Effect of *Blarina brevicauda* on trap response of *Microtus pennsylvanicus*

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The response of *Microtus pennsylvanicus* to traps with or without various prior occupants is described. *Microtus* were most frequently captured in traps previously visited by *Microtus*, but they showed a significant avoidance of traps previously visited by *Blarina brevicauda*. However, the probability of entry into such traps was no lower than into traps previously visited by other rodent species (*Mus musculus*, *Peromyscus leucopus*, or *Zapus hudsonicus*). There was an even lower probability of entry into traps which were previously empty. *Blarina* had a significantly higher probability of entering traps previously capturing *Blarina* than traps previously capturing *Microtus* or no one. We conclude that this evidence gives no support for the hypothesis that *Blarina* is a significant predator of *Microtus pennsylvanicus*.

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Les réactions de *Microtus pennsylvanicus* à des pièges nouveaux ou à des pièges qui ont déjà contenu divers occupants ont fait l'objet d'une étude. Les *Microtus* sont capturés surtout dans les pièges déjà visités par d'autres *Microtus*, mais ils évitent de façon significative les pièges déjà visités par *Blarina brevicauda*. Cependant, la probabilité pour un *Microtus* d'entrer dans ces pièges est la même que celle d'entrer dans des pièges déjà visités par d'autres espèces de rongeurs (*Mus musculus*, *Peromyscus leucopus* ou *Zapus hudsonicus*). La probabilité d'entrer dans un piège jamais visité est moindre. *Blarina* a une probabilité très significative d'entrer dans les pièges déjà visités par d'autres *Blarina* et une probabilité moindre d'entrer dans les pièges qui ont déjà capturé des *Microtus* ou des pièges neufs. Les résultats ne corroborent pas la théorie qui prétend que *Blarina* est un prédateur important de *Microtus pennsylvanicus*.

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Introduction

Microtine rodents generally live in grassland habitat where cover prohibits the long distance visual or acoustic signalling that occurs in other mammals (Stoddart 1974). This has resulted in a highly developed olfactory sense to obtain information such as reproductive status and perhaps dominance from the odoriferous substances produced by various glands or voided in the urine (Richmond and Stehn 1976; Stoddart 1980). Some of the mammalian predators of microtines, such as weasels, also produce strong odours. One would expect that if these predators are a significant cause of mortality for these rodents, there would be strong selection pressure to detect and avoid them if the prey can perceive the predator odour. In the only study done on this aspect of microtine ecology, Stoddart (1976) found that *Microtus agrestis* showed a significant avoidance of traps tainted with odoriferous substances produced by the anal glands of weasels.

The short-tailed shrew, *Blarina brevicauda*, is a small (up to 26 g) potential predator of *M. pennsylvanicus* and possesses well defined lateral and ventral glands which produce a strong musky odour (Pearson 1946). The main food items of the short-tailed shrew are earthworms, slugs, snails, and other invertebrates (Hamilton 1941; Ingram 1942; Whitaker and Mumford

1972). However, given the opportunity, *Blarina* will readily eat various species of rodents (Rood 1958; Martinsen 1969; Mauer 1970). Eadie (1952) used evidence collected from scats to infer that *Blarina* was a significant predator of *M. pennsylvanicus* and may have been responsible for a 6-year depression of *Microtus* numbers. If *Blarina* is a serious predator of *Microtus*, the latter should avoid all contact with the former. Our study was designed to investigate whether voles avoid live traps previously visited by these shrews, and whether this avoidance is different from the response shown by *M. townsendii* to strange or novel odours (Boonstra and Krebs 1976).

Methods and materials

The study was carried out on an abandoned pasture north of Toronto, Ontario, from June 1978 to November 1980. The study area contained five livetrapping grids. Each grid was covered by a checkerboard pattern of points spaced 7.6 m (25 ft.) apart. Three grids were square and two were irregular; four contained 100 trap points and one contained 98. One Longworth live trap was placed at each trap point and baited with oats; cotton nesting material was provided. Traps were left permanently on the trapping grids, locked open when not in use, and covered with a board. We trapped all grids for 2 days every 2nd week. Traps were set in the afternoon and checked the following morning and again in the afternoon.

TABLE 1. Effect of prior *Blarina brevicauda* presence in traps on trap entry by *Microtus pennsylvanicus*. Total number of traps available for capture in parentheses

Grid	Probability of entry into traps with prior <i>Blarina</i> presence	Probability of entry into other traps	Cole's coefficient of interspecific association	χ^2
A	0.13 (87)	0.29 (3468)	-0.562	11.42
B	0.24 (84)	0.41 (2961)	-0.409	9.72
C	0.31 (83)	0.43 (3475)	-0.263	4.36
D	0.40 (76)	0.57 (3246)	-0.302	9.11
E	0.31 (71)	0.42 (1617)	-0.251	3.28
Means and totals	0.27 (401)	0.42 (14,767)	-0.349	37.89
Total chi-square	37.89	df	P	
Pooled chi-square	36.11	5	<0.005	
Heterogeneity chi-square	1.78	1	<0.001	
		4	>0.50	

Following the third check on the next morning, we locked all traps open. During the summer, traps were only set overnight to prevent mortality from the heat. Grids A and B were trapped throughout the winter of 1978–1979; the others were not trapped from October 6, 1978, to June 1, 1979, and from November 2, 1979, to May 27, 1980. Grids A and B were excluded from the analysis of 1980. Grid A was excluded because 150 traps were used in 1980, 2 at every other station, and a record was not kept of which of the 2 traps caught the various species present. Grid B was excluded because only a very small number of *Blarina* were captured on it throughout 1980. Though a variety of experimental procedures were in effect on the grids, the results we obtained were reasonably constant over all grids.

Six small mammal species were caught in the area: *Microtus pennsylvanicus*, *Blarina brevicauda*, *Peromyscus leucopus*, *Mus musculus*, *Sorex cinereus*, and *Zapus hudsonicus*. All rodents were ear-tagged, and on each capture the following data were recorded: tag number, species, trap location, sex, reproductive condition, and weight. On capture of either of the shrews, *Blarina* or *Sorex*, only the location was recorded as they were not tagged and often were dead from their long stay in the trap. The basic analysis involved determining where the various species were captured on each of the checks and how capture history in checks 2 or 3 varied as a function of the species present in checks 1 or 2. For example, the number of *Blarina* captured in check 1 determined the number of traps potentially available in that class in check 2.

Results

Response of *Microtus* to traps previously capturing *Blarina*

To determine whether *Microtus* avoids traps which have previously captured a *Blarina* within the same trapping session, we recorded the location of capture of *Blarina* in the first and second checks, and of *Microtus* in the second and third checks. Traps which captured

Blarina on the third check and other species on checks 2 and 3 were excluded from the analysis.

When the data are pooled for all classes of animals for all grids, *M. pennsylvanicus* had a 15% higher probability of entering a trap which had not previously captured a *Blarina* than one that had (Table 1). All grids showed a significant negative association between the two species (Cole's coefficient of interspecific association = -0.35 (Cole 1949)), though the relationship was not equally strong among them. Therefore, *Microtus* avoided traps previously visited by *Blarina*. However, *Microtus* may simply have avoided *Blarina*-visited traps because these traps contained a novel odour. To determine whether this may be part of the explanation, we performed the following analysis.

Response of *Microtus* to previously empty traps and to traps capturing other species

To understand how *Microtus* responded to traps with differing immediate past histories, we determined the locations of traps that captured other species (not including *Blarina*), *Microtus*, and no one on the first and second checks, and the subsequent locations of capture of *Microtus* on the second and third checks. Since there was no difference in response of *Microtus* to traps that had previously captured *Mus*, *Peromyscus*, or *Zapus* for all the data pooled ($\chi^2 = 1.06$, $df = 2$), these data were combined.

Trap entry by *Microtus* was not independent of the prior occupant, even with *Blarina* excluded from the analysis (Table 2). *Microtus* most readily entered traps which had previously captured a *Microtus* (probability of capture = 0.58), but showed a significant avoidance of traps capturing *Mus*, *Peromyscus*, or *Zapus* (probab-

TABLE 2. Effect of prior presence of various species or of no one on trap entry by *Microtus pennsylvanicus*. Total number of traps available for capture in parentheses. Chi-square contingency test was used to test for independence

Grid	Probability of subsequent trap entry by <i>Microtus</i> into traps previously visited by:				P
	<i>Microtus</i>	<i>Sorex</i>	<i>Mus</i> , <i>Peromyscus</i> , or <i>Zapus</i>	no one	
A	0.50 (1377)	0.42 (12)	0.41 (17)	0.15 (2058)	<0.001
B	0.54 (1594)	0.64 (11)	0.31 (32)	0.24 (1324)	<0.001
C	0.58 (2041)	0.40 (10)	0.31 (83)	0.21 (1322)	<0.001
D	0.70 (2020)	0.67 (12)	0.33 (58)	0.36 (1158)	<0.001
E	0.52 (911)	0.27 (15)	0.20 (55)	0.29 (636)	<0.001
Pooled results	0.58 (7943)	0.47 (60)	0.30 (245)	0.23 (6498)	<0.001

ility of capture = 0.30; $\chi^2 = 81.3$, $P < 0.001$) and traps which had caught no animals in checks 1 and 2 (probability of capture = 0.23; $\chi^2 = 1810.9$, $P < 0.001$). There was no significant difference between the probability of trap entry by *Microtus* into traps previously capturing a *Microtus* and traps previously capturing a *Sorex* (probability of capture = 0.47; $\chi^2 = 2.89$, $P > 0.05$). *Microtus*, therefore, avoided empty traps and all traps with prior occupants which were not *Microtus* or *Sorex*. It could be argued that *Microtus* were simply restricting their activities to sites within their home range and that sites capturing other species or no one did not occur within that range for reasons such as interspecific competition. However, grid E, a removal grid, from which almost all *Microtus* were removed on first capture, also showed the same trends. The *Microtus* which entered the traps on checks 2 or 3 were different from those which entered on check 1, because the latter had been removed. Therefore, *Microtus* showed this avoidance behavior even when they probably had not yet established a home range.

The important question with respect to the possibility of *Blarina* being a significant predator is whether *Microtus* avoided *Blarina*-visited traps more than it avoided other traps. There is no significant difference between the probability of *Microtus* entry into traps previously visited by *Blarina* (0.27, Table 1) and those previously visited by *Mus*, *Peromyscus*, or *Zapus* (0.30, Table 2) ($\chi^2 = 0.39$). However, *Microtus* did avoid traps previously empty more than traps previously catching *Mus*, *Peromyscus*, or *Zapus* ($\chi^2 = 5.43$, $P < 0.05$). Therefore, *Microtus* did not avoid *Blarina*-visited traps more than it avoided *Mus*-, *Peromyscus*-, or *Zapus*-visited traps.

Response of *Blarina* to *Microtus*-visited traps

If *Blarina* are significant predators of *Microtus*, one

might expect them to search for *Microtus* in areas where *Microtus* have recently been. To determine whether *Blarina* preferentially entered traps in which *Microtus* had been caught earlier within the same trapping session, we tallied the presence or absence of *Blarina* for the second and third checks for traps which (a) had not caught anything previously within the trapping session, (b) had caught a *Microtus* previously within the trapping session, and (c) had caught a *Blarina* previously within the trapping session. Traps which caught other species were excluded from the analysis. When the data were pooled, *Blarina* had a significantly higher probability of entering traps previously capturing a *Blarina* (0.130) than those capturing *Microtus* (0.027) or nothing (0.027) (Table 3). The heterogeneity chi-square was significant in this analysis because, although the direction of the differences among the five grids was consistent for the three classes (though grid A was only marginally so), the magnitudes were unequal. Therefore, *Blarina* did not seek out traps recently visited by *Microtus*.

Discussion

Microtus pennsylvanicus should avoid *Blarina brevicauda* and places they frequent if *Blarina* are significant predators. The presence of *Blarina* in a locked trap can readily be detected by humans because of the strong musky odour. We assume that *Microtus* can also smell this odour and that it lingers after the *Blarina* have been removed because of the presence of glandular secretions (Pearson 1946), faeces, and urine. Our study shows that *Microtus* does avoid traps capturing *Blarina*, but no more than it avoids traps visited by *Mus*, *Peromyscus*, or *Zapus*. The latter species are not predators of *Microtus*, but may be competitors (Grant 1972). Eadie (1952) suggested that *Blarina* was a major predator of *Microtus*, but his work involved only the collection and

TABLE 3. Effect of the prior presence of *Blarina brevicauda*, *Microtus pennsylvanicus*, or no one on trap entry by *Blarina*. Total number of traps available for capture in parentheses

Grid	Probability of subsequent <i>Blarina</i> entry into traps previously capturing:			χ^2	df
	<i>Blarina</i>	<i>Microtus</i>	no one		
A	0.048 (84)	0.044 (671)	0.032 (1072)	8.39	2
B	0.135 (111)	0.018 (1418)	0.024 (1028)	56.00	2
C	0.167 (90)	0.039 (811)	0.025 (988)	45.03	2
D	0.133 (75)	0.024 (628)	0.026 (623)	27.86	2
E	0.155 (103)	0.048 (693)	0.026 (1076)	41.03	2
Means and totals	0.130 (463)	0.027 (4221)	0.027 (4787)	178.31	10
Total chi-square	178.31	df		P	
Pooled chi-square	150.54	10		<0.001	
Heterogeneity chi-square	27.77	2		<0.001	
		8		<0.001	

analysis of scats. He could not exclude the possibility that *Blarina* was simply scavenging on dead *Microtus*. Platt (1976), who worked in the same area as Eadie, also suggested that *Blarina* was a significant predator of *Microtus* in winter, especially in his enclosures. However, whereas *Microtus* and *Blarina* densities declined simultaneously inside his enclosures, neither species did so outside them. This suggests that some process other than direct predation may have accounted for the declines. Webster and Brooks (1980) found that at least 5 of 12 (and perhaps up to 8 of 12) *M. pennsylvanicus* with radio transmitters were killed by *Blarina*. However, the transmitter collar may have been responsible for inhibiting movement to some extent, predisposing these voles to predation; voles without radios had higher survival rates during the winter. Although *Blarina* has poisonous salivary glands, extracts of which are able to kill mice, rabbits, and cats (Pearson 1942, 1956), this shrew does not appear to be capable of injecting sufficient quantities of it into the small mammals it bites to cause death (Tomasi 1978). Rather, it appears to rely on its ability to corner and bite its prey to death (Rood 1958; Martinsen 1969; Tomasi 1978). However, voles, when not cornered, can easily outmaneuver a *Blarina* (Martinsen 1969). All this evidence, therefore, suggests that it is unlikely that *Blarina* are serious predators of adult, healthy voles, though they may take them if the opportunity arises. They may, however, be a significant predator of nestling voles (Barbehenn 1958), since this age group cannot escape attack.

The response of *M. pennsylvanicus* to the traps in which various small mammal species were caught in this study may not be different from the response of *M. townsendii* towards clean traps (Boonstra and Krebs 1976). *Microtus townsendii* exhibited a neophobic

response to an item which was totally new and outside the range of normal experience for a vole. Since species such as *Mus*, *Peromyscus*, and *Zapus* were not common during this study the probability that a single vole may have had repeated exposure to them was low. Therefore, *Microtus* avoidance of these species may also be a response to something which is strange and different. This may also be part or all of the explanation for their avoidance of *Blarina*-visited traps. For reasons which are not clear, traps capturing *Sorex* are visited by *Microtus* with about the same probability as traps previously capturing *Microtus*. *Sorex* were extremely rare, relative to the other species captured, and so their odour should have been novel.

It is possible that *Microtus* appeared to be avoiding these other species simply because they have all separated themselves spatially according to microhabitat requirements. Fulk (1972), from a laboratory study, also found that voles avoided places which had shrew odour and avoided the shrew itself. However, from field studies, both Barbehenn (1958) and Fulk (1972) found that there was often a great deal of spatial overlap in the distribution of the two species, indicating that although *Microtus* may avoid direct contact with *Blarina*, they do not occupy mutually exclusive home ranges. We have no evidence that the distributions of the rodent species in the study area were segregated according to habitat preferences. Except for a small part of grid E which was treed and excluded from the analysis, all the rest of the area was a relatively uniform grassland.

The failure of *Blarina* to visit traps in which *Microtus* have recently spent a great deal of time (up to 16 h while they were captured in the trap) also suggests that they do not actively search for *Microtus* as prey items. Although Rood (1958) suggested that *Blarina* has a poor sense of

smell, the evidence of Platt (1976) clearly indicates that they can readily detect the presence of other *Blarina* by odour. It is likely, therefore, that they also have the ability to detect prey by odour but did not choose to in this setting. Getz (1961) found that the distribution of *Blarina* was not dependent on the presence of *Microtus*. The higher probability of *Blarina* entering a trap previously capturing a *Blarina* in our study suggests that these traps simply occurred within the home range of the shrew and were frequently visited by the same individuals.

It is possible that a large population of *Blarina* could significantly depress the population estimates of *Microtus*. However, since the maximum number of *Blarina* caught in this study in a trapping session was 17, and the maximum caught in one check was only 11, it is unlikely to have affected population estimates.

We conclude that *Microtus* avoids the odour of *Blarina*, but probably not because *Blarina* is a significant predator on *Microtus*. Rather, it is because *Microtus* shows a general avoidance of odours which are strange, including traps that have not been recently visited by *Microtus* and, therefore, may not have any vole odour associated with them. More definitive experiments could be performed to determine the impact of *Blarina* on *Microtus* populations either by radioactively tagging *Microtus* and assessing their fate, or by removing *Blarina* from some areas and allowing them to remain on others and following the survival rates of the *Microtus* on the two areas.

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- BARBEHENN, K. R. 1958. Spatial and population relationships between *Microtus* and *Blarina*. *Ecology*, **39**: 293–304.
 BOONSTRA, R., and C. J. KREBS. 1976. The effect of odour on trap response in *Microtus townsendii*. *J. Zool.* **180**: 467–476.

- COLE, L. C. 1949. The measurement of interspecific association. *Ecology*, **30**: 411–424.
 EADIE, W. R. 1952. Shrew predation and vole populations on a localized area. *J. Mammal.* **33**: 185–189.
 FULK, G. W. 1972. The effect of shrews on space utilization of voles. *J. Mammal.* **53**: 461–478.
 GETZ, L. L. 1961. Factors influencing the local distribution of shrews. *Am. Midl. Nat.* **66**: 160–170.
 GRANT, P. R. 1972. Interspecific competition among rodents. *Annu. Rev. Ecol. Syst.* **3**: 79–106.
 HAMILTON, W. J., JR. 1941. The food of small forest animals in eastern United States. *J. Mammal.* **22**: 250–263.
 INGRAM, W. M. 1942. Snail associates of *Blarina brevicauda talpoides* (Say). *J. Mammal.* **23**: 255–258.
 MARTINSEN, D. L. 1969. Energetics and activity patterns of short-tailed shrews (*Blarina*) on restricted diets. *Ecology*, **50**: 505–510.
 MAUER, F. W., JR. 1970. Observation of fighting between a vole and a shrew. *Am. Midl. Nat.* **84**: 549.
 PEARSON, O. P. 1942. On the cause and nature of a poisonous action produced by the bite of a shrew (*Blarina brevicauda*). *J. Mammal.* **23**: 159–166.
 ———. 1946. Scent glands of the short-tailed shrew. *Anat. Rec.* **94**: 615–625.
 ———. 1956. A toxic substance from the salivary glands of a mammal (short-tailed shrew). In *Venoms*. Edited by E. Buckley. Am. Assoc. Adv. Sci. **44**: 55–58.
 PLATT, V. J. 1976. The social organization and territoriality of short-tailed shrew (*Blarina brevicauda*) populations in old-field habitats. *Anim. Behav.* **24**: 305–318.
 RICHMOND, M., and R. STEHN. 1976. Olfaction and reproductive behavior in microtine rodents. In *Mammalian olfaction, reproductive processes and behavior*. Edited by R. L. Doty. Academic Press, New York. pp. 197–217.
 ROOD, J. P. 1958. Habits of the short-tailed shrew in captivity. *J. Mammal.* **39**: 499–507.
 STODDART, D. M. 1974. The role of odour in the social biology of small mammals. In *Pheromones*. Edited by M. C. Birch. North Holland, Amsterdam. pp. 297–315.
 ———. 1976. Effects of the odour of weasels (*Mustela nivalis* L.) on trapped samples of their prey. *Oecologia*, **22**: 439–441.
 ———. 1980. The ecology of vertebrate olfaction. Chapman and Hall, London.
 TOMASI, T. E. 1978. Function of venom in the short-tailed shrew, *Blarina brevicauda*. *J. Mammal.* **59**: 852–854.
 WEBSTER, A. B., and R. J. BROOKS. 1980. Effects of radiotransmitters on the meadow vole, *Microtus pennsylvanicus*. *Can. J. Zool.* **58**: 997–1001.
 WHITAKER, J. O., JR., and R. E. MUMFORD. 1972. Food and ectoparasites of Indiana shrews. *J. Mammal.* **53**: 329–335.