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A STUDY OF RODENTS IN NORTHEASTERN COLORADO

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INTRODUCTION

Although there have been numerous studies on small mammal populations, few have had simultaneously available extensive information about the environment. Selected for intensive ecosystem analysis, the Pawnee Site in northeastern Colorado provides a unique opportunity to study small mammals. Data are available concerning a number of biotic and abiotic factors in the environment that may be related to small mammal populations. Further, rodents other than the Northern pocket gopher (*Thomomys talpoides*) and Plains pocket gopher (*Geomys bursarius*) have received little attention in eastern Colorado.

Study Area

These studies are located on the Central Plains Experimental Range (CPER) portion of the Pawnee Site. Within the CPER are three half-section pastures, each exposed to different grazing intensities and schedules for intensive investigation. These are referred to as pastures 23 west (lightly grazed), 23 east (heavily grazed), and 15 east (moderately grazed). Only live trap studies of small mammals are allowed within the three half-sections. Kill type trapping is relegated to other areas on the CPER and on adjacent prairie.

Target Species

Preliminary investigations indicated that small mammals present in large enough numbers to obtain meaningful data are *Dipodomys ordii luteolus* (Goldman), *Onychomys leucogaster arcticeps* Rhoads, *Peromyscus maniculatus osgoodi* Mearns, and *Spermophilus tridecemlineatus alleni* Merriam. This study is concerned primarily with these species.

Objectives

As the objectives of this study are quite varied and numerous, they are listed below and discussed, along with pertinent literature, under separate headings.

(1) Obtain a more accurate method for evaluating small mammal density from small live trap grids.

(2) Examine the effect of different grazing intensities on the density and distribution of the target species.

(3) Determine which of the target species is most important in terms of biomass at different times of the year.

(4) Estimate litter sizes, breeding seasons, breeding rates and mortality rates for the target species; moreover, if possible, isolate some factors that may affect these estimates.

(5) Determine if any of the target species have aberrant sex ratios at birth, and if so, examine how this ratio compares with juvenile and adult ratios from snap and live trap data, to test whether trap bias is as important as many investigators consider.

(6) Compare sex ratios from snap and live trap data to determine if the two methods give different results.

(7) Determine seasonal trophic level for *O. leucogaster*, *P. maniculatus* and *S. tridecemlineatus*.

Method for Evaluating Small Mammal Density from Small Live Trap Grids

At the Pawnee Site, three differently grazed half sections and three soil types within these half-sections needed sampling for small mammal density. In order to sample these areas with live trap grids, it was necessary to use grids of small size and relatively few traps (otherwise, the manpower and trap needs would be enormous.) However, with a small grid, a substantial number of captures, perhaps even a majority, come from areas peripheral to the grid. This peripheral effect can be reduced by increasing the size of the grid and/or by trapping both peripheral and grid areas with equal pressure and determining if an animal lives in or out of the grid on the basis of recaptures. Either of the above methods gives a large grid unsuitable for this study. One could obtain an estimate using the method of Blair (1941), who recommended trapping for one week to capture the resident animals, adding one-half the average home range of each species to the perimeter of the grid to estimate the area trapped, and then subtracting an estimate of transients in the population. However, determining the degree of transiency for each species is a major task itself. Moreover, the period necessary to capture most of the resident population at least once would be difficult to determine in advance. With a small grid, the assumption of a closed population needed for evaluating tag recapture data, as applied in the methods of Lincoln (1930), Hayne (1949), and Tanaka (1951), could not be made. Further, Smith (1968) found that density estimates of small mammals, using the Lincoln (1930) and Hayne (1949) indices, differed greatly from the actual density.

To evaluate small mammal density from live trap grids, an area is first trapped with live traps and subsequently "absolute" density is determined for the same area. The "absolute" density is determined with an electric fence enclosure similar to that described by Pequegnat (1949). The number of any species trapped, using the live traps, is then compared to the "absolute" density to obtain a correlation and thus a means of interpreting the live trap results in terms of density.

Effects of Different Grazing Intensities on Small Mammal Density and Distribution

Several researchers have observed the effects of different grazing practices on small mammals. Phillips (1936) found that *S. tridecemlineatus* and *P. maniculatus* were most abundant in moderately overgrazed grasslands of Oklahoma, and that they decreased in density with an increase or decrease in grazing beyond the moderately overgrazed stage. He also noted that *Sigmodon hispidus* and *Microtus ochrogaster* were restricted almost entirely to areas of heavy cover. According to Koford (1958), the results of overgrazing (such as short vegetation, increases in seed-producing forbs, and a high proportion of bare ground) favor *P. maniculatus*, while lack of grazing favors *M. ochrogaster*. Grinnell and Linsdale (1936) and Kalmback (1948) reported that *Citellus beecheyi* (Richardson) prefer low vegetation, as they dislike having their vision obscured. A study of overgrazing by Smith (1940a and 1940b) in Oklahoma indicates overgrazing and consequent erosion favor *P. maniculatus* and harvest mice (*Reithrodontomys*). Vorhies and Taylor (1940) noted a decrease in meadow mice and harvest mice and an increase in kangaroo rats, prairie dogs and ground squirrels with overgrazing of the North American Southwest. In Utah, Black (1968) found that *P. maniculatus* preferred heavily grazed pastures while the western harvest mouse (*Reithrodontomys megalotus*) was located in heavy grass or brush. Hawbecker (1940) noted that *Dipodomys venustus* rejected available perennial grass seeds and fed only on annual grasses and forbs which are favored by overgrazing. 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 are favored by grazing.

At the Pawnee Site, small mammal density and distribution are compared for lightly-, heavily-, and moderately-grazed short grass prairie. Unfortunately, a sufficiently large area of non-grazed short grass prairie is not available for study. These studies provide a basis for predicting the effects of different grazing intensities on the target species.

Litter Size, Breeding Periods, Breeding Rates, and Mortality Rates

Data concerning these parameters are lacking for the target species in northeastern Colorado. Further, with the possible exception of *P. maniculatus*, the total amount of data concerning these parameters for each of the target species is quite incomplete and in need of additional work.

D. ordii

Studying *D. ordii* in Nevada, Alcorn (1941) recorded a mean of 3.6 young per litter and a range of two to five from 50 pregnant females. In 22 pregnant *D. ordii* from New Mexico, Johnson (1956) recorded 2.37 embryos per litter with a range of two to three. Day, Egoscue, and Woodbury (1956) noted a mean of three young and a range of two to four per litter for 10 pregnant *D. ordii* from western Utah.

Breeding season was examined by Duke (1944) in central Utah on the basis of *corpora lutea*. He found two breeding seasons per year, the first from early January to or possibly through March, and the second from September through October. Determinations were made from 35 specimens. In New Mexico, Johnson (1956) recorded births from the end of February to early July with most births from March 21 to April 10. He theorized a second fall breeding season might occur when food is abundant. Breeding season, as indicated by male fecundity, was found to correspond closely to that found from observation of pregnant females. Breeding rates apparently have not been reported.

Estimations of mortality rates are not available for *D. ordii*, though Chew and Butterworth (1964) estimate that 12% to 19% of a *D. merriami* population survived one year. No correction was made for dispersal from the study area.

O. leucogaster

A range of four to six young per litter, with four normal for the first litter and five to six thereafter, was reported for *O. leucogaster* by Bailey and Sperry (1929). Svihla (1936) recorded a range of two to five per litter for laboratory-reared individuals. In 205 laboratory-reared *O. leucogaster*, Egoscue (1960) found a mean litter size of 3.6. For *Onychomys*, Hall and Kelson (1959) give a range of two to six young per litter.

According to Svihla (1936), *O. leucogaster* in Washington reproduce from May to August. Hall and Kelson (1959) recorded that *Onychomys* breed all year long, but mostly in summer and spring. Laboratory-reared individuals in Utah bore young from February through August.

Data on *O. leucogaster* breeding rates and mortality rates have not been reported.

P. maniculatus

From 48 pregnant *P. maniculatus* in central Washington, Scheffer (1924) recorded a mean litter size of five and a range of three to nine. In southern Michigan, Blair (1940) recorded an overall mean litter size of 4.0 ± 0.02. In Wyoming's Laramie Basin, Brown (1966) found 5.31 ± 0.49 embryos per pregnant female. Jameson (1953), in a four-year study of *P. maniculatus* in the Sierra Nevada Mountains in California, gave a much more comprehensive breakdown of litter size than the previously mentioned workers. He recorded the number of embryos per pregnant female to be as follows: March (4.0 ± 0.24), April (4.4 ± 0.10), May (4.9 ± 0.16), June (4.1 ± 0.61), July (5.7, N=3), August (4.7, N=3), September (4.2 ± 0.43), October (4.6 ± 0.35), and November (4.4 ± 0.19). He also found an increase in litter size with weight in females, though the increase was not significant. Beer, Macleod and Frenzel (1957) found that the potential litter size, based on *corpora lutea*, for *P. maniculatus* was smaller for young females than for old.

At 3,500-5,000 ft, in the Sierra Nevada of California, Jameson (1953) found pregnant females from March to April. A one-year study in Wyoming by Brown (1966), indicated the breeding season lasts from April to August. In a two-year study in Michigan, Blair (1940) noted *P. maniculatus* reproduction from April 1 to the end of October. Reproduction in *P. maniculatus* occurs year-round in central Washington, according to Scheffer (1924).

Breeding rates were observed for *P. maniculatus* by Brown (1966) in the Laramie Basin of Wyoming. Pregnant or lactating females included 41.7% in April, 92.8% in May, 93.3% in June, 75% in July, and 23.1% in August. Percentages of females pregnant were recorded in central Washington by Scheffer (1924) as follows: January (60%), February (22%), April (41%), May (16%), June (58%), July (27%), August (44%), September (46%), November (66%), and December (11%).

In Michigan, Blair (1948) found that 86.2% of the resident population disappeared in the fall and winter of 1938-39, and 90% in the fall and winter of 1939-40. These figures were used as estimates of mortality rates, despite some obvious dispersal effect. When compared with spring and summer mortality rates, the summer rate was slightly lower, but not enough to conclude there is a difference.

S. tridecemlineatus

In a three-year study of a population averaging 131 individuals in northern Texas, McCarley (1966) recorded an average of 4.9 young emerging from the nests of young females and 7.0 from old females. Rongstad (1965) recorded a litter size of 8.7 ± 0.3 (range 5-12) from 13-line ground squirrels in southern Wisconsin.

Breeding occurs from mid-April to May, with young born about 20-25 of May in southern Wisconsin (Rongstad 1965). McCarley (1966) recorded breeding in April, May, and June, with young born in May, June, and July, in northern Texas. Near Lincoln, Nebraska, Wade (1927) records that 13-line ground squirrels emerge from hibernation from mid-March to April and then begin breeding in three or four weeks. Although McCarley (1966) noted that some two-year-old females in Texas may have two litters per year, other authors have found only one litter per breeding season in areas farther north.

In Wisconsin, Rongstad (1965) noted that adult-mortality was highest in early summer. For juveniles, he found a large part of annual mortality occurs just before they enter hibernation. The density decreased from eight per acre, following emergence of young, to two the following spring.

Factors Affecting Breeding

Factors responsible for yearly and/or seasonal differences in litter size, breeding periods, breeding rates, male fecundity cycles, and mortality rates for the target species have received little attention on a species specific basis. There are indications that litter size increases with age in *O. leucogaster* (Bailey and Sperry 1929), *P. maniculatus* (Jameson 1953, Macleod and Frenzel 1957), and *S. tridecemlineatus* (McCarley 1966). Laboratory studies of *Peromyscus polionotus* by Williams, Carmona, and Golley (1965) and of *Mus musculus* by Rugh and Wohlfromm (1967) showed an increase in litter size from the first to the fourth litters. Working on *Perognathus longimembris, Perognathus formosus, Dipodomys merriami,* and *Dipodomys microps*, French, Maza, and Aschwanden (1967) presented evidence that breeding season and breeding rates were dependent on rainfall and subsequent plant growth. In *S. tridecemlineatus*, breeding closely follows emergence from hibernation (Wade 1927). Brown (1966) noted that the annual reproductive cycle in *P. maniculatus* coincided rather closely with the annual photoperiod cycle in Wyoming. He theorized that increased day lengths in spring initiate breeding activity, and decreasing photoperiods in late summer and fall are a factor in terminating it. According to Johnson (1956), the availability of food may regulate whether *D. ordii* have only a spring breeding season or an additional breeding season in the fall.

Discussion of Objective

In this study, litter size is determined for the whole pregnant population. Further, litter size is compared for young versus old adult females. Comparisons are made between different periods within a year and between the two summer periods. Breeding season is determined for the target species in northeastern Colorado and compared for the two different years. Breeding rates are examined for young versus old adults, total adults, periods within years, and between the two summers. Mortality rates are determined for different periods through the year where possible, and comparisons between years and periods are made.

All data are examined in relation to environmental factors that may affect them. In addition, the data are compared with those found by other workers at different altitudes, latitude, temperatures, etc., and suggestions made concerning the similarities and differences.

Aberrant Sex Ratios

Unequal sex ratios observed in small mammal studies quite often are blamed on trap bias (Blair 1940, Stickel 1946). Few authors have entertained the theory that some small mammal species may have sex ratios differing significantly from 1:1 because of inherent aberrancy of sex ratios in the offspring. Recently Terman and Sassaman (1967) produced substantial evidence that such an aberrant sex ratio exists in *P. maniculatus* and speculated that this aberrancy rather than trap bias may explain the unequal ratios generally observed for wild populations.

Embryos from the target species are used to estimate the sex ratios at birth, to determine if the ratio differs significantly from 1:1. Any aberrant ratios then are compared with those of adults and juveniles trapped with snap and live traps. These data provide a test of the assumed 1:1 sex ratio at birth for most small mammals and a basis for examining the ratios observed for juveniles and adults.

Comparison of Sex Ratio from Snap and Live Trap Data

Sex ratio data from live and snap traps are often considered noncomparable, due to differences in trap bias. Unfortunately, a great deal of valuable data may be lost because of this noncomparability.

At the Pawnee Site, sex ratios are compared for snap and live trap data, to determine whether or not the two methods give significantly different results for the target species. This provides an excellent test of the comparability of the two methods of obtaining sex ratios.

METHODS AND PROCEDURES

Evaluation of Small Mammal Density from Small Live Trap Grids

Comparison of "absolute" versus live trap data occurred only during the summers of 1969 and 1970, when sufficient manpower was available. Thirty by thirty meter grids were established and 16 Tomahawk live traps (3' x 3' x 10', metal) were placed at 10-meter intervals within each of the grids. Traps were baited with molasses and rolled barley. Captured animals were toe-marked and released daily for five days. At the conclusion of the five-day live trap period, a 40 x 40 m electric fence enclosure was set up with the live trap grid centered inside it. The electric fence enclosure is similar to that described by Pequegnat (1949), though several modifications were made. A description of the fence seems appropriate here. The vertical fence for slowing down and grounding small mammals consisted of 9" high, 1" mesh, chicken wire, held up with short pieces of rebar. Wire mesh of the same dimensions also was placed horizontally on the ground under the vertical fence to provide additional grounding. Nails bearing small porcelain insulators were driven in the ground on each side of the vertical fence. The electric fence wire was wound around the insulators on both sides of the vertical mesh wire and kept approximately one inch above the ground and away from the fence. Model A Ford spark coils were attached to each of the electric fence wires and attached to six-volt batteries. Small mammals attempting to cross the fence were electrocuted. Live traps were also run inside the grid to help remove the resident population. The electric fence was tended periodically throughout the day, but left without attendance in the evenings and at night. Mammals killed were recorded as from outside or inside the grid on the basis of position at death. Several small mammals could be dead on the same electric wire simultaneously without eliminating the killing power of the fence. Each electric fence was run continuously for five days. Few animals were caught after the third day.

Effects of Grazing

Pastures 23 east (heavily grazed), 23 west (lightly grazed) and 15 east (moderately grazed) were examined periodically for small mammal density and distribution from late June 1969, through the summer of 1970. Twelve 30 x 30 m grids, each containing 16 live traps spaced at 10 m intervals were placed in each half-section. The traps were further stratified with different soil types within each field, to eliminate the possible effects of small mammal soil preference on the results. Five grids were placed in sandy loams, four in the Midway Renohill complex (contains loose shale), and three in undifferentiated bottomland soils. Grids were trapped for five days during each trap period, with half the grids in each pasture in operation simultaneously. Thus, each trap period required a minimum of 10 days plus trap-moving time. Trap periods were scheduled to begin 52 days apart on the following dates: May 30, July 22, September 12, and November 3, 1969 and February 15, April 8, May 30, and July 22, 1970. Traps were baited with molasses and rolled barley, and animals marked, recorded, and released each morning. During extremely hot days, additional tending of traps was necessary to prevent mortality.

Litter Size, Breeding Season, Breeding Rates, and Mortality Rates

In the six-week intervals between live trap periods, small mammals were snap-trapped in areas adjacent to the differentially-grazed pastures. These animals were used for determination of litter size, breeding seasons, breeding rates, and age structure. Litter size is estimated from the number of embryos per pregnant female. Determinations of breeding seasons are based on the presence of embryos and interpolation, using gestation periods and embryo ages to estimate the beginning and end of breeding activity. Breeding rates are estimated from the percentage of pregnant and lactating adults captured. The target species are classified into juveniles, young adults, and old adults. Juveniles that are terrestrially active but have not yet begun reproducing are considered as young. These are identified on a weight basis. Young adults are identified by tooth wear and/or the presence of epiphyseal cartilage. These are adults born in the same breeding season as captured. Old adults are identified by the absence of epiphyseal cartilage and/or by tooth wear.

Overall mortality rates for each species during non-reproductive periods are obtained by comparing total live trap captures between trap periods and calculating the rate of decrease in population size.

Sex Ratio Studies

Sex ratios are examined by dissection in embryos from animals snap-trapped in areas adjacent to the differentially-grazed pastures. Sex determinations are made externally for live trapped animals and both externally and internally for snap-trapped animals.

RESULTS

Electric Fence Enclosure

Determination of "absolute" density with the electric fence enclosure has thus far proved to be an extremely time-consuming and difficult operation. Within the time limits of this study, it is doubtful that a good correlation can be obtained between live trap captures in the small grids and "absolute" density. Work on the electric fence will test the feasibility of making the comparison, improve the method for determining "absolute" density, and obtain a rough relationship (probably in the form of a linear function) between live-trap grid captures and "absolute" density. Four reasonably good electric fence versus "absolute" density comparisons have been made thus far and the results are given in Table 1.

Grazing and Rodent Biomass

Figures 1-4 provide comparisons between the numbers of target species captured in the three intensive study pastures. Thus far only *S tridecemlineatus* and *O. leucogaster* have been caught in large enough numbers to make any early conclusions. The results indicate there is no relationship between grazing intensities and number of *O. leucogaster* and *S. tridecemlineatus* captured per live-trap period. The habitat changes caused by different grazing intensities at the Pawnee Site probably are neither avoided nor preferred by these species and thus do not affect rodent biomass.

Fluctuations in Rodent Populations

Figure 5 shows total live trap captures for the live-trap periods. From late spring through mid-summer of 1969, *S. tridecemlineatus* represent the primary rodent biomass, while in late summer and mid-fall *O. leucogaster* become the primary rodent biomass. This is due to both a population peak in *O. leucogaster* and *S. tridecemlineatus* hibernation. Both *D. ordii* and *P. maniculatus* were found in low numbers and never were the primary rodent biomass.

Litter Sizes, Breeding Seasons, Breeding Rates, and Mortality Rates

Most of the snap-trapped rodents have been dissected and the uterus, testis, leg bones and skulls saved (stomachs also--see below). Examination for embryos, placental scars, male fecundity and general age of animals has just begun and no data are yet available.

Trophic Level Studies

Stomachs are being saved. Slides will be made and examined for frequency of occurrence of animal versus plant matter in different months. Ground and dried stomach contents will be saved for Dr. Richard Hansen.

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Table 1. Electric fence results.

Grid #	Species	Live Trap Captures	Electric Fence Enclosure Captures	
			All Captures	Toe-Marked Captures
1	*Onychomys leucogaster*	4	1	1
	Dipodomys ordii	2	0	0
	Spermophilus tridecemlineatus	6	0	0
2	*Spermophilus tridecemlineatus*	3	2	1
	Dipodomys ordii	0	1	0
	Peromyscus maniculatus	1	0	0
3	*Peromyscus maniculatus*	1	0	0
	Spermophilus tridecemlineatus	4	5	2
	Dipodomys ordii	0	1	0
	Onychomys leucogaster	0	1	0
4	*Onychomys leucogaster*	1	0	0
	Peromyscus maniculatus	1	1	0
	Spermophilus tridecemlineatus	1	0	0
TOTAL	*Onychomys leucogaster*	5	2	1
	Dipodomys ordii	2	2	0
	Spermophilus tridecemlineatus	14	7	3
	Peromyscus maniculatus	2	1	0

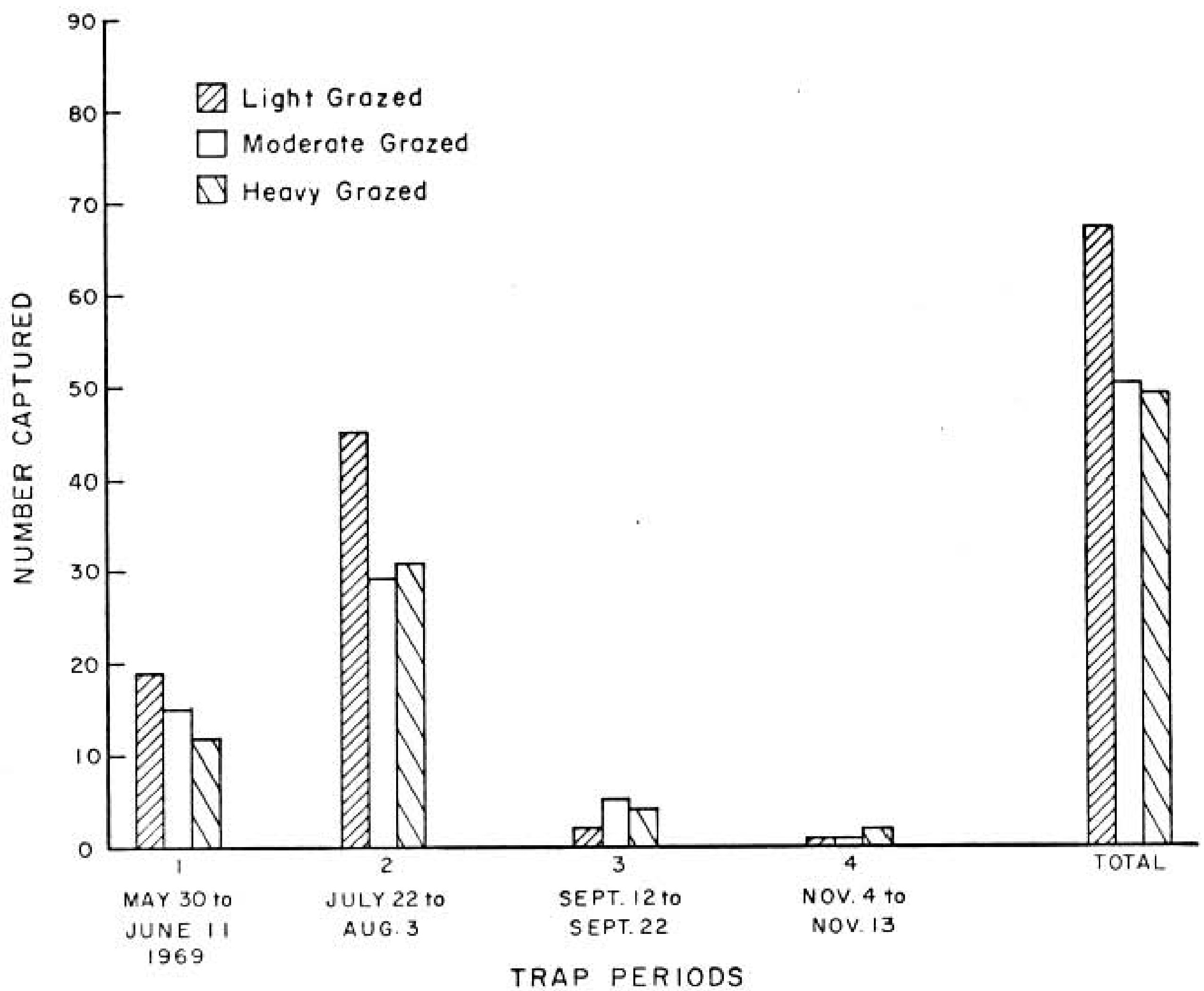
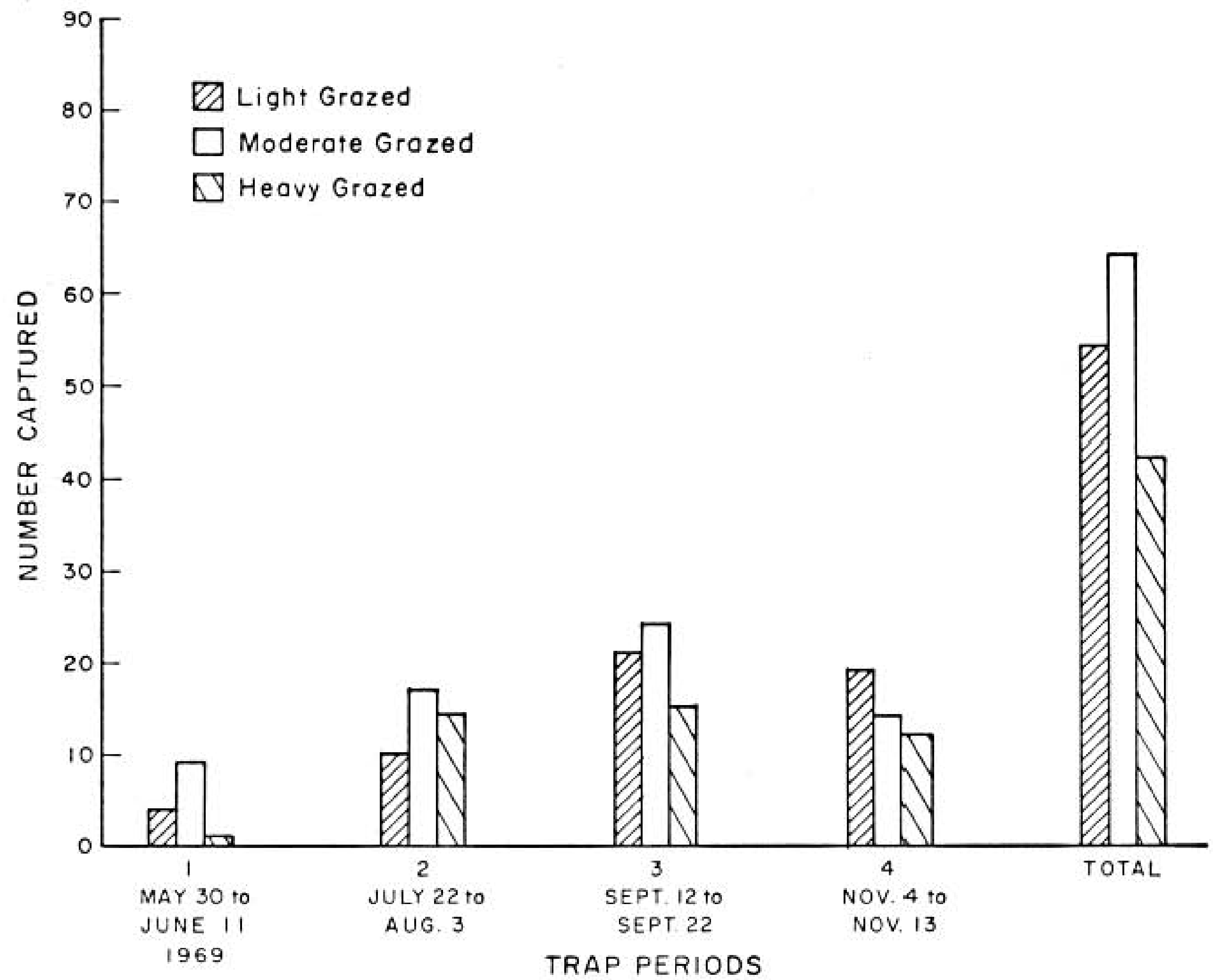


Fig. 1. *Spermophilus tridecemlineatus* captured per trap period in light, moderate and heavy grazed pastures.



. 2. *Onychomus leucogaster* captured per trap pe[illegible]od in light, moderate and heavy grazed pastures.

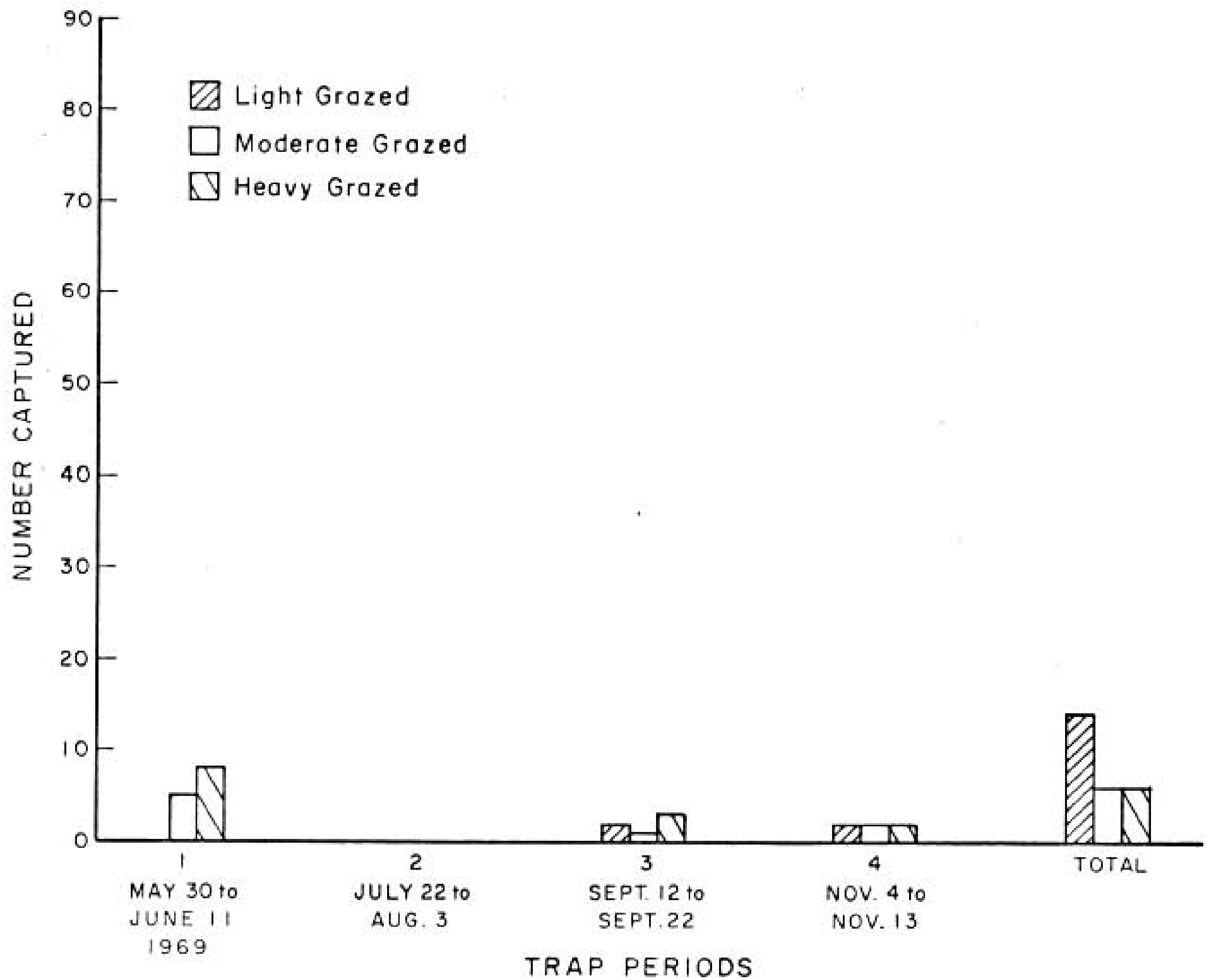


Fig. 3. *Peromyscus maniculatus* captured per trap period in light, moderate and heavy grazed pastures.

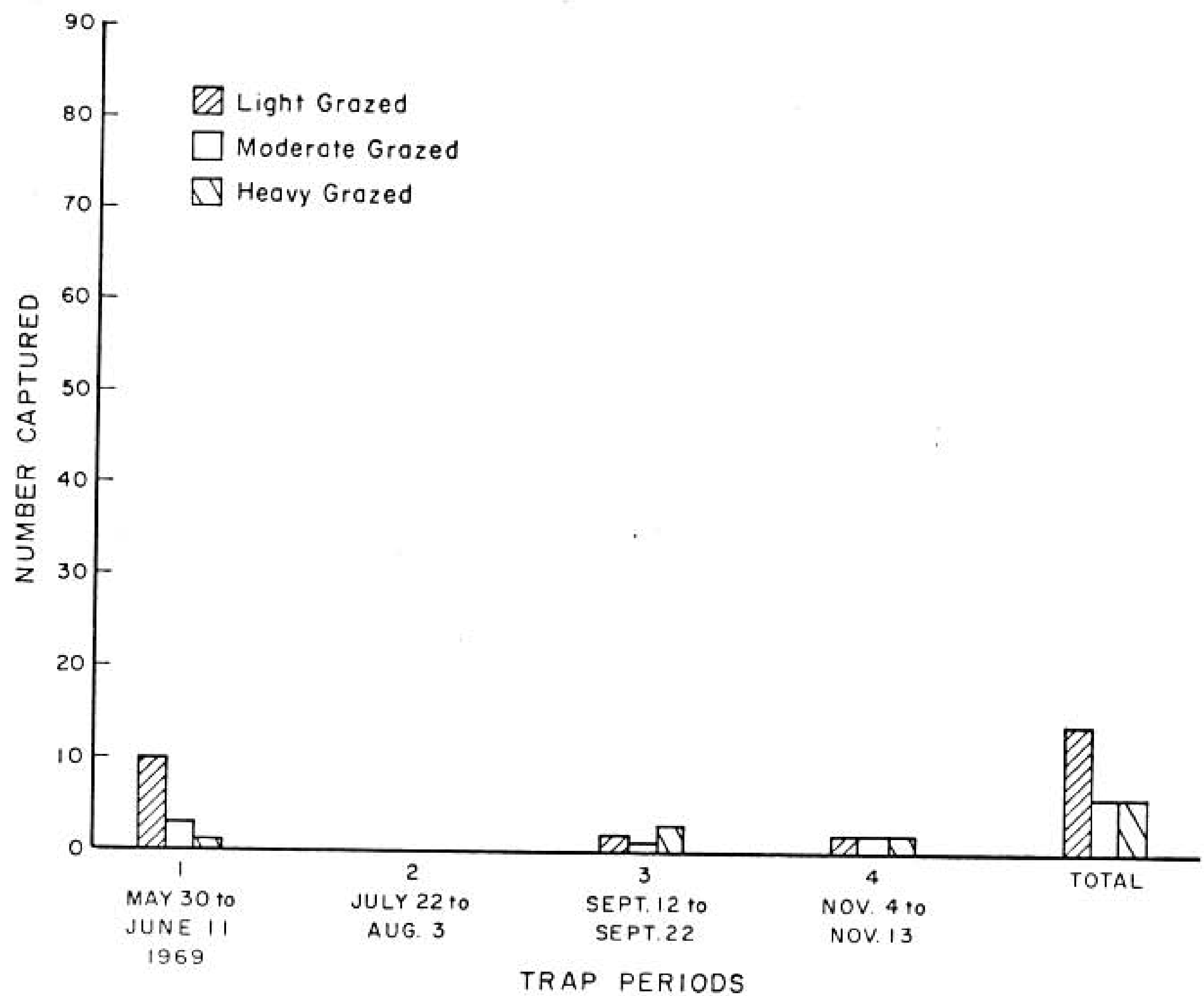


Fig. 4. *Dipodomys ordii* captured per trap period in light, moderate and heavy grazed pastures.

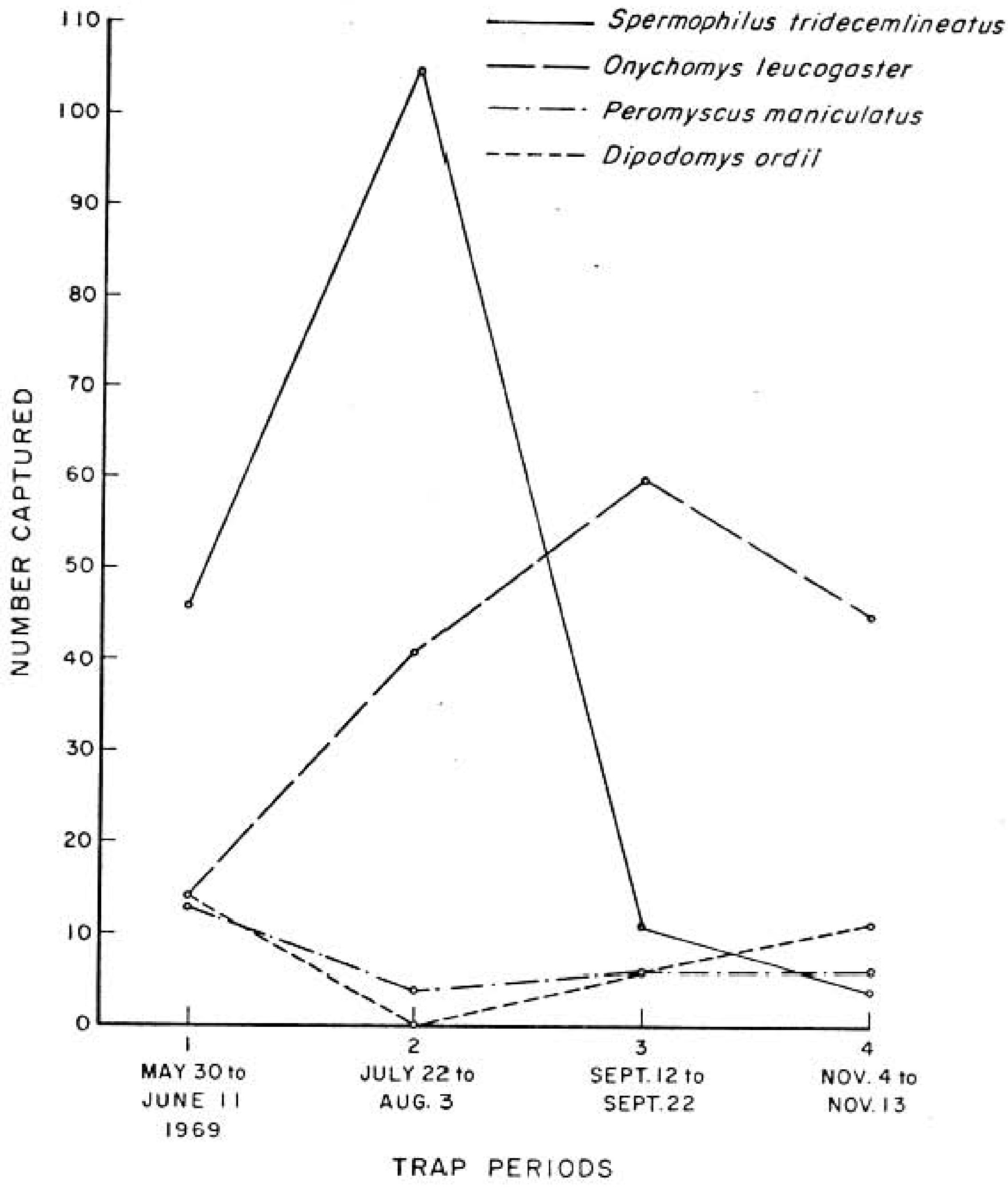


Fig. 5. Total number of the target species captured per live-trap period.