Differences in Home-Range Size between Sexes of Microtus ochrogaster

Robert K. Swihart; Norman A. Slade


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enclosure, short duration of the study, age of the foxes (8–12 months), and forced pairing of the foxes also may have contributed to the results. The nonrandom, spatial distribution of feces within the enclosure may reflect simply the amount of time foxes spent in the various sampling areas.

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LITERATURE CITED


DIFFERENCES IN HOME-RANGE SIZE BETWEEN SEXES OF MICROTUS OCHROGASTER

ROBERT K. SWIHART AND NORMAN A. SLADE

Department of Plant Pathology and Ecology, The Connecticut Agricultural Experiment Station,

Box 1106, New Haven, CT 06504

Museum of Natural History and Department of Systematics and Ecology,
The University of Kansas, Lawrence, KS 66045

Differences in patterns of space use by the two sexes have been reported for a variety of mammalian species (Apps, 1986; Baber and Coblentz, 1986; Cameron and Spencer, 1985; Cranford, 1977; Kitchens and Story, 1984). One possible evolutionary explanation for such differences is that ranging patterns are related to reproductive tactics. Gaulin and Fitzgerald (1986, 1989) hypothesized that in populations characterized by promiscuous or polygynous mating systems, selection should favor larger home ranges for males than females because of more intense male-male competition for mates. In contrast, home ranges of the sexes of monogamous species should be comparable (Gaulin and Fitzgerald, 1986). Further, only reproductive males should exhibit expanded home ranges in a polygynous system; reproductive males should have larger home
ranges than nonreproductive males. Gaulin and Fitzgerald (1986, 1988) suggested that if divergent reproductive tactics lead to differences in patterns of movements by the two sexes, then home-range size could be used to predict the mating system in species or populations for which the mating system is unknown.

To test their hypothesis, Gaulin and Fitzgerald (1986) examined ability to orient in a maze and home-range size for two species of voles, one (pine voles, *Microtus pinetorum*) characterized by a monogamous mating system and the other (meadow voles, *Microtus pennsylvanicus*) by a promiscuous system. They found equal levels of home-range size and ability to orient in a maze in male and female *M. pinetorum*, whereas male *M. pennsylvanicus* exhibited larger home ranges and better orientation skills in a maze than female conspecifics.

As an additional test, Gaulin and Fitzgerald (1988) used radiotelemetry to examine home-range size in male and female prairie voles, *M. ochrogaster*, and meadow voles. Prairie voles apparently are monogamous (Getz and Carter, 1980; Getz et al., 1981; Thomas and Birney, 1979), thus Gaulin and Fitzgerald (1986) predicted that home-range sizes of males and females would not differ. As predicted, no statistical differences were evident for home-range sizes of male and female prairie voles, and home-ranges of male meadow voles were larger than those of females (Gaulin and Fitzgerald, 1988). In addition, male and female prairie voles exhibited similar orientation skills in a maze, whereas male meadow voles performed better than female conspecifics (Gaulin and Fitzgerald, 1989).

Aside from the work of Gaulin and Fitzgerald (1988), we know of only one other study (Meserve, 1971) for which differences in home-range size were tested statistically in prairie voles. Meserve (1971) found no differences in sizes of home ranges of males and females. In the present paper, we report on home ranges of prairie voles captured during a live-trapping study from 1973 to 1984 at the Nelson Environmental Study Area, 14 km NE Lawrence, Kansas. Specifically, we examined three predictions of the hypothesis of Gaulin and Fitzgerald (1988) as applied to prairie voles: there are no differences in home-range size of the two sexes in adults; there are no differences in home-range size of reproductive and nonreproductive males; and ratios of home-range size of males and females are comparable, regardless of whether measured during or after the breeding season. Because prairie voles in northeastern Kansas are capable of breeding in all months of the year (Fitch, 1957; Martin, 1956), we modified the third prediction to compare movement ratios between males and females for those in reproductive and nonreproductive condition.

Prairie voles were trapped on a 2.25-ha rectangular grid, with traps spaced at 15-m intervals. Two traps (one Sherman and one modified Fitch trap) were placed at each station. Traps were baited with a mixture of grain sorghum, corn, and wheat. Before 1976, trapping was conducted at biweekly intervals for a 3-day period. Subsequently, trapping was conducted for one 3-day period each month. Upon capture, each vole was toe-clipped for individual identification, and body mass, sex, reproductive condition, and trap location were recorded. Animals weighing >32 g were judged to be adults. Males with scrotal testes were scored as reproductively active. Females with either well-developed nipples or a perforate vagina and an open pubic symphysis were scored as reproductively active.

Sizes of home-ranges were estimated only for animals with at least four captures. To control for the covariance between reproductive status and age, only adult voles were used in analyses. We estimated size of home ranges by four methods: minimum-convex polygon (Jennrich and Turner, 1969); $S_\infty$, the number of traps at which an animal would occur if captured an infinite number of times in its home range, multiplied by the effective area around each trap; $S_\omega$ is estimated from $S_\omega = S_\infty/(1 - e^{-k})$, where $e$ is the number of captures, $S_\infty$ is the number of trap stations at which the animal was captured, $e$ is the base of natural logarithms, and $k$ is a constant (Metzgar and Sheldon, 1974); mean-squared distance from the arithmetic center of activity (Calhoun and Casby, 1958; Slade and Swihart, 1983); and home-range length (the maximum distance between capture points—Abramsky and Tracy, 1980). Animals were classified as reproductive if they were scored as such for ≥50% of their capture records. Unless stated otherwise, Welch tests, two-sample *t*-tests with correction for unequal variances between groups, were used in pair-wise comparisons (Huntberger and Billingsley, 1987:340).

Six hundred seventy-two adult prairie voles (319 males, 353 females) were captured at least four times. Mean ($\pm SE$) length of tenure on the grid was 119 ± 3.1 days and did not differ between males ($\bar{X} = 117$ days) and females ($\bar{X} = 121$ days, $P = 0.57$). The mean ($\pm SE$) number of captures per individual was 7.0 ± 0.14 and did not differ between adult males and females (6.9 and 7.1, $P = 0.57$) or between reproductive males and females (7.1 and 7.2, $P = 0.64$). Differences were evident between mean-capture frequencies of nonreproductive and reproductive males (5.9 and 7.1, $P = 0.01$).

Means of each of the home-range measures were significantly larger for males than for females both for all adults and when restricted to reproductively active individuals (Table 1). Because Gaulin and Fitzgerald (1988) studied prairie voles during summer only, we conducted a separate analysis for movements of reproductively active males and females whose modal number of captures occurred during summer. Once
Table 1.—Comparisons* of mean home-range sizes of prairie voles livetrapped near Lawrence, Kansas, 1973–1984, and categorized by sex and reproductive condition.

<table>
<thead>
<tr>
<th>Category</th>
<th>Sex</th>
<th>Minimum convex polygon (m²)</th>
<th>S₀⁺ (m²)</th>
<th>Mean-squared distance from center (m²)</th>
<th>Home-range length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>X</td>
<td>SE</td>
<td>n</td>
<td>X</td>
</tr>
<tr>
<td>Year-round</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td>♂</td>
<td>367</td>
<td>29</td>
<td>183</td>
<td>830</td>
</tr>
<tr>
<td></td>
<td>♀</td>
<td>236</td>
<td>18</td>
<td>118</td>
<td>574</td>
</tr>
<tr>
<td>Reproductive</td>
<td>♂</td>
<td>385</td>
<td>32</td>
<td>148</td>
<td>857</td>
</tr>
<tr>
<td></td>
<td>♀</td>
<td>243</td>
<td>21</td>
<td>100</td>
<td>576</td>
</tr>
<tr>
<td>Summer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reproductive</td>
<td>♂</td>
<td>306*</td>
<td>34</td>
<td>32</td>
<td>835</td>
</tr>
<tr>
<td></td>
<td>♀</td>
<td>232*</td>
<td>32</td>
<td>19</td>
<td>585</td>
</tr>
<tr>
<td>Year-round, males only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reproductive</td>
<td>♂</td>
<td>385*</td>
<td>32</td>
<td>148</td>
<td>857*</td>
</tr>
<tr>
<td>Nonreproductive</td>
<td>♂</td>
<td>290*</td>
<td>62</td>
<td>36</td>
<td>727*</td>
</tr>
<tr>
<td>Male : female ratio</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reproductive</td>
<td></td>
<td>1.58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonreproductive</td>
<td></td>
<td>1.57</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Within each home-range measure, means bearing the same letter were not significantly different (P > 0.05) by the Welch procedure for samples with unequal variances.

S₀⁺ = S₀/(1 – e⁻μ), μ = number of captures, S₀ = number of trap stations at which the c captures occurred, e = base of natural logarithms, and k = a constant.
again, males had larger home ranges than females, although the result for the convex polygon was not significant ($P = 0.12$; Table 1).

When reproductive and nonreproductive males were compared, mean values were larger for reproductive males in all instances, although statistical significance was achieved only with home-range length (Table 1). Home ranges of males averaged about 1.5 times the size of female ranges for both reproductive and nonreproductive voles (Table 1). In addition, male : female ratios of home-range size were slightly larger for reproductive than nonreproductive voles, (0.6%, 6.4%, 1.5%, and 12.3% for convex polygon, $S_{coh}$, mean-squared distance, and home-range length, respectively).

Males in our study had home ranges averaging 1.58 times larger than those of females, based on minimum-convex-polygon estimates (Table 1). Home ranges of males in the study of Gaulin and Fitzgerald (1988) were 1.52 times larger than those of females. Although the values of 1.58 and 1.52 are nearly identical, Gaulin and Fitzgerald (1988) failed to find a significant difference between home-range sizes of males and females ($P = 0.12$), whereas, in our study, males had significantly larger home ranges than those of females (Table 1). The inability of Gaulin and Fitzgerald (1988) to detect differences in the size of the home ranges of males and females was related to relatively small sample sizes (21 males and 26 females). Sample sizes in the present study were larger (e.g., for the convex polygon, $n = 148$ and 100 for reproductive males and females, respectively), leading to smaller standard errors (SE for convex polygons of males and females were 31.9 and 21.2 in our study and 63.7 and 24.0 in the study by Gaulin and Fitzgerald [1988]). The large standard error for male prairie voles may have been responsible for the inability of Gaulin and Fitzgerald (1988) to find differences in home-range size between the sexes at the 0.05 level. Similarly, when we analyzed home ranges of voles captured primarily during summer, reduced sample sizes, similar to those of Gaulin and Fitzgerald (1988), were partially responsible for our failure to reveal significant differences in estimates of home-range size of males and females by the convex-polygon method (Table 1).

Reproductive males had larger home ranges than reproductive females, and males with scrotal testes tended to have larger home ranges than males without scrotal testes (Table 1). Both of these findings are consistent with movement patterns typifying a poligamous mammal by the criteria of Gaulin and Fitzgerald (1986). Yet, most laboratory (Getz and Carter, 1980; Getz et al., 1981; Shapiro et al., 1986; Thomas and Birney, 1979) and field (Getz et al., 1981; Getz and Hofmann, 1986; Hofmann et al., 1984) studies indicate that prairie voles are monogamous. Although it is possible that intraspecific variability in mating systems occurs (Lott, 1984), our concern is that the mating system of a population erroneously might be assumed to be a given type on the basis of what often is a highly variable set of movement data. In fact, relative home-range sizes of male and female voles in the present study may be unrelated to the prevailing mating system. Ratios of home-range size for males and females were similar for reproductive and nonreproductive segments of the population (Table 1). Only detailed field studies based on techniques such as electrophoresis and radionuclide labels (Sheridan and Tamarin, 1986) or immunological markers (Glass and J. Childs, pers. comm.) will permit critical analysis of mating systems of microtines.

Even if mating system and home-range size are causally related in microtines, we question the utility of testing for statistical differences in home-range size of males and females as a means of determining the mating system. Choice of an alpha level is arbitrary, and failure to reject the null hypothesis of equal home-range sizes of males and females at the 0.05 level does not shed any more light on the mating system than does a test at the 0.10 or 0.20 level. Rather, if relative home-range sizes of males and females are related to the prevailing mating system, it may be more useful to rank populations or species along a continuum of reproductive tactics. The continuum represents a measure of the degree to which males compete for mates relative to competition among females for mating opportunities with males (Dewsbury, 1981; Ralls, 1977).

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DAYTIME SPATIAL CHARACTERISTICS OF COTTONTAIL RABBITs IN CENTRAL PENNSYLVANIA

Donald P. Althoff and Gerald L. Storm

Pennsylvania Cooperative Fish and Wildlife Research Unit,
The Pennsylvania State University, University Park, PA 16802

Present address of DPA: McKinzie Scientific, 1840 Kerr Avenue, Lancaster, OH 43130

There is a need for more information on use of space to understand the distribution and behavior of cottontail rabbits (*Sylvilagus floridanus*) and management of habitats. Distances between consecutive bed sites, amount of space overlap, and size of home ranges are indicators of spatial distribution over time for