

**Habitat Selection Experiment: Examining the Coexistence of Two Sympatric
Peromyscus Species**

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Alyse Kinchen

Advisor: Jennifer Hsia

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Abstract

Although deer mice (*Peromyscus maniculatus*) and white-footed mice (*P. leucopus*) have been observed to regularly co-occur in habitats, the mechanisms and niche partitioning underlying their continued coexistence are still being determined. During the summer of 2006, eight live-trapping plots were set up around the UNDERC property in mixed hardwood forests. At each site, vegetation surveys were taken to measure ground cover and vertical stratification to test their affect on relative species abundance. A multiple regression was run on both species separately, revealing statistically significant values for the Levins index versus white-footed mice and percent canopy cover versus deer mice. Although results revealed the coexistence of deer mice and white-footed mice on property, the mechanisms behind habitat segregation and resource partitioning still require further investigation.

Introduction

Previous studies on resource partitioning and the distribution and abundance of rodents in mixed deciduous-coniferous forests have demonstrated that many rodents in the family Cricetidae reduce competition by partitioning vertical space (Vickery, 1980). In the *Peromyscus* genus, deer mice (*P. maniculatus*) and white-footed mice (*P. leucopus*) are both semi-arboreal (Barry, Jr. et al., 1984) and nocturnal (King, 1968) species, which forage for similar food sources and prefer similar habitats, giving them the potential to coexist. Although these two species regularly co-occur in habitats, the mechanisms and niche

partitioning underlying their continued coexistence are not well understood (Kantak, 1983).

Examining species distributions and site-specific competition is useful for understanding the species composition of the surrounding community (Harney and Dueser, 1987). Resource partitioning and habitat segregation among similar species reduces competition, allows more species with similar niches into a given area, and thereby effectively maintains community diversity.

Methods of resource partitioning include segregation into generalists and specialists. Drickamer (1976) found that white-footed mice are more of a generalist than deer mice in relation to foraging strategies. Indeed, white-footed mice were more likely to adjust their food habits to their habitats or vice versa. On the contrary, deer mice failed to shift their food habits and had little to no flexibility in their foraging. Studies have also found deer mice to show signs of territoriality and competition by pushing other conspecifics out of their areas (Fairbairn, 1978, Frischknecht, 1965). White-footed mice have also been concluded to readily explore new habitats (Sheppe, 1966) making them more likely to leave one habitat for another. Because white-footed mice are more flexible, they are found in a wider variety of habitats, while deer mice are found to be more specialized to sites that cater to their food habits (Drickamer, 1976).

An example of habitat segregation is microhabitat preference. Some studies have concluded that deer mice are far more arboreal than white-footed mice (Harney and Dueser, 1987, Burt, 1957). A study examining microhabitat

variables found a direct positive correlation between the relative species abundance and the availability of preferred microhabitats in rodents (Dueser and Shugart, 1978). Past studies have found deer mice prefer habitats of higher tree density while white-footed mice prefer habitats of higher shrub density and understory vegetation (Barry, Jr. et al., 1984; Harney and Dueser, 1987).

Based on the aforementioned conclusions and proposed mechanisms, white-footed mice and deer mice can coexist, the question that remains is how. Using two species with similar morphological and ecological characteristics provides the opportunity to investigate the effects of site-specific competition. Consequently, I studied if and how the two *Peromyscus* species coexist on the University of Notre Dame's Environmental Research Center (UNDERC) property and how their microhabitats differ structurally. I predicted to find a higher density of deer mice in areas with higher tree density and a higher white-footed mouse density in areas of high shrub density with fewer trees. UNDERC has varying habitats and is not dominated by any one habitat type, thus a generalist species would do far better than a specialist. Because white-footed mice are versatile in their habitat selection and food habits, I expect a higher abundance of white-footed mice (Drickamer, 1976).

Methods

UNDERC property has mixed hardwood forests, and both *Peromyscus* species have been collected on property in the past three years (K. Francl, *personal comm.*). In this study, I explored the habitat variables that affect and

influence the *Peromyscus* species' coexistence and related them to deer mice and white-footed mice densities. I examined the two species' preferred habitats and based the size of my trapping sites on their average home range. Sites were chosen for their mixture of coniferous and deciduous trees. Deer mice have an average home range of 7080 m², and white-footed mice have an average home range of 4050m² (Burt, 1957).

Small Mammal Trapping

To estimate population densities of deer mice and white-footed mice, I used the catch per unit effort (number of individuals captured/number of trap-nights) at eight sites on the UNDERC property (Wilson et al., 1996). At each site, I set up four 100m transects at 15m intervals within each plot (0, 15, 30, 45m). Each transect consisted of 10 Sherman traps placed every 10m. I trapped twice at each site for five consecutive nights, for a total of ten trapping sessions per site over the course of June and July, non-consecutively. Traps were baited with rolled oats and peanut butter. Traps were checked at 0700-1000 CDT and 1530-1830 CDT daily. I measured all trapped individuals (species, gender, age, weight), recorded location and ear tagged them (No. 1, National Band and Tag Co., Newport, KY). All methods and procedures were in compliance with the University of Notre Dame's Institutional Animal Care and Use Committee standards.

Habitat Analysis

To measure ground cover, ten coordinates were chosen from random number tables for each site. At each point, I selected a shrub and measured the basal area. I then divided the shrub's area into four quadrants and recorded the distance to the closest ground cover in each quadrant.

I measured vertical stratification by choosing 30 random points within each site. Using a 7m range pole, I recorded any vegetation touching the pole at each of eight intervals (0-0.5m, 0.5-1m, 1.5-2m, 2.5-3m, 3.5-4m, 4.5-5m, 5.5-6m, and >6.5m). I calculated the degree of vertical plant diversity using the Levins diversity index, L (Levins, 1968),

$$L = \sum 1 / (d_i)^2$$

where d_i = number of vegetation hits recorded within each 0.5-m increment for each point "t."

To determine if tree diversity affected habitat choice and relative abundance, plots (25m^2) were set up on each transect every 20m (0m, 20m, 40m, 60m, 80m). In each plot, mature trees ($\text{d.b.h} \geq 5\text{cm}$) were identified and measured (Brooks *et al.* 1998). The trees were then grouped into deciduous and coniferous.

Statistical Analysis

Using a multiple regression, I compared the relative abundances of each *Peromyscus* species to the vegetation measures of ground cover, Levins index, and canopy cover. I also employed a linear regression to examine the relationship

between the relative abundance of each species and the percentage of coniferous trees for each site.

Results

I captured 89 unique *Peromyscus* individuals in 157 captures in 3,200 trap nights, with deer mice present at all eight sites and white-footed mice present at seven of the eight sites. Seventeen *Peromyscus* individuals were captured and identified only to genus; therefore, they were omitted from the analyses. Figure 1 shows the relative abundance (as estimated by captures per trap night) of each species at all sites.

Prior to statistical analyses, data for ground cover were log transformed, while data for percent canopy cover were arcsine-transformed to normalize the data. A multiple regression revealed a significant positive relationship between percent canopy cover and relative deer mice abundance (Fig. 2; $R^2 = 0.581$, $p = 0.028$). Results of the multiple regression also found that there was a significant negative relationship between Levins diversity index and relative white-footed mice abundance (Figure 3; $R^2 = 0.66$, $p = 0.013$).

A linear regression of relative abundance and percent coniferous species returned two p-values that did not show statistical significance.

Discussion

The results of this study supported my first hypothesis that tree and shrub density affect relative species abundance. My research also is supported by both Vickery (1981) and Harney and Dueser's (1987) conclusions that deer mice

choose more arboreal sites, because my results showed deer mice to have a higher relative abundance in areas with higher canopy cover.

Just as Harney and Dueser (1987) also concluded that white-footed mice concentrated their activity on the ground, I found the higher the Levins index the lower the white-footed abundance. Because this index measures the degree of vertical stratification the higher the index numbers may mean that the structure is less preferable for white-footed mice. Another theory is that the lower vertical diversity (lower Levins index) the lower deer mice abundance creating less competition for white-footed mice and increasing overall white-footed abundance.

This could be why deer mice are more prevalent at sites with high Levins index; sites like Beaver Bog and Palmer show low to no white-footed mice relative abundance. It is not that the sites are unsuitable for white-footed mice, but they are more of a generalist forager (Drickamer 1976) and therefore are more flexible in habitat.

Vickery (1981) found that deer mice are most active in areas of higher canopy cover, which is directly related to vertical stratification and they are restricted to much narrower ranges of habitat. Ed's Bog, Northeast Gate and Kickapoo all fall into the middle range of index numbers (Fig. 4, Table 1) which is why it could be harder to see a pattern in the relative abundance.

My results failed to support my second hypothesis of finding overall higher white-footed mice abundance (Fig. 1). Vickery (1981) found that different rodents use habitats differently throughout the summer, possibly due to

competition. If both *Peromyscus* species are partitioning the habitat at different times of the summer the observed abundances would be an inaccurate representation. If the mice are shifting habitats over time, the observed species overlap could simply be due to the species shift in habitats.

Levins (1979) also showed that coexistence could be a result of temporal disparity and nonlinear resource expenditure; therefore rodents could be coexisting without needing to partition habitat or food. Factors like resource abundance and predation could affect whether resource and habitat partitioning are necessary. In support of my conclusions, Vickery (1981) also found that certain other studies' conclusions about rodents coexisting through habitat partitioning do not apply to all eastern forests.

The results focus on each species separately with respect to the habitat, but do not account for any species interactions. Indeed, these results show that the two species coexist at most sites, but it is unclear as to whether co-existence is due to deer mice moving in and white-footed mice moving out or if they are partitioning their habitat. A future study could look at sites like Long Lake and Tenderfoot long-term to see if deer mice are moving into the area and pushing white-footed mice out. With white-footed mice being more of a generalist species, a rise in deer mice population could decrease white-footed population in a particular area. A decrease in white-footed abundance in one area could increase abundance at another site that is less inhabitable for deer mice.

Since this study only took *Peromyscus* species into mind, it did not account for other rodents that may affect habitat selection. *Myodes gapperi* have been known to displace deer mice populations (Vickery, 1981), making competition more important in determining habitat. While this study does not show how rodents partition habitat or manage coexistence, it does show that habitat composition, in terms of variables I measured, is not a driving force in determining *Peromyscus* relative abundance.

Because there were unidentified *Peromyscus* individuals, there might be error in some of the indexes, and this hypothesis should be further tested to see if white-footed mice are more generalist foragers than deer mice. Because deer mice are specialist foragers, they are possibly more aggressive in attaining territories. This could be a future hypothesis in explaining relative abundance differences at varied sites. Future studies could look at more varied sites to see if there is a greater difference in species presence based on tree species composition. It could look at whether habitat or competition plays a bigger role between the two species.

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Tables

Table 1. The Levins index and relative abundances. All of the indexes and relative abundances for each species calculated for each site used in Figures 1 and 2.

Sites	Levins Diversity Index	Relative Abundance of Pema	Relative Abundance of Pele
Palmer	2.576	2.44444	0.44444
Northeast Gate	1.66	0.44444	0.44444
Kickapoo	1.488	2	1.77778
Long Lake	0.441	0.22222	0.44444
Cranberry	1.631	2.66667	0
Tenderfoot	1.76	0.66667	0.88889
Beaver Bog	3.203	1.33333	0.22222
Ed's Bog	0.983	1.33333	0.88889

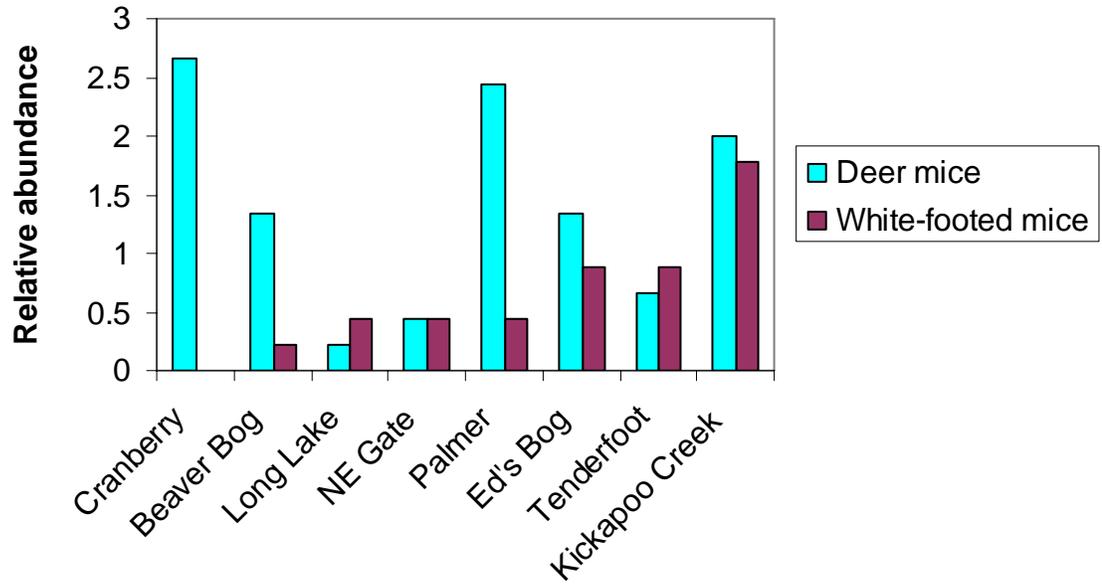


Figure 1. Relative abundance (captures per trapnight, 3200 trapnights) of each *Peromyscus* species over eight sites surveyed in summer 2006. .

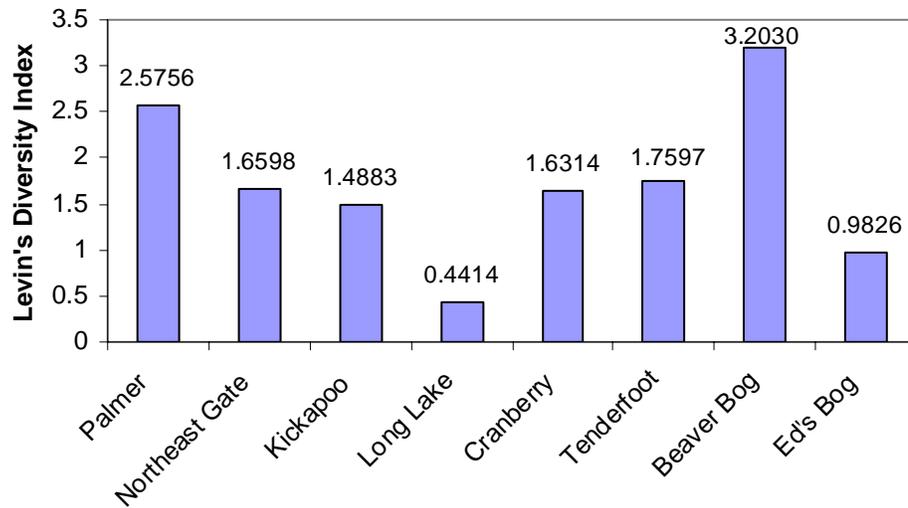


Figure 2. Levins diversity index at each site. The higher the Levins index the more vertical stratification found at the site. Long Lake had the least stratification (0.4414) and Beaver Bog had the most (3.2030).

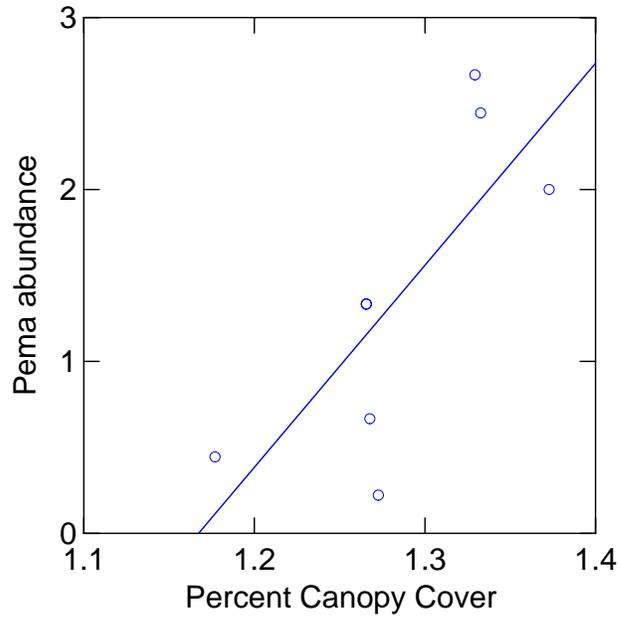


Figure 3. Percent Canopy Cover vs. Deer Mice abundance. A multiple regression returned a significant p-value of 0.028 and an R^2 of 0.581. Percent canopy cover data was normalized by taking the arcsin(x).

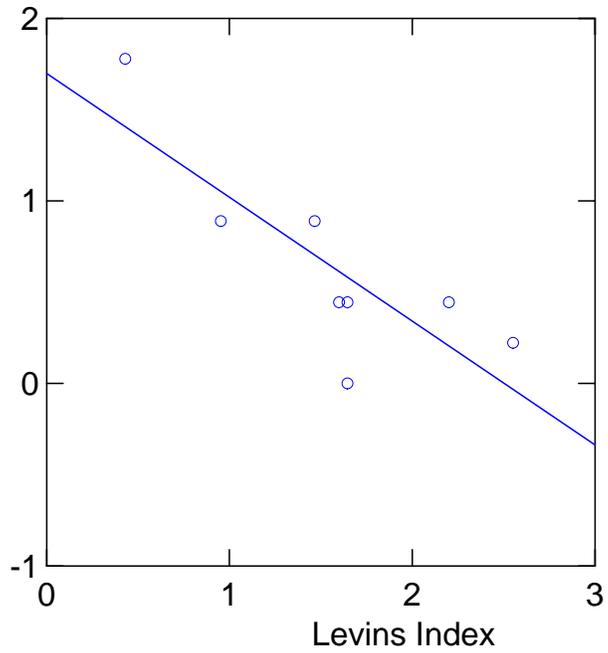


Figure 4. Regression of Levins index vs. White-footed mice abundance. A multiple regression returned a statistically negative relationship with a significant p-value of 0.013 and an R^2 of 0.66.