

## **Investigating the effect of differential elevation of food on foraging behavior of the Eastern grey squirrel (*Sciurus carolinensis*)**

Binh Nguyen, Nima Farchadi, Stephen Schiltz

*University of Maryland, Department of Biology (BSCI335), College Park, Maryland.*

The Eastern grey squirrel (*Sciurus carolinensis*) is a prominent small mammal that exhibits high vigilant behavior in times of foraging. Previous research has determined that horizontal distance to safety influences the how the squirrels consume their food. Our study aimed to see how vertical distance influences foraging behavior of squirrels at the University of Maryland campus. An adjustable feeding apparatus was designed to test a difference in foraging behavior of three different levels of elevation. Results were gathered as a mean duration foraging spent at each height, in order to determine significant behavioral differences due to elevation. Results showed no significant difference existed in the amount of time the squirrels spent foraging at the different heights of the food. This lack of significance could potentially be a result of our experimental process, which does not actively measure the effects of predation in addition to variable heights of available food. A modification of our experiment, with an introduction of predators, could further illuminate the significance of vertical distance to safety in the foraging behavior of squirrels.

Key words: Behavior, Eastern Grey Squirrel, Foraging, Height, Predation, *Sciurus carolinensis*, Vigilance

Smaller mammals tend to display higher vigilance than those of larger sizes due to their increased risk of predation. Some of these behaviors include scanning the environment for threats, resting in high branches, burrowing underground, and keeping a large distance from potential predators. It is widely believed that these behaviors help to increase the overall survival and reproductive fitness of the mammals (Steven *et al.* 1985).

The Eastern gray squirrels (*Sciurus carolinensis*) are a commonly seen, small-sized mammals on the University of Maryland campus that exhibit high vigilance. These squirrels spend up to 38% of their time in intermittent pause in order to search for predators (McAdam and Kramer 1998). Additionally, they portray higher vigilance while handling food in their forepaws in a semi upright position (Makowska and Kramer 2007). This species thusly devotes copious time in vigilance during both on- and off-foraging in order to detect and avoid threats.

A theme of vigilant behavior is exhibited by the Eastern gray squirrel during foraging periods on the ground. These squirrels are able to weigh trade-off between energy intake and predation risk while foraging; they exhibit preference for food that is closer to their safety covers because this lowers the probability of predation per unit foraging time (Newman and Caraco 1987). Additionally, when food is further from covers they tend to immediately consume at that location or carry the food to the safety of trees prior to consumption (Steven *et al.* 1985). Tree tops provide safety for squirrels from volant predators, but unless they climb to higher ground, ground predators can still pose a threat to survival. Although the foraging and vigilance behaviors of Eastern gray squirrels are well-documented in experiments involving horizontal distance to safety, much less is known about the effects of vertical distance to safety.

Using the squirrels at the University of Maryland, College Park campus, we analyzed how varying the elevation of food affects the amount of time squirrels spend foraging at that height. An adjustable pole with a feeding platform designated at increasingly elevated intervals was used as a model for varying heights of food in order to measure the duration of time squirrels spent foraging at each height. We hypothesized that at different heights of the platform, there will be a significant difference in time spent foraging due to difference in vertical distance

from potential predators. These squirrels have habituated to human interaction due to abnormally increased exposure to college students; however, squirrels should still perceive humans as threats and flee when the distance is too close (Engelhardt and Weladji 2011). Results of this study provide insight into the vertical aspect of foraging behaviors in squirrels and are applicable for conservational efforts of other small mammals.

## MATERIALS AND METHODS

*Experimental Subjects*-- A total of 27 random Eastern gray squirrels (*S. carolinensis*) were studied in this experiment; 9 from each of our three selected locations. Due to the nature of our experiment, each squirrel volunteered to participate in each of our trials. We lacked the necessary equipment to identify each subject, so we assumed each squirrel was a previously untested volunteer for each trial.

*Location*--The study was conducted at three specific locations on the University of Maryland, College Park, all of which are illustrated in Figure 1. These three locations (Tydings, Mckeldin Mall, and North Campus) are chosen with significant distances in-between in order to reduce the chance that the same squirrel would participate in each of our trials.

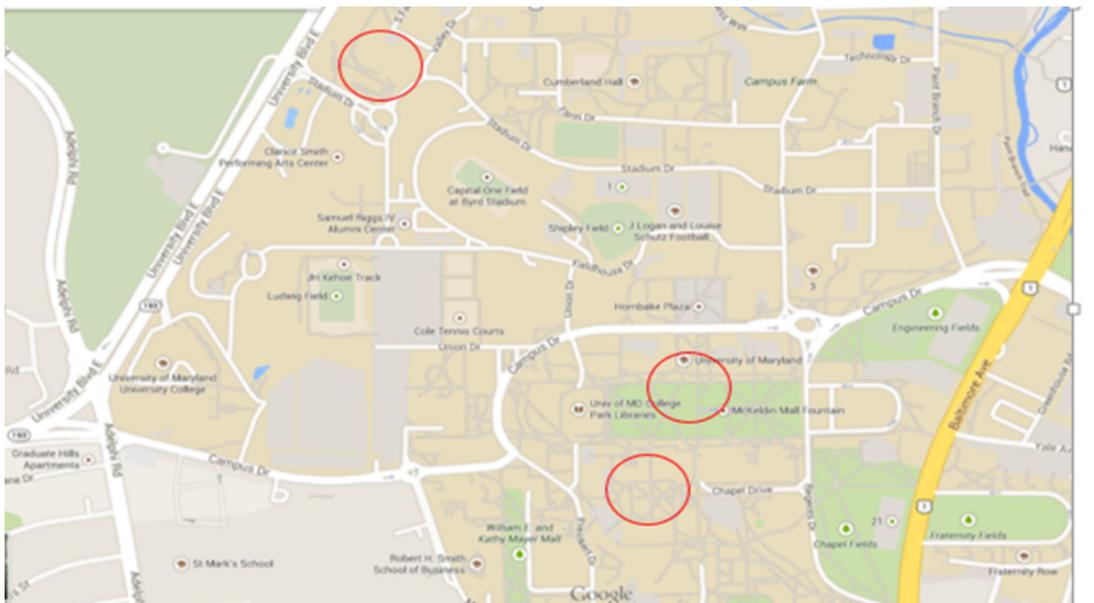


Figure 1: A map of the University of Maryland, College Park campus. Three locations used in the study are circled in red.



Figure 2: The feeding apparatus assembled in the ground level position with the feeding platform at 0 feet and the pole connected by a PVC pipe coupler.

*Feeding apparatus--* We designed and constructed a six-foot tall feeding apparatus with an adjustable platform from PVC pipe materials. The entire apparatus was composed of 4 basic parts: two PVC pipes that were three feet in length and two inches in diameter, a PVC pipe coupler, and a feeding platform composed of a three-way PVC pipe splitter, one-foot PVC pipe and a 1x1 square of plywood. The connected pieces were arranged in three configurations that established the platform at heights of 0 feet (ground level), 3 feet, and 6 feet as seen in Figures 2, 3, and 4 respectively. The three-way PVC pipe splitter on the platform allowed for attachment to the PVC pipe either on the bottom of two connected PVC pipes, in between two PVC pipes, or on the top of two connected PVC pipes. One of the PVC pipes was cut at an slight angle on the bottom, which was used to firmly plant the entire apparatus into the ground. In order to eliminate the difficulties of reaching the elevated platform, the apparatus was wrapped in drawer lining to

provide grip and was always leaned against a large tree. On the underside of the platform, we hung a small net full of peanut butter as an attractant for squirrels.



Figure 3: The feeding apparatus assembled in the middle level position with the feeding platform at 3 feet in-between the two PVC pipes.



Figure 4: The feeding apparatus assembled in the highest position with the feeding platform at 0 feet and the pole connected by a PVC pipe coupler.

*Food--* One cup of Wagner's Wildlife Food was mixed thoroughly with one spoonful of peanut butter and placed onto the platform. This precise mixture was reset after each squirrel had visited, of which ensured that each trial had the same amount of food.

*Experimental Design--* This study was performed over the course of several afternoons in the month of April under clear and sunny weather. A trial consisted of a squirrel eating our placed food without leaving. With three locations, three various heights, and three squirrels per height level; we devised a randomly selected schedule of each of the 27 trials. The feeding apparatus was established at the base of a tree at the randomly selected areas, and the allocated food mixture was placed on the platform. We then retreated to well over 20 feet from the apparatus and timed the duration a squirrel would eat the food at that location. After each trial, we re-established our apparatus and food at the randomly selected location and height.

*Statistical Analysis*-- We ran a One Way Analysis of Variance (ANOVA) on Microsoft Office Excel to determine whether the variations in height (0 feet, 3 feet, and 6 feet) has the same effect on foraging behavior on the population of squirrels. For our ANOVA test we determined a 95% Degree of Certainty, which gave us our alpha value of 0.05.

## RESULTS

We conducted a total of 27 trials during our experiment. Nine trials were conducted for each category of interest: 0 feet, 3 feet, and 6 feet. Of those trials, squirrels were seen to forage longer at an elevation of 0 feet compared to the heights of 3 feet and 6 feet (Figure 5). The average amount of foraging at 0 feet, 3 feet and 6 feet were 147.29 seconds, 125.68 seconds, and 86.02 seconds respectively. To calculate the significance of whether height has an effect on time spent foraging, we used an One-Way ANOVA test since we wanted to analyze the difference between three or more group means. Based on our results, we accepted our null hypothesis that no significant difference existed between the height of the food and amount of time the squirrel spent foraging ( $F_{crit}=3.468$ ,  $df=2$ ,  $p=0.658$ ).

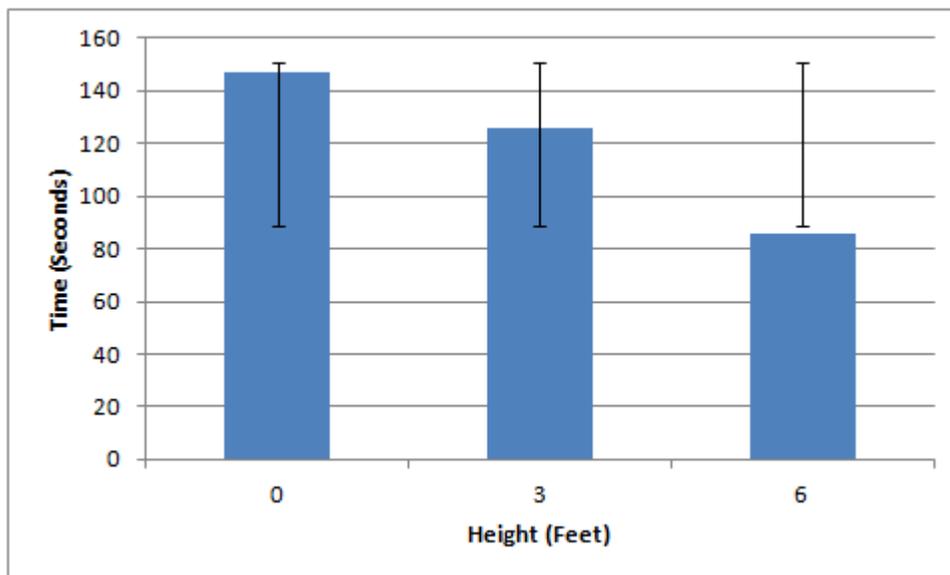


Figure 5: The comparison of the average time squirrels foraged at 0 feet, 3 feet, and 6 feet. The bars indicate the average amount of time squirrels spent foraging at each respective elevation.

**Table 1. ANOVA**

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	18676.54083	2	9338.270417	0.426751233	0.65816	3.466800112
Within Groups	459526.9175	21	21882.23417			
Total	478203.4583	23				

A summary of results from the One Way ANOVA test to determine whether the variations in height (0 feet, 3 feet, and 6 feet) has the same effect on foraging behavior on the population of squirrels.

## DISCUSSION

The results did not support our hypothesis that there would be a significant difference in time spent foraging at varying elevated feeding platforms. Although our data implies a trend of decreasing foraging time as the platform height increases, our statistical result proved insignificance. Thus, we were unable to determine whether the vertical distance to safety from predators had an influence on foraging behavior in squirrels.

Nevertheless, this trend adequately conforms to previous studies of Eastern gray squirrels. For instance, Lima *et al.* found that these squirrels are able to weigh foraging efficiency against predation risk. In our study, the nearby trees provided a safeguard against ground predators. Therefore, squirrels might have been reluctant to forage for food at higher altitude because they would spend more energy climbing and keeping balance. In addition, the Eastern gray squirrels are known to have high vigilance while foraging (Makowska and Kramer 2007; McAdam and Kramer 1998). On several occasions, we observed instances where squirrels were attacked by wild birds. These squirrels therefore could have spent more time foraging on the ground level in order to avoid potentially harmful predators from above.

After re-evaluating the experiment, there are several aspects that could be improved in order to achieve more conclusive results. One area of improvement would be to conduct trials at locations with higher population density of squirrels than those we had visited. Often times, our areas of interest only had a sparse number of squirrels. This could affect our data because the same squirrel could have can come back to our food station. Therefore, we may have recorded

the same squirrel for multiple trials, which doesn't give us a heterogeneous mixture of squirrels. During the experiment we also encountered difficulties with squirrels not climbing up the feeding apparatus. This was an issue because since the feeding apparatus did not represent a tree structure, squirrels were not willing to risk potential danger in order to climb up an unfamiliar object. We fixed this problem by leaning our feeding apparatus on the trunks of trees in order for the squirrels to climb up a natural ladder and forage the food. In addition, the squirrels might be unable to see the top the platform while looking from below. Thus, they might have been reluctant to spend energy and climb up the feeding apparatus. We addressed this problem by hanging a ball of peanut butter from the platform to attract the squirrels by scent rather than visual cues. Lastly, conducting our research in mid-afternoon may have also impacted our conclusion. As previously mentioned, squirrels are more active during sunrise and sunset. This could have led to a limited amount of data sample where the squirrel in each trial might not have been uniquely distinct.

In essence, the goal of our project was to better understand squirrel foraging behavior. We tested how vertical distance was as an important factor similarly to the influence of horizontal distance when foraging for food. Information on the foraging habits of squirrels regarding the duration of feeding at specific heights could be used to study other organisms with similar lifestyles. Additionally, this information could predict the basis for predator/prey foraging behaviors of small mammals in the same suborder Sciuromorpha. Essentially this information could potentially be used in conservation efforts in order to efficiently provide food to endangered species. We encourage for future research studies to replicate our studies, however with the improvements mentioned previously. Also as our experiment only tested the effect of height on foraging time future research should dive into testing two or more factors simultaneously, such as the effect of height and food type or tree type on foraging time. It is still unclear whether vertical distance has an effect on squirrel foraging behavior, however, future research with the addition of a predation variable, could invoke more differentially significance.

#### ACKNOWLEDGEMENT

We would like to thank Danielle Adams for her suggestion of using peanut butter as an attractant for squirrels.

## LITERATURES CITED

- Engelhardt, S.C., and R.B. Weladji. 2011. Effects of levels of human exposure on flight initiation distance and distance to refuge in foraging eastern gray squirrels. *Canadian Journal of Zoology* 89: 823-830.
- Makowska, I. Joanna, and Donald L. Kramer. 2007. Vigilance during food handling in grey squirrels, *Sciurus Carolinensis*. *Animal Behaviour* 74: 153-158.
- McAdam, Andrew G., and Donald L. Kramer. 1998. Vigilance as a benefit of intermittent locomotion in small mammals. *Animal Behaviour* 55: 109-117.
- Newman, Jonathan A, and Thomas Caraco. 1987. Foraging, predation hazard and patch use in grey squirrels. *Animal Behaviour* 35: 1804-1813.
- Steven L. Lima, Thomas J. Valone, Thomas Caraco. 1985. Foraging-efficiency-predation-risk trade-off in the grey squirrel. *Animal Behaviour* 33: 155-165.