The Effects of Distance from a Tree, Elevation, and Food Type on Foraging Patterns of Sciurus carolinensis and Sciurus niger

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Introduction

In order to survive and reproduce, organisms must obtain energy from food. While plants are capable of producing sugars, animals must find their source of energy. One mechanism animals have for acquiring food is foraging. Many factors influence the foraging behavior of animals, including energy reward, predation risk, and energy expenditure (Jones & Dornhaus 2011, Abu Baker & Brown 2009). For example, when Bombus impatiens, commonly known as the bumblebee, is attacked on a low-energy reward flower, it does not return to forage for a period of time. However, when the bumblebee is attacked on a high-energy reward flower, it switches flower types on subsequent foraging visits (Jones & Dornhaus 2011).

Squirrels experience a similar tradeoff between energy gain and predation risk. In order to maximize energy gain, Sciurus carolinensis alters its attentiveness to its surroundings, feeding times and positions, feeding choices, and food handling times (Makowska & Kramar 2007). To evade predation, S. carolinensis eats vigilantly in an upright position near trees, where it has cover from predators (Makowska & Kramar 2007). S. carolinensis also attempts to counteract the energy gain-predation risk tradeoff by carrying larger food items when it is closer to a tree and eating smaller food items immediately when it is farther from a tree (Lima et al. 1985).

Organisms must also weigh energy reward with energy expenditure when foraging (Abu Baker & Brown 2009). It is often not beneficial for an organism to exert a significant amount of energy in foraging, because doing so lessens their net energy gain. However, when the energy reward from a food item is so large, organisms may still choose to exert excess energy. This is the case for S. carolinensis, which chooses to forage for a particular type of chestnut even though it is in low abundance and more difficult to find (Lewis 1980).

The findings of Makowska and Kramar (2007) and Lima et al. (1985) led us to question whether distance from a tree would have an effect on S. carolinensis' and Sciurus niger's foraging of in-shell and out-of-shell peanuts in South Campus of Lake Forest College (Illinois). Since in-shell peanuts yield two peanuts and thus a greater energy gain than one out-of-shell peanut, we hypothesized that there would be greater giving up densities (GUDs) for out-of-shell peanuts than in-shell peanuts when we set a tray containing both peanut types 10 meters away from a tree. Due to there being reduced predation risk underneath a tree (Lima et al. 1985), we did not expect a significant difference in GUDs for in- and out-of-shell peanuts when we set a tray of both peanut types underneath a tree. Additionally, based upon the findings in Abu Baker and Brown (2009) and Lewis (1980), we hypothesized that increasing the elevation of a tray next to a tree would decrease the GUDs for both in- and out-of-shell peanuts, because squirrels must exert more energy to obtain food at a higher elevation than they do on the ground.

*This author wrote the paper as a part of BIOL220: Ecology and Evolution under the direction of Dr. Maine

Methods

Experimental Methods

We conducted this study in late October and early November of 2014 between 11 AM and 2:30 PM behind Nollen Hall on South Campus of Lake Forest College. For each of our experiments, we used two 30 x 58 x 5.5 green trays, which were half-filled with sand and contained a varied amount of in-shell and/or out-of-shell unsalted peanuts. At the beginning and end of each trial, we counted the number of in-shell and out-of-shell peanuts to determine the GUD of each peanut type.

Distance from a Tree Experiment

We randomly selected two trees of similar height and appearance in the area. 20 in-shell and 20-out-of-shell peanuts were added to each tray, and both trays were placed either underneath the two trees or 10 m away from each of the trees for one hour. The trays were placed underneath the trees on four days and 10 m away from the trees on four days. Each tray constituted a trial, so eight trials were conducted underneath the trees and eight trials were completed 10 m away from the trees.

Elevation Experiment

For this experiment, trial times were cut to 30 minutes, and the number of each type of peanut was increased to 30 each. This was done in an attempt to avoid 0.00 GUDs. To test the effects of elevation on squirrel foraging, we used a wooden chair with a height of 40 cm. One tray was set up on the chair underneath the tree that had greater squirrel activity in the distance from a tree experiment, while another was placed underneath the same tree on the ground. For this experiment, six trials were conducted over six days.

Energy Tradeoff Experiment

In this experiment, the tree from the elevation experiment was used, but the tray that was placed on the wooden chair contained 30 in-shell peanuts, while the tray that was set on the ground contained 30 out-of-shell peanuts. We ran five 20-minute trials on five different days.

Statistical Methods

For each experiment, we computed the average GUDs for in-shell and out-of-shell peanuts and compared the averages in paired t-tests.

Results

In order to test the effects of distance from a tree on S. carolinensis' and S. niger's foraging of in-shell and out-of-shell peanuts, we compared the average GUDs for each of the peanut types underneath a tree and 10 m away from a tree (Figure 1). For in-shell peanuts, there was no significant difference between the 0.763 average GUD underneath a tree and the 0.575 average GUD 10 m away from a tree ($t=0.017$, $df=14$, $p=0.99$). There was also no significant difference for out-of-shell peanuts, in which the average GUD was 0.759 underneath a tree and 0.794 10 m away from a tree ($t=1.14$, $df=14$, $p=0.27$).

In order to test the effects of elevation on S. carolinensis' and S. niger's foraging, we compared the average GUDs for peanuts underneath a tree and on a 40 cm tall chair (Figure 2a). We found the 0.426 average GUD of peanuts on the chair to be significantly higher than the 0.00833 average GUD of peanuts on the ground ($t=5.32$, $df=18$, $p= <0.001$).

To examine how elevation affected the types of peanuts S. carolinensis and S. niger would forage for, we compared the average GUDs for in-shell and out-of-shell peanuts on the ground and on the chair (Figure 2b). On the ground, there was no significant difference between the 0.00556 average GUD of in-shell peanuts and the 0.0111 average GUD of out-of-shell peanuts ($t=0.45$, $df=10$, $p=0.66$). On the chair, the 0.183 in-shell average GUD was significantly lower than the 0.669 out-of-shell average GUD ($t=8.41$, $df=10$, $p= <0.001$).

To determine the extent to which S. carolinensis and S. niger preferred in-shell peanuts, we compared the average GUD for in-shell peanuts on the chair to the average GUD for out-of-shell peanuts on the ground when only one type of peanut was offered at each elevation (Figure 3). The 0.112 average GUD of out-of-shell peanuts on the ground was significantly lower than the 0.893 GUD of in-shell peanuts on the chair ($t=24.31$, $df=8$, $p= <0.001$).

Discussion

Our results did not support the hypothesis that the average GUD of larger in-shell peanuts would be higher than the average GUD of smaller out-of-shell peanuts in a tray 10 m away from a tree (Figure 1). These findings are inconsistent which those in Lima et al. (1985), suggesting that S. carolinensis tends to carry food of larger size when trees are in close proximity.

There are a number of reasons why the average GUDs of in-shell and out-of-shell peanuts may not have differed significantly when distance from a tree was increased. For our distance from a tree experiment, we selected two trees we thought were similar based upon their heights and appearances. However, there are confounding factors, such as human interaction and distance from the street, which may have altered the foraging behavior of S. carolinensis and S. niger. We think this is likely, because the tree we selected near the street with greater human interaction had 1.00 average GUDs for in- and out-of-shell peanuts, both underneath the tree and 10 m away from the tree. The other tree, which was further from the street with less human interaction, demonstrated patterns of squirrels preferring in-shell peanuts to out-of-shell peanuts when distance from the tree was increased. Unfortunately, these trends cannot be statistically supported. It is also possible that there is not a significant predation risk for S. carolinensis and S. niger on South Campus of Lake Forest College. Squirrels living in close proximity to humans may be less sensitive to predation risk than squirrels living in more natural areas (Bowers & Breland 1996). If so, it is reasonable that there was no significant difference between the average GUDs of in- and out-of-shell peanuts 10 m away from a tree in South Campus of Lake Forest College.

Our data did provide support for the hypothesis that increasing the elevation of a tray next to a tree would increase the average GUD of peanuts compared to that on the ground (Figure 2a). This is consistent with ideas presented in Abu Baker & Brown (2009), suggesting that increased energy expenditure can lead to decreased foraging of a particular food item. We also found the average GUD of in-shell peanuts to be significantly lower than the average GUD of out-of-shell peanuts at an increased elevation (Figure 2b). This result is consistent with the findings in Lewis (2008), suggesting that S. carolinensis will exert more energy foraging if there is a greater energy reward from the food.

However, while S. carolinensis and S. niger consumed more in-shell peanuts than out-of-shell peanuts at the increased elevation, they still consumed significantly more out-of-shell peanuts on the ground than in-shell peanuts on the chair (Figure 3). This suggests that reducing energy expenditure outweighed the increased energy reward S. carolinensis and S. niger received from in-shell peanuts compared to out-of-shell peanuts. Future studies should be conducted to determine whether a lack of predation risk or confounding factors, such as human interaction and distance from the street, influenced the results in our distance from a tree experiment. This can be achieved by repeating the experiment with two trees in the area that are approximately the same distance from the street with similar human interaction.This experiment should also be repeated during different times of year to account for potential seasonal differences in predators.

Future studies that build upon the results of our elevation experiment should also be conducted. It may be beneficial to perform the elevation experiment 10 m away from a tree and compare the results to those underneath a tree to determine whether S. carolinensis' and S. niger's preference for in-shell peanuts at a greater elevation is intensified when predation risk is potentially increased.

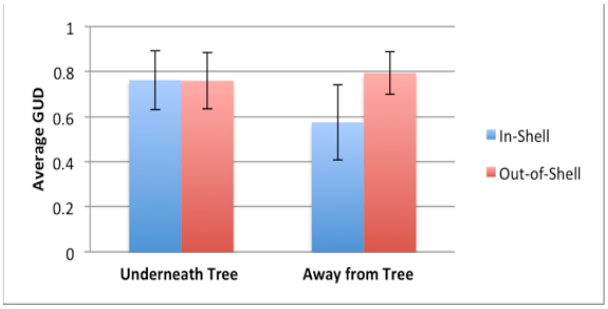

Figure 1. The average giving up densities (GUDs) for in-shell and out-of-shell peanuts underneath a tree and 10 m away from a tree.

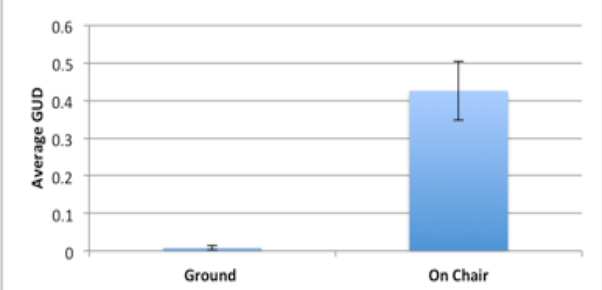

Figure 2a. The average giving up densities (GUDs) for peanuts on the ground and on a wooden chair underneath the same tree.

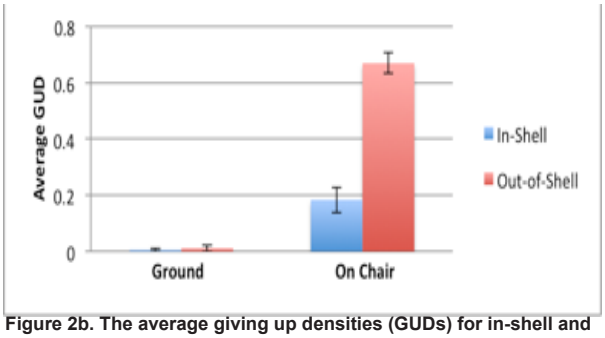

Figure 2b. The average giving up densities (GUDs) for in-shell and out-of-shell peanuts on the ground and on a wooden chair underneath the same tree.

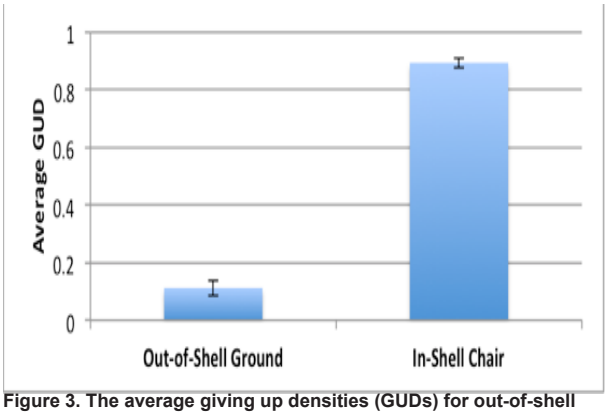

Figure 3. The average giving up densities (GUDs) for out-of-shell peanuts on the ground and in-shell peanuts on a wooden chair underneath the same tree.

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