RP 526

Demography of the Meadow Jumping Mouse (Zapus hudsonius) in Eastern Massachusetts

GREGORY H. ADLER, LAWRENCE M. REICH,[1] and ROBERT H. TAMARIN

Boston University, Department of Biology, Boston, Massachusetts 02215

ABSTRACT: The meadow jumping mouse (*Zapus hudsonius*) was live-trapped for 5 years in eastern Massachusetts. Densities were low throughout the study, with yearly peak numbers ranging from 3.1-7.5 per ha. Female jumping mice reached sexual maturity at a weight heavier than males. Survival rates were low, but this could be attributed largely to a high degree of transiency; once mice achieved residency, loss rates were low. Demographic attributes of this population of *Zapus* were compared with populations of the meadow vole (*Microtus pennsylvanicus*) and the white-footed mouse (*Peromyscus leucopus*) in eastern Massachusetts. The most important differences between *Zapus*, which hibernates, and the two nonhibernating species were in the life span and survival of residents and the length of the breeding season. We suggest that some demographic classifications of zapodids may have been premature.

INTRODUCTION

Jumping mice (genus *Zapus*) are distributed widely in North American grasslands, and many natural history studies have been conducted on several species (Whitaker, 1972). However, few detailed studies on demography have been reported on these hibernating mice. Brown (1970) and Cranford (1983) studied the demography of several populations of *Z. princeps* in Wyoming and Utah, respectively, and Nichols and Conley (1982) studied a population of *Z. hudsonius* in Michigan. Further data on demography from *Zapus* populations are needed for comparison with more widely studied nonhibernating small mammals to determine how the strategies of demography of hibernators and nonhibernators differ.

We report here the results of a 51-month study on the demography of a population of *Zapus hudsonius* in eastern Massachusetts. We compare these results with demographic features of two nonhibernating small mammals, the meadow vole (*Microtus pennsylvanicus*) and the white-footed mouse (*Peromyscus leucopus*), inhabiting grasslands in eastern Massachusetts. We are testing the model of French *et al.* (1975), which suggests that *Zapus* will show high survival, low reproductive activity and low density compared to the two nonhibernating species.

MATERIALS AND METHODS

Live trapping was conducted year-round in grassy fields at the Broadmoor/Little Pond Audubon Sanctuary in South Natick, Massachusetts, from August 1978 to October 1982. Data were collected from two 0.8-ha rectangular grids (grids J and K) consisting of 100 trap stations each. Trap stations were spaced 7.6 m apart. Grid K was bounded on three sides by a 0.75-m high galvanized steel fence as part of an experimental study of the meadow vole *Microtus pennsylvanicus*. The fence did not restrict movement of *Zapus* because individuals trapped on Grid K were often captured outside the fence. Both fields were dominated by bluegrass (*Poa pratensis*) and goldenrod (*Solidago* spp.). Eighteen additional trap stations were located 15.2 m from grid J in deciduous woodland.

One Ketch-All, multiple-capture live trap was placed at each station. Traps were baited with oats and supplied with cotton for bedding. Trapping was conducted month-

[1] Present address: George S. Wise Faculty of Life Sciences, Department of Zoology, Tel Aviv University, Ramat Aviv, Tel Aviv, Israel.

ly, and traps were set for 2 consecutive nights and checked the following mornings. At the end of each trapping period, traps were left in place unset. Captured mice were ear-tagged with serially numbered fingerling fish tags, weighed to the nearest gram, and sexed. Reproductive data recorded consisted of position of the testes (scrotal or abdominal) in males and vaginal perforation and size of the nipples (small, medium or large) in females. Obvious pregnancies were detected by palpation. A male was considered breeding if it had scrotal testes. A female was considered breeding if it had medium or large nipples, a perforated vagina, or was pregnant. After data were recorded, mice were released at their point of capture.

Preliminary analyses showed homogeneity between grids in terms of structure of the population and trends in density, and data were therefore combined. We used the age groups of Whitaker (1963). Juveniles weighed < 13 g, subadults weighed 13-14 g, and adults weighed > 14 g.

We used enumeration techniques (Krebs, 1966) to measure density monthly. These techniques give reliable results if trappability (defined as the percentage of mice known to be alive that were actually captured in a given trapping period) is 50% or greater (Hilborn *et al.,* 1976.).

RESULTS

Zapus first appeared in traps each year in May or June and stopped entering traps in late summer or early autumn (Fig. 1). Overall trappability for *Zapus* during the ac-

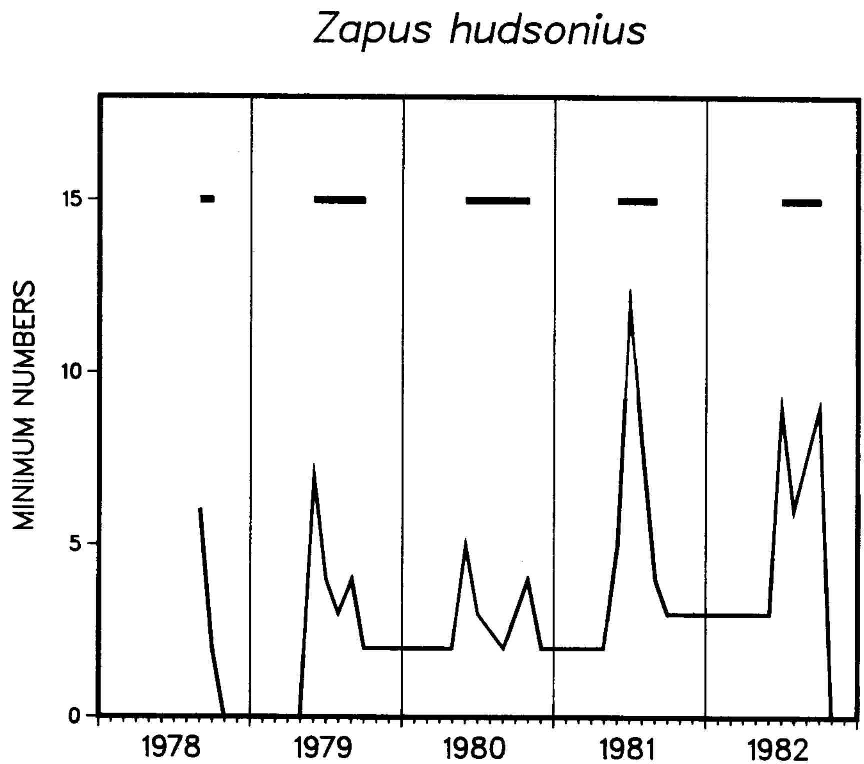

Fig. 1.—Changes in density of *Zapus hudsonius* on the study area, estimated as minimum number alive on the 1.6 ha study site. Seasons of activity are indicated by the solid horizontal bars at the top of the graph. Density estimates during hibernation include only those mice known to have survived the winters

tive seasons was 84.5%. Estimates of density during the periods of hibernation include those mice known to have survived the winters. Examination of the plot of density estimates (Fig. 1) shows that: (1) densities were low throughout the study period, and (2) peak densities varied from 3.1-7.5 per ha.

Breeding individuals were captured during every month of each active season. We calculated the intensity of adult reproduction over the entire study (Table 1). The age at which an individual reaches sexual maturity can have important demographic consequences. In this study, weight was used as an indirect measure of age. We used the probit technique (Leslie *et al.*, 1945) to determine a median weight at sexual maturity. Data from all years were pooled, and pregnant females were excluded from the analysis. The median weight at sexual maturity (and 95% confidence interval) was 14.5 g (12.1-17.4) for females and 12.5 g (6.4-24.6) for males. Thus, females matured at a greater age (higher weight) than males.

Weighted-mean, 14-day survival rates were calculated for each active season and pooled over the entire study period (Table 1). To determine how emigration may have influenced survival rates in this study, we divided mice into transients and residents. Transients were mice that were captured only during one trapping period, while residents were captured in more than one trapping period. Transiency was high: 26 of 33 males and 32 of 36 females were classified as transients.

To analyze the fates of resident mice, we constructed curves for the survival of male and female residents (Fig. 2). We regressed log number remaining on the grid on weeks for males and females separately to obtain weekly rates of disappearance (Snyder, 1956). Regressions were highly significant ($F = 25.73$, $p < .001$ for males and $F = 99.72$, $p < .001$ for females). The weekly rate of loss is given by the absolute value of the slope of the regression line (Table 1).

Interspecific associations were calculated as the expected number of *Zapus-Microtus* co-occurrences. Only five *Zapus-Microtus* co-occurrences were recorded over the entire study, whereas 19 were expected ($X^2 = 10.19$, $p < .005$). Thus, it appears that *Microtus* and *Zapus* tend to avoid one another in traps.

TABLE 1.—Comparison of demographic parameters of the population of *Zapus hudsonius* with populations of *Peromyscus leucopus* and *Microtus pennsylvanicus* in eastern Massachusetts

		Zapus	*Peromyscus*[2]		*Microtus*[3]	
		Grids J and K	Grids C and D	Grids A and B	Grid D	Grid F
Average density[1]		3.22	3.29	1.88	67.90	87.77
Overall survival (14-day rate)	Males	0.13	0.63	0.36	0.73	0.71
	Females	0.09	0.73	0.21	0.78	0.78
Transiency rate (%)	Males	78.8	56.8	77.8	53.9	53.7
	Females	88.1	47.1	89.7	46.3	43.4
Weekly resident loss rate	Males	0.006	0.055	0.060	0.044	0.046
	Females	0.008	0.020	0.020	0.034	0.034
Mean length of residency (Weeks)	Males	38.00	13.00	7.20	11.69	12.79
	Females	48.00	16.00	24.00	12.86	13.70
Mean length of breeding season (Weeks)	Sexes Combined	16.0	28.5	34.0	continuous[4]	
Intensity of adult reproduction (%)	Males	60.6	36.6	73.0	92.1[5]	81.1[5]
	Females	81.1	68.3	74.1	73.0[5]	71.5[5]

[1]Measured as the mean minimum number alive per hectare
[2]Adler and Tamarin (1984)
[3]Tamarin (1977)
[4]Breeding was continuous, though greatly reduced during winter
[5]Summers only

Discussion

Estimates of density and survival rate during the active season for *Zapus hudsonius* in our study population were considerably lower than those obtained by Nichols and Conley (1982). Survival rates were also low compared to other small mammals in eastern Massachusetts (Adler and Tamarin, 1984; Tamarin, 1977). The low rate of survival could be attributed largely to a high degree of transiency, since loss of resident mice was low. Nadeau *et al.* (1981) hypothesized that *Peromyscus* become vagrants at low densities as males search for breeding females. The high rate of transiency in our *Zapus* population may be due to a similar reason.

French *et al.* (1975) characterized zapodids by low rates of reproduction, high rates of survival and low densities. We compared six demographic parameters of *Zapus hudsonius* with those of the other species of small rodents (*Microtus pennsylvanicus* and *Peromyscus leucopus*) in grasslands of eastern Massachusetts (Table 1). These populations were influenced by similar environmental conditions and were studied by similar experimental methods. Of the six parameters compared in Table 1, the most important differences between *Zapus* and the two nonhibernating species are associated with the life span and survival of residents and the length of the breeding season. Nichols and Conley (1982) criticized this classification on the basis of similar rates of survival of *Zapus* and *Microtus* in their study area. However, they analyzed data from only one *Zapus* season of activity, and their analysis did not account for possible differences in the rate of transiency between the two species. Data from additional active seasons may have revealed much greater survival of resident *Zapus* compared to *Microtus*, as in our study.

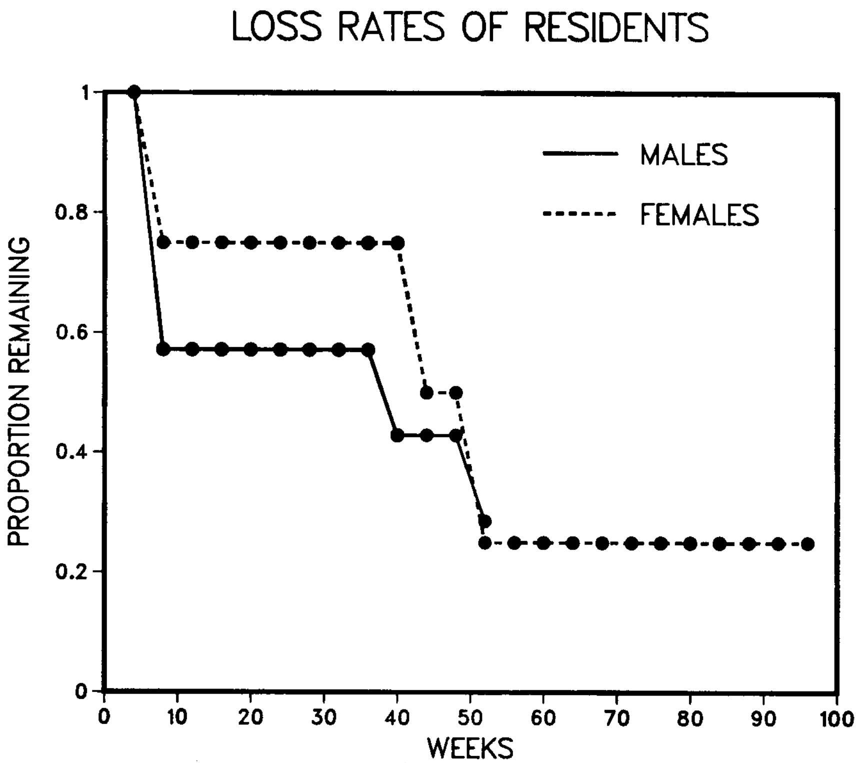

Fig. 2.—Survival of resident *Zapus hudsonius* from the study area. Only mice present at least two trapping periods were considered residents

Although our results tend to support the classification of French *et al.* (1975), their classification of zapodid populations as typically low density in nature was based on only one study. Subsequent studies have shown that *Zapus* populations may reach high densities [up to 24 per ha for *Z. hudsonius* (Nichols and Conley, 1982); up to 38.5 per ha for *Z. princeps* (Cranford, 1983)].

Zapus have smaller litter sizes than *Microtus* and *Peromyscus* and Kirkland (1979) suggested that *Zapus* were more K-selected than nonhibernating small mammals. We have shown here that *Zapus* breeding seasons are much shorter than those of *Microtus* and *Peromyscus*. However, overall reproductive output per *Zapus* female may be commensurate with that of nonhibernators owing to the two- to fivefold greater life spans of *Zapus* individuals.

It is evident that confusion over the demographic strategies of *Zapus* exists and that care must be taken in attempting to place zapodid populations into a demographic category. We suggest that additional comparative studies be conducted to more adequately categorize the strategies of demography of zapodids relative to other small mammals.

Acknowledgments.—This work was supported by NIH grant HD11682 and grants from the Boston University Graduate School (to RHT). We thank Carol Moyer and Marita Sheridan for helping in the field, and Gerald Svendsen and an anonymous reviewer for commenting on the manuscript.

LITERATURE CITED

ADLER, G. H. AND R. H. TAMARIN. 1984. Demography and reproduction in island and mainland white-footed mice (*Peromyscus leucopus*) in southeastern Massachusetts. *Can. J. Zool.*, **62**:58-64.

BROWN, L. N. 1970. Population dynamics of the western jumping mouse (*Zapus princeps*) during a four-year study. *J. Mammal.*, **51**:651-658.

CRANFORD, J. A. 1983. Ecological strategies of a small mammal hibernator, the western jumping mouse *Zapus princeps*. *Can. J. Zool.*, **61**:232-240.

FRENCH, N. R., D. M. STODDART AND B. BOBEK. 1975. Patterns of demography in small mammal populations, p. 73-102. *In*: F. B. Golley, K. Petrusewicz and L. Ryszkowski (eds.). Small mammals: their productivity and population dynamics. Int. Biol. Progr., vol. 5. Cambridge Univ. Press, Cambridge, England.

HILBORN, R., J. A. REDFIELD AND C. J. KREBS. 1976. On the reliability of enumeration for mark and recapture census of voles. *Can. J. Zool.*, **54**:1019-1024.

KIRKLAND, G. L. 1979. Are small mammal hibernators K-selected? *J. Mammal.*, **60**:164-168.

KREBS, C. J. 1966. Demographic changes in fluctuating populations of *Microtus californicus*. *Ecol. Monogr.*, **36**:239-273.

LESLIE, P. H., J. S. PERRY AND J. S. WATSON. 1945. The determination of the median bodyweight at which female rats reach maturity. *Proc. Zool. Soc. Lond.*, **115**:473-488.

NADEAU, J. H., R. T. LOMBARDI AND R. H. TAMARIN. 1981. Population structure and dispersal of *Peromyscus leucopus* on Muskeget Island. *Can. J. Zool.*, **59**:793-799.

NICHOLS, J. D. AND W. CONLEY. 1982. Active-season dynamics of a population of *Zapus hudsonius* in Michigan. *J. Mammal.*, **63**:422-430.

SNYDER, D. P. 1956. Survival rates, longevity, and population fluctuations in the white-footed mouse, *Peromyscus leucopus*, in southeastern Michigan. *Misc. Publ. Mus. Zool. Univ. Mich.*, **95**:1-33.

TAMARIN, R. H. 1977. Demography of the beach vole (*Microtus breweri*) and the meadow vole (*Microtus pennsylvanicus*) in southeastern Massachusetts. *Ecology*, **58**:928-934.

WHITAKER, J. O., JR. 1963. A study of the meadow jumping mouse, *Zapus hudsonius* (Zimmerman), in central New York. *Ecol. Monogr.*, **33**:215-254.

______. 1972. *Zapus hudsonius*. *Mamm. Species*, **11**:1-7.

SUBMITTED 1 AUGUST 1983 ACCEPTED 18 NOVEMBER 1983