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SMALL MAMMAL COMMUNITY DYNAMICS IN COOK COUNTY, MINNESOTA

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ABSTRACT

This research included the fifteenth year of consecutive annual monitoring of the small mammal populations in Cook County, Minnesota. Nineteen sites were included and censuses were attempted at two additional sites. The sites include those where rock voles (*Microtus chrotorrhinus*), heather voles (*Phenacomys intermedius*), and smoky shrews (*Sorex fumeus*) were previously secured. Numbers of small mammals (1984-1997) were analyzed with respect to data on pine marten (*Martes americana*) (1985-1996). All specimens of the three small mammal species mentioned above which have been secured 1992-1997 are tallied by year and site.

At the 19 monitoring sites, the average number of rock voles declined in 1997 from 1996. The average number of red-backed voles (*Clethrionomys gapperi*) increased from its 15-year nadir in 1996. Smoky shrews were more common than in any previous year except 1995. There was a total of 15 smoky shrews secured in 1997. No heather voles were secured in 1997. At the two sites with attempted censuses for which only Museum Special traps were used, there was no second peak of specimens of rock voles as had occurred previously with a two-stage-two-trap-type enumeration.

Analysis of pine marten-small mammal interaction included two measures of marten populations: the estimated size of the population and the ratio of juveniles to adult females. Numbers of small mammals analyzed with respect to the marten were those of rock voles, red-backed voles, deer mice (*Peromyscus maniculatus*), all species of shrews combined, and all species of small mammals combined. Analyses of correlations without time lags indicated that there were large and significant correlations between the numbers of prey (red-backed voles, shrews, all small mammal species combined) and the ratio of juvenile to adult female pine marten, thus supporting the hypothesis that prey availability correlates with success of breeding and/or raising young. There was a large and significant negative correlation between red-backed vole numbers and the population estimate of marten, thus suggesting a depressive effect of marten on red-backed voles. There was no significant correlation when prey indices were lagged one year nor when marten indices were lagged one year.

Numbers of specimens of small mammal species of greatest interest secured in 1992-1997 included four heather voles at two sites (two consecutive years), 117 smoky shrews at 19 sites, and 1,236 rock voles at all 21 sites. Smoky shrews and rock voles were secured each year. Heather vole occurrence is sporadic, despite uniformity of collecting effort and personnel. Smoky shrews seem to be increasing in numbers. Rock voles are relatively stable and common, despite a "crash" in their numbers in 1997, only the second such event in 15 years.

PART 1: MONITORING AND CENSUS ATTEMPTS IN 1997

INTRODUCTION

The community of small mammals was sampled on the usual 16 boulder sites, on two eskers, and on one old clearcut. Each site is characterized as having boulders, but each trap line configuration encompasses as much habitat variability as possible, *e.g.*, surrounding woods and alder swamps. Censuses were attempted at two additional sites, C24 and C30S. There is no discrete boulder field at site C30S, but such boulder fields are proximate there and within the distances traversed by individual rock voles as evidenced by radio-telemetry (Jannett, unpublished).

MATERIALS AND METHODS

Design and protocol for the monitoring replicated those used in previous years and detailed in Jannett (1990a and 1990b). Additionally, three of the 19 monitoring trap lines were left out for an additional four days to ascertain a possible change in species and numbers over time. Results of extending sampling will be presented elsewhere after additional effort to yield sufficient data for analyses.

Two census attempts were made. (They are termed attempts out of an understanding that the trap effort is still minor compared to the size of the population and the low trappability of many individuals.) These differed from monitoring lines in that 1) there was a higher density of trap placement, and 2) traps were left out for six consecutive days. At site C24, the 100 trap stations were those previously used (*e.g.*, see Jannett, 1990b). At C30S, the 50 trap stations were those used only from 1991 through 1996 along the border of an alder swamp. Only one Museum Special trap was deployed per station, instead of one live trap set on day one and one Museum Special trap on day three as in previous years. The change in protocol was to test the hypothesis that the previous usual two temporal peaks in captures merely reflected trappability with respect to trap type.

To test if the numbers of rock voles in 1997 were different than in previous years in the monitoring lines, ANOVA's were undertaken on square-root transformed data. To count the rock voles on days with >50% set-off traps, I added them to the next day with <50% set-off traps. Disruption of the trap lines due to bear, marten, and rain was low in 1997, and so only one line was left out for a third day for a qualifying second 24-hour period. Only data from days one and two were used, even when there were six qualifying days of data, because, except in 1983, previous transects were for two, rarely three days. Data from site C11 were not included in the analyses in 1988-1997 because an immediately adjacent area, including some of the marginal trap stations, was clearcut in early 1988. There were two ANOVA's performed: one on the data from the 1983 subset of sites trapped 1983-1997, one on the data from all sites (except C11) trapped 1984-1997. Duncan multiple range tests were done, where a=0.05.

To more accurately reflect the traps available for rock voles, numbers were expressed per 100 trap-nights, and the following were subtracted from the total number of trap-nights per site, determined after there were two nights with <50% set-offs: one-half trap-night for each trap upon being checked which was set-off or broken, had another species, or was nonfunctional as when an object had been blown under the treadle; one trap-night for each trap not found. Again, there were two ANOVA's performed: one on the data from the 1983 subset of sites trapped 1983-1997, one on the data from all sites (except C11) trapped 1984-1997. Duncan multiple range tests were done.

The same four analyses done for rock voles were performed also for red-backed voles, the most abundant species in the community. The same four were performed for smoky shrews. No analysis was done for heather voles because only four specimens have been identified, 1983-1997.

Trapping efforts are listed in Table 1. Figure 1 depicts the average number of rock voles per two-day sample. Figure 2 depicts the average number of red-backed voles per two-day sample. Figure 3 depicts the catch of rock voles by day at the two census sites.

Specimens secured in 1997 were given the accession number Z97:10 at the Science Museum of Minnesota.

RESULTS

Rock Voles.

One or more rock voles were secured at each of 15 monitoring sites, none at four sites. In the 1983 subset of eight sites, there was a significant difference in numbers of voles between years in both the analyses of numbers and of numbers per 100 trap nights (perTN) ($P<0.0001$). For numbers of rock voles and voles perTN, the Duncan test grouped 1997 with 1983, 1990, and 1991.

In the overall suite of sites over 1984-1997, there was also a significant difference between years in both the analyses of numbers and of numbers perTN ($P<0.0001$). In the Duncan procedure, numbers of voles were grouped with those in only 1990, numbers perTN with those in only 1990 and 1991.

At the C24 census site, seven rock voles were secured. At the C30S census site, only two were secured. There was no pattern of two peaks of voles entering the traps. The order of voles entering traps by day is depicted in Figure 3.

Rock vole numbers in 1997 were the lowest in 15 years of study.

Red-backed Voles.

There was a significant difference in numbers of voles between the years in all four tests ($P<0.0001$). For both numbers and number perTN in the 1983 subset of sites, the Duncan procedure grouped 1997 with 1996 or with 1996, 1987, and 1989. For both numbers and numbers perTN at all sites 1984-1997, 1997 was grouped with only 1996.

In 1997, red-backed voles had very low numbers; only in 1996 had there been fewer in the 15 years.

Smoky Shrews.

In the two-day monitoring efforts, a total of seven smoky shrews was secured. Among the extended four day trap period at three sites, three additional specimens were secured. Among the two sites with census attempts, a total of five specimens were secured. A total of 15 smoky shrews was secured at a total of six sites.

For both the 1983 subset of sites and the overall suite of sites, there was a significant difference in numbers of smoky shrews between years in both the analyses of numbers and numbers perTN. For the numbers of shrews in the 1983 subset of sites, the Duncan test grouped 1991-1993, and 1994-1997; for the numbers perTN, the groupings were 1991-1993, a group of 1994+1996+1997, and another of only 1995; for both data sets, an alternative grouping placed 1994 with 1991-1993. For the entire suite of sites, for both numbers and numbers perTN, there were the same unambiguous groupings: 1991-1993 (relatively low numbers), 1994+1996+1997 (intermediate numbers), and 1995 (high numbers).

DISCUSSION

Rock vole numbers have been remarkably constant, 1984-1989, 1992-1995. Only in 1996 were numbers significantly higher than usual. There have been only two crashes of the population: one in 1990 with continued relatively low numbers in 1991, and another in 1997. Numbers of red-back voles were higher in 1997 than in 1996 when the population was at a 15-year nadir. Future analyses will concentrate on time series analyses to test hypotheses about interactions among the small mammals themselves, between small mammals and marten, and between small mammals and owls. One such hypothesis is that the short-tailed shrew (*Blarina brevicauda*) is an important predator on other small mammals, and another that the timing of fluctuations in numbers of voles is a result of prey switching by shrews.

Although numbers of rock voles were small at the census sites, there was no pattern of two peaks for voles entering the traps, corresponding to the deployment of two types of traps on different days, as there had been in previous years when both Sherman and Museum Special traps were used for the census attempts. Previously, the second peak following deployment of the Museum Special traps on day three was based on increased trappability with that type of trap.

Smoky shrews first appeared in the monitoring lines in 1991 at two of 21 sites (Jannett and Oehlenschlager, 1994). In subsequent years, they have generally increased in numbers and have been found at increasing numbers of sites. In 1997, they were more abundant than in any other year except 1995 when small mammals in general were unusually abundant. In 1997, they were secured at 19 of 21 sites.

No heather vole was obtained in 1997. The reason(s) for the occurrence of this species in 1995 and 1996 at two sites is not yet understood. Jannett and Oehlenschlager (1997) discussed possible explanations for its sudden appearance after 10 and 11 years, respectively, at those sites.

PART 2: THE RELATIONSHIP OF PINE MARTEN (*Martes americana*) POPULATIONS AND SMALL MAMMAL NUMBERS

INTRODUCTION

Small mammals, including insectivores (Berg, personal communication), constitute a large part of the prey base for the pine marten in northern Minnesota. The Minnesota Department of Natural Resources has extensive data on the pine marten population in northern Minnesota, but little on small mammals. An exploratory series of analyses was undertaken on the Cook County data for small mammals and the DNR pine marten data which begins in 1985. I attempted to find a correlation between two figures ("indices") for the pine marten population and five statistics for the small mammal prey. The two pine marten indices were the population estimate and the ratio of juveniles to adult females. The five small mammal statistics were five yearly averages in 18 monitoring lines.

MATERIALS AND METHODS

The ratio of adult females to young of the year in the annual harvest was used because it was felt that it represents, in part, success at rearing young. The population estimate was used because it represents the overall status of the population. Both were assumed to be influenced by prey availability. The ratio of adult females to young of the year was taken from Dexter (1997) (Table 26 therein). I calculated the overall population estimate from the harvest and the estimated percentage of the population which that harvest represented, for each respective year from the same Table 26. The marten indices herein are presented in Table 2.

I chose to analyze a correlation between pine marten and each of the three most common rodent species in the data sets, namely, red-backed voles, rock voles, and deer mice. I also analyzed for a relationship with shrew numbers (all species combined), and all small mammal species combined. For each species or group, the average used was based on the numbers per 100TN, and the number of sites included in the calculation was the same as in the respective ANOVA's. The complete list of species in the data set consists of those given by Jannett (1990a) plus *Sorex fumeus* and *Phenacomys intermedius*.

I followed the procedure of Boutin et al. (1995) and computed a Pearson correlation coefficient for each of the two pine marten indices with each of the five small mammal averages. Each year's index in each of the series of longitudinal data is not independent of the previous year's index. However, demographic changes are obviously not wholly dependent on the previous year's index (witness only two crashes of rock voles among 10 other years with stable numbers).

RESULTS

For unlagged data, that is, for small mammal data and the marten indices in the same year, there were large and significant correlations (at a=0.05) between the numbers of three prey species and groups (red-backed voles, all shrew species combined, and all small mammal species combined) and the ratio of juveniles to adult female pine marten (Table 3). There was a large and significant negative correlation between red-backed vole numbers and the population estimate of marten (Table 3). There was no significant correlation when prey indices were lagged one year, nor when marten indices were lagged one year.

DISCUSSION

The correlation analyses support the hypothesis that prey availability correlates with success of breeding and/or raising young. The analyses also suggest a depressive effect of predators on the most common small mammal prey species, the red-backed vole.

The data indicate effects of prey numbers on one important aspect of predator dynamics, and the effect of the overall predator population on the small mammal community.

The ratio of adult females to young of the year may in part also be dependent on the degree of trapping pressure (Berg, personal communication). Given additional data, especially for another year with a low ratio of juvenile to adult female marten, it may be possible to separate the effect of trapping pressure.

The analyses suggest that, following low numbers of small mammals in fall, 1997, the harvest of pine marten in the winter of 1997-1998 will again have a low ratio of juveniles to adult females as the 1990.

Other data for pine marten were not analyzed because of different reason. For example, the harvest number may represent trapping effort and accessibility more than anything to do with the marten population. The ratio of yearlings to adult females may be largely correlated with the ratio of juveniles to adult females in the previous year.

However, further analyses are suggested. For example, if the case could be made that yearling marten are more dependent on small mammal prey than are marten in other age classes, then the ratio of adult females to yearling would be worth analyzing separately. If the case could be made that ovulation rate and/or litter size is dependent on the nutritional status of the female in the previous year, then the analyses could all be undertaken after first using a lag of one year between prey indices and the ratio of juvenile to adult female pine marten. Other significant dynamic relationships could be explored.

The most fruitful analyses in the future will be time series analyses such as serial autocorrelation. No such analyses have been done on the marten data themselves (Berg, personal communication). These would allow us to better analyze data with respect to time lags, and so would be more conducive to elucidating interactions between the small mammals themselves, and between the mammals and other predators such as owls. Such analyses are planned (Jannett, 1998).

PART 3: SPECIMENS OF ROCK VOLES (*Microtus chrotorrhinus*), HEATHER VOLES (*Phenacomys intermedius*), and SMOKY SHREWS (*Sorex fumeus*) SECURED 1992-1997.

INTRODUCTION

The rock vole was previously a Species of Special Concern in Minnesota. The smoky shrew was first discovered in Minnesota during the course of this research (Jannett and Oehlenschlager, 1994), and is currently a Species of Special Concern. The heather vole is rare in Minnesota; before 1991 when it was secured in this research, it was known from only two specimens.

MATERIALS AND METHODS

The numbers of specimens of these interesting species were collated from the data entered in the monitoring data sets and from original census attempt data. Species verifications upon cranial, mandibular, and/or dental character were done for heather voles and the earliest specimens of smoky shrews reported here. The known specimens of both are distinguishable in the field. Verification of all other specimens must still be done. It is possible, for example, that a few specimens of rock voles have been misidentified. Very few of the specimens have been assigned catalog number for the Science Museum.

Specimens are tallied in Tables 4, 5, and 6 by species, year, and site.

RESULTS

The total numbers of specimens reported are 117 smoky shrews, four heather voles, and 1,236 rock voles.

DISCUSSION

The tally is not useable for any detailed analyses because it is the aggregate of specimens secured in monitoring lines over the usual two days, in some monitoring lines left for an additional four days to ascertain the profile of the species and numbers with continued effort, and in census attempts.

However, the following generalizations are valid. The rock vole is common in Cook County and populations are generally stable. The heather vole is rare and/or is not easily secured with Museum Special traps. The smoky shrews is becoming more common. It would be interesting to know if the increasing numbers of smoky shrews will be correlated with diminishing numbers of arctic shrews (*Sorex arcticus*) which are about the same size.

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LITERATURE CITED

Boutin, S., C.J. Krebs, R. Boonstra, M.R.T. Dale, S.J. Hannon, K. Martin, A.R.E. Sinclair, J.N.M. Smith, R. Turkington, M. Blower, A. Bryom, F.I. Doyle, C. Doyle, D. Hik, L. Hoffer, A. Hubbs, T. Karels, D.L. Murray, V. Nams, M. O'Donoghue, C. Rohner, and S. Schweiger. 1995. Population changes of the vertebrate community during a snowshoe hare cycle in Canada's boreal forest. Oikos, 74: 69-80.

Dexter, M.H., compiler. 1997. Status of wildlife populations, fall 1997. Unpub. Rep., Section of Wildlife, Minn. Dept. Nat. Res., St. Paul, Minnesota. 168pp.

Jannett, F.J., Jr. 1990a. Population constancy of the rock vole, *Microtus chrotorrhinus*, in northeastern Minnesota. *In*, Social Systems and Population Cycles in Voles. R.H. Tamarin, R.S. Ostfeld, S.R. Pugh, and G. Bujalska, Eds. Birkhauser Verlag AG, Basel. Pp. 81-87.

_____. 1990b. Habitat breadth and population stability and structure of the rock vole, *Microtus chrotorrhinus*, in northeastern Minnesota. Reported submitted to the Nongame Wildlife Program, Minnesota Department of Natural Resources. 23pp.

_____ and Oehlenschlager. 1994. Range extension and first Minnesota records of the smoky shrew Sorex fumeus. Am. Midl. Nat, 131: 364-365.

_____ and _____. 1997. Range extension and unusual occurrences of the heather vole, *Phenacomys intermedius*, in Minnesota. Canadian Field-Nat., 111: 459-461.

_____. 1998. Community ecology and management of northern Minnesota forests. Proposal submitted to the Legislative Commission on Minnesota Resources.

APPENDIX

There are two appendices: a series of six 35mm transparencies and a diskette with the report.

Table 1. Sites and collecting dates in Cook Co., Minnesota during 1997.

Site Code*	Trapping Dates	Total Number of Nights	Number of Nights with <50% Sprung Traps
C1	Sept. 4- 6	2	2
C3	Sept. 4- 7	3	2
C5	Sept. 4- 6	2	2
C10	Sept.10-12	2	2
C11	Sept. 9-11	2	2
C18	Sept. 8-14	6	6
C21	Sept. 7-13	6	6
C23	Sept. 7-13	6	6
C24**	Sept. 8-14	6	6
C30S**	Sept. 8-14	6	6
C31	Sept.12-14	2	2
C32	Sept. 9-11	2	2
C54	Sept. 5- 7	2	2
C56	Sept. 6- 8	2	2
C57	Sept. 6- 8	2	2
C59	Sept.11-13	2	2
C60	Sept.13-15	2	2
C61	Sept.12-14	2	2
C62	Sept.13-15	2	2
J4	Sept. 4- 6	2	2
J14	Sept.10-12	2	2

* Locations are given in Jannett (1990b)
**Census attempts; all other sites were monitored sites

Table 2. Indices of pine marten populations.

Year	Population Estimate	Juveniles per Adult Female
1985	7167	17.2
1986	8867	12.3
1987	8519	11.2
1988	10360	8.6
1989	10595	9.7
1990	8431	3.6
1991	5467	16.1
1992	9418	15.1
1993	7978	7.5
1994	8483	6.4
1995	8333	8.2
1996	9028	4.8

Table 3. Correlations between marten and small mammal indices.

Prey Species and Groups	Marten Indices			
	Juveniles:1 adult female		Population Estimate	
Clethrionomys gapperi	r=0.58	P=0.048	r=-0.61	P=0.036
Microtus chrotorrhinus	r=0.04	P=0.912	r=0.23	P=0.466
Peromyscus maniculatus	r=0.08	P=0.804	r=-0.29	P=0.367
All shrews	r=0.60	P=0.037	r=0.01	P=0.971
All small mammals	r=0.64	P=0.025	r=-0.51	P=0.091

Table 4. Rock vole specimens, 1992 - 1997.

Site	Year					
	1992	1993	1994	1995	1996	1997
C1	17	21	27	13	6	5
C3	12	7	10	8	3	3
C5	4	5	10	24	15	3
C10	9	3	12	8	7	0
C11	6	10	20	18	13	1
C18	0	1	3	1	2	0
C21	1	3	9	15	7	2
C23	8	6	8	20	12	0
C24	18	16	28	60	20	7
C30S	1	1	4	14	19	2
C31	7	4	7	13	5	1
C32	17	29	27	22	24	1
C54	15	9	10	16	15	1
C56	5	1	8	2	7	1
C57	6	14	5	13	16	3
C59	7	14	14	13	2	0
C60	8	14	12	10	9	1
C61	11	0	7	28	12	4
C62	12	20	25	15	13	3
J4	7	5	5	11	10	3
J14	5	8	17	14	3	2

Table 5. Heather vole specimens, 1992 - 1997.

Site	Year					
	1992	1993	1994	1995	1996	1997
C1	0	0	0	0	0	0
C3	0	0	0	0	0	0
C5	0	0	0	2	1	0
C10	0	0	0	0	0	0
C11	0	0	0	0	0	0
C18	0	0	0	0	0	0
C21	0	0	0	0	0	0
C23	0	0	0	0	0	0
C24	0	0	0	0	0	0
C30S	0	0	0	0	0	0
C31	0	0	0	0	0	0
C32	0	0	0	0	0	0
C54	0	0	0	0	0	0
C56	0	0	0	0	0	0
C57	0	0	0	0	0	0
C59	0	0	0	0	0	0
C60	0	0	0	0	0	0
C61	0	0	0	0	0	0
C62	0	0	0	0	0	0
J4	0	0	0	1	0	0
J14	0	0	0	0	0	0

Table 6. Smoky shrew specimens, 1992 - 1997.

Site	Year					
	1992	1993	1994	1995	1996	1997
C1	0	0	1	0	3	0
C3	0	0	0	1	0	0
C5	0	0	0	0	0	0
C10	0	0	2	1	0	2
C11	0	0	1	3	0	0
C18	0	0	0	1	4	0
C21	0	0	0	2	4	3
C23	0	1	0	0	2	0
C24	0	3	9	10	3	5
C30S	1	2	5	7	0	0
C31	1	0	0	1	0	0
C32	0	0	6	0	1	0
C54	0	0	0	2	0	0
C56	0	0	0	1	0	0
C57	0	0	0	0	1	3
C59	1	1	1	2	0	0
C60	0	0	0	0	3	1
C61	1	0	1	1	2	0
C62	0	4	1	2	2	0
J4	0	0	0	1	0	1
J14	0	0	0	0	0	0