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Home Range Dynamics of Meadow Jumping Mice, *Zapus Hudsonius*

Introduction

Meadow jumping mice, *Zapus hudsonius*, are widely distributed in North America and occupy habitat types that are quite common, generally wet meadow or old-field and to a lesser extent in forests (Quimby 1951; Getz, 1961; Whitaker, 1963). Though widespread, MJM have been reported to be relatively rare. Boonstra and Hoyle (1986) found MJM densities increased after removal of abundant meadow voles, *Microtus pennsylvanicus*, but this increase occurred only after a 2-year lag. Boonstra and Hoyle (1986) hypothesized that meadow voles are competitively dominant, forcing MJM to avoid interactions, thus suppressing MJM numbers. In our opinion, few studies have focused on MJM due to their lower capture success and population densities than meadow voles.

MJM are generally active May through September (Quimby, 1951; Whitaker, 1963; Muchlinski, 1988). Given that MJM spend 7 months per year hibernating, surprisingly little known about their hibernation biology (Quimby 1951; Muchlinski, 1988). They are among the smallest of non-volant mammalian hibernators weighing approximately 26g when entering hibernation. They experience heavy over wintering mortality, but can be long-lived relative to other sized small mammals comparably (Quimby, 1951; Whitaker, 1963).

The only published reports to examine home range size of MJM are Blair (1940) and Quimby (1951). Blair reported 24 and 26 monthly home ranges for female and male MJM, respectively. Mean home range estimates were 0.37 ± 0.04 ha (range: 0.07 – 1.01 ha) for females and 0.36 ± 0.04 ha (range: 0.06 – 1.05 ha) for males. These monthly estimates were based on an average of

4.4 and 4.9 captures for females and males. Since monthly estimates were generated individual MJM may have been represented multiple times within the data set; however, no information regarding this was presented. Blair (1940) is the only source to mention home range overlap for MJM. Both genders were reported to '*generally overlap'* that of the same species and sex. No additional information was provided. Overlap could have been inflated since MJM activity was reported to have been concentrated along shorelines. Quimby (1951) provided data on home range size for MJM at two locations. At the first site, mean home range estimates were 0.15 ha (range: 0.08 – 0.35 ha) for 4 females and 0.17 ha (range: 0.06 – 0.45 ha) for 5 males. These monthly estimates were based on an average of 4.0 captures for both sexes. At the second site, mean home range estimates were 0.64 ± 0.09 ha for 17 females and 1.09 ± 0.20 ha for 9 males. These monthly estimates were based on an average of 7.4 and 6.2 captures for females and males. In summary, both studies estimated home range size for few individuals with few capture points using methods no longer in use.

In this study, we used live trapping to capture MJM and powder tracking and radio telemetry to obtain data on home range size, overlap, habitat use, and movement patterns. Our two primary goals were to investigate new capture/detection strategies that might increase our trapping efficiency of MJM; and to investigate home range dynamics and movement patterns of MJM.

Methods and Materials

We established live trapping grids at Pierce Cedar Creek Institute (PCCI), Hastings MI in May-August 2007 and in Allendale, Michigan, on GVSU property in mid-April – October 2007. Traps were placed in habitats known to support MJM, a fen at PCCI and an old field at GVSU.

Our general live trapping procedure was to open traps prior to dusk (1830-2000 hrs), check and close traps the following morning (0600-0730 hrs). All captured individuals were identified to species and marked uniquely with numbered ear tags. Standard trapping data were collected on all captured individuals. Traps were provisioned with sunflower seeds for bait and cotton batting for nesting material, and were placed under cover to avoid thermally stressing captured individuals. Traps were cleaned after captures occurred.

We established four live trapping grids at PCCI (Figure 1); along the east edge of Brewster lake (A), a grid to the southwest of the research lab (B), a grid located to the southwest of Batts cottage off of the red trail near Brewster lake (C), and a grid to the north of Brewster lake (D). Grid A had 60 stations and Grids B,C, and D each had 40 stations all with two Sherman live traps per station. Grid A was trapped from May-August. Grid B was trapped for one week in May, but no MJM were captured. Grid C was trapped for a week and half in June, it was abandoned due to low capture success of MJM and high raccoon disturbance throughout the grid. Finally Grid D, was trapped for two weeks in July with no MJM captures. Our live trapping grid at GVSU had 72 stations, also with two Sherman live traps per station.

We implemented a new strategy in an attempt to capture MJM more efficiently. At each trapping station one trap was placed on cleared, bare ground as is typical for small mammal trapping. The other trap was placed on a 5cm blueboard block to elevate it off the ground. Preliminary powder tracking from fall 2006 confirmed past reports that MJM often forage off the ground and are able climbers (Whitaker, 1963). Meadow voles generally confine their foraging to runways they construct and maintain (Wolff, 1985). We hypothesized that elevated traps may more efficiently capture MJM than live traps placed at ground level.

A subset of captured MJM were dusted with ultraviolet-reflective powder on their venter. The following evening a portable UV light (Longwave Ultraviolet Lamp, UVP Inc.) was used to illuminate the resulting trails (Leman and Freeman, 1985). Trails were flagged at 1m intervals and mapped to document movement patterns within their home ranges. Habitat featured used by MJM was quantified along the route (i.e., moving on vole runways, over vegetation, or climbing into vegetation, as well as the height above the ground). This information was used in an attempt to locate nests, hopefully to find and mark pups prior to natal dispersal (Jacquot & Vessey, 1995), to supplement radio telemetry data on home range size, and to characterize foraging routes of MJM, something that has not been adequately described in the primary literature.

A subset of captured MJM (mass of at least 14g) were fitted with radio collars. Individuals were anesthetized using Halothane during installation and removal of transmitters. MJM were allowed to fully recover before release at the point of capture. Radio collars did not exceed 5% of individual body mass (ASM Animal Care Guidelines). A handheld telemetry receiver and antenna were used to locate collared individuals. Radio fixes were obtained daily (one day-light fix) additional fixes taken at night when MJM are active (Quimby 1951; Whitaker, 1963). Night fixes were obtained an hour after dusk (2300 hrs) with a minimum of 60 minutes between fixes. On a typical night 5 telemetry fixes were obtained per individual. We collected 50 data points for each radio collared individual.

Home ranges of radio tracked individuals were quantified using two methods minimum convex polygon (MCP) and kernel estimation. MCP is the only estimation technique that is strictly comparable among studies and is a simple robust estimator, but is not useful for quantifying core areas or habitat use (Harris et al., 1990). Kernel estimation is a relatively new technique that is requires substantial quantities of data but is effective at identifying core areas and habitat use (Worton, 1989). We used the program CALHOME, (John Kie, version 1.0) to calculate home ranges.

We quantified habitat at each trapping station on Grid A at PCCI using a $1m^2$ wooden sampling frame. At a randomly selected area near each station we measured the amount of ground cover, canopy cover, % monocot, and % dicot to the nearest 5%. We compared habitat data from stations that captured MJM to those stations that had no MJM captures, using Point-Biserial Correlation Coefficient & T-tests (Kent & Coker, 1992)

Results

Live trapping occurred on 47 nights, during May – August 2007 at PCCI (4,880 trap nights). The majority of our trap effort was on grid A with 3360 trap nights. We averaged 2.68 total captures per 100 trap nights. The total number of captures on all PCCI grids from May through August 2007 was 131 (Table 1). The number of total captures for all species were as follows; MJM – 29 (21 females, 8 males), White-footed Mouse – 24 (1 female, 23 males), Meadow Vole – 60 (16 females, 44 males).

Twelve MJM individuals were captured 29 times at PCCI. Grid A had the most MJM captures with 27 of our 29 captures. We averaged 0.80 MJM captures per 100 trap nights on Grid A. The maximum population density of grid A was estimated to be 3 MJM/ha using the minimum number known alive technique.

Live trapping occurred on 9 nights at GVSU (1,296 trap nights). On this grid we averaged 18.8 total captures per 100 trap nights. The total number of captures on the GVSU grid from August through October 2007 was 243 (Table 1). We captured the same five species at GVSU as we captured at PCCI.

Thirty four MJM were captured 56 times at GVSU (18 females & 16 males). We averaged 4.32 MJM captures per 100 trap nights at GVSU. Maximum population density at GVSU was estimated to be 20 MJM/ha (MNKA estimate).

At PCCI, high and low traps had total captures of 41 and 90, respectively. Total MJM captures were 13 and 16, respectively. Trap height did not affect the number of captures of MJM, nor any other species, other than meadow voles, which were captured more frequently in low traps ($\chi^2 = 38.4$, $P < 0.001$;Table 2). Though trap height did not effect the number of MJM captures, high traps were more efficient at capturing MJM as a result of lower meadow vole captures (31.7% and 17.8% of captures were MJM in high and low traps).

We powder tracked three MJM at PCCI, one of these individuals was tracked twice. The average trail length was 32m with a total of 95 m of MJM trail for three individuals. We used these powder trails to generate a 100%MCP home range estimate to determine if they would compare favorably with estimates generated from radio telemetry. Home range estimates from powder tracking averaged 59 m^2; two orders of magnitude smaller than estimates generated from radio telemetry (Table 3). At GVSU, 17 MJM were powder tracked, their trails averaging 59m, with a total of 1,015 m of trail. Though trail lengths were longer at GVSU than PCCI, this difference was not significant ($T_{19} = -1.59$, $P = 0.13$).

Trail heights at PCCI averaged 3.84cm ± 0.74cm and at GVSU averaged 6.19 ± 0.14 (Figure 2 & 3). At both locations, MJM rarely traveled on the ground, rather they moved over moss, grass, leaves, and particularly plant stems (Figures 4 & 5).

Radio telemetry was successfully completed on two MJM (#101 female & #120 male). Overall home range estimates were ≈ 2,500 m^2 and core areas were ≈ 800 m^2 using 95% & 50% MCP (Table 4). The mean distance between locations was 15.4 m for the female and 5.7 m for the male.

On Grid A at PCCI, we found that trapping stations with higher levels of monocots captured more MJM (T = -2.23, P = 0.015; Table 5). Higher levels of overall cover resulted in more MJM captures (T = -1.77, P = 0.041) and there was a trend for more MJM captures at sites with lower levels of canopy cover (T = 1.50, P = 0.070). Dicot cover did not affect MJM capture success (T = 0.87, P = 0.193).

Discussion

At PCCI, MJM had low population densities during the summer of 2007. We had few captures and relatively low trap success as a result. Nichols and Conley (1982) had higher capture success, and Muchlinski (1988) reported higher population densities our PCCI study site. Population densities at the GVSU site were comparable to Muchlinski (1988). This is somewhat surprising, since past work has found habitat adjacent to water to be high quality habitat for MJM (Quimby, 1951; Whitaker 1963; 1972). We experienced relatively low capture success during work at PCCI in 2005. It is not clear why this would be so.

Capture success for high and low traps did not differ significantly from 1:1, with the exception of meadow voles. We captured nine times as many voles in low traps as compared to high traps (54 versus 6). Meadow voles generally restrict their movement to cleared runways, which would be more conducive to entering our low traps (Wolff, 1985). As a result of high traps capturing few meadow voles, elevated traps were more efficient at capturing MJM. Our powder tracking data revealed that MJM are generally moving a few centimeters off the ground, thus they were captured in both the 5cm high and 0cm low traps.

We hypothesized that past researchers had low MJM capture success due to their avoidance of meadow voles. Interesting at PCCI, the two grids with the lowest MJM capture success also had abundant meadow voles (Grid C & D, see Table 1). However, on Grid A and at the GVSU site, both species appeared to be coexisting. It is possible that high vole densities may suppress jumping mice densities as suggested by Boonstra & Hoyle (1986) and warrents future study.

We quantified MJM trail height for over 1 km of trail (20 individuals). MJM generally did not move on the ground as is typical of most local small mammals (Kurta, 2001). We found no case of MJM using meadow vole runway systems while tracking, also common among other small mammals, such as shrews. Instead, MJM were moving within the vegetation most commonly 4-5 cm off the ground, sometimes climbing over 50cm. This suggests that MJM are spatially partioned from meadow voles, explaining how this smaller species can coexist with the larger, more aggressive meadow vole. At PCCI, we tried to determine if powder tracking would produce good home range estimates. These estimates were very small and at least for short trails we conclude that powder tracking is not an effective means to assess home range size in MJM.

We were able to complete radio tracking on two MJM at PCCI. The female had a slightly larger home range than that of male (0.548 ha female, 0.472 ha male). These estimates are comparable to past studies, Blair (1940) had estimates of 0.37 ± 0.04 ha (range: 0.07 – 1.01 ha) for females and 0.36 ± 0.04 ha (range: 0.06 – 1.05 ha) for males. More work on MJM home range dynamics is warrented (e.g., home range overlap).

We captured MJM at locations with higher amounts of ground and monocot cover and at locations with less canopy cover. These variables were clearly linked, lower canopy cover results in higher levels of ground cover, which on Grid A was mainly grasses. Small mammals generally prefer high cover as it provides protection from larger predators (Wolff, 1985).

Acknowledgements

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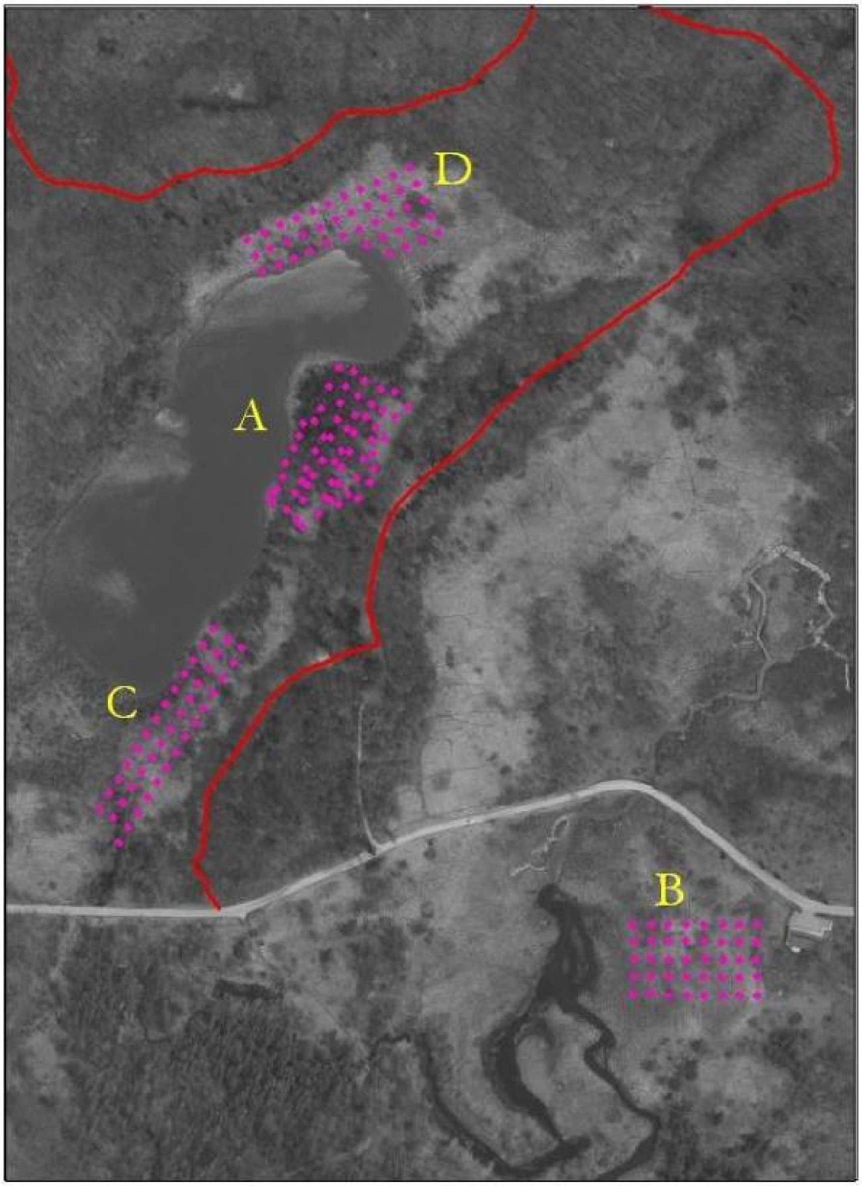

Figure 1. The location of our four live trapping grids at PCCI, Hastings MI.

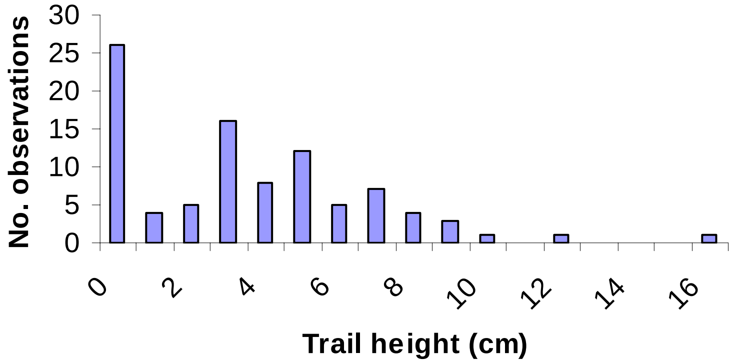

Figure 2. Height of MJM trails as revealed by powder tracking at PCCI (n = 3 mice, 95m of trail). Height was estimated every meter along trails.

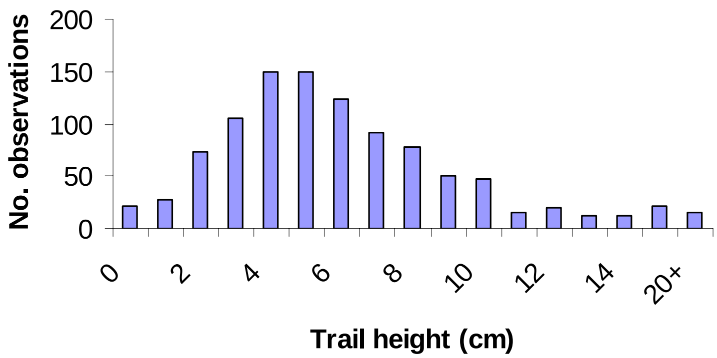

Figure 3. Height of MJM trails as revealed by powder tracking at GVSU (n = 17 mice, 1,015m of trail). Height was estimated every meter along trails.

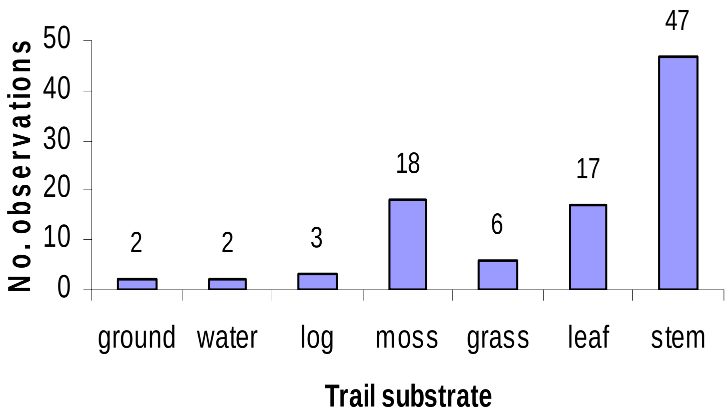

Figure 4. Substrate of MJM trails as revealed by powder tracking at PCCI (n = 3 mice, 95m of trail). Substrate was identified every meter along trails.

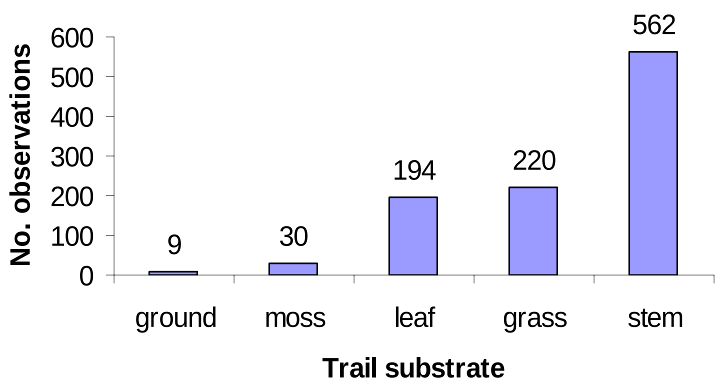

Figure 5. Substrate of MJM trails as revealed by powder tracking at GVSU (n = 17 mice, 1,015m of trail). Substrate was identified every meter along trails.

Table 1. Total captures by grid location using Sherman live traps on 4 grids at PCCI (A – D see Figure 1 for exact locations), from May - August, 2007. The GVSU grid was located in Allendale, MI and was trapped from August – October, 2007.

Species	Grid A	Grid B	Grid C	Grid D	PCCI Total	GVSU
Meadow Jumping Mice	27	0	2	0	29	56
White-footed Mice	22	2	0	0	24	13
Meadow Vole	16	0	10	34	60	108
Short-tailed Shrew	2	1	0	0	3	36
Masked Shrew	7	3	0	3	13	30
Total	74	6	12	37	131	243

Table 2. Total number of captures by trap type, high (5cm raised) and low (on bare ground). Species on 4 grids at PCCI, Hastings, MI. May-August, 2007

Species	High Traps	Low Traps
Meadow Jumping Mice	13	16
White-footed Mice	16	8
Meadow Vole	6	54
Short-tailed Shrew	1	2
Masked Shrew	4	9

Table 3. 100% MCP home range estimates produced from one night of pwder tracking at PCCI.

ID	Gender	Trail Length(m)	100%MCP (m^2)
102	Female	20	24
102	Female	22	57
108	Female	43	132
120	Male	12	24

Table 4. Home range estimates produced from 50 radio telemetry locations on two meadow jumping mice, completed at PCCI from May - August 2007. Adaptive kernel and minimum convex polygon were the estimators we used. The 95% and 50% estimates give an overall home range estimate and core area, respectively.

ID	Gender	% estimate	AK(m^2)	MCP(m^2)
101	Female	95%	5500	2800
		50%	420	93
120	Male	95%	4700	2300
		50%	880	730

Table 5. We measured four habitat variables at all 60 trap stations on Grid A, PCCI in August 2007 using $1m^2$ non-destructive plant sampling. Each variable was estimated to the nearest 5%. We compared habitat structure of stations capturing meadow jumping mice (MJM present) with those lacking MJM captures (MJM absent).

Habitat variable	MJM present	MJM absent	t-value	P value
% Ground Cover	85.3	72.1	-1.767	0.0412
% Monocot	46.9	27.7	-2.225	0.0150
% Dicot	38.4	45.1	0.8724	0.1933
% Canopy Cover	23.4	39.8	1.496	0.0700

References

Adler, G. H., Reich, L. M. & Tamarin, R. H. (1984). Demography of the meadow jumping mouse (*Zapus hudsonius*), Eastern Massachusetts. *American Midland Naturalist*, 112, 387-391

Baker, R. H. (1983). Meadow jumping mouse *Zapus hudsonius* (Zimmerman), *Michigan Mammals*, 357-364

Blair, W. F. (1940). Home ranges and populations of the jumping mouse. *American Midland Naturalist*, 23, 244-250

Boonstra, R. & Hoyle, J. A. (1986). Rarity and coexistence of a small hibernator, *Zapus hudsonius*, with fluctuation populations of *Microtus pennsylvanius* in the grasslands of southern Ontario. *Journal of Animal Ecology*, 55, 773-784

Elbroch, M. 2003. Mammal tracks and sign: A guide to North American species. Stackpole Books, Mechanicsburg, PA. 778pp.

Harris, S., W.J. Cresswell, P.G. Forde, W.J. Trewhella, T. Woollard, S. Wray. (1990). Home-range analysis using radio-tracking data - a review of problems and techniques particularly as applied to the study of mammals. *Mammal Review* 20: 97-123.

Jacquot, J.J. & S.H. Vessey. (1995). Influence of the natal environment on dispersal of white-footed mice. *Behavioral Ecology and Sociobiology* 37: 407-412

Kurta, A. 2001. *Mammals of the Great Lakes region*. University of Michigan Press: Ann Arbor, 376pp.

Lemen, C. A. & Freeman P. W. (1985). Tracking mammals with fluorescent pigments: a new technique. *Journal of Mammalogy.*, 66(1), 134-136

Muchlinski, A. E. (1988). Population attributes related to the life-history strategy of hibernating *Zapus hudsonius*. *Journal of Mammalogy.*, 69(4), 860-865

Nams, V.O. & E.A. Gillis. (2003). Changes in tracking tube use by small mammals over time. *Journal of Mammalogy* 84:1374-1380.

Nichols, J. D. & Conley, W. (1982). Active-Season Dynamics of a Population of *Zapus hudsonius* in Michigan. *Journal of Mammalogy*, 63(3), 422-430

Quimby, D. C. (1951). The life history and ecology of the jumping mouse, *Zapus hudsonius*. *Ecological Monographs*, 21, 61-95

Whitaker, J. O., Jr. (1963). A study of the meadow jumping mouse, *Zapus hudsonius* (Zimmerman), in central New York. *Ecological Monographs*, 33, 215-234

Whitaker, J. O., Jr. (1972). *Zapus hudsonius. Mammalian Species*, 11, 1-7

Wolff, J.O. (1985). Behavior. In: Biology of new world Microtus. Ed. R.H. Tamarin. Special Publication No. 8. *American Society of Mammalogists*. 893pp.

Worton, B.J. (1989). Kernel methods for estimating the utilization distribution in home-range studies. *Ecology* 70:164-168.