Seed Predation in Canopy Gaps: A Look at Seed Predation by *Peromyscus maniculatus* in the Northwoods

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Abstract

Canopy gaps are a natural occurrence in a forest, the gap is caused by the fall of a tree and results in an opening in the forest crown cover. These gaps can affect the foraging habits of small mammals such as *Peromyscus maniculatus*. The preferential feeding habits of *Peromyscus* species have been well documented. Foraging in canopy gaps has also been well studied. However, the two are not often documented together. The vegetation growth in canopy gaps can be influenced strongly by *Peromyscus* seed predation. In this experiment, I study the preferential feeding of *Peromyscus maniculatus* in the Northwoods of northern Wisconsin/Upper Peninsula of Michigan. Bait cages were set out at dusk for mice to feed on. The bait consisted of three different types of seed, beaked hazelnut, sugar maple, and black cherry. The cages were made of wire mesh which deterred chipmunks, squirrels, and birds from getting the seeds while mice had full access. Many complex factors contribute to seed predation in canopy gaps include seed species, precipitation, nocturnal illumination, temperature, distance from forest edge, and time of year. Further experimentation is necessary to fully understand the complexity of foraging in *Peromyscus*.

Introduction

Canopy gaps are defined as an open space in the forest crown cover that is caused by a natural disturbance, such as a wind storm or tornado, which causes the fall of a tree. Foraging animals such as small mammals, ants, and birds must obtain adequate nutrients for survival and reproduction while simultaneously avoiding being eaten by predators (Kelt et al. 2004). Seed predation in canopy gaps can be more risky for small mammals because it makes them more susceptible to predators such as hawks, owls, or eagles flying overhead (Yu et al. 2014). However, there is a trade-off for more secure cache sites (Yang et al. 2016). Cache sites can be dug up by other small mammals, if the caches are in an area where there is a greater risk of predators, other small mammals will not spend as much time looking for the cache sites.

Seed predation is important because although the seeds may have been removed, this does not necessarily mean that they were all consumed (Vander Wall et al. 2005). One outcome of the seeds that are being cached, and not consumed, is a transformation from a seed into a plant. Whether or not the seed is placed in a canopy gap can have an effect on the performance of growth because with enough light, water and nutrients the seed can germinate and potentially grow to age of reproduction. The gap will provide more sunlight for the budding vegetation, thus, in theory, the vegetation will have a better chance to grow with less competition from established vegetation (Yu et al. 2014). The seed preferences that mice and small mammals exhibit could affect the plant's natural regeneration within gaps (Yang et al. 2016). There have been studies done on the seed preference of mice (Eckert, 2013 and Lobo, 2014).

Developing new ways to measure foraging in small mammals is an ever evolving field. Thus, in this experiment I tested seed preference of *Peromyscus maniculatius* in the Northwoods forest. I set out three types of seeds that varied in size, beaked hazelnut (large), sugar maple (medium), and black cherry (small). I had paired sites set fifteen meters apart, one being in a closed canopy, the other in an open canopy. Having different sizes of seeds allowed me to analyze seed preference and whether it differs from gap to non-gap. This can give insight to giving up density (GUD), if the risk is too high in the canopy gap, they might choose a smaller seed compared to a bigger seed. Or they could avoid the canopy gap altogether and go for the covered area (Kelt et al. 2004). Thus, the objectives of this study are to determine seed preference in canopy gaps versus closed canopy.

Methods and Materials

Study site: All experiments was conducted at University of Notre Dame Environmental Research Center (UNDERC). UNDERC is located on the border of Wisconsin and the Upper Peninsula of Michigan (46° 13' N, 89° 32' W). The entire property is approximately 3,035 hectares (7,500 acres). The property has forests, lakes, streams, fields, and bogs. Each site was chosen at random in second-growth forests. A handheld GPS was used to mark the sample site locations.

To decide on the sites I would use, I cut a map of the property into a 1inx1in grid. Out of the grid, six random sections had been selected. In each section I found multiple canopy gaps and used a random number generator to decide which gap to use. For the paired site, I randomly chose a cardinal direction (north, east, south, or west). To make it as random as possible, I made cards that have each direction and picked them unsystematically. For control, each paired site (gap and non-gap) is set 15 meters apart. Trials were ran for four consecutive days in July of 2017, which resulted in twenty-four paired trials.

Field Work: Once I had my sample sites defined, I made small cages that allowed *Peromyscus maniculatus*. The cages were constructed out of chicken wire (18inx12in), a small Tupperware bowl (square), a stake, and wire to hold it all in place. The chicken wire acts as a semipermeable barrier for the seeds by limiting access to birds, deer, squirrels, and chipmunks. Since mice are primarily active during the night, traps were set out at dusk and picked up at dawn. This allowed the mice to have priority over other seed predators such as chipmunks and squirrels, which are active during the day (Figures 1.1 - 1.4).

The types of seeds were chosen by size and availability. Seeds were bought from the Sheffield's Seed Co., Inc., in Locke NY. The large (beaked hazel), the medium (sugar maple), and the small (black cherry). Each type of seed was weighed out to 50 grams to the nearest 0.01 gram for sugar maple and black cherry, 0.10 for the beaked hazelnut. In total, at each individual site, (canopy gap and no canopy gap) there were 150 grams of seeds.

When the seeds were collected at dawn, they were air dried and reweighed to the nearest 0.01 gram for sugar maple and black cherry, 0.10 gram for beaked hazelnut, to determine how much the *Peromyscus maniculatus* had eaten (see Kelt et al. 2004 for more in depth description). The seeds from each site were separated into seed type (beaked hazelnut, sugar maple, or black cherry) and weighed independently by type. The difference in the initial amount of seeds put out and the post-experimental weight equals how much seed that had been consumed.

Data Analysis: I used the paired t-test analysis in MYSTAT. I looked at the open vs. closed canopy gaps at each site for the four consecutive days. To determine seed preference I used the formula Pc/Pa, Pc being the proportion of seeds consumed that were a single type and Pa being the proportion of all available seeds that were the same type (Cramer, 2014).

Results

Twenty four paired trials were done prior to analyzing data. I used a paired t-test to compare open versus closed canopy for a single site on all four days. The results of my paired t-test were not significant for any of the sites, all p values were 0.10 or higher (Table 1). A paired t-test was also used to compare open versus closed at all sites for every day. The p value was 0.051 (Table 2). A paired t-test was not done on a single site for a single day because of zero values, refer to Table 3.1 and 3.2 for raw data.

To analyze seed preference in gap versus non-gap, I used another paired t-test, the p value was .81, and thus, the data was not significant. A non-parametrical Mann-Whitney U test was also ran on the data, the U value was 116 and the p value was .67 meaning neither of the values were significant. The values of the seed preference were plotted on a line chart, negative values favored small seeds while positive values favor large seeds, a zero value means no preference (see Figures 2.1 and 2.2).

There was a documented increase in moisture within the seed on day two, which added weight to the seeds. The results of this experiment could have been skewed by moisture uptake of the seeds by this one day, though it is not expected. Instead of counting the added weight as a negative value, they were counted as a zero value to show that no seeds had been consumed or removed.

Discussion

Weighing the seeds by seed type gives insight to seed preference. The more seeds removed from the area, the greater the preference for that type of seed. Although I found my data to be not significant, with more resources and further studies the data could be stronger. Other factors should also be considered for future studies such as seed species, precipitation, nocturnal illumination, temperature, distance from forest edge, and time of year (Manson and Stiles, 1998).

To better calculate for moisture uptake, an additional tray of seeds could have been set out that excluded all types of seed predators to act as a control for environmental conditions that may have affected seed weight. These seeds would be picked up at dawn along with the seeds from the cages and reweighed immediately. The increase from 50 grams could be used to determine the amount of moisture uptake. With this information, the total mass from the seeds that were open to predators can be adjusted to account for moisture intake. (Kelt et al. 2004). Additionally, seeds could be dried in an oven to eliminate moisture completely.

Another concept that should be taken into account is the moon cycle or nocturnal illumination. When the moon is full, mice would be less likely to venture into canopy gaps because the full moon would be a favorable hunting time for predators because of the increased lighting at night (Bowers et al. 1993). Vice versa, a new moon would result in higher seed removal because of favorable conditions for the small prey mammals.

Another considering factor is that many predators focus their activity along forest edges, this would make foraging in the area unsafe for small mammals. Types of predators known to hunt along these areas include foxes, coyotes, raccoons, and owls. To avoid falling prey to these large predators, mice and other small mammals would avoid these areas and the general vicinity (Manson and Stiles, 1998).

Depending on the time of year, mouse diets are thought to change based on the availability during a given season. Insects are the main diet during the spring and summer, while seeds are mainly eaten during the fall and winter months. Thus, mice may not be prominent seed predators when seeds are not naturally dispersed (spring and summer) (Manson and Stiles, 1998). This could be a huge factor in my data analysis because my study was done in the mid-summer. Mice may not be preying on seeds as much as they are insects. A replication of this study could be done in the fall/winter and compared to this one for further insight on the matter.

Appendix

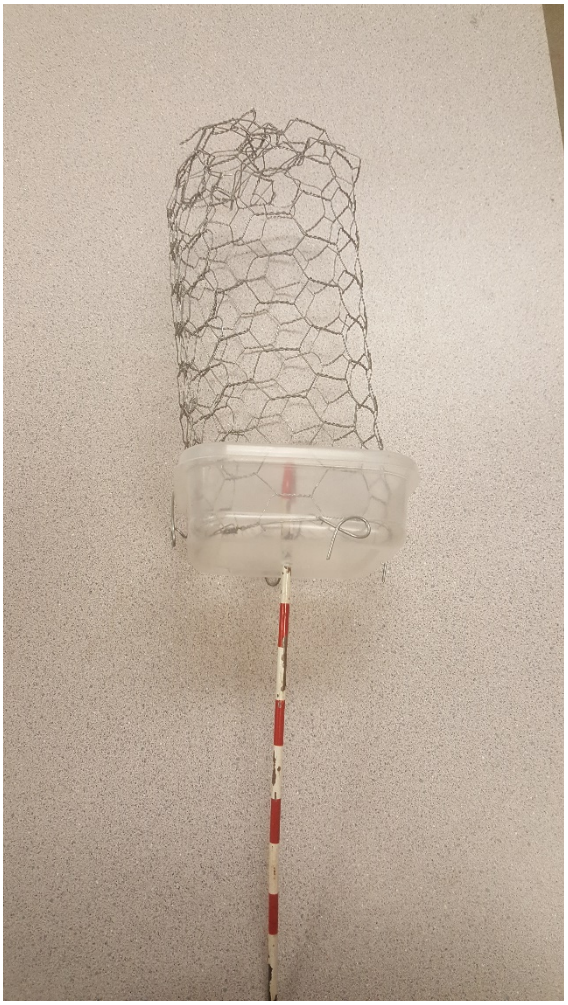

Figure 1.1, side view of cage

Figure 1.2, top view, cage in ground with seeds

Figure 1.3, side view of cage, in ground with seeds

Figure 1.4, side view of cage, in ground without seeds

Paired t-test p values, all days		
Site 1	0.19	
Site 2	0.41	
Site 3	0.39	
Site 4	0.21	
Site 5	0.13	
Site 6	0.29	

Table 1, paired t-test values for each site for four consecutive days

Paired t-test for all sites and days			
p=	0.05		

Table 2, paired t-test for all sites and all days, comparing open vs. closed canopy

Closed	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Day1						
Hazelnut	3.89	0	0	0	0	0
Cherry	38.99	0	0.54	0	0	0
Maple	4.75	0	1.51	0	0	0
Day2						
Hazelnut	3.04	0	0	0	0	0
Cherry	33.1	0	0	0	0.5	0
Maple	1.72	0	0	0	0	0
Day 3						
Hazelnut	0	0	0	0	0	0
Cherry	19.36	0	0	0	0.25	0
Maple	0	0	0	0	3.67	0
Day4						
Hazelnut	0	0	29.89	0	0.86	0
Cherry	12.85	0	0	0.19	0	0
Maple	2.46	2.29	1.69	0.54	0	0

Table 3.1, raw data for Closed canopy, all days, all sites

Open	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Day1						
Hazelnut	6.9	0	0	0	0	0
Cherry	45.4	0	2.24	5.71	0	0
Maple	8.43	0	1.4	3.85	0	0
Day2						
Hazelnut	0	0	0	0	0	0
Cherry	25.25	0.27	0	0	0.39	0
Maple	0.09	0.04	0	0	5.83	0
Day3						
Hazelnut	3.01	0	0	0.05	5.65	1.43
Cherry	34.56	0	0	0	20.8	0
Maple	1.98	0	0	0	2.06	0
Day4						
Hazelnut	0	0	16.22	0	0.28	14.56
Cherry	24.89	0	0.42	0	2.9	0

Table 3.2, raw data for open canopy, all sites, all days

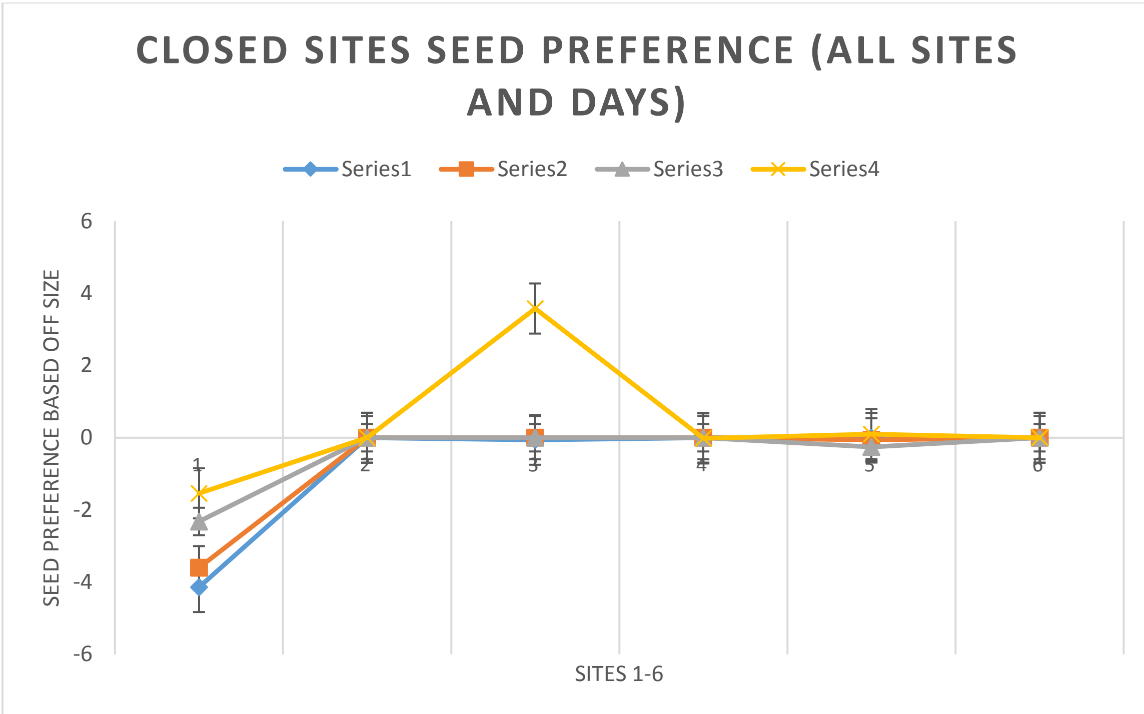

Figure 2.1, seed preference for closed gaps (above)

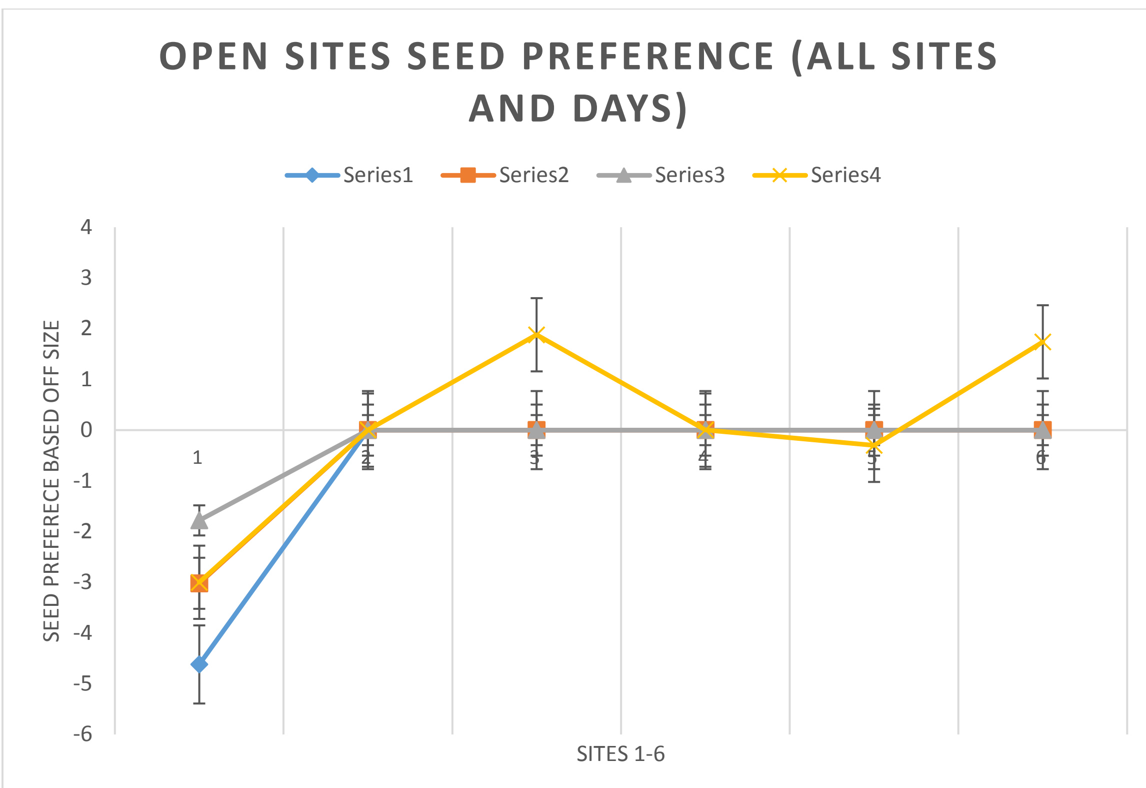

Figure 2.2, seed preferences for open gaps (above)

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