THE SPECIES COMPOSITION AND ABUNDANCE OF TERRESTRIAL SMALL MAMMALS IN THE FINNISH-RUSSIAN FRIENDSHIP NATURE RESERVE

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The Finnish-Russian Friendship Nature Reserve is a relatively undisturbed area, where human influence on ecosystems is small. Research here is particularly important as this area is a highly vulnerable northern forest land and an essential element of the Green Belt of Fennoscandia. Small mammals are often used as model objects in studies of a great variety of ecological issues. Generalised data are provided on the species composition and abundance of small mammals encountered in model areas in the Finnish-Russian Friendship Nature Reserve during specialised surveys in 1995–2003. Activities on the Finnish side were carried out in the Elimyssalo Nature Reserve, featuring virgin coniferous forests and numerous small mires and streams, and in the Ulvinsalo Strict Nature Reserve, which also contains undisturbed coniferous forest areas, wetlands and small rivers, and falls under strict protection regulations. On the Russian side, research was done in the Kostomuksha State Nature Reserve: along the phenological route and in the Kalivo locality. The first area was monitored on a long-term basis for environmental changes, which was somewhat disturbed by infrastructural developments in the Kostomuksha District, in the Kalivo locality, mostly occupied by undisturbed native coniferous forests. We found that the small mammal populations are typical for north-boreal Fennoscandia. The number of species encountered in the areas over the study period is however significantly lower than in Finland or Karelia. This suggests that the study area has been understudied. A comparison of the species composition and abundance of small mammals among the models areas showed that the universal dominants were *Sorex araneus* and *Myodes glareolus,* while the presence of other species in the samples varied. The analysis of variations in the mammal abundance revealed a spatial synchronisation of fluctuations in some pairs of the model areas for dominant species, while all other species demonstrated various degrees of agreement in abundance variations. In addition, a temporal synchronisation of abundance fluctuations of some species was registered on each studied site. The studies on the species composition and abundance of small mammals in the Finnish-Russian Friendship Nature Reserve need to be extended both by continuing the time series of surveys and by implementing specialised activities to study the environmental factors influencing this mammal group.

Key words: abundance, dominants, insectivores, population dynamics, rodents, spatial and temporal synchronisation

Introduction

The role of small mammals (Micromammalia), as a crucial component of natural ecosystems often decisive for their formation and stability has been repeatedly emphasised previously. They are often used as model research objects of a great variety of ecological issues from effects of their abundance on the population size of predators (Koprimäki & Norrdahl, 1991; Samelius et al., 2011; Sundell et al., 2013; Korpela et al., 2014) up to indicating ecosystem integrity disturbance (Ivanter & Korosov, 1998; Diekmail, 1999; Pearce & Venier, 2005; Leis et al., 2008; Haapakoski & Ylönen, 2010). The significance of this animal group is especially high in tundra and north-boreal ecosystems (Batzli, 1975; Hanski et al., 2001; Ims & Fuglei, 2005; Krebs et al., 2011; Bobretsov, 2016; Ivanter, 2017).

Unfailing interests to scientists are the population size cycles in small mammals and the factors behind them (Kalela, 1962; Lidicker, 1988; Krebs, 1996; Zhigalskii, 2002; Boonstra & Krebs, 2012; Zub et al., 2012; Ivanter et al., 2015; Ivanter, 2018). Other issues of relevance concern temporal and spatial contingency between the sizes of cyclic small mammal populations (Henttonen et al., 1977; Mackin-Rogalska & Nabaglo, 1990; Henttonen & Hansson, 1993; Erlinge et al., 1999; Krebs et al., 2002; Koprimäki et al., 2004).

The principal factor for the species composition and abundance of small mammals is the habitat conditions. The connection of these animals to specific habitats is very stable (Peterson et al., 1999), and their conservatism in the choice of habitats is thought to be one of their ecological adaptations (Bashenina, 1977). They are among the first to respond to any habitat alterations. It is therefore even more important to study the characteristics of the composition and abundance, as well as the habitat distribution of certain small mammal species both in disturbed and in intact (protected) areas as reference habitats. Our study area included the Finnish-

Russian Friendship Nature Reserve. It is a relatively undisturbed area, where human influence on ecosystems is minimal. Research conducted here is particularly important because this area is a highly vulnerable north-taiga forest land and an essential element of the Green Belt of Fennoscandia.

The first studies of small mammals in the Finnish-Russian Friendship Nature Reserve were implemented in 1994. In the Finnish part of the Finnish-Russian Friendship Nature Reserve, surveys were carried out in the Elimyssalo Nature Reserve, the largest one among the conservation areas, harbouring virgin coniferous forests and lots of small mires and streams. The second one is the Ulvinsalo Strict Nature Reserve, which also contains undisturbed coniferous forest areas, wetlands and small rivers, and falls under strict protection regulations. On the Russian side, studies were carried out along the phenological route and in the Kalivo locality in the Kostomuksha State Nature Reserve. The first area was somewhat damaged by infrastructural developments in the Kostomuksha District, the Kalivo locality, mainly covered by intact natural coniferous forests. The results of the conducted counts have remained only in research reports included into «Nature Chronicles», while primary data have been lost unfortunately.

This study was aimed to analyse data from these surveys as well as other archived and published data of relevance for the small mammal studies in the Finnish-Russian Friendship Nature Reserve, and to compile the species list for this animal group, providing abundance data for certain species.

Material and Methods

Study site

The Finnish-Russian Friendship Nature Reserve was founded to facilitate the preservation and study of the natural environment in the borderlands. It encompasses (Fig. 1) Kostomuksha State Nature Reserve (490 km^2) on the Russian side, and five Protected Areas on the Finnish side, including Juortanansalo-Lapinsuo Mire Reserve (38 km^2), Iso-Paolonen and Maariansärkät Nature Reserve (36 km^2), Lentua Nature Reserve (51 km^2), Elimyssalo Nature Reserve (73 km^2) and Ulvinsalo Strict Nature Reserve (25 km^2). Basically, the nature on both sides of the Russia-Finland border is similar. The study area belongs to the Fennoscandian Archaean bedrock area with gently undulating terrain, formed by several glaciations during the last two million years. Nowadays the intact nature on the Finnish side is very fragmented due to intensive forest logging and mire ditching. On the Russian side there are still very large areas of more or less intact forest, mires and lakes, while on the other hand, there are also large-scale industry and large clear-cut areas in the forests. The Finnish-Russian Friendship Nature Reserve offers a globally unique and extremely interesting research field of biodiversity and human impact on it. It is also an important part of the Fennoscandian Green Belt concept (Heikkilä & Lindholm, 2009). Small mammal counts were carried out in 1995–2003 by S.A. Pozdnyakov in the Kostomuksha State Nature Reserve in four model areas within the Finnish-Russian Friendship Nature Reserve (Fig. 1), including i) Kalivo locality, ii) phenological route in the Kostomuksha State Nature Reserve, iii) Elimyssalo Nature Reserve, and iv) Ulvinsalo Strict Nature Reserve. On each of the sites, their most typical (reference) habitats were chosen as animal sampling locations.

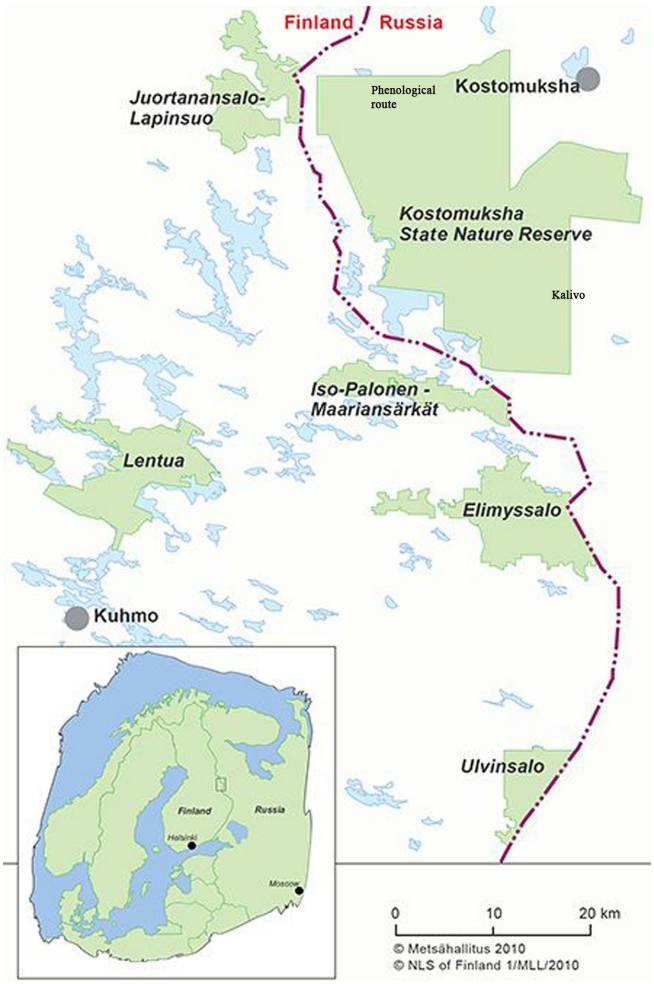

Fig. 1. Location of the study sites in the Finnish-Russian Friendship Nature Reserve according to www.nationalparks.fi/friendshippark with amendments.

Kostomuksha State Nature Reserve is one of the largest Protected Areas in the Republic of Karelia, Northwest Russia. It lies in the northwest of the Republic of Karelia, near the Russian-Finnish border. The Protected Area has a composite broken terrain, but most of that is poorly drained. Over 95% of its area is occupied by two most typical north-taiga landscapes, represented by highly and moderately paludified pine-dominated landscapes (Gromtsev et al., 1997). In the study area, north-taiga forests cover about 300 km^2, i.e. over 60% of the territory, and have remained virtually undisturbed by human activity. Over 80% of all forest stands are mature and over-mature ones. Pine (*Pinus sylvestris* L.) forests predominate (almost 84% of the forested area), while spruce (*Picea abies* (L.) H. Karsten) forests are rarer (16%, at the foothills and in depressions between ridges). The proportion of secondary small-leaved forests is negligible (less than 0.5%). Mires occupy about 20% of the study area (Belousova et al., 1988; Gromtsev & Shelekhov, 1997). The phenological route passes through an area modified somewhat during the design and construction of the Kostomuksha State Nature Reserve's infrastructure and the road to the Russia-Finland border. In addition to coniferous forests, other forest types are secondary, represented by post-felling mixed forests and overgrowing meadows occupying abandoned human settlements. Kalivo locality differs from the phenological route by a solid area of primary coniferous forests (primarily pine ones), while the proportion of mixed forests is small.

Elimyssalo Nature Reserve is located near Finland's eastern border. It forms a central part of the Finnish-Russian Friendship Nature Reserve and features diverse rock types and habitats. This is dominated by mires, old-growth spruce forests (90% of its forest stand is older than 120 years, sometimes the age of trees is 200 years), woodlands and pine swamps, fens, small lakes and rivers (Leinonen et al., 1997; Heikkilä & Lindholm, 2009; Boychuk et al., 2017). The area of Ulvinsalo Strict Nature Reserve is composed of microcline granite and occupied by old-growth forest (old spruce forests dominate), various mires, small rivers and streams. This Protected Area is closed for visitors, apart from researchers with legal permissions (Leinonen et al., 1997; Heikkilä & Lindholm, 2009; Boychuk et al., 2017).

Small mammal sampling

In the study area, small mammals were captured in the summer and autumn of 1995–2003 by standard snap trap line and pitfall methods (Karaseva et al., 2008). Snap traps (with dimensions 13 × 6.5 cm) were arranged in lines of 25 traps each, with 4–5-m spacing between traps. Trap lines covered all of the studied habitats during all study years. At each trapping session, all habitat types were sampled. However, no records of the exact co-ordinates and names of habitats where trap lines were deployed have been preserved. Pitfalls were established occasionally. The obtained data were used in relation to species diversity. For orders of insectivores (Eylipotyphla) and rodents (Rodentia), the scientific names of species are given according to Lissovsky et al. (2019).

Data analysis

Species abundance was determined using data from snap trap lines. Data collected by pitfall trapping were used only to study the species diversity, since not all small mammal species can be captured by regular traps. The measure of abundance (*I*) is the number of animals captured over 24 h of operation in 100 snap traps, expressed as individuals per 100 trap days (hereinafter – ind. per 100 t/d):

$$I = \frac{a \times 100}{b \times c},$$

where *a* is the number of animals captured during the total number of trapping days; *b* is the total number of traps; *c* is the number of trapping days. The spatial and temporal contingency of small mammal abundance in the model areas was analysed using Spearman's rank correlations in Statgraphics for Windows 2.1.

Results

Species composition and abundance parameters of small mammals in the Finnish-Russian Friendship Nature Reserve

Over all the years of sampling in the Finnish-Russian Friendship Nature Reserve's model areas, ten small mammal species have been encountered (Table 1). Five of them belong to the insectivorous order Eylipotyphla (*Sorex araneus* Linnaeus, 1758, *S. caecutiens* Laxmann, 1924, *S. minutus* Linnaeus, 1766, *S. isodon* Turov, 1924, *Neomys fodiens* Pennant, 1971) and five to the order Rodentia (*Myodes glareolus* Schreber, 1780, *Craseomys rufocanus* Sundevall, 1846, *Agricola agrestis* Linnaeus, 1761, *Alexandromys oeconomus* Pallas, 1776; *Myopus schisticolor* Lilljeborg, 1844). Like anywhere in Eastern Fennoscandia, the dominants in the small mammal fauna were *Sorex araneus* and *Myodes glareolus*. The prevalence and abundance of the species spotted in the model areas

varied; sampling results are shown in Table 1. During later surveys in 2007, *Micromus minutus* Pallas, 1771 was trapped in the Finnish-Russian Friendship Nature Reserve, but outside of our model areas (Bugmyrin et al., 2008).

In the Elimyssalo Nature Reserve, all of the ten species were encountered. However, only *Sorex araneus* and *Myodes glareolus* occurred annually, and *Agricola agrestis* and *Myopus schisticolor* almost annually (except for one or two years). The samples contained *Sorex isodon*, a rare species listed in the Red Data Book of the Republic of Karelia (2007). In this area, dominants were *Myodes glareolus* (species abundance varied from 0.0 ind. per 100 t/d to 12.2 ind. per 100 t/d) and *Agricola agrestis* (species abundance varied from 0.0 ind. per 100 t/d to 7.1 ind. per 100 t/d). *Sorex araneus* was co-dominant. Its abundance varied from 0.36 ind. per 100 t/d to 2.63 ind. per 100 t/d. The rest of the studied species were scarce or skipped years.

In the Ulvinsalo Strict Nature Reserve, small mammal counts were conducted only over a short period of time, i.e. from 1999 to 2003 (except 2001). Eight small mammal species were recorded over this period, five of which belong to the order Eylipotyphla (*Sorex araneus*, *S. caecutiens, S. minutus, S. isodon*, and *Neomys fodiens*), and three represent the order Rodentia (*Myodes glareolus*, *Agricola agrestis* and *Myopus schisticolor*). The dominant species was *Myodes glareolus*, which abundance varied from 0.67 ind. per 100 t/d to 17.2 ind. per 100 t/d over the study period. The rest of the found species were either rather scant (*Sorex araneus*, *Myopus schisticolor*), or occurred not every year. Samples from this period did not contain *Myodes rutilus* Pallas, 1779, which is common in some other parts of the Finnish-Russian Friendship Nature Reserve. This can be explained by a more southern location of the Ulvinsalo Strict Nature Reserve compared to other areas surveyed.

Table 1. Abundance (individuals per 100 trap days) of small mammal species in the Finnish-Russian Friendship Nature Reserve's model areas

Year	Model area	*Sorex araneus*	*Sorex caecutiens*	*Sorex minutus*	*Sorex isodon*	*Neomys fodiens*	*Myodes glareolus*	*Craseomys rufocanus*	*Agricola agrestis*	*Alexandromys oeconomus*	*Myopus schisticolor*
1995	Kostomuksha State Nature Reserve	+	+	+	+	+	+	+	+	+	+
	Elimyssalo Nature Reserve	+	–	–	+	+	+	–	+	+	+
1996	Phenological route	0.6	–	–	–	0.05	8.6	0.1	1	0.05	0.8
	Kalivo	1.7	0.2	0.25	–	–	12.6	0.4	0.3	–	0.5
	Elimyssalo Nature Reserve	1.0	0.4	–	–	–	9.9	–	7.1	0.4	3.0
1997	Phenological route	0.74	0.1	0.06	0.1	0.06	3.74	–	0.26	–	0.4
	Kalivo	0.29	0.2	0.07	–	–	6.71	–	0	–	1.1
	Elimyssalo Nature Reserve	0.36	–	–	–	–	3.37	–	1.27	–	0.9
1998	Phenological route	0.86	0.36	–	–	–	1.43	–	0.21	–	–
	Kalivo	0.73	0.29	0.4	–	–	0.43	–	0	–	–
	Elimyssalo Nature Reserve	1.4	0.07	–	–	–	3.5	–	0.5	–	–
1999	Phenological route	2.73	0.7	0.13	0.25	0.06	8.25	0.06	2.29	–	0.06
	Kalivo	2.29	0.5	0.13	–	0.06	5.97	–	0.7	–	–
	Elimyssalo Nature Reserve	2.63	0.1	–	–	0.17	12.2	–	3.66	–	0.06
	Ulvinsalo Strict Nature Reserve	2.0	2.0	–	0.22	0	16.4	–	–	–	0.89
2000	Phenological route	0.9	0.2	0.1	0.13	0.06	10.3	0.13	3.8	0.25	0.8
	Kalivo	0.8	–	0.1	–	–	14.0	0.06	1.7	–	–
	Elimyssalo Nature Reserve	0.6	–	0	–	0.19	7.4	0.25	1.3	–	1.1
	Ulvinsalo Strict Nature Reserve	0.4	–	0.1	–	0.27	17.2		0.3	–	0.7
2001	Phenological route	0.63	0.2	0	0	0.13	2.9	–	0.51	–	0.19
	Kalivo	1.97	0.2	0.06	0	0.06	7.0	0.06	0.83	–	0.83
	Elimyssalo Nature Reserve	2.29	0.1	0.19	0.25	0.13	3.7	–	0.83	0.06	0.76
2002	Phenological route	5.14	0.57	0.38	0	0.19	1.52	–	1.14	–	–
	Kalivo	5.33	0.19	0.57	0.19	–	0.19	–	–	–	–
	Elimyssalo Nature Reserve	1.71	–	0.19	0.1	–	0	–	–	–	–
	Ulvinsalo Strict Nature Reserve	0.89	0.22	–	0.22	–	0.67	–	–	–	–
2003	Phenological route	0.95	0.19	–	–	–	1.9	–	0.76	–	–
	Kalivo	0.19	0.19	–	–	–	2.1	–	–	–	–
	Elimyssalo Nature Reserve	0.95	–	–	–	–	3.24	–	0.76	–	0.38
	Ulvinsalo Strict Nature Reserve	0.67	–	–	–	–	2.22	–	–	–	0.22

Note: «+» – the species is present in the samples, «–» – the species is absent in the samples

Surveys of the phenological route in the Kostomuksha State Nature Reserve during small mammal surveys in the Finnish-Russian Friendship Nature Reserve (1995–2003) yielded records of all the ten species. The dominated species were *Sorex araneus* (0.6 ind. per 100 t/d to 5.14 ind. per 100 t/d) and *Myodes glareolus* (1.43 ind. per 100 t/d to 10.3 ind. per 100 t/d). The co-dominants were *S. caecutiens* (0.1 ind. per 100 t/d to 1.1 ind. per 100 t/d) and *Agricola agrestis* (0.1 ind. per 100 t/d to 3.8 ind. per 100 t/d), while the rest species occurred not every year and with lower abundance. Yet, according to the studies conducted here by the Kostomuksha State Nature Reserve researchers in another period (1985–2019), the small mammal species composition became wider in the phenological route. In particular, *Sorex minutissimus* Zimmermann, 1780 and *Myodes rutilus* Pallas, 1779 (Sikkilya, 2014; Yakimova, 2020) were additionally found, as they were not captured previously by researchers surveying the Finnish-Russian Friendship Nature Reserve.

Small mammals found in samples from the Kalivo locality during the study years in the Finnish-Russian Friendship Nature Reserve belong to nine species. Five of them are insectivores (*Sorex araneus*, *S. caecutiens, S. minutus, S. isodon*, and *Neomys fodiens*) and four belong to the order Rodentia (*Myodes glareolus*, *Craseomys rufocanus*, *Agricola agrestis*, and *Myopus schisticolor*). Here, the dominants were again *Sorex araneus* (species abundance varied from 0.29 ind. per 100 t/d to 5.33 ind. per 100 t/d) and *Myodes glareolus* (0.19 ind. per 100 t/d to 12.6 ind. per 100 t/d). The annually encountered *S. caecutiens* and *S. minutus* were not numerous, as during the study period their maximal abundance was 0.5 ind. per 100 t/d and 0.57 ind. per 100 t/d, respectively. The rest of the small mammal species were not found annually and with low abundance values. In our study, we did not sample *Alexandromys oeconomus*, which was reported from this area before and after the study period (Sikkilya, 2014; Yakimova, 2020).

Abundance dynamics of small mammals

By examining the sampling results across time, we may see some spatial synchrony in abundance fluctuations in some species in all the studied model areas (Fig. 2). Thus, the usual dominants *Sorex araneus* (in Elimyssalo Nature Reserve and in Kalivo) and *Myodes glareolus* (in Kalivo and in the phenological route) in the study period showed a common pattern of abundance dynamics, where the Spearman rank correlation was r = 0.7619 (p = 0.0438) and r = 0.8810 (p = 0.0198), respectively. The co-dominants *S. caecutiens*, *Agricola agrestis* and *Myopus schisticolor* also demonstrated some similarity in their abundance variations, while only *Myopus schisticolor* (in Elimyssalo Nature Reserve and in the phenological route) had a significant Spearman rank correlation (r = 0.9262, p = 0.0143). Across the Finnish-Russian Friendship Nature Reserve's model areas in the study period, various degrees of similarity in abundance were found for the rest of the species (scant and skipping years), although no significant Spearman rank correlation was found. For *S. minutus,* a common pattern of abundance variation was observed from 1999 to 2003 only. For *S. isodon*, the common feature in all model areas was an abrupt change of species abundance, from absence in the samples to high levels. Interestingly, population phases almost fully matched with a two-year lag between the Elimyssalo Nature Reserve and the phenological route. For *Neomys fodiens* and *Alexandromys oeconomus*, missing in the samples in some years, no common patterns were found in the abundance dynamics in different model areas. *Craseomys rufocanus*, was however absent in some study years, exhibited a marked agreement in abundance dynamics, with population abundance increases and declines in all model areas in the same years.

Additionally, we observed some temporal synchrony in abundance fluctuations for some species in all studied model areas. Some of the species pairs showed a common pattern of abundance dynamics in the study period (Table 2, Fig. 3). However, these results require further special analysis.

Discussion

Species composition and abundance parameters of small mammals

The distribution and abundance of animals in each specific area depend on their ecological demands and certain habitat conditions including, first of all, food and shelter, predators and competitors. The conditions in various habitats vary substantially even along the same geographic latitude. The combinations of different factors also vary, and urge the animals to adopt various models of the territory use (Rosenzweig, 1991; Morris, 1996). As a consequence, the species composition and abundance of small mammals vary among habitats (Rosenzweig, 1981; Ivanter,

2018). Protected Areas are more homogenous in terms of habitat diversity. Their forest composition inside is more uniform and the proportion of secondary forest formations is smaller, hence the rodent fauna is more stable owing to a similarity of habitat conditions all over the study area. On the other hand, this is also the reason for the small mammal species diversity being usually lower than in areas affected by past or ongoing disturbance factors, which affect a higher variety or mosaics of habitats and, hence, of living conditions for the animals.

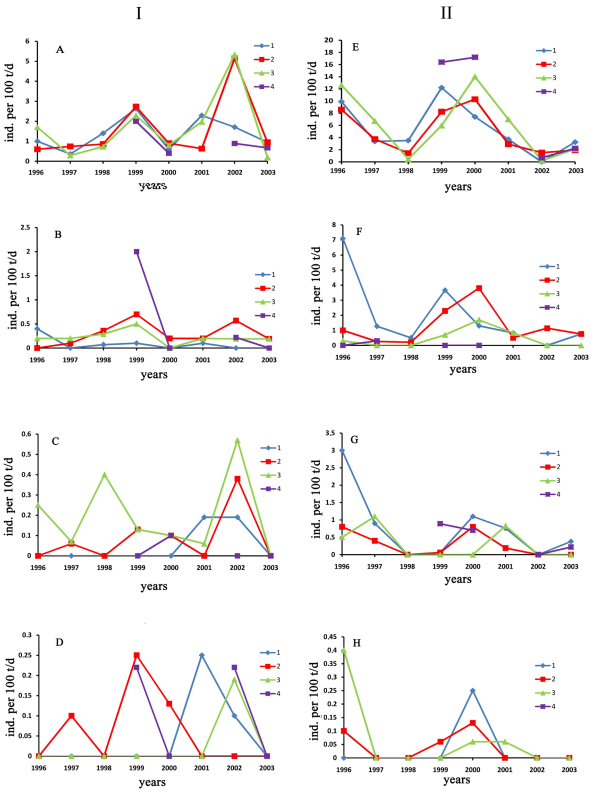

Fig. 2. Small mammal abundance (individuals per 100 trap days – ind. per 100 t/d) dynamics in the Finnish-Russian Friendship Nature Reserve. Designations: I – order Eulipotyphla: A – *Sorex araneus*, B – *S. caecutiens*, C – *S. minutus*, D – *S. isodon*; II – order Rodentia: E – *Myodes glareolus*, F – *Agricola agrestis*, G – *Myopus schisticolor*, H – *Craseomys rufocanus*; The studied model areas: 1 – Elimyssalo Nature Reserve, 2 – phenological route, 3 – Kalivo, 4 – Ulvinsalo Strict Nature Reserve.

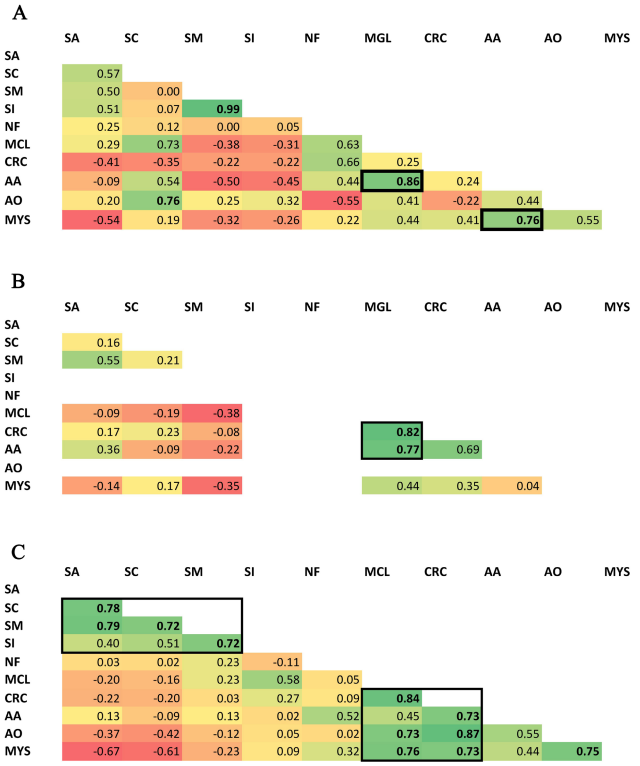

Fig. 3. Temporal synchrony in abundance fluctuations of small mammals in the Finnish-Russian Friendship Nature Reserve (confident Spearman rank correlation (r) values are in bold; clusters of similar small mammal species are framed). Designations: Protected Areas: A – Elimyssalo Nature Reserve; B – Kalivo; C – Phenological route. Species: SA – *Sorex araneus*, SC – *S. caecutiens*, SM – *S. minutes*, SI – *S. isodon*, NF – *Neomys fodiens*, MCL – *Myodes glareolus*, CRC – *Craseomys rufocanus*, AA – *Agricola agrestis*, AO – *Alexandromys oeconomus*, MYS – *Myopus schisticolor*.

Table 2. Temporal synchrony in abundance fluctuations of small mammals in the Finnish-Russian Friendship Nature Reserve

Model area	Species pair	r	p
Elimyssalo Nature Reserve	*Myodes glareolus – Agricola agrestis*	0.8571	0.0233
	Agricola agrestis – Myopus schisticolor	0.7546	0.0459
	Alexandromys oeconomus – Sorex caecutiens	0.7608	0.0441
	Sorex isodon – Sorex minutus	0.9897	0.0088
Kalivo	*Myodes glareolus – Craseomys rufocanus*	0.8248	0.0291
	Myodes glareolus – Agricola agrestis	0.7737	0.0407
Phenological route	*Myodes glareolus – Craseomys rufocanus*	0.8416	0.0173
	Myodes glareolus – Alexandromys oeconomus	0.7303	0.0389
	Myodes glareolus – Myopus schisticolor	0.7607	0.0314
	Craseomys rufocanus – Agricola agrestis	0.7327	0.0382
	Craseomys rufocanus – Alexandromys oeconomus	0.8677	0.0141
	Craseomys rufocanus – Myopus schisticolor	0.7272	0.0397
	Alexandromys oeconomus – Myopus schisticolor	0.7543	0.0329
	Sorex araneus – Sorex caecutiens	0.7782	0.0277
	Sorex araneus – Sorex minutus	0.7921	0.0251
	Sorex caecutiens – Sorex minutus	0.7211	0.0414
	Sorex isodon – Sorex minutus	0.7246	0.0404

Note: r – Spearman rank correlation, p – significance value.

The Republic of Finland is known to harbour 22 small mammal species (Siivonen, 1976; Mitchell-Jones et al., 1999; Siivonen & Sulkava, 1999), while the Republic of Karelia has 21 (Ivanter, 2018). Like in other parts of Fennoscandia, the dominants are *Sorex araneus* and *Myodes glareolus*. In the Finnish-Russian Friendship Nature Reserve, the small mammal species composition is typically north-boreal, but quite different from that known for the mentioned areas. We attribute this difference to the short study period, insufficient use of pitfall traps, considering that some small mammal species would mainly be captured by this method, and the geographical and habitat characteristics of the Finnish-Russian Friendship Nature Reserve's model areas. In these territories, a majority of the species are either forest-dwelling (*Sorex minutus, S. isodon, Craseomys rufocanus, Myopus schisticolor*) or eurytopic (*Sorex araneus, S. caecutiens, Myodes glareolus, Agricola agrestis*) animals. Hydrophilic species, *Neomys fodiens* and *Alexandromys oeconomus*, which prefer watersides in forests, were also quite typical in the studied region, although their numbers were not high. The fact that the samples contained no species associated with open spaces is explained by the very low proportion of such habitats in the Finnish-Russian Friendship Nature Reserve's model areas.

Abundance dynamics of small mammals

Some researchers argue that explicit synchrony in abundance dynamics is typical for cyclic small mammal populations. There are two dimensions to this synchrony, including spatial (i.e. between populations of the same species on different localities) and temporal (i.e. between species on a single locality) conjugations (Krebs et al., 2002).

Explicit temporal and spatial synchrony in the abundance dynamics is typical for small mammals in Finland (Henttonen & Hansson, 1993; Koprimäki et al., 2004). Common patterns (e.g. synchronous deep population decline) have been reported for rodent populations in northern Finland (Henttonen, 1997). Actually, spatial synchrony of the abundance dynamics between widespread rodent species is observed across fairly large distances. In Finland, the spatial synchronisation of abundances in areas up to 500 km apart has been observed (Henttonen et al., 1977; Sundell et al., 2004).

The spatial synchrony of abundance fluctuations usually decreases with distance between the compared areas (Bjørnstad et al., 1999; Liebhold et al., 2004). Furthermore, the spatial synchrony of small mammal abundance depends on the characteristics of the given area. For instance, the degree of the *Agricola agrestis* population size synchronisation between various areas was higher in western Finland than in the east of the country (Hiutu et al., 2003). In the Republic of Karelia, the abundance peaks of this animal recur synchronously over most of its area (Ivanter & Ivanter, 1986), apart from the Kivach State Nature Reserve (Kutenkov, 2006). However, Predavec et al. (2001) reported the absence of spatial synchrony in the abundance dynamics of different populations of the same species, even where the distance between them was small. In the Republic of Karelia, spatial agreement was lacking also in the abundance dynamics of Eylipotyphla and Rodentia species at stations 150 km apart (Kutenkov, 2006).

The interspecies temporal synchrony of abundance fluctuations is more typical for cyclic small mammal populations. It has been described especially well for northern Fennoscandia (Kalela, 1962; Koshkina, 1980; Koprimäki, 1986; Hiutu et al., 2004). Population declines happen simultaneously in many members of Eylipotyphla and Rodentia in this territory. On the other hand, asynchrony of abundance fluctuations in various small mammal species is also quite common. This is more frequent in sympatric species, including *Agricola agrestis* and *Alexandromys oeconomus* in Fennoscandia (Hoset & Steen, 2007), *Myodes glareolus* and *M. rutilus* in the Republic of Karelia (Ivanter, 2018), in the Kola Peninsula (Koshkina, 1971), and in southern Arkhangelsk Region of Russia (Kupriyanova, 1980). In the Republic of Karelia, no temporal synchrony was found in variations of small mammal abundance inside one model area either in the south Karelian (Ivanter, 2018) or in the middle Karelian (Kutenkov, 2006) zoogeographic subdistrict. However, in some areas there was a temporal synchrony in the abundance dynamics of dominants *Sorex araneus* and *Myodes glareolus* (Yakimova, 2018).

In our study the areas lie on the same geographic latitude in very similar natural and anthropogenic settings, with 20–60-km distance in between, which explains some synchrony of the observed fluctuations. However, the short duration of the studies of the small mammal population in the Finnish-Russian Friendship Nature Reserve does not permit for a specialised statistical analysis of agreement in the abundance dynamics of the species or for drawing any definitive implications. For small mammals, given the characteristics of their abundance variations, long-term observation series are needed. Longer observation series and application of various survey methods would also enable their species composition to be studied more thoroughly, since the absence of a specimens from catches of rare and threatened species can be very long, like for *Myodes rutilus* in the Kostomuksha State Nature Reserve (Sikkilya, 2014). Detailed descriptions of geobotanical relevés and collection of data on forage yields or lev-

els of potential predators would also enable a special analysis of the factors influencing small mammals at the northern limit of the boreal zone, possibly revealing their adaptations to the environment conditions.

Conclusions

By analysing the collected data, we conclude that in the Finnish-Russian Friendship Nature Reserve the small mammal population is typical for north boreal regions, but somewhat differs from the neighbouring areas, being so far understudied. Like in the other parts of Fennoscandia, the dominants were *Sorex araneus* and *Myodes glareolus*. Other species were found in the samples with various abundance levels. The synchrony of abundance fluctuations observed for some species was caused by the similarity of geographical and climatic conditions, possibly common external impacts, and short distance between the model areas. However, this matter also needs to be investigated further in more details. Our results on the species composition and abundance of small mammals in the Finnish-Russian Friendship Nature Reserve are not final, and need to be extended both by continuing the time series of surveys and by implementing specialised activities to study the environmental factors influencing this group of wildlife.

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ВИДОВОЙ СОСТАВ И ДИНАМИКА ЧИСЛЕННОСТИ МЕЛКИХ МЛЕКОПИТАЮЩИХ РОССИЙСКО-ФИНЛЯНДСКОГО ЗАПОВЕДНИКА «ДРУЖБА»

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Изучаемая нами территория Российско-Финляндского заповедника «Дружба» является практически нетронутой деятельностью человека и его влияние на экосистемы здесь минимально. Ее изучение тем более важно, поскольку она относится к числу наиболее уязвимых северных лесных территорий и является важным элементом Зеленого пояса Фенноскандии. Мелкие млекопитающие, являясь важным компонентом экосистем, часто выступают в качестве модельных объектов исследований самого широкого спектра проблем экологии. В статье приводятся обобщенные данные по видовому составу и численности мелких млекопитающих, отмеченных на модельных территориях Российско-Финляндского заповедника «Дружба» в ходе специальных исследований в 1995–2003 гг. В его финской части работы проводились на территории природного заповедника Элимюссало, отличающемся наличием массивов девственных хвойных лесов и множество небольших болот и рек, а также на территории природного заповедника Улвинсало, также характеризующегося наличием нетронутых хвойных лесов, болотных угодий и небольших рек, при этом имеющего строгий заповедный режим. С российской стороны исследования проводились на территории заповедника «Костомукшский», включая фенологический маршрут – участок Костомукшского заповедника, на котором проводятся многолетние наблюдения за изменениями в природе и подвергшемся некоторой антропогенной трансформации при формировании инфраструктуры Костомукшского района, а также на территории урочища Каливо, отличающегося преобладанием нетронутых коренных хвойных лесов. Проведенный анализ характеризует население мелких млекопитающих как типичное для территории северо-таежной Фенноскандии. При этом количество встреченных здесь в годы исследования видов значительно меньше, чем для территорий Финляндии и Карелии в целом, что свидетельствует о недостаточном изучении рассматриваемых территорий. Сравнение видового состава и численности мелких млекопитающих модельных территорий показало, что доминантами повсеместно являются *Sorex araneus* и *Myodes glareolus*, остальные виды зверьков проявляли различную степень встречаемости в уловах. Анализ динамики численности отмеченных животных показал, наличие пространственной синхронизации колебаний численности на всех модельных территориях у доминирующих видов, остальные виды проявляли различную степень согласованности хода численности. Также нами отмечено наличие временной синхронизации динамики численности мелких млекопитающих на каждой из модельных территорий. Проведенные исследования носили кратковременный характер, изучение видового состава и динамики численности мелких млекопитающих Российско-Финляндского заповедника «Дружба» нуждается в дальнейшем изучении, как за счет продолжения временных рядов исследований, так и за счет проведения специализированных исследований по изучению факторов окружающей среды, влияющих на эту группу животных.

Ключевые слова: временная и пространственная синхронизация, грызуны, доминанты, насекомоядные, популяционная динамика, численность