

Influence of Habitat on the Aggressive Behavior of 13-lined Ground Squirrels (*Spermophilus tridecemlineatus*)

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Abstract

13-lined ground squirrels (*Spermophilus tridecemlineatus*) are becoming more common on the campus of University of Michigan Biological Station (UMBS) in the northern Lower Peninsula of Michigan. We tested the hypothesis that this increase is due to areas of open habitat resulting from increased use of the UMBS environment by human residents. During the summer of 2014, we trapped and marked seven 13-lined ground squirrels. We observed the aggressive interactions between the ground squirrels with other species when competing for food. *S. tridecemlineatus* behaved more aggressively in open areas (Table 7: $\chi^2 = 10.011$, $df = 2$, $P \geq 0.05$) and dominated other diurnal squirrel species in them (Table 3: $\chi^2 = 7.735$, $df = 1$, $P \leq 0.05$).

Introduction

Interspecific and intraspecific competition to obtain essential resources such as food, territory, and mates are often associated with aggressive behavior. Aggression is a general term used to describe the intention to inflict harm on another organism (Olivier & Young, 2002). Population density plays a role in the aggressive behavior of squirrels. We chose the 13-lined ground squirrel as our study species due to the recent increase in population size found along the shoreline of Douglas Lake in University of Michigan Biological Station (UMBS) located at Cheboygan Co., Northern Michigan.

S. tridecemlineatus is a small sciurid commonly found in open, grassland areas of the United States of America. A 13-lined ground squirrel is slightly bigger than an eastern chipmunk (*Tamias Striatus*) with an average body length of 250mm. These squirrels give birth to an approximate of 8 to 9 offspring annually in the spring and hibernate from August to March (Kurta, 1995).

In recent years, an increase in land use around UMBS campus has resulted in more open ground in residential areas. *Spermophilus* numbers have increased, and we suggest that in part this is due to the increase in the open habitats that it prefers. In particular, we hypothesized *S. tridecemlineatu* would be more successful in aggressive encounters in open environments compared to success in other areas. Other squirrel species including eastern chipmunk, red squirrel (*Tamiasciurus hudsonicus*), and eastern gray squirrel (*Sciurus carolinensis*) share the same general area but are believed to favor woodier habitats.

We caught and marked seven individual ground squirrels and documented their behavior. In two weeks, we recorded the results of aggressive encounters in open areas, shrubby areas, and border areas (Figure 2). Using data on four of the ground squirrels that exhibited the most activity, we documented and compared their behavior in different habitats.

Methods

Study site

The study took place at University of Michigan Biological Station campus located on the southern shore of Douglas Lake near Pellston, Cheboygan Co., Northern Lower

Michigan. This study involved three zones situated at the east end of East State Street where faculty cabins are found (Figure 1). The zones were a blend of sparsely woodland areas with a majority of aspen (*Populus spp.*), red and white pine (*Pinus resinosa* and *Pinus strobus*), red oak (*Quercus rubra*), and sugar and red maple (*Acer saccharum* and *Acer rubrum*). Within the woodland are interspersed areas of shrubs and some open grassy or sandy areas. The shrubs consists of mainly bracken fern (*Pteridium aquilinum*), blueberry and huckleberry (*Vaccinium spp.*), and wintergreen (*Gaultheria procumbens*) plants.

Squirrel activity Protocol

The students of the UMBS Field Mammalogy course trapped and marked 13-lined squirrels and observed their behavior for 12 days, from 30th of June to 11th of July 2014.

Capture-mark-release technique

We trapped squirrels using Havahart (17”L x 5”W x 5”H) and Tomahawk (19”L x 6W” x 6”H) traps baited with sunflower seeds. We used a solution of Nyanzol-D fur dye (Melchior and Iwen, 1965) to mark 13-lined ground squirrels with individually-recognizable patterns. We weighed individuals captured using a spring balance and determined their sex, then released squirrels at their capture sites and followed them to locate their burrows. These were marked with colored flags.

Behavioral Study

Observers worked in pairs. We observed squirrels between 9-4pm, when they were most active. In each zone, we recognized 3 different habitat types as follows: open ground, border (between open ground and patches of shrubs), and shrubs (Figure 2). We placed a

feeding tray with approximately 1 cup of sunflower seeds in one of these habitats, which was chosen randomly. We made a behavioral ethogram in which observers recorded types of aggressive behavior exhibited by ground squirrels in their interactions with other squirrel species (Table 1). We noted the identity of the aggressor and the individual(s) that was (were) the object of aggression. We categorized ground squirrels as winners if they chased away the opponent(s) or continued to feed with the opponent(s) after confrontation. A losing individual stopped feeding and fled. Because each of the 3 habitats was observed for a different number of hours, to determine if the number of observations of ground squirrels activity was different for each habitat, we corrected the actual numbers of observed by the amount of time spent by observers in each habitat.

Statistical analyses

Statistical analyses were carried out using chi-squared tests.

Results

Seven ground squirrels were marked. Of the marked animals, four exhibited high activity, while three exhibited low to no activity during the observation period. Feeders were also visited by chipmunks (*Tamias striatus*), red squirrels (*Tamiasciurus hudsonicus*), gray squirrels (*Sciurus carolinensis*), and mourning doves (*Zenaida macroura*); however, encounters with gray squirrels and mourning doves were uncommon and are not included in the analyses below.

Overall Success in Interspecific Encounters

The proportion of wins and losses by ground squirrels against the two other species of scurids that were common enough to consider was significantly different (Table 2: $\chi^2=20.0144$, $df = 1$, $P \leq 0.05$).

Interspecific Aggression in Different Habitats

The overall proportion of encounters won varied significantly among the habitats (Table 3: $\chi^2 = 7.735$, $df = 1$, $P \leq 0.05$). The success rate for 13-lined ground squirrel was highest in open habitats and lowest in shrubs (Table 3), but ground squirrels won a majority of all encounters regardless of habitat. When we broke the encounters down by interacting species, we found that the percentage of encounters won by 13-lined ground squirrels against both eastern chipmunks and red squirrels was highest in the open environment. In the shrub habitat, ground squirrels won no encounters with red squirrels but continued to win a high proportion of encounters with chipmunks (Table 4 and Figure 3; we were unable to test the significance of this pattern due to the low number of encounters with red squirrels). To determine if the number of encounters won by ground squirrels against chipmunks varied among habitats, we corrected the observed number of wins by the number of hours spent by observers in each habitat (Table 5: χ^2 value = 12.06; $d.f = 2$, $P \leq 0.05$).

Number of Observations in different habitats

We corrected the number of observations based on the number of hours spent by observers in each habitat to determine if the number of observations differed among

habitats. 13-lined ground squirrels were most active in the border environment but least active in the shrub environment (Table 6: χ^2 value = 14.9961, df = 2, $P \geq 0.05$).

Behavior of 13-lined Ground Squirrels in different habitats

Frequency of the aggressive behaviors “chasing” and “chattering/growling” differed significantly among open, border, and shrub sites (Table 7: $\chi^2 = 10.011$, df = 2, $P \geq 0.05$), and ground squirrels exhibited agonistic behavior most frequently in open habitats.. “Biting,” “scratching,” and “pushing” were seldom seen. “Growling/chattering” was commonest in open habitats while “chasing” was most commonly seen in shrub habitats (Figure 4).

Behavior by individual 13-lined ground squirrels

Among the four 13-lined ground squirrels with large numbers of encounters, the most successful won 87% of encounters and the least successful won 73.5% (Figure 5). Percent of encounters won was negatively related to body mass, but the number of squirrels was too low to permit statistical testing of the relationship (Figure 6).

Discussion

The proportion of encounters won by 13-lined ground squirrels, the number of observations, and the behavior of the squirrels all differed among open, border, and edge habitats.

Interspecific Aggression and body size

We first compared the social behavior of 13-lined ground squirrels with eastern chipmunks and red squirrels across all types of habitats. Although other species like gray

squirrels and dove interacted with 13-lined ground squirrels, encounters were too rare to analyze. 13-lined ground squirrels are slightly larger than eastern chipmunks but smaller than red squirrels. 13-lined ground squirrels had a higher chance of succeeding in aggressive encounters with eastern chipmunks than with larger red squirrels, suggesting that the size of opponent influenced the success rate of our study species.

Habitats

13-lined ground squirrels stood the greatest chance of winning a fight/competition in open habitats, and they did most poorly in shrub habitats. Ground squirrels also appeared to behave more aggressively in open environments as compared to border and shrub habitats. In addition, we observed growling/chattering behavior the most often in an open habitat, followed by a border habitat, and lastly a shrub habitat. On the contrary, 13-lined ground squirrels chased off their opponents most often in a shrubby environment but least often in an open environment.

13-lined ground squirrels were more active in border environments than in open and shrub environments. Border habitats may serve as an intermediate environment that provide a place for squirrels to seek refuge from predators but at the same time, immediate access to the open habitat they prefer. The observation that 13-lined ground squirrels were least active in shrubby areas supports Kurta's (1995) statement that thirteen-lined ground squirrels avoid wooded areas. In fact, all the results suggested that thirteen-lined ground squirrels were most aggressive in an open environment but least aggressive in a shrub habitat.

Behavior by individual 13-lined ground squirrels

Aside from our focal study, we investigated the behavior of the most active individual ground squirrels. Throughout the observation period, we observed the greatest behavioral activity in squirrel no.3 (Chickadee). Almost half of the total number of observations involved Chickadee (135 of 277 observations). One possible explanation was that most of the observations were carried out near Chickadee's burrow.

Squirrel 5 (two-spots) won the highest percentage of encounters. 2-spots was a male juvenile that weighed the least of the four ground squirrels with adequate numbers of interactions for analysis. Sex and growth stage might be important factors.

The weight of 13-lined ground squirrels was negatively related to their percentage of encounters won. It is possible that the lightest squirrels urgently needed to gain fat and prepare for the upcoming winter and hence, behaved more aggressively while competing for food. Other possible reasons for aggression exhibited by female ground squirrels include gathering food for their babies, defending babies, and recovering from producing them. Nevertheless, the individual most successful at aggression was a male.

Future study

Towards the end of observation period, a large number of baby 13-lined ground squirrels emerged. Previous studies reported that female ground squirrels may kill other females' babies to secure resources for their own babies. It would be interesting to address this problem in the future. Measuring a female's level of aggression as function of distance from burrow might be one way to do this.

Conclusion

In conclusion, the behavior of 13-lined ground squirrels varied among the habitats. We rejected our null hypothesis that claimed no difference in the aggressive behavioral activity but accepted our alternative hypothesis that a markedly difference of activity was observed among the habitats with a greater rate of aggressive behavior in open ground. In addition, we observed a higher success rate of thirteen-lined ground squirrel in open habitats than in shrub habitats. Their success in open habitats might explain why 13-lined ground squirrels have increased in number and area colonized on the UMBS campus.

Acknowledgements

We thank the students of UMBS Field Mammalogy 2014 for spending their precious time in collecting data for this study over the observation period. Also, we thank Ari for providing the methods section. Lastly, we wish to express our gratitude and appreciation to Professor Philip Myers and Teaching Assistant Kayla Paulson for providing useful advice and guidelines in helping us to complete this study and paper.

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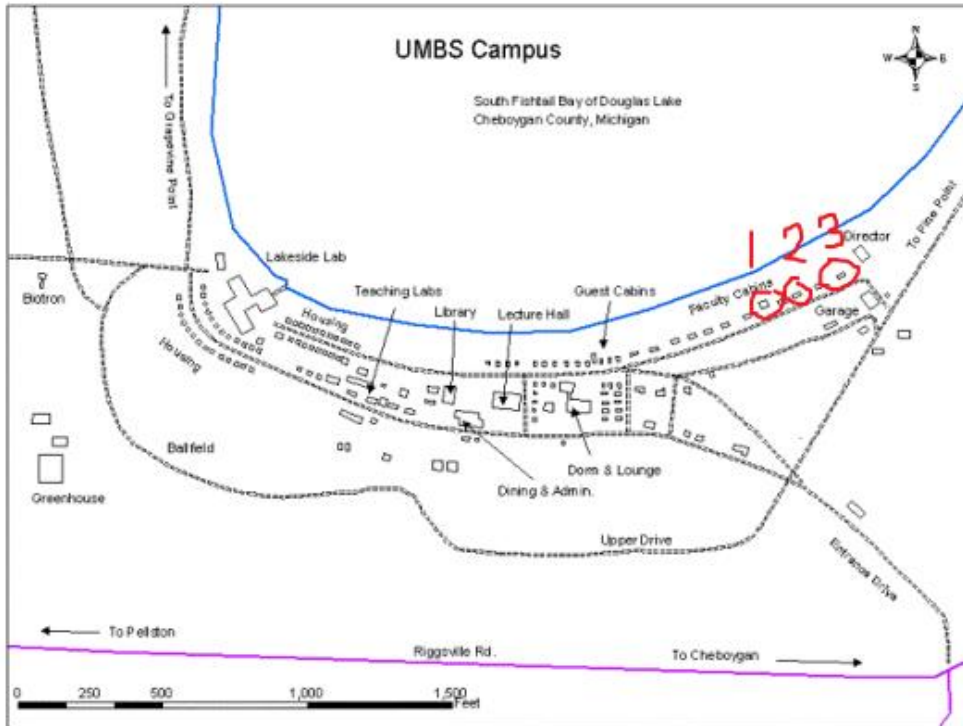


Figure 1:
Study
zones at the
UM
Biological
Station
campus



Figure 2: Open, border, and shrub habitat at one of the zones

Table 1: Types of aggressive behavior exhibited by 13-lined ground squirrels

Types of aggressive behavior					
Biting					
Chasing					
Scratching					
Pushing					
	Win		Loss		Total
	Observed	Expected	Observed	Expected	
Eastern Chipmunks	140	130.61	20	29.39	160
Red Squirrel	20	29.39	16	6.61	36
Total	160		36		196
Growling/chattering (verbal communication)					
Fleeing					
No reaction					

Table 2: Interspecific encounters of 13-lined ground squirrels

Table 3: Number of wins and losses of 13-lined ground squirrels in different habitat

	Open		Border		Shrub		Total
	Observed	Expected	Observed	Expected	Observed	Expected	
Win	62	56.28	70	70.55	21	26.16	153
Losses	9	14.72	19	18.45	12	6.84	40
Total	71		89		33		193
Success rate	87.32%		78.65%		63.64%		-

Table 4: Interspecific behavior in different habitats

	Open		Border		Shrub	
	Win	Loss	Win	Loss	Win	Loss
Chipmunks	60	6	59	8	21	6
Red Squirrel	7	1	13	11	0	4
Total	67	7	72	19	21	10

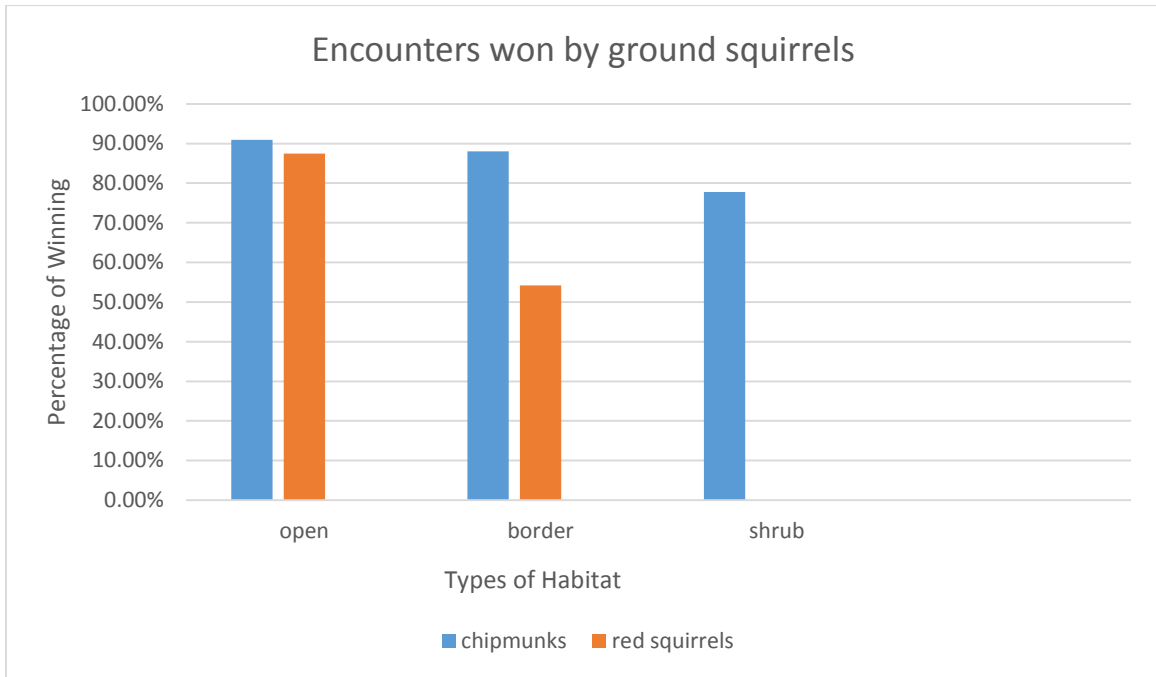


Figure 3: The percentage of encounters won by 13-lined ground squirrels in each habitat

Table 5: The number of encounters won between 13-lined ground squirrels and chipmunks.

	Open	Border	Shrub		Total
Winning against Chipmunks	Observed 60	Observed 70.8	Observed 42	Expected 57.6	172.8

Table 6: Number of Observations in different habitats corrected by the number of hours of observation carried out in each habitat.

Habitat	Open	Border	Shrub	Expected	Total:
No. of observations	100	116	42	---	258
Hours of observation	24	20	12	---	---
No. of observations (corrected)	100	139.2	84	107.73	323.3

Table 7: Types of aggressive behavior exhibited by 13-lined ground squirrels in different habitats.

	Open		Border		Shrub		Total
	Obs.	Expected	Obs.	Expected	Obs.	Expected	
Chase	26	35.29	35	33.94	16	10.41	100
Chatter/ Growling	52	42.71	40	41.06	7	12.59	121
Total	78		75		23		221

*Obs. (Observation)

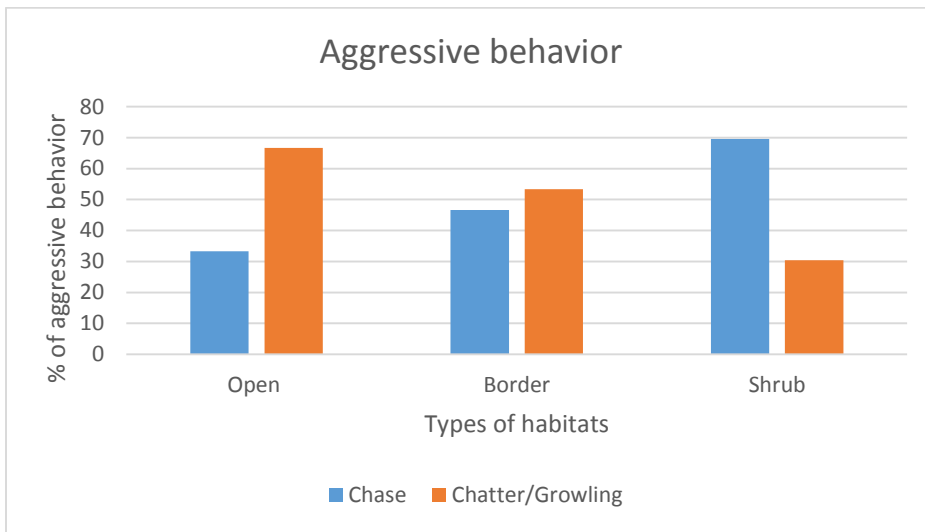


Figure 4: Types of aggressive behavior exhibited by 13-lined ground squirrels among habitats

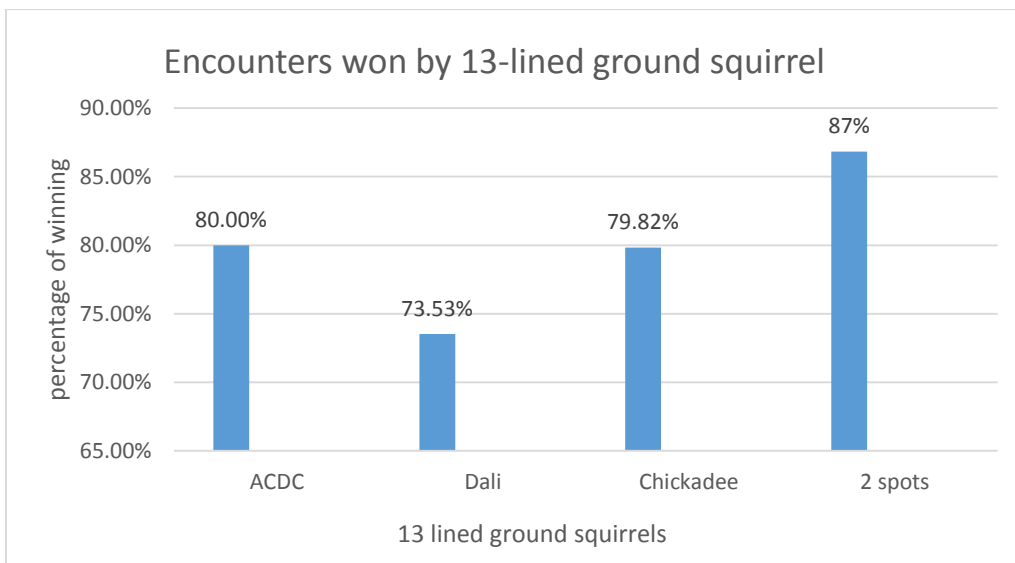


Figure 5: Interspecific encounters won by each squirrel

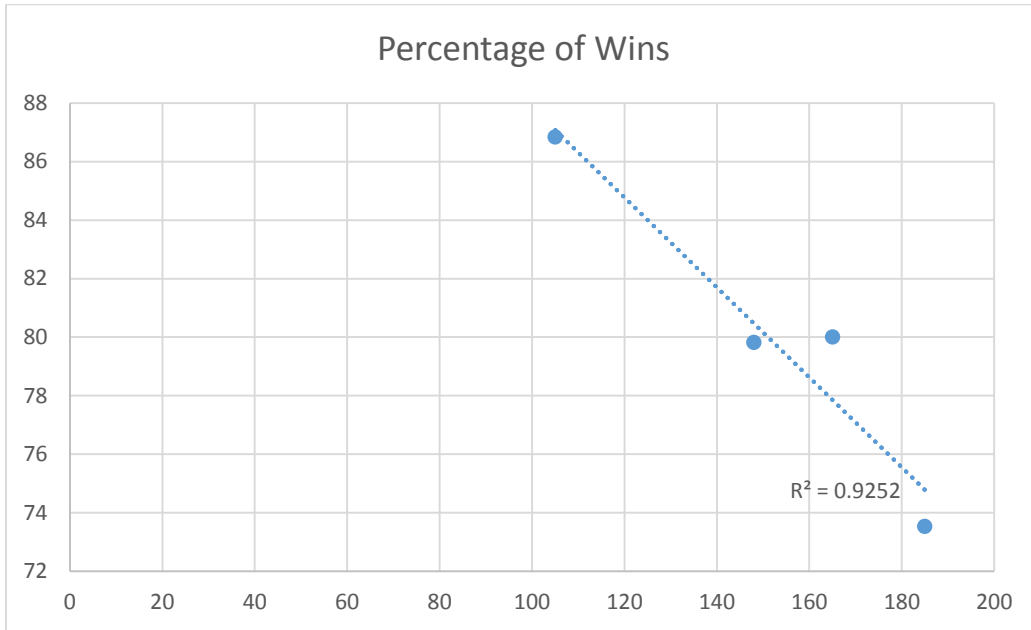


Figure 6: the relationship between weight of 13-lined ground squirrels and percentage of wins