Shaping seed preference: familiarity with food sources in forest deer mice

(*Peromyscus maniculatus gracilis)*

Kaya Moore

Advisor: Dr. Michael J. Cramer

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Abstract

Foraging decisions are not only affected by nutritional value and toxicity, but also by individual familiarity with that food source. This study examines the foraging choices of deer mice (*Peromyscus maniculatus gracilis*) between red maple (*Acer rubrum*) and balsam fir (*Abies balsamea*) seeds. I hypothesized that mice trapped in deciduous forests would prefer red maple seeds, whereas those trapped in coniferous forests would prefer balsam fir seeds. Mice were left overnight with 5 g of both seed species to choose from. While there was no preference for balsam fir seeds in mice trapped in coniferous forests, there was a significant preference for red maple over balsam fir seeds for all mice tested. These results suggest that habitat does not shape seed preference. Despite these results, familiarity could still be occurring with *P. m. gracilis*. Either the assumption that mice trapped in coniferous forests would have been exposed to balsam fir seeds was incorrect, or the effect of familiarity may have been masked by the species' innate preference for red maple seeds. Further experimentation is necessary to determine whether familiarity with a food source shapes seed preference in *P. m. gracilis*.

Introduction

Familiarity with a resource can shape individual preferences in adult life. To become familiar with something, in this sense, is to have a certain level of experience or exposure to it early in life. Familiarity is sometimes referred to as imprinting, however, imprinting suggests that there is a 'sensitive period' when the individual is particularly susceptible to that experience and that any experience occurring after this period cannot reverse the imprint (Davis and Stamps 2004).

Individuals can become familiar with conspecifics, habitats, and food sources. Kavaliers et al. (2005) showed that deer mice, *Peromyscus maniculatus*, need familiarity with a conspecific for social learning, while habitat selection in deer mice (Wecker 1963) and brush mice (Mabry and Stamps 2007) are affected by an individual's early experience with that habitat. When experience with a natal habitat influences an individual's habitat preference, it is referred to as natal habitat preference induction (NHPI). Similarly, when an individual's food preference is shaped by early experience, as it is in Mearns' grasshopper mice with respect to food-borne olfactory cues (Punzo 2004), it can be considered diet preference induction (DPI).

The question being addressed is whether deer mice trapped from two different areas—one deciduous forest and the other coniferous forest—have a strong preference for seeds commonly found in those forest types. Specifically, *P. m. gracilis* provide a good model system for studying the effect of familiarity on seed preference because this species dominates the small mammal community in northern Wisconsin where the University of Notre Dame Environmental Research Center (UNDERC) is located (Cramer, unpublished data). The forests on the UNDERC property are primarily deciduous with few conifer stands. The availability of coniferous trapping areas, and the fact that size, nutrients, and plant secondary compounds of seeds indicate their quality to a seed predator (Lobo et al. 2013), resulted in balsam fir seeds (*Abies balsamea*) being used to represent coniferous forest food sources. The seed species used to represent deciduous forests was red maple (*Acer rubrum*); both balsam fir and red maple are naturally-occuring tree species in northern Wisconsin. I hypothesized that mice trapped in deciduous forests would prefer red maple seeds, whereas mice trapped in coniferous stands would prefer balsam fir seeds.

Methods

Study site

Approximately 2490 hectares of land area on the border between Wisconsin and Michigan constitutes the University of Notre Dame Ecological Research Center (UNDERC). There are 30 lakes in this region, and the altitude ranges from ranges between 500 and 520 meters. As indicated by Curtis (1959), northern mesic forest compromises the upland habitat. I set up trapping grids that were randomly located within deciduous forests containing red maple (*Acer rubrum*) or within forest dominated by balsam fir (*Abies balsamea*).

Trapping protocol

Forest deer mice, *Peromyscus maniculatus gracilis*, were trapped in the two areas outlined above: Bono and Storage were the deciduous grids, while the coniferous grids were Firestone and Plum Coniferous. The deciduous grids contained 25 traps in a 5 x 5 configuration with 15 m spacing, and the Firestone and Plum Coniferous grids had 24 traps in a 3 x 8 configuration and a 4 x 6 configuration, respectively. Mice were live-trapped using Sherman traps (7.62 x 8.89 x 22.86 cm; H. B. Sherman Traps, Inc., Tallahassee FL) and baited using a mixture of rolled oats and black oil sunflower seeds. All captured animals were identified to species, and were sexed, marked, weighed and their body length measured. *P. m. gracilis* were taken to the laboratory for testing after their second capture.

Experimental procedure

I took individuals into the laboratory and singly housed them in cages (19 x 29 x 12.5 cm) with corncob bedding. Only mice that were not lactating or pregnant were used for trials. Throughout the day, individuals were provided standard mouse feed and water *ad libitum*. Five hours prior to trials, mice were starved. After the starvation period, I transferred mice from their

cages into another cage (19 x 29 x 12.5 cm) that had sand bedding. This new cage had two petri dishes, each containing 5 g of each seed (*A. rubrum and A. balsamea*) and the mice remained in those trial cages for 12 hours during the night. I obtained the seeds from Sheffield Seed Co., N.Y. I separated uneaten *A. rubrum* from *A. balsamea*, dried them at around 45˚C until their mass dropped by 0.001 g per hour, and weighed them. I calculated the mass of consumed seeds by taking the difference between initial mass and uneaten mass.

Statistical analyses

Seed selectivity was determined as a ratio of consumed red maple seeds to consumed balsam fir seeds (R_{RM}/R_{BF}). When the value is above 1, maple seeds are the preferable choice. When less than 1, balsam is preferable. Mann-Whitney U tests determined whether there was a statistical difference between the seed selectivity of mice trapped in the two different forest types. I also determined the seed preference of individual mice by running a paired t-test that compared the mass of consumed red maple seeds to consumed balsam fir seeds. All statistical analyses were conducted with R (R Development Core Team 2008), and all statistics are reported as means ± standard error of the means.

Results

Ten trials from each forest type was run, with five coming from each coniferous grid and six from Bono and four from Storage. There was no significant difference between the ratio of consumed red maple to balsam fir seeds eaten between the coniferous (10.032 ± 4.2) and deciduous (10.484 ± 4.2) forests at UNDERC (W = 59, p = 0.5288; Figure 1).

To ascertain which is the more preferable seed, a paired t test was conducted (t_{19} = 11.5648, p < 0.001; Figure 2) that compared the mass of consumed red maple seeds (4.640 g ±

0.043) to balsam fir seeds (1.563 g ± 0.24). This result shows that there is a significant difference between the consumed masses of the two seeds, and that red maple seeds are preferred.

Discussion

These results demonstrate that there is no significant relationship between the habitat in which a mouse resides and the seed it prefers because mice that were trapped in both coniferous and deciduous forest types inherently preferred red maple seeds over balsam fir seeds. This suggests that habitat does not shape seed preference.

Familiarity, however, may still be affecting preferences. I made the assumption that mice trapped in a specific forest type would have had early experiences to seeds found in that forest, and although deer mice juveniles commonly remain in their natal area, they have been shown to move between habitats (Walter 1991). I avoided the problem of mice moving through my grids by only using recaptured mice in the trials. Had I not done this, it is likely that I could have tested mice whose habitat was not the forest type associated with that grid. However, I could not control the natal habitats of the adult mice I used. Not only do some juveniles disperse from their natal habitat (Walter 1991), but also the forests at UNDERC contain very few stands of coniferous canopy that are relatively small. My coniferous trapping sites, therefore, were located near large expanses of deciduous forest, which means that some of the mice trapped in these grids could have had early experiences with deciduous seeds, as well as coniferous seeds. Further experimentation could avoid this limitation by using lab-reared mice and controlling the seeds to which juveniles are exposed.

Alternatively, innate preferences for red maple over balsam fir could outweigh the familiarity with balsam fir seeds that *P. m. gracilis* may have had. *P. m. gracilis* has a documented preference for red maple over sugar maple seeds (Cramer 2014), while balsam fir

seeds are not preferred to white pine seeds with pine seed predation being ten times greater than that of balsam fir seeds (Duchesne et al. 2000). Further experimentation could focus on different seed species. A similar experiment looking into familiarity and olfactory cues has shown imprinting to occur in larval anemonefish with chemical cues, but familiarity had less of an impact on certain cues, specifically the cues that are more necessary for survival (Dixson et al. 2014). Although familiarity was important in the laboratory portion of that study, the field-based portion did not find familiarity to have an effect on the individuals (Dixson et al. 2014). This suggests that familiarity with a resource or an individual can be affected by complex field conditions, which could be affecting the results of my study.

Additional experimentation could look into the physical characteristics—such as size, nutrient value, and toxicity—of each seed species to determine which of these factors are affecting *P. m. gracilis* seed preference. Although nutritional values play an important role in seed preference, it has been shown that the rate of energy intake has a greater significant relationship with seed preference (Kerley and Erasmus 1991). It may be the case that *P. m. gracilis* can maximize their rate of energy intake when consuming red maple seeds, which would also explain the preference for that seed species over balsam fir seeds.

An alternative idea that may explain the unexpected results is that of neophilia, wherein individuals prefer to explore novel resources rather than familiar ones. *P. maniculatus* is thought to be neophilic due to their large geographic distribution and the fact that they are diet generalists, however, they are no more neophilic than other *Peromyscus* species studied (Martin et al. 2007). Moreover, had *P. m. gracilis* been neophilic, the mice trapped from the deciduous forests would have eaten more balsam fir seeds, which was not the case.

Despite the limitations of this study, there is still a potential for familiarity to be occurring in *P. m. gracilis* with regards to seed preference. Either my assumption—that mice trapped in a particular forest type would have been exposed to seeds associated with that forest— is incorrect, or the seemingly innate preference for red maple seeds may be overriding the individual's familiarity with balsam fir seeds. If it is the former, then future studies could use lab-reared mice and control their early exposure; if the latter, then further evaluation could focus on different seed species. In conclusion, the habitat in which *P. m. gracilis* individuals are trapped does not indicate what seed species is preferred.

Acknowledgements

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Figure Legends

Figure 1. Plot showing the similarity between the selectivity in different forest types. Mice from either coniferous or deciduous forests were left with both red maple and balsam fir seeds overnight to determine whether a mouse's familiarity with a certain seed made the individual more likely to select that seed over another. Selectivity was determined as a ratio of consumed red maple seeds to consumed balsam fir seeds (R_{RM}/R_{BF}) and analyzed between the two forest types (deciduous 10.032 ± 4.2; coniferous 10.484 ± 4.2). The ratios of the consumed seeds were analyzed using the Mann-Whitney U test ($W = 59$, p-value $= 0.5288$). There was no significant difference between the ratio of consumed red maple seeds to balsam fir seeds eaten across the coniferous and deciduous forests at UNDERC.

Figure 2. Mass of consumed red maple seeds exceeded that of consumed balsam fir seeds. A paired t test was conducted ($t_{19} = 11.5648$, $p < 0.001$) to ascertain whether red maple or balsam fir is the more preferable seed. The graph shows that red maple (4.640 g ± 0.043) is significantly more preferred over balsam fir (1.563 g ± 0.24).