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Arboreal Behavior of the Red-Backed Vole of the Genus *Myodes* (Rodentia, Cricetidae) in the Northern European Taiga

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Abstract—The arboreal activity of small mammals was studied in the foothill taiga of the northern Urals. The research was conducted in August over three years. Each time, 100 traps were placed on the ground, and 50 were located in the surrounding trees at 1.5–2 m above the ground. In total, 279 mammals representing seven species were captured in live traps. Of these, two individuals of the bank vole (*Myodes glareolus*) and 51 individuals of the northern red-backed vole (*M. rutilus*) were recorded in trees. Trees were mostly used by resident animals within their home area. The catchability of voles in trees was significantly related to the density of the species in the ground tier. The use of trees by red-backed voles depended neither on the type of tree nor the thickness of the trunk. The sex-and-age composition of voles registered in trees did not differ from the composition in the ground tier. After a night of rain, the catch of voles in the upper traps increased significantly. The visiting of trees by voles is associated with voles feeding on arboreal lichens.

Keywords: red-backed voles, arboreal behavior, climbing

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INTRODUCTION

The vole genus *Myodes* can actively use trees. This is well known for the European bank vole (*Myodes glareolus* Schreber 1780), which has repeatedly been caught in traps set on trees (Holisova, 1969; Montgomery, 1980; Tattersall and Whitbread, 1994; Buesching et al., 2008; Bobretsov et al., 2019) and has been found in artificial nests and nests of birds (Formozov, 1948; Juškaitis, 1999). In a number of works, the ability of this species to climb was investigated experimentally (Trebatická et al., 2008; Karantanis et al., 2017). The ability to climb is also known for other representatives of this genus, for example, Gupper voles (*M. gapperi* Vigors 1830) were caught at a height of up to 5 m (Getz and Ginsberg, 1968), and Californian bank voles (*M. californicus* Merriam 1890) were recorded at a height of 10.8 m (Swingle, 2005). Red voles (*M. rutilus* Pallas 1779) were also caught on trees at a height of 1.5–2 m in Alaska (Nations and Olson, 2015) and in the Upper Pechora taiga (Bobretsov et al., 2007, 2019); in Eastern Siberia, these voles were recorded on the tops of cedars (Reimers and Voronov, 1963). Although forest voles can visit trees, they do not climb as well and are less common in trees than some other small terrestrial mammal species. In Europe, comparative studies have shown that forest (*Apodemus uralensis* Pallas 1811) and, especially, yellow-throated mice (*A. flavicollis* Melchior 1834) use trees more often (Holisova, 1969; Montgomery, 1980; Buesching et al., 2008) and are better adapted to climbing (Karantanis et al., 2017). In North America, the white-footed hamster (*Peromyscus leucopus* Rafinesque 1818) (Getz and Ginsberg, 1968) climbs trees.

Some works suggest that voles climb trees to escape predators. Indeed, experiments have shown that, in the presence of a weasel (*Mustela nivalis* Linnaeus 1766), bank voles spent more time in the upper layer (Trebatická, 2008). But in nature, only yellow-throated mice were observed, which, when attacked by a weasel, climbed trees, while this behavior was not observed in bank voles (Jędrzejewski et al., 1992). It is believed that the use of the tree layer can reduce the competition between species and, as a result, increase the overlap in the horizontal plane (Lukyanova and Bobretsov, 2008; Albanese et al., 2011). The ability to climb allows access to additional resources, in particular, tree lichens (Nations and Olson, 2015). Lichens occupy a significant place in the diet of forest voles. For example, in the Gapper vole, 90% of the diet consists of fungi and lichens, and lichens are consumed more often in winter (Dubay et al., 2008). Lichens are eaten by bank voles (Formozov, 1948; Ivanter, 1975) and red voles (Vol'pert and Shadrina, 2012; Dokuchaev, 2012; Ivanter and Moiseeva, 2015; Nations and Olson 2015), and in red voles arboreal lichens of the genus *Usnea* can form the basis of food:

Fig. 1. Tree trap.

in 57% of red voles, lichens accounted for more than 70% of the stomach contents (Dokuchaev, 2009).

Thus, although the very fact of the use of trees by forest voles of the genus *Myodes* is known, there are very few works that allow quantitatively assessing the role of the tree layer in the ecology of these species.

MATERIALS AND METHODS

This study was carried out in August for three years on the western macroslope of the Northern Urals in the valley of the Ilych River in the foothill area of the Pechora–Ilych State Natural Biosphere Reserve (62.6° N, 58.9° E), which belongs to the northern taiga of the Kama–Pechora–West Ural dark coniferous forests (Karpenko, 1980). The site is located in a fir–spruce–green moss–forb forest with a significant admixture of cedar.

Trapping was carried out with springless trapeze traps (Shchipanov, 1986), which make it possible to catch the entire complex of small mammal species, including insectivores (Shchipanov et al., 2008). As a bait, we used several grains of oatmeal, moistened with unrefined vegetable oil. On the ground, live traps were placed in a line, with a distance of 7.5 m between the traps. Checks were carried out during daylight hours after 1.5 h, twice in a row, then the traps were left unattended until the next day, accessible to animals (Shchipanov et al., 2000). The counting line on the ground consisted of 100 traps, and the total length was 750 m. A similar live trap was attached to each odd trap on a tree trunk at a height of 1.5–2 m (Fig. 1). Thus, the tree counting line consisted of 50 live traps placed 15 m apart. The trees were checked twice a day, and the traps were not closed.

In total, during the counts, 279 mammals of seven species were recorded, which gave 1127 registrations. The total amount of material is given in Table 1.

The calculation of the density indices of the sedentary population (individuals/ha) when marking on the lines of live traps was carried out according to the previously described method (Kalinin, 2012). The data obtained on the lines are in good agreement with the results of counts over large areas (Kalinin et al., 2018).

Comparison of two independent groups was carried out by the Mann–Whitney test (U, Mann–Whitney U-test), and several independent samples were compared using the Kruskal–Wallis test (H, Kruskal–Wallis test). Paired linear relationships were assessed by Spearman's correlation coefficient (r_s, Spearman rank order correlation). The ratio of the shares was assessed using the Pearson criterion (χ^2, Pearson Chi-square test). The mean is given with the standard deviation (Mean ± SD).

Table 1. Number of individuals of different species recorded at ground level and in trees

View	2005		2006		2007	
	ground	trees	ground	trees	ground	trees
Myodes glareolus	7	2	0	0	0	0
M. rutilus	83	26	99	25	2	0
Microtus agrestis	0	0	1	0	0	0
Sorex araneus	1	0	21	0	20	0
S. caecutiens	3	0	20	0	17	0
S. minutus	1	0	3	0	0	0
S. tundrensis	0	0	1	0	0	0

RESULTS

Over the entire period of the counts, 51 red voles and two bank voles were recorded in traps installed on trees. The catchability of voles on trees with a high reliability is associated with the density of the species calculated from the data of surveys at ground level (Fig. 2), with the Spearman correlation coefficient $r_s = 0.95$, $p = 0.003$. In the years when the abundance was minimal (for the red vole it is 2007, and for the bank vole, 2006 and 2007), forest voles were not observed at all in tree counts. Such a synchronicity in the change in the number of animals on trees and on the ground was also noted by other researchers (Bobretsov et al., 2007; Buesching et al., 2008), while in the habitats of red and bank voles, a clear selectivity was observed in visiting trees by different species. The share of red-backed voles caught on them was higher than on the ground (Lukyanova and Bobretsov, 2008; Bobretsov et al., 2019), which may indicate a greater tendency of red-backed voles to use the upper long-lines.

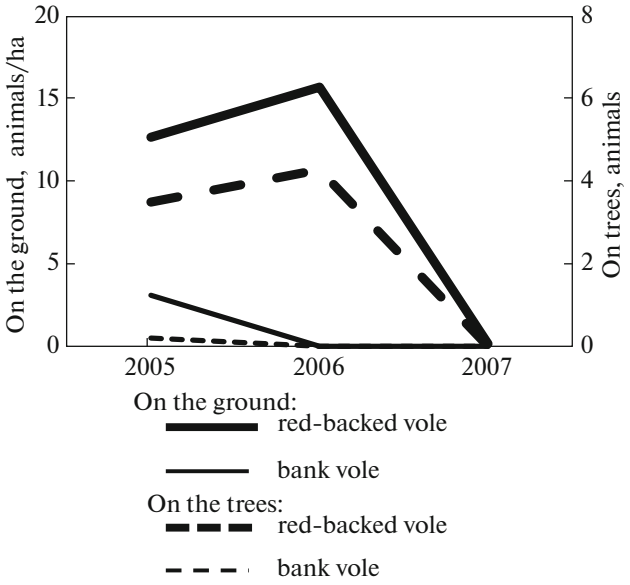

Fig. 2. Density of resident red and bank voles in counts on the ground and number of catches in trees.

When conducting counts in live traps, sedentary animals give repeated registrations, which makes it possible to identify their individual areas. The simplest way to highlight the boundaries of individual areas of animals on the marking lines is to select areas at the extreme points. It should be borne in mind that this method of calculation significantly reduces the real amount of space use by sedentary animals, especially with a small number of registrations (Shchipanov et al., 2000). Most of the voles recorded in the trees were caught either on the territory of their land plots or in the immediate vicinity of them (Fig. 3). It can be assumed that trees are part of the structure of the site and are regularly visited by resident individuals.

With a general low number of bank voles in the area of the counting line and on trees, very few of them were caught. Sufficient material for statistical processing was obtained only for red voles (Table 2). Among the red voles caught in trees, 68.6% of the individuals were also caught on the ground, and most of them (91.4%) gave two or more registrations on the ground, which allows them to be classified as sedentary individuals.

When comparing the samples recorded on the ground and on trees, it was shown that the sex ratio of red voles, assessed by Pearson's test, did not differ in these samples: $\chi^2 = 2.59$, df = 1, $p = 0.11$. Males and females of this species equally use trees; in total, 21 males and 30 females were recorded in the upper traps.

Trees are visited by all age groups of voles. When marked with live traps, three groups can be distinguished with confidence: children (juv), young (sad), and adults (ad). In total, four pups, ten adults and 37 juveniles of the red-backed vole were recorded on the trees, which does not differ in composition from those caught at ground level: $\chi^2 = 2.85$, df = 2, $p = 0.24$.

In the upper tier, traps were set on various tree species (spruce, fir, birch) with a trunk diameter of 8–35 cm. The use of trees by the red backed vole, assessed by the total number of records, did not depend on the tree

Table 2. Number of red-backed voles marked at ground level and in trees

Year	On ground		In trees			
	total individuals	with two or more captures	total individuals	on ground	of these, on the ground with two or more captures	only in trees
2005	83	52	26	22	21	4
2006	99	60	25	13	11	12
2007	2	1	0	0	0	0
Total	184	113	51	35	32	16

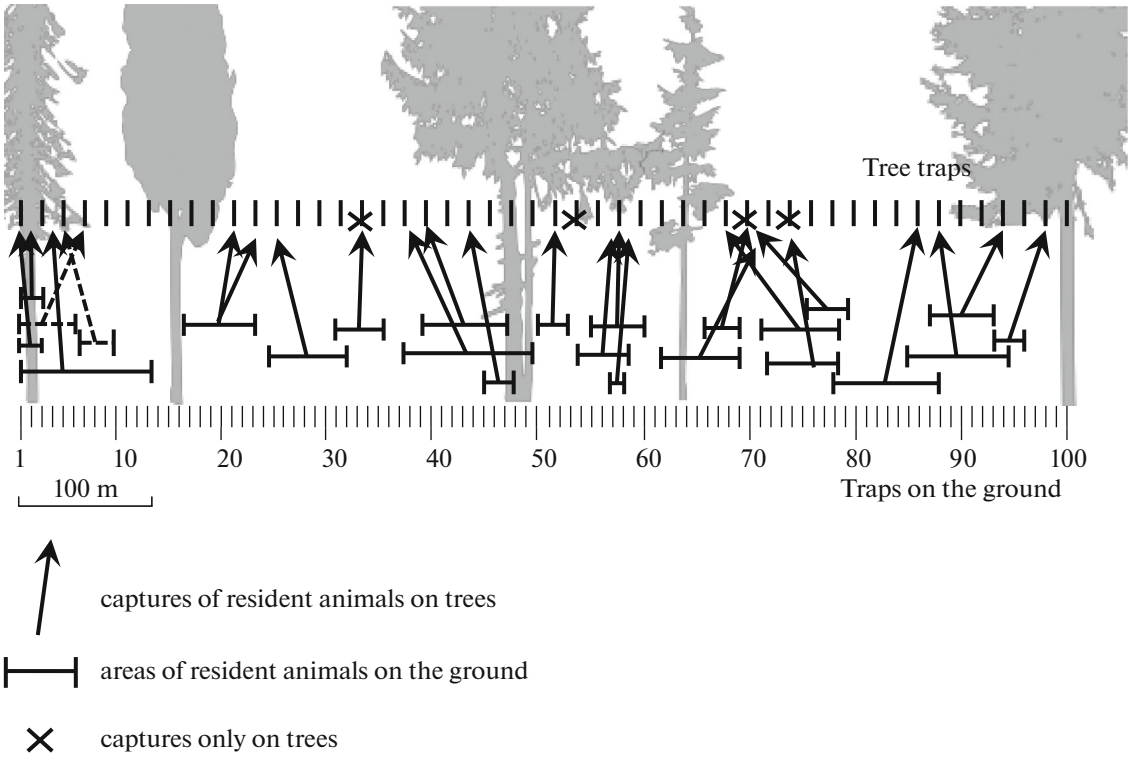

Fig. 3. Individual areas of red (solid line) and bank (dotted) voles on the ground and their visits to trees in 2005.

species (Kruskal–Wallis criterion $H = 1.59$, $N = 50$, $p = 0.45$), nor on the thickness of the trunk (Spearman's correlation coefficient $r_s = 0.05$, $p = 0.75$).

The efficiency of counts with top traps was significantly influenced by the weather. In the presence of night rain, the catchability of voles in the upper traps increased significantly. We used the data only for 2005 and 2006, when there were catches in the upper traps. On rainy nights ($n = 6$) the catch rate was 8.33 ± 3.6 catches per day for 50 traps, and from dry nights ($n = 11$) 1.54 ± 1.7. The differences in the Mann–Whitney test are significant $U = 3.12$, $p = 0.002$. It should be noted that an increase in the activity of voles in the tree layer is not associated with an increase in overall activity. On the same days, the number of registrations of voles on the ground did not differ (34.4 ± 5.9 and 37.9 ± 10.7 registrations per 100 traps, respectively).

DISCUSSION

Thus, forest voles, in particular the red vole, can actively use the upper tiers of the forest, climbing up tree trunks. In some cases, voles can make shelters in trees, including using bird nests or artificial nests (Formozov, 1948; Juškaitis, 1999). Voles visit various tree species, with all age and sex groups recorded in the upper layer. Apparently, the use of trees is associated with an abundance of woody lichens, including the genus *Usnea,* which are widespread in the region. Lichens are one of the main components of the winter food of red voles, although they are eaten by them in other seasons as well (Dokuchaev, 2009; Nations and Olson, 2015). In this case, both bank and red voles can store lichens in the form of neatly twisted balls (Formozov, 1948; Dokuchaev, 2012). Red voles were repeatedly observed feeding on lichens on tree trunks at a height of 0.3–2 m in early spring and winter, or traces of such activity were encountered (Bobretsov et al., 2004, 2019). The pronounced lichenophagy of forest voles leads to their active use of trees in the presence of a significant number of lichens on them. The increase in vole activity on trees after rain may be associated with an increase in the attractiveness of waterlogged lichens as a food item.

When conducting tree counts, we did not register any other species of small mammals, except for forest voles. Some studies indicate the presence of shrews in the arboreal layer (Atkins et al., 2018), usually, the lesser shrew (*Sorex minutus* L. 1766) (Holisova, 1969; Juškaitis, 1999; Stepánková and Vohralík, 2009). We also observed in Tver oblast a young of the year of the lesser shrew, which, after being released from the live-catcher, went to the pine trunk, freely moved along the trunk, examined the cracks in the bark, found and ate the imago of a mosquito (family Tipulidae), and within ten minutes climbed to a height of 5 m, where it

was lost from sight. The middle shrew (*Sorex caecutiens* Laxmann 1788) was observed in small numbers during catches on trees in the foothill taiga of the Northern Urals (Bobretsov et al., 2019). In this experiment, 87 individuals of four species of shrews were registered in land surveys, but they were not recorded on trees.

The use of trees by terrestrial small mammals, in particular forest voles, may have regional characteristics. In red voles, feeding on tree lichens is mainly significant for the northern regions, especially in the Arctic (Dokuchaev, 2009). These regions are characterized by abundant overgrowth of trees with epiphytic lichens, and it is here that the highest arboreal activity of red voles can be expected.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest. The author declares that he has no conflict of interest.

Statement on the welfare of animals. All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

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