Long-distance Movements by Female White-footed Mice, *Peromyscus leucopus*, in Extensive Mixed-wood Forest

THOMAS J. MAIER

Northeastern Research Station, USDA Forest Service, Holdsworth Natural Resources Center, University of Massachusetts, Amherst, Massachusetts 01003-9285 USA

Maier, Thomas J. 2002. Long-distance movements by female White-footed Mice, *Peromyscus leucopus*, in extensive mixed-wood forest. Canadian Field-Naturalist 116(1): 108–111.

Two adult female White-footed Mice (*Peromyscus leucopus*) were recovered 14 730 m and 6840 m from where they were originally captured and tagged in central Massachusetts. Similar combinations of factors throughout an extensive forested landscape, including poor acorn (*Quercus* spp.) crops, high population densities of mice, and the exclusive social behaviour of other female mice, may have been responsible for these long distance movements.

Key Words: White-footed Mouse, *Peromyscus leucopus*, dispersal, distance, mixed-wood forest, movement, *Quercus*, small mammals, social dynamics, Massachusetts.

Movement in space-time remains a little understood process for most organisms (Turchin 1998). Even less understood are long-distance movements (Koenig et al. 1996), such as those made by small mammals dispersing across landscapes (Zollner and Lima 1999; Andrzejewski et al. 2000; Bowman et al. 2001). Nonetheless, even sporadic long-distance movements by small mammals may profoundly affect species' evolution, population dynamics, and community structure (Cockburn 1992; Allen et al. 1993; Berlow 1999). As such, recognition of the spatial scale of such movements and their proximal causes becomes integral to understanding certain wildlife requirements, the effects of habitat perturbation, and possible epidemiological risks (Dickman et al. 1995; Kozakiewicz and Szacki 1995; Calisher et al. 1999). Here I report long-distance movement events by two female White-footed Mice (*Peromyscus leucopus*) in extensive, New England mixed-wood forest, and discuss these movements in relation to the associated environmental conditions.

Observations

One month after capture on a small mammal trapping grid within the Quabbin watershed in central Massachusetts (42°27'13.7"N, 72°21'03.7"W), a tagged White-footed Mouse was recaptured 14 730 m north of the original capture site. The adult female (21.2 g), apparently healthy and not exhibiting any signs of reproductive activity, was ear-tagged with a No. 1 Monel tag (National Band and Tag Co., Newport, Kentucky, USA) on initial capture, 15 October 1998, and subsequently recaptured twice more at the same site. Approximately 4 weeks later, this mouse was trapped within a residence. Its identity was verified based upon gender and the fact that no other small mammal researchers working in the area were using tag numbers in this sequence; a necropsy was not performed. A second tagged White-footed Mouse was trapped at another residence 750 m northeast of the same Quabbin trapping grid during the same time period. This mouse was disposed of before verification of its identity. In mid-April 1993, the desiccated remains of another tagged White-footed Mouse were found outside a third residence 6840 m north of its original capture site. This adult female, when captured on another small mammal trapping grid within the Quabbin watershed (42°26'50.9"N, 72°19'29.8"W) on 12 August 1992 (its only capture), appeared healthy and did not exhibit any signs of reproductive activity. Its identity was verified as described above.

Both trapping grids on which these mice were initially captured were located within a fenced portion of the Quabbin watershed, with vehicle entry restricted by locked gates (this property is managed by the Metropolitan District Commission to provide water for the Boston municipal area). The landscape between the initial capture and final recovery sites consisted of contiguous, closed-canopy mixed-wood forest of a predominately Red Oak (*Quercus rubra*)-White Pine (*Pinus strobus*)-Red Maple (*Acer rubrum*) forest cover type (Eyre 1980) with scattered residential and agricultural openings. For the two mice traveling the furthest, potential travel routes were bisected by a minimum of six light-duty forest roads, three small streams, a two-lane primary highway, and a powerline right-of-way. Geomorphological features run mostly north-south and range in elevation from 200–380 m. Distances, unless otherwise specified, were measured using a Rockwell PLGR+96 Global Positioning System receiver with a minimum horizontal accuracy of 10 m, and analyzed using ARC/INFO on a Sun SPARC station.

Other environmental conditions characterizing the 1998 period included high White-footed Mouse density at the Quabbin trapping site (136/ha) and adjacent sites (58–89/ha) (T. Maier, unpublished data). Few mice were actively breeding at this time, but large numbers of juveniles were observed (T. Maier, unpublished data). In comparison, historic densities for these mice for similar local habitat at the same time of year have ranged from 1 to 126/ha, with a mean density of 27.8/ha, SD = 30.6 (9 years data; W. Healy, USDA Forest Service, personal communication). Area acorn (*Quercus* spp.) crops yielded > 75% less than the previous year, with virtually the entire 1998 crop consumed by Acorn Weevil (*Curculio* spp.) larvae (R. Field, USGS Biological Resources, personal communication; W. Healy, personal communication). Local climatological statistics for a 44-day period in 1998 encompassing the potential travel of mice were a mean maximum temperature of 10.5° C; mean minimum temperature of -0.9° C; mean temperature of 4.9° C, and total precipitation of 24.3 mm, all as rain from five precipitation events (NWS*). Environmental conditions characterizing the 1992 period beginning in August similarly included high White-footed Mouse density at the Quabbin trapping site (81/ha) and adjacent sites (40–126/ha), and the absence of an acorn crop throughout the area, with mice populations dramatically declining by October of the same year (Elkinton et al. 1996). All population density estimates were generated using program CAPTURE (Otis et al. 1978; White et al. 1982).

Discussion

Although the distance covered by the furthest traveling White-footed Mouse reported here supersedes previous reports of long-distance movement by either homing or non-homing individuals of this species (2 km, Wegner and Henein 1991), the genus *Peromyscus* (3.2 km, Murie and Murie 1931), and the family Muridae (14 km, Dickman et al. 1995), travel over the 14.7 km tract during the period from initial to final capture was well within the potential capability of *Peromyscus* mice. Murie and Murie (1931) reported a Deer Mouse (*Peromyscus maniculatus*) returning over 3 km to its capture site in 2 days. Similarly, Calisher et al. (1999) reported an adult Deer Mouse homing 1200 m within 24 hrs. Dice and Hoslett (1950), comparing the performances of seven species of *Peromyscus* on activity wheels, reported a maximum 24-hr record the equivalent of 37 km of travel by an individual White-footed Mouse. Besides possessing the stamina to travel great distances in short amounts of time, these mice have additionally been observed to surmount various obstacles to travel (Sheppe 1965; Teferi and Millar 1993; Calisher et al. 1999) similar to those found in this observation. The possibility that these mice may have been transported via human conveyance cannot be totally discounted, but this seems unlikely given that the mice were initially captured within a restricted area behind locked gates. Additionally, personal interviews with the residents who collected these mice revealed that their closest physical proximity consisted of one or two instances of a briefly parked vehicle (< 4 h during daylight) approximately 2.5 km from where the 1998 mice were initially captured.

Most dispersal (*sensu* Lidicker and Stenseth 1992) by small rodent species has been observed to occur over short distances (McShea and Madison 1992; but see Koenig et al. 1996), with longest distances associated with travel by males for most species. What factors may have contributed to long-distance travel by female White-footed Mice? First, the contiguous forest was likely advantageous to long-distance movements, compared to a more fragmented landscape (Yahner 1983; Krohne and Hoch 1999). Second, food deprivation has resulted in increased activity by *Peromyscus* (Falls 1968 and references therein). Although Acorn Weevil larvae infestations may represent a significant dietary supplement, they are unsuitable as a primary energy source compared to sound acorns (Semel and Andersen 1988; Steele et al. 1996) from autumn through spring (Kirkpatrick and Pekins 2002). Third, an increase in population density has been observed to increase the number of dispersing *Peromyscus* mice (Fairbairn 1978; Krohne et al. 1984). Fourth, resident *P. leucopus* females may especially exclude conspecific female immigrants when resources decline (Metzgar 1971; Wolff 1989). Together, these factors suggest that the combination of high mouse density and low food supply throughout a large extensively-forested area may have created a social environment that inhibited local immigration, as posited by Stickel (1968) and Anderson (1989), thereby increasing the probability of long-distance travel by emigrating female mice. Other reports of long-distance movement by small mammals through large areas of continuous habitat have suggested high population densities as the incentive (Clark et al.1988; Bowman et al. 1999). Nevertheless, as observed by Fairbairn (1978), such movement is not likely a simple function of density or its fluctuation, but rather relates to individual behaviour within a social structure along with changing resource patterns.

Proximal factors leading to long-range movements are difficult to elucidate; this may be due to the interaction of contributing factors, and perhaps, in part, because so few observations of such movements exist. Various studies have attempted to assess the spatial mobility of small mammals using arrays of traps (Krohne et al. 1984; Liro and Szacki 1994; Dickman et al. 1995; Andrzejewski et al. 2000; Bowman et al. 2001); yet, due to logistical and methodological constraints, the probability of detection of marked animals may be expected to decline exponentially with distance, resulting in the significant underestimation of long-distance movements (Koenig et al. 1996; Turchin 1998). The long-distance movements reported here may eventually prove more common than previously thought, requiring those studies modeling the spatial distribution of similar small mammals to adopt a new metric.

Acknowledgments

I particularly thank T. Cox, M. Delano, D. Small, and J. Starkey for reporting the collection of these mice. I also thank D. Clark for site information; D. Goodwin for analyzing distance data; R. Field and W. Healy for data on local small mammal density and acorn crops; G. Boettner, J. Bowe, Jr., R. Brooks, R. DeGraaf, K. Doyle, J. Hestbeck, D. King, J. Wolff, and P. Zollner for suggestions regarding the manuscript; S. Cooter for ethological instruction; and the Massachusetts Metropolitan District Commission, Division of Watershed Management, Quabbin Section, for access to their management areas.

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Received 4 July 2000
Accepted 12 March 2002