Executive Summary

The Preble's meadow jumping mouse (*Zapus hudsonius preblei*; PMJM) is a federally threatened small mammal found from southeastern Wyoming south to Colorado Springs, Colorado. This small (~20g) rodent's habitat consists of the dense herbaceous and shrub vegetation along and in proximity to creeks and rivers along the Front Range. Such habitats have declined since the mid-1900s and this habitat loss has driven the declines in abundance and distribution of PMJM. Movement studies using radio telemetry documented the strong association PMJM have with dense, riparian vegetation. However, radio-telemetry studies rarely allow researchers to see PMJM using vegetation and substrate found along the ground (microhabitat). It is believed, that being granivorous, PMJM use riparian habitats, because they provide a diverse, dense concentration of palatable and nutritious energy resources for the physiological demands of breeding and hibernation. To understand PMJM microhabitat use, we used fluorescent dye powder to track their movements along South Boulder Creek, Boulder County, Colorado. The advantage of fluorescent dye powder is that once it is applied to the animal it will slough off as the animal moves in and among vegetation and the animal can move without the restrictions of a cumbersome radio-telemetry collar. Despite over 1,000 trapnights over multiple trapping sessions we only captured 2 PMJM during the study. One lactating female was captured 3 times and one male was captured once. All 4 pathways from dusted PMJM were less than 25 m in length. Vertical vegetation density along PMJM pathways was less dense than off PMJM pathways. Sample size limitations prevent extrapolating results to meaningful explanations of PMJM microhabitat use; however, we believe this technique may provide insights if the dye powder could be retained longer and our ability to detect dye particles increases.

Understanding Preble's meadow jumping mouse microhabitat use: pilot study using fluorescent dye powder tracking

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Abstract

The federally-threatened Preble's meadow jumping mouse (PMJM) is found in dense, riparian vegetation along the Front Range of Colorado and in southeastern Wyoming. Populations have declined because of the reduction and fragmentation of these riparian habitats. Why PMJM spend a majority of their time in these habitat types is unclear, and most movement studies have been unable to describe PMJM microhabitat use. We dusted PMJM in fluorescent dye powder and tracked their paths to describe how they move among the dense herbaceous and shrub vegetation. We captured 2 PMJM 4 times, creating 4 fluorescent dye pathways. Pathways were less than 25 m in length and there were imperceptible differences in ground cover composition and canopy cover, but vertical vegetation cover on the pathways was less than areas away from pathways. We believe the technique for PMJM microhabitat use has promise, but is challenged by the density of the vegetation and the retention of the dye powder, which are likely correlated complications. For this study, sample size limitations do not allow concrete management decisions for PMJM habitat management. However, this technique could provide some the microhabitat and natural history information, such as day nest use, that is lacking for PMJM.

Keywords: fluorescent dye powder, microhabitat, Preble's meadow jumping mice, ultraviolet light, *Zapus hudsonius preblei*

Introduction

The Preble's meadow jumping mouse (PMJM) is a federally threatened subspecies (*Zapus hudsonius preblei*) that is found from southeastern Wyoming, southward to Colorado Springs, Colorado, along the Front Range. This small (~20 g) mouse is a riparian obligate that lives in streamside habitats with dense shrub cover, with dense grass and forb ground cover along streams, rivers, and associated waterbodies (USFWS 1998). These habitats have declined since the mid-1900s because of increasing human population growth and the expanse of urban development (Baron et al. 2004, Kuby et al. 2007), thus the PMJM Recovery Plan (USFWS 2015) prioritizes conservation and expanse of the existing riparian systems that support PMJM. Current understanding of PMJM habitat use has come from movement studies employing radio telemetry. These studies have identified PMJM activity within the dense riparian vegetation (Shenk and Sivert 1999, Schorr 2001, Schorr 2003, Trainor et al. 2012). These habitat use assessments have been vital for understanding the coarse-scale habitat for PMJM. Unfortunately, there has been little progress in describing how PMJM move through the vegetation, and if they prefer open areas under the overstory of dense shrubs (Schramm and Willcutts 1983). For example, meadow voles (*Microtus pennsylvanic*us) and PMJM share riparian habitats, but voles use areas that are more mesic and have more dense grass cover than PMJM (Schorr, pers. obs.). It is unclear if PMJM select specific areas within the riparian shrublands that are more advantageous for their diet, mode of movement, or reproduction, or to avoid other small mammals, like voles (Boonstra and Hoyle 1986).

Most microsite-specific descriptions of habitat use for PMJM come from records of day nests (Ryon 2001, Bain and Shenk 2002). Ryon (2001) found PMJM using multiple leaf- and grass-lined day nests and a leaf-lined underground maternal nest at Rocky Flats Environmental Technology Site. Similarly, Bain and Shenk (2002) describe PMJM use of leaf- and litter-lined day nests, maternity nests, and hibernacula that typically had an associated burrow. These descriptions are valuable for understanding nest characteristics, but do not elucidate what microsite movement behaviors are used by PMJM. Additionally, it is unknown how frequently PMJM use day nests and for how long.

We propose to describe PMJM microsite habitat and understand their movement pathways through riparian vegetation by using fluorescent dye powder to track movements. If PMJM movement pathways through dense vegetation are identified, conservation biologists might understand why PMJM are reliant on dense, riparian-associated vegetation.

Methods

Study site. Sampling for PMJM was conducted along South Boulder Creek south of Baseline Road. This area was selected because of prior PMJM trapping success at these locations. Past trapping effort produced 8 PMJM captures (transect SBC 1 West) and 7 PMJM captures (transect SBC 2 West) (City of Boulder Open Space and Mountain Parks data) in 2014.

Sampling and tracking. Trapping was conducted during multiple 5-day trapping sessions, during which traps were opened in the evening and checked in the morning, from 27 June to 22 July 2015. Traps were not set every day from 27 June to 22 July to prevent altering PMJM movement patterns because of the availability of baited traps, and to minimize stress to individuals that may be captured repeatedly. At each trapping station, 2 Sherman traps (7.6 x 8.9 x 22.9 cm, Sherman Trap Inc., Tallahassee, Florida) were set at each of the stations along a transect. Traps were set several hours prior to sunset and were set in shaded areas that prevented animals from becoming overheated. Traps were baited with a 50:50 mix of crimped oats and commercial “sweet feed”, which is a mix of oats, barley, and corn in light molasses. All traps received a small ball of polyester batting (polyfil) as prescribed by USFWS PMJM trapping protocol. Traps were checked at sunrise or shortly after and any non-PMJM captures were released immediately. Any captured PMJM were sexed, weighed using a Pesola spring scale (Pesola AG, Schindellegi, Switzerland), and marked using a 12-mm passive integrated transponder (PIT) tag (Biomark, Inc., Boise, Idaho). After marking, PMJM were coated in a fluorescent dye powder (DayGlo Corporation, Cleveland, Ohio) below their head. The dye powder was spooned over the back, tail, and legs while avoiding the head and face. Animals were released at the site of capture.

The evening following PMJM captures, we returned to the capture location with ultraviolet lights (Streamlight Twin-Task 3C UV, Eagleville, Pennsylvania) to follow fluorescent trails left by powdered PMJM. Technicians marked trails using pin flags, and returned the following day to map paths using a global position system and describe movement paths of PMJM. We recorded the length of paths, locations of turns that were more than 10° off the path direction (node), distances between nodes, and major shrub cover components along paths. We measured ground cover composition (using 1/10-m^2 Daubenmire plot), and canopy cover (spherical densitometer) at 2 heights: low (0.5 m) and mid-level (1.5 m). To compare vertical vegetation cover along PMJM pathways to the surrounding environment, we measured vegetation height using a 1.5-m coverboard (Schorr 2003) at 6 random locations along each path and at 6 random locations off the path.

Results

We captured 2 PMJM over a total of 1,472 trapnights (1 trap set for 1 night = 1 trapnight). Two 5-day trapping sessions (2 sessions of 4 nights with 100 traps (2 traps at 50 stations)) for 800 trapnights) were spent along the former transect SBC1 West. An additional 2 5-day trapping sessions (2 sessions of 4 nights with 84 traps (2 traps at 42 stations) for 672 trapnights along the former transect SBC2 West. One lactating female PMJM (23.5 g, PIT tag: 4358004D52) was trapped and dusted 3 times along SBC1 West. One male non-reproductive PMJM (17.0 g, PIT tag: 4347753C14) was trapped once and dusted along the former transect SBC2 West. Because only 2 PMJM were captured, statistical comparison between males and females was not conducted. Statistical comparisons between vertical vegetation on and off the pathway for all PMJM was conducted, but we acknowledge that pseudo-replication of samples for the same individual (both male and female) exists.

The female was tracked for 11.0 m, 13.5 m, and 24.5 m, while the male was tracked for 13.9 m. A majority of the ground cover along PMJM pathways was dominated by grass, forb, and woody debris (Table 1). Shrub-level canopy cover was greater at the lower height of 0.5 m (48% ± 33% SD) than at 1.5 m (22% ± 34% SD) (Table 1). Vertical vegetation cover decreased further from the ground with ground level (0.0 – 0.5 m) having over half the cover board covered (52% ± 30% SD), with less cover at 0.5 – 1.0 m (11% ± 14% SD) and 1.0 – 1.5 m (3% ± 8% SD) (Table 1).

There was less vertical vegetation along PMJM pathways than at randomly selected points off the pathway, with vegetation density being thinner above ground level along PMJM pathways ($p = 0.001$, Table 2). Statistical tests were performed, but were invalid because of pseudo-replication of 2 individuals.

Discussion

Too few PMJM were captured to provide generalities for PMJM movement, microhabitat use, and day nest locations. Despite exceeding trapping effort from previous years when up to 15

PMJM were captured in the same areas, we were unable to capture many PMJM. We were confident that we sampled the appropriate habitats and the available PMJM because we captured 1 individual 3 times. In other regions, similar fluctuations in PMJM capture success have occurred (Schorr 2012). For example, between years of sampling along Monument Creek in El Paso County, Colorado, PMJM capture success fluctuated between 10 and 220 captures (Schorr, pers. obs.). Annual changes in capture success can be a product of trapping success, population-level changes, or a combination of both factors (Conn et al. 2006). It is possible that PMJM populations along South Boulder Creek in 2016 were experiencing a trough in natural population cycles, limiting capture success (Schorr 2012).

Pathways left by the fluorescent dye were shorter than expected. Early research using fluorescent dye powder to track PMJM suggested that pathways greater than 50 m could be expected (M. Bakeman, pers. comm.). However, this early research was conducted at the former Rocky Flats Environmental Technology Site, where riparian systems are more constrained than the South Boulder Creek watershed. Having broader floodplains with dense riparian vegetation means that the likelihood of dusted PMJM retaining fluorescent dye powder is reduced. Although fluorescent dye tracking has shown promise for small mammals of desert or open shrublands where pathways of nearly 1 km have been documented (Lemen and Freeman 1985, Mullican 1988), Nicolas and Colyn (2007) found the use of fluorescent dyes for tracking small mammals in African rainforests less efficient because of humidity and vegetation density. Despite the short pathways that were documented using dye tracking for PMJM we believe the technique has promise because it provides specific, ground-level pathways that can elucidate diet material, any arboreal tendencies, and day nest locations (Lemen and Freeman 1985, McShea and Gilles 1992, Morzillo and Feldhamer 2001). For PMJM this technique may explain dietary choices, microhabitat use selection, and intraspecific interactions that can inform conservation and management of PMJM and riparian habitats.

Vegetation data from tracked PMJM reaffirm the subspecies' affinity for densely vegetated riparian habitats (Bakeman 1997, Schorr 2003, Trainor et al. 2007). Most of the ground cover along PMJM pathways was dominated by forbs and grasses (Table 1). Interestingly, the male tended to travel through more densely vegetated forb habitats than the female (not significant). The female moved through habitats that had a fair amount of bare ground (~30%), and when compared to areas off the pathway (Table 2), had less vertical vegetation cover (not significant). It is possible that some individuals choose pathways through the dense riparian vegetation that allow easier movement, while still providing enough overhead cover (vertical vegetation cover and canopy cover, Table 1) to limit exposure to aerial predators (Kaufman et al. 1983).

Along South Boulder Creek there are areas where vegetation height exceeds 3 m, but tracked PMJM were not typically captured in these locations and did not venture into these areas. The vertical vegetation height along PMJM pathways had moderate cover up to 1 m, but thinned considerably above 1 m (Table 1). Areas with vertical vegetation exceeding 1 m generally were confined to the areas immediately along South Boulder Creek, whereas consistent cover below 1 m was more broadly distributed within the floodplain. This cover was in the form of grasses, snowberry (*Symphoricarpos albus*), thistle (*Cirsium* spp.), and various forbs. Similarly, the New Mexico meadow jumping mouse (*Z. h. luteus*) has been found more frequently in "good" (dense, but less than 1 m) vegetation cover than in vegetation greater than 1 m in height or in sparsely vegetated areas (Morrison 1990). One potential bias in habitat use interpretations using fluorescent dye powder is the time of release. Menzel et al. (2000) found that a majority of day-time releases showed small mammals using more densely vegetated habitats than night-time releases during mammals' typical activity periods. It is unlikely that permission to hold PMJM for extended periods of time for evening release after trapping would be granted, but it is valuable to understand the degree to which our conclusion that PMJM use dense habitats may be inflated because of PMJM behavioral response to increased exposure during the day time.

With the limited number of captures, inference on PMJM habitat use is restricted to 2 individuals. Although one individual was captured 3 times, the sample size for understanding PMJM individual habitat use is 2, an insufficient sample size to make meaningful statistical comparisons. Coupling low sample size with shorter-than-expected pathway trails, the use of this technique did not clarify our understanding of what habitat conditions PMJM may be selecting along South Boulder Creek. However, the use of fluorescent dye tracking is one of the few methods that can adequately portray PMJM microhabitat use, plant selection, and potentially locate day nests. For these reasons, we believe fluorescent dye tracking has utility for understanding PMJM ecology. To increase our ability to follow fluorescent pathways we advise the increased use of UV lasers to illuminate any trace of dye powder in the environment (Rice et al. 2015). We believe this technique is advantageous compared to radio telemetry because of the reduced threat of injury, better depiction of natural movement patterns, and reduced impact on activity (Mikesic and Drickamer 1992, Stapp et al. 1994). The reduced impacts on health and movement are especially relevant for PMJM because they are federally-listed small mammal, and, thus, requires added precaution in reducing risk to individuals and populations, and requires additional information on microhabitat value for conservation and management of habitat.

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Table 1. Mean and standard deviation (SD) of percent ground cover by type, canopy cover by height above ground, and vertical cover by height above ground for Preble's meadow jumping mouse male (n = 1) and female (n = 3) along South Boulder Creek, Boulder County, Colorado. Sample sizes reflect number of samples taken along 1 pathway for the male and 3 pathways for the female.

	male (n = 6)		female (n = 18)		all (n = 24)	
	mean	SD	mean	SD	mean	SD
Ground cover						
Grass/graminoid	22.5	21.4	31.4	29.8	28.6	26.7
Forb	65.0	28.1	22.8	24.7	34.4	30.6
Woody debris	5.0	3.2	9.7	15.2	8.2	12.8
Bare ground	3.3	8.2	29.4	31.2	21.6	28.7
Leaf litter	4.2	3.8	6.7	10.4	5.9	8.8
Moss/lichen	0.0	0.0	0.0	0.0	0.0	0.0
Water	0.0	0.0	0.0	0.0	0.0	0.0
Canopy cover						
0.5 m	31.8	21.1	52.7	35.6	47.5	33.5
1.5 m	2.0	3.3	29.0	36.5	22.3	33.6
Vertical vegetation cover						
0.0 - 0.5 m	56.7	26.2	48.3	32.0	51.5	30.0
0.5 - 1.0 m	6.7	5.4	12.7	15.6	11.4	14.0
1.0 - 1.5 m	0.4	1.4	3.1	9.5	2.5	8.4

Table 2. Comparison of percent vertical vegetation cover up to 1.5 m above the ground at locations along Preble's meadow jumping mouse (PMJM) pathways and off PMJM pathways. Sample sizes reflect the number of samples taken along the male PMJM pathway (n = 1) and the female PMJM pathways (n = 3). Statistical tests are presented, but are invalid because of pseudo-replication of n = 2 individuals.

	male (n = 6)				female (n = 18)				all (n = 24)				
	on the path		off the path		on the path		off the path		on the path		off the path		
Vegetation cover height	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	p-value
0.0 - 0.5 m	56.7	26.2	66.3	16.5	48.3	32.0	54.3	27.4	51.5	30.0	57.4	25.4	0.14
0.5 - 1.0 m	6.7	5.4	12.5	5.8	12.7	15.6	19.4	24.0	11.4	14.0	17.6	21.0	0.04
1.0 - 1.5 m	0.4	1.4	2.1	3.3	3.1	9.5	7.9	14.5	2.5	8.3	6.4	12.8	0.001