Inter-annual differences in abundance of thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) in Colorado shortgrass steppe

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Abstract

We live-trapped thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) on three grassland and three saltbush-dominated sites in June and July 1999 to estimate population densities in representative vegetation types in shortgrass steppe, and to describe changes in population structure and body weight during their summer active period. We also compared population densities in 1999 to estimates from 1995, the last time that ground squirrel populations were surveyed on the SGS-LTER site in north-central Colorado. As in 1995, most squirrels captured in June 1999 were adults; the near absence of juveniles in June 1999 compared to the earlier study suggested that reproduction was delayed this year. Juveniles comprised >70% of individuals captured in both habitats in July 1999, and were especially numerous on grassland sites. However, in contrast to 1995, when squirrels much more common in saltbush habitats, squirrels were significantly (2-3X) more abundant on grassland webs in 1999. The difference in population densities between habitats in 1995 vs. 1999 was unexpected because both years had similarly high early-season precipitation, and presumably, similar vegetation. Moreover, there were no consistent differences in the abundance of arthropod prey between years that could readily explain the differences in squirrel abundance. Additional long-term studies of ecology and population dynamics of thirteen-lined ground squirrels in shortgrass steppe will be necessary to identify the factors that determine patterns of abundance of this critical species over time.

Introduction

Thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) are common small mammals in shortgrass steppe, and comprise most of the small mammal biomass in these grasslands. As such, these semi-fossorial omnivorous rodents play an important role as consumers of arthropods and seeds, and are major prey of many of the resident and migratory predators in the region, including raptors, snakes, and mammalian carnivores. Long-term studies, initiated as part of the Shortgrass Steppe Long-Term Ecological Research Project (SGS-LTER), have focused on monitoring temporal changes in populations of small nocturnal mammals in representative grassland and saltbush (*Atriplex canescens*) vegetation types in north-central Colorado. In comparison, there is relatively little information on trends in abundance of ground squirrels, which are diurnal and active aboveground only during late-spring and summer. Higgins and Stapp (1997; *Prairie Nat. 29:25*) reported that, on average, ground squirrels were nearly 5 times more abundant in saltbush habitats than shortgrass-dominated grasslands. They speculated that saltbush areas may of higher quality for ground squirrels, in part because of the abundance of potential arthropod prey in shrub areas. However, their study was limited to a single, unusually wet year (1995). Here, we report population densities of thirteen-lined ground squirrels in grassland and saltbush habitats in 1999, and compare them to density estimates from 1995. Estimates of abundance of arthropod prey are also available for both years and are compared to assess whether consistent differences in prey abundance can explain patterns of squirrel population density. We also describe changes in population structure and body weight that occur during summer, when squirrels are most active aboveground.

Methods

Trapping methods followed those described in Higgins and Stapp (1997), except that traps were open for 4 (rather than 3) consecutive days. Trapping webs (3.14 ha) were established in three grassland and three saltbush areas in 1994 to estimate population densities of nocturnal rodents. To estimate ground squirrel abundance, we placed 61 traps on each web, with traps spaced 20 m apart along 12 transects (five traps/transect) and one trap in the center. Traps were covered with thick cardboard to prevent animal's from overheating. Webs were trapped 1-11 June (hereafter, June) and 19-29 July (hereafter, July). Traps were opened at dawn and checked approximately hourly from 0930-1200. Sex, age, reproductive status, and weight were recorded for all individuals. All individuals were marked with a felt marker and released at the capture location.

We calculated population density for each site for June and July combined by dividing the mean number of individuals captured by the effective trapping area (4.6 ha). The effective trapping area was estimated by adding a 20.4-m boundary ring to the area bounded by the traps to account for captures of individuals on the web boundary.

Higgins and Stapp (1997) suggested that variation in the abundance of arthropod prey may partially explain differences in squirrel abundance between shrub and grassland cover types. We estimated abundance of arthropods on trapping webs in 1999 from captures of insects and spiders in pitfall traps established on each web. Pitfalls (20 per web) were opened for 4 consecutive days in July and early August, periods that were comparable to arthropod sampling in 1995 (10-24 July). Arthropods were identified to the species level whenever possible, but here we restricted our comparisons to the most common families of Coleoptera and orders of other groups.

Results - Population structure and body weight (Table 1)

Nearly all individuals captured in June were adults (Table 1). In contrast, juveniles made up >70% of the captures in July on both habitats as a result of breeding in May and June. However, grassland areas not only supported more adult females in June but in July, these females also had higher average reproductive success (2.1 juveniles/female) than those living in saltbush areas (1.3 juveniles/female). (We assume that juveniles were born on-site and were not immigrants from other habitats).

Adult weights were significantly lower in June than July (ANOVA, F=18.00, P=0.0001), which may have reflected the lower weight of squirrels soon after emergence from hibernation, or the fattening of adults prior to estivation in autumn. The increase in weight between June and July was similar for males (14.8%) and females (12.5%). However, there was no significance difference in adult body weight between grassland and saltbush areas (F=0.78, P=0.38).

Results - Squirrel and arthropod abundance (Figs. 1 & 2)

Overall, ground squirrels were significantly more abundant in grassland areas than saltbush sites (t-test, P=0.01; Fig. 1), due primarily to large differences in the number of squirrels captured in July (P=0.0002). Squirrel numbers remained relatively constant between trapping sessions on saltbush areas. In contrast, squirrel numbers increased from early to mid-summer on grassland webs as a result of production and/or immigration of juvenile and subadult animals.

Beetles, and especially tenebrionids, the most commonly captured arthropods in pitfall traps, were significantly more abundant in grassland than saltbush areas (Fig. 2). No other arthropod groups differed significantly in abundance between habitat types. We do not have estimates of differences in abundance of grasshoppers (all Orthoptera captured were sand and field crickets).

Results - Comparisons with 1995 results (Fig. 3)

Higgins and Stapp (1997) found higher population densities of ground squirrels in saltbush than grassland areas. But this pattern was completely reversed in 1999, with 2-3 times more squirrels captured on grassland than saltbush webs (Fig. 3). Densities in saltbush areas in 1999 were equivalent to that in grasslands in 1995.

More juveniles (ca. 3 per web) were captured in June 1995, especially on saltbush sites, than in June 1999, suggesting that reproduction apparently was delayed in 1999. In July 1995, some 79% of the captures in grassland areas were juvenile squirrels, which was similar to our results for 1999 (71%). Juveniles made up only 61% of saltbush captures in July 1995, compared to 74% for the same period 4 years later, reflecting the scarcity of adults on saltbush sites (<2 per web) in mid-summer 1999.

Early-season precipitation in 1995 was the highest recorded during the previous 31 years (**Table 2**). However, rainfall in late-spring and early summer 1999 was almost as high, and precipitation for the entire 1999 growing season (April-September) was 168% of the 31-year mean, and second only to 1997 in total rainfall. The striking difference in squirrel abundance in grassland and shrub habitats between two similarly wet years therefore suggests that the amount and timing of precipitation alone cannot explain squirrel abundance. We recorded vegetation characteristics on trapping webs in 1999, and can compare these data with similar data collected in 1995 to determine if there are differences in habitat features between years that might have affected squirrel abundance. We are not aware of differences in grazing intensity between grassland and saltbush areas in 1995 and 1999. However, in wet years we would expect high squirrel densities on sites with more grazing pressure because cattle would keep vegetation short, and hence more suitable for ground squirrels (Higgins and Stapp

Conclusions

Thirteen-lined ground squirrels are an important and representative component of the vertebrate fauna in shortgrass steppe. Our results showed substantial differences in population densities between habitats and over time, differences that cannot be easily explained with existing data. The tentative conclusions reached by Higgins and Stapp (1997) regarding the relative quality of saltbush vs. grassland habitats and the importance of certain arthropod prey therefore seem premature. Regular monitoring of long-term trends in ground squirrel abundance, as well as intensive studies of population dynamics, diet and prey availability, would contribute greatly to our knowledge of this species' biology and the ecology of shortgrass steppe.

Table 1. Age structure, sex ratio and body weight (mean ± 1 s.e.; n = 3 webs) of thirteen-lined ground squirrels on three grassland and three saltbush sites on the SGS-LTER site in June and July 1999. Weights of individuals from grassland and saltbush areas were combined in each month.

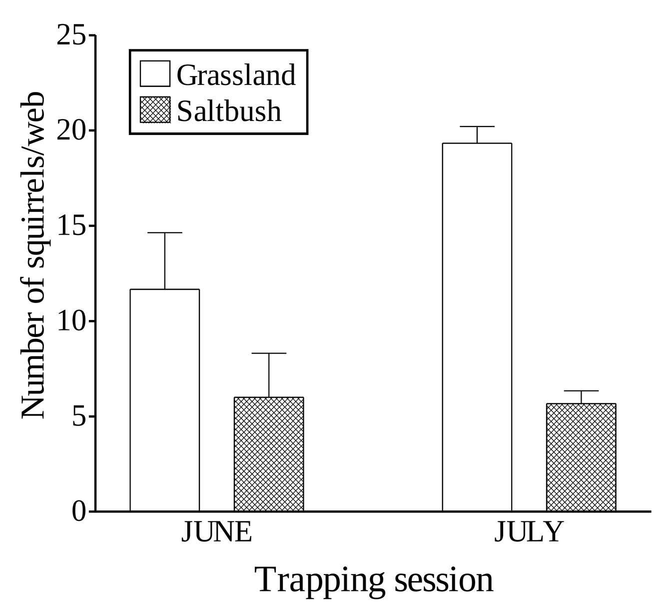
	June		July	
	Grassland	Saltbush	Grassland	Saltbush
ult/juvenile	2.6 ± 2.6	0	71.4 ± 7.7	72.4 + 7.63
ırecorded)				
	14:20:0	9:9:0	11:9:0	2:3:0
ıile	0:1:0	0	18:23:1	7:3:2
	125.9 ± 10.2 (50)		142.9 ± 23.1 (22)	
	-		84.4 ± 20.1 (45)	
	22.0 (1)		58.0 ± 12.5 (8)	

Table 2. Rainfall (mm) on the SGS-LTER site during the July-September growing season in 1995 and 1999. Values in parentheses are precipitation values expressed as a percentage of the 31-year mean (1969-1999; April-June = 147 mm; July-September = 129 mm).

period	1995	1999
-season (April-June)	318 (216%)	311 (211%)
season (July-September)	91 (70%)	155 (120%)

Table 2 (OLD). Population densities (mean ± 1 s.e.; n = 3 webs) of thirteen-lined ground squirrels on the SGS-LTER site in 1999 relative to estimated densities in 1995 (Higgins and Stapp 1997). Values in parentheses are precipitation estimates expressed as a percentage of the 31-year mean (1969-1999; April-June = 147 mm; July-September = 129 mm).

	1995		1999	
	Grassland	Saltbush	Grassland	Saltbush
Squirrel density (no./ha)	1.3 ± 0.4	5.8 ± 2.3	3.4 ± 0.3	1.3 ± 0.3
Precipitation (mm)				
April-June	318 (216%)		311 (211%)	
July-September	91 (70%)		155 (120%)	



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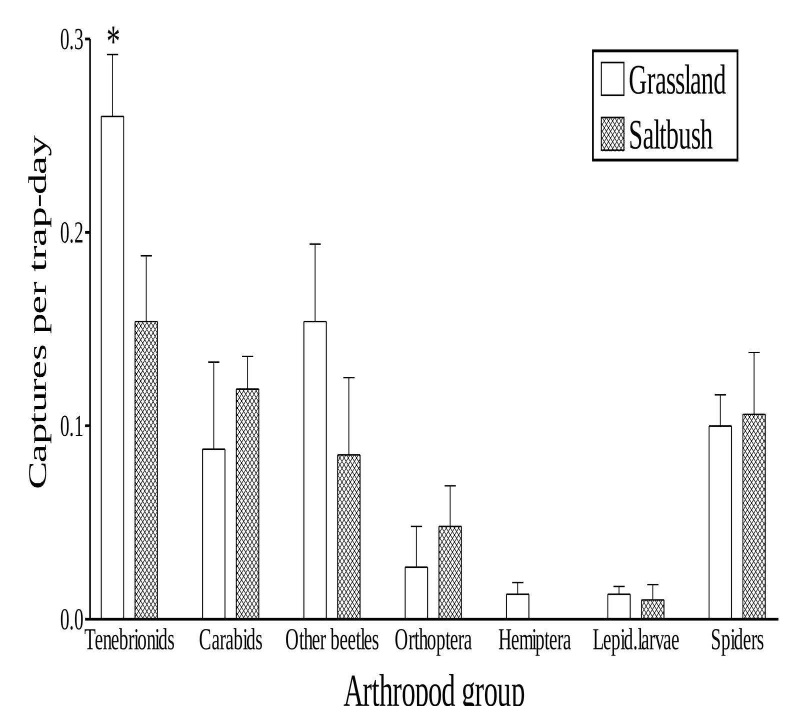

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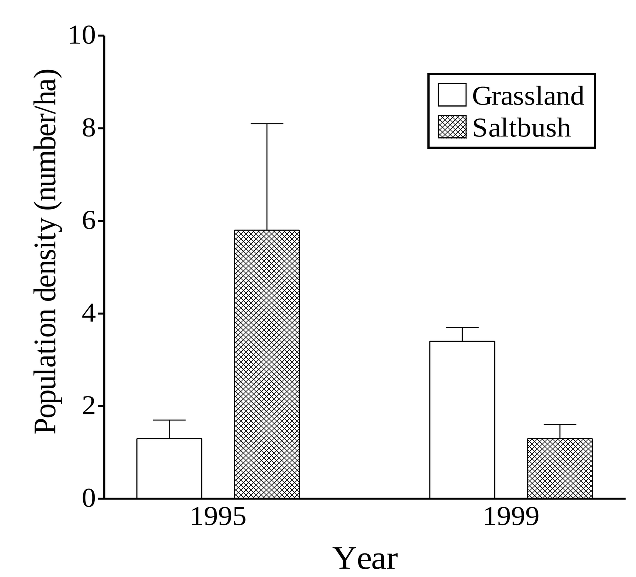

Fig. 3. Population densities (mean + 1 s.e., n = 3 webs) of thirteen-lined ground squirrels on the SGS-LTER site in 1999 relative to estimates from 1995 (Higgins and Stapp 1997).