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AN ECOLOGICAL STUDY OF RODENTS IN A SHORT-GRASS PRAIRIE OF NORTHEASTERN COLORADO

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AN ECOLOGICAL STUDY OF RODENTS IN A SHORT-GRASS

PRAIRIE OF NORTHEASTERN COLORADO

ABSTRACT

by Lester Dennis Flake, Ph.D.
Washington State University, 1971

Chairman: Vincent Schultz

Four rodent species (*Dipodomys ordii*, *Onychomys leucogaster*, *Peromyscus maniculatus*, and *Spermophilus tridecemlineatus*) were studied on the short-grass prairie of northeastern Colorado during 1969 and 1970 in conjunction with the International Biological Program's grassland biome studies. Three half-section pastures (intensive study pastures) subject to long-term cattle grazing at light, moderate, and heavy intensities, respectively, were live trapped to determine possible effects of grazing on rodent populations. Traps within each pasture were stratified into the three main soil types (Vona and Ascalon sandy loam, Midway-Renohill complex, and undifferentiated bottomland soils) to examine rodent abundance and distribution in relation to these soils. Live-trap data also provided information on sex ratios, annual population cycles, and population levels between years. Rodents were snap trapped in areas adjacent to the intensive study pastures and used for estimating litter size (embryo counts), reproductive seasons (presence of embryos, placental scars, and mean testis length), and sex ratios. Stomachs of snap-trapped rodents were collected and food habits examined using microscopic techniques. Habitat relations, reproduction, and food habits were emphasized in this study.

Populations of *P. maniculatus* were directly related to intensity of grazing pressure while *S. tridecemlineatus* were inversely related to grazing pressure, although the differences between pastures for both species were not great. *O. leucogaster* showed no definite relation to grazing pressure though populations were generally lowest in the heavily grazed pasture. Low sample size made relationship to grazing pressure, unless extreme, difficult or impossible to observe in *D. ordii*.

Definite soil relations were noted only in *O. leucogaster* and *D. ordii* as both showed an aversion for the undifferentiated bottomland soils, probably due to frequent flooding in this habitat, and in the case of *D. ordii*, lack of barren surface soil and thus dusting places. There were other less definite but probable soil relationships.

Pregnant *D. ordii* were found from February through August, *O. leucogaster* from March through August, *P. maniculatus* from February through November, and *S. tridecemlineatus* in May. Mean litter sizes and ranges were 2.87 (2-4), 4.58 (3-7), 4.70 (2-8), and 8.55 (7-11) for *D. ordii*, *O. leucogaster*, *P. maniculatus*, and *S. tridecemlineatus* respectively.

Mean percent volume of animal matter in diets of rodent species was as follows: *D. ordii* (4.4%), *O. leucogaster* (73.9%), *P. maniculatus* (39.0%), and *S. tridecemlineatus* (44.0%). Amounts of animal matter in adults and juveniles were about equal though there were some differences between sexes. The greatest amount of seasonal variation in percent volume animal matter in the diet was in *P. maniculatus*. Animal matter in the diets of all four species was composed almost entirely of arthropods with a few vertebrate parts present. Arthropods commonly identified in the diets included Coleoptera adults, Lepidoptera larvae, Coleoptera larvae, and grasshoppers (except in *D. ordii*). Plant matter in the diets of all species included unidentified seeds, leaves, stems, and flowering parts of various species of grasses and sedges, forbs, and shrubs and tissues of mosses, lichens, and fungi. Seeds were by far the most common type of plant matter in diets of *D. ordii* and *P. maniculatus* while plant matter in *S. tridecemlineatus* and *O. leucogaster* was more equally divided between seeds and non-seed parts of grasses (and sedges) and forbs. Much seasonal variation in types and relative amounts of different kinds of plant and animal matter was noted.

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INTRODUCTION

Selected for intensive ecosystem analysis in October of 1967 by the International Biological Program (IBP), the Pawnee Site in northeastern Colorado has become the center for numerous studies of animal, plant, and abiotic parameters. This dissertation research is concerned with rodent species at the Pawnee Site and, in particular, with the effect of different intensities of long-term cattle grazing on rodent abundance, rodent abundance and distribution in relation to certain soil types, annual cycles and fluctuations of rodent populations, rodent reproduction and sex ratios, and rodent food habits. Species studied include the Ord's kangaroo rat (*Dipodomys ordii luteolus* [Goldman]), northern grasshopper mouse (*Onychomys leucogaster arcticeps* Rhoads), prairie deer mouse (*Peromyscus maniculatus osgoodi* Mearns), and thirteen-lined ground squirrel (*Spermophilus tridecemlineatus arenicola* [Howell]).[1] These were the only rodent species captured regularly at the Pawnee Site and are hereafter referred to as "target" species.

Previous studies of "target" species in the environs of the Pawnee Site have not been conducted and, in fact, research on these species has apparently not been conducted on any of the short- and mixed-grass prairies of eastern Colorado. An appreciable number of studies have been published on "target" species in other parts of their range. Studies relating to

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[1]Taxonomic assignment of rodents after Hall and Kelson (1959).

"target" species, and of particular importance to this research, are briefly summarized in Table 1 and discussed hereafter in relation to findings of this study.

Data on several aspects of "target" species at the study area, aspects which have not been previously studied in these environs and thus warrant attention, are provided by this study. Moreover, objectives of this study contribute to general knowledge of each species and provide data needed to fulfill overall IBP objectives, which are "to study the different states of grassland ecosystems to determine interrelationships of structure and function, to determine the variability and magnitude of rates of energy flow and nutrient cycling, and to include these parameters and variables in an overall systems framework and mathematical model" (Van Dyne, 1969).

TABLE 1.--Literature concerning "target" species of particular importance to Pawnee Site studies.

Species	Author(s) and Date	Information Cited	Region of Study
D. ordii	Bailey, 1931	Reproduction	New Mexico
	Dale, 1939	Habitat	California
	Monson and Kessler, 1940	Habitat	Arizona and New Mexico
	Vorhies and Taylor, 1940	Habitat	Arizona
	Alcorn, 1941	Reproduction	Nevada
	Duke, 1944	Reproduction	Utah
	Day, Egoscue, and Woodbury, 1956	Reproduction	Utah
	Johnson, 1956	Reproduction	New Mexico
	University of Utah, 1960	Food Habits	Utah
	Johnson, 1961	Food Habits	Idaho
	McCulloch and Inglis, 1961	Reproduction	Texas and Oklahoma
	Eisenberg and Isaac, 1963	Reproduction	California
	Maxwell and Brown, 1968	Habitat	Wyoming
	Beatley, 1969		
O. leucogaster	Bailey and Sperry, 1929	Food Habits and Reproduction	Western U.S.
	Bailey, 1931	Food Habits	New Mexico
	Svihla, 1936	Reproduction	Washington
	Cockrum, 1952	Food Habits	Kansas
	Egoscue, 1960	Habitat and Reproduction	Utah
	Johnson, 1961	Food Habits	Idaho
	Maxwell and Brown, 1968	Habitat	Wyoming
	Pinter, 1970	Reproduction	Western U.S.

TABLE 1.--Continued

Species	Author(s) and Date	Information Cited	Region Studied
P. maniculatus	Bailey, 1931	Food Habits	New Mexico
	Townsend, 1935	Sex Ratios	New York
	Phillips, 1936	Habitat	Oklahoma
	Clark, 1938	Reproduction	Michigan
	Blair, 1940	Reproduction	Michigan
	Smith, 1940 (a and b)	Habitat	Oklahoma
	Hamilton, 1941	Food Habits	New York
	Jameson, 1952	Food Habits	California
	Jameson, 1953	Reproduction	California
	Beidleman, 1954	Reproduction	Colorado
	Reed, 1955	Reproduction	Colorado
	Manville, 1956	Sex Ratios	Michigan
	Williams, 1959	Food Habits	Wyoming and Colorado
	Johnson, 1961	Food Habits	Idaho
	Sheppe, 1963	Reproduction	British Columbia and Washington
	Long, 1964	Reproduction	Wyoming
	Brown, 1966	Reproduction	Wyoming
	Whitaker, 1966	Food Habits	Indiana
	Terman and Sassaman, 1967	Sex Ratios	Virginia
	Maxwell and Brown, 1968	Habitat	Wyoming
S. tridecemlineatus	Bailey, 1893	Food Habits	Mississippi Valley
	Lantz, 1904	Food Habits	Kansas
	Fitzpatrick, 1925	Food Habits	Iowa
	Hisaw and Emery, 1927	Food Habits	Wisconsin and Illinois
	Wade, 1927	Reproduction	Nebraska
	Bailey, 1931	Food Habits	New Mexico
	Schmidt, 1931	Food Habits	Wisconsin
	Foster, 1934	Reproduction	Wisconsin

TABLE 1.--Continued

Species	Author(s) and Date	Information Cited	Region of Study
S. tridecemlineatus (Continued)	Weaver and Flory, 1934	Habitat	Oklahoma
	Phillips, 1936	Habitat	Oklahoma
	Criddle, 1939	Reproduction	Manitoba
	Smith, 1940 (a and b)	Habitat	Oklahoma
	Rongstad, 1965	Reproduction and annual population cycle	Wisconsin
	McCarley, 1966	Reproduction	Texas
	Maxwell and Brown, 1968	Habitat	Wyoming

DESCRIPTION OF THE STUDY AREA

The Pawnee Site is delimited by boundaries of the western division of the Pawnee National Grassland. At the western edge of the Pawnee Site is located the Central Plains Experimental Range (CPER) (Figure 1). The primary site for intensive IBP ecosystem analysis is CPER, though studies requiring additional space, such as rodent and other mammal studies, extend into additional areas of the Pawnee Site. My rodent studies were centered in and adjacent to the intensive study pastures (HG, MG, and LG) (Figure 1). About 42,494 ha (105,000 A) are included in the western division of the Pawnee National Grassland (Pawnee Site) and, of this, about 6,071 ha (15,000 A) are included in CPER. International Biological Program field headquarters at the Pawnee Site are located on CPER about 48 km (30 mi) northeast of Fort Collins, Colorado (Figure 1).

Climatological records collected at CPER headquarters since 1939 indicate precipitation ranges from 25-38 cm (10-15 in) per year with more than 72% occurring from May 1 to September 30. Mean monthly precipitation as measured at CPER headquarters from 1939-1967 is presented in Figure 2. Mean monthly maximum and minimum temperatures at CPER from 1948-1967 are shown in Figure 3. Altitude within the intensive study pastures (HG, MG, and LG) ranges from 1,686-1,704 m.

Vegetation at the Pawnee Site and in adjacent areas is classified as short-grass prairie and has been described by Klipple and Costello (1960), Hyder et al. (1966), and Daniel W. Uresk (unpublished data, Range Science Department, Colorado State University, Fort Collins, Colorado). Native

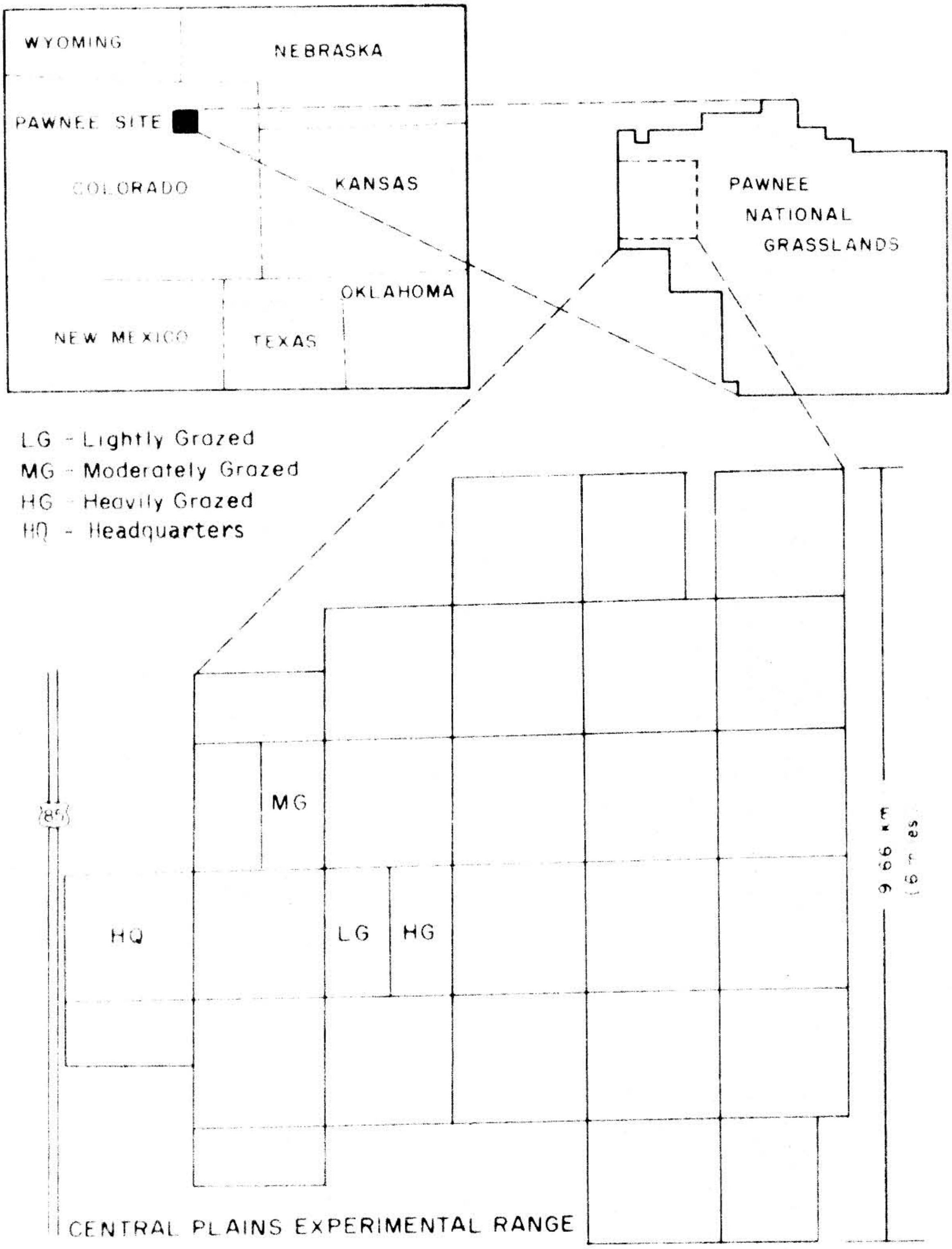

FIGURE 1.--Location of Pawnee Site, intensive study pastures (LG, MG, and HG) and International Biological Program field headquarters (HQ). (Modified from Jameson, 1969)

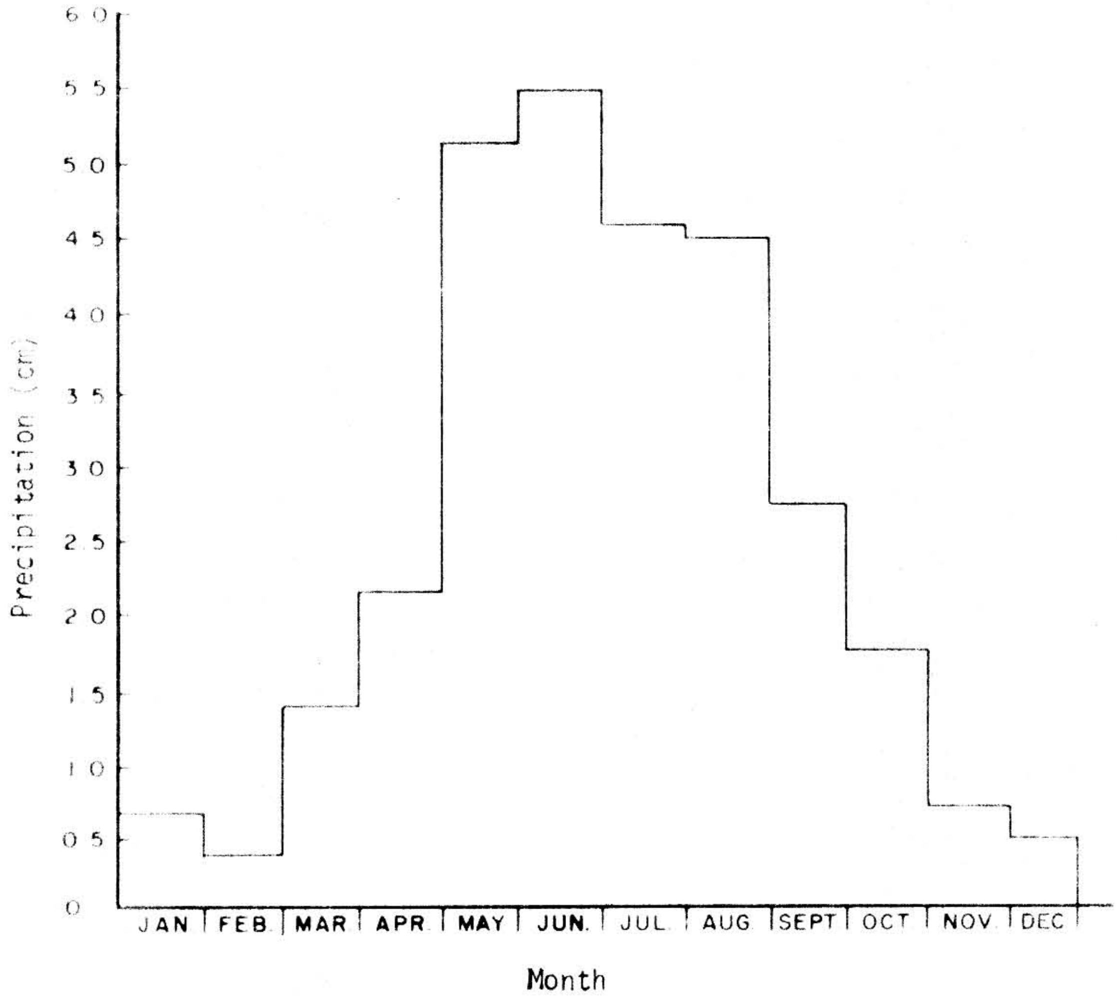

FIGURE 2.--Mean monthly distribution of precipitation at the Pawnee Site. (Recorded at Central Plains Experimental Range Station from 1939-1967.)

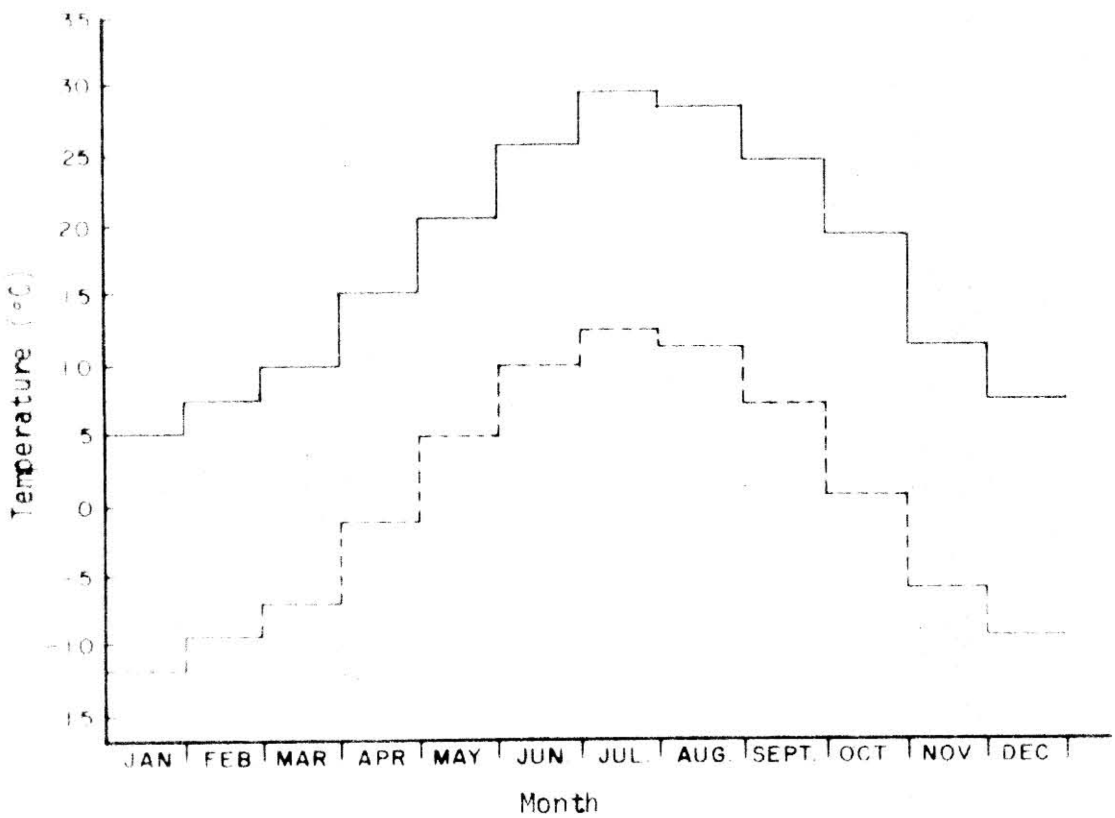

FIGURE 3.--Mean monthly maximum and minimum temperatures at the Pawnee Site. (Recorded at Central Plains Experimental Range Station from 1948-1967.)

short-grass prairie is composed primarily of blue grama (*Bouteloua gracilis* [H. B. K.] Lag.), buffalo grass (*Buchloe dactyloides* [Nutt.] Engelm.), and sun sedge (*Carex heliophila* Mackenz). Other grasses associated with short-grass prairie include western wheatgrass (*Agropyron smithii* Rydb.), red three-awn (*Aristida longiseta* Steud), and needle and thread (*Stipa comata* Trin and Rupr.). Some of the more common perennial forbs at the Pawnee Site include scarlet globemallow (*Sphaeralcea coccinea* [Pursh] Rydb.), slim flower scurfpea (*Psoralea tenuiflora* Pursh), slenderbush eriogonum (*Eriogonum effusum* Nutt.), scarlet gaura (*Gaura coccinea* Nutt. Ex. Pursh), and plains prickly pear (*Opuntia polycantha* Haw.). Bee spiderflower (*Cleome serrulata* Pursh), evening primrose (*Oenothera* L.), and slimleaf goosefoot (*Chenopodium leptophyllum* nutt.) are a few of the characteristic annual forbs. Shrubs include broom snakeweed (*Gutierrezia sarothrae* [Pursh] Britt. + Rusby), fringed sagewort (*Artemisia frigida* Willd.), rubber rabbitbush (*Chrysothamnus nauseosus* [Pall.] Britt.), and saltbush (*Atriplex canescens* [Pursh] Nutt.).[2] A list of plants collected at the Pawnee Site is found in Jameson (1969).

A brief description of the more common vertebrates at the Pawnee Site serves to further acquaint readers with the grassland ecosystem. Amphibians are generally not encountered in large numbers on the Pawnee Site, though the plains spadefoot toad (*Scaphiopus bombifrons* Cope) may sometimes be quite abundant. Leopard frogs (*Rana pipiens* Schreber) and tiger salamanders (*Ambystoma tigrinum* [Green]) are abundant in permanent and semipermanent ponds found in drainage basins throughout the Site. Among reptiles occasionally encountered are prairie rattlesnake (*Crotalus viridis* Rafinesque), western hognose snakes (*Heterodon nasicus* Baird and Girard), earless lizards

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[2]Taxonomic assignment of plants after Harrington (1964).

(*Holbrookis maculata* Girard), and short-horned lizards (*Phrynosoma douglassi* [Bell]). Small birds often seen at the Pawnee Site include lark buntings (*Calamospiza melanocorys* Stejneger), McCown's longspur (*Rhynchophanes mccowni* Lawrence), and mountain plover (*Eupoda montana* [Townsend]) in late spring and summer, with horned larks (*Eremophila alpestris* [Linnaeus]) present throughout the year. Several raptors are common at the Pawnee Site including the burrowing owl (*Speotyto cunicularia* [Molina]), ferruginous hawk (*Buteo regalis* [Gray]), marsh hawk (*Circus cyaneus* [Linnaeus]), prairie falcon (*Falco mexicanus* Schlegel), Swainson's hawk (*Buteo swainsoni* Bonaparte), and golden eagle (*Aquila chrysaetos* [Linnaeus]).[3] A list of birds found at the Pawnee Site is included in Jameson (1969).

Common mammals of the Pawnee Site, other than the rodent species previously mentioned, include pronghorn antelope (*Antilocapra americana* Ord.), coyote (*Canis latrans* Say), badger (*Taxidea taxus* [Schreber]), white-tailed jackrabbit (*Lepus townsendii* Bachman), and black-tailed jackrabbit (*Lepus californicus* Gray). A list of mammals found at the Pawnee Site is included in Jameson (1969).

Within the CPER are three half-section pastures, each having been exposed to different intensities of cattle grazing from May 1 to October 31 of each year since 1939. These are referred to as the lightly grazed (LG), moderately grazed (MG), and heavily grazed (HG) pastures or as the intensive study pastures (Figure 1). According to Dr. Donald A. Jameson (personal communication, Range Science Department, Colorado State University, Fort Collins, Colorado), number of cattle (heifers) placed in these pastures per six-month period varies between years and is regulated so that above ground

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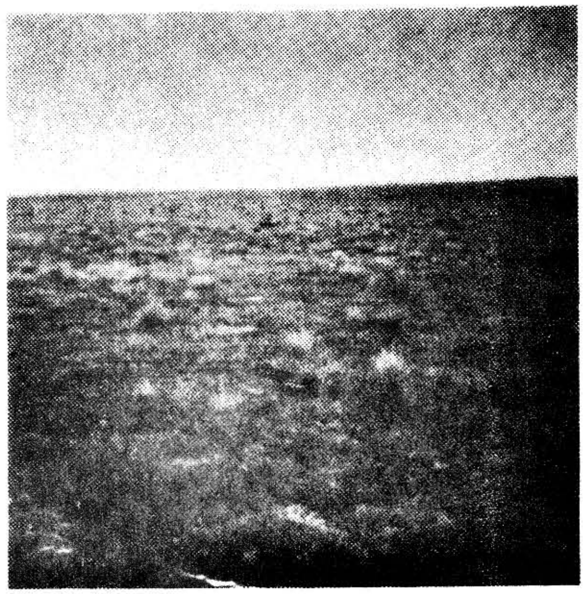
[3]Taxonomic assignments of amphibians, reptiles, and birds after Blair et al. (1957).

biomass is generally not reduced below 341 kg/ha (300 lb/A) in the heavily grazed pasture, 455 kg/ha (400 lb/A) in the moderately grazed pasture, and 568 kg/ha (500 lb/A) in the lightly grazed pasture. Photographs of the intensive study pastures (Figure 4) show a primary difference between the differentially grazed pastures to be height of vegetation. As would be expected, the tallest grasses and forbs are found in the lightly grazed pasture with the shortest vegetation present in the heavily grazed pasture and a condition somewhat between these two in the moderately grazed pasture. According to Daniel W. Uresk (unpublished data, Range Science Department, Colorado State University, Fort Collins, Colorado), if one excludes plains prickly pear (*O. polycantha*), there is a decrease in biomass of total forbs in the intensive study pastures with increased grazing, though frequency of these forbs does not appear to be related to grazing intensity. Further, plains prickly pear (*O. polycantha*) biomass and frequency is greatest in the heavily grazed pasture and least in the moderately grazed pasture while the lightly grazed pasture has a somewhat intermediate amount. Finally, shrubs such as broom snakeweed (*G. sarothrae*), fringed sagewort (*A. frigida*), and rubber rabbitbush (*C. nauseosus*) have a higher frequency and biomass in the lightly grazed pasture than in the heavily grazed pasture, with the moderately grazed pasture having an intermediate amount. Hyder et al. (1966) concluded that 23 years of long-term grazing at different intensities on the intensive study pastures had not affected frequency percentage of plant species to any detectable extent. These results are compatible with those just discussed except for shrubs and *O. polycantha*. My visual observations indicate a definite decrease in frequency and biomass of shrubs with increased grazing. Little or no increase in amount of bare surface soil and erosion with increased grazing is evident.

a. Heavily grazed (HG)



b. Moderately grazed (MG)

c. Lightly grazed (LG)

FIGURE 4.--Intensive study pastures at the Pawnee Site in June, 1970 (7.5 cm x 7.5 cm x 25.4 cm mammal traps in foreground).

In terms of area covered, major soil types in the intensive study pastures are Vona and Ascalon sandy loam soils, Midway-Renohill complex soils, and undifferentiated-bottomland soils (Jameson, 1969). The contour of these soils in each of the intensive study pastures is shown in Figure 5. Ascalon and Vona sandy loams are deep, well-drained soils containing little shale or sandstone and not subject to frequent water overflow. Because of their similarity, they are grouped as one major soil type for rodent habitat analysis. Midway-Renohill complex soils are shallow to deep soils containing large amounts of shale and interbedded shale and limestone and are moderately well drained and not subject to frequent water overflow. Undifferentiated-bottomland soils contain little or no shale or sandstone, are well drained and deep, but are subject to frequent flooding.

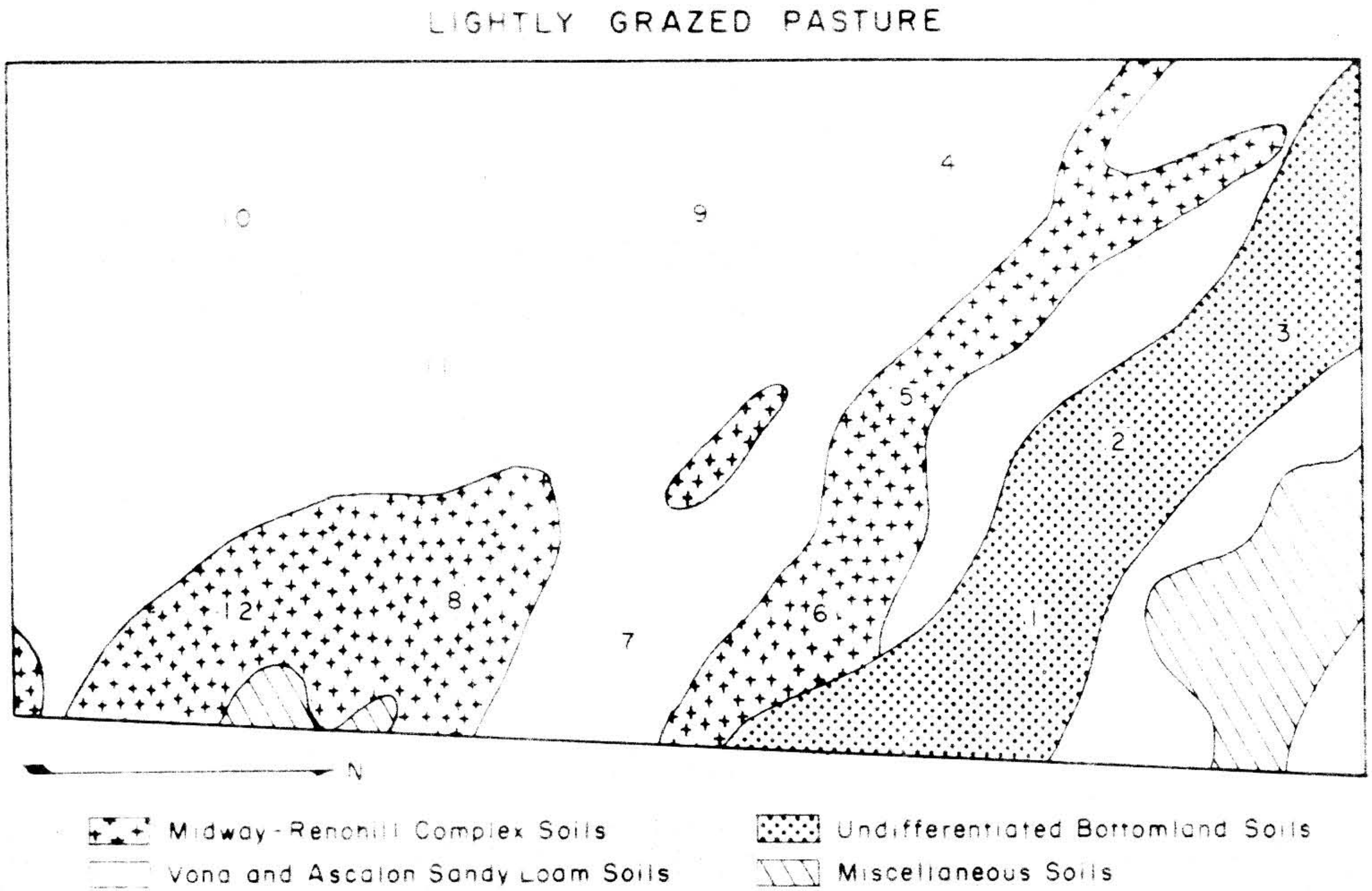


FIGURE 5.--Soil contour and rodent live-trapping grid sites (numbered 1-12) in the lightly (LG), moderately (MG), and heavily (HG) grazed pastures (intensive study pastures) at the Pawnee Site. Each pasture about 130 ha or 640 A.

MODERATELY GRAZED PASTURE

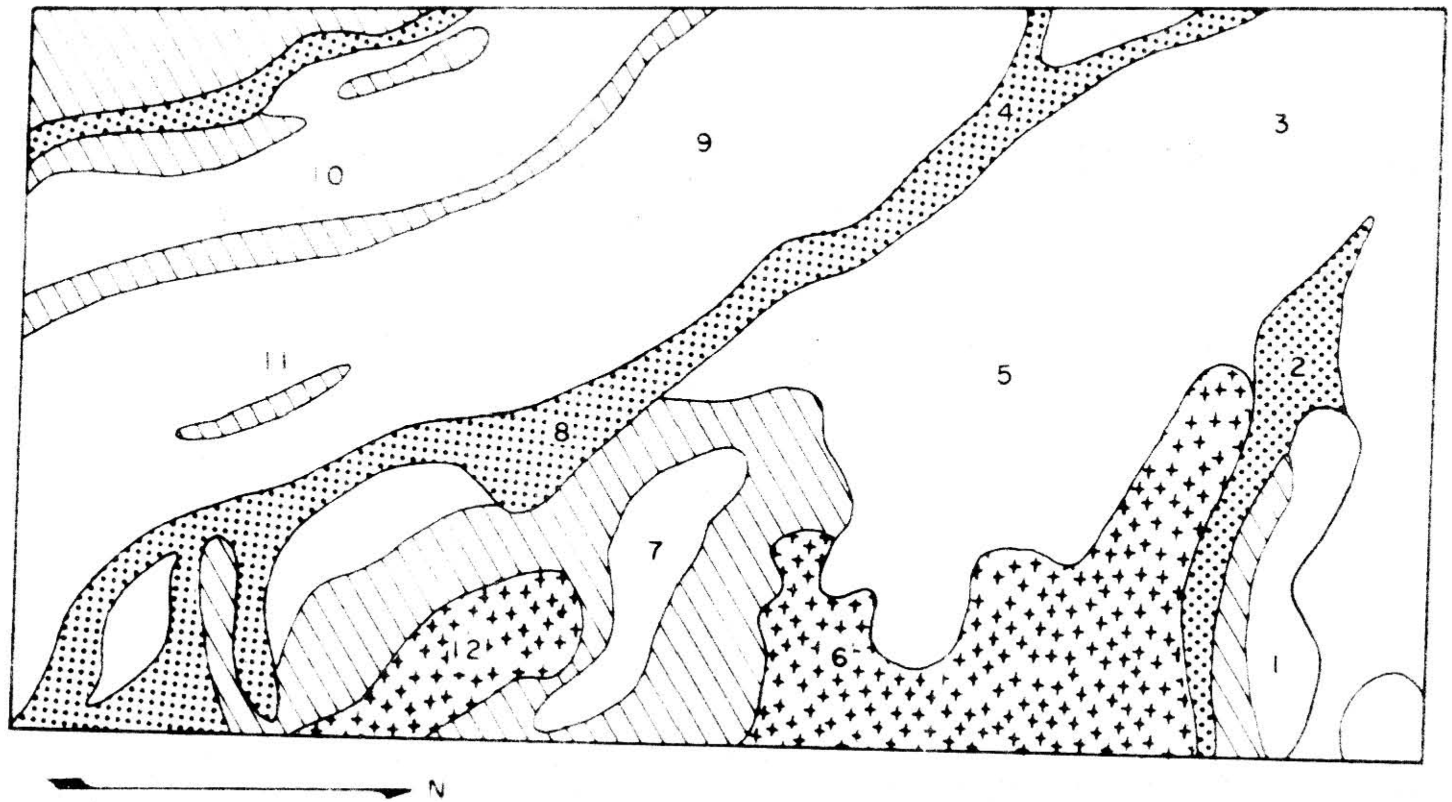


FIGURE 5.--Continued

HEAVILY GRAZED PASTURE

FIGURE 5.--Continued

METHODS

Field Methods

Within each of the intensive study pastures, twelve permanent live-trapping grid sites were established and nonrandomly numbered from 1 through 12 (Figure 5). Grid sites were numbered in a manner that allowed easy recall of grid numbers when checking live traps but without regard to soil types. Grid sites were stratified into the three main soil types, with number of grids in each soil constant between pastures and with grid sites within each soil subjectively selected. Five grid sites were placed in Ascalon and Vona sandy loam soils, four in Midway-Renohill complex soils, and three in undifferentiated-bottomland soils. The number of grid sites in each soil type is roughly proportional to the percentage of area covered by these soils in each of the intensive study pastures.

Live-trapping procedures were periodically initiated in the lightly, heavily, and moderately grazed pastures from late May, 1969, through late July, 1970. Except for winter and early spring, when snow and extreme cold prevented live trapping, trapping periods were scheduled at about two-month intervals. During these live-trapping periods, 30 x 30 m grids, each containing 16 Tomahawk live traps[4] (7.6 cm x 7.6 cm x 25.4 cm, metal) spaced at 10-m intervals, were placed at each sampling site in the intensive study pastures. Traps in each grid were set for five days per live-trapping period, as preliminary data indicated nearly all trappable animals would be recaptures by the fifth day. Half the grids in each pasture were trapped simultaneously,

[4]National Live-Trap Corporation, Tomahawk, Wisconsin

with traps being moved to the remaining grids after five days. Throughout the study, even-numbered grids were run during the first five days and odd-numbered grids the second five days of each live-trapping period. Live-trapping periods required a minimum of 10 days plus one or two days for moving traps between grids and rebaiting. Prebaiting procedures were not used due to time and manpower limitations. Each morning during live-trapping periods, traps were baited with molasses-rolled barley and animals toe- and/or ear-marked, recorded as to species, sex, reproductive condition (lactating, pregnant, or fecund), and released. During extremely hot days, additional tending of traps was necessary in the early afternoon to reduce trap mortality.

Toe-marking consisted of clipping toes numbered distally to proximally from one through four on the front feet and from one through five on the back feet. Up to one toe was removed from each foot with the front right feet counting as thousands, front left as hundreds, back right as tens, and back left as ones. Additionally, right and left ears were clipped as six and seven thousands, respectively. Each animal was recorded as a four digit number from these marks. Identical marks were used for different species.

In areas of CPER and Pawnee National Grassland adjacent to the intensive study pastures, snap-trap lines were set each month to capture rodents for reproductive, food habits, and age-structure analyses (based on weight). Snap traps were primarily museum specials with some larger rat-type traps being used. Traps were baited with a peanut butter-oatmeal mixture and tended once each morning except during warmer months when it was necessary to visit traps more frequently during the day to prevent decomposition of *S. tridecemlineatus* (diurnal species) and for rebaiting due to theft of bait by ants. All animals were given a species number, recorded as to sex, weight, and date of capture and returned to the laboratory at Colorado State University for later analysis.

Laboratory Methods

In the laboratory, the animals were dissected and the uterus, both testis, and stomach placed in 70% ethyl alcohol for later examination. The percentage of females with visible pregnancies was determined and embryos were counted. Recent placental scars were counted by placing uteri towards a light source and counting numbers of distinct dark spots. If scars were present but difficult to count, they were recorded as present without attempting to count them. Testis length was recorded as a general index of male fecundity.

All animals were classified as juvenile or adult on a weight basis. *D. ordii* weighing less than 59 g were classified as juveniles since none below this weight were found to be pregnant, and this was the minimum weight of most specimens captured in January and February of 1970, six months after the last recorded pregnancy. Those weighing 59 g or more were classified as adults. If one interpolates from the growth curve for *D. nitratoides* (Eisenberg and Isaac, 1963), the juveniles are probably less than four months of age and the adults four months or older. Northern grasshopper mice (*O. leucogaster*) weighing less than 24 g were classified as juveniles since no pregnant females were found weighing less than this. Further, during November, December, January, and February, at least three months after the last recorded pregnancy, no specimens weighing less than 24 g were trapped. Animals weighing 24 g or more were classified as adults. Juveniles were probably less than two months old, as Egoscue (1960) records puberty is reached at 6-7 weeks in northern grasshopper mice (*O. leucogaster*). Juvenile *P. maniculatus* were defined as specimens weighing less than 18 g since pregnant females were not found under this weight. Adults were classed as those weighing 18 g or more. For *P. maniculatus*, minimum weights of specimens captured in mid-winter were not a good estimate of minimum adult weights since reproduction occurred almost all year and juveniles were captured in every month. Clark (1938) found *P maniculatus* seldom conceived before five weeks of age, and thus, juveniles were probably in this age category. *S. tridecemlineatus* were classified as juveniles or adults on the basis of weight difference up until estivation in mid- or late summer. In general, juveniles weighed less than 100 g and adults more than 100 g from emergence of young in June until mid-August when almost all adults were in estivation. By mid-August or later, active adults usually weighed 150 g or more while juveniles weighed considerably less than 150 g. All *S. tridecemlineatus* captured in spring and early summer before den emergence of young were classified as adults.

Stomach contents were examined under a dissecting microscope to determine what types of animal matter were being consumed. Animal matter was identified from undigested parts such as chitonous body walls and appendages, hair, lizard scales, etc. Types of animal matter were given percent volume of total animal matter (composition) rankings as follows: one (1-20%), two (21-40%), three (41-60%), four (61-80%), and five (81-100%). Further, total animal versus plant matter in each stomach was estimated using this same volume ranking plus one additional ranking of zero (0%). Though it is difficult to separate ingested plant and animal materials, some rather good clues are available. Primarily, animal material generally has less cell structure and is more translucent than plant materials. Moreover, much of the ingested animal material remains connected with appendages, chiton, hair, etc., revealing its nature. These observations are in agreement with those of

Harriss (1950). A more detailed discussion of these methods along with photographs of insect parts commonly found in diets of "target" species is found in Cwik (1970).

Following the above procedures, stomach contents were oven dried and ground in a Wiley laboratory mill. Slides were made using Hertwig's and Hoyer's solutions as described by Hansen and Flinders (1969). Twenty fields were systematically examined under the compound microscope (10 x) on each slide and the frequency precentage of different species of plants and of less specific categories such as lichens, fungi, seeds, etc., were recorded. Plant tissues were identified from reference slides of plant tissues at the Pawnee Site. Percent frequency was converted to density using a table developed by Fracker and Brischle (1944) and density converted to percent dry weight using a formula developed by Sparks and Malechek (1968). A more detailed discussion of these microtechnique procedures is found in Hansen and Flinders (1969).

RESULTS AND DISCUSSION

Population Relations of Rodents to Cattle Grazing and Soils

Effects of grazing, especially by cattle and sheep, may alter habitat and subsequently cause a change in rodent populations, depending on their habitat requirements. The ensuing "target" species subsections present and discuss Pawnee Site data on relative abundance per intensive study pasture to compare how long-term cattle grazing at light, moderate, and heavy intensities has possibly affected "target" species populations. Further, relative abundance and distribution of "target" species within the three main soil types of the intensive study pastures are examined and miscellaneous habitat preference observations are made from snap-trapping procedures in the areas adjacent to the intensive study pastures.

D. ordii

Ord's kangaroo rats (*D. ordii*) were present in extremely low numbers in each of the intensive study pastures at the Pawnee Site, with captures generally lower than for any other "target" species (Table 2). There were no consistent relationships between numbers of *D. ordii* captured and long-term intensity of cattle grazing though low population levels and length of this study would make any trends difficult to observe (Table 2 and Figure 6). Evidence in the literature is quite conclusive that disturbance of desert and grassland ecosystems by cattle grazing can increase the carrying capacity of these habitats for *Dipodomys*. For example, Vorhies and Taylor (1940) observed that kangaroo rats increase in density as ranges in the southwest deteriorate due to grazing practices and perennial grasses tend to be replaced by annuals

TABLE 2.--Captures per grid per live-trapping period (mean ± one standard error) of "target" species in lightly (LG), moderately (MG), and heavily (HG) grazed pastures at the Pawnee Site.[a]

Year	Year and Live-Trapping Period	*D. ordii*			*O. leucogaster*			*P. maniculatus*			*S. tridecemlineatus*		
		LG	MG	HG	LG	MG	HG	LG	MG	HG	LG	MG	HG
1969	May 29 - June 11	.83 ±.47	.25 ±.18	.08 ±.08	.33 ± .19	.75 ± .41	.08 ± .08	.00	.33 ±.14	.67 ±.36	1.58 ± .26	1.25 ± .30	1.00 ± .37
	July 21 - August 3	.08 ±.08	.00	.00	.75 ± .22	1.33 ± .33	1.08 ± .40	.08 ±.08	.17 ±.17	.08 ±.08	3.75 ± .45	2.42 ± .53	2.58 ± .36
	September 11 - 22	.17 ±.11	.08 ±.08	.25 ±.13	1.75 ± .14	2.00 ± .33	1.17 ± .37	.08 ±.08	.17 ±.17	.25 ±.18	.17 ± .11	.42 ± .19	.33 ± .19
	November 3 - 13	.17 ±.11	.17 ±.16	.17 ±.11	1.58 ± .42	1.17 ± .32	.92 ± .36	.33 ±.18	.17 ±.11	.42 ±.23	Hibernating		
1970	April 8 - 26	.00	.00	.00	1.25 ± .43	1.42 ± .36	.50 ± .34	.33 ±.26	.08 ±.08	.41 ±.23	1.92 ± .36	.67 ± .31	.50 ± .23
	May 31 - June 11	.17 ±.17	.00	.00	.42 ± .26	.75 ± .15	.42 ± .15	.33 ±.22	.50 ±.29	.67 ±.26	1.08 ± .34	.75 ± .30	.58 ± .23
	July 20 - 30	.08 ±.08	.00	.00	1.17 ± .32	1.33 ± .28	.92 ± .36	.00	.17 ±.11	.67 ±.33	5.00 ± .56	3.16 ± .49	4.00 ± .64

[a]Animals are counted only the first time they are captured within any live-trapping period, unless recaptured in different pastures, in which case, they are counted the first time captured in each pasture. There were 12 grids per pasture per live-trapping period and 15 traps per grid. Each grid was run for five days per period.

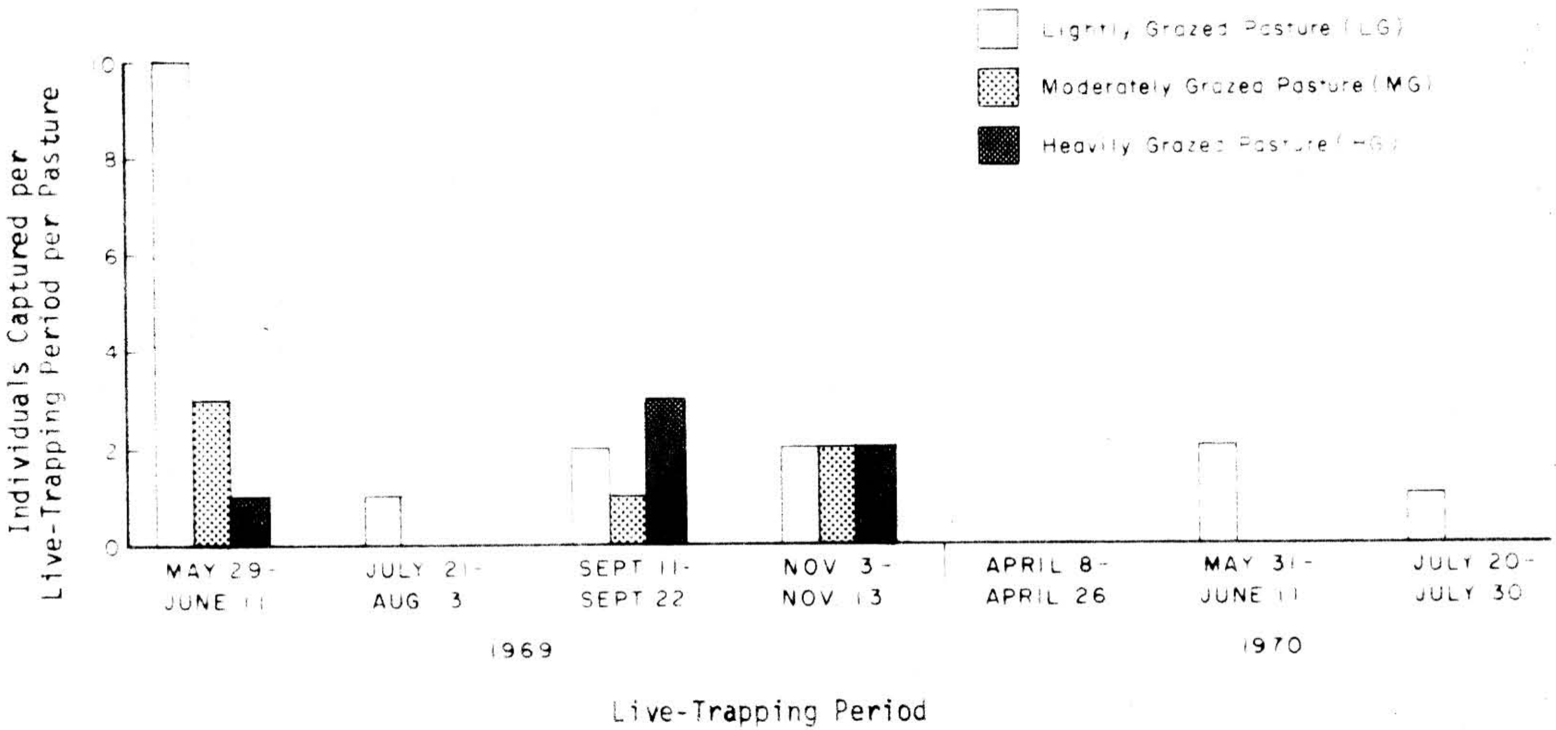


FIGURE 6.--*Dipodomys ordii* trapping success in relation to grazing pressure on the intensive study pastures at the Pawnee Site. (There were 12 grids per pasture and 16 traps per grid. Each grid was run for five days per live-trapping period.)

and weed species. Likewise, Monson and Kessler (1940) observed that the banner-tailed kangaroo rat (*Dipodomys spectabilis*) and Merriam's kangaroo rat (*Dipodomys merriami*) subsist mainly on seeds of annual plants which seem to be favored by increased cattle grazing. Plant standing crop data collected by Daniel W. Uresk (unpublished data, Range Science Department, Colorado State University, Fort Collins, Colorado) indicate little or no increase in annual grasses as a result of increased grazing intensity. It seems doubtful that grazing practices at the Pawnee Site have affected *D. ordii* populations though grazing at an intensity heavy enough to cause substantial erosion as well as replacement of perennial grasses with annual grasses and forbs would most likely result in higher *D. ordii* populations.

Mean captures per grid in Vona and Ascalon sandy loam, Midway-Renohill complex, and undifferentiated bottomland soils are given in Table 3. There is clearly an aversion to the undifferentiated bottomland soils. This is not surprising since Dale (1939) notes that *Dipodomys* are favored by well-drained soils, light ground cover, and an availability of dusting places. The undifferentiated bottomland soils at the Pawnee Site, though generally well drained, are subject to flooding during heavy rain storms and have a high percentage of ground cover with little bare soil and available dusting places. Captures per grid also indicate a preference for Midway-Renohill complex soil habitats over Vona and Ascalon sandy loams. Percent of bare surface soil and therefore dusting places is highest of the three soil habitats in Midway-Renohill complex, and thus, such a preference would be expected.

Observations made from snap trapping in areas outside the intensive study pasture show *D. ordii* concentrations were highest in naturally occurring dry washes and weedy borders of old fields or wheat fields. These areas are

TABLE 3.--Captures per grid per live-trapping period (mean ± one standard error) of "target" species in Vona and Ascalon sandy loam (VASL), Midway-Renohill complex (MRC), and undifferentiated bottomland (UB) soils in the intensive study pastures at the Pawnee Site.[a]

Year	Year and Live-Trapping Period	*D. ordii*			*O. leucogaster*			*P. maniculatus*			*S. tridecemlineatus*		
		VASL	MRC	UB	VASL	MRC	UB	VASL	MRC	UB	VASL	MRC	UB
1969	May 29 - June 11	.07 ±.07	1.08 ± .47	.00	.40 ± .29	.42 ± .26	.33 ±.24	.13 ±.09	.50 ± .19	.44 ±.44	1.87 ± .29	.83 ± .21	1.00 ± .37
	July 21 - August 3	.00	.08 ± .08	.00	1.40 ± .25	1.42 ± .36	.00	.20 ±.14	.08 ± .08	.00	3.00 ± .39	3.08 ± .48	2.67 ± .65
	September 11 - 22	.20 ±.11	.25 ± .13	.00	1.87 ± .41	2.00 ± .17	.78 ±.40	.20 ±.14	.25 ± .18	.11 ±.11	.33 ± .16	.33 ± .19	.22 ± .15
	November 3 - 13	.20 ±.14	.25 ± .13	.00	1.47 ± .35	1.83 ± .34	.22 ±.15	.07 ±.07	.50 ± .23	.44 ±.24	Hibernating		
1970	April 8 - 26	.00	.00	.00	1.73 ± .41	1.08 ± .34	.33 ±.17	.07 ±.07	.42 ± .23	.33 ±.24	1.20 ± .31	1.17 ± .44	.89 ± .45
	May 31 - June 11	.00	.17 ± .17	.00	.73 ± .27	.67 ± .19	.00	.20 ±.14	1.00 ± .33	.33 ±.24	.73 ± .25	.58 ± .29	1.22 ± .29
	July 20 - 30	.00	.08 ± .08	.00	1.80 ± .30	.92 ± .23	.33 ±.24	.13 ±.09	.25 ± .13	.67 ±.47	5.07 ± .57	3.67 ± .67	3.44 ± .34

[a]Animals are counted only the first time they are captured within each live-trapping period, unless recaptured in different soils, in which case, they are counted the first time captured in each soil. There were 15 traps per grid with 9 grids in UB soils, 12 grids in MRC soils, and 15 grids in VASL soils per live-trapping period. Each grid was run for five days per period.

characterized by a low percentage of ground cover, generally an increase in annual grasses and forbs, and an availability of dusting areas.

O. leucogaster

Captures of *O. leucogaster* in the intensive study pastures were generally higher than captures of *D. ordii* or *P. maniculatus* and were only surpassed by *S. tridecemlineatus* (Table 2). During fall and winter when most of the *S. tridecemlineatus* were hibernating, *O. leucogaster* was the predominant rodent captured. Captures in the moderately grazed pasture consistently outnumbered those in the heavily grazed pasture and were higher than captures in the lightly grazed pasture in all live-trapping periods except November 3-13 (Table 2 and Figure 7). Lightly grazed captures outnumbered heavily grazed in all but two out of seven live-trapping periods and these two cases could easily have been the result of sampling error. These observations indicate the heavily grazed pasture may be suboptimal *O. leucogaster* habitat in relation to the lightly and moderately grazed pastures. Perhaps this is due to an increased density of arthropods (major food item) in lightly and moderately grazed pastures in relation to the heavily grazed pasture as observed by John Leetham (personal communication, Insect Sampling Coordinator, IBP, Colorado State University, Fort Collins, Colorado). I cannot explain why captures in the moderately grazed pasture should generally outnumber those in the lightly grazed pasture though one can see the differences are not great (Table 2 and Figure 7).

Effects of grazing on *O. leucogaster* habitats have not been examined for prairies nor does there appear to be any reference to such studies elsewhere. Egoscue (1960), studying *O. leucogaster* in Utah, noted no clear-cut habitat preferences though they did avoid "marshy areas, extremely rocky

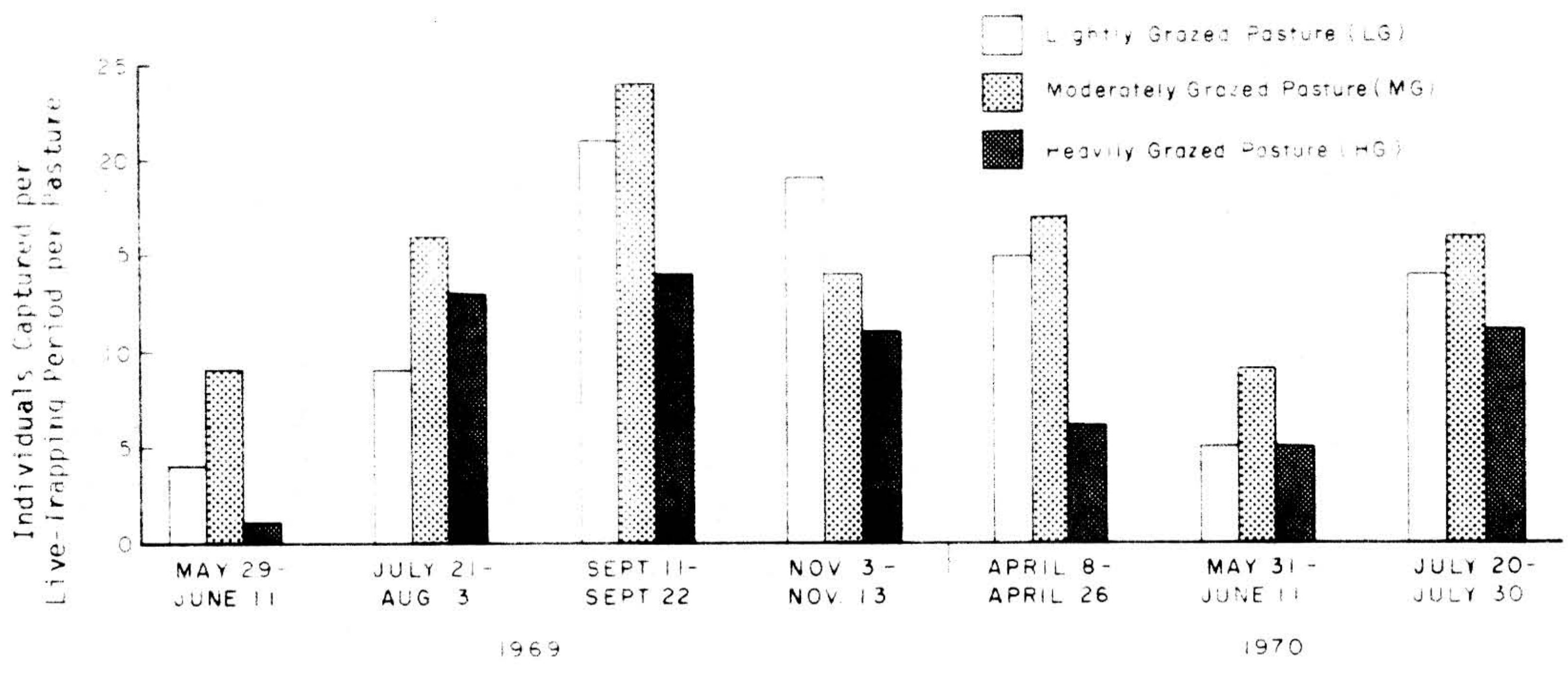


FIGURE 7.--*Onychomys leucogaster* trapping success in relation to grazing pressure on the intensive study pastures at the Pawnee Site. (There were 12 grids per pasture and 16 traps per grid. Each grid was run for five days per live-trapping period.)

situations, precipitous hillsides, the extensive but generally featureless shadscale flats with their alkaline soils and the pickleweed hummocks." In Wyoming, Maxwell and Brown (1968) found *O. leucogaster* broadly and quite evenly distributed in relation to different types of prairie vegetation and noted no particular habitat preference.

Mean captures of *O. leucogaster* per grid per live-trapping period in different soil types disclosed that consistently lower numbers are captured in the undifferentiated-bottomland soil than in either Vona and Ascalon sandy loam or Midway-Renohill complex soils (Table 3). The latter two soils are upland soils and not subject to as frequent or severe flooding as the undifferentiated-bottomland soil. This is a possible cause for avoidance of the bottomland soils by *O. leucogaster*. Personal observations show a decrease in prickly pear cactus (*O. polycantha*) and an increase in *Carex* in the bottomland habitats though both upland and lowland habitats are usually dominated by blue gramma (*Bouteloua gracilis*) and appear quite similar in vegetation life form. Such minor differences in vegetational environment are doubtful as the primary cause of low *O. leucogaster* numbers in the undifferentiated soils, particularly in respect to the findings of Maxwell and Brown (1968), noting *O. leucogaster's* broad habitat tolerance.

P. maniculatus

The effect of cattle grazing on *P. maniculatus* habitat has received some attention by other researchers. Smith (1940b) reports that overgrazing of grasslands with consequent erosion and increase in annuals improves the habitat for *P. maniculatus*. In the grasslands of central Oklahoma, Phillips (1936) found that *P. maniculatus* reached maximum numbers in moderately overgrazed grassland, and further noted an avoidance of deep grass areas unless such areas were accompanied by barren habitat within easy range of the mice. Black (1968) obtained results indicating that *P. maniculatus* populations were much higher in grazed than non-grazed foothill rangeland in Utah. These observations by other workers are particularly helpful in explaining results at the Pawnee Site.

Numbers of *P. maniculatus* captured in the moderately grazed pasture outnumbered captures in the lightly grazed pasture in five of seven live-trapping periods, while numbers captured in heavily grazed habitat were higher than either of the forementioned in six out of seven live-trapping periods (Table 2 and Figure 8). This indicates *P. maniculatus* populations increase with increased grazing of short-grass prairie as would be expected from the literature. The results on grazing effects at first seem highly contradictory to habitat observations made from snap-trapping procedures in other areas of the Pawnee Site. These observations showed *P. maniculatus* much more abundant in tall grasses, forbs, and shrubs, especially in or around dry washes and wheat fields than in any of the short-grass prairie habitats. However, the amount of bare surface soils under the vegetation was much greater in the taller vegetation than in the intensive study pastures and numerous barren areas were interspersed in easy access of resident mice. Thus, as shown by Phillips (1936), deep vegetative cover may provide favorable habitat under these circumstances.

Consistent aversion to a particular soil or soils was not observed for *P. maniculatus* as it was for *D. ordii* and *O. leucogaster* (Table 3). However, there may be a preference for the Midway-Renohill complex soils, as relative densities in this soil exceeded those in both Vona and Ascalon sandy loams and undifferentiated bottomland soils in six of seven live-trapping periods. Midway-Renohill complex soil is considerably more stony and has substantially

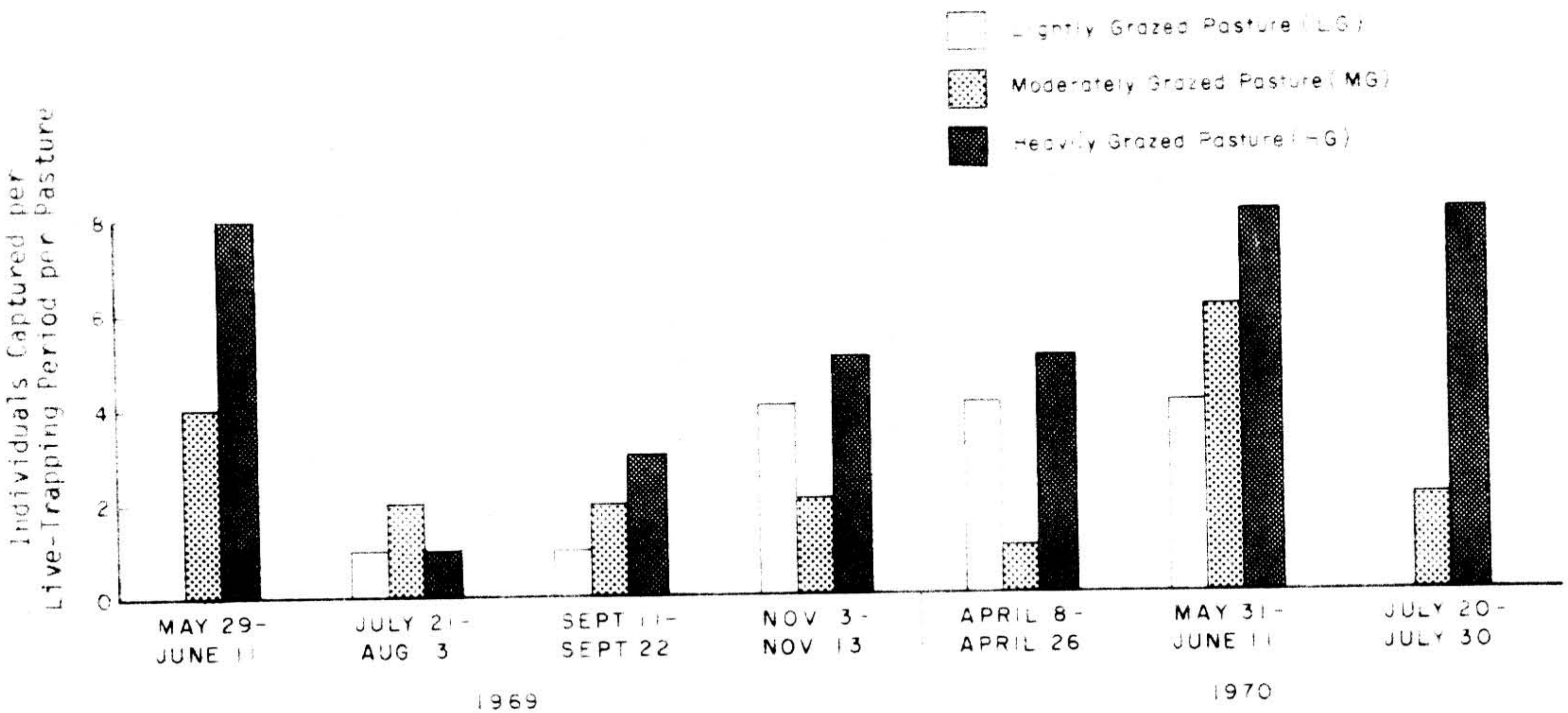


FIGURE 8.-- *Peromyscus maniculatus* trapping success in relation to grazing pressure on the intensive study pastures at the Pawnee Site. (There were 12 grids per pasture and 16 traps per grid. Each grid was run for five days per live-trapping period.)

more barren surface soils than the other soil types. Since, as has been discussed, *P. maniculatus* seem to prefer heavily grazed and eroded areas as well as other habitats with interspersed barren areas, a preference for the Midway-Renohill complex soil and its associated barren surface soil is not surprising.

S. tridecemlineatus

Thirteen-lined ground squirrels (*S. tridecemlineatus*) were, with the exception of the September live-trapping period, consistently captured in higher numbers in the lightly grased pasture than in the moderately or heavily grazed pastures (Table 2 and Figure 9). Since almost all *S. tridecemlineatus* were dormant by September, captures during this period are probably a poor representation of relative abundance and are not included in further discussion. There appeared to be no difference in relative abundance in the moderately and heavily grazed pastures in the data as a whole. However, if one considers only the periods when the population consists primarily of adults (live-trapping periods prior to July in both years), captures were greatest in the lightly grazed pasture, least in the heavily grazed pasture, and intermediate in the moderately grazed pasture. Since there is likely a large amount of dispersion of young into new acres (McCarley, 1966), the results from adults perhaps give a better indication of effects of grazing on *S. tridecemlineatus* habitat and populations.

Effects of grazing and/or vegetation height on *S. tridecemlineatus* have been examined by several researchers. Weaver and Flory (1934) concluded that overgrazing of grasslands in Oklahoma always results in an increase in *S. tridecemlineatus*. However, in another study in Oklahoma with a greater number of grazing treatments, *S. tridecemlineatus* populations were found in

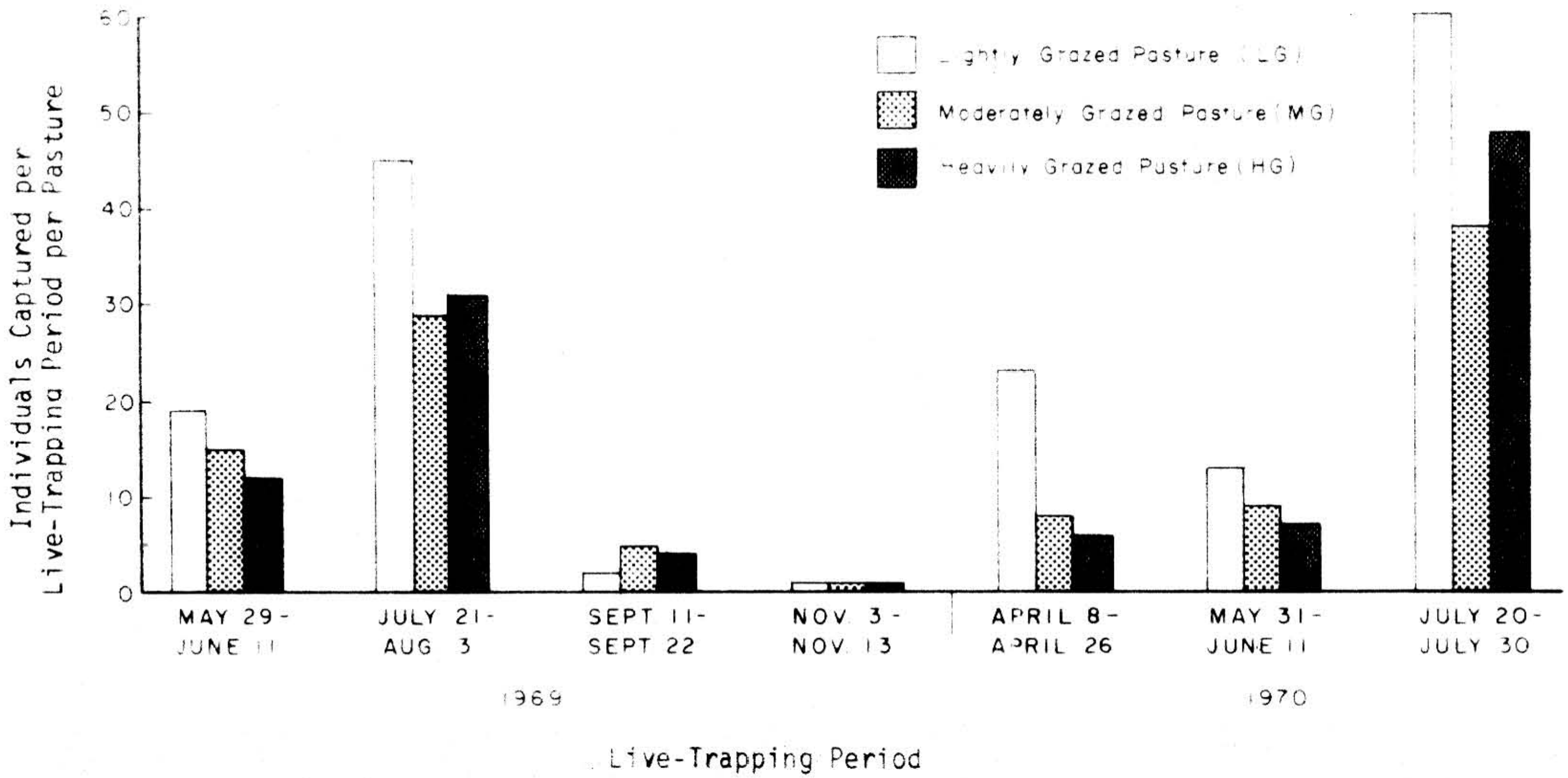


FIGURE 9.-- *Spermophilus tridecemlineatus* trapping success in relation to grazing pressure on the intensive study pastures at the Pawnee Site. (There were 12 grids per pasture and 16 traps per grid. Each grid was run for five days per live-trapping period.)

higher numbers in normally grazed or moderately overgrazed grasslands than in heavily overgrazed areas while areas undisturbed by grazing had extremely low population levels (Phillips, 1936). Again in Oklahoma, Smith (1940a) found *S. tridecemlineatus* most abundant in areas where taller grasses were eliminated leaving a dense mat of shorter grasses and forbs. McCarley (1966) found *S. tridecemlineatus* in high densities in a golf course study area in Texas but noted almost complete avoidance by these squirrels of the tall grass and forested regions around the course. Further, Rongstad (1965) found *S. tridecemlineatus* in a mowed habitat in Wisconsin and observed that unmowed areas surrounding the study area were avoided. These studies show an increase in *S. tridecemlineatus* populations with increased grazing, favoring short-grass habitats, though heavy overgrazing with consequent erosion may be detrimental. As previously shown, populations at the Pawnee Site appear to decrease with increased grazing intensity. Increase rather than decrease in the population with decreased grazing intensity is not really unusual as the Pawnee Site habitat is characteristically short grass even under light grazing intensity. As previously discussed, other studies noted decreased population levels when grazing caused heavy erosion. However, little or no erosional differences were evident between the intensive study pastures. Decrease of *S. tridecemlineatus* populations at the Pawnee Site with increased grazing may be related to decreased availability of both arthropod and plant foods with increased grazing.

Captures per soil type of *S. tridecemlineatus*, with the possible exception of Vona and Ascalon sandy loam soils, indicates no preference for any particular soil type habitat. In the literature there is little evidence of any specific soil preference in *S. tridecemlineatus* though Phillips (1936) noted that burrows are more abundant in well-drained soils. All three soil types at the Pawnee Site are classified as well-drained soils although the undifferentiated-bottomland soils receive frequent flooding during rain storms. The lack of definitive soil type preferences observed in this study is in agreement with the conclusions of Maxwell and Brown (1968) in Wyoming, that *S. tridecemlineatus* are unaffected in distribution and abundance by soil types.

Reproduction

D. ordii

Visible embryos were present in adult female *D. ordii* in all months from the beginning of the study in May, 1969, through August of that year and from February of 1970 to the end of the study in August, 1970. Neither pregnancies nor recent placental scars were observed from September through January (Figure 10). Further supporting evidence on breeding season was obtained from the presence or absence of newly weaned young among snap-trapped individuals and mean testis length in adult males. Recently weaned juveniles weighing less than 40 g were trapped as early as March (1970) and as late as August (1970). Slightly older juveniles weighing from 40-45 g were captured as late as September (1970). No juveniles in these weight categories were captured from November, 1969, through February, 1970, though a few specimens weighing over 50 g but less than the 59 g specified for adults in this paper were captured. These animals probably represent older juveniles born in the previous breeding season or adults suffering from weight loss. As a measure of fecundity, mean monthly testis lengths of adult male *D. ordii* were plotted for all months except November and December of 1969 and January of 1970 when no adult males were captured (Figure 11). Combined results from 1969 and 1970 show that mean testis length and thus fecundity were quite high from April

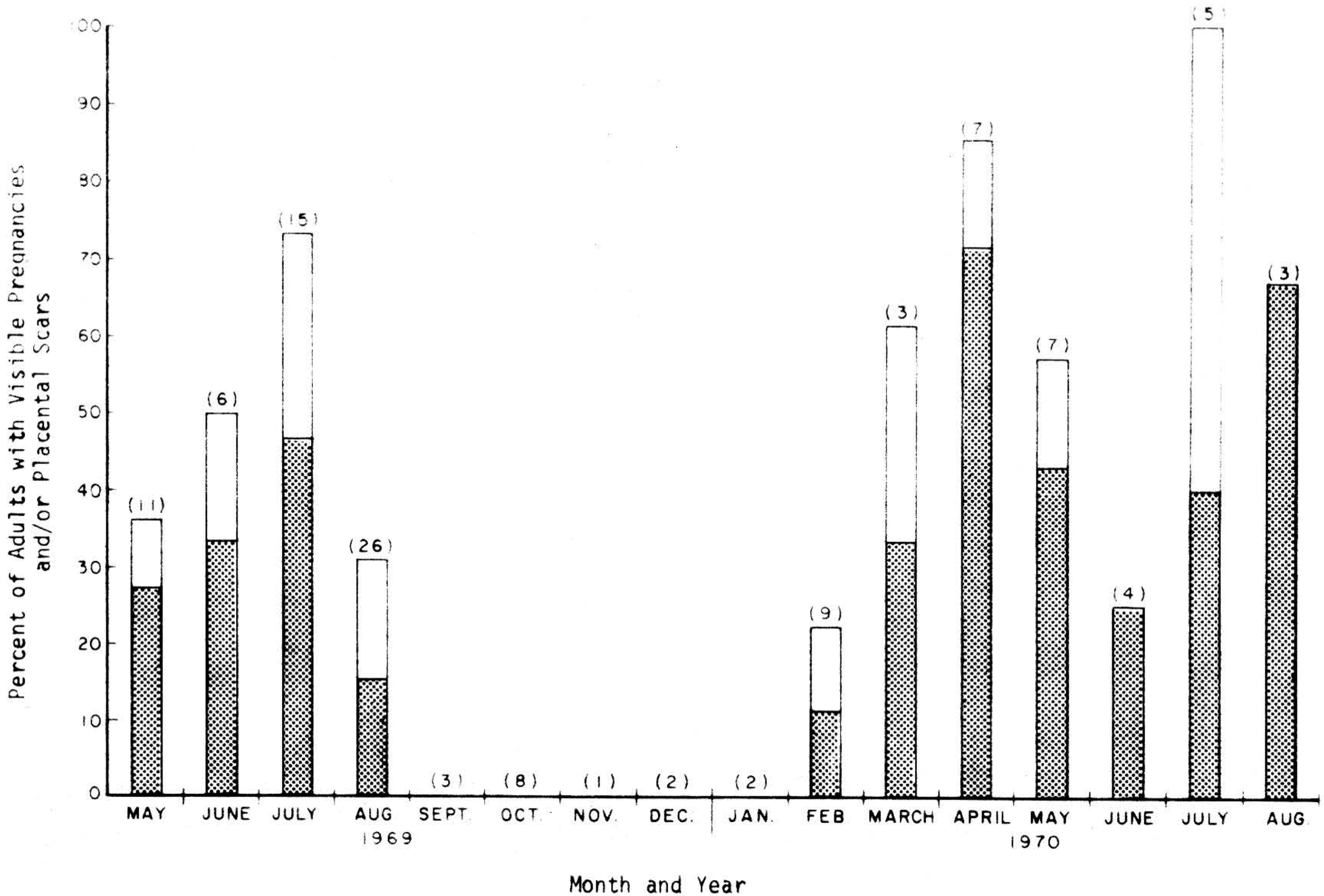


FIGURE 10.--Monthly occurrence of pregnancies and placental scars in adult female *Dipodomys ordii* at the Pawnee Site. (Darkened parts of rectangles represent visible pregnancies and non-darkened areas represent placental scars. Numbers in parenthesis equal sample size.)

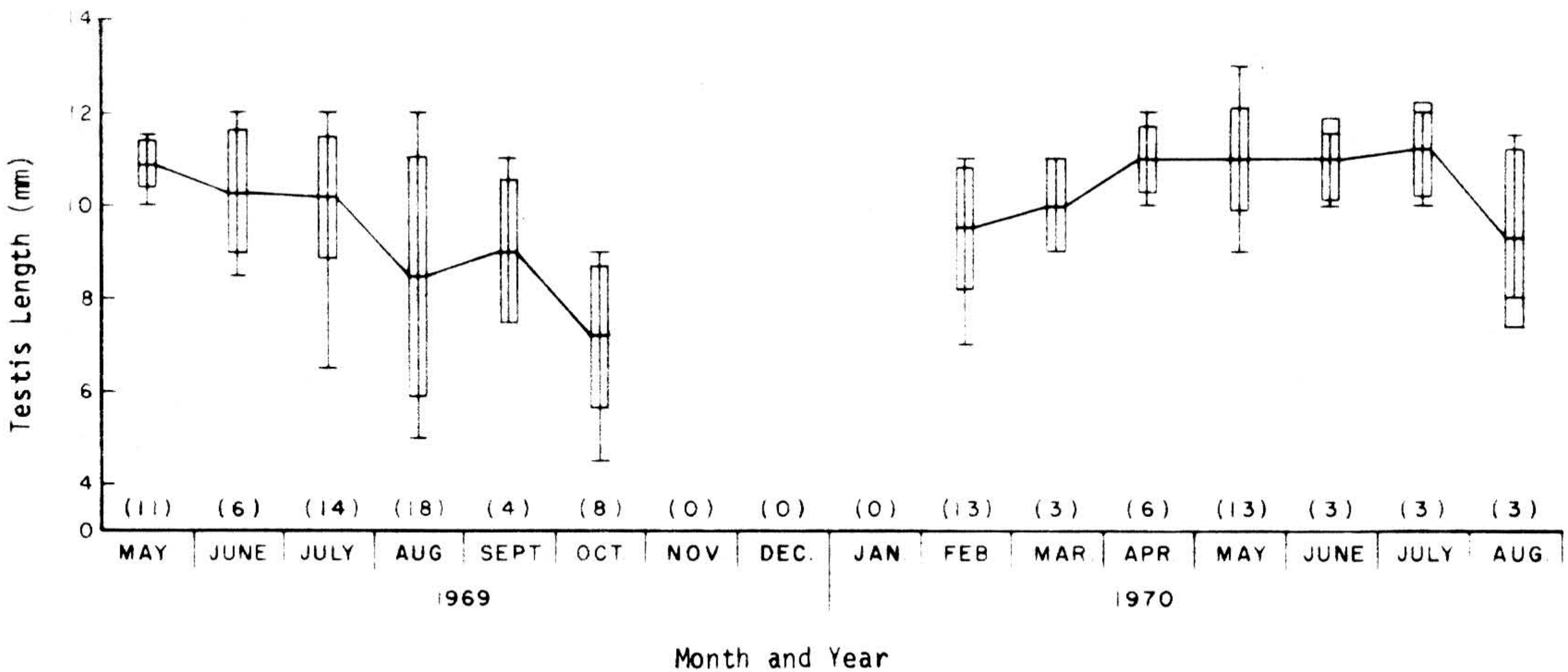


FIGURE 11.--Mean monthly testis length in adult male *Dipodomys ordii* at the Pawnee Site. (Lines between rectangles connect means, narrow rectangles represent one standard deviation on each side of mean, vertical lines through center of rectangles equal to range, and numbers in parenthesis equal to sample size.)

through July. After July, fecundity decreased, reaching a low level sometime in mid-fall or early winter. By February, mean monthly testis length and thus fecundity were increasing again, reaching a fairly high level by April. In brief, the pregnancy and placental scar data discussed are definite evidence of reproduction occurring from February through August at the Pawnee Site while occurrence of very young juveniles and mean monthly testis length lend support to this conclusion.

Data for other geographic regions are available from several researchers. Duke (1944) concluded that *D. ordii* in central Utah have two breeding seasons per year, one from early January to or possibly through March and one from September through October. Pregnancies were found as early as December and young as late as October in western Utah by Day, Egoscue, and Woodbury (1956). Embryos were present in female *D. ordii* from February through March in Nevada (Alcorn, 1941). In New Mexico, pregnant females were found from the end of February to early July by Johnson (1956). Bailey (1931) recorded an additional breeding period in New Mexico in October, November, and December. The cause of this late breeding season was thought to be an unusual abundance of food in the fall. In the Texas panhandle and western Oklahoma, *D. ordii* seldom bred from April to July, but began breeding usually in August or September and ended in March (McCulloch and Inglis, 1961).

In summary, the literature indicates that breeding occurs in late winter, spring and sometimes early summer in New Mexico, Utah, and Nevada, with occasional fall breeding when there is an unusual abundance of food during this period. In Texas and Oklahoma, *D. ordii* breed primarily in fall, winter, and spring. As indicated by this study, breeding may occur at least from February through August in Colorado. Fall breeding was not observed, though only one fall period was studied. Availability of food materials may be important in determining breeding season for *D. ordii* as suggested by Bailey (1931). However, if this is the primary controlling factor for *D. ordii*, it is difficult to explain winter or early spring breeding in most areas of their range since a high proportion of their diet consists of seeds which would be more readily available in late spring, summer, or early fall. Recently, Beatley (1969) suggested that reproduction in *Dipodomys* is correlated with the presence or absence of succulent annuals. She notes that these must be present prior to or at the start of the breeding season to meet increased physiological water, and perhaps vitamin, needs. Such an increase in water needs during reproduction has been discussed for mule deer by Leopold (1933). He notes that does can live on succulence for much of the year but need drinking water when nursing fawns. Thus, perhaps *D. ordii* can live with few succulents in their diet for much of the year but need this added water source during reproduction, especially when nursing young. This is a logical hypothesis for the geographical variation in breeding seasons in *D. ordii*. Obvious possibilities for research are available in following up this hypothesis.

Percent of adult female *D. ordii* that were pregnant varied widely within the 1969 and 1970 reproductive seasons (Figure 10). Maximum percent observed in 1969 was 48% (n=7) in July and maximum percent in 1970 was 73% (n=7) in April. Small sample sizes for most months prevent useful comparisons for the populations between months.

Mean litter size of *D. ordii* at the Pawnee Site during 1969 and 1970 is recorded in Table 4. The difference between mean litter size in 1969 (2.63) and 1970 (3.13) is statistically significant ($P \leq .05$) as determined by Student's t-test. A decrease in litter size through the breeding season

TABLE 4.--Mean yearly and total litter size (± one standard deviation) in "target" species at the Pawnee Site as estimated from embryo counts.[a]

	Year(s) of Collection								
	1969			1970			Total		
	X ± 1SD	Range	n	X ± 1SD	Range	n	X ± 1SD	Range	n
D. ordii	2.63 ± .48	2-3	16	3.13 ± .54	2-4	15	2.87 ± .56	2-4	31
O. leucogaster	3.89 ± .57	3-5	9	4.81 ± 1.04	3-7	27	4.58 ± 1.02	3-7	36
P. maniculatus	5.02 ± 1.14	2-8	41	4.26 ± .98	2-6	30	4.70 ± 1.14	2-8	71
S. tridecemlineatus	8.13 ± .81	7-9	8	8.79 ± 1.19	7-11	14	8.55 ± 1.10	7-11	22

[a]Data for *S. tridecemlineatus* includes counts of recent placental scars.

could cause the observed difference between years since late winter and early spring reproduction were sampled only in 1970. However, if litter size is computed only from months sampled in both years (May through August), mean litter sizes of 2.60 ± .26 (± 1SD) and 3.25 ± .21 (± 1SD) are found in 1969 and 1970, respectively, and these means are still significantly different ($P \leq .05$). Further, mean monthly litter size (Table 5) indicates no decrease and possibly a slight increase in litter size through the breeding season though low monthly sample size precludes useful month by month comparisons.

Litter size can be influenced by age structure of the breeding population and available food materials. An increase in litter size after the first litter in certain rodent species has been reported by several authors including Bailey and Sperry (1929), Williams, Carmon, and Golley (1965), McCarley (1966), and Rugh and Wohlfromm (1967). Leopold (1933) relates increased litter size in deer to increased food availability, and Errington (1963) concluded that annual variation in litter size of muskrats was similarly influenced by food availability. Live-trapping results from the intensive study pastures (Table 2) indicate that the population of *D. ordii* declined from 1969 to 1970, and unrecorded observations from snap-trapping success in other areas of the Pawnee Site further varify this conclusion. Such a decrease is often preceded or accompanied by poor reproduction (1969) or survival of young and may result in an older mean age of the population. Mean litter size could markedly be increased between years by such an increase in mean age of reproducing females. There was a slight increase in spring primary productivity in the intensive study pastures in 1970 over 1969, while summer productivity was about equal between years except in the lightly grazed pasture where it was higher in 1970 (Daniel W. Uresk, personal communication, Colorado State University, Fort Collins, Colorado). Either the

TABLE 5.--Mean monthly litter size in "target" species at the Pawnee Site as estimated from embryo counts.

Year	Month	*D. ordii*			*O. leucogaster*			*P. maniculatus*		
		$\bar{X}$	Range	n	$\bar{X}$	Range	n	$\bar{X}$	Range	n
1969	May	2.0	none	3	4.0	none	1	4-7	4-7	8
	June	2.5	2-3	2	3.9	1-3	7	4.9	3-6	9
	July	3.0	2-3	7	4.0	none	1	5.1	4-6	5
	Aug.	2.8	2-3	4			0	5.2	2-7	13
	Sept.			0			0	4.0	none	3
	Oct.			0			0	6.0	none	1
	Nov.			0			0	4.5	4-5	2
	Dec.			0			0			0
1970	Jan.			0			0			0
	Feb.	3.0	none	1			0	3.7	3-4	3
	March	3.0	none	1	4.0	none	1	4.0	none	4
	April	3.0	2-4	5	5.3	4-6	8	4.1	2-6	12
	May	3.0	none	3	4.6	3-7	8	5.2	4-6	5
	June	3.0	none	1			0	4.0	none	1
	July	3.0	none	2	4.6	4-6	5	4.4	4-5	5
	Aug.	4.0	none	2	4.8	4-6	5			0

increased food supply in 1970, as a result of the slight increase in primary productivity, or an increase in mean age of reproducing females or both in combination are plausible explanations for the observed litter size difference between years.

Mean litter size for combined 1969 and 1970 reproductive periods at the Pawnee Site (2.87) can be compared with the 2.37 found for one breeding season in southern New Mexico by Johnson (1956), the 3.0 average recorded by Day, Egoscue, and Woodbury (1956) for captive *D. ordii* from western Utah and the 3.37 and 2.76 averages reported by McCullouch and Inglis (1961) for succeeding breeding seasons in the Texas panhandle and western Oklahoma. The above data were obtained from embryo counts except for the Utah study where births were recorded.

O. leucogaster

Pregnancies were observed in adult female *O. leucogaster* from the beginning of the study in May, 1969, through July, 1969, and from March, 1970, through the end of the study in August, 1970 (Figure 12). In August, 1969, and June, 1970, recent placental scars were found but no pregnancies, while pregnancies were present in these same months during June, 1969, and August, 1970. Mean monthly testis length in adult males fell rapidly from May and June, 1969, to a low level in September, October, November, and December and subsequently increased rapidly up to March, 1970, where it stayed at a rather high level until the end of the study in August, 1970 (Figure 13). Range of mean monthly testis length was much greater in *O. leucogaster* than for any other "target" species. An apparent increase in length of reproductive season occurs between years with pregnancies occurring in August, 1970, but not in August, 1969. This is further reflected in the higher mean testis

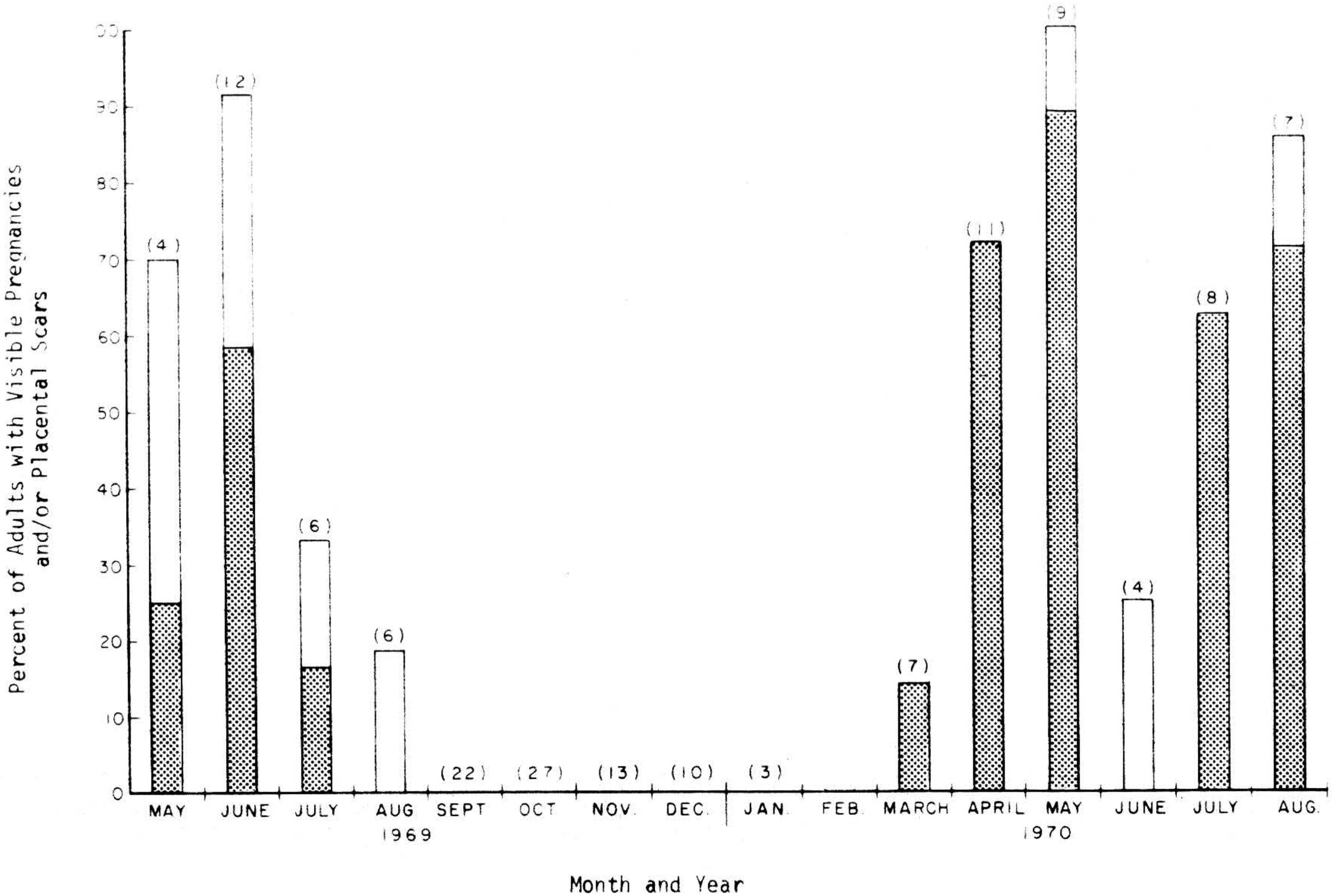


FIGURE 12.--Monthly occurrence of pregnancies and placental scars in adult female *Onychomys leucogaster* at the Pawnee Site. (Darkened parts of rectangles represent visible pregnancies and non-darkened areas represent placental scars. Numbers in parenthesis equal sample size.)

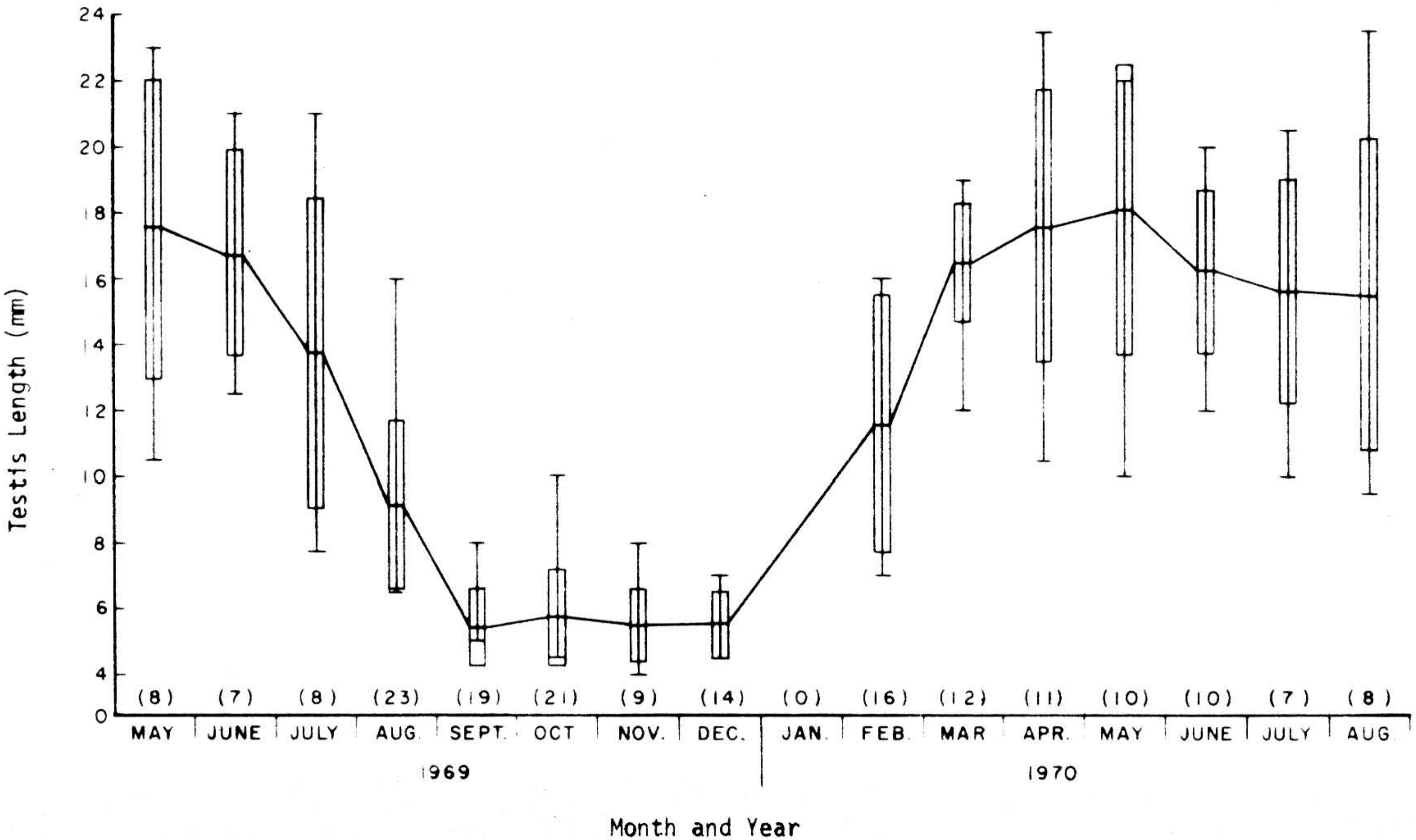


FIGURE 13.--Mean monthly testis length in adult male *Onychomys leucogaster* at the Pawnee Site. (Lines between rectangles connect means, narrow rectangles represent one standard deviation on each side of mean, vertical lines through center of rectangles equal to range, and numbers in parenthesis equal to sample size.)

length in July and August, 1970, in comparison with July and August, 1969.

Northern grasshopper mice (*O. leucogaster*) reproduce from May through August in the northern United States according to Bailey and Sperry (1929). In Colorado they generally breed from April to late September (Lechleitner, 1969). Pregnancy data from this study show breeding in northeastern Colorado can occur at least from March through August. Since females were still pregnant and males had high mean testis length at the end of this study in August, 1970, it is probable that breeding extended at least into September of that year. Pinter (1970) suggested that breeding in *O. leucogaster* is photoperiodic, beginning with increased day length and ending when day length begins decreasing. This seems plausible though the difference observed between years (August, 1969, versus August, 1970) is difficult to explain. Perhaps the abundance of food material, primarily insects, has some effect on length of the breeding season while initiation of breeding season is photoperiodic.

Percent of adult females pregnant varied widely through the breeding season. Maximum observed was 89% in May, 1970 (Figure 12). According to Pinter (1970), maximum breeding activity for *O. leucogaster* should occur in July when daylight hours are greatest since increasing length of photoperiod increases their breeding activity. Small sample sizes for most months preclude a useful comparison of Pawnee Site data with this hypothesis. Further, environmental conditions in terms of available food are probably optimal in June or July at the Pawnee Site providing additional reasons for maximum reproductive activity during this period.

A litter size range of 4-6 has been reported in *O. leucogaster* by Bailey and Sperry (1929). Svihla (1936) notes 2-5 young per litter in captive individuals from Washington. In Utah, Egoscue (1960) recorded a mean of 3.54 (n=205; range 1-6) in captive individuals. Lechleitner (1969) gives a range of 2-6 and a mode of 4 per litter for *O. leucogaster* in Colorado.

Litter size in *O. leucogaster* at the Pawnee Site, as estimated from embryo counts in pregnant females, averaged 4.58 over the total study period with 3.89 in 1969 and 4.81 in 1970 (Table 4). These yearly mean litter sizes were significantly different ($P \leq .05$) as determined by Student's t-test. However, the mean litter size in 1970 includes samples from March and April, months not included in the 1969 average. When litter size is computed only from months sampled in both years (May through August), a mean litter size of 3.88 ± .41 (± 1SD) is found in 1969 versus 4.67 ± 1.18 (± 1SD) in 1970. These means are not significantly different ($P \leq .05$). Mean monthly litter sizes are shown in Table 5 though low sample sizes preclude useful month by month comparisons.

P. maniculatus

Breeding of *P. maniculatus* reportedly occurs primarily from April through September in Colorado though instances of October and January breeding have been reported in Larimer County (Lechleitner, 1969). The October and January pregnancies were reported by Beidleman (1954) and Reed (1955), respectively. Pregnant *P. maniculatus* were found at the Pawnee Site from the start of this study in May, 1969, through November, 1969, and from February, 1970, to July, 1970 (Figure 14). Reproduction probably occurred during August, 1970, but only two adult females were captured for this month and neither was pregnant. Mean testis lengths in adult males reached lowest levels during November and December of 1969 and January of 1970, further substantiating the pregnancy observations (Figure 15). These results

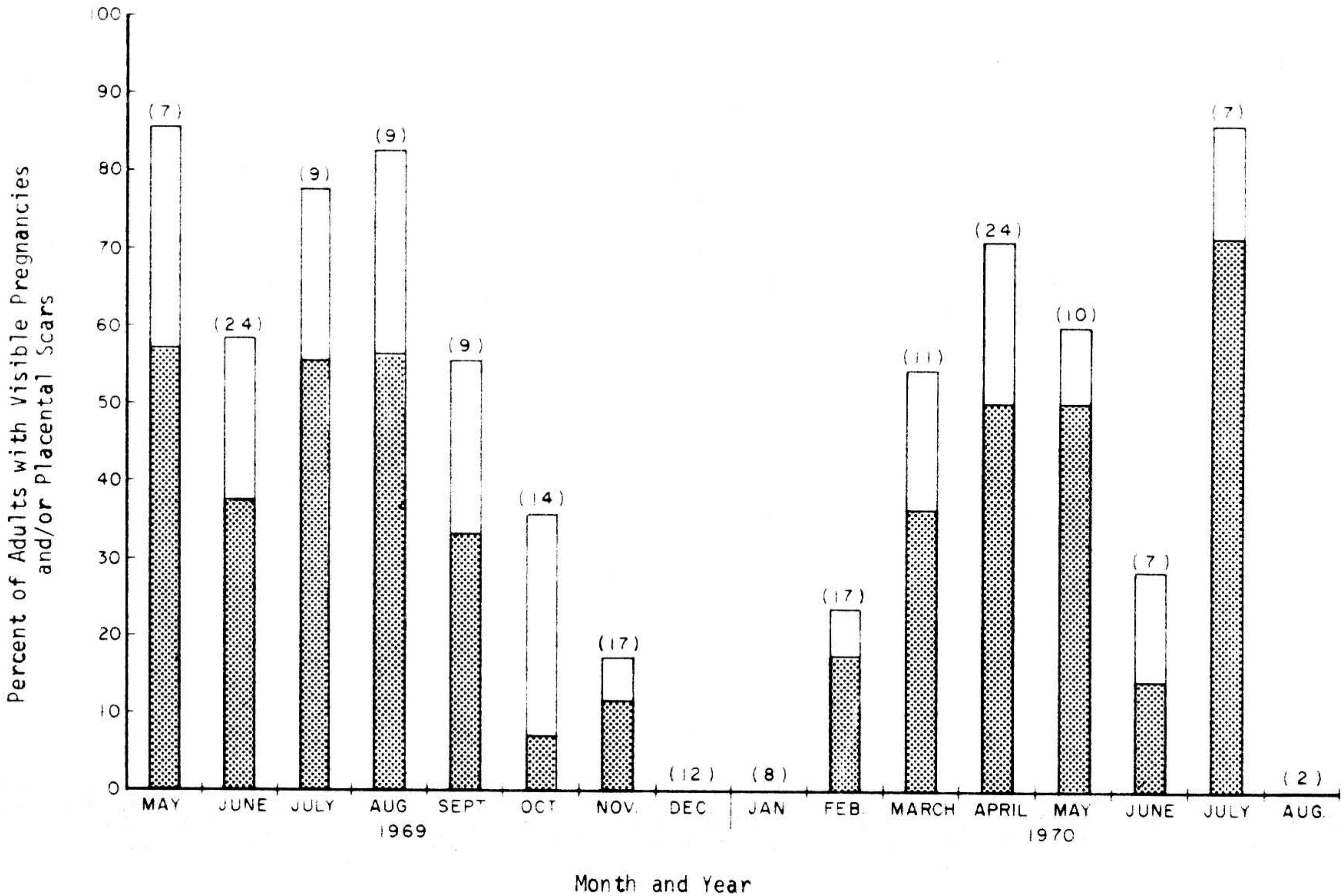


FIGURE 14. Monthly occurrence of pregnancies and placental scars in adult female *Peromyscus maniculatus* at the Pawnee Site. (Darkened parts of rectangles represent visible pregnancies and non-darkened areas represent placental scars. Numbers in parenthesis equal sample size.)

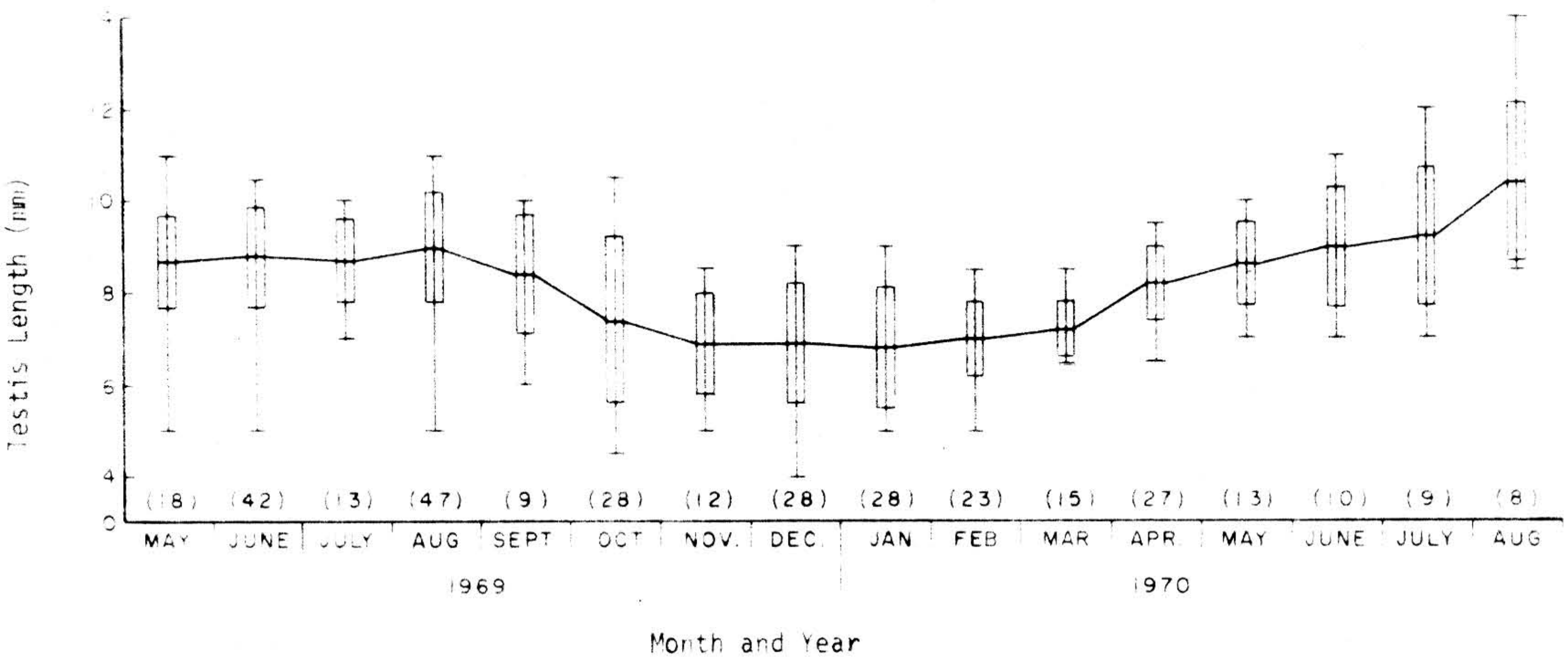


FIGURE 15.--Mean monthly testis length in adult male *Peromyscus maniculatus* at the Pawnee Site. (Lines between rectangles connect means, narrow rectangles represent one standard deviation on each side of mean, vertical lines through center of rectangles equal to range, and numbers in parenthesis equal to sample size.)

indicate that late fall and winter breeding are not unusual in northeastern Colorado. There is likely a shorter breeding season in areas of higher altitude and more severe climatic conditions in Colorado. A decrease in breeding season with altitude has been shown by Jameson (1953) in California and by Long (1964) in Wyoming. Thus, in Colorado, the shorter breeding season reported by Lechleitner (1969) is possibly true for mountainous regions but not for the northeastern prairies where climatic conditions are less severe.

Although pregnant females were found from February through November, the percent of adult females pregnant was rather low during October, November, and February (Figure 14). These percentages show the majority of breeding occurred from March through September with the highest percentages observed being in May, 1969 (57%), and July, 1970 (71.5%). However, both percentages are based on rather small samples.

Examples of *P. maniculatus* litter size obtained from embryo counts in other geographic areas include means of 4.00 in Michigan (Blair, 1940), 5.5 in western Washington and British Columbia (Sheppe, 1963), and 5.57 in southern Wyoming (Brown, 1966). Long (1964) and Jameson (1953) have shown evidence of an increase in litter size in *P. maniculatus* with increased altitude and latitude and shorter reproductive seasons. Litter size at the Pawnee Site study averaged 4.70, with yearly means of 5.02 in 1969 and 4.26 in 1970 (Table 4). The Pawnee Site is considerably lower in altitude and slightly lower in latitude than the Laramie Basin in Wyoming where Brown (1966) recorded a mean litter size of 5.57. Thus, this comparison agrees with the observations of Long (1964) and Jameson (1953) on the relationship of litter size to latitude and altitude. According to the Student's t-test, yearly means were significantly different between years at the five percent level of significance. When litter size is computed only from months sampled in both years (May through August), mean litter sizes of 5.29 ± 1.38 (± 1SD) and 5.18 ± .62 (± 1SD) are found in 1969 and 1970, respectively, and the difference is not statistically significant ($P \leq .05$). Mean monthly litter size is shown in Table 5 though low sample sizes preclude comparisons between months.

S. tridecemlineatus

Breeding in thirteen-lined ground squirrels (*S. tridecemlineatus*) reportedly occurs a few weeks after emergence from hibernation which takes place from mid-March to early April (Wade, 1927; Criddle, 1939; and Rongstad, 1965). This breeding lasts only a few weeks to a month, with females producing only one litter per breeding season in the northern parts of their range (Wade, 1927 and Foster, 1934). McCarley (1966) has reported *S. tridecemlineatus* producing two litters per breeding season in Texas. Criddle (1939) noted that cold, damp springs will set back initial spring breeding by as much as a week or more, while hot, dry springs have a reverse effect. Most young are born in the last week of May and early June in Manitoba (Criddle, 1939) while a similar period of May 20-25 has been reported in Wisconsin (Rongstad, 1965). In Texas, McCarley (1966) noted births in May, June, and July. Young in the northern parts of their range generally emerge between mid- and late June (Johnson, 1917; Criddle, 1939; and Rongstad, 1965).

Visible embryos were observed only in uteri of snap-trapped *S. tridecemlineatus* from the Pawnee Site in May of 1969 and 1970 (Figure 16). Mean testis length in 1970 was at a high level in March when males began emerging from hibernation and continued at a high level through April when it

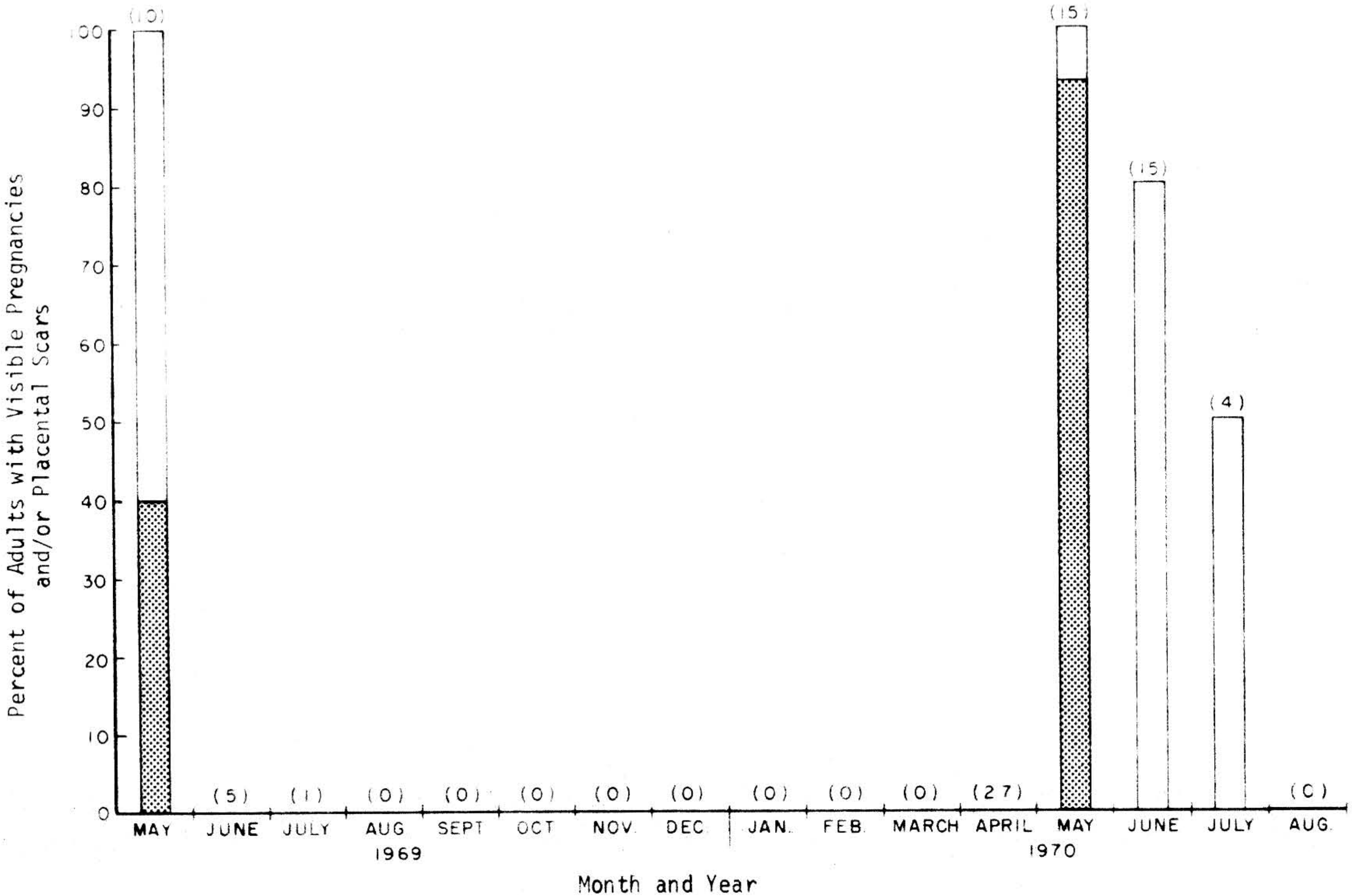


FIGURE 16.--Monthly occurrence of pregnancies and placental scars in adult female *Spermophilus tridecemlineatus* at the Pawnee Site. (Darkened parts of rectangles represent visible pregnancies and non-darkened areas represent placental scars. Numbers in parenthesis equal sample size. Most adults estivate or hibernate from late July or August until April.)

began to drop (Figure 17). Male fecundity was probably past its peak when the study began in May, 1969. In 1969 the first newly emergent juvenile was captured on June 12 and, assuming the young leave their nest at 6-7 weeks (Wade, 1927), this animal was born around late April or early May. Further, subtracting a gestation period of 28 days (Wade, 1927) indicates initial breeding activity began at least by early April or perhaps late March. All females snap trapped in May of both years had either pregnancies or placental scars (Figure 16). This indicates that nearly all females in the population are reproductively active during the breeding season.

Using embryo counts, mean litter size was recorded by Criddle (1939) as 8.1 for Manitoba, Canada, and by Rongstad (1965) as 8.7 in southern Wisconsin. Over a 25-year period, Criddle (1939) noted no appreciable difference between mean litter size for different years though he did find that old females average larger litters than first-year females. In comparison, an overall mean litter size of 8.55 was observed for *S. tridecemlineatus* at the Pawnee Site with yearly averages of 8.13 in 1969 and 8.79 in 1970 (Table 4). The difference between means for May of 1969 and 1970 was not statistically significant ($P \leq .05$) according to the Student's t-test. These data are obviously very similar to those observed in Manitoba and Wisconsin by Criddle (1939) and Rongstad (1965).

Annual Population Cycles

Due to low relative abundance and subsequently few captures per live-trapping period as well as the limited length of the study, the annual population cycles of *D. ordii* and *P. maniculatus* cannot be deduced from live-trapping data (Figure 18). Annual cycles of abundance for *O. leucogaster* and *S. tridecemlineatus* can be deduced from Pawnee Site data as shown in Figure 18.

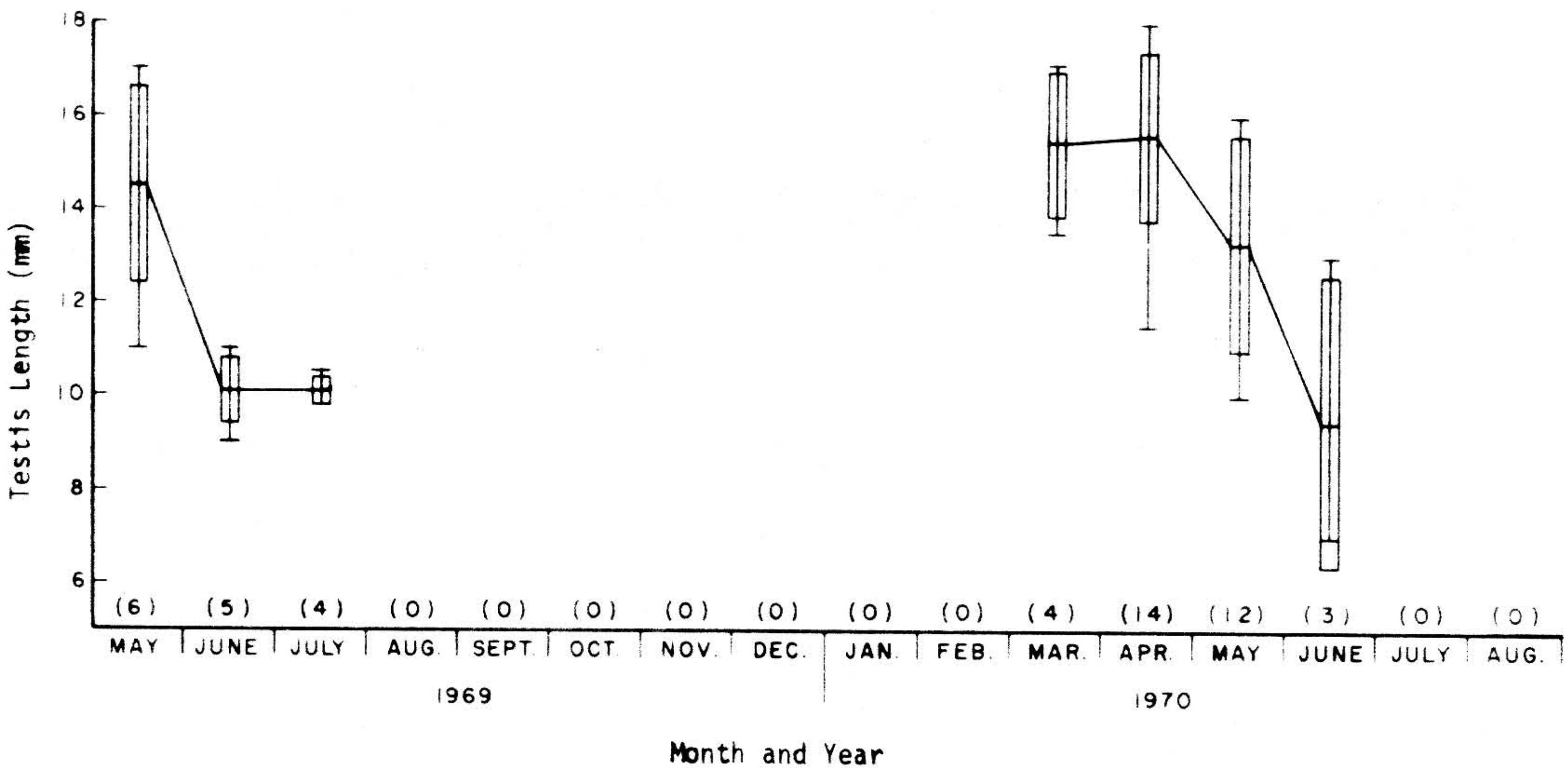


FIGURE 17.--Mean monthly testis length in adult male *Spermophilus tridecemlineatus* at the Pawnee Site. (Lines between rectangles connect means, narrow rectangles represent one standard deviation on each side of mean, vertical lines through center of rectangles equal to range, and numbers in parenthesis equal to sample size.)

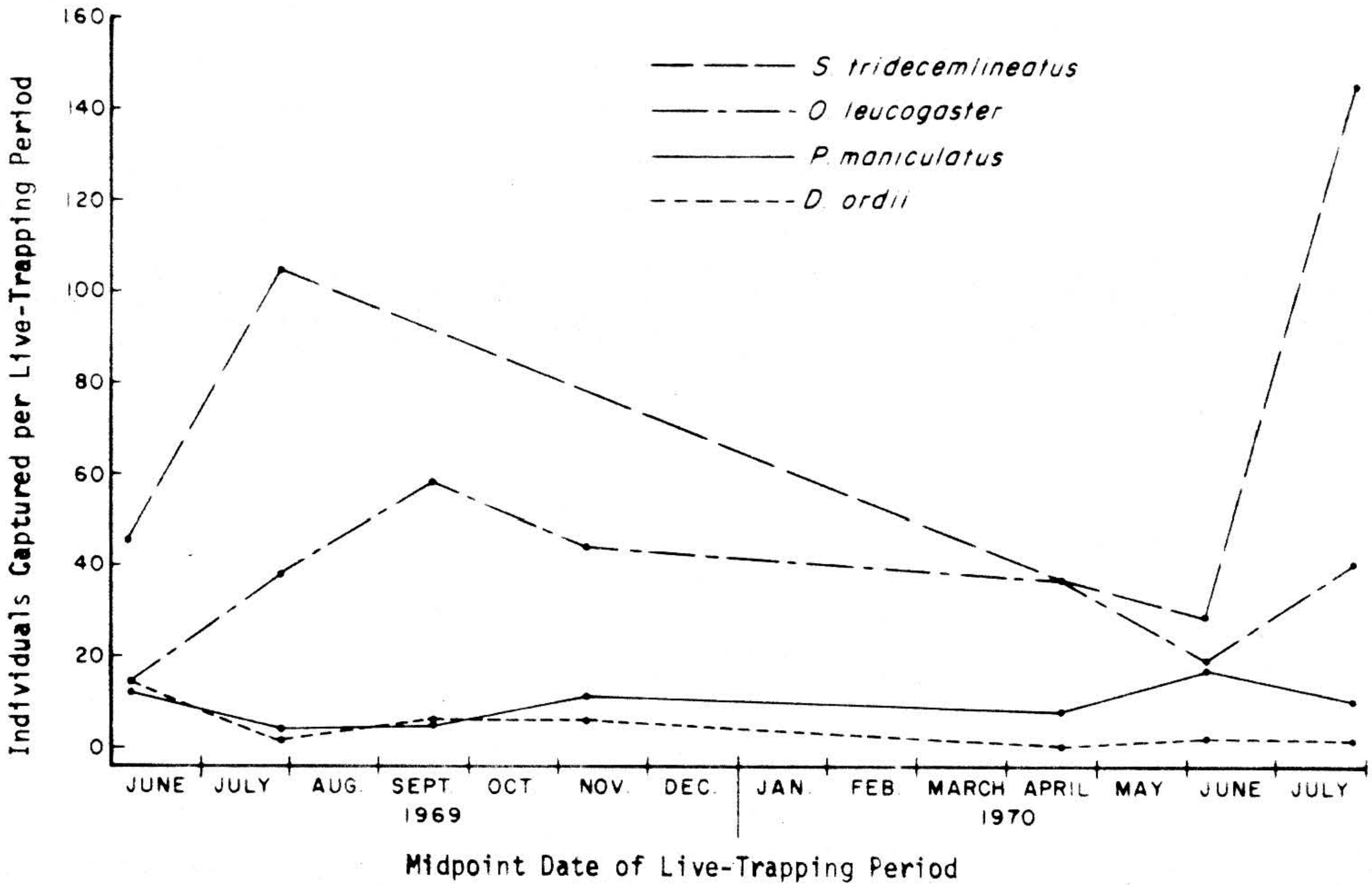


FIGURE 18. Monthly live-trapping records for "target" species in the combined intensive study pastures (lightly, heavily, and moderately grazed) at the Pawnee Site. (Most *S. tridecemlineatus* had begun estivation (or hibernation) by September, 1969, and did not emerge until late March or April, 1970.)

O. leucogaster reached peak relative densities in early fall after the breeding season. They decreased in numbers from fall until late spring when new reproduction exceeded mortality and the population increased rapidly. *S. tridecemlineatus* reached peak population levels when most young had emerged in June or early July. The population level then decreased greatly (from 129 captures in July 1969, to 29 captures in June, 1970) to a low level prior to the addition of young individuals in June or early July of the following year. September live-trap captures of *S. tridecemlineatus* are not shown on Figure 18 as most of the population were estivating by late August, and September captures are, therefore, a poor representation of the actual population. This annual cycle in *S. tridecemlineatus* is similar to that observed by Rongstad (1965) in Wisconsin who noted a decrease from eight individuals per acre after emergence of young in June to two per acre the following spring.

Population Levels Between Years

Populations of *D. ordii*, though extremely low in the intensive study pastures during both years, appear to decline from 1969 to 1970 (Table 2, Figure 18). Snap-trapping success in adjacent areas further substantiated this observation. Population levels of *O. leucogaster* and *P. maniculatus* were quite similar between years. Total captures of *S. tridecemlineatus* in late July were considerably higher in 1970 than in 1969. Almost all animals captured in July of both years were juveniles so production of emergent young was obviously higher in 1970 than in 1969. Mean number of embryos per pregnant female and percent of females with embryos or placental scars have previously been shown to be similar between years. Further, captures for both years during the early June live-trapping period (Figure 18), all of which were adults, indicate a possible decrease in numbers of adults from 1969 to 1970 rather than an increase. Thus, it is not probable that the increase in emergent young in 1970 was due to an increase in adults (breeding stock) producing young in 1970 over 1969. Increase in mortality of young before emergence in 1969 over 1970 seems most suspect as it could be the result of heavy rainfall and flooding of burrows, a phenomenon which was observed in early June of 1969 during the May-June live-trapping period when most females were nursing young.

Sex Ratios

Sex ratios of "target" species are shown in Table 6 for snap-trapped animals and in Table 7 for live-trapped animals. The following results and accompanying discussion are in reference to these two tables. The chi-square test with Yates correction for continuity is used to compare sex ratios. Significant difference refers to a statistically significant difference at the five percent level. Unless stated otherwise, all sex ratios referred to below are those for the total study period (1969 and 1970) and not for individual years.

D. ordii

Sex ratios of snap-trapped adults and juveniles were not significantly different from 1:1 nor from each other. Similarly, sex ratios of live-trapped adults and juveniles were not significantly different from 1:1 nor from each other. Sex ratios of live-trapped and snap-trapped adults were not significantly different from each other.

TABLE 6.--Sex and sex ratios of "target" species snap trapped at the Pawnee Site.

Species	Year(s)	Adults			Juveniles		
		Males	Females	Males/Female	Males	Females	Males/Female
D. ordii	1969	63	77	.82	25	22	1.14
	1970	45	40	1.13	17	20	.85
	1969 + 1970	108	117	.92	42	42	1.00
O. leucogaster	1969	109	111	.98	17	21	.81
	1970	75	55	1.36	14	10	1.40
	1969 + 1970	184	166	1.11	31	31	1.00
P. maniculatus	1969	197	115	1.11	106	66	1.61
	1970	133	86	1.55	47	39	1.21
	1969 + 1970	330	201	1.64	153	105	1.46
S. tridecemlineatus	1969	16	16	1.00	34	36	.94
	1970	36	61	.59	16	19	.84
	1969 + 1970	52	77	.68	50	55	.91

TABLE 7.--Sex and sex ratios of "target" species live trapped at the Pawnee Site.[a]

Species	Year(s)	Adults			Juveniles		
		Males	Females	Males/Female	Males	Females	Males/Female
D. ordii	1969	9	8	1.13	1	4	.25
	1970	1	1	1.00	0	0	
	1969 + 1970	10	9	1.11	1	4	.25
O. leucogaster	1969	36	36	1.00	20	16	1.25
	1970	32	35	.91	6	7	.86
	1969 + 1970	60	63	.95	26	23	1.13
P. maniculatus	1969	9	6	1.50	10	3	3.33
	1970	13	5	2.60	11	3	3.67
	1969 + 1970	17	11	1.55	21	6	3.50
S. tridecemlineatus	1969	21	28	.75	62	46	1.35
	1970	33	29	1.14	79	50	1.58
	1969 + 1970	46	44	1.05	141	96	1.47

[a]Animals counted only the first time they are captured in 1969, 1970, and total (1969 + 1970) live-trapping periods. For this reason, 1969 + 1970 totals generally less than summation of 1969 and 1970 subtotals.

O. leucogaster

Northern grasshopper mouse (*O. leucogaster*) sex ratios were not significantly different from 1:1 for adults or juveniles captured by snap trapping nor for adults or juveniles captured by live trapping. Adult versus juvenile ratios were not significantly different for either trapping method and further, adult and juvenile sex ratios were not significantly different between methods.

P. maniculatus

Males consistently outnumbered females in all age and capture method categories for the total study period (1969 and 1970). The same observations are true for individual years. These sex ratios observed for the total study period are significantly different from 1:1 for all groups except live-trapped adults. Ratios for snap-trapped adults are not significantly different from those of snap-trapped juveniles or live-trapped adults. Similarly, ratios for live-trapped juveniles are not significantly different from that of live-trapped adults and snap-trapped juveniles.

It is not unusual to find a preponderance of males in snap-trapped or live-trapped *Peromyscus*. Several researchers, including Townsend (1935), Burt (1940), Blair (1942), and Manville (1956), have reported this preponderance of males and suggested it may be caused by greater wandering tendency in males. Recently, Terman and Sassaman (1967) have shown significantly ($P \leq .05$) more males than females in *P. maniculatus* litters born in captivity and suggested this may be an additional factor explaining the preponderance of males trapped in the wilds. The preponderance of males trapped at the Pawnee Site may be caused by both these factors.

S. tridecemlineatus

Sex ratios of live-trapped adults were not significantly different from 1:1 while juvenile captures record significantly more males than females. Snap-trap data show adults with significantly fewer males than females; however, this is the result of the 1970 data. I am unable to explain this preponderance of adult females snap trapped in 1970 as no such phenomenon was observed in live-trapped adults nor in 1969 snap-trapped adults. Sex ratio of snap-trapped juveniles was not significantly different from 1:1. Sex ratio of snap-trapped juveniles was significantly different from live-trapped juveniles and snap-trapped adults. It is particularly difficult to provide a plausible explanation for this excess of males in live-trapped juveniles. If the cause were due strictly to increased wandering behavior among juvenile males, then one would expect similar results for snap-trapped juveniles. This was not the case. Perhaps there is a difference in trapability with Tomahawk live traps between juvenile males and females.

Food Habits

Food habits discussed in the ensuing "target" species subsections are for total captures of each species without reference to sex or age. However, it is of interest to examine briefly the relationship of percent animal matter in the diet to sex and age. Tables 8, 9, 10, and 11 present mean percent volume of animal matter in the diets by sex (adults only) and age during the various periods for *D. ordii*, *O. leucogaster*, *P. maniculatus*, and *S. tridecemlineatus*, respectively. There was no consistent relationship of percent volume animal matter to sex in *D. ordii* and *O. leucogaster*. However, adult male *P. maniculatus* contained a higher percentage of animal matter in the diet than adult females in all periods except one, indicating that males

TABLE 8.--Mean percent volume (± one standard error) of animal matter in stomach contents of *Dipodomys ordii* by age (adult[a] or juvenile[b]) and sex (adults only) through 1969 and 1970 sample periods at the Pawnee Site.

Year	Two-Month Sample Period	Adult[a] Males		Adult Females		Total Adults		Juveniles[b]	
		$\overline{X} \pm 1SE$	n	$\overline{X} \pm 1SE$	n	$\overline{X} \pm 1SE$	n	$\overline{X} \pm 1SE$	n
1969	May - June	4.6 ± 2.4	13	14.5 ± 7.4	11	9.2 ± 3.7	24	8.0 ± 5.8	5
	July - Aug.	1.0 ± 0.6	29	1.6 ± 0.7	31	1.3 ± 0.4	60	1.5 ± 0.8	20
	Sept. - Oct.	5.4 ± 3.9	13	0.0 ± 0.0	8	3.3 ± 2.4	21	0.9 ± 0.9	11
	Nov. - Dec.	0.0 ± 0.0	1	0.0 ± 0.0	1	0.0 ± 0.0	2	0.0 ± 0.0	1
1970	Jan. - Feb.	6.9 ± 1.3	13	6.0 ± 2.4	5	6.7 ± 1.1	18	10.0 ± 0.0	1
	March - April	10.0 ± 0.0	9	10.0 ± 0.0	7	10.0 ± 0.0	16	14.0 ± 4.0	5

[a]Includes only adults weighing 65 g or more.

[b]Includes only juveniles weighing 55 g or less.

TABLE 9.--Mean percent volume (± one standard error) of animal matter in stomach contents of *Onychomys leucogaster* by age (adult[a] or juvenile[b]) and sex (adults only) through 1969 and 1970 sample periods at the Pawnee Site.

Year	Two-Month Sample Period	Adult[a] Males		Adult Females		Total Adults		Juveniles[b]	
		$\overline{X} \pm 1SE$	n	$\overline{X} \pm 1SE$	n	$\overline{X} \pm 1SE$	n	$\overline{X} \pm 1SE$	n
1969	May - June	86.7 ± 2.2	12	84.3 ± 3.3	14	85.4 ± 2.0	26	90.0 ± 0.0	8
1969	July - Aug.	80.0 ± 3.4	24	86.7 ± 1.8	18	82.9 ± 2.1	42	75.6 ± 5.1	18
1969	Sept. - Oct.	71.9 ± 4.4	31	69.7 ± 4.8	38	70.7 ± 3.3	69	75.0 ± 9.6	4
1969	Nov. - Dec.	78.0 ± 3.4	20	74.7 ± 6.5	17	76.5 ± 3.5	37		0
1970	Jan. - Feb.	58.3 ± 7.5	15	58.9 ±11.6	9	59.2 ± 6.3	24		0
1970	March - April	56.4 ± 5.9	22	71.5 ± 6.2	13	62.0 ± 4.5	35	70.0 ± 15.5	5

[a]Includes only adults weighing 25 g or more.

[b]Includes only juveniles weighing 22 g or less.

TABLE 10.--Mean percent volume (± one standard error) of animal matter in stomach contents of *Peromyscus maniculatus* by age (adult[a] or juvenile[b]) and sex (adults only) through 1969 and 1970 sample periods at the Pawnee Site.

Year	Two-Month Sample Period	Adult[a] Males $\bar{X} \pm 1SE$	n	Adult Females $\bar{X} \pm 1SE$	n	Total Adults $\bar{X} \pm 1SE$	n	Juveniles[b] $\bar{X} \pm 1SE$	n
1969	May - June	74.0 ± 3.7	50	57.4 ± 5.0	31	76.7 ± 3.1	81	56.2 ± 6.5	26
	July - Aug.	37.7 ± 4.4	43	25.6 ± 5.9	27	33.0 ± 3.6	70	49.1 ±11.2	11
	Sept. - Oct.	34.7 ± 6.1	30	34.0 ± 5.6	25	34.4 ± 4.2	55	35.9 ± 5.1	34
	Nov. - Dec.	24.8 ± 5.3	29	7.5 ± 1.0	20	17.8 ± 3.4	49	23.3 ± 3.8	52
1970	Jan. - Feb.	18.7 ± 3.6	46	13.0 ± 3.3	20	17.0 ± 2.7	66	20.0 ± 6.5	15
	March - April	62.5 ± 5.2	40	63.7 ± 6.8	24	63.0 ± 4.1	64	53.3 ± 6.7	24

[a]Includes only adults weighing 19 g or more.

[b]Includes only juveniles weighing 16 g or less.

TABLE 11.--Mean percent volume (± one standard error) of animal matter in stomach contents of *Spermophilus tridecemlineatus* by age (adult[a] or juvenile[b]) and sex (adults only) through 1969 and 1970 sample periods at the Pawnee Site.

Year	Two-Month Sample Period	Adult[a] Males $\overline{X} \pm 1SE$	n	Adult Females $\overline{X} \pm 1SE$	n	Total Adults $\overline{X} \pm 1SE$	n	Juveniles[b] $\overline{X} \pm 1SE$	n
1969	May - June	50.0 ± 8.5	11	60.0 ± 5.4	14	55.6 ± 4.8	25	41.9 ± 6.1	21
1969	July - Aug.	27.6 ± 5.4	17	47.1 ± 7.2	14	36.5 ± 4.7	31	37.5 ±18.9	4
1969	Sept. - Oct.	54.0 ±11.7	5	62.5 ± 8.4	8	59.2 ± 6.6	13		0
1969	Nov. - Dec.		0		0		0		0
1970	Jan. - Feb.		0		0		0		0
1970	March - April	36.7 ± 7.4	18	37.4 ± 6.7	19	37.0 ± 4.9	37		0

[a]Includes all adults and any juveniles weighing 80 g or more.

[b]Includes only juveniles weighing 60 6 or less.

may be more carnivorous than females. Further, *S. tridecemlineatus* females consistently had a higher percent volume of animal matter in their diets than adult males. There were no consistent relationships between percent volume animal matter in stomach contents and age (adult and juvenile) in any of the "target" species.

D. ordii

Ord's kangaroo rats are primarily herbivorous, eating large amounts of seeds along with succulent leaves of grasses, forbs, and shrubs and a few arthropods (Johnson, 1961; University of Utah, 1960; and Wood, 1969). At the Pawnee Site, mean stomach contents of *D. ordii* for the entire study consisted of only 4.4 ± 0.6 (± 1SE) percent volume of animal matter. Most of this consisted of arthropods along with substantial amounts of the animal's own hair (Table 12). Percent volume animal matter in the stomach contents varied through the year (1.5-10.4) with highest percentages present in winter, spring, and early summer and lowest from mid-summer through late fall and early winter (Figure 19). The causes for variation in amounts of animal matter are probably due to some combination of availability of preferred plant matter such as seeds (Table 13) and the availability of more commonly eaten animal matter such as Lepidoptera and Coleoptera larvae and Coleoptera adults (Table 12). Thus, the drop in amounts of animal matter in the diet by mid-summer could have been due to decrease in available larval food with drying out of the prairie and an increase in desirable plant materials, primarily seeds. Figure 20 shows such a drop in larval forms in the diet by mid-summer. Furthermore, the increase in amount of animal matter in the diets by mid-winter, most of which consisted of Coleoptera adults, could be a response to depletion of stored seed supplies as well as of unharvested seeds.

TABLE 12.--Mean percent composition[a] (± one standard error) of animal matter in stomach contents of "target" species from May 1, 1969, to April 30, 1970, at the Pawnee Site.

Type of Animal Matter	*D. ordii*	*O. leucogaster*	*P. maniculatus*	*S. tridecemlineatus*
	n=216	n=291	n=656	n=158
	$\overline{X}$ ± 1SE	$\overline{X}$ ± 1SE	$\overline{X}$ ± 1SE	$\overline{X}$ ± 1SE
Ant	0.4 ± 0.4	0.9 ± 0.2	0.3 ± 0.1	3.9 ± 0.8
Ant Egg		0.1 ± 0.1		
Ant Pupa		b	b	0.7 ± 0.5
Centipede		b	0.1 ± 0.0	
Coleoptera Adult	27.3 ± 4.5	40.4 ± 1.8	16.8 ± 1.1	35.4 ± 2.1
Coleoptera Egg		0.3 ± 0.2	0.4 ± 0.2	0.3 ± 0.2
Coleoptera Larva	5.0 ± 2.1	12.5 ± 1.4	8.2 ± 0.8	16.2 ± 2.1
Cricket		0.2 ± 0.2	0.6 ± 0.3	0.1 ± 0.1
Diptera Adult	1.0 ± 1.0	1.0 ± 0.2	0.8 ± 0.3	0.2 ± 0.1
Flea	1.0 ± 1.0	0.3 ± 0.1		
Grasshopper		25.3 ± 1.7	9.5 ± 0.9	26.5 ± 2.2
Hymenoptera Larva		b		
Leaf Hopper	1.3 ± 0.8	2.2 ± 0.6	7.9 ± 0.9	1.1 ± 0.3
Lepidoptera Adult	0.4 ± 0.4	0.2 ± 0.1	3.2 ± 0.5	0.1 ± 0.1

TABLE 12.--Continued

Type of Animal Matter	*D. ordii*	*O. leucogaster*	*P. maniculatus*	*S. tridecemlineatus*
	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$
Lepidoptera Larva	20.9 ± 4.3	6.1 ± 1.0	10.3 ± 0.9	10.8 ± 1.6
Moth			b	
Orthoptera Egg		b	b	
Rubber Fly			0.8 ± 0.3	0.1 ± 0.1
Spider	1.3 ± 1.3	4.4 ± 0.5	4.1 ± 0.6	3.2 ± 0.5
Tick			b	
Unidentified Arthropod	16.6 ± 4.1	0.6 ± 0.4	2.9 ± 0.6	0.6 ± 0.6
Total Arthropod	75.1 ± 3.7	94.7 ± 1.4	66.1 ± 1.7	99.1 ± 2.1
Unidentified Mammal Hair and Tissue	0.7 ± 0.5	2.7 ± 0.8	0.6 ± 0.3	1.5 ± 0.8
O. leucogaster or *P. maniculatus* Hair and Tissue		1.0 ± 0.5		
Feathers		0.1 ± 0.0		
Lizard Scales and Tissue		0.6 ± 0.4		
Total Vertebrates	0.7 ± 0.5	3.4 ± 0.9	0.7 ± 0.3	1.5 ± 0.8
D. ordii Hair	16.3 ± 3.5	5.8 ± 0.7		

TABLE 12.--Continued

Type of Animal Matter	*D. ordii*	*O. leucogaster*	*P. maniculatus*	*S. tridecemlineatus*
	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$
O. leucogaster Hair		5.8 ± 0.7		
P. maniculatus Hair		0.1 ± 0.0	12.5 ± 1.1	
S. tridecemlineatus		b		3.0 ± 1.0
Unidentified Mammal Hair	1.0 ± 1.0	0.2 ± 0.1	3.2 ± 0.6	0.1 ± 0.1
Trochobezoars		0.3 ± 0.3	10.3 ± 1.0	0.1 ± 0.1

[a]Percent composition of each item equal to percent volume of each item of total animal matter in diet. Totals (summation of percent compositions) not equal to 100 as all types of animal matter given composition of total animal matter rankings from 1-20%, 21-40%, 41-60%, 61-80%, and 81-100% and midpoint of these rankings used in calculating means. Totals range from 92.8 to 104.5.

[b]Present but mean percent volume <0.1.

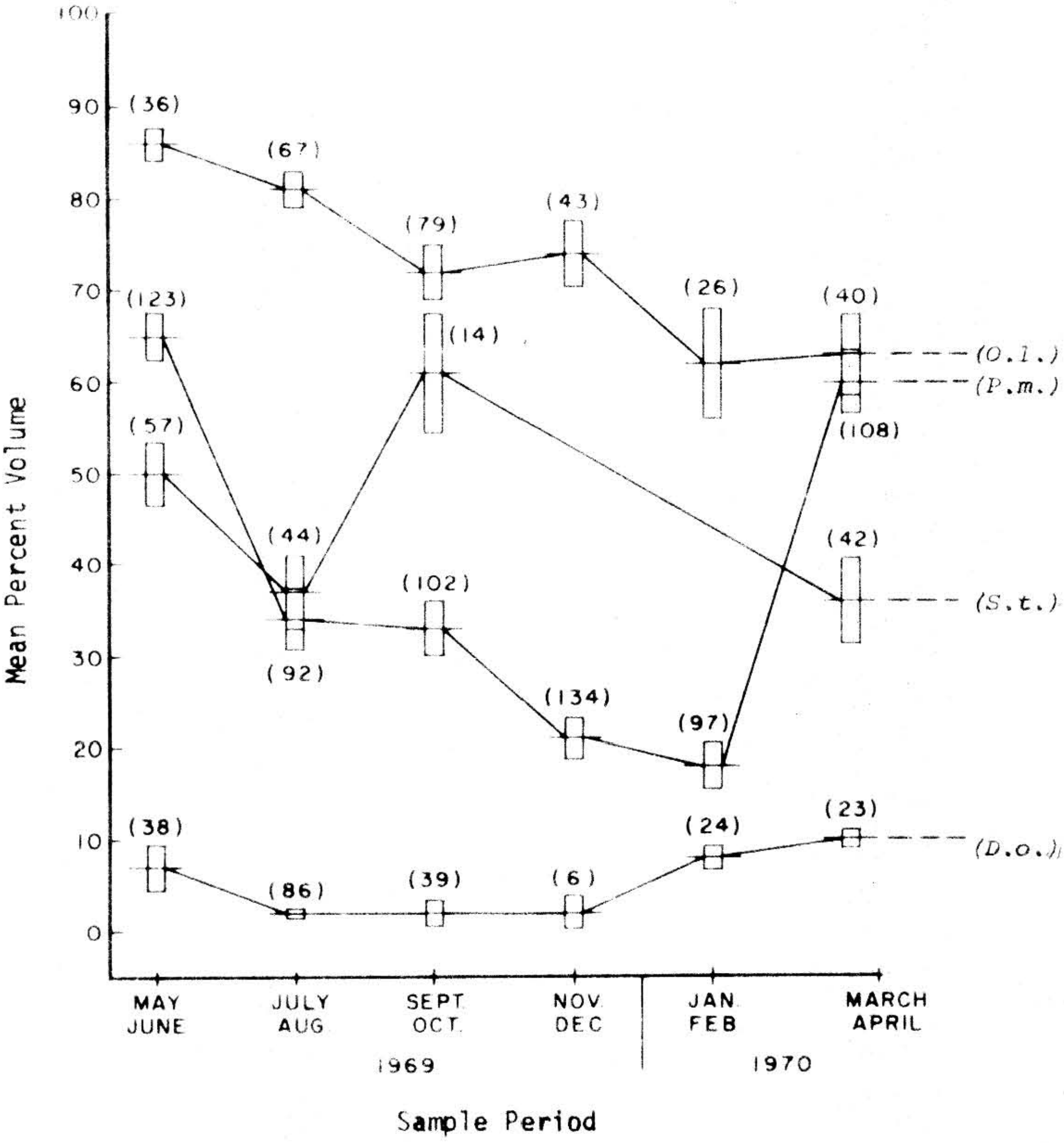


FIGURE 19.--Mean percent volume of animal matter in stomach contents of *Dipodomys ordii (D.o.)*, *Onychomys leucogaster (O.l.)*, *Peromyscus maniculatus (P.m.)*, and *Spermophilus tridecemlineatus (S.t.)* through 1969 and 1970 sample periods at the Pawnee Site. (Lines between rectangles connect means, rectangles represent one standard error on each side of mean, and numbers in parenthesis equal to sample size. Standard error used instead of standard deviation to keep rectangle overlap at a minimum

TABLE 13.--Mean percent dry weight (± one standard error) of plant materials in stomach contents of "target" species from May 1, 1969, to April 30, 1970, at the Pawnee Site.

	D. ordii	*O. leucogaster*	*P. maniculatus*	*S. tridecemlineatus*
	n=216	n=291	n=656	n=158
	$\overline{X}$ ± 1SE	$\overline{X}$ ± 1SE	$\overline{X}$ ± 1SE	$\overline{X}$ ± 1SE
Agropyron cristatum		0.9 ± 0.4	0.3 ± 0.1	
Agropyron smithii	0.5 ± 0.2	2.3 ± 0.5	0.8 ± 0.2	0.4 ± 0.2
Andropogon halii		0.1 ± 0.1		
Aristida longiseta	a	0.5 ± 0.2	0.1 ± 0.1	a
Bouteloua gracilis	3.7 ± 0.8	19.8 ± 1.7	2.2 ± 0.4	13.1 ± 1.7
Bromus inermis			0.5 ± 0.2	0.2 ± 0.2
Buchloe dactyloides			a	a
Carex heliophila	0.1 ± 0.0	2.4 ± 0.6	1.5 ± 0.3	5.0 ± 1.1
Festuca octoflora				0.5 ± 0.3
Muhlenbergia torreyi			a	a
Oryzopsis hymenoides		0.1 ± 0.1		
Schedonnardus paniculatus		0.1 ± 0.1		
Sporobolus cryptandrus	0.7 ± 0.5	1.5 ± 0.7	0.1 ± 0.1	0.7 ± 0.4
Unknown Grasses	0.2 ± 0.1	0.5 ± 0.2	0.2 ± 0.1	0.8 ± 0.3
Total Grasses and Sedges	5.2 ± 0.9	28.1 ± 2.0	5.7 ± 0.6	13.8 ± 4.4

TABLE 13.--Continued

Plant Material	*D. ordii*	*O. leucogaster*	*P. maniculatus*	*S. tridecemlineatus*
	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$
Allium textile	a	0.1 ± 0.1	a	
Astragalus	1.4 ± 0.6	1.6 ± 0.4	0.9 ± 0.2	4.0 ± 1.2
Bahia oppositifolia	a	0.1 ± 0.1	0.1 ± 0.0	0.5 ± 0.3
Chrysopsis villosa				a
Cirsium undulatum	a	a		0.8 ± 0.4
Descurainia pinnata			a	
Descurainia sophia	a		0.1 ± 0.1	
Dyssodia papposa			a	
Erigeron canadensis				a
Erigeron divergens	a	0.1 ± 0.1		0.2 ± 0.2
Eriogonum effusum		0.3 ± 0.2	0.2 ± 0.2	
Helianthus annuus		0.4 ± 0.2	a	1.0 ± 0.4
Kochia scoparia	4.7 ± 1.1	4.1 ± 0.9	6.0 ± 0.8	1.7 ± 0.7
Lathyrus eucosmus			0.4 ± 0.2	1.8 ± 0.9
Lesquerella ludoviciana			a	a
Leucocrinum montanum	1.0 ± 0.5		0.3 ± 0.2	0.1 ± 0.1

TABLE 13.--Continued

Plant Material	*D. ordii*	*O. leucogaster*	*P. maniculatus*	*S. tridecemlineatus*
	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$
Lithospermum incisum		0.1 ± 0.1		
Marrubium vulgare		0.2 ± 0.2		
Medicago sativa	1.9 ± 0.6	0.1 ± 0.0		
Mentzelia nuda	0.2 ± 0.2		0.2 ± 0.1	
Mirabilis linearis			0.2 ± 0.1	0.6 ± 0.6
Musineon divaricatum				2.5 ± 1.0
Oenothera coronopifolia	a	0.6 ± 0.3	0.2 ± 0.1	0.1 ± 0.1
Opuntia polyacantha	a	0.1 ± 0.1	0.3 ± 0.1	2.0 ± 0.9
Oxytropis lambertii	0.1 ± 0.1	0.2 ± 0.1	0.3 ± 0.1	
Petalostemon candidus				0.3 ± 0.2
Plantago purshii			0.1 ± 0.1	
Psoralea tenuiflora		0.3 ± 0.2		
Salsola kali	1.9 ± 0.7	0.7 ± 0.4	0.1 ± 0.0	0.3 ± 0.2
Senecio multicapitatus		0.2 ± 0.2		2.2 ± 0.9
Solanum rostratum	0.1 ± 0.1	0.5 ± 0.4	0.1 ± 0.1	

TABLE 13.--Continued

Plant Material	*D. ordii*	*O. leucogaster*	*P. maniculatus*	*S. tridecemlineatus*
	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$	$\overline{X} \pm 1SE$
Sophora sericae	0.1 ± 0.1	0.5 ± 0.3	0.3 ± 0.1	1.9 ± 0.7
Sphaeralcea coccinea	0.4 ± 0.3	14.0 ± 1.4	2.9 ± 0.5	4.7 ± 0.9
Tradescantia occidentalis	1.2 ± 0.5	0.3 ± 0.1	0.4 ± 0.2	5.8 ± 1.3
Tribulus terrestris	a			
Verbena bracteata			a	
Viola nuttallii				a
Unknown Forbs	0.1 ± 0.1	1.6 ± 0.6	0.2 ± 0.1	5.6 ± 1.3
Total Forbs	13.4 ± 1.8	26.1 ± 1.9	13.2 ± 1.0	36.2 ± 2.5
Artemisia frigida	0.5 ± 0.3	6.2 ± 1.1	2.3 ± 0.5	5.0 ± 1.3
Atriplex canescens	0.9 ± 0.4	0.3 ± 0.2	1.2 ± 0.3	1.4 ± 0.6
Chrysothamnus nauseosus		0.2 ± 0.2		0.1 ± 0.1
Eurotia lanata		0.2 ± 0.2	0.1 ± 0.1	0.1 ± 0.1
Total Shrubs	1.3 ± 0.5	6.9 ± 1.2	3.7 ± 0.6	6.5 ± 1.4
Fungus	1.6 ± 0.6	2.9 ± 0.7	1.8 ± 0.4	8.1 ± 1.5

TABLE 13.--Continued

Plant Material	*D. ordii*	*O. leucogaster*	*P. maniculatus*	*S. tridecemlineatus*
	$X \pm 1SE$	$X \pm 1SE$	$X \pm 1SE$	$X \pm 1SE$
Lichen	[a]	1.2 ± 0.5	0.7 ± 0.3	1.7 ± 0.4
Moss	0.5 ± 0.4	0.2 ± 0.1	0.1 ± 0.1	0.7 ± 0.4
Seed	77.3 ± 2.1	26.4 ± 2.0	65.7 ± 1.6	21.6 ± 2.4

[a]Present but mean percent volume 0.1.

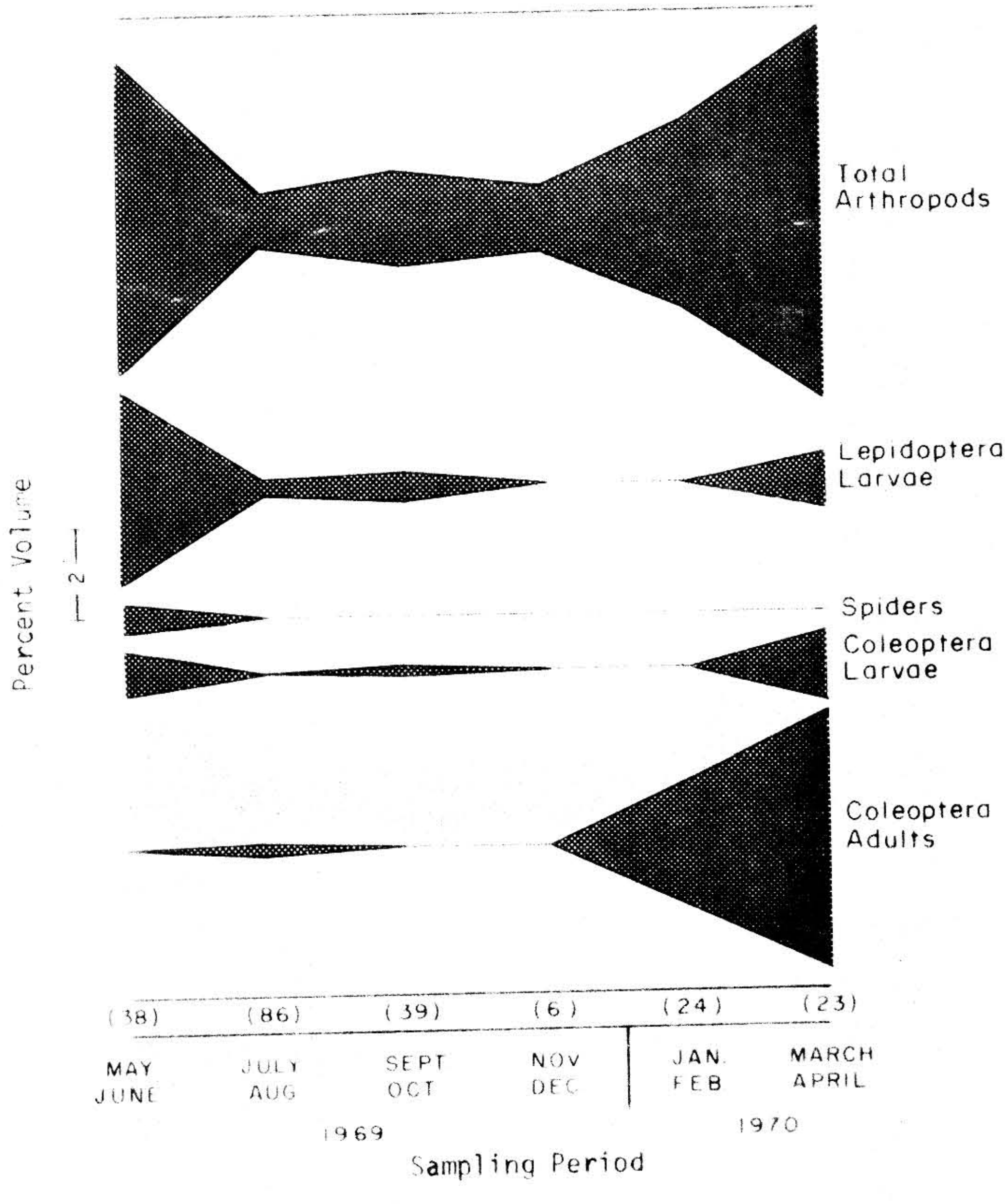


FIGURE 20.--Mean percent volume of major types of animal matter in stomach contents of *Dipodomys ordii* through 1969 and 1970 sample periods at the Pawnee Site. (Categories never composing 5% or more of total animal matter not included. Numbers in parenthesis represent sample size. Percent composition (percent volume of each item of total animal matter) converted to percent volume of total stomach contents for this figure as follows: percent volume = percent composition x fraction animal matter in diet for particular sample period.)

Table 12 lists the various types of animal matter consumed by *D. ordii* in terms of percent composition (percent volume of each item of total animal matter in diets). It is of interest that grasshoppers were completely bypassed as a food source. Major types of animal matter, in the stomach contents, excluding *D. ordii* hair, are shown through time (1969 and 1970) in Figure 20. Lepidoptera larvae, Coleoptera larvae, and Coleoptera adults were dominant types of animal matter eaten. Larval forms are present in the diet primarily in spring and early summer. As previously mentioned, this is probably due to their abundance at this time. Coleoptera adults were the predominant arthropods in the diet when averaged over the entire study.

Plant matter (percent dry weight of diet) identified in diets of *D. ordii* is listed in Table 13. Tissues of grasses and sedges, forbs, shrubs, fungi, lichens, and mosses were present in the diet. Grass, sedge, forb, and shrub tissues identified are epidermal tissues of leaves, stems, or flowering parts and do not include seeds. Seeds by themselves formed the predominant portion of the diet though a species breakdown of these seeds was not possible. Figure 21 shows that forbs, though always present in lesser amounts than seeds, are most important in the diet in late spring or early summer. Seeds are at peak levels in the diet in late fall and early winter falling off to lowest levels in late spring or early summer after which they increase in percent dry weight of the diet.

O. leucogaster

For the duration of the diet studies (May 1969-March 1970), percent animal matter in the stomach contents of *O. leucogaster* averaged 73.9 ± 1.4 (± 1SE). High percentages of animal matter and limited amounts of plant matter have previously been recorded in *Onychomys* by Bailey and Sperry (1929),

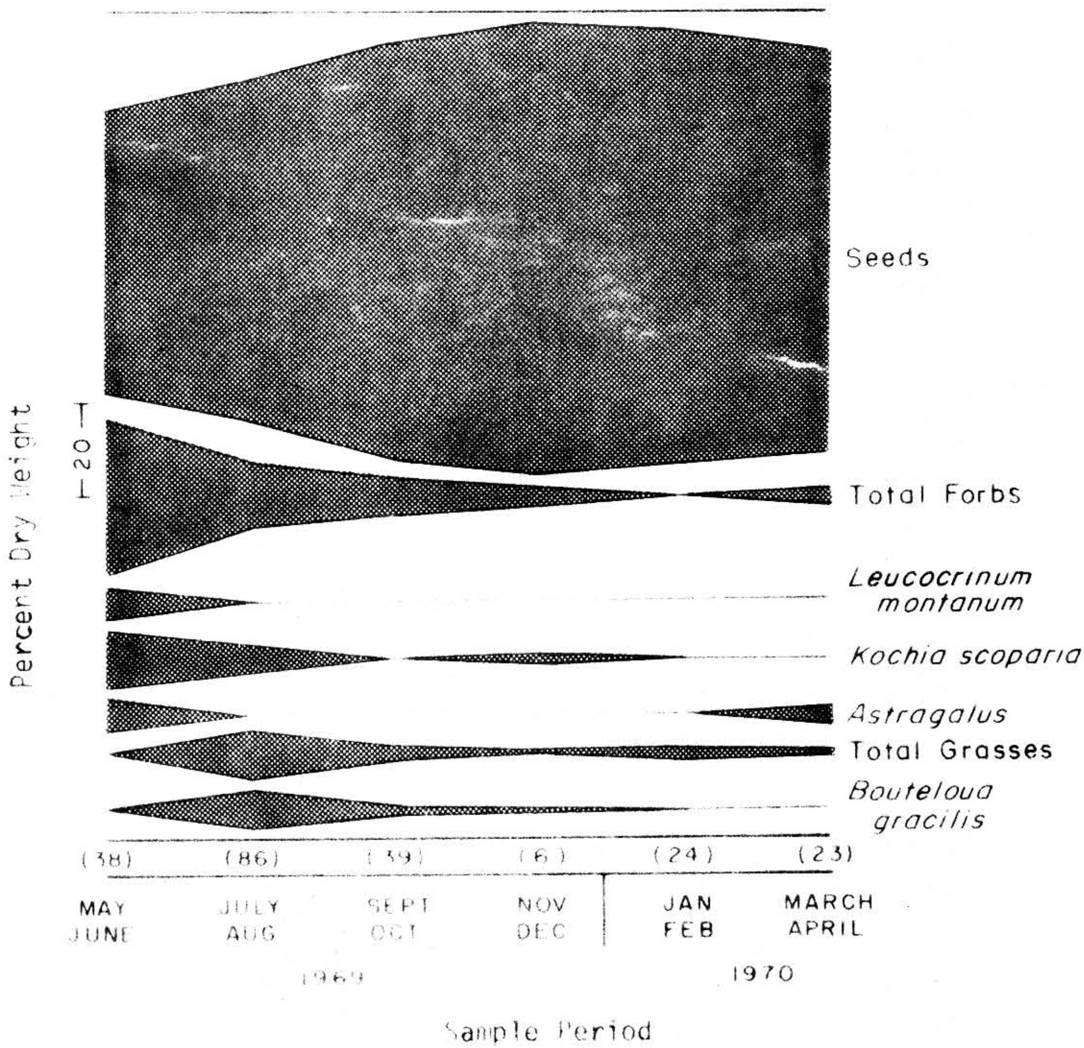


FIGURE 21.--Mean percent dry weight of major plant materials in stomach contents of *Dipodomys ordii* through 1969 and 1970 sample periods at the Pawnee Site. (Plant materials never exceeding 5% dry weight not included. Numbers in parenthesis represent sample size. Total grasses category includes sedges.)

Bailey (1931), Cockrum (1952), and Johnson (1961). At the Pawnee Site, highest percentages of animal matter were found in the diet during late spring and early summer and lowest levels during mid-winter with a range of 61.5-85.6 (Figure 19). These variations in percent animal matter in the diet are probably due to changes in availability of animal food matter, primarily arthropods. This must not be confused with availability of particular kinds of arthropods such as grasshoppers, which increase through the summer (personal observations), perhaps into early fall, but do not make up completely for decrease in other arthropods prominent in the diet of *O. leucogaster*.

Types of animal matter found in stomach contents of *O. leucogaster* and their percent composition of total animal matter during the study are shown in Table 12. Important forms of animal matter eaten include Coleoptera adults and larvae, grasshoppers, Lepidoptera larvae, and spiders. In addition, mammal hair, skin, and tissue, primarily of rodents, including *P. maniculatus* and other *O. leucogaster*, and even feathers and lizard skin and tissue were present in the diet, substantiating the carnivorous nature of *O. leucogaster*. The percent volume of major types of animal matter found in the stomach contents graphed through two-month sample periods is shown in Figure 22. Larvae of Lepidoptera and Coleoptera are most important in spring and early summer. Conversely, Coleoptera adults are found in highest concentrations in the diet from mid-summer through winter and in lowest numbers during spring and summer. Grasshoppers are found throughout the year in fairly substantial numbers, increasing in importance as food matter from early spring to early fall. According to total as well as sample period observations, Coleoptera adults were more important in the diet of *O. leucogaster* than were grasshoppers at the Pawnee Site. To the contrary, Bailey and Sperry (1929) found grasshoppers the most important arthropod in

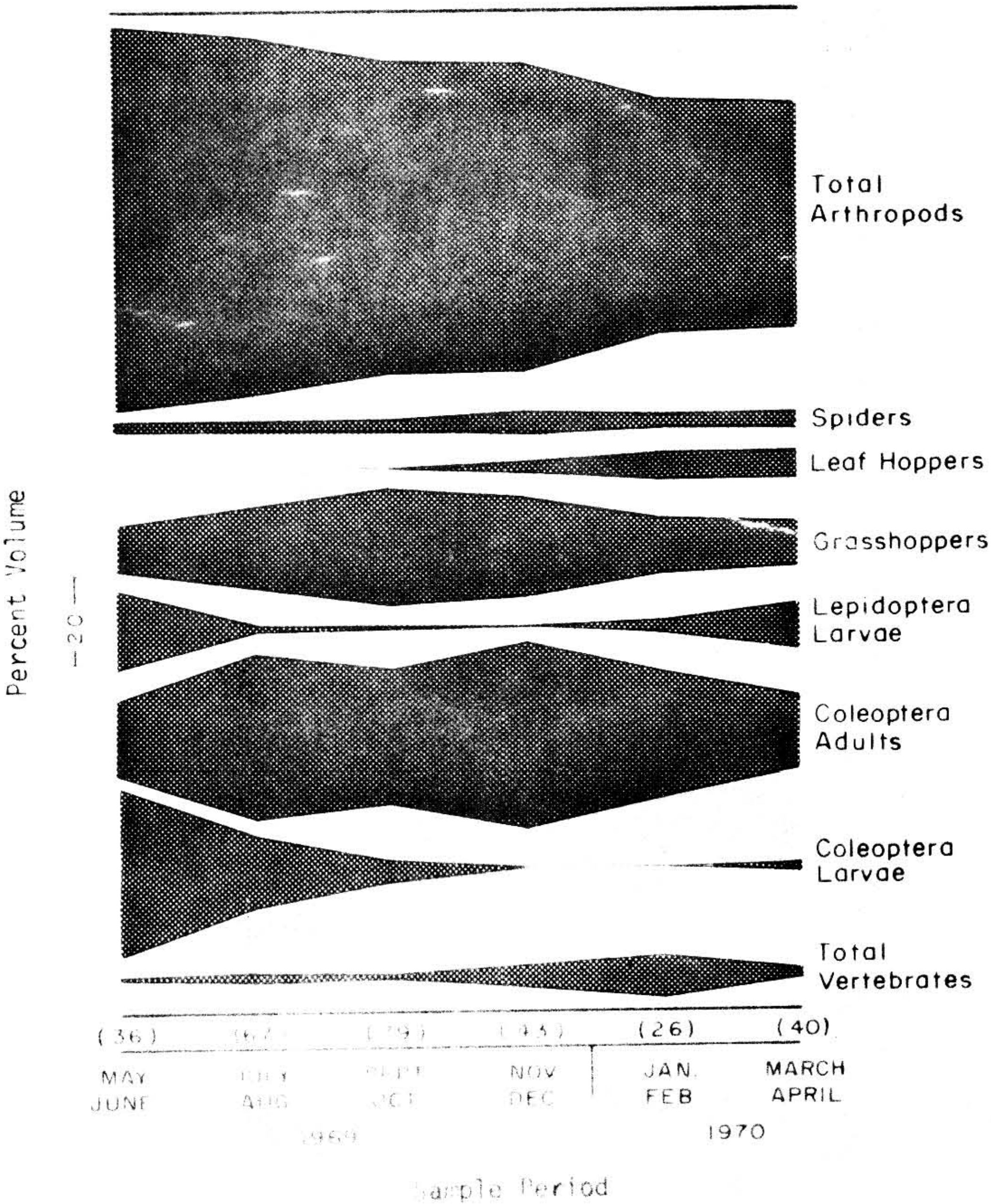


FIGURE 22.--Mean percent volume of major types of animal matter in stomach contents of *Onychomys leucogaster* through 1969 and 1970 sample periods at the Pawnee Site. (Categories never composing 5% or more of total animal matter not included. Numbers in parenthesis represent sample size. Percent composition (percent volume of each item of total animal matter) converted to percent volume of total stomach contents for this figure as follows: percent volume = percent composition x fraction animal matter in diet for particular sample period.)

O. leucogaster diets with Coleoptera second in importance. The relative amounts of particular arthropods in the diet probably depends on a combination of availability and preference. The killing and eating of other rodents and lizards has been recorded for *Onychomys* by Bailey and Sperry (1929), Bailey (1931), Cockrum (1952), and Johnson (1961).

Plant matter identified in stomach contents of *O. leucogaster* is shown in Table 13. Percent dry weight of major types of plant matter graphed through two-month sample periods from the beginning to the end of the study is shown in Figure 23. Forbs, grasses, and sedges (non-seed parts) and seeds are all about equal in percent dry weight of the diet. Forbs are highest in percent dry weight of the diet in late spring and early summer but remained relatively important among plant food matter until winter and early spring. Grasses and sedges were most important in the diet from late spring through early fall decreasing greatly in mid-winter. Seeds increase in importance in fall and early winter, probably in response to lower populations of arthropods. Bailey (1893) records a similar increase in seeds in the diet of *O. leucogaster* when arthropods are scarce.

P. maniculatus

Food matter consumed by *P. maniculatus* may contain large amounts (over 50%) of animal matter, primarily arthropods, with the amounts of animal matter varying greatly between seasons with change in abundance of arthropods (Jameson, 1952; Williams, 1959; Johnson, 1961; and Whitaker, 1966). Over the entire study at the Pawnee Site, 39.0 $\pm$ 1.3 ($\overline{X} \pm$ 1SE) percent volume of total stomach contents were composed of animal matter. Percent volume of animal matter in the diet ranged from 18.2-64.6 with highest percentages occurring in spring and early summer and lowest occurring in mid-winter (Figure 19).

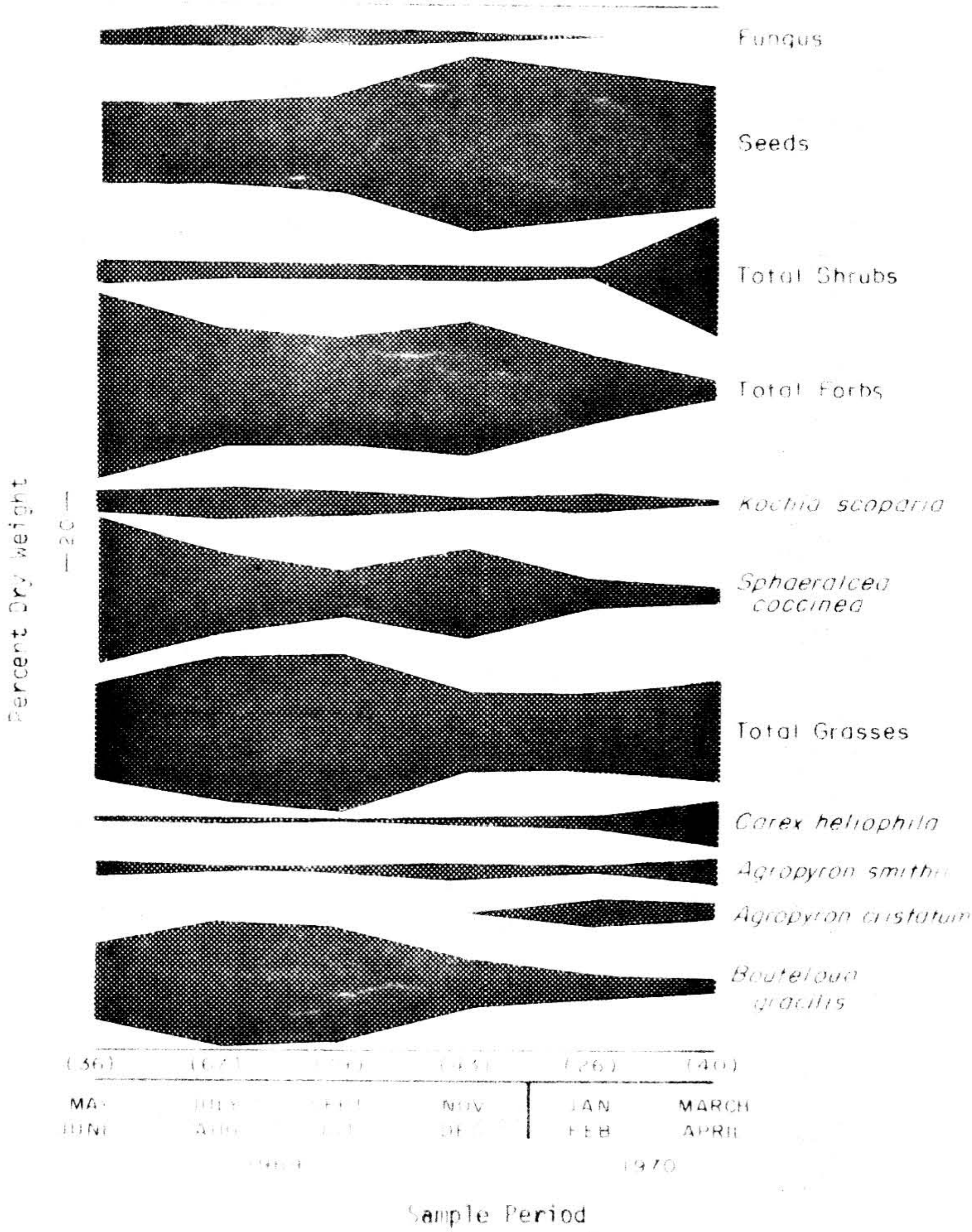


FIGURE 23.—Mean percent dry weight of major plant materials in stomach contents of *Onychomys leucogaster* through 1969 and 1970 sample periods at the Pawnee Site. (Plant materials never exceeding 5% dry weight not included. Numbers in parenthesis represent sample size. Total grasses category includes sedges.)

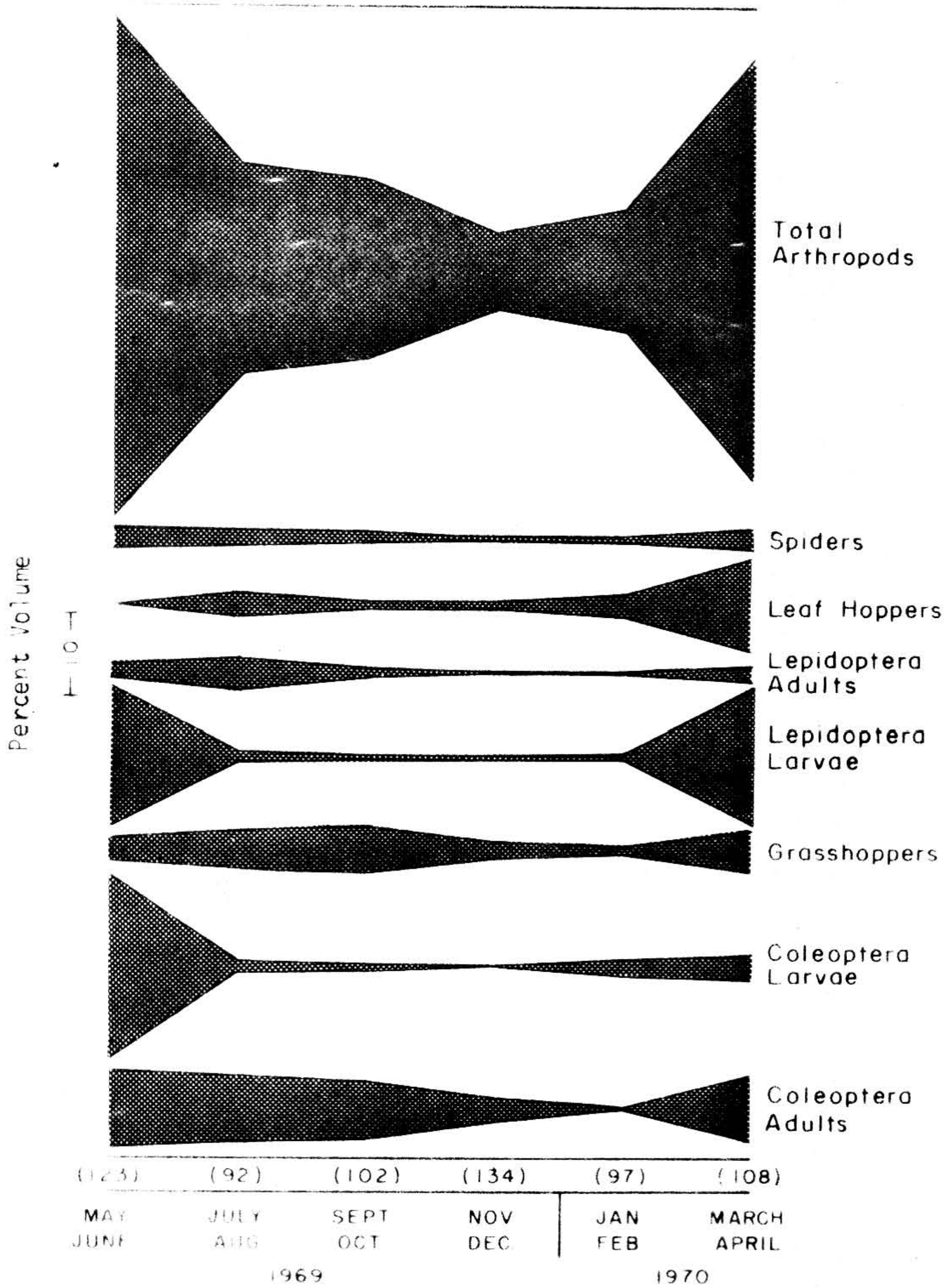
This variation in amounts of animal matter (almost all of which was arthropods) is likely due to changes in availability of total arthropods through the year and is more pronounced for *P. maniculatus* than for any other "target" species.

Composition of animal matter in diets of *P. maniculatus* is shown in Table 12. Larval and adult forms of Lepidoptera and Coleoptera as well as grasshoppers, spiders, and leaf hoppers are prominent in the diet. Over the entire study, Coleoptera adults were the dominant arthropod. In Indiana, Whitaker (1966) found Lepidoptera larvae by far the predominant animal matter in *P. maniculatus* diet and Coleoptera adults a distant second. Though he found various other types of arthropods in the diet, grasshoppers were absent. Diet work by Hamilton (1941), Jameson (1952), Williams (1959), Johnson (1961), and Whitaker (1966) indicates that *P. maniculatus* is highly opportunistic, eating the particular types of animal and plant materials available. This opportunism leads to great regional variation in diet composition and is a reflection of the adaptability and broad distribution of *P. maniculatus*.

Major types of animal matter in the diet are graphed through time in Figure 24. The larvae of Lepidoptera and Coleoptera are noticeably more abundant in the diet in spring and early summer than during other portions of the year. Grasshoppers increase in importance from mid-winter to a peak in early fall. These changes through time reflect the availability of these arthropods in the environment. Total arthropods in the diet show wide seasonal variation with a peak in spring and early summer as can be observed in Figure 24.

Percent dry weight of different plant matter in the diet of *P. maniculatus* is shown in Table 13. Plant matter in the diet includes seeds, epidermal tissues (leaves, stems, and flowering parts) of grasses

FIGURE 24.--Mean percent volume of major types of animal matter in stomach contents of *Peromyscus maniculatus* through 1969 and 1970 sample periods at the Pawnee Site. (Categories never composing 5% or more of total animal matter not included. Numbers in parenthesis represent sample size. Percent composition (percent volume of each item of total animal matter) converted to percent volume of total stomach contents for this figure as follows: percent volume = percent composition x fraction animal matter in diet for particular sample period.)



Sample Periods

FIGURE 24

and sedges, forbs, and shrubs and tissues of fungi, lichens, and mosses. As noticed in kangaroo rats (*D. ordii*), seeds are the major type of vegetative matter eaten. Predominance of seeds in vegetative matter eaten has previously been shown by Hamilton (1941), Jameson (1952), Williams (1959), Johnson (1961), and Whitaker (1966). Major types of plant foods in the diet at the Pawnee Site are graphed through time in Figure 25. Forbs show a peak in the diet in early spring and summer as one would expect on the basis of their abundance at this time. Shrubs likewise are most apparent in the diet at this time of year, probably due to rodent preference for new shoot growth. Seeds reached peak levels in the diet in late fall and early winter. Peak amounts of seeds in the diet in fall and winter have previously been shown by Jameson (1952), Johnson (1961), and Whitaker (1966). Increase in percent dry weight of seeds during this period is probably due to a decrease in available arthropods. Seeds are at low levels in the diet in late spring and early summer when arthropods are probably most abundant and few seeds have ripened.

S. tridecemlineatus

The omnivorous nature of *S. tridecemlineatus* has been reported by a number of authors including Bailey (1893), Lantz (1904), Johnson (1917), Fitzpatrick (1925), Hisaw and Emery (1927), Schmidt (1931), and Criddle (1939). Fitzpatrick (1925) noted a range of 25-80% insect matter in the stomach contents with highest amounts through summer and into early fall and lowest percentages in early spring after emergence from hibernation. At the Pawnee Site, thirteen-lined ground squirrel (*S. tridecemlineatus*) stomachs contained 44.0 $\pm$ 2.2 ($\bar{X} \pm$ 1SE) percent animal matter over the entire study, with seasonal variation ranging from 61.4% in late summer and early fall to

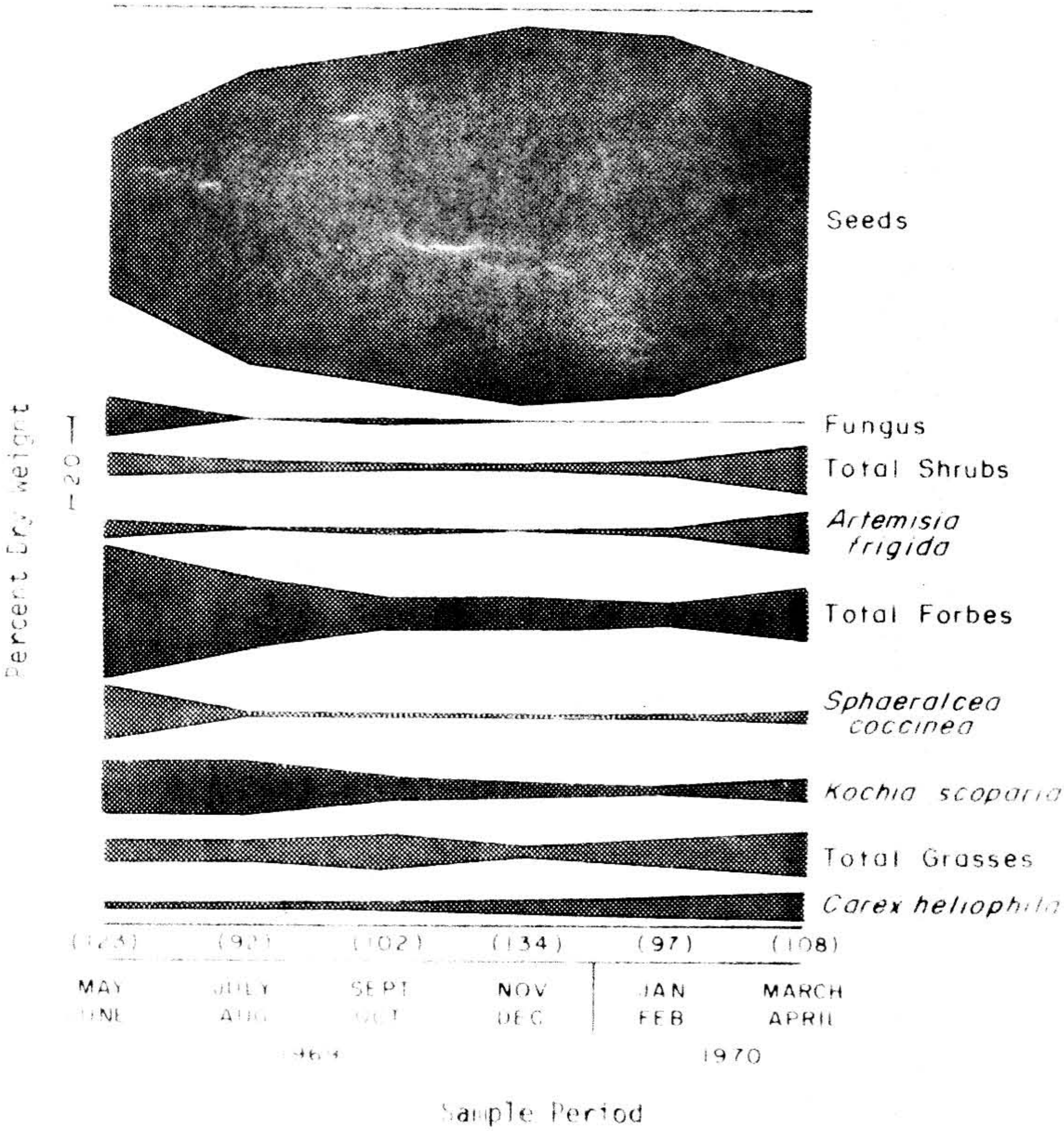


FIGURE 25.--Mean percent dry weight of major plant materials in stomach contents of *Peromyscus maniculatus* through 1969 and 1970 sample periods at the Pawnee Site. (Plant materials never exceeding 5% dry weight not included. Numbers in parenthesis represent sample size. Total grasses category includes sedges.)

36.4% in early spring (Figure 19). Actually, the variation is rather erratic, with the late spring and early summer average being higher than that for mid-summer. This may be partly due to the increased percentage of grasshoppers in the diets of *S. tridecemlineatus* in late summer and early fall (Figure 26).

Presence of crickets, caterpillars, beetles, ants, and insect eggs in the diet of *S. tridecemlineatus* has been reported by Bailey (1931). Lantz (1904) and Bailey (1923) record the presence of bird and mammal tissues in the stomach contents of *S. tridecemlineatus*. Composition of animal matter in the diet of *S. tridecemlineatus* at the Pawnee Site is included in Table 12. As with the other target species, Coleoptera adults are the most important animal food at least in terms of average composition over the entire study. Figure 26 shows Coleoptera adults and other important types of animal matter in the diet through time. It can be seen that Coleoptera adults are present in the diet in rather stable amounts through the year while Lepidoptera and Coleoptera larvae are most abundant in late spring and early summer and grasshoppers are most important in the diet in late summer and early fall. Arthropods make up the vast majority of animal matter consumed, but a few vertebrates (unidentified mammal hair and tissue) are also taken.

Plant matter reported in the diet of *S. tridecemlineatus* includes primarily seeds along with some grass leaves, various fruits, bark, and roots (Fitzpatrick, 1925; Bailey, 1931; and Schmidt, 1931). Plant matter in the diet of *S. tridecemlineatus* at the Pawnee Site contained grasses, sedges, shrubs, forbs, fungi, lichens, mosses, and seeds (Table 13). Of the "target" species, *S. tridecemlineatus* had the lowest percent dry weight of seeds in the diet. It is of interest that fungi and mosses are present more in the diet of *S. tridecemlineatus* than in the diet of any other "target" species (Table 13). Major types of plant matter found in the diet are graphed

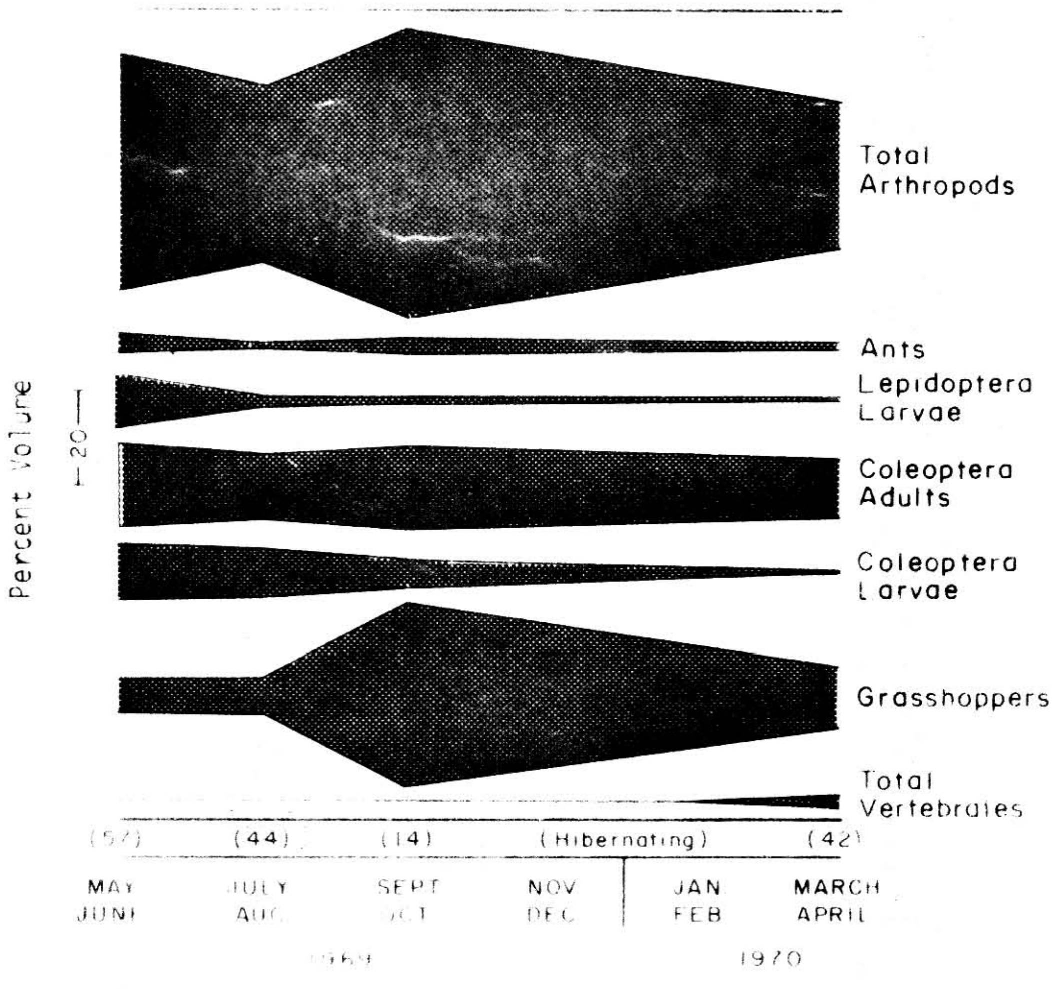


FIGURE 26.--Mean percent volume of major types of animal matter in stomach contents of *Spermophilus tridecemlineatus* through 1969 and 1970 sample periods at the Pawnee Site. (Categories never composing 5% or more of total animal matter not included. Numbers in parenthesis represent sample size. Percent composition (percent volume of each item of total animal matter) converted to percent volume of total stomach contents for this figure as follows: percent volume = percent composition x fraction animal matter in diet for particular sample period.)

through time in Figure 27. It can be seen in Figure 27 that total forbs and even total grasses and sedges composed a greater portion of diet dry weight than did seeds.

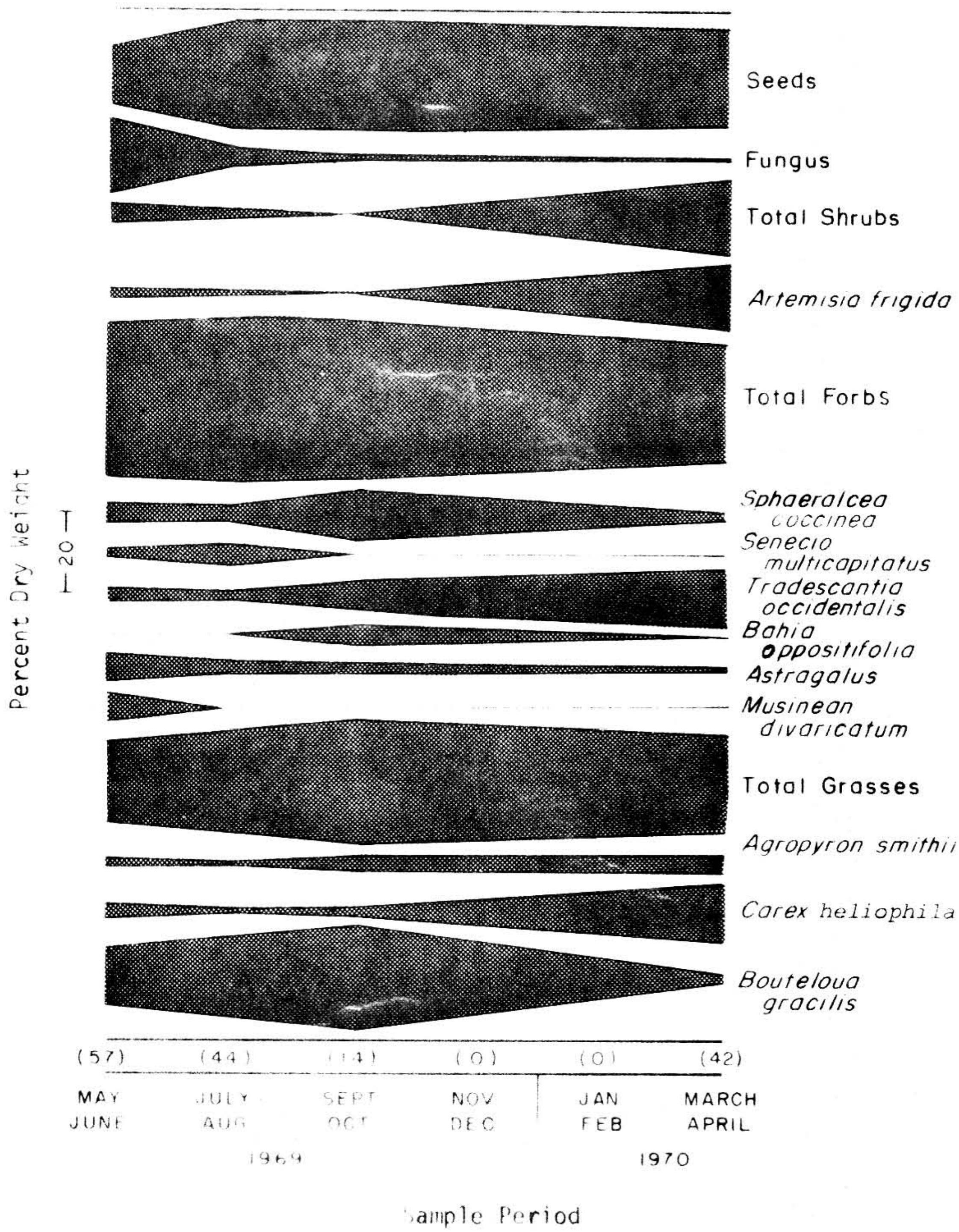


FIGURE 27.--Mean percent dry weight of major plant materials in stomach contents of *Spermophilus tridecemlineatus* through 1969 and 1970 sample periods at the Pawnee Site. (Plant materials never exceeding 5% dry weight not included. Numbers in parenthesis represent sample size. Total grasses category includes sedges.)

SUMMARY AND CONCLUSIONS

Four species of rodents were captured regularly in the intensive study pastures at the Pawnee Site. In the order of lowest to highest frequency of captures during most live-trapping periods, these were *D. ordii*, *P. maniculatus*, *O. leucogaster*, and *S. tridecemlineatus*. In late summer and fall when most *S. tridecemlineatus* were hibernating, *O. leucogaster* was the predominant rodent captured in the intensive study pastures.

Effects of long-term grazing intensity on rodent populations as observed by this short-term study on selected areas were minor and generally inconclusive. Populations of *D. ordii* were present in each intensive study pasture but in such scant numbers that a relationship to grazing intensity, even if present, could probably not be detected unless extreme. Effects of increased grazing intensity on *O. leucogaster* populations were inconclusive, though the lightly and moderately grazed pastures appeared to be slightly more favorable habitats than the heavily grazed pasture. Lower *O. leucogaster* populations in the heavily grazed pasture would probably be due to reduction of arthropods with increased grazing. During most live-trapping periods, captures of *P. maniculatus* in the intensive study pastures were directly related to grazing intensity, indicating that the habitat becomes more favorable for *P. maniculatus* with increased grazing. Conversely, populations of *S. tridecemlineatus* were inversely related to grazing intensity during most live-trapping periods, indicating that an increase in grazing intensity may be adverse to habitat and populations of this species on short-grass prairie.

Abundance of "target" species showed some apparent relationships to soil type habitats. *D. ordii* were most abundant in Midway-Renohill complex soils, probably due to the availability of dusting places, and showed an aversion for undifferentiated bottomland soils. *O. leucogaster* populations were consistently lower in the undifferentiated bottomland soils, indicating a preference for upland soils. Relatively low populations of *O. leucogaster* and of *D. ordii* in undifferentiated bottomland soils is probably due to occurrence of frequent flooding in this habitat. Ord's kangaroo rat (*D. ordii*) may further avoid it due to low amounts of barren surface soil (dusting places). *P. maniculatus* captures indicate a slight preference for Midway-Renohill complex soils over the other soil habitats, probably due to the increased amount of bare surface soil in this habitat. Abundance and distribution of *S. tridecemlineatus* showed no definitive relationship to soil type.

Snap-trapping procedures in areas outside the intensive study pastures yielded additional information on distribution and abundance of "target" species in relation to different habitats. *D. ordii* populations were much higher than on most of the short-grass prairie in generally disturbed habitats with large amounts of sand and/or barren surface soil and a general abundance of annual forbs and shrubs. *O. leucogaster* were widespread, avoiding only bottomland areas subject to flooding. Abundance of deer mice (*P. maniculatus*) was much greater than on "normal" short-grass prairie in areas with deep vegetative cover, a high percentage of bare surface soil and/or nearby barren areas. *S. tridecemlineatus* were widespread on the Pawnee Site, avoiding only areas of deep vegetative cover.

Reproduction in *D. ordii* at the Pawnee Site can occur at least from February through August. Litter size, as estimated from embryo counts, ranged from 2-4 with a mean of 2.87 over the entire study and differed significantly[5] between years. This variation was probably due to variation in age structure of reproductively active females or in availability of food during the reproductive seasons. The northern grasshopper mouse (*O. leucogaster*) reproduced from March through August and had a mean litter size of 4.58 and a range of 3-7. Mean litter size did not differ significantly between years. *P. maniculatus* reproduced from February through November with a litter size range of 2-8 and a mean of 4.70. Mean litter size difference between years was not significant. *S. tridecemlineatus* apparently have only one litter per year at the Pawnee Site, with pregnant females found only in May. Breeding probably occurred in late March or April and most young were born in May or early June. Litter size averaged 8.55 and ranged from 7-11. Mean litter size difference between years was not significant.

Peak annual population levels of *O. leucogaster* were attained in early fall after the breeding season and low levels in late spring. *S. tridecemlineatus* reached peak levels in mid-summer after emergence of young and lowest levels in late spring before emergence of young. Population fluctuations from peak to low levels were much more pronounced in *S. tridecemlineatus* than in *O. leucogaster*, indicating a higher annual mortality in *S. tridecemlineatus*. These cycles are based on trappable juveniles and adults and do not include populations of unweaned young. Definite seasonal changes in abundance of *D. ordii* and *P. maniculatus* were not observed.

Population levels of *D. ordii* and *S. tridecemlineatus* showed differences between years while *O. leucogaster* and *P. maniculatus* population levels appeared quite stable between years. Both live-trapping and snap-trapping

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[5] Significant difference refers to $P \leq .05$ throughout Summary and Conclusions section.

data strongly indicate a decline in *D. ordii* populations from 1969 to 1970 though the cause is not clear. *S. tridecemlineatus* populations were considerably higher in mid-summer of 1970 than in 1969. This may have been caused by increased mortality of young prior to emergence in 1969, due to flooding of burrows during heavy spring rains.

Sex ratios of adult or juvenile *O. leucogaster* captured by snap trapping or live trapping never differed significantly from 1:1. Similarly, juveniles and adults captured by different trapping methods were not significantly different from each other. *P. maniculatus* consistently showed a surplus of males for all age and capture method categories. The ratios of adults and juveniles were not significantly different from each other for each capture method and adults and juveniles captured by snap trapping did not differ from adults and juveniles captured by live trapping. The preponderance of males for all groups of *P. maniculatus* was unusually high and perhaps caused by a combination of aberrant sex ratios at birth, greater wandering tendency of males, and differential mortality between sexes. Sex ratios of snap-trapped adult *S. tridecemlineatus* were significantly different from 1:1 in favor of females in 1970 but not in 1969. I am unable to offer a plausible explanation for this. Significantly more males than females were captured among live-trapped juveniles and they differed significantly from snap-trapped juveniles and from live-trapped adults. The cause for a preponderance of males in live-trapped juveniles is unclear and cannot simply be due to greater wandering tendency in males or similar results would have occurred with the snap traps. There may be a difference in trapability of juvenile males and females with the metal live traps.

Percent volume of animal matter in the diets varied greatly between species with mean values of 4.4% in *D. ordii*, 73.9% in *O. leucogaster*, 39.0%

in *P. maniculatus*, and 44.0% in *S. tridecemlineatus*. Adult male *P. maniculatus* contained a higher percentage of animal matter in the diets than adult females, and adult female *S. tridecemlineatus* contained higher percentages of animal matter than adult males. Adult male and adult females of *D. ordii* and *O. leucogaster* appear to be equal in percent animal matter in diets and no differences were evident between juveniles and adults for any "target" species. Percent volume of plant matter in diets may be considered the remaining part of 100% volume after volume of animal matter is subtracted. Animal matter in the diets was composed almost entirely of arthropods with Coleoptera adults being predominant in the diets of all "target" species. Lepidoptera larvae were an important part of animal matter in the diet in all species, especially *D. ordii*, and were of greatest importance in late spring and early summer. Grasshoppers were a common item of animal matter in the diet of all species except *D. ordii*, especially in late summer and early fall when most abundant. Coleoptera larvae were an important component of animal matter in all species. Remains of rodent species, lizards, and birds were found most commonly in *O. leuocogaster* though a few vertebrate remains were also found in the other "target" species. Even in *O. leucogaster*, these vertebrate parts formed only a small proportion of total animal matter eaten.

Plant matter identified in the diets of all "target" species included unidentified seeds, epidermal tissues (leaves, stems, and flowering parts) of various species of grasses and sedges, forbs and shrubs, and tissues of fungi, lichens, and mosses. In *D. ordii*, seeds made up a high percentage of total plant matter and of total diet. Peak amounts of seeds were found in *D. ordii* in fall and early winter and lowest amounts in spring. *D. ordii* contained substantially more forbs (non-seed parts) in the diet in late spring and early summer than during other portions of the year. In

O. leucogaster, seeds and non-seed parts of grasses (and sedges) and forbs, were all of about equal importance in total plant matter though much less plant matter was contained in the diet than in any other "target" species. Seeds were at peak levels in the diet in winter and early spring when arthropods were at low levels. Seeds were the primary food eaten by *P. maniculatus*. Peak amounts of seeds were found in the diet during late fall and winter when they made up the major component of the total diet. Forbs (non-seed parts) formed a substantial part of total plant matter in the spring although they were always secondary to seeds. Of plant matter in the stomachs of *S. tridecemlineatus*, unidentified seeds and non-seed parts of various species of forbs and grasses (and sedges) were in about equal proportion. Fungi were more abundant in the diet of *S. tridecemlineatus* than in any other "target" species.

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APPENDIX I

FIELD DATA

Rodent Live Trapping

Rodent live trapping data collected in 1969 at the Pawnee Site is Grassland Biome data set A2U105B. An explanation of the data format and an example of the data follow.

Columns	Contents
1- 4	Specimen number (unique within a species)
5- 8	Species code (as in A2U109B)
9	Trapping period
10	Year
11	Pasture (1 = 23E, 2 = 23W, 3 = 15E)
12-13	Grid number where caught (indicates soil type as follows)

	Undifferentiated Bottomland	Midway-Renohill	Vona and Ascalon Sandy Loam
Pasture 1	05, 06, 11	01, 07, 10, 12	02, 03, 04, 08, 09
Pasture 2	01, 02, 03	05, 06, 08, 12	04, 07, 08, 10, 11
Pasture 3	02, 04, 08	01, 06, 07, 12	03, 05, 09, 10, 11

Columns	Contents
14	Sex (1 = male, 2 = female)
15	Reproductive condition (1 = pregnant, lactating, or fecund; 2 = no reproductive activity)
16	Age (1 = juvenile, 2 = adult)
17-19	Weight (g)
20	Burrow position (1 = inside grid or within 5 m perimeter; 2 = outside 5 m perimeter; 3 = no observation)
22-23	Month } Date of capture
25-26	Day } Date of capture
28-29	Year } Date of capture

*** EXAMPLE OF DATA ***

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9049PEMA113 12020183 06-10-69

Rodent Diet Data

Rodent diet data collected in 1969-1970 at the Pawnee Site is Grassland Biome data set A2U108B. An explanation of the data format and an example of the data follow.

Columns	Contents
	I. ID Card for One Animal
1- 4	Animal speciman number
5- 8	Animal genus-species code
9-11	Weight of animal (g)
12	Sex (M or F)
13	Reproductive status (P = pregnant female)
14-21	Date of collection (month, day, year)
22-25	Stomach weight (g)
26-28	Number of animal codes on following card(s)
29-31	Number of plant codes on following cards

II. Stomach Contents Card(s)

Up to 10 groups per card, as needed, with each group made up of six columns coded for the material in the stomach, and two columns for the proportion of frequency of that material. Two measuring schemes were used, one for animal material and one for plant material. Total animal (ANIMAL) material was assigned a code of 0 to 5 representing a proportion of .0, .1, .3, .5, .7, and .9, respectively, of the total amount of material present. Total plant material (PLANT) was estimated in the same fashion. Subdivisions of the animal matter were then recorded as proportions of the total animal matter. Subdivisions of the plant material were recorded as frequency counts by genus-species codes. Animal groups are entered on the cards first, followed by plant codes.

A list of the specialized animal codes used follows:

Code	Meaning
ANT	Ant
ANTEGG	Ant egg
ANTPUP	Ant pupae
CEN	Centipede
CITHAI	CITR hair
CISKHA	CITR skin and hair
COLADU	Coleoptera adult
COLEGG	Coleoptera egg
COLLAR	Coleoptera larvae
CRI	Cricket
DIOHAI	DIOR hair
DIPADU	Diptera adult
FEA	Feather or feather and tissue
FLEA	Flea
GRA	Grasshopper
HAIBAL	Hair ball
HOM	Homoptera
HYMLAR	Hymenoptera larvae
LEAHOP	Leaf hopper
LEPADU	Lepidoptera adult
LEPLAR	Lepidoptera larvae
LISKTI	Lizard skin and tissue
MAMHAI	Mammal hair
MAHATI	Mammal hair and tissue
MISANI	Miscellaneous animal matter
MOTH	Moth
ONLHAI	ONLE hair
OPHATI	ONLE or PEMA hair, skin, or tissue
ORTEGG	Orthoptera egg
PEMHAI	PEMA hair
ROBFLY	Robber fly
SPIDER	Spider

TICK	Tick
UNI	Unidentifiable
UNIART	Unidentifiable arthropod
UNIINS	Unidentifiable insect
PLANT	Total plant material
ANIMAL	Total animal material

*** EXAMPLE OF DATA ***

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         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

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0002CITR131FP05-10-6901.7005004
GRA    02COLADU04CITHAI01PLANT 02ANIMAL04ASTR   11TROC   01MUDI   05SEED   01
0003CITR110F 05-11-6903.6006003
ANT    01LEPLAR05COLLAR01CITHAI01PLANT 04ANIMAL02ASTR   14ARFR   04SEED   01
0004CITR139FP05-12-6900.9005003
GRA    02COLADU02LEPLAR02PLANT 02ANIMAL04BOGR   03CAHE   06UNKF   01
0005CITR125FP05-15-6913.0007003
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0006CITR122F 05-22-6918.8006002
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0008CITR119F 05-23-6909.6007004
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UNKF   03
0009CITR118F 05-23-6905.6005003
COLLAR03COLADU02GRA    02PLANT 04ANIMAL02CAHE   02TROC   14SEED   05
0010CITR120F 05-24-6909.8008003
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SEED   1
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COLADU03COLLAR03PLANT 01ANIMAL05BOGR   02SEED   03
0012CITR144F 06-13-6933.4006003
GRA    02COLLAR03COLADU02LEPLAR01PLANT 04ANIMAL02MUDI   04SEED   07FUNGUS 1
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0014CITR026F 06-14-6900.9003007
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0015CITR104F 06-14-6905.5004004
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0017CITR042F 06-23-6903.5007003
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0018CITR042F 06-23-6903.6008003
SPIDER01GRA    01LEPLAR04ANT    01COLADU01CITHAI01PLANT 02ANIMAL04UNKG   01UNKF   01
FUNGUS03
0019CITR125F 06-23-6913.0006003
COLADU03COLLAR03SPIDER01GRA    01PLANT 01ANIMAL05UNKG   03SPCO   02UNKF   02
0020CITR040F 06-23-6900.3004005
COLADU03GRA    03PLANT 03ANIMAL03BOGR   01UNKG   01SEED   03MOSS   08FUNGUS02
0021CITR044F 06-23-6903.6004004
COLADU04LEPLAR02PLANT 04ANIMAL02BOGR   02ASTR   01SEED   02FUNGUS10
0022CITR059F 06-24-6905.5006005
LEPLAR03SPIDER01ANT    01COLADU02PLANT 05ANIMAL01BOGR   03SPCO   06ASTR   01MOSS   01
FUNGUS09
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0023CITR038F 06-24-6901.9007002
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0024CITR052F 06-25-6905.4005004
COLADU05ANT    01COLLAR01PLANT 05ANIMAL01HEAN   05SEED   07LICHEN03FUNGUS11
0026CITR079F 06-26-6912.1007003
COLLAR02COLADU02ANT    01LEPLAR02ANTPUP02PLANT 03ANIMAL03AGSM   02ASTR   05SOSE   03
0025CITR060F 06-26-6905.3006003
LEPLAR02COLLAR03GRA    01COLADU01PLANT 03ANIMAL03SPCO   01ATCA   02FUNGUS02
0027CITR047F 06-26-6905.0006004
SPIDER01GRA    03COLADU03ANT    01PLANT 05ANIMAL01BOGR   02LAEU   05SPCO   01FUNGUS05
0028CITR062F 06-26-6906.5007004
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FUNGUS04
0029CITR049F 06-26-6902.8006004
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0030CITR074F 06-26-6904.2006004
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0031CITR050F 06-26-6902.6003000
COLADU05PLANT 02ANIMAL04
0032CITR052F 06-26-6902.7005003
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0033CITR060F 06-27-6903.4006003
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0034CITR062F 06-27-6904.0006002
COLLAR01LEPLAR03ANT    02COLADU01PLANT 01ANIMAL05CHNA   02FUNGUS11
0035CITR046F 06-29-6908.0007004
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FUNGUS02
0036CITR047F 07-07-6902.5004005
GRA    03COLADU03PLANT 05ANIMAL01BOGR   02SEED   02SEMU   09MOSS   02FUNGUS02
0037CITR101F 07-08-6906.5005002
COLLAR04COLADU02GRA    01PLANT 02ANIMAL04BOGR   15SEED   01
0038CITR055F 07-08-6900.3002004
PLANT 05ANIMAL00BOGR   01SEMU   03SEED   07FUNGUS19
0039CITR068F 07-08-6908.7005003
COLLAR04GRA    01COLADU01PLANT 04ANIMAL02SEMU   04SEED   10FUNGUS02
0040CITR067F 07-08-6902.8005004
COLLAR04GRA    01COLADU01PLANT 02ANIMAL04BOGR   01SEMU   10FULA   02FUNGUS01
0041CITR066F 07-13-6907.5006006
CITHAI01COLADU02COLLAR04SPIDER01PLANT 04ANIMAL02BOGR   03ARLO   02AGSM   02ASTR   13
LICHEN02FUNGUS06
0042CITR089F 07-16-6904.4004004
LEPLAR02COLADU04PLANT 05ANIMAL01BOGR   02AGSM   01ARFR   03TROC   03
0043CITR096F 08-12-6904.7004004
ANT    01COLADU05PLANT 04ANIMAL02BOGR   02TROC   05CIUN   03SEED   03
0044CITR089F 08-13-6906.8007005
COLADU04GRA    01LEPLAR02SPIDER01CITHAI01PLANT 03ANIMAL03BOGR   02UNKG   01SPCO   02
SOSE   06LICHEN01
0045CITR091F 08-16-6901.5004005
COLADU02GRA    04PLANT 01ANIMAL05CAHE   01BOGR   02AGSM   01SPCO   05UNKN   06
0046CITR096F 08-16-6900.4004004
ANT    02COLADU04PLANT 04ANIMAL02BOGR   12SPCO   04TROC   01SEED   02
0047CITR085F 08-17-6907.7006005
GRA    03COLADU02COLEGG02LEAHOP01PLANT 03ANIMAL03SPCR   11CIUN   08SPCO   02SEED   01
LICHEN03
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COLADU03GRA    03CITHAI01PLANT 02ANIMAL04BOGR   06SPCO   05LICHEN01
0050CITR091F 08-18-6907.4006005
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LICHEN01
0051CITR087F 08-18-6902.9006006
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ASTR   02SEED   02
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0053CITR082F 08-26-6902.9004003
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0054CITR095F 08-27-6908.2003001
COLADU05PLANT 05ANIMAL01SEED   06
0055CITR120F 09-03-6909.0007005
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SEED   11MOSS   02
0056CITR090F 09-03-6903.9005005
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0057CITR128F 09-05-6904.6007004
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TROC   01SEED   03
0059CITR078F 09-08-6907.7007004
GRA    04COLADU02COLLAR01ANT    01MAMHAI01PLANT 01ANIMAL05BOGR   06KOSC   01BAOP   03
SPCO   03
0060CITR096F 09-23-6906.2006003
GRA     4ANT     1COLADU 2CITHAI 1PLANT   3ANIMAL 3BOGR    2TROC    7ASTR    3
0061CITR123F 09-25-6910.2005004
COLADU04GRA    01COLLAR02PLANT 03ANIMAL03BOGR   05TROC   07SPCO   05SEED   01
0062CITR130F 10-01-6907.3006005
GRA    04COLADU01COLLAR01CITHAI01PLANT 01ANIMAL05BOGR   07UNKG   01AGSM   01SOSF   01
UNKF   02
0063CITR119F 10-24-6934.3005006
GRA    04COLADU02COLLAR01PLANT 01ANIMAL05AGSM   06CAHF   01BOGR   03SOSE   02UNKF   01
SPCO   03
  66CITR 69F 04-23-70 3.2   3   1
UNIART05PLANT 05ANIMAL01SEED   20
  67CITR 89F 04-24-70 8.3   5   3
GRA    04COLADU02LEAHOP01PLANT 05ANIMAL01AGSM   05CAHF   08ASTR   05
  68CITR 63F 04-24-70 0.7   2   1
PLANT 05ANIMAL00SEED   14
  69CITR 73F 04-24-70 2.8   3   3
GRA    33PLANT 05ANIMAL01BOGR   01TROC   18SEED   02
  70CITR 68F 04-24-70 0.3   3   1
MAHATI05PLANT 00ANIMAL05SEED   20
  71CITR 96F 04-24-70 1.5   6   2
GRA    03SPIDER01LEAHOP01COLADU02PLANT 04ANIMAL02CAHF   04SEED   15
  72CITR 92F 04-25-7010.2   8   7
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COLADU03ROBFLY01DIPADU01LEPLAR02LEAHOP01ANT    01PLANT 03ANIMAL03CAHE   05BOGR   01
ARLO   01AGSM   01VINU   01ATCA   01SEED  06
  73CITR 78F 04-25-70 7.6  7  4
LEAHOP02GRA    02SPIDER01LEPLAR01COLADU02PLANT 03ANIMAL03ARLO   02AGSM   04CAHE   01
ARFR  01
  74CITR106F 04-25-70 3.3  5  6
GRA    05COLADU01CITHAI01PLANT 02ANIMAL04AGSM   03BOGR   01CAHE   01ARFR   08TROC   03
UNKF   03
  75CITR 95F 04-25-70 5.2  7  5
GRA    05LEAHOP01SPIDER01COLADU01CITHAI01PLANT 01ANIMAL05FEOC   04CAHE   01TROC   03
ARFR   01SEED  03
  76CITR 84F 04-25-70 4.9  5  3
LEAHOP01LEPLAR04COLADU01PLANT 05ANIMAL01FEOC   03CAHE   12KOSC   03
  77CITR 83F 04-26-70 3.5  5  5
DIPADU01GRA    04COLADU01PLANT 05ANIMAL01FEOC   02CAHE   01ARFR   02TROC   03SEED   03
  78CITR101F 04-26-70 7.6  6  1
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  79CITR 92F 04-26-7013.4  7  3
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  80CITR102F 04-27-7013.7  5  4
GRA    04SPIDER01COLADU01PLANT 05ANIMAL01AGSM   02CAHE   02TROC   02UNKF   03
  81CITR106F 04-27-70 4.2  5  3
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  83CITR104F 04-28-70 2.4  4  3
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  84CITR 93F 04-28-70 9.9  5  5
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  85CITR 92F 04-29-70 2.9  4  2
COLADU04SPIDER02PLANT 05ANIMAL01KOSC   13SEED   01
  86CITR 91F 04-29-70 7.3  5  4
GRA    04COLADU01MAHATI02PLANT 03ANIMAL03CAHE   04BOGR   01ARFR   09SEED   01
  87CITR 95F 04-29-70 0.9  3  3
COLADU05PLANT 05ANIMAL01BOGR   01OPPO   04ARFR   03
  88CITR118F 04-30-70 2.8  4  4
COLADU04GRA    02PLANT 05ANIMAL01SPCO   01UNKF   01SEED   17FUNGUS01
  89CITR 90F 04-30-70 0.5  3  4
GRA    05PLANT 03ANIMAL03CAHE   08BOGR   01ARFR   15SEED   01
  90CITR112F 04-30-70 2.9  5  4
COLADU03GRA    03LEAHOP01PLANT 02ANIMAL04BOGR   01ARLO   01TROC   05ARFR   07
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Rodent Reproductive

Rodent reproductive data collected in 1969 at the Pawnee Site is Grassland Biome data set A2U109B. An explanation of the data format and an example of the data follow.

Columns	Contents
1- 3	Speciman number (unique within a species and sex)
4- 7	Species code (CITI = *Spermophilus tridecemlineatus*, DIOR = *Dipodomys ordii*, ONLE = *Onychomys leucogaster*, PEMA = *Peromyscus maniculatus*)
8-13	Month, day, year
14	Sex (1 = female, 2 = male)
15	Reproductive condition (females; 1 = lactating, 2 = pregnant)
16	Disregard any information in this column
17-19	Weight (g)
20-21	Embryo stage (1 = early, 2 = mid-term, 3 = late term)
23-24	Number of recent placental scars
25	Presence or absence of placental scars

*** EXAMPLE OF DATA ***

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

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014PFMA052369101014
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023PFMA061769101014
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026PFMA062369102024042
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059PFMA071369122018041
060PFMA071569112020        1
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065PFMA071769113030052
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103PFMA092369113021        1
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122PFMA10246910 1017
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127PFMA10296911 2025
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135PFMA10296910 2018
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152PFMA112069122023052
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162PFMA11206910 1010
163PFMA11206910 3021
164PFMA11206910 2018
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167PFMA11216910 1015
168PFMA11216910 1012
169PFMA11216910 1012
170PFMA11216911 2019
171PFMA12036910 2018
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