Mammalia (2006): 86–89 © 2006 by Walter de Gruyter • Berlin • New York. DOI 10.1515/MAMM.2006.015

Aggregations of masked shrews (*Sorex cinereus*): density-related mating behavior?

Agrégation de musaraignes masquées (*Sorex cinereus*): accouplement relatif à la densité de la population?

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Abstract

Large aggregations of shrews have been reported and various explanations offered for this seemingly rare behavior; however, there has been little evidence to support any particular interpretation. We observed two small aggregations of highly active vocalizing *Sorex cinereus* while performing wildlife surveys in forested habitats in central Massachusetts, USA. These observations, in conjunction with a review of other reports, including genetic analyses, strongly suggest that such aggregations of adult *Sorex* are associated with mating behavior, more readily observed during periods of high population density. Published accounts of such behavior may be rare because primarily large aggregations have been reported; however, smaller breeding aggregations may be common.

Keywords: breeding groups; Massachusetts; mating behavior; mating chases; *Sorex cinereus*; vocalizations.

Résumé

Diverses explications ont été proposées au comportement grégaire et assez rare des musaraignes. Toutefois, les interprétations y afférentes étaient supportées par très peu de preuves. Nous avons observé deux petits groupes très actifs de musaraignes de l'espèce *Sorex cinereus*, par leur vocalisation, dans un habitat forestier au centre de l'Etat de Masssachusetts aux Etats-Unis d'Amérique. A l'issue de revue de la littérature et de nos analyses génétiques, nos résultats suggèrent que le comportement grégaire des adultes est lié à l'accouplement, période pendant laquelle les densités des populations sont importantes. Ces petits groupes d'accouplement, souvent plus fréquent que les larges agrégations, sont très peu reportés.

Mots cles: accouplement; groupes d'accouplement; Massachusetts; *Sorex cinereus*; vocalisations.

Introduction

Adult Soricidae, especially *Sorex* spp., are usually solitary animals, but large aggregations have occasionally been reported (Barrett-Hamilton and Hinton 1921 and references therein; Ognev 1928; Pitt 1945; Woolfenden 1959; Vispo 1988). Behavioral accounts similarly describe frenzied shrew activity accompanied by high-pitched vocalizations. Various explanations have been offered for such aggregative behavior by shrews, including family groups defending territories (Crowcroft 1957, p. 86), aggressive mating behavior by multiple rutting males over a single female (Barrett-Hamilton and Hinton 1921, p. 103; Ognev 1928, p. 149), joint hunting behavior (Spitzenberger 1978), and prey concentrations during drought (Verme 1958; Vispo 1988); however, there has been little empirical evidence to support any particular interpretation of this behavior.

Here we report two observations of such aggregative behavior by masked shrews *Sorex cinereus*, including morphologic and reproductive data for probable members of one such gathering, the diet of these individuals at the time of their capture, and the relative local abundance of *S. cinereus* during both observations. This species is the most widely distributed shrew in North America (van Zyll de Jong 1999; Whitaker 2004), is often the most abundant shrew (Buckner 1966; Spencer and Pettus 1966; Brooks and Doyle 2001), and is sometimes the most common local mammal (Moore 1949; Whitaker 2004); Yet, little is known about their social behavior. Accordingly, we discuss these and other observations of aggregations in relation to previous interpretations of such shrew behavior, population density, and other reports regarding mating behavior and multiple paternity in shrew litters.

Observations

While performing a small-mammal trapping survey as part of an avian nest predation study in central Massachusetts, USA, 23 July 1997, we closely observed (<2 m; TJM) a small aggregation of vocalizing *S. cinereus*. The animals were rushing above and below leaf litter, over and along rocks and logs, and in one case, jumping off the end of a log and landing more than 30 cm away. This frenzied chase-like activity lasted for over 20 min with only brief intermissions and occurred entirely within a small area (ca. 15 m^2). Shrews were not observed making physical contact with each other or feeding. A maximum of four individuals could be accounted for

simultaneously, although more shrews may have been present at the site.

The following day, 24 July 1997, one male *S. cinereus* was incidentally captured in a snap trap on an operational 20-trap/20-m-diameter trapping grid (set on 22 July 1997; DeGraaf et al. 1999) immediately adjacent (<5 m) to where the aggregation was observed. Three additional *S. cinereus* individuals were captured (two males in snap traps, one female in a Sherman live trap) in the same grid on 25 July 1997 (the third and final day of trapping). Given that no shrews were captured within this trap grid prior to observing the aggregation (i.e., trap-session day #1; 23 July 1997), there is a reasonable chance that those captured were members of this group.

All four *S. cinereus* were reproductively active adults (Table 1) as determined by necropsy and tooth wear (Rudd 1955). The reproductive organs of both sexes were enlarged (Woolfenden 1959; Vispo 1988) and a smear taken from the uterus of the single female revealed the presence of sperm in the uterine horns.

An analysis of the stomach contents of the three snap-trapped male shrews (the live-trapped female, dead on our arrival, had no identifiable stomach contents) revealed that the three guts contained Diptera larvae (one also containing adult Diptera) and Tipulidae larvae, with two guts also containing Arachnidae; no food item predominated.

The site of this observation (42°20′33.6″ N, 72°22′07.9″ W) was within a relatively dry, previously thinned, red oak *Quercus rubra*-white pine *Pinus strobus*-red maple *Acer rubrum* forest-cover type (Eyre 1980) with sparse scattered ground vegetation, exposed rock, and woody debris.

A second small aggregation of vocalizing *S. cinereus* was observed on 14 June 1999, ca. 13 km north (42°27′12.0″ N, 72°21′41.5″ W) of where the first aggregation was observed. Members of this aggregation, estimated to include at least three individuals (N. Perry, personal communication), were briefly observed running over and around a large flat rock at the base of an old stone wall; no specimens were collected. This site was in a more mesic mature forest, similar in composition to that of the first observation but with more ground vegetation. After observing this second aggregation, we noted from two different sets of local, multi-year, small-mammal trapping data that this species was more abundant during the years of both observations than contiguous years by an order of magnitude.

Discussion

Our observations suggest that aggregations of adult *S. cinereus* are associated with mating behavior, as suggested by both Collett (in Barrett-Hamilton and Hinton 1921, p. 103) and Ognev (1928) for similarly behaving groups of adult *S. araneus*. Crowcroft (1957) considered such behavior by an observed aggregation of six to nine individual shrews (taxon not reported, but likely *Sorex*) to be a family's territorial defense against an intruding shrew. Nevertheless, the four *S. cinereus* specimens that we collected were all adults, all reproductively active and of different ages, and thus were unlikely littermates or female parent, as proposed by Crowcroft. Spitzenberger (1978) interpreted such behavior by a group of at least seven vocalizing *S. araneus* as joint hunting behavior, based primarily on observations of occasional quick forward jumps thought to be prey-catching. Nevertheless, *S. araneus* have been observed to repeatedly leap 60 cm during breeding chases (Barrett-Hamilton and Hinton 1921, p. 97), and Spitzenberger (1978) did not observe capture of prey, despite a noted abundance of insects at the site on a warm mid-April day. As such, with all factors considered, Spitzenberger's observation was just as likely that of mating behavior. Vispo (1988) contended that an aggregation of *S. cinereus* observed at a seep during a drought was brought together by a concentration of prey, rather than being motivated by "courtship", based primarily on the predominance of larval sciarids (Diptera) in the stomachs of captured shrews. In contrast, the stomachs of the *S. cinereus* specimens we collected contained various prey types (i.e., none were predominant). Furthermore, all shrews captured by Vispo were reproductively active and mating behavior might be a more parsimonious explanation for his observation, given that all other shrews captured and examined from aggregations have also been reproductively active adults, often including one female (Ognev 1928; Woolfenden 1959; this study). Finally, all reported accounts of aggregative behavior by *Sorex* (genus affirmed or suspected), including Vispo's, have included vocalizations, occasionally with aggressive behavior (Ognev 1928; Crowcroft 1957; Woolfenden 1959; Tuttle 1964; Spitzenberger 1978; this study; but see a description of a small non-vocalizing aggregation by Hieshetter 1972), which is widely associated with mating (Blossom 1932). Other behaviors may cause shrews such as *S. cinereus* to group (e.g., hunting groups, caravan/play); however, such groups have nei-

Table 1 Morphologic and reproductive data for four *Sorex cinereus* captured on an operational trapping grid within 42 h and 5 m of where an aggregative group was observed, 23 July 1997, central Massachusetts, USA.

Museum no.	Sex	Total length (mm)	Tail length (mm)	Hind foot length (mm)	Ear length (mm)	Penis length (mm)	Testes length (mm)	Uterus length (mm)	Uterus width (mm)	Weight (g)	Age (weeks)
UMA 4912	M	95	35	11	6	14	4.5	–	–	4.4	48–54
UMA 4913	M	100	38	12	6	15	5	–	–	4.5	48–54
UMA 4914	M	94	37	12	7	14	4	–	–	4.4	54–60
UMA 4915	F	97	43	11	6	–	–	23	2	4.3	54–60

All specimens were reproductively active adults, as revealed by enlarged testes/uterus and sperm in the uterine horns. Museum numbers are for the Vertebrate Collection, University of Massachusetts-Amherst, USA. Total length includes the tail. Age in weeks is adapted from Rudd (1955).

ther been reported to produce sounds nor to consist solely of adults (Buckner 1970; Goodwin 1979).

Further support for the existence of breeding aggregations may be provided by studies examining the synchrony of estrus in *S. araneus* and concurrent behavior of males, as well as genetic analyses examining multiple paternity commonly observed in litters of this species. Multi-paternal litters of *S. araneus* have been sired, on average, by two to three males (Searle 1990; Tegelström et al. 1991; Stockley 1996). Females, however, may encounter a minimum of five to eight males around their time of estrus (Stockley 1996), as certain breeding males nomadically mate-search over large areas (Shillito 1963; Buckner 1969; Stockley et al. 1994). In addition, depending on mate-searching tactics, successful *S. araneus* males inseminate an average of only one to two females (Stockley et al. 1994). Given the difference between the number of successful versus attendant *S. araneus* males (i.e., low reproductive success), as well as the brevity and reported synchrony of estrus among females, competition among males may tend toward scramble competition, as suggested by Stockley (1996).

Aggregative behavior by soricids may also relate to their population density. We observed small aggregations during periods of relatively high *S. cinereus* abundance, as did Hieshetter (1972). Such observations might simply be attributed to the greater likelihood of observing shrews when populations are at high density (Fowle and Edwards 1955); however, mating behavior may also be affected by population density. For example, shrews from the epicenter of a *S. cinereus* eruption in Manitoba bred precociously, were unusually excitable when trapped, and died more readily in captivity (Buckner 1966) – febrile behavior similar to that exhibited by many other small mammals from high population densities (Lee and McDonald 1985). Changes in mating behavior have also been observed in sciurid aggregations as the number of participants increased (Bakken 1959; Thompson 1977), with individual female eastern gray squirrels *Sciurus carolinensis* attracting up to 34 males during their 1-day asynchronus estrus (Koprowski 1993). If very large aggregations of *Sorex* form during periods of high population density, we might expect such groups to be more readily detected during daylight hours, especially in open cover, given the increased noise more shrews would make and their more "excited state" (Ognev 1928). Nonetheless, the reported existence of very large aggregations of shrews (e.g., 20–40 individuals) is difficult to reconcile with the paucity of reports, common sex ratios, and the brief duration of estrus and its synchrony in certain species of female *Sorex.*

How large may such soricid breeding aggregations become? Aggregations consisting of relatively few shrews often appear larger on initial observance (Crowcroft 1957). In addition, frenzied shrew activity may drive other small mammals, including other species of shrews (Tuttle 1964; Vispo 1988) from oft-shared cover and tunnels, contributing to the illusion of more conspecific participants in an aggregation. Published accounts of *Sorex* aggregations have generally estimated (or inferred) greater numbers of participant shrews (e.g., Woolfenden 1959, 20; Vispo 1988, 30–40) than non-published accounts, for which estimates have ranged from 8 to 24 individuals, with a mode of 12 shrews (J. Auch, G. Feldhamer, J. Foster, J. King, and S. Vessey, personal communications). Thus, very large aggregations of shrews may rarely occur and even more rarely be observed. Small breeding aggregations consisting of one female and two to four males, however, may commonly occur, given the multiple paternity frequently exhibited by shrew litters and the frequent multiple captures of *Sorex* in pitfall traps (Moore 1949; Buckner 1969; Williams and Braun 1983; Dowler et al. 1985; Doyle, unpublished data showing that five of 12 30-m-diameter pitfall arrays, as described in Brooks and Doyle 2001, captured at least one adult female *S. cinereus* with multiple adult males within a single trapping session; numbers of males ranging from two to eight, with a mode of five males per female). Nonetheless, these small breeding aggregations may seldom be observed owing to obstructing cover, the small size of shrews, their predominantly nocturnal epigeal movement (Teferi and Herman 1995), and the ephemeral nature of such activity.

Conclusions

Our observations, in conjunction with other reports, including genetic analyses, strongly suggest that highly active, often vocalizing aggregations of adult *Sorex* – aptly described as a "rush" of shrews – are associated with mating behavior. This behavior may relate to the density of shrew populations; however, aggregations of reproductively-active shrews as large as those observed with certain sciurids may rarely, if ever, occur, whereas small breeding aggregations of shrews may occur frequently, but are seldom observed.

Acknowledgements

We thank S. Vessey and W. Haberl (The Shrew Site) for providing the motivation to publish our observations; J. Auch, G. Feldhamer, J. Foster, J. King, N. Perry, and S. Vessey for their field observations; K. Frafjord of the Tromsø Museum for his assistance with Norwegian literature; and R. DeGraaf, T. French, S. Goodman, R. Hutterer, D. King, J. Merritt, and J. Whitaker Jr. for their comments regarding the manuscript.

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