

**Morphological and Habitat
Differentiation of *Peromyscus leucopus* and *P.
maniculatus*.**

Becky Norris & Dr. Joseph Jacquot

Grand Valley State University

Biology Department

**1 Campus Drive
Allendale MI, 49401**

Introduction

White-footed mice (*Peromyscus leucopus*) and deer mice (*Peromyscus maniculatus*) are widespread in North America and their ranges broadly overlap throughout Eastern North America. Locally *P.l noveboracensis* mainly utilize forest habitats and our local subspecies of DM, *P.m. bairdii*, utilize open prairie habitats (Kurta, 1995). However, local live-trapping in open prairies has resulted in more captures of WFM than DM.

WFM are more general in terms of habitat use than DM (Kamler and Pennock, 2004). WFM prefer forest habitat, are considered semi-arboreal, and are generally the most common small mammal in local forests (Lackey et al, 1985). The preferred habitat of WFM often includes high canopy cover, high woody stem densities, and vertical structural complexity (Lackey et al, 1985). In open habitats, vertical structural complexity would increase with age (i.e., time since last burn). We therefore predicted more WFM would be captured in older than younger prairies and we expected the opposite pattern for DM.

Past work has documented that WFM utilize prairie habitats when adjacent forest populations were at high densities (Adler & Tamarin, 1984). Adler and Tamarin also suggested that WFM captured in prairies had been displaced from preferred habitat and were dispersing or were forced into a habitat of a lower quality. We therefore predicted that prairie WFM would be younger and smaller than forest WFM, since most WFM disperse as subadults (Clark et al, 1987.)

A confounding problem is that WFM and DM can be difficult to distinguish in the field when using only external characteristics. As a result, many studies have attempted

to identify key distinguishing characteristics for use in the field (Kurta, 1995; Rich et al, 1996; Kamler et al, 1998). In general, WFM tend to be larger than DM, with longer tails, hind feet, and ears than *P.m. bairdii* (Kurta, 1995). DM have darker dorsal pelage than WFM, but WFM have a more distinct dorsal stripe than DM. WFM have completely white throat hairs, whereas those DM are white with a gray base. DM have more strongly bicolored tails than WFM and a more pronounced tuft of hair at their tail tip (Kurta, 1995). Traits useful for distinguishing these species vary by region (Choate et al., 1979; Rich et al., 1996; and Kamler et al, 1998). Our morphologic analyses required independent confirmation of species identity which was done using mtDNA sequencing.

We tested five main hypotheses regarding habitat use and identification of the two *Peromyscus* species in Southwest Michigan. 1.) We tested the null hypothesis that WFM and DM use forest and open habitats equally and 2.) that WFM and DM use open habitats with no regard to its age (i.e., burn history). 3.) We tested the null hypothesis that population densities and age structure of WFM would not differ in forest and open habitats. 4.) Our fourth hypothesis was that there are no distinguishing characteristics between the two *Peromyscus* species. 5.) We also tested the null hypothesis that no microhabitat features influenced habitat use by *Peromyscus*.

Methods

Our study was conducted at Pierce Cedar Creek Institute (PCCI), Hastings, MI and the Edward Lowe Foundation (ELF) near Cassopolis, MI which is approximately 90 miles SSW of PCCI (Fig. 1.) Four spatial replicates were established at each site. Each replicate consisted of an 11 x 5 live trapping grid at 15 m intervals, centered on the interface of adjacent forest and prairie habitat. We used the forest edge as a reference

with each grid oriented parallel to and away from the reference line which also had a line of 5 traps (Fig. 2.) Each grid point was marked with a numbered flag and one Sherman live trap (i.e., 55 live traps per replicate).

Replicates were spaced as far from one other as possible to promote independent sampling of habitat replicates. Habitat was quantified at each trap station with the following measures: litter/mat depth to nearest cm (average of 4 measures/m²), DBH and species identity of trees greater than 5 cm, visual estimation (to nearest 5%) of grass, forbs, bare ground and woody vegetation using a 1 m² sampling frame and finally, vegetation contacts on a pvc pipe scored every ¼ meter up to 2 m. Habitat analyses were split into a broad scale analysis including data from all three habitat types and a narrow scale analysis that only considered forest. We used Detrended Correspondence Analyses (DCA) to analyze our habitat data and compared the microhabitat features at trap stations with captures to those stations that did not capture target species.

General Trapping Procedures: Trapping occurred from mid-May through mid-July, 2008. Live traps were set just prior to dusk and checked at either midnight or just after dawn. Traps were baited with sunflower seeds and 2-3 cotton balls were added for nesting material. Non-target species were released immediately at the point of capture. All *Peromyscus* were given uniquely-numbered ear tags. Captured *Peromyscus* were returned to the lab to obtain a tissue sample, to take additional measurements described below, and to photograph adults under standardized conditions. A sharp, sterilized biopsy punch was used to obtain $\approx 2\text{-}3\text{ mm}^2$ tissue for subsequent genetic analysis (i.e., species determination.)

Morphological Measurement Procedures: We measured hind foot length, ear length, tail length, and total length to the nearest 0.1 cm on all adult *Peromyscus* as indicated by pelage coloration. Hind foot length was measured from the heel to the tip of the middle claw. Ear length was standardized by measuring from the bottom notch near the ear opening to the tip of the ear. Tail length was measured from the upper base to the tip, not including any extending hairs past the tip (following the methods of Kamler et al, 1997).

Photography Procedures: Photographs were taken of adult *Peromyscus* to compare pelage coloration on the dorsum, side of tail, and tail tip as these are regions that are reported to differ between the two study species. All photographs were taken under standardized lighting and camera settings. Pelage coloration was quantified using Photoshop©. Values were assigned to the following attributes of color: red, green, blue, cyan, magenta, yellow and black. The values for each color range from 0 – 255, with higher numbers indicating a larger proportion of that color in the individual pixel selected. Three pixels from each of the four areas were sampled and averaged for each of the seven values. We used ANOVA and univariate statistics to analyze our data and discriminant function analyses to analyze both our habitat and morphometric data.

Results

We captured 103 *Peromyscus* a total of 327 times during the study. Our trapping effort consisted of 4034 trap nights. We captured several non target species which included meadow voles (*Microtus pennsylvanicus*,) short-tailed shrews (*Blarina brevicauda*,) eastern chipmunks (*Tamias striatus*,) meadow jumping mice (*Zapus hudsonius*) and southern flying squirrels (*Glaucomys volans*.)

WFM were most often captured in forests and were only captured in prairie in one replicate at PCCI (Tab. 1). DM were not captured in forest, edge, or prairie; additional trapping in a soy bean field and a sunflower food plot (both at ELF) yielded only 4 DM. The prairie age hypothesis could not be tested because WFM were only caught in 1 prairie out of 8. We also could not test the morphometric/coat color hypothesis because only 1 adult DM was captured during the study, not allowing a statistical comparison. There were significant differences in adult population densities of WFM between the two habitats. There were more adult WFM in forest habitats than in prairie habitats (Fig. 1.)

We investigated habitat preferences at two scales for WFM. In the first analysis we included all three habitat types: forest, edge, and prairie. In this analysis, DCA axis 1 explained 47% of the variation in capture probability for a given trap station (Fig. 4.) DCA axis 2 explained an additional 14% of variation (Figure 5). DCA axis 1 had high values for percent cover of grass, mean litter depth and vegetation hits from 0-1 m, which was another measure of grass. We interpreted axis 1 to represent a gradient from prairie to forest, with high values corresponding to prairie-like conditions and fewer WFM captures. We interpreted axis 2 to represent a gradient from areas with high cover levels to areas of lower cover. Values for % forbs, number of woody stems and vegetation hits from 1-2 m corresponded with high capture values in axis 2.

When considering only forest stations (i.e., narrow-scale analysis) DCA axis 1 accounted for 48% of the variation in capture probability for a given trap station. DCA axis 2 explained an additional 10% of (Fig. 6.) DCA axis 1 had high positive values for total basal area, amount of coarse woody debris and number of trees, which we

interpreted as a gradient from higher to lower tree density and was positively correlated with capture probability of WFM. DCA axis 2 had high positive values for percent bare ground, number of stems and mean litter depth, which we interpreted as a gradient from lower to higher levels of brushiness and was negatively correlated with capture probability of WFM (Fig 7.)

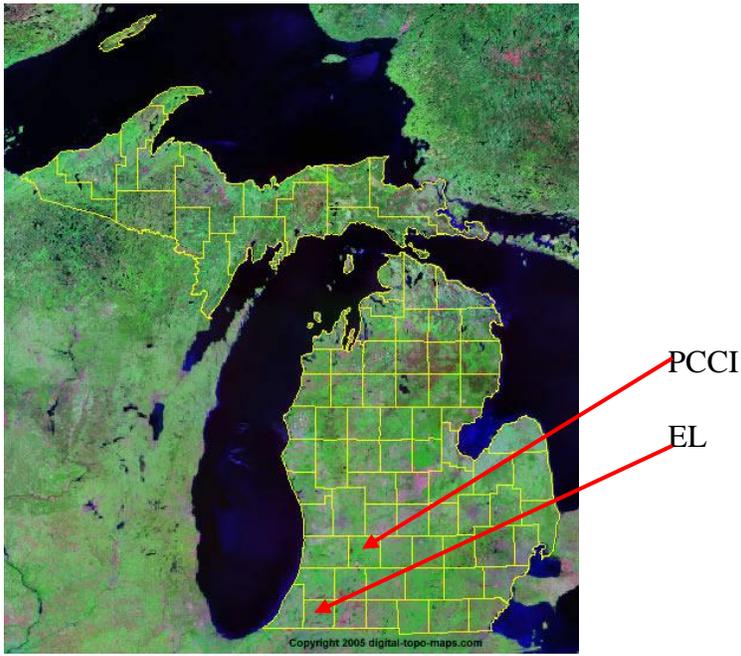


Figure 1. Our two study sites were located at Pierce Cedar Creek Institute in Barry County, MI and the Ed Lowe Foundation in Cass County, MI.

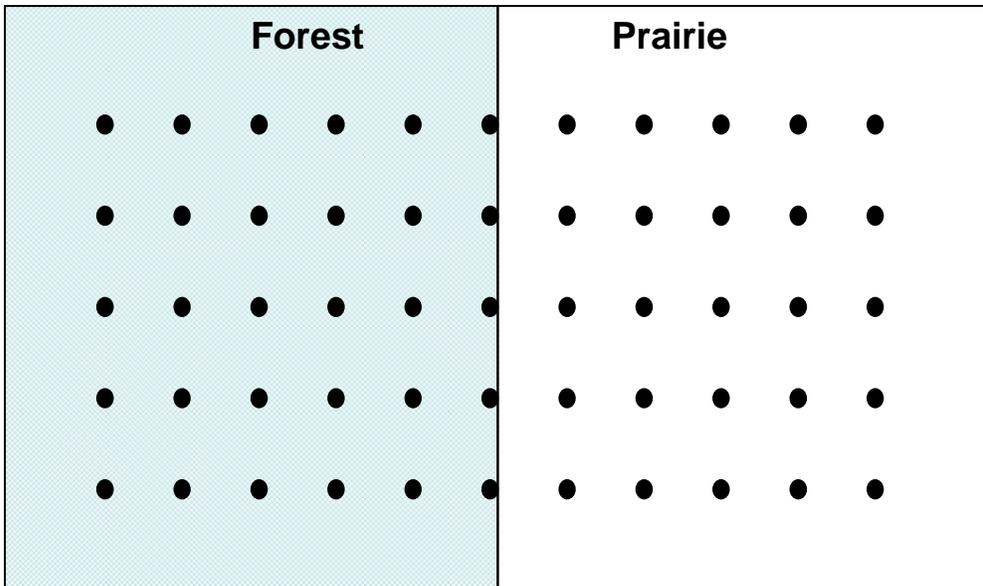


Figure 2. At each of our study sites we had four replicates; each consisted of an 11 x 5 grid with a 5 x 5 grid of live traps in forest and prairie centered on the forest edge. Stations were spaced at 15m intervals.

Site	Habitat	WFM captures	DM captures	Trap Nights	Captures/100 trap nights
Pierce	Forest	128	0	1075	11.9
Cedar	Edge	10	0	215	4.7
Creek	Prairie	19	0	1075	1.8
Institute	AG	0	0	48	0
Edward	Forest	106	0	645	16.4
Low	Edge	3	0	150	2.0
Foundation	Prairie	0	0	750	0
	AG	0	4	80	5.0

Table 1. White-footed mouse and Deer mouse captures by site and habitat show higher WFM captures in forests than prairies and DM captures only in agricultural fields. Overall trap nights are higher at PCCI than EL and captures/100 trap nights in forest are higher at EL than PCCI. There was less trapping effort in agricultural habitats than the other habitat types.

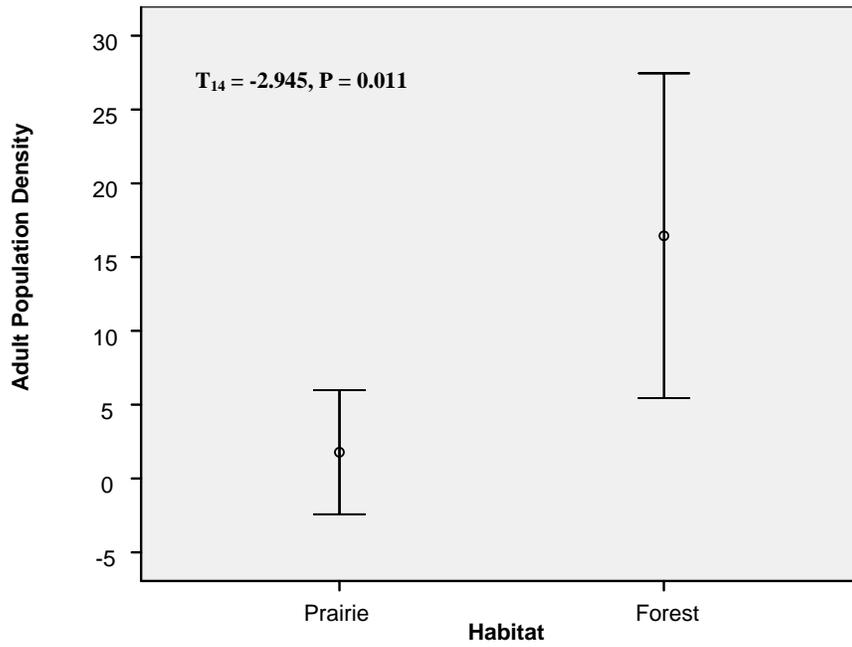


Figure 3. Population densities of adult white-footed mice were significantly higher in forest than in prairie. We estimated population density as the minimum number known alive.

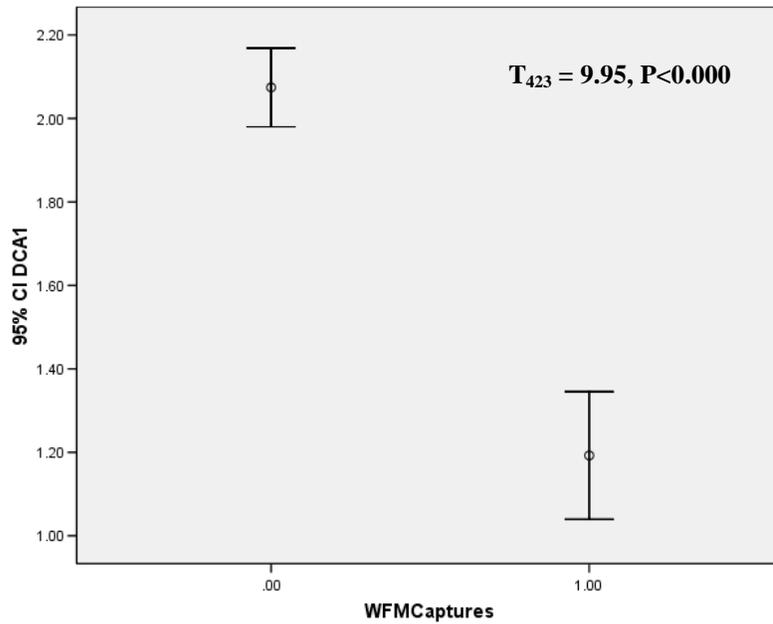


Figure 4. Detrended Correspondence Analyses (DCA) compare combinations of factors to determine which have the greatest effect on large datasets. The broad scale DCA of axis 1 includes both forest and prairie habitats. Values loaded high for % grass, mean litter depth and vegetation hits from 0-1 m. This corresponds to the DCA value of .00 (WFM non captures.)

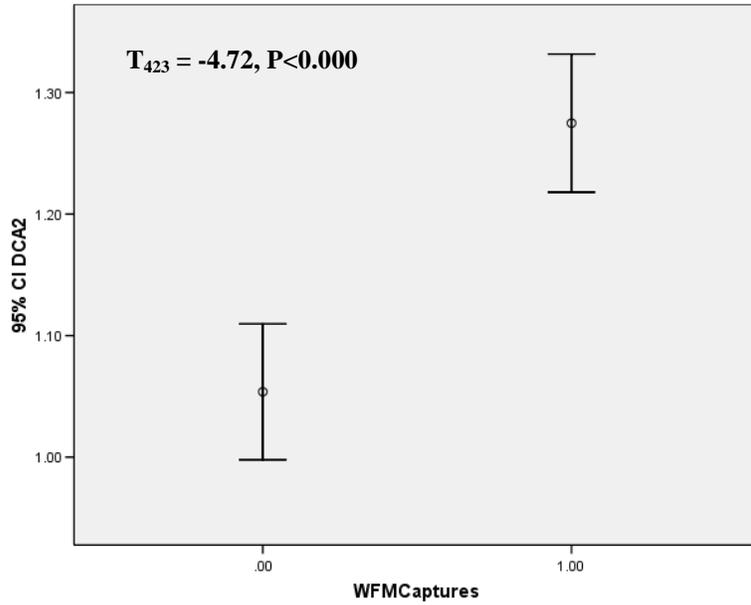


Figure 5. Broad scale DCA of axis 2 includes both forest and prairie habitats. Values loaded high for % forbs, number of woody stems and vegetation hits from 1-2 m. This corresponds to a DCA value of 1.00 (WFM capture.)

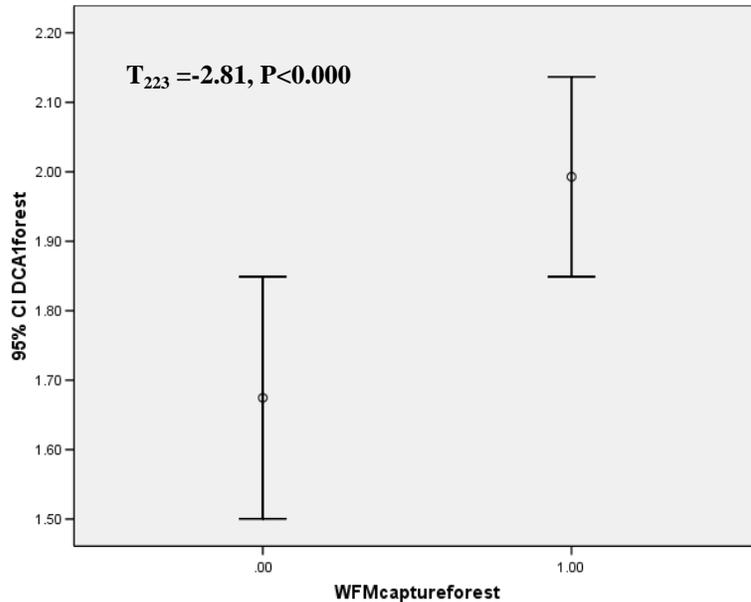


Figure 6. Narrow scale DCA of axis 1 includes analysis of forest qualities only. Values loaded high for total basal area, CWD size and number of trees. This corresponds to a DCA value of 1.00 (WFM capture.)

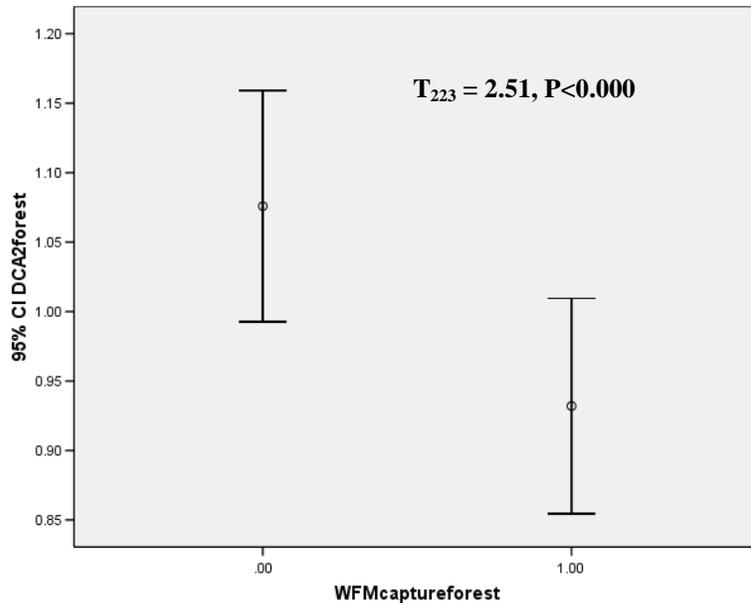


Figure 7. Narrow scale DCA of axis 2 includes analysis of forest qualities only. Values of % bare ground, number of stems and mean litter depth loaded high. This corresponds to a DCA value of .00 (WFM non capture.)

Discussion

We did not capture deer mice in forest, edge, or prairie habitat in either study site despite a relatively high trapping effort (4034 trap nights). We were only able to capture four DM in two food plots at the EL site. Others authors have also reported an unexpected absence of DM in high-quality habitats (Kamler and Pennock, 2004; Long, 1996). One possible explanation is that WFM are outcompeting DM in their preferred prairie habitat. However, we can reject this explanation because relatively few WFM were caught in prairies. In fact, we only captured WFM in one of our eight sampled prairies. At this point, we are unsure as to why DM populations are absent from local prairies.

We were able to reject our first hypothesis, WFM and DM did not use habitat equally. WFM were captured in forests the majority of the time. DM were only captured

in food plots or agricultural fields at one site. No evidence of sympatry was found at either study site and their habitat use matched our expectations based on published accounts of these species, except for the lack of DM in prairies (Kurta, 1995; Kamler and Pennock, 2004).

We were also able to reject our third hypothesis that population density did not vary between forest and prairie populations of WFM. WFM reached higher adult densities in forest than prairie habitats. We considered the possibility that WFM were found in only one prairie because the densities were relatively high in the adjacent forest, thus forcing surplus individuals out of the desired habitat. The forest population near the prairie in question did not have a noticeably higher WFM density than the other forest areas that had no WFM captures in adjacent prairies.

The broad scale analysis showed that WFM are more likely to utilize habitats that have low litter depth, little ground vegetation, higher levels of forbs and more woody vegetation. These characteristics are indicative of a forest-like habitat. For the local subspecies of *P. leucopus*, this trend is expected. Many studies have shown that WFM prefer wooded habitats to open, grassy habitats (Kamler and Pennock, 2004; Lackey et al, 1985.)

On a narrow scale, WFM were found to most importantly prefer high values for total basal area, CWD size and number of trees. Secondly, they tended to avoid areas that had high values of percent bare ground, number of stems and mean litter depth. These characteristics combined are indicative of WFM preferring older, more mature forest systems. We can therefore make the conclusion that WFM prefer these older forest

systems with larger and higher density trees and higher densities of large sized CWD over younger, brushier forests with more litter and smaller, less dense CWD.

In conclusion, we documented several broad- and narrow-scale habitat preferences for WFM at our study sites. However, our most compelling result was the absence of DM from local prairies, which hindered testing many of our hypotheses, but in itself is important. Others, such as Long (1996) have seen trends similar to those we observed in Southwest Michigan. This indicates that there is some, or possibly many factors in the area that are effecting DM populations and the habitats they use. Jannet et al (2007) suggest that global warming has an impact on species ranges; causing them to expand upslope and northward. This is certainly a possible cause for the trends noted in our study. Other factors that are possibly influencing the lack of DM in the area are still uncertain, and future research is certainly warranted.

Acknowledgements

We would like to thank the staff at Pierce Cedar Creek Institute in Hastings, MI for all the help they provided; the Edward Lowe foundation in Cassopolis, MI for the use of their property; Dr. Bradley Swanson for his assistance with our genetic analyses; and finally, Katelyn Schumacher for the hours she spend in the field and for her invaluable assistance with the genetic analyses.

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