 1938:112 (*olivaceus* J. A. Allen a synonym).

*S. t. parvus* J. A. Allen, 1895:337. Type locality Kennedy's Hole, Uncompahgre Indian Reservation, 20 mi NE Ouray, Uintah Co., Utah.

*S. t. texensis* Merriam, 1898:71. Type locality Gainesville, Cooke Co., Texas (*badius* Bangs a synonym).

*S. t. alleni* Merriam, 1898:71. Type locality near head of Canyon Creek, 8000 ft., W slope Bighorn Mtns., Wyoming.

*S. t. hollisteri* V. Bailey, 1913:131. Type locality Elk Valley, 8000 ft., Mescalero Indian Reservation, Sacramento Mtns., New Mexico.

*S. t. monticola* A. H. Howell, 1928:214. Type locality Marsh Lake, 9000 ft., White Mtns., Arizona.

*S. t. arenicola* A. H. Howell, 1928:213. Type locality Pendennis, Lane Co., Kansas.

*S. t. blanca* Armstrong, 1971:533. Type locality near Blanca, San Luis Valley, Colorado.

**DIAGNOSIS.** The dorsal area of *S. tridecemlineatus* is striped, which separates it from other species in the subgenus *Ictidomys*; the metaloph of P4 is not continuous, which separates the species from ground squirrels of other subgenera.

**GENERAL CHARACTERS.** Hall and Kelson (1959) described *S. tridecemlineatus* as follows: "Upper parts marked with a series of alternating dark (brownish or blackish) and light longitudinal stripes; a row of nearly square white spots in each of the dark dorsal stripes; lowermost stripes on sides less well defined than on back; in some subspecies some of the light dorsal stripes are broken into spots. Skull long, narrow, and lightly built in comparison with that of *S. townsendii*; molariform tooth rows only slightly convergent posteriorly." A more detailed description may be found in Howell (1938).

*Spermophilus tridecemlineatus*, the thirteen-lined ground squirrel, is a small- to medium-sized member of the genus similar in size to *S. spilosoma*. External measurements (millimeters) range as follows: total length, 170 to 297; length of tail, 60 to 132; length of hind foot, 27 to 41.

Average cranial measurements (millimeters) taken from nine subspecies listed by Howell (1938) and Armstrong (1972) are: greatest length of skull, 38.0; palatilar length, 17.6; zygomatic breadth, 21.9; cranial breadth, 16.8; interorbital breadth, 7.6; postorbital constriction, 11.5; length of nasals, 13.2; and maxillary toothrow, 6.7. For more detailed morphological comparison of the subspecies of *S. tridecemlineatus* see Howell (1938) and Armstrong (1971, 1972). The skull is illustrated in Figure 1.

**DISTRIBUTION.** The thirteen-lined ground squirrel has a wide distribution from south-central Canada to Texas and gen-

erally east of the Rocky Mountains to the northern Lake States; the eastern extent of its range is east-central Ohio. Figure 2 shows the approximate distribution of the nine currently recognized subspecies of *S. tridecemlineatus*.

*Spermophilus tridecemlineatus* is found in habitats ranging from the well drained grasslands of the Lake States to high (2740 m) mountain grasslands in eastern Arizona (Howell, 1938; Hall and Kelson, 1959; Armstrong, 1971). Evans (1951), attesting to the preference of this species for grasslands, noted that from about 1900 to 1950 it expanded its range northward in Michigan and Wisconsin, and eastward in Ohio as the land was cleared. The species also adapts to grassy roadsides and fencerows in intensively farmed areas.

**FOSSIL RECORD.** Hibbard (1940) found a number of lower jaws, maxillaries, and other skeletal elements of *S. tridecemlineatus* in a Pleistocene deposit in Meade County, Kansas, that appeared identical to those of the modern populations. In Texas, Dalquest (1965) collected about 20 cheekteeth of this species from an outcrop of the Seymour Formation of the Kansan (mid-Pleistocene) age.

**FORM AND FUNCTION.** The species has two distinct pelages and molts per year. Adults emerge from hibernation in winter pelage; the summer pelage is attained in May in Colorado.

The physiology of *S. tridecemlineatus* has been studied more

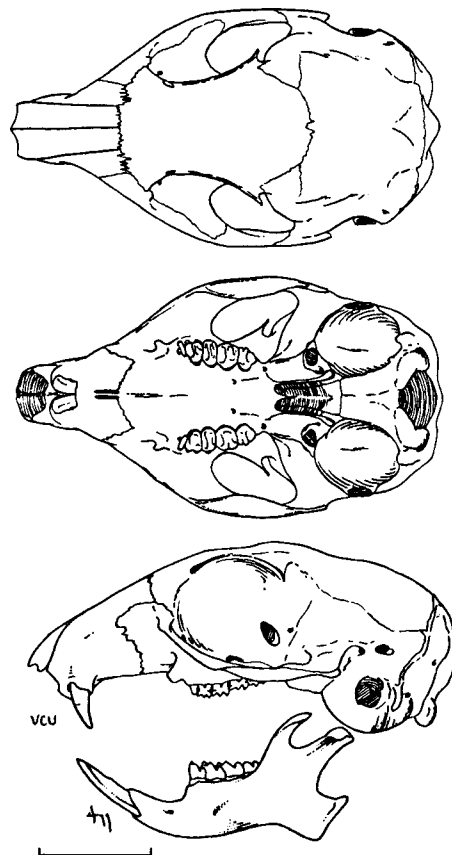


FIGURE 1. Views of skull of *Spermophilus tridecemlineatus* from 6 mi W Bird City, Cheyenne Co., Kansas, KU 12079 (from Hall, 1955). The scale shown at lower left represents 10 mm.

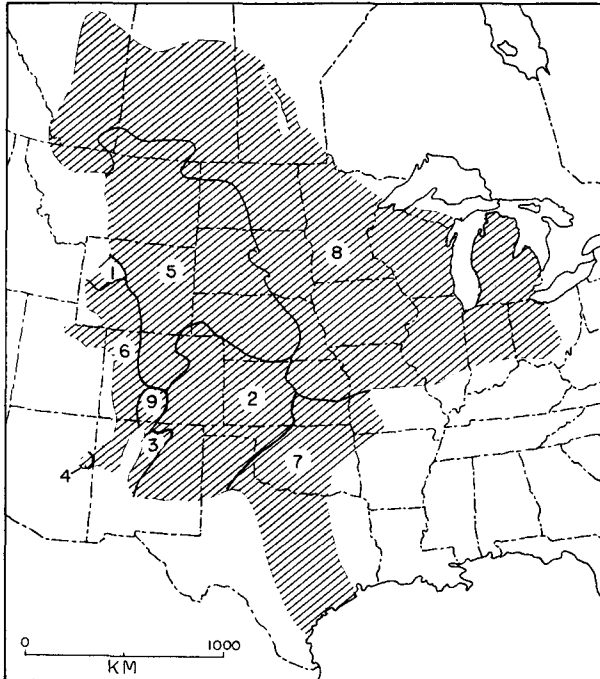


FIGURE 2. Distribution of *Spermophilus tridecemlineatus*, modified from Hall and Kelson (1959) and Armstrong (1971). 1, *S. t. alleni*; 2, *S. t. arenicola*; 3, *S. t. hollisteri*; 4, *S. t. monticola*; 5, *S. t. pallidus*; 6, *S. t. parvus*; 7, *S. t. texensis*; 8, *S. t. tridecemlineatus*; 9, *S. t. blanca*.

extensively than that of most ground squirrels, primarily in relation to hibernation (Johnson, 1930; Wells, 1935; Fisher and Mrosovsky, 1970; and others).

The ultrastructure of the pineal gland was studied by Matsushima and Reiter (1975), and by Povlishock *et al.* (1975). West and Dowling (1975) studied the structure of the eye and found that 4 to 5% of the light receptors were rodlike. Forman (1974) studied the microscopic structure of the accessory reproductive glands. The baculum of *S. tridecemlineatus* was described in detail by Wade and Gilbert (1940) and compared with that of certain other members of the genus.

Hudson and Deavers (1973) studied the physiological adaptations of eight species of ground squirrels and found *S. tridecemlineatus* to be unusually well insulated as compared to desert species such as *S. spilosoma*.

Thirteen-lined ground squirrels gain weight rapidly prior to hibernation. For example, Hohn (1966) observed two adult females in Minnesota that gained 85 g in 22 days and 48 g in 13 days, respectively. He also reported that an adult male gained 59 g in 13 days and another weighed 246 g prior to hibernation, a 38% weight increase during its season of activity.

**ONTOGENY AND REPRODUCTION.** Bridgewater (1966), in laboratory studies, documented four matings and a gestation period of 27 to 28 days for *S. tridecemlineatus*; Asdell (1964) also reported a 28-day gestation period for the species.

Males are capable of reproduction when they emerge from hibernation. Wells (1935) and Asdell (1964) reported spermatozoa in testes as early as December, more than a month before the testes had reached maximum size and nearly three months before breeding.

Wade (1927), Wells (1935), Hohn (1966), McCarley (1966), and Flake (1974) all reported on the sexual condition of males, based on testes size. However, because of the advanced testicular activity necessary for spermatogenesis, testes size may not be a good indicator of the breeding period (Wells, 1935; Tomich, 1962). Two-year-old (or older) males reach breeding condition earlier than do one-year-old males (Wade, 1927; Wells, 1935; McCarley, 1966).

In females, ovaries begin to enlarge as early as the first of January (Asdell, 1964) and females are in "full heat" approximately five days after emergence (Foster, 1934). Asdell (1964) and McCarley (1966) reported that older females emerge in a more advanced sexual state than do young animals. Johnson *et al.* (1933) observed that females exhibit the usual stages of the es-

trous cycle and that they are induced ovulators. Foster (1934) noted that ovulation occurred within 48 hours after copulation and implantation probably occurred on the fifth day.

Litter sizes (means and standard deviations) have been reported for *S. tridecemlineatus* as follows:  $8.1 \pm 0.1$  in Manitoba (Criddle, 1939),  $8.7 \pm 0.3$  in Wisconsin (Rongstad, 1965),  $9.0 \pm 0.4$  in Kansas (Johnson, 1931), and in Colorado  $8.7 \pm 1.1$  (Flake, 1974) and  $6.2 \pm 1.4$  (Streubel, 1975). In Texas, McCarley (1966) noted differences between litter sizes of old and young females; old females had a mean litter size of  $7.0 \pm 0.3$  and younger females an average of  $4.9 \pm 0.6$ . McCarley found in one year of his study that five of 22 females produced second litters; all five females were older than one year, and all conceived their first litter in April. McCarley's observations refuted statements by Wade (1927) and Asdell (1964) that *S. tridecemlineatus* is monestrous. However, the thirteen-lined ground squirrel could be monestrous in the northern part of its range and diestrous in the south.

Emergence dates of litters have been reported as 20 to 23 June in Wisconsin (Rongstad, 1965), 23 June to 5 July in Minnesota (Hohn, 1966), 16 June in Oklahoma (Bridgewater, 1966), and 8 June to 19 August in Texas (McCarley, 1966).

Conception dates, usually estimated from the time of litter emergence, have been reported as follows: 13 April to 4 May in Wisconsin (Rongstad, 1965), 25 April to 7 May in Minnesota (Hohn, 1966), 18 April in Oklahoma (Bridgewater, 1966), and 10 April to 22 June (second litter) in Texas (McCarley, 1966). The breeding period may be prolonged if, during the breeding period, a week or more of warm weather is followed by a period of cold weather (Foster, 1934). Apparently, cold weather suppresses estrus in the female.

Bridgewater (1966) observed the following ontogenic chronology of *S. tridecemlineatus*: light coat of hair beginning to emerge at postnatal day four, eyes opened during a two-day period from day 21 to 31, lower incisors appeared by day 17, upper incisors appeared two days later, molars appeared from day 24 on. The young acquired adult coloration from day 21 to 25, weaning began when the upper and lower incisors erupted and was essentially completed by day 28. In the field, weaning of young occurred along with emergence from burrows (Rongstad, 1965). Most adult modes of behavior are acquired by the young prior to emergence from the nest burrow (Bridgewater, 1966). Average weight increments of 1.3 g per day were noted through week 11 by Bridgewater (1966). The weight then (about 100 g) was well below average adult weight. Adult body length was attained by week 11.

**ECOLOGY.** *Spermophilus tridecemlineatus* is typically a grassland inhabitant. In Michigan and Wisconsin, the species extended its range after land was cleared for farming (Evans, 1951). Throughout its range, it is found predominantly on relatively high prairies and knolls; wet ground is avoided (Johnson, 1917). In Nebraska, Jones (1964) noted that the species preferred areas of short grass such as heavily grazed pastures, golf courses, and mowed borders of highways. In Kansas, it is generally considered a species of the native prairies and closely mown grasslands (Hall, 1955).

Johnson (1917) reported that *S. tridecemlineatus* preferred black or clay soil to sand. However, Whitaker (1972) trapped the species on a strip of sandy soil along the Wabash River, Indiana, and none were trapped in the river bottom or in upland silt-loam soils. In southeastern Wyoming, Maxwell and Brown (1968) found *S. tridecemlineatus* primarily in a grass community (*Bouteloua* sp., *Stipa* sp., *Aristida* sp.) where the vegetation was less than 250 mm tall and the soil a sandy loam.

Fitzpatrick (1925) related the habitat of *S. tridecemlineatus* to food supply and stated that the species was partly dependent on insects for food. He noted that the squirrels left areas where grazing was discontinued and moved into newly mown fields where insects were readily available. According to Weaver and Flory (1934), grazing causes an increase in thirteen-lined ground squirrels, but Phillips (1936) noted a reduction in burrow density on normally grazed and moderately overgrazed conditions.

Grant (1972) estimated population density on four experimental environmental control areas on the Pawnee National Grasslands in northeastern Colorado. He found populations lowest on sites receiving irrigation and fertilizer treatment where vegetation had the greatest density, and highest on the "natural" short-grass prairie where the vegetation had the lowest density. Johnson (1917) reported that the species was sometimes found in "thin woods or shrubbery." Population estimates by Rongstad (1965) were 2.5 to 5.0 per ha in the spring and 24.6 per ha follow-

ing emergence of young. Mitchell (1972) estimated 18 per ha on grazed prairie and Grant (1972) estimated 4.5 per ha on ungrazed pasture, both in Colorado.

McCarley (1966) found that in one year of his study the mortality rates of juvenile males was 96% and that of juvenile females was 74%. The following year, the mortality rates for juvenile males and females were 89 and 88%, respectively, but the following spring the male population appeared sharply reduced. Rongstad (1965) estimated the annual mortality to be 81% and found that the adult population declined slightly during the early part of the summer but then remained stationary. Most mortality among juveniles occurred prior to hibernation. Differential mortality of males and females probably is due to greater predation on juvenile males because of their greater tendency to disperse, especially into marginal habitats.

Both Rongstad (1965) and McCarley (1966) found initially even juvenile sex ratios. McCarley reported the overall sex ratios of one male to 2.8 females and one male to 2.1 females in two years of his study. Rongstad reported that the juvenile sex ratio remained even until early August and decreased progressively to one male to 1.7 females by the end of September.

McCarley (1966) observed that the cohesiveness of family units began breaking down 12 to 14 days after emergence of juveniles, and he speculated that the mock fighting prevalent in juvenile behavior may have contributed to dispersal. McCarley observed that juvenile males dispersed an average of 267 m from their nest burrows, whereas juvenile females dispersed an average of 189 m. Rongstad (1965) noted that juveniles began dispersing eight days after emergence, and he reported that 46 juvenile females dispersed a mean distance of  $53 \pm 4.7$  m, whereas 45 juvenile males dispersed a mean distance of  $80 \pm 8.4$  m.

The structure of burrows and burrow systems and their use has been studied by Johnson (1917), Fitzpatrick (1925), Evans (1951), and Rongstad (1965). Desha (1966) found that of 65 burrows (with a total of 100 entrances), 78% were shallow burrows in which squirrels simply sought retreat and 22% were below the average frost depth of the study area and contained nests.

The mean home range size of the males is  $4.74 \pm 0.85$  ha (greatest, 12.7 ha) and for females  $1.42 \pm 0.20$  ha (greatest, 5.7 ha) according to McCarley (1966). Males remain close to their nest burrows shortly after emergence from hibernation, then expand their home ranges to maximum size during the breeding season, and again restrict their movements in late June prior to entrance into estivation (McCarley, 1966; Streubel, 1975). Females restrict their movements after emergence; their primary period of home range expansion evidently occurs during pregnancy and lactation when litters are within the nest burrows. Once litters emerge, females again restrict home ranges until after young are weaned. Females tend to use the same home range area year after year (Evans, 1951; Rongstad, 1965).

Few direct observations of predation on the species are available in the literature. Streubel (1975) observed a bull snake (*Pituophis melanoleucus*) attempt to prey on a large male *S. tridecemlineatus*. The snake had already constricted around the ground squirrel, but released it when the observer approached too closely. McCarley (1966) observed predation on the species by roadrunners (*Geococcyx californicus*) in Texas.

*Spermophilus tridecemlineatus* has been observed preying on the following animals: house sparrows, *Passer domesticus* (Grubitz, 1963); small chickens (Bailey, 1923; Green, 1925); young cottontails, *Sylvilagus floridanus*, a six-lined racerunner, *Cnemidophorus sexlineatus* (Bridgewater and Penny 1966); and a blue racer, *Coluber constrictor* (Wistrand, 1974). Fitzpatrick (1925) and Streubel (1975) observed the species preying on grasshoppers and lepidopterous larvae.

Jones (1964) suggested that *S. tridecemlineatus* occurs sympatrically with *S. spilosoma* in Nebraska, but did not mention possible competition. In Colorado, Streubel (1975) found that competition between the two species was minimized because seasonal events of the annual cycle of *S. tridecemlineatus* occurred from two to four weeks before these events for *S. spilosoma*. Thus, despite their coexistence in the same habitat, competition was minimal. In about 150 hours of observation of the two species, only 20 interspecific encounters were observed.

Johnson (1917) reported that the stomach contents of *S. tridecemlineatus* consisted of nearly 50% animal matter. Fitzpatrick (1925) examined 82 stomachs of the species from Iowa; insects comprised about 70% of the diet in May, 30% in June and July, and increased to about 50% in August and September. Grass and seeds comprised the remainder of the stomach contents. Fitzpatrick noted that insect larvae were important in the spring, but that grasshoppers were the preferred food. He suggested that the

thirteen-lined ground squirrel acted as an important natural check on the increase of grasshoppers.

Whitaker (1972) examined 135 stomachs in Indiana and found lepidopterous larvae to be the most important food item, followed by clover leaves (*Trifolium* sp.). Seeds collectively amounted to 39.4% and animal matter 38.8% of the total volume. In Colorado, Streubel (1975) observed that the species fed heavily on lepidopterous larvae in May, but that flowers and fruit heads of *Festuca octoflora* and *Distichlis stricta* became important food sources in late May and June. Adult males appeared to feed almost entirely on fruit heads of *Festuca octoflora* prior to hibernation.

Bridgewater (1966) described laboratory breeding of the species in detail; he observed 12 litters born in captivity. Zimmerman (1974) also reported on laboratory breeding and observed nursing behavior. Zimny (1965) reported that capture of pregnant females does not prevent successful birth and rearing of young while in captivity; 32 of 35 females captured in one year bore litters in captivity, and of the 220 young born, 180 survived and grew to adulthood.

Internal parasites of *S. tridecemlineatus* include *Fasciola hepatica* (Ford and Lang, 1967), *Nippostrongylus brasiliensis* (Cross et al., 1964), and *Riticularia citelli* and ascariid larvae (Fritz et al., 1968). Whitaker (1972) studied the external parasites of *S. tridecemlineatus* and presented an extensive literature review.

Many ground squirrels have been subjected to control measures by man. Fitzpatrick (1925) reviewed the economic status of *S. tridecemlineatus* in Iowa. He concluded that the species is beneficial in that it consumes many insects that are injurious to crops, but that it can be detrimental by destroying newly planted grain. He reviewed the analyses of other workers, all of whom seemed to rate the species as neutral relative to economic impact on man. Burnett (1924) reached a similar conclusion.

**BEHAVIOR.** *Spermophilus tridecemlineatus* generally is considered to be nonterritorial (Hohn, 1966; Wistrand, 1974; Streubel, 1975), but individuals do defend specific areas; violation by another squirrel of such a defended area stimulates intraspecific agonistic behavior (Wistrand, 1974; Streubel, 1975). Streubel reported that individual squirrels concentrated their activities in relatively confined areas within what appeared to be larger home ranges, a form of social organization defined as "core monopolization" by Fisler (1969).

Agonism is not a major component of the behavioral repertoire of this species; Wistrand (1974) observed only 19 intraspecific interactions in approximately 150 hours of observation, and Streubel (1975) observed 45 intraspecific encounters during 61 hours of observation. He noted that the majority of agonistic encounters occurred during the breeding season.

Wistrand (1974) and Streubel (1975) described in detail the sexual behavior of *S. tridecemlineatus*. Streubel (1975) observed copulation on three occasions; one continued without interruption for 14.66 minutes, whereas the other two copulations both were interrupted by intruding males and lasted only 3.16 and 5.0 minutes, respectively. Wistrand (1974) speculated that copulation may occur in burrows.

In Colorado, sexual behavior occurred most frequently the first two weeks after emergence from hibernation, and thereafter was insignificant.

Bailey (1893) and McCarley (1966) described the call of *S. tridecemlineatus*. Bailey referred to the communicative function of the call and McCarley observed several behavior patterns in the auditory communication between females and their young. He found that the female alarm call was given only after the young emerged from their nest burrows, but that young did not respond to the alarm call for one to three days after emergence. After three to four days, the young responded by diving for a burrow entrance. A female did not give the call later than four weeks after her litter emerged.

McCarley (1966) also observed a distress call given by the young when they wandered from their nest burrow and apparently got lost. He described it as a "peep" call and observed that a female would retrieve her young when she heard the call.

Wistrand (1974) noted that the primary means of locomotion by *S. tridecemlineatus* was walking, which occurred while the animal was in three different positions, and that individuals ran in a quadrupedal ricochet fashion as described by Eisenberg (1968). Wistrand (1974) and Streubel (1975) described the various postures assumed while feeding and while alert, which were similar to those observed in *S. armatus* (Ralph and Stokes, 1963) and *S. spilosoma* (Streubel, 1975).

According to Streubel (1975), foraging and feeding comprises about 70% of the aboveground time of a thirteen-lined ground squirrel, alert behavior 12%, maintenance behavior (including sunning, grooming, eliminating, resting in the shade, sandbathing) 8%, nesting activities 6%, and investigative (nonforaging) behavior about 3%. Sexual and agonistic behavior made up only a small percentage of the total behavior budget.

Bridgewater (1966) studied the development of behavior in young and observed that the attainment of characteristic adult behavior patterns appeared to coincide with weaning.

McCarley (1966) noted that activity in March and April was represented by a unimodal curve with a peak between noon and 1400. In May and early June, the curve lengthened out and activity was greatest from 0900 to 1700. From late June through early September, the activity curve was bimodal with peaks in mid-morning and late afternoon. Activity was inhibited when the temperature was less than 10°C and surface winds were more than 25 km/hr. Individuals were not consistent in their daily activity patterns, and changeable weather made generalizations difficult.

The annual activity cycle includes a long period of hibernation. In Texas, McCarley (1966) recorded the mean hibernation time of six males as 237 days and that for 28 females as 240 days. He noted that the onset of hibernation coincided with decreasing photoperiod length, increased temperatures, and accumulation of fat deposits. In Colorado the species emerged from hibernation generally between 1 and 15 April, and more males than females seemed to be present during the first week after emergence (Streubel, 1975). Males entered hibernation in July, females in late July and early August, and most young in early September (Streubel, 1975). Streubel estimated the seasonal periods of activity to be 100 to 120 days for females.

*Spermophilus tridecemlineatus* has been used for the study of hibernation by many investigators. Fitzpatrick (1925) suggested that cold weather in the autumn reduced activity of the species. He further observed that only one individual existed per hibernation burrow, hibernation burrows had plugged entrances, the pulse rate of hibernating animals was reduced from 200 to four per minute, and respiration was reduced to "practically zero." Johnson (1928) found the body temperature of hibernating *S. tridecemlineatus* to be about 1 to 3°C above the environmental temperature.

Behavior changes prior to hibernation; individuals become more aggressive and intolerant of others (Wade, 1930), their home range is reduced, and they become relatively inactive (Streubel, 1975). Mrosovsky (1971) suggested that the intolerance may tend to limit one squirrel to a nest burrow. The greatest pre-hibernation weight gain occurs during this period of inactivity (Hohn, 1966), but the intake of food does not increase significantly (Richter, 1967). Johnson (1930) observed that fat animals enter hibernation more readily and sooner than do thin animals.

Hibernation is interrupted by periodic arousal. Intervals between arousals vary from 10 to 26 days (Johnson, 1931; Fisher, 1964; Folk, 1957). The stimulus for arousal has been studied by Fisher and Mrosovsky (1970), who found that potassium may cause arousal. Johnson (1929) found that a decrease in environmental temperature acted as an arousal stimulus, but he noted that if the environmental temperature approached 0°C, death might occur rather than arousal.

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