The effect of interspecific competition on the foraging behavior of the Eastern Gray Squirrel

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Interspecific competition between the Eastern Gray Squirrel, *Sciurus carolinensis,* and the European Red Squirrel, *Sciurus vulgaris,* has been shown to negatively affect both populations' growth rates by limiting resource availability. In response to the outside threat of another competitor, it is hypothesized that *S. carolinensis* will modify the time of their foraging behavior in order to more optimally collect resources. A study was conducted in the urban environment of a college campus measuring the differences in foraging behavior based on the absence or presence of a simulated competitor. Research was conducted by evaluating a total of 33 squirrels appearing in one of three scenarios; empty plot, simulated competitor, and non-competitor object . Results showed no statistical difference between the proportion of time spent foraging in the plot containing the competitor or object and an empty plot. More trials could be completed in replicate studies to ensure the most accurate results. It is recommended future studies be done in an environment with little human presence as that was believed to have possibly affected the results.

KEY WORDS: Interspecific competition, foraging, behavior, Eastern gray squirrel, European red squirrel, competitor, niche, McKeldin Mall, University of Maryland, ANOVA.

When an individual's niche overlaps with another individual's niche, there is competition for the resources within that environment (Peterson 2003). When this competition occurs between individuals in separate species it is called interspecific competition (Schoener 1983). This study focuses on the effect of interspecific competition on foraging behaviors in a small species of North American mammal. It is not uncommon for an individual's foraging behavior to be affected by external elements. Animals modify their foraging behavior in response to factors such as density of food source, perceived risk of predation, and interference from other foragers (Ward 2000). An optimal forager will use behavioral strategies that increases the payoff, or resources obtained, while minimizing risks of mortality. In many cases, this means modifying the time spent foraging in order to remain vigilant of outside threats. This paper will takes a look at the foraging habits of the eastern gray squirrels (*Sciurus carolinensis*) and how it is modified in response to specific outside factors.

In Europe, eastern gray squirrels are invasive and directly compete with European red squirrels (*Sciurus vulgaris*) for resources. It has been found that when these two species of squirrel compete for the same resources, there is a decrease in reproduction rates in both types of squirrel (Gurnell et al. 2004). Since the amount of resources available can determine a population's growth rate, limiting resources can decrease a population's growth rate (Grover 1997). It was hypothesized that over time the competition over resources between the two squirrels will result in a decline in population size and eventual extinction of the red squirrel population. Because the appearance of an invasive squirrel population poses such a threat to the longevity of the native squirrel population, it is suspected that current squirrel populations will behave

differently in the presence of the competitor in order to outcompete it. More specifically, this study hypothesizes that in the presence of another squirrel competitor, the average time the Eastern gray squirrel spends foraging will be different from the average time the Eastern gray squirrel spends foraging without the presence of a competitor. To test this theory, the foraging behavior of gray squirrels were monitored with and without the presence of a competitor squirrel.

By performing this study, we hope to gain further insight into the behavioral patterns of small mammal populations. If our hypothesis is not rejected, our study will further expand upon the knowledge of interspecific competition as well as provide important information on invasive mammals and their effect on native mammals in foreign environments. Also, as this is a species that is in close proximity with humans, whether in forested or other urban areas, it is important that we understand their behaviors.

MATERIALS AND METHODS

Study site and species -- This study was conducted on McKeldin Mall, the center of the University of Maryland's campus, in College Park, Maryland. College Park is less than 10 miles from Washington, D.C., and is a highly urbanized area. McKeldin Mall is an open grassy area with several sidewalks and a large fountain; this area is similar to a typical quad on many other college campuses. More than 35,000 students attend the University of Maryland, and a great deal of students, faculty and staff visit McKeldin Mall each day (University of Maryland 2016). Specifically, our study was conducted on the southern edge of McKeldin Mall in an open mulched area beneath oak trees. Our study site is slightly shaded and sheltered from the impacts of harsh weather conditions.

This landscaped area is managed by University of Maryland Facilities Management and is naturally filled with acorns from oak trees above.

The test subject, the Eastern gray squirrel, is a small, native rodent in high abundance on the University of Maryland campus. The gray squirrel will den inside of trees or build a large nest from leaves in the canopy (Smithsonian Museum of Natural History). Because of the squirrel's high affinity for trees, the test location included oak trees to encompass a squirrel's natural habitat. Eastern gray squirrels are crepuscular and most active after dawn, and before dusk.

Experiment -- We established a single fifteen by fifteen foot plot to apply each of our three treatments and observe the foraging behavior of gray squirrels. Orange flags were placed at the four corners of our plot to clearly identify boundaries for the video review. Saltine crackers with peanut butter were scattered randomly around the center of the plot to draw squirrels into our test area (Figure 1). Experiments were conducted for five mornings with similar, clear weather conditions at 7:00 am. Each treatment was applied for 30 minutes, with 10 minutes between each treatment to prevent humans from affecting the test results. The order of treatments was altered each day to account for differences in peak activity time. All behavior of the gray squirrels was video recorded to be analyzed at a later period.

The first treatment tested the effect of an identified interspecific competitor. A stuffed squirrel, roughly the same size as an eastern gray squirrel, was placed in the center of the plot to represent a competitor species. The second treatment tested the effect of a random object on squirrel foraging behavior. A black camera bag, also approximately the same size as an eastern gray squirrel, was placed at the center of the

plot. This treatment was applied to see if grey squirrels were reacting to the stuffed squirrel as a competitor or simply as a foreign object. Lastly, the third treatment was the control; we observed foraging behavior of gray squirrels in the absence of both the camera bag and identified interspecific competitor.

Video Observation -- Each trial, and treatment, was recorded using a digital camera. At a later time, individuals observed the videos to make note of foraging behavior for each gray squirrel visiting the experimental plot. The video for each trial was viewed by two individuals, in separate locations. For every video observed, each individual made note of the treatment applied, the time each squirrel was in the plot, and the time spent with their heads down foraging. For this experiment, foraging behavior recorded consisted of a squirrel with its head facing the ground and front limbs searching through the terrain. The time spent foraging was for each squirrel was then averaged between the values obtained by each person viewing the videos. Averaging these values accounted for inter-observer variation that could occur and possibly skew results. The average foraging value for each squirrel was then used to observe patterns in squirrel behavior.

Statistical Analysis -- Analysis was performed using a one-way ANOVA to determine if the presence of a competitor or non-competitor object significantly affected the proportion of time spent foraging when compared to an empty plot. Using ANOVA allows for multiple samples to be drawn from the same population, and for even the smallest amount of variability between samples to be detected. The average foraging time for each gray squirrel was used as one data point. Each treatment applied was counted as

a random and independent sample; and, each sample was assumed to be normally distributed. An alpha value of 0.05 was used in ANOVA analysis.

RESULTS

A total of 33 squirrels were observed, divided as such: 14 squirrels analyzed for the plot containing no object, 11 squirrels in the plot containing an interspecific competitor, and 8 squirrels in the presence of a non-competitor object (in this case a camera bag). The mean proportion of time spent foraging was 0.5478 in the presence of the camera bag, 0.5022 with the competitor, and 0.3383 in the empty plot. The results of the average proportion of time spent foraging in the plot show the squirrels foraged most in the presence of the non-competitor object and least in the plot containing no object (Figure 2). To determine if these results were statistically significant a one-way ANOVA was performed (Table 1). This resulted in the inability to reject the null hypothesis ($F_{2,30} = 1.11861794$, $p > 0.05$), indicating there is no significant correlation between the proportion of time spent foraging and the presence of the competitor.

DISCUSSION

The results from this study indicate that Eastern gray squirrels do not significantly alter their foraging habits in the presence of the stuffed squirrel competitor. It was predicted that the competitor would disrupt squirrel foraging activity, possibly by lessening the amount of time squirrels spent in plots when compared to the control and empty trials. In fact, though not statistically significant, plots with a foreign object, either the competitor or the bag, showed a higher rate of foraging activity than those without.

This potentially demonstrates a lack of perceived interspecific competition and potential attraction to sites with evidence of human impact, which could be related to the level of urbanization and habituation.

In urban and suburban habitats, gray squirrels do exhibit decreased wariness and increased intraspecific competition, leading to higher levels of aggression and territoriality (Parker and Nilon 2008). The tendency towards more overt aggression could explain the squirrels' increased frequency in plots with a competitor. The stuffed squirrel used in this study was intended as a substitute for the European red squirrel due to the competition between the two species in regions of gray squirrel invasion in Europe (Gurnell et al. 2004). However, it is possible that the gray squirrels in the area of the University of Maryland study site, unfamiliar with the presence of another species overlapping in niche, perceived the competing squirrel as gray and a source of intraspecific range overlap. An intraspecific threat in an urban area explains the increase in foraging around the competitor.

Urbanization could also rationalize the increased foraging activity around the control, in this case a foreign and human object. Urban squirrels are able to use human food as a provisioning source and can increase in abundance as a result of decreased resource pressure (Hadidian et al. 1988). Human presence becomes associated with food supply and an obviously human object might spark interest in squirrels habituated to recognize that connection. In this study, the use of the camera bag could register with urban squirrels as a non-threatening human item, encouraging their approach with the possibility of food being involved.

The results of our study, though non-statistically significant, do correspond with the findings of previous studies on urban gray squirrel behavior. We were limited in our number of trials by time constraints and inconsistent squirrel presence, but with greater numbers and more consistent sampling, data might begin to show more concrete trends. The potential of the human object as a foraging encouragement device should be studied in more depth, not only as an indicator of squirrel behavior, but also as a sign of urbanization's effects on all local wildlife.

Human presence drastically alters the environment--buildings, vegetation, and food provisioning follow a strong rural to urban gradient, directly and indirectly impacting all area wildlife species (McCleery et al. 2007). In order to study the effect of inter or intraspecific competition between squirrels as an isolate, future studies will have to be done eliminating the effects due to human impact. However, gray squirrels, in their small size and abundance, also represent a useful indicator species to document trends in human influence along the progression from rural to urban. Research on their foraging behavior in relation to anthropogenic development hold implications for best management practices surrounding human-wildlife interaction in the greater urban context.

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TABLES AND FIGURES

TABLE 1

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit*
Between Groups	0.2799937053	2	0.139996853	1.1186179	3.32
Within Groups	3.754548742	30	0.125151625	4	
Total	4.034542447	32			

Table 1. Significant values for ANOVA analysis

FIGURE 1

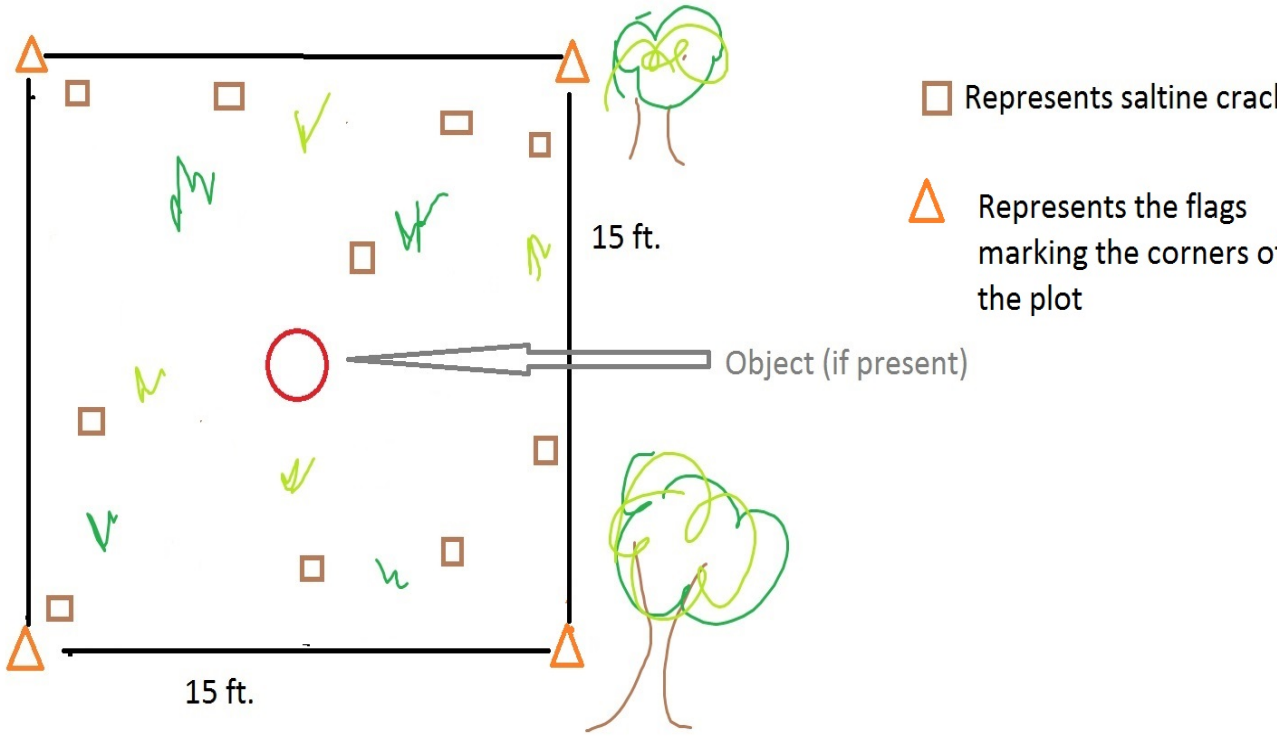

Figure 1. Plot design to test the foraging habits of gray squirrels.

FIGURE 2

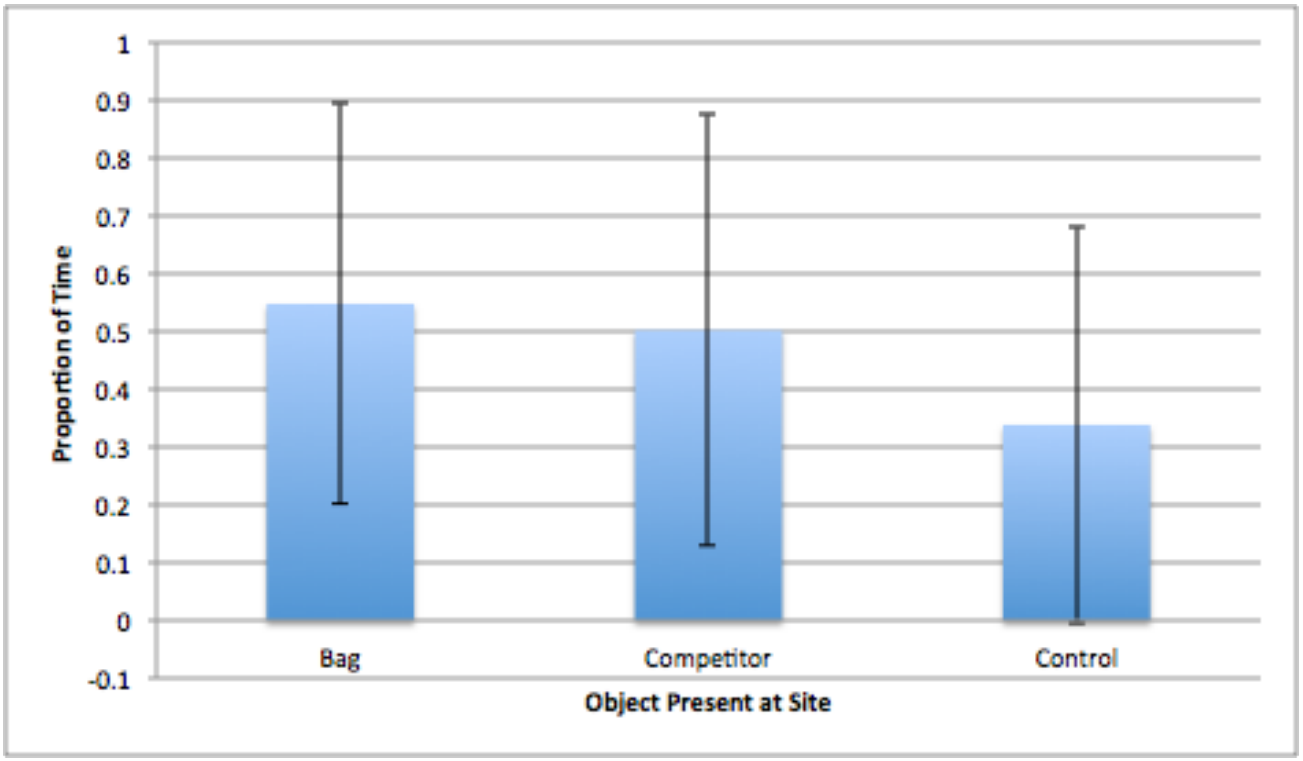

Figure 2. Average proportion of time spent foraging at the experiment site based on object present in the field. (Bag: n=8, Competitor n=11, Control n=14).