Data on the long-distance dispersal of Laxmann's shrew (*Sorex caecutiens* Laxmann, 1788) and the pygmy shrew (*Sorex minutus* Linnaeus, 1766)

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Short Report

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Abstract

We studied the long-distance dispersal of two species of shrews – Laxmann's shrew (*Sorex caecutiens*) and the pygmy shrew (*Sorex minutus*). Group marking with bait containing rhodamine B was used. These were the first data obtained on the long-distance movements of the pygmy shrew (n = 5), which extended from 475 m to 2570 m in a straight line. In the course of dispersion, Laxmann's shrews (n = 12) moved distances of up to 4500 m, which is the maximum movement distance known for this species.

Introduction

Dispersal is defined as “circumstances in which individuals leave their existing home ranges and do not return” (Stenseth, Lidicker, 1992). This process can provide animals with several benefits, including empty patch colonization and avoidance of inbreeding (Bowler, Benton, 2005; Clobert et al., 2012). The main determinants of dispersal include the range of movements of the species and its ability to overcome various landscape discontinuities. Many species of small mammals, including murine rodents, are known to be able to travel distances of several kilometres (Allred, Beck, 1963; Clark et al., 1988; Dickman et al., 1995; Jung et al., 2005; Tolkachev, 2016a; Grigorkina, Olenov, 2018). For example, the maximum distance recorded for mouse-sized mammals is 14,730 m (Maier, 2002).

Animals of the family *Soricidae* are among the least studied species in this respect. There are only a few studies that include data on the long-distance movements of shrews (Michielsen, 1966 cit. on Tegelström, Hansson, 1987; Faust et al., 1971; Tegelström, Hansson, 1987; Bol'shakov, Bazhenov, 1988; Shchipanov et al., 2001; Shchipanov, 2007; Shchipanov, Pavlova, 2016). Laxmann's shrew (*Sorex caecutiens* Laxmann, 1788) and the pygmy shrew (*Sorex minutus* Linnaeus, 1766) are among the smallest extant mammalian species. Nevertheless, they have ranges that occupy a significant part of Eurasia (Zaitsev et al., 2014). Given their high reproductive rates and regular local extinctions in the winter, it is incredible that these animals maintain their species unity in such large areas. Long-range dispersal may be one of the key explanatory factors. However, there are very few data on the long-distance movement of Laxmann's shrews and none at all on pygmy shrews. This is primarily due to methodological difficulties in studying dispersal over long distances in small mammals (Bondrup-Nielsen, 1985; Stenseth, Lidicker, 1992; Sutherland et al., 2000; Nathan, 2001; Mohr et al., 2007).

One of the solutions to this problem is the use of group self-marking through bait. This technique allows for the automatic marking of a large number of animals living in or passing through a local area (marking plot) and focuses all efforts on catching marked individuals outside of the area (Lavoie et al., 1971; Szacki, Liro, 1991; Tolkachev, 2016 a, b, Grigorkina, Olenov, 2018;). Rhodamine B (RB) is a non-toxic dye that, when ingested with bait, binds to structures containing keratin, such as hair, vibrissae, and claws (Fisher, 1999). Thus, this biomarker can be successfully used for group marking of animals (Weerakoon et al., 2013; Cooney et al., 2015). The mark is detected by yellow fluorescence under green light. The retention time of the mark in the bodies of mammals is at least several months (up to 1 year). The

possibility of marking shrews with RB was shown previously (Mohr et al., 2007; Tolkachev, 2019). Nevertheless, the long-distance movements of shrews have not been studied using this biomarker.

This paper presents the results of a study of the long-distance dispersal of *S. caecutiens* and *S. minutus*, which was carried out using group marking with rhodamine B.

Materials And Methods

The data presented in this work were obtained within the framework of a long-term (since 1990), ongoing study of small mammal communities inhabiting areas with different levels of industrial pollution (Mukhacheva, 2021; Mukhacheva, Sozontov, 2021). The investigated areas were located in fir-spruce forests near the Middle-Ural Copper Smelter (MUCS, 56°85'N, 59° 90'E).

To assess the long-distance dispersal of these animals, we used a group marking technique with rhodamine B (RB) in June–September 2018–2019. We prepared the bait based on oat flakes according to published guidelines (Tolkachev, Bespamyatnyh, 2019). The RB concentration was 800 mg/kg flakes. Before use, pieces of the bait were sprayed with unrefined sunflower oil. The experimental design included a marking plot where the RB bait was dispensed. The area of the marking plot was $1.5 \cdot 10^4 \text{ m}^2$ in 2018 and $4 \cdot 10^4 \text{ m}^2$ in 2019 (Fig. 1). The pieces of bait were distributed in the nodes of the $5 \times 5 \text{ m}$ grid at a rate of 4 kg per $1 \cdot 10^4 \text{ m}^2$. As shown earlier, this protocol is quite effective (Tolkachev, 2019a). We repeated the marking in dry weather every 10–15 days during the summer (June 1 – August 30).

Three rounds of trapping of small mammals were carried out annually: in June (1st decade), July (2nd decade), and September (3rd decade). For a complete accounting of the animals, different types of traps located at different distances (0–6 km) from the marking plots were used. Fig. 1 shows only the test plots where shrews with RB marks were caught.

Wooden snap traps with hooks (Tolkachev, 2019b) were set in 6 test plots (3 lines in each plot per round). Each line consisted of 25 traps set at 5–7 m intervals and left open for four days with a daily check. The wooden live traps were set in 6 test plots (25 traps at 10 m intervals, set for three days, checked two times a day) during the 2nd round. In addition, we examined shrews that were caught in Barber pitfall traps (15 traps in every test plot, in the nodes of each $10 \times 10 \text{ m}$ grid) during parallel studies of terrestrial invertebrates (2nd round of 2018, 2 test plots; third round of 2019, 6 test plots). In 2019, two long transects were additionally established, including 100 and 170 traps (in an alternating sequence of 4:1 snap traps to live traps), spaced 10 m apart. The traps were set for four days with a single daily check. A total of 240 shrews of two species (*S. caecutiens*, *S. minutus*) were caught: 47 in snap traps, 21 in live traps, and 172 in Barber pitfall traps.

All captured animals were frozen and transported to the laboratory. The shrews were identified to the species level using appropriate identification keys based on exterior features (body weight and lengths of the body, tail, and hindfoot), condylobasal skull length, and toothrow structure. Unfortunately, animal

dissection was not carried out due to the peculiarities of collecting and processing material from the Barber pitfall traps. Therefore, the sex of some animals was unknown.

RB marks were detected according to published procedures (Tolkachev, Bespamyatnyh, 2019; Tolkachev, 2019a). The range of distances at which the shrews with the RB marks could be detected was 0–4500 m. To estimate the distance of the movement of individuals, the minimum distance (with an accuracy of 10 m) from the point of capture to the nearest border of the marking plot was calculated. The calculation was carried out based on data from an eTrex 20 GPS receiver using detailed terrain maps.

Results And Discussion

Laxmann's shrew

Over two years, 158 *S. caecutiens* were captured, including 14 with an RB mark, 12 of which were found outside the marking plot (Table 1). The movement distances ranged from 80 m to 4500 m in a straight line. The movement occurred mainly within one forest area. Nevertheless, all animals had to cross at least one open area – a clearing approximately 20 m wide. Three shrews that covered the most significant distances (point 2, Fig. 1) crossed a river approximately 5 m wide. After that, they could move through the field and along the river's floodplain, which could potentially be a landscape conduit. In the literature, only one study was found describing the spontaneous movement of individuals of this species over long distances (Shchipanov et al., 2001). The maximum dispersal distance was 2500 m in that case. In our study, two animals were found at a distance of 4500 m from the edge of the marking plot. Group marking approach does not allow determining whether the animal had a home range before the start of the movement. Nevertheless, the considerable distance of the movement enabled us to confidently attribute it to dispersal. All the animals were immature, except for one female who moved 4150 m.

Pygmy shrew

A total of 67 *S. minutus* were caught. Most of them were immature yearlings of both sexes. Only five individuals were marked. All of them were caught outside the marking plot (Table 1). An immature male showed the maximum movement, with a distance of 2570 m. As in the case of *S. caecutiens*, all five individuals overcame landscape heterogeneity in the form of a clearing. We did not find data on the movements of individuals of this species outside of their home ranges in the literature. In test plots 4 and 7, only marked animals were captured. If these samples adequately reflect the composition of the population, then points 4 and 7 are located in transit habitats without residents. These were the most unfavourable conditions for this species in terms of the surrounding plants and high levels of pollution of the territory, particularly the soil, forest litter, and food objects of the shrews (Vorobeichik, Kaigorodova, 2017; Bezel et al., 2013).

Declarations

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Compliance with ethical standards

Conflicts of interest. The authors declare that they have no conflicts of interest.

Ethical approval. All applicable international, national, and institutional guidelines for the care and use of animals were followed. In the main experiment, a second marker was used for tagging rodents – tetracycline, which forms a mark only in the growing bone structures of the body (mainly teeth) and cannot be used for marking shrews. In addition, for this study, it was necessary to determine the content of heavy metals in the organs and diet of the animals. The Bioethics Commission of the Institute of Plant and Animal Ecology, Ural Branch, RAS, approved the study (protocol №6 May 18, 2021).

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Tables

Table 1. Discovered cases of long-distance movements of two species of shrews

Year	Test plot	<i>S. caecutiens</i>		<i>S. minutus</i>	
		Trapped*, Ind.	Travelled distances*, m	Trapped*, Ind.	Travelled distances*, m
2018	1	1	-	0	-
	2	0	-	0	-
	3	3 (1)	0 (1)	0	-
	4	0	-	0	-
	5	2 (1)	2900 (1)	8	-
	6	5	-	0	-
	7	0	-	0	-
	8	6 (1)	3300 (1)	0	-
2019	1	1	-	0	-
	2	29 (3)	4150 (1), 4500 (2)	30	-
	3	34 (2)	2500 (1), 2550 (1)	32 (1)	2570 (1)
	4	8 (2)	750 (2)	2 (2)	725 (1), 750 (1)
	5	0	-	0	-
	6	31 (1)	80 (1)	7	-
	7	26 (2)	450 (2)	2 (2)	475 (1), 500 (1)
	8	0	-	0	-
	A	1	-	1	-
	B	11 (1)	0(1)	0	-

* - the number of marked individuals caught at a given point or at a given distance is shown in brackets

Figures

Figure 1

Spatial design of the experiment and the revealed movement directions of *S. caecutiens* and *S. minutus*. I – marking plots in 2018–2019; II, A, B – snap trap transects; III – snap and live trap test plots; IV – pitfall trap plots; V – observed movements of *S. caecutiens*; VI – observed movements of *S. minutus*. Map source: Google Earth