Giving-up densities of gray squirrels in a forest and suburban environment and the effect of substrate depth

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Abstract

An efficient foraging strategy is necessary for the survival of all consumers. Studying organisms' foraging behavior can further our understanding of optimal feeding conditions for various species. In this study, we were interested in observing the differences in giving-up density (GUD) of gray squirrels between a forest and suburban habitat and also with increased substrate depth. We predicted that GUD of gray squirrels would be greater in the suburban habitat than in the forest habitat because in the suburban environment, squirrels do not have to invest as much energy to foraging due to the availability of birdseed from feeders and other food items left on the ground. In addition, we predicted that when the substrate depth is increased in both habitats, GUD would increase because of the increased foraging cost. Our results suggest that foraging organisms in a forest will have lower GUD than organisms in a suburban environment; however, the increasing marginal cost of a food source does not seem to affect foraging.

Introduction

The ability to find food is necessary for the survival and reproduction of all consumers, but their foraging strategies may differ based on their environment. To measure the foraging strategies of different organisms, the giving-up density (GUD), or the percentage of food left unconsumed, is measured. This measure assesses when a particular food patch may become too risky that the cost of foraging outweighs any benefit. Brown et al. (1992) found that the GUD of fox squirrels was greater in open areas away from trees than in areas closer to trees or in the bush microhabitat. This finding suggests that fox squirrels do not consume as much food in open patches due to the increased risk of predation or increased cost of foraging. In another study, the foraging of gray squirrels was observed, and it was found that gray squirrels in a city or town environment had lower GUD than squirrels in the forest (Bowers & Breland, 1996). These findings suggest a GUD pattern is observed between varying environments such that as one moves from more open to forested habitat, GUD increases. However, the microhabitat in which a forager interacts in is one of many variables that influence GUD.

Another variable is the depth of the substrate a forager must dig through to obtain the food resource. In a study by Baker & Brown (2009), mourning doves and cottontail rabbits were found to have increasing GUD as the substrate depth was increased. This result suggests that as more energy is invested to obtain a food resource, foraging becomes more costly to the consumer. In our study, we were interested in observing the difference in GUD (measured as percent consumption) of gray squirrels between a forest and a suburban habitat and also with increased substrate depth. We postulated that GUD of gray squirrels would be greater in the suburban habitat than in the forest habitat because in the suburban environment, squirrels do not have to invest as much energy to foraging due to birdseed from feeders and other food items left on the ground. In addition, we hypothesized that when the substrate depth is increased in both habitats, GUD would be increased due to the increased cost of foraging, consistent with the findings of Baker & Brown (2009).

Materials and Methods

In the first study, we examined differences in the foraging behavior of squirrels between suburban and forested areas. Field sites included the ravines behind the Shooting Star Savannah, Lake Forest, IL, and a suburban backyard in Northbrook, IL. We used four large green trays, each approximately half filled with sand. About 40.0 grams of whole peanuts per tray were weighed on a balance, and this initial mass was recorded. The measured peanuts were then placed at the bottom of each sand-filled tray. Each day of the study, two trays were placed in both the forest and suburban site. The trays were left out for any two hours between 9:00am-7:00pm. The final mass was then measured, and percent consumption was calculated by dividing the difference between the initial and final masses by the initial mass times 100. GUD was measured by the average percent consumption over all of the trials, and this served as our most important metric. Trials were repeated over seven days. Due to an error in data collection, suburban trials were run over a period of two days, with six trays laid out simultaneously each day for two hours. A total of 10 samples were obtained from suburban trials, and seven samples were collected from forest trials.

In the second study, we tested whether variation in sand depth between trays affected the foraging behavior of squirrels. Studies were carried out in the same forest and suburban backyard sites as in experiment 1; however, each site had two trays of different sand depths: one tray was completely filled to the brim while the other remained half filled. 40.0 grams of whole peanuts were used, and percent consumption was calculated for each tray in each site. As in the previous experiment, GUD was calculated from the average percent consumption. This experiment was run for five days at each site for two hours per day between 9:00am-7:00pm. Twenty total samples were collected (ten forest + ten suburban). Data from each first experiment was analyzed using an independent samples t-test to examine GUD differences between forest and suburban habitats. For the second experiment, independent samples t-tests were run separately for forest and suburban data. These t-test values were then compared to evaluate differences in the GUD of full versus half filled trays in the forest and suburban habitats.

Results

In the first experiment, GUD of gray squirrels was measured in suburban versus a forested environment. GUD in this experiment was measured as average percent consumption. A higher average percent consumption translated into a lower GUD and vice versa. A significant difference was found between average percent consumption in a suburban versus a forested environment (Fig.1, t16=2.232, P=0.039).

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Therefore, on average, GUD was greater in a suburban environment than forested environment.

In the second experiment, GUD of gray squirrels was measured in both a suburban and a forested environment, but in this experiment, the effect of substrate depth on the GUD of squirrels was taken into account. Again, the average percent consumption was used to interpret the GUD. In a forested environment, no significant difference was found between average percent consumption in trays that were half filled with substrate and trays that were completely filled with substrate (Fig. 2, t18=-0.341, P=0.737). Similarly, in a suburban environment, no significant difference was found between average percent consumption in trays that were half filled with substrate and trays that were completely filled with substrate (Fig. 3, t10=-0.043, P=0.967). Therefore, on average, there was no significant difference in GUD in half full versus completely filled trays in either location.

Discussion

Our hypothesis that GUD of gray squirrels would be greater in the suburban habitat than in the forest habitat was supported by our first experiment in which we found a significant difference in average percent consumption in suburban versus forested habitat (Fig. 1). This finding is likely due to the fact that in a suburban environment, squirrels have access to bird feeders and other food sources that allow them to invest less time in foraging. Also, a forested area is less open than a suburban area, so it is likely that a squirrel finds greater protection in a forested area and can invest more energy in foraging. This idea is consistent with the finding that GUD in fox squirrels is greater in more open areas as opposed to areas relatively close to a tree or bush (Brown et al., 1992).

Our hypothesis that GUD would increase in completely filled trays versus half filled trays in both suburban and forested environments was rejected by the observed data. There was no significant difference in completely filled trays in comparison to half filled trays in the forested environment (Fig. 2), nor was there a significant difference in completely filled trays versus half filled trays in the suburban environment (Fig. 3). Our data is not consistent with the study performed by Baker & Brown (2009) because their data showed that for mourning doves and cottontail rabbits, GUD increased as substrate depth increased. One of the reasons our study was not consistent with their result could be due to the fact that our trays were consistently placed in relatively the same area every day for the entire month. This suggests that the squirrels may have detected some sort of pattern as the study progressed and adjusted their foraging habits accordingly. Additionally, perhaps the difference in substrate depth was not great enough to significantly alter the foraging habits of squirrels. It can be concluded that substrate depth had an insignificant effect on the foraging behavior of gray squirrels.

Our results suggest that foraging organisms in a forest will have lower GUD than organisms in a suburban environment. However, the increasing marginal cost of a food source does not seem to affect foraging. The findings of this study can be used in Project Squirrel, a citizen-scientist initiative, to understand differences in forest and suburban habitats and how humans change the habitat and influence foraging behavior. In addition to Project Squirrel, the observed patterns in this study can be applied to other foraging species, such as mourning doves and cottontail rabbits. (Baker & Brown, 2009). Ultimately, this study contributes to the body of research comparing foraging behavior across different environmental gradients.

There is room for improvement in our experimental design. First, our forest site was more of a fragmented ravine located in the middle of a suburb than a true forest ecosystem. We could refine our first experiment by placing trays in a forest preserve, more closely resembling the native environment of squirrels to provide a sharper contrast between foraging behavior in a forest versus suburban habitat. Additionally, it would be useful to try this experiment at different times of the year.

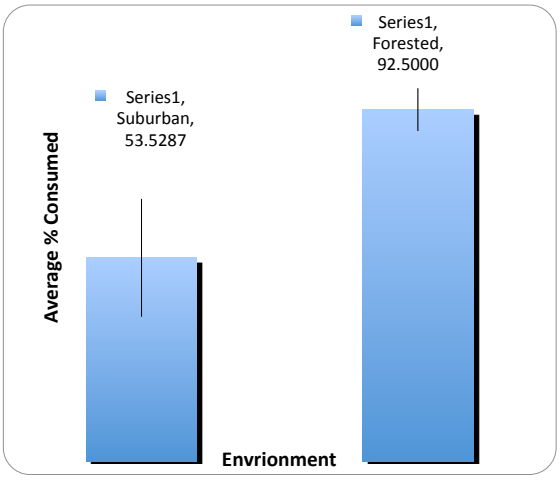

Figure 1: Average (± SE) percent of peanuts in the shell consumed in suburban versus forested environments. P=0.039

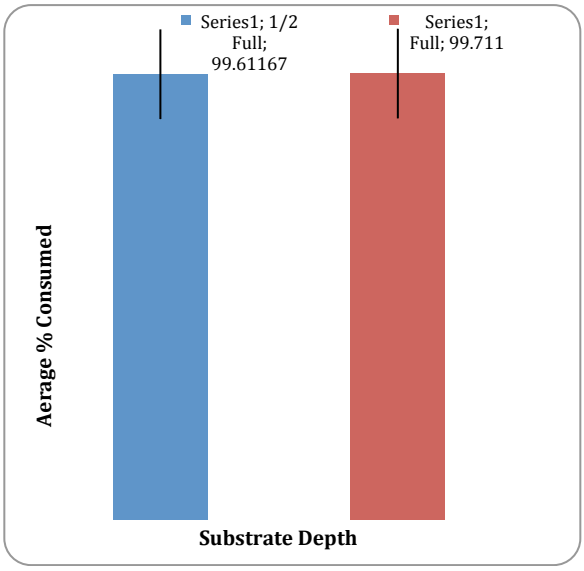

Figure 2: Average (± SE) percent of peanuts in the shell consumed in half full versus full substrate in trays located in a forested environment. P=0.737

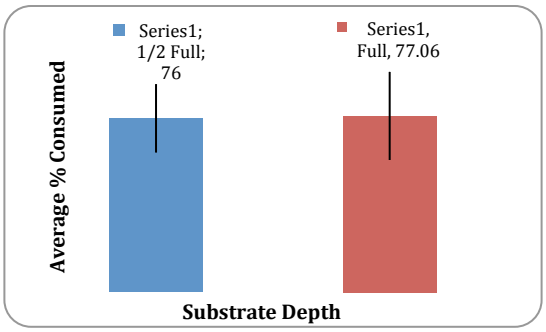

Figure 3: Average (± SE) percent of peanuts in the shell in half full versus full substrate trays located in a suburban environment. P=0.967

For example, in the fall, when this experiment was conducted, squirrels are preparing for dormancy and will forage more often to set aside extra food for the winter. Thus, we should run experiments in the spring and fall, comparing foraging behavior in both suburban and forest environments pre- and post-hibernation. These changes would determine the differences in foraging behavior various times of the year in the two environments.

References

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