# Route Choice by Deer Mice (Peromyscus maniculatus): Reducing the Risk of Auditory Detection by Predators

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Source: The American Midland Naturalist, 142(1):194-197.
Published By: University of Notre Dame
DOI: http://dx.doi.org/10.1674/0003-0031(1999)142[0194:RCBDMP]2.0.CO;2
URL: http://www.bioone.org/doi/full/10.1674/0003-0031%281999%29142%5B0194%3ARCBDMP%5D2.0.CO%3B2

Am. Midl. Nat. 142:194–197

# Route Choice by Deer Mice (Peromyscus maniculatus): Reducing the Risk of Auditory Detection by Predators

ABSTRACT.—The influence of predation risk on microhabitat selection in male adult deer mice (*Peromyscus maniculatus*) was examined using an enclosure experiment. The relative amount of time spent by the deer mice on coniferous leaf litter, hardwood leaf litter and logs was measured. Mice preferred dry coniferous litter over dry hardwood litter, but had no preference when both litter types were wet. Deer mice traveled more along logs placed on hardwood litter than on coniferous litter. Nocturnal mammalian and avian predators of deer mice often use sound to locate their prey, and mice rustling in hardwood leaf litter should be more easily detected. Therefore, deer mice restrict their movements to routes that reduce the risk of auditory detection by predators.

## INTRODUCTION

Some animals assess the risk of predation under different circumstances and incorporate this information into their behavioral decisions (Lima and Dill, 1990). On bright nights, nocturnal small mammals restrict activities to areas closer to cover and vegetative debris to reduce detection from visual predators (Clarke, 1983; Harestad and Shackleton, 1990; Travers *et al.,* 1988). Small mammals prefer to travel on quieter substrates such as logs and wet leaf litter rather than noisy substrates such as dry leaf litter. Using quieter substrates reduces the risk of auditory detection by predators (Vickery and Bider, 1981; Fitzgerald and Wolff, 1988; Barnum *et al.,* 1992; Planz and Kirkland, 1992). Traveling along logs may also reduce the risk of detection by enabling mice to travel a given distance as quickly and quietly as possible (Barry and Francq, 1980; Kaufman *et al.,* 1983; Hayes and Cross, 1987; Graves *et al.,* 1988).

If small mammals make behavioral decisions to reduce the risk of auditory detection by predators, they should restrict their movements to substrates and pathways on which they produce less noise. We tested this hypothesis, in an enclosure experiment, by examining whether deer mice (*Peromyscus maniculatus gracilis*) preferred traveling on relatively ''quiet'' substrates such as logs and wet leaf litter, or dry leaf litter, which is a ''noisy'' substrate. Additionally, we tested whether mice preferred coniferous leaf litter over hardwood leaf litter, which produces louder rustling when traveled on. We compared the use of logs on the two leaf litter types, predicting that logs placed on the noisier (hardwood) leaf litter would be used more than logs placed on the quieter (coniferous) leaf litter, and that decayed logs would be used more than fresh logs. The surface of decayed logs is usually mossy and is therefore spongier and quieter when traversed than the hard surface of fresh logs (Barnum *et al.,* 1992). We also determined the frequency and relative intensities of the sounds produced by the mice traveling on the different substrates and compared them to the optimal hearing ranges of common deer mice predators.

## MATERIALS AND METHODS

Three experiments, consisting of six trials each, were conducted at the Wildlife Research Area, Algonquin Park (45°30′N, 78°40′W), from mid-July until the end of August 1996. We trapped 18 adult male deer mice (*Peromyscus maniculatus*) from coniferous (*Abies balsamea, Tsuga canadensis*), hardwood (*Acer saccharum, Fagus grandifolia*) and mixed forests using Sherman live traps (7.5 × 9 × 23 cm) baited with sunflower seeds soaked in water for 3–4 h. Mice were kept for up to 48 h in cages (15 × 20 × 30 cm) lined with newspaper and cotton, and provided with water, sunflower seeds and rat chow (Purina Laboratory Rat Diet no. 5001) *ad libitum.*

A circular enclosure 4 m in diameter and 0.75 m high was constructed from sheet metal. The floor of the enclosure was divided equally into two ground litter types: coniferous (balsam fir, eastern hemlock) and hardwood (sugar maple, american beech), with no barrier between. To create the different habitat floors, soil and leaf litter (7–10 cm deep) was collected from coniferous and hardwood forests, respectively. A tarpaulin was strung 1 m above the enclosure to keep light levels low and as constant as possible. A 25-W red light was hung through the center of the tarpaulin to enable observation of the deer mice. For the first experiment, only dry leaf litter was used. For the second experiment, 1

TABLE 1.—Mean proportional use of coniferous and hardwood leaf litter by deer mice (*Peromyscus maniculatus gracilis*) in an enclosure. In experiments 1 and 2, leaf litter is dry; in experiment 3, leaf litter is wet. N = 6 for each experiment

| | Exp. 1 | | Exp. 2 | | Exp. 3 | |
|---|---|---|---|---|---|---|
| Litter type | $\bar{x} \pm$ SD | t value | $\bar{x} \pm$ SD | t value | $\bar{x} \pm$ SD | t value |
| Coniferous | 0.550 ± 0.021 | 2.63* | 0.574 ± 0.012 | 6.23** | 0.496 ± 0.019 | 0.22 |
| Hardwood | 0.445 ± 0.021 | | 0.426 ± 0.012 | | 0.504 ± 0.019 | |

Use of leaf litter differed between coniferous and hardwood litter types within the experiment (* $P < 0.05$, ** $P < 0.002$)

fresh and 1 decaying log (mean length: 235.2 cm, mean diameter: 7.7 cm) were placed on each litter type. Decaying logs were mossy and less than 75% of the surface was solid wood. Intact logs were not decayed or mossy and over 75% was solid wood (Hayes and Cross, 1987). In the third experiment, the logs were removed from the enclosure and the leaf litter was soaked with water immediately before each trial. This was done to make the sound level of hardwood leaves similar to levels produced on the coniferous litter.

A different mouse was randomly chosen for each trial (n = 6) in each experiment. Trials were conducted on dry calm nights to reduce background noise from rain and wind that would mask the noises made by the deer mice. A mouse was released into the middle of the enclosure at nightfall and was given 5 min to make contact with both litter types and logs in the enclosure before observations began. The position of the mouse in the enclosure was recorded every 30 sec for 1 h from a concealed observation post level with the rim of the enclosure. In experiment 1, the location of each mouse was recorded as dry coniferous or dry hardwood litter. In experiment 2, the location of each mouse was recorded as dry coniferous or dry hardwood litter or decayed or intact logs on either litter type. A mouse was considered to have used a log when it traveled along at least 75% of its length. In experiment 3, each mouse was recorded on wet coniferous or wet hardwood litter. The intensity of the movements of the mice was recorded from 0.5 m away using a Realistic Sound Meter. Following the completion of the experiment, the mouse was recaptured and released at the original point of capture. Proportional data from each of the three experiments were arcsine transformed and analyzed using a two-tailed paired sample t-test (Zar, 1984).

## RESULTS

In experiment 1, we observed mice more often on dry coniferous leaf litter than on dry hardwood leaf litter ($t = 2.63$, $df = 5$, $P < 0.05$, Table 1). In experiment 2, mice were also observed more often on dry coniferous leaf litter than on dry hardwood leaf litter ($t = 6.23$, $df = 5$, $P < 0.002$, Table 1). In experiment 3, we found no significant difference in the use of the wet coniferous and wet hardwood litter ($t = 0.22$, $df = 5$, $P < 0.05$, Table 1).

Mice were observed more often on logs placed on hardwood leaf litter than on logs placed on coniferous leaf litter ($t = 2.68$, $df = 5$, $P < 0.05$). However, there was no significant preference between the use of fresh and decayed logs ($t = 0.20$, $df = 5$, $P < 0.05$). Mice were observed on the logs significantly more than expected if movements were random ($\chi^2 = 344.69$, $df = 1$, $P < 0.001$).

Mice explored the entire enclosure throughout the experimental hour. They traveled the perimeter and interior of the enclosure, although in experiment 2 they frequently traveled on the logs. Only one mouse moved constantly. Most mice spent between 1.5 and 15 min of the observation time immobile (motionless or grooming). We found no significant difference between the amount of time spent immobile on either leaf litter type (Exp. 1: $t = 0.91$, $df = 5$, $P < 0.05$; Exp. 2: $t = 1.11$, $df = 4$, $P < 0.05$; Exp. 3: $t = 0.97$, $df = 5$, $P < 0.05$). The original habitat in which the mice were captured did not influence their behavior towards the substrates in the enclosure.

## DISCUSSION

Deer mice restrict their movements in ways that should reduce auditory detection by predators. Mice make less noise traveling on dry coniferous leaf litter than on dry hardwood leaf litter, a difference readily detected by a human observer. Deer mice preferred traveling on the coniferous litter in the enclosure, implying a behavioral response to reduce sound. The finding that deer mice no longer avoided the hardwood litter when it was wet is consistent with results from other experiments where mice preferentially chose wet deciduous substrate over dry deciduous substrate for escape or travel (Vickery and Bider, 1981; Fitzgerald and Wolff, 1988).

Logs serve as possible navigational cues (Barry and Franq, 1980; Planz and Kirkland, 1992) and, if rotted, may provide nesting and foraging opportunities for *Peromyscus* (Hayes and Cross, 1987). They are also used as pathways and escape routes, as small mammals can travel silently and quickly along them (Graves *et al.,* 1988; Barnum *et al.,* 1992). Similarly, in our experiment, although the logs covered less than a tenth of the total surface area of the enclosure, mice used them in more than half of the observations. Mice used logs placed on the hardwood litter significantly more than logs on the coniferous litter. This may represent a predator avoidance strategy, because traveling on logs on hardwood litter results in more silent passage across that litter type. Because travel on coniferous litter already produces less noise and mice could be more easily caught on top of a log (Kaufman *et al.,* 1983), they were not expected to use the logs as much on coniferous litter.

Deer mice showed no significant preference for hard versus soft logs. This may be because the logs in this experiment were not different enough to merit a choice, or perhaps because decay state is not a factor in using logs as travel routes. Our results agree with those of Hayes and Cross (1987) but are not consistent with those of Barnum *et al.* (1992) who found that mice preferred mossy logs over fresh hard logs. They suggested that mossy decayed logs are easier to climb, offer more foraging opportunities and are quieter for travel than fresh logs.

Predators use both frequency and intensity of sounds to locate prey (Stebbins, 1983). Mammalian and avian predators of deer mice use high frequencies for sound localization, and intensity of sounds to determine the distance to the source (Mills, 1972; Payne, 1962). The reported frequency of "rustling leaves" is 8 kHz (Payne, 1971). This frequency is within the optimal hearing range of barn owls (*Tyto alba*) (Payne, 1962), least weasels (*Mustela rixosa*) (Heffner and Heffner, 1985), red foxes (*Vulpes fulva*) (Osterholm, 1964) and coyotes (*Canis latrans*) (Peterson *et al.,* 1969). Given the hunting methods of these predators, it would be advantageous for mice to alter the sounds they produce during their nightly activities. Although mice may not be able to alter the frequencies of the sounds produced, they can lower the intensity. Sound production can be reduced by remaining immobile. All but one mouse in our experiments spent time immobile in the enclosure. There was a higher frequency of immobility on the leaf litter; mice ran significantly more along the logs, perhaps to minimize the amount of time spent exposed. Mice increase defensive (freezing) and self-oriented (grooming) behavior in response to the threat of predation (Hendrie and Neill, 1991). Predators of deer mice that hunt using hearing (fox and owls) may lose interest in prey if the sound ceases before the prey is captured (Hendrie and Neill, 1991; Osterholm, 1964).

The intensity of a sound may indicate the distance from the listener if the source and characteristic intensity is familiar (Mills, 1972). If the intensity dictates whether a frequency will be detected, minimizing the intensity will minimize the likelihood of being detected. The movements of a mouse on hardwood leaf litter produced an average intensity of 55 dB from 0.5 m away, an intensity easily detectable to a human observer. We could not hear the mice while they were traveling on the coniferous litter, wet litter or logs, indicating that the intensity was much less than 55 dB. Preferential selection of these substrates by mice during this experiment supports the hypothesis that they were "attempting" to inhibit detection by auditory predators by reducing the sounds they produced.

This study demonstrates that deer mice often restrict their movements to pathways that reduce the risk of auditory detection by predators. To do this, deer mice must assess predation risk, related to the relative amount of sound they produce on different substrates, and use this information to make decisions about the selection of microhabitat patches used for foraging and other daily activities.

*Acknowledgments.*—We thank the Wildlife Research Station in Algonquin Park where this study took place. R. J. Brooks was supported by the Natural Sciences and Engineering Research Council of Canada; Grant A5990.

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