Effect of coarse woody debris on *Peromyscus leucopus* population size

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Abstract

Peromyscus leucopus (white-footed mouse) is commonly found throughout Michigan in forested habitats. Recently, a small mammal census discovered a large increase in the numbers of *P. leucopus* at an experimental plot that produced large amounts of coarse woody debris at the University of Michigan Biological Station in Pellston, MI. We hypothesized that the increase in the amount of downed coarse woody debris at the experimental plot provided high quality habitat for *P. leucopus*, leading to an increase in the population, and we predicted that traps set at an increasing distance from the experimental plot would be less successful than traps set close to the plot. We set up 3 trapping grids: one in the experimental plot, 1 450 m from the plot, and 1 1150 m from the plot. The mice were assessed for their pelage class, sex, reproductive condition, and mass. Measurements of the amount of downed coarse woody debris and number of trees at each trapping station were also taken. The proportion of traps that caught mice differed among plots (experimental plot: 0.627 mice/trap night, plot A: 0.47 mice/trap night, plot C: 0.74 mice/trap night; χ^2=15.44, df=2, p<0.001), but the plot with the largest number of mice was the furthest from the FASET plot, leading to rejection of the hypothesis.

Introduction

In the spring of 2016, a small mammal census performed at the University of Michigan Biological Station (UMBS) in northern Michigan revealed exceptionally high numbers of *Peromyscus leucopus* (white-footed mouse). One trap line in particular produced white-footed mouse numbers greater than 50% higher than observed previously in the annual small mammal census, which has been performed annually for the last 27 years (Philip Myers, [University of Michigan, Ann Arbor, MI], personal communication, [July 2016]). White-footed mice are common to northern Michigan, although they are not typically found in such high population densities. *Peromyscus leucopus* is found in various habitats, including forests and areas with shrubs and downed coarse woody debris (CWD). White-footed mice often use trees, logs, and other vegetative cover to avoid predators and find food (Kurta, 1995).

The Forest Accelerated Succession ExperimenT (FASET, 45.563 ˚N, 84.697 ˚W, University of Michigan) began in 2008 at UMBS, when >6700 birch (*Betula* spp.) and aspen trees (*Populus tremuloides* and *P. grandidentata*) in a 39 ha area were girdled to induce early mortality. The objective of the experiment is to project the future succession of Michigan forests and predict its effects on carbon uptake (Maurer, 2011). Eight years after the trees were girdled, many of them have now fallen and are in the process of decomposing on the forest floor ("Forest Accelerated Succession Experiment," UMBS). This experiment has caused a substantial increase in the amount of CWD, including large branches, tree stumps, and logs (Christopher Vogel, [University of Michigan Biological Station, Pellston, MI], personal communication, [July 2016]). The large amount of decomposing wood provides cover and nesting sites for small mammals, including *P. leucopus* (Baker, 1983).

We hypothesized that the increased CWD at FASET caused the sharp increase in the population of mice on the census trap line, which lies approximately 200 m from the FASET plot. We predicted that trap lines at increasing distance from FASET would show decreasing numbers of *P. leucopus*.

Materials and methods

Study area: This study was performed at the University of Michigan Biological Station in Cheboygan County, Michigan (45.563 ˚N, 84.697 ˚W). The study area consisted of three plots: FASET plot (45.5626 ˚N, 84.6974 ˚W); plot A, located 450 m east of the FASET plot; and plot C, located 1150 m east of the FASET plot. The habitat is similar across the three plots and is composed of a mix of coniferous and deciduous trees, including red pine (*Pinus resinosa*), white pine (*Pinus strobus*), northern red oak (*Quercus rubra*), sugar maple (*Acer saccharum*) and aspen (*Populus tremuloides* and *P. grandidentata*). The undergrowth in the forest includes bracken fern (*Pteridium* spp.) and wild blueberry plants (*Vaccinium angustifolium*).

Trapping and processing: Sherman traps (7.62 x 8.89 x 22.86 cm; H. B. Sherman Co., Tallahassee, FL) were placed approximately five meters apart in eleven separate trap lines. Trap lines in the same plot were set approximately 30 meters apart. Plot A contained two trap lines, one line of 30 traps and one line of 40 traps. The FASET plot contained four trap lines, each with 25 traps. Plot C contained five trap lines, each with 20 traps. The traps were set in the evening between 2000 h and 2100 h and picked up the following morning between 0800 h and 0900 h. The trap lines in the FASET plot and plot C were trapped once, for a total of 100 trap nights in each plot. The 30-trap line in plot A was set on two nights, and the 40-trap line was set for one night, for a total of 100 trap nights in plot A.

Approximately one tablespoon of oats was used to bait each trap. Captured mice were given a second tablespoon of oats before processing occurred. Sex, reproductive condition (male-abdominal, male-scrotal, female-nipples enlarged, female-nipples tiny), pelage class (juvenile, sub-adult, adult), and mass were recorded for each mouse. Additionally, the total number of mice trapped on each plot was recorded, and any individuals of other species were recorded as well. Mass was measured using Pesola spring scales. A 1 cm^2 patch of fur was trimmed from the back of each mouse to prevent recounting of recaptured mice. Mice were released within approximately 500 meters of their capture location.

Downed CWD/Trees: CWD was measured at every other trapping station and the number of trees with circumference >10 cm was recorded. The amount of downed CWD at a trapping station was estimated using the circumference and length measurements of each piece of CWD with a circumference greater than 5 cm. These measurements were used to calculate the volume of each piece as the volume of a cylinder, and the volumes of all pieces of CWD were summed at each station.

Data analysis: Chi-square (χ^2) tests for homogeneity were used to test for similarity in categorical variables between populations, and ANOVAs were used to test for significant differences among quantitative variables. Using these two tests, number of mice trapped, proportion of female to male mice, proportion of reproductively active to reproductively immature mice of each sex, mass of mice, and proportion of mice in each pelage class were compared among the three plots. An alpha (α) value of significance of 0.05 was used for each test. The measurement for number of mice trapped in line 2 of the FASET plot was discarded due to interference by raccoons (*Procyon lotor*).

Results

P. leucopus *population*

Discrepancies in number of trap stations or mice captured among tables are due to the escape of some mice prior to the assessment of their pelage, mass, sex, and/or reproductive condition. Additionally, while we did not include the data from the FASET trap line with which the raccoons tampered when analyzing the number of mice captured, we did use those captures when comparing age structure, reproductive condition ratios, sex ratios, and mass among the plots.

The proportion of successful traps in each plot significantly differed among plots (χ^2=15.44, df=2, p<0.001; Table 1). In plot C, 74 of 100 trap nights captured mice, compared to 47 of 100 trap nights in plot A and 47 of 75 trap nights in the FASET plot. This pattern is not, however, concordant with our prediction of decreasing numbers of mice with increasing distance from the FASET plot. Age structure, based on pelage class, did not differ significantly among plots (χ^2=6.522, df=4, p=0.082; Table 2, Figure 1). The proportion of male mice to female mice did not differ significantly among plots (χ^2=1.396, df=2, p=0.249; Table 3).

The proportions of reproductively active and inactive male and female mice were calculated separately. The proportion of males with abdominal testes vs. scrotal testes did not differ significantly among plots (χ^2=2.304, df=2, p=0.316; Table 4). The majority of the male mice had abdominal testes in all plots. A greater proportion of females in plot A appeared to have enlarged nipples than in plots B or C (χ^2=6.818, df=2, p=0.033; Table 5). The mass of the adult mice (males and females combined) did not differ significantly among plots (ANOVA, F=1.666, df=2, p=0.197; Table 6).

Cover (downed CWD and trees)

The average number of trees (dead and alive) within 2 m of a trap varied significantly among plots (ANOVA, F=5.605, df=2, p=0.005; Table 7). The number of trees in plot A was much higher than the number of trees in either plot C or the FASET plot. The average volume of downed CWD within 2 m of a trap also varied significantly among plots (ANOVA, F=12.2, df=2, 132, $p<0.000$; Table 8). As expected, the FASET plot was characterized by a much larger volume of CWD than plot A or plot C.

Discussion

The results of this study indicated that increased amounts of downed coarse woody debris in the FASET plot is not responsible for the population spike in *P. leucopus* observed in the nearby small-mammal census transect. The FASET plot did have the greatest amount of downed CWD, but the highest proportion of successful traps was found in plot C. Plot C, the area furthest from the FASET plot, had a significantly greater number of mice in comparison with the other plots. This result contradicts the initial prediction of a decreasing number of mice with increasing distance from the FASET plot. Age structure, sex ratio, reproductive condition of male mice, and mass of adult mice did not differ significantly among the plots. The only characteristic of the mouse population that varied among plots was the proportion of females who appeared to be reproductively active; a larger proportion of females in plot A appeared to have reproduced than in plot C or the FASET plot.

The average number of trees at each trapping station varied significantly among plots, with a greater number of trees in plot A than in plot C or the FASET plot. It is possible that the higher number of dead and living trees in plot A created higher quality nest sites, resulting in the higher proportion of female *P. leucopus* who were lactating or pregnant. *Peromyscus leucopus* is known to build nests in tree stumps, logs, and hollow trees, although they also utilize abandoned burrows of other animals such as chipmunks, groundhogs, squirrels, and birds (Baker, 1983).

A mild winter and abundant acorn production by oak trees could at least partially explain the dramatic increase in the white-footed mouse population in 2016. White-footed mice do not hibernate, but rather forage throughout the winter and store food (Baker, 1983). A mild winter would allow the mice more time to forage and decrease the amount of energy required for survival. The 2015-2016 winter in Pellston, MI was unusually mild, with a mean temperature of -2.2 ˚C between December 1, 2015 and April 1, 2016 (“Weather History for KPLN,” 2016). This was the highest mean temperature for this period since the winter of 2011-2012, when the mean temperature in Pellston was -1.1 ˚C (“Weather History for KPLN,” 2012). If the mild winter was solely responsible for the high numbers of *P. leucopus*, high numbers of mice would be expected in the spring 2012 small mammal census. However, in spring 2012, the small mammal census recorded 7 *P. leucopus*, which is greater than the mean of 5.07, but much lower than the spring 2016 count of 35 *P. leucopus* (Philip Myers, [University of Michigan, Ann Arbor, MI], personal communication, [July 2016]). This suggests that other factors influenced the *P. leucopus* population.

Autumnal acorn production has been shown to be positively correlated with summer rodent population densities, including that of *P. leucopus* (Wolff, 1996). The forests surrounding the University of Michigan Biological Station (UMBS), the location of this study, have experienced abundant acorn production in each of the last three years (Philip Myers, [University of Michigan, Ann Arbor, MI], personal communication, [July 2016]). However, in a study performed between 1989 and 2003 at UMBS, no relationship was found between oak masting and number of mice captured by trap lines (Myers, 2005).

A third potential factor that may have influenced the *P. leucopus* population is snow coverage. The subnivean layer, which forms between the soil and snow once several inches of snow have accumulated, serves as an insulated microhabitat for many species of small mammals, including *P. leucopus*. A study investigating winter habitats of voles found that their subnivean tunnels reached temperatures as high as 3 ˚C greater than air temperatures (McCafferty, 2003).

Snow cover protects small mammals from predators and from fluctuations in air temperature. Differential snow accumulations may have impacted the number of *P. leucopus* able to survive throughout the winter and breed in the spring.

This study was limited by several elements including the interference with the trap lines by raccoons and the placement of traps by students with minimal experience in small mammal trapping. However, the numbers of mice trapped were large, so it is unlikely that these issues significantly affected the data. Further research should be dedicated to determining the cause or causes of the dramatic increase in population, including investigating the possible correlation between acorn abundance and *P. leucopus* at UMBS. Populations of white-footed mice of this size have not been observed at UMBS before, so it will also be important to investigate the ecological consequences. Effects of the population increase on predators and seed distribution should be examined.

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Tables and Figures

Table 1: Number of *P. leucopus* captured (χ^2=15.44, df=2, p<0.001).

Number of mice	**Traps with mice**	**Traps without mice**	***Totals***
Plot A	47	53	*100*
Plot B (FASET)	47	28	*75*

Plot C	74	26	*100*
Totals	168	107	*275*

Table 2: Pelage class of *P. leucopus* (χ^2=6.522, df=4, p=0.082).

Pelage class	**Plot A**	**Plot B (FASET)**	**Plot C**	***Totals***
Juvenile	4	4	15	*23*
Sub-adult	17	22	34	*73*
Adult	23	19	25	*67*
Totals	44	45	74	*163*

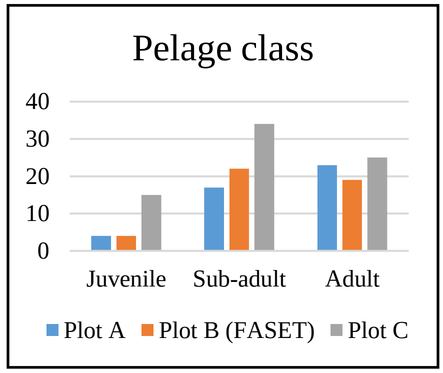

Figure 1: Pelage class by plot.

Table 3: Sex ratio of *P. leucopus* (χ^2=1.396, df=2, p=0.249).

Sex ratio	**Plot A**	**Plot B (FASET)**	**Plot C**	***Totals***
Female	19	25	34	*78*
Male	23	19	38	*80*
Totals	42	44	72	*158*

Table 4: Reproductive condition of male *P. leucopus* (χ^2=2.304, df=2, p=0.316).

Rep. condition-M	**Plot A**	**Plot B (FASET)**	**Plot C**	***Totals***
Testes abdominal	18	12	30	*60*
Testes scrotal	4	7	8	*19*
Totals	22	19	38	*79*

Table 5: Reproductive condition of female *P. leucopus* (χ^2=6.818, df=2, p=0.033).

Rep. condition-F	**Plot A**	**Plot B (FASET)**	**Plot C**	***Totals***
Nipples tiny	5	16	21	*41*
Nipples enlarged	13	9	13	*35*
Totals	18	25	34	*77*

Table 6: Mass of *P. leucopus* (ANOVA, F=1.666, df=2, p=0.197).

Mass	**N**	**Mean (g)**	**Std. Deviation (g)**
Plot A	23	24.00	2.892
Plot B (FASET)	17	23.47	2.452
Plot C	24	22.46	3.270
Totals	64	23.28	2.968

Table 7: Average number of trees (>10 cm in diameter) within 2 m of a trap (ANOVA, F=5.605, df=2, p=0.005).

Trees	**N**	**Mean**	**Std. Deviation**
Plot A	46	6.74	5.787
Plot B (FASET)	49	4.14	3.021
Plot C	48	4.56	2.657
Totals	143	5.12	4.161

Table 8: Average volume of CWD within 2 m of a trap (ANOVA, F=12.2, df=2, 132, p<0.000).

CWD	**N**	**Mean (cm^3)**	**Std. Deviation (cm^3)**
Plot A	35	38053.9	66237.94

Plot B (FASET)	50	128970.1	160890.66
Plot C	48	27237.0	58708.65
Totals	133	68329.1	119232.76