Distance from protective tree cover affects foraging times of urbanized gray squirrels at the University of Maryland
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Abstract
Prey animals like the eastern gray squirrel exhibit foraging behaviors that balance the costs of exposure with the acquisition of food resources. Past research suggests that small mammals and birds prefer to forage for food in areas close to protective cover, and spend less time foraging in open areas. Concordantly, the purpose of our study is to identify a significant relationship between distance from protective tree cover and foraging times for eastern gray squirrels at the University of Maryland. We placed peanut butter at distances of 15 and 30 feet from the tree line and recorded how long squirrels spent eating at each station. Data analysis showed a significant difference between mean times of the two distances, with the near distance of 15 feet having a significantly higher average time of peanut butter consumption. Therefore, despite prolonged exposure to humans and habitation in an urban environment, squirrels at the University of Maryland retain their instinctual aversion to prolonged foraging in exposed areas. This finding can be extrapolated to many other urbanized species and should be considered in suburban and urban development.
Introduction
All prey animal species have to weigh the costs between foraging and safety. When faced with a possible threat, the animal can exhibit three basic actions. They can flee to a refuge, remain very still to possibly blend with the surroundings, or fight off approaching threats. In each case there is a potential cost, and a potential benefit. If the animal flees, it expends energy and possibly loses its food source, but is likely to survive the threat. If it remains still, it expends no energy and retains the food source, but detection could lead to death. Fighting is more of a method reserved against other competition for the food source. This expends energy, but may allow the animal to keep its food source.

The foraging model of Ydenberg and Dill expects that the animal will not leave the food source until the cost of staying risk is equal to the cost of fleeing (Lagos et al. 2009). The optimal flight initiation distance model expresses the idea that an animal will not flee right away, and will not only want to equalize energy expenditure with energy intake, but will want to elevate fitness levels as much as possible (Cooper and Frederick 2007). Varying distances from refuge play a major role in this decision making process.

The expected thought is that an animal will spend less time, and flee sooner at foraging sites further from a refuge. In general, it was observed that small mammals and birds do tend to spend less time at foraging sites in open environments, often grabbing the food and moving a little ways off towards protective cover. Also, the animals tended to be more alert at further distances with more time spent scanning for danger than at the sites closer to safety (Lagos et al. 2009, and Lee et al. 2005). One element that encouraged a greater length of stay was a higher reward. Degus that were further from their burrows were more likely to stay longer if the food patch was of greater quantity (Lagos et al. 2009). Another factor observed in ruddy turnstones was that individuals who were at a better state of health (not as desperate), were more likely to flee sooner (Beale and Monaghan 2004).

Another issue in this cost-benefit analysis is how habituated a prey species is to a perceived threat. Our focus for this study is on the eastern gray squirrel (Sciurus carolinensis) in the semi-urban environment of the University of Maryland campus. Humans are identified as a threat by most animal species, but a constant exposure with no resulting damage can lead to a decreased level of wariness (Engelhardt and Weladji 2011). In fact, humans are one reason for the increased squirrel population in urban and suburban environments due to increased food supplies from bird feeders or other sources (Parker and Nilon 2008). Squirrels accustomed to the urban environment are more likely to eat more food from a provided source compared to rural squirrels (Bowers and Breland 1996). Because of lowered sensitivity to predator risk, and more competition due to limited habitat and larger population, the urbanized squirrel may be more likely to stay at a food source patch for a greater length of time, even at a greater distance from refuge.

In our study, we aimed to see what effect distance would have on the time spent foraging at different distances from shelter. This could lead to information on habitat needs for prey species in a fragmented, urban environment. We hypothesized that even though the squirrels are quite habituated to humans, and there is a fairly large squirrel population on
Materials and Methods
McKeldin Mall at the University of Maryland was used as the study space as it is a large grassy space on campus at the University of Maryland. It is lined with Willow Oaks (*Quercus phellos*) and Golden Rain Trees (*Koelreuteria paniculata*) on either side, which have been observed to be homes to many eastern gray squirrels (*S. carolinesis*). During the study, three lanes were observed starting at the base of three trees on the Mall, tree 1 was a Golden Rain Tree and trees 2 and 3 were Willow Oaks (Figure 1).

On May 5 2015, the day before data collection began we mounted a plastic red cup on a stick staked through a small paper plate containing about 2 tablespoons of Jif® Extra Crunchy Peanut Butter at the base of each of the three selected trees on the McKeldin Mall. This set-up was maintained throughout the experiment and will be referred to as the peanut butter construction. This peanut butter construction was placed at the base of each tree to assimilate the local squirrels to the significance of the red plastic cup as a source of food.

Data collection took place on May 6- May 9, 2015 in two increments of 30 minutes. The first replication began at 7 AM each morning, and the second replication at 7:35 AM. Between the two replications each day, the peanut butter was replenished for each replication. Throughout the data collection period either one of two distances were randomly selected for observation each day. In the “near” distance, the peanut butter construction was placed 15 feet towards the center of the Mall from the base of the tree. In the “far” distance, the peanut butter construction was placed 30 feet from the furthest protrusion of branches of the tree towards the center of the mall (Figure 1). The determination of which tree received which treatment on each of the first 3 days was performed with a random number generator from a Texas Instruments TI-84 calculator and the fourth day was the remaining treatment that had not yet been tested for two days.

After the treatment had been determined, we measured out the distances with a Stanley 34-790 100-Foot Open Reel Fiberglass Long Tape Rule. Each tree had one observer that watched from a distance and counted how many squirrels approached the peanut butter and lowered their head to begin eating. As soon as a squirrel lowered their head to the plate, the observer started their timer on their mobile phone (due to limited resources, the timers were not identical and may have differed by a fraction of a second). As soon as the squirrel took a step away from the peanut butter, the timer was stopped and the duration was recorded.

After four days of data collection, the recorded data was analyzed by use of Welch’s 2-sample t-test because the two different samples, near and far, had different population sizes and variances for time. The t-test tests if the two unpaired populations have equal means.
**Results**  
Twelve trials of thirty minutes each were conducted at both distances. 43 squirrels foraged at 15 feet (Figure 2.1) and 61 foraged at 30 feet (Figure 2.2). On average, squirrels foraged for 173.4 seconds at 15 feet and 51.6 seconds at 30 feet (Figure 3). This indicates a significant difference in time spent between the distances ($t=3.543$, $df=102$, $p<0.05$).

**Discussion**  
Our experiment was designed to determine if distance from protective cover affects time spent foraging among gray squirrels at the University of Maryland. We had three hypotheses; either there was no effect of distance from protective cover on gray squirrel foraging time, the squirrels spent more time foraging closer to protective cover, or the squirrels spent more time foraging farther from protective cover. As is shown by our data analysis, we found that each squirrel on average spent significantly more time foraging when the peanut butter was 15 feet from the base of the tree (173.4 seconds on average) and therefor under the protective cover of the tree branches. This means that the squirrels spend more time foraging when they are closer to the protective cover. We found that although more squirrels foraged at the “far” distance (61 at the far site compared to the 43 at the near site), 30 feet from the tree branches, they spent significantly less time there (51.6 seconds on average) either taking one bite and leaving or grabbing a part and running back to the trees. The likely reason for this is that squirrels inherently feel more vulnerable when they are out in the open. While they take risks to go out to retrieve the food, they will not stay long enough to be seen and attacked by predators such as birds of prey. Conversely, they may not feel as vulnerable when they are protected from sight under cover of trees, which would enable them to spend more time at the food source.

One variable that was not accounted for in the study was the size of the tree and its effect on the number of squirrels in the area. While trees two and three were very large Willow Oak trees, tree one was a smaller Golden Rain Tree. This did appear to affect the amount of squirrels seen at each station. In further study, replicating this experiment while also taking into account the differences among tree size could be very informative as to normal foraging behavior of eastern gray squirrels. Additionally, for further study, performing this experiment in a more removed, natural habitat would enable better understanding of the species as the population on the University of Maryland campus have developed uncommon foraging techniques as they are in such close contact with a large number of humans. Some of these uncommon techniques include scavenging for any sort of food in trashcans as well as approaching humans who offer food. Because of this knowledge, upon further study we would perform the same experiment off campus in a more removed location amongst a population of squirrels that are more representative of the species. Additionally, in any future similar studies without time constraints, we would perform more trials at more than just two distances to increase the data. We would also use more than three trees over a period of time longer than four days in order to increase the significance of our conclusions. It would likely also be informative to vary the amount of peanut butter used at the different distances. This variation could examine whether the amount of food, or reward, affect the length of time spent foraging at different distances from the protective cover.
Our findings, while very useful in the understanding of foraging among eastern gray squirrels, can likely also be applicable to many other tree-dwelling prey species. The conclusions were similar to other observations of urban wildlife. These squirrels demonstrated elements of “urban wildlife syndrome” with a higher density per area, resulting in more intraspecific competition, and also a lower sensitivity towards humans (Parker and Nilon 2008). Yet they still showed a preference for food sources nearer to a safe refuge as shown in other studies (Lee et al. 2005, Lagos et al. 2009). This indicates that small prey species tend to run for cover at intermittent intervals while foraging.

Our conclusions can be demonstrative of squirrels’ inherent instinct to flee from potential danger even though they are highly desensitized to natural dangers because of their urban setting. In general, there tends to be less biodiversity in urban environments (Ricketts and Imhoff 2003). An increase in protective habitat and shorter distances between such spaces may help create a sense of safety for a greater number of species. This can be applied to many urbanized species and as such should be taken into consideration during the design of urban and even suburban development.
Figure 1: Map of McKeldin Mall and the experimental set-up
This figure shows the design of our experiment on McKeldin Mall. The trees are numbered where 1 was the Golden Rain tree while 2 and 3 were Willow Oaks. Each tree trunk is indicated by a black star while the “near” and “far” treatments are indicated by red stars. This diagram is not to scale but intended to give a general idea of where the distances lie in relation to the trees on the Mall.
Figures 2.1 and 2.2: Time spent foraging for squirrels 15 to 30 feet from tree line. Box and whisker plots showing values for maximum, minimum, median and quartile times. A total of 104 squirrels foraged at the two distances.
Figure 3: Average time spent foraging based on food source distance from tree line. Distance of the food source from the tree line is measured in feet, starting from the base and the furthest branch of the tree. Mean time spent foraging is measured in seconds, with the time period beginning upon squirrel’s first ingestion of food from plate.
References


