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Species diversity, abundance and dynamics of small mammals in the Eastern Latvia

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Abstract

The paper presents the results of small mammal monitoring carried out in Eastern Latvia in the period from 1991 to 2005. Rodents and shrews were snap-trapped in early summer and autumn using the method of trap-line census. During the investigation, 12 small mammal species were found. In open type habitats *Microtus arvalis* prevailed with *Apodemus agrarius* and *Sorex araneus* subdominating. In forest habitats *Clethrionomys glareolus*, *Apodemus flavicollis* and *Sorex araneus* were more common. The average abundance and species diversity was low in the studied grassland habitats (17.1 ± 2.2 individuals per 100 trap-days; Shannon index H = 1.084; Simpson index c = 0.471). In forest habitats the average small mammal abundance was 10.5 ± 1.4 ind. per 100 trap-days and species diversity H = 1.153; c = 0.407. No cyclicity of small mammal population dynamics and no temporal synchrony among coexisting species were found, although fluctuations of small mammal density were observed in the area in different years. Nevertheless, small mammal populations exhibited spatial synchrony among the fluctuations of density in the sample areas in distances of 10 to 25 km.

Key words: abundance, dynamics, Latvia, small mammals, species diversity.

Introduction

Small mammal communities are little studied in Latvia. The information is available about small mammal distribution in Riga city (Zorenko, Leontyeva 2003) and small mammal dynamics have been studied in North-western part of Latvia in Slitere National Park in 1991 - 1998 (Brauna 1992; Brauna, unpublished data). No information regarding small mammal species diversity and abundance in Eastern Latvia has been published up to this time.

The long-term monitoring of small mammals was started in the territory of the Teiči Nature Reserve, in the study area "Apsalas", in 1991. The initial aim of the research was to clarify relationships between breeding success of the Lesser Spotted Eagle and abundance of their pray – small mammals (Bergmanis 2005). Subsequently two new study areas for small mammal monitoring were established in the region – "Lisiņa" and "Žūklis", respectively, at the monitoring study areas of the Lesser Spotted Eagle. The aim of this paper is to present data obtained about species composition, species diversity and population dynamics of small mammals resident in the area.

Table 1. Habitat description of sites of small mammal monitoring in the eastern Latvia. *, according to the forest ecosystem classification (Bušs 1997)

Habitat type	**Description**
Grassland habitats	
Apsalas	Earlier a cornfield where agro activity has not occurred since 1993. Now this habitat can be considered to be 100 % abandoned grassland with *Dactylis glomerata* and *Phleum pratense* dominating. Overgrowing of the field by bushes and trees has not occurred, but separate young birch trees and *Salix* sp. are found on the edge.
Lisiņa	70 % agricultural land (corn or leguminous cultivated) and 30 % new eutrophic abandoned grassland where *Tussilago farfara*, *Dactylis glomerata*, *Cirsium arvense* dominates.
Žūklis	100% eutrophic abandoned grassland (since year 2003 it has been mowed once a year) with *Dactylis glomerata*, *Urtica dioica*, *Anthriscus sylvestris* dominating.
Forest habitats	
Apsalas	*Myrtillosa turf. mel.**, pine and spruce forest on mesoeutrophic drained peat soil. Tall shrub-sapling layer: *Frangula alnus*, *Sorbus aucuparia*; groundcover: *Vaccinium myrtillus*, *Oxalis acetosella*, *Maianthemum bifolium*.
Lisiņa	*Oxalidosa turf. mel.**, spruce stands mixed with birch and black alder, forest on eutrophic rich drained peat soils. Tall shrub-sapling layer: *Frangula alnus*, *Sorbus aucuparia*, *Salix cinerea*; groundcover: *Oxalis acetosella*, *Dryopteris* sp., *Convallaria majalis*, *Stellaria nemorum*, *Urtica dioica*.
Žūklis	*Mercurialiosa mel.**, spruce and birch forest on rich eutropic drained mineral soil. Tall shrub-sapling layer: *Frangula alnus*, *Sorbus aucuparia*; groundcover: *Mercurialis perennis*, *Oxalis acetosella*, *Impatiens nolintangere*, *Athyrium filix-femina*.

Materials and methods

The monitoring of small mammals was carried out by the researchers of the Teiči Nature Reserve and financed by the state budget. The work was started in 1991 in the sample area "Apsalas" at the boundary of the Teiči Nature Reserve, in Eastern Latvia (N 56° 41', E 26° 27'). In 2002 and 2003 two new sample areas were established – "Lisiņa" (N 56° 41', E 26° 38') and "Žūklis" (N 56° 51', E 26° 25'), respectively. All of the study areas are situated in the monitoring sample areas of the Lesser Spotted Eagle (*Aquila pomarina*). The distances between the study areas are 10 to 25 km.

Trapping was conducted in one grassland habitat site and in one forest habitat site in each study area. For grassland habitats extensively exploited agricultural or semi agricultural lands were chosen, as typical feeding sites for Lesser Spotted Eagle. For forest habitats the prevailing forest type in the area was chosen for small mammal trapping. Trap

Table 2. Small mammal community parameters in the sample areas. N, number of trap-days operated; s, number of species; n, number of individuals; H, Shannon's indices; EH, Shannon's equitability; c, Simpson's indices

Parameter	Apsalas (1998 - 2005)		Lisņa (2002 - 2005)		Žūklis (2003 - 2005)	
	Grassland	Forest	Grassland	Forest	Grassland	Forest
N	10.368	7.320	2.960	2.100	2.400	1.680
s	9	8	10	6	9	5
n	1.854	651	491	275	273	206
H	1.041	1.147	1.033	1.075	1.283	1.071
EH	0.501	0.552	0.470	0.600	0.617	0.665
c	0.521	0.439	0.533	0.419	0.384	0.421

lines where set along the drainage ditches existent in the habitats.

Several persons were involved in the small mammal trapping. Monitoring was initiated by U. Bergmanis and J. Rubenis, later G. Dambenieks participated and finally, since 2000, A. Pupila and U. Bergmanis conducted the work.

Trapping was conducted biannually (late May/early June and September) using the method of trap-line census. One hundred plastic snap traps were placed in grassland habitats and 70 in forest habitats at 5 m intervals. Traps were set for three or mostly for four nights and checked once a day. Initially, from 1991 to 1998, animals of genus *Microtus* and *Sorex* were not identified to the species. Later till 2005, animals were identified to species, except *Microtus rossiaemeridionalis* which were considered as *M. arvalis*.

The relative small mammal abundance was estimated as the number of animals caught per 100 trap-days. Calculating the total abundance of small mammals in the area, all "attended" traps were entered into the calculations. *Traps "attended"* are defined here as those where presence of small mammals in the trap was evident but no animal was found in there (for example, fragment of fur or tail was found). Species diversity and dominance of small mammals was calculated using Shannon's (H) and Simpson's (c) indices. The synchronism of changes in small mammal abundance was determined by Spearman's rank correlation coefficient.

Results

Species composition and diversity

There were 12 small mammal species recorded in the area. Almost all of them, except *Mus musculus* that was trapped only once and then in the forest habitat in "Apsalas", were found in grassland habitats. Of these, three species, *Micromys minutus*, *Neomys fodiens* and *Microtus rossiaemeridionalis* were not found in forest habitats. In total voles prevailed (67.5 % of the total catch) in the small mammal community in the area with *Microtus arvalis* and *Clethrionomys glareolu*s dominating. The main parameters of small mammal community in the sample areas are shown in Table 2.

In grassland habitats 11 species of small mammals were identified, belonging to five genera: *Microtus* (72.5 %), *Apodemus* (14.2 %), *Sorex* (12.2 %), *Clethrionomys* (0.8 %) and *Micromys* (0.5 %). The most numerous species were *Microtus arvalis*, *Apodemus*

Table 3. Mean abundance of small mammal species in studied habitats in early summer (first row, respectively) and autumn (second row) trapping sessions in the period of 2003 to 2005. *, traps "attended" have been taken in account

Species	Grassland habitats			Forest habitats		
	Apsalas	Lisiņa	Žūklis	Apsalas	Lisiņa	Žūklis
Microtus arvalis	2.6 ± 2.1	1.4 ± 0.6	3.6 ± 1.6	0	0	0
	15.9 ± 7.8	8.9 ± 4.5	7.5 ± 1.8	0	0	0
Microtus agrestis	0.1 ± 0.3	0.2 ± 0.1	0.3 ± 0.3	0	0	0
	0.5 ± 0.1	1.0 ± 0.5	0.2 ± 0.2	0.1 ± 0.1	0.1 ± 0.1	0
Clethrionomys glareolus	0	0	0	0.6 ± 0.4	1.0 ± 0.4	2.7 ± 0.8
	0.6 ± 0.4	0.3 ± 0.1	0.2 ± 0.2	4.1 ± 1.0	7.6 ± 2.7	10.0 ± 4.2
Apodemus agrarius	0.2 ± 0.2	0.8 ± 0.6	0.9 ± 0.8	0	0	0
	4.9 ± 3.2	3.8 ± 1.5	3.1 ± 1.5	0	0	1.1 ± 1.1
Apodemus flavicollis	0.2 ± 0.2	0	0.1 ± 0.1	0	1.3 ± 0.5	1.4 ± 0.8
	1.9 ± 1.3	1.1 ± 0.9	0.2 ± 0.2	0.1 ± 0.1	5.5 ± 1.9	4.4 ± 2.3
Apodemus uralensis	0	0.1 ± 0.1	0	0	0.4 ± 0.4	0
	0	0.1 ± 0.1	0	0	1.6 ± 1.6	0
Sorex araneus	0.1 ± 0.1	0.1 ± 0.1	0.2 ± 0.1	-	-	0.2 ± 0.2
	1.2 ± 0.7	0.5 ± 0.4	2.3 ± 0.5	1.6 ± 1.1	0.1 ± 0.1	1.9 ± 1.4
Sorex minutus	0	0.1 ± 0.1	0.1 ± 0.1	0	0	0
	0.2 ± 0.1	0	0.4 ± 0.2	1.6 ± 1.4	0.1 ± 0.1	0.1 ± 0.1
Micromys minutus	0	0	-	0	0	0
	0	0.2 ± 0.1	0.5 ± 0.5	0	0	0
Total *	3.7 ± 2.1	2.6 ± 1.0	5.8 ± 2.7	0.8 ± 0.5	3.3 ± 1.4	5.1 ± 2.1
	27.7 ± 9.7	19.3 ± 6.5	16.9 ± 3.1	8.1 ± 4.0	17.0 ± 4.5	19.4 ± 3.1

agrarius and *Sorex araneus*. Abundance of small mammal species in each of the sample areas is shown in Table 3. The rarest species in grasslands were *Neomys fodiens*, *Apodemus uralensis*, *Micromys minutus* and *Clethrionomys glareolus*. Species composition did not differ significantly in the "Apsalas" and "Lisiņa" grasslands, where *Microtus arvalis* composed 70.5 % to 71.4 % of the small mammal community respectively and *A. agrarius* and *S. araneus* were subdominant. In "Žūklis" *Microtus arvalis* contributed 57.2 % of the total small mammal number in the habitat, at which the most abundant were *Apodemus agrarius*, *Sorex minutus* and *Micromys minutus*.

In the period from 2003 to 2005 the mammal species diversity was similar in all the grasslands observed ($H = 1.114 \div 1.317$, $c = 0.373 \div 0.466$, $p < 0.1$).

In years when populations reached their maximum, species diversity was lower than in minimum years ($H_{max} = 0.739 \div 0.866$, $H_{min} = 1.222 \div 1.520$; $p < 0.01$), since the proportion of dominating species was much higher in peak years.

In forest habitats nine species of four genera of small mammals have been registered: *Clethrionomys* (59.1 %), *Apodemus* (24.5 %), *Sorex* (15.4 %) and *Microtus* (1.0 %).

The most common species in forest habitats were *C. glareolus* (59.1 %), *A. flavicollis* (20.4 %) and *S. araneus* (11.6 %). Subdominating species in coniferous forest were *S.*

araneus and *S. minutus*, while in mixed forests *A. flavicollis*, *A. uralensis* and *S. araneus* formed the greatest proportion of the small mammal community (SMC) after *C. glareolus* (Table 3).

Species diversity of SMC in the forest habitats was higher than in the open type habitats ($H = 1.153$; $c = 0.407$, $p < 0.1$). In all the habitats in the study period of 2003 to 2005 the species diversity was similar ($H = 1.062 \div 1.096$; $c = 0.383 \div 0.421$, $p < 0.1$).

Species diversity in forests was the highest in the autumn trapping session when prevalence of dominating species was less pronounced than in early summer ($H_{September} = 1.103 \div 1.113$, $H_{May/June} = 0 \div 0.986$). However, in contrast to grassland habitats, the proportion of dominating species in the SMC was higher in years of population minimum than in years of minimum ($H_{max} = 0.928 \div 1.143$, $H_{min} = 0.548 \div 0.693$; $p < 0.01$).

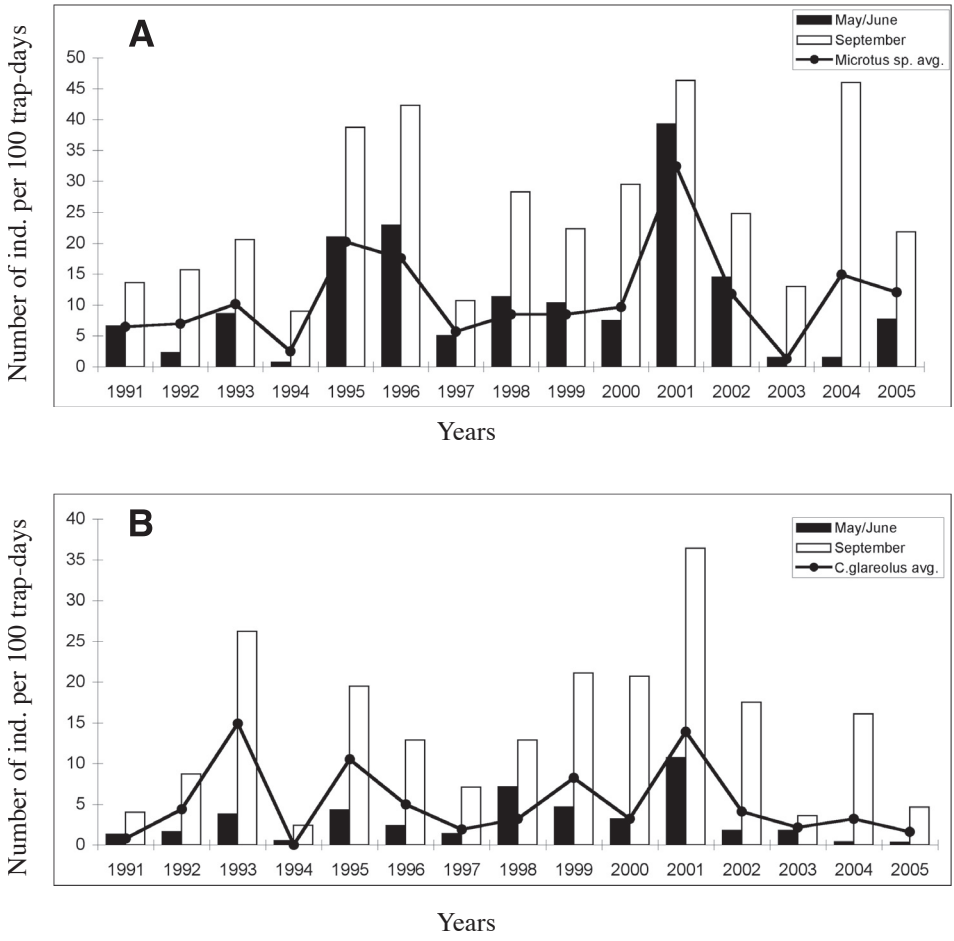

Fig. 1. Density fluctuations of the total small mammal number (columns) in relationship to the mean number of dominant species (line) in grassland (A) and forest (B) habitats in the sample area "Apsalas" in summer and autumn trapping sessions.

Abundance of small mammals

The average abundance of small mammals in the area was 13.8 ± 1.4 ind. per 100 trap-days. In the grasslands the average abundance of small mammals was 17.1 ± 2.2 ind. per 100 trap-days (9.9 ± 2.2 in early summer, 24.4 ± 2.6 in September). In the period 2003 to 2005, on average from both trapping sessions, the highest relative abundance of small mammals in the field areas was found in the old abandoned grassland "Apsalas" (15.5 ± 4.8) compared to 11.1 ± 3.7 and 11.4 ± 2.9 ($p < 0.1$) in the "Lisiņa" and "Žūklis", respectively.

The average abundance of *M. arvalis* in the grasslands was 10.1 ± 1.7 ind. per 100 trap-days. In the abandoned old grassland "Apsalas" the abundance of this species was about 1.7 times higher than in other grassland territories. The average abundance of *M. agrestis* in grasslands was 0.5 ± 0.1 ind. per 100 trap-days, *C. glareolus* 0.1 ± 0.0, *A. agrarius* 1.7 ± 0.5, *A. flavicollis* 0.4 ± 0.2, *A. uralensis* 0.2 ± 0.0, *S. araneus* 1.6 ± 0.4, *S. minutus* 0.2 ± 0.1 and *M. minutus* 0.1 ± 0.0.

The abundance of species in early summer and autumn trapping in the sample areas is shown in Table 3.

The total average abundance in forest habitats in the area was 10.5 ± 1.4 ind. per 100 trap-days, 3.6 ± 0.6 in late May/early June and 16.6 ± 2.2 in September. The highest abundance was found in mixed forest (12.3 ± 2.1) in the sample area "Žūklis", and the lowest in coniferous forest in "Apsalas" 4.5 ± 1.9 (three times lower). To a great extent, the general abundance in forest habitats was determined by the dominant species *C. glareolus*. The average degree of abundance of *C. glareolus* in forest habitats in the area was 5.6 ± 1.1 ind. per 100 trap-days, in mixed forest on mineral soils the abundance of *C. glareolus* was the highest (6.4 ind. per 100 trap-days in the period of 2003 to 2005), and comparatively 2.7 times lower in coniferous forest. The average abundance of *A. flavicollis* in forest habitats was 1.8 ± 0.5 (2.9 ± 0.2 animals per 100 trap-days in mixed forests and only 0.1 ind. in coniferous forests). The average degree of abundance of the *S. araneus* was 1.1 ± 0.3 and of *S. minutus* 0.4 ± 0.2 ind. per 100 trap-days. The rarest species in the forest habitats were *A. uralensis*, *A. agrarius* and *Microtus* species (Table 3).

Dinamycs and sinchronism of small mammals

The fluctuation of small mammal relative population density was observed in the study period investigations. Although there were pronounced peak and low population phases in several years, the dynamics were not clearly regular and the amplitudes of the fluctuation were variable (Fig. 1). For three years, from 1998 to 2000 the number of small mammals in the area was nearly stable. Subsequently from 2000 to 2004, a fluctuation cycle was observed where the number of small mammals trapped in the grassland habitats in the low phase was 7.3 ind. per 100 trap-days and 41.4 ind. per 100 trap-days in the peak year. The average amplitude of small mammals in grassland habitats, based on combined early summer and autumn data, varied from three to ten fold (n_{max}/n_{min}), with minimum and maximum densities of 3.7 and 41.4 individuals per 100 trap-days, respectively.

For the dominating species *M. arvalis*, the amplitude in different cycles varied from four to 28 fold. The highest density of this species in the study area "Apsalas" was recorded in 2001 with 32.1 ind. per 100 trap-days and the lowest density in 2003 with 1.1 individuals trapped in 100 trap-days. In years of peak density of the total number of all small mammal species, the proportion of *M. arvalis* in grassland habitats was higher (85.6 ÷ 92.0 % of SMC) than in low years of depression (16.6 ÷ 47.6 %, $p < 0.01$). *A. agrarius* showed a

regular fluctuation of density every one to three years, with an amplitude of five to 21 fold. The maximum number of *A. agrarius* observed was 5.8 ind. per 100 trap-days in 2004. *A. flavicollis* in open areas reached a maximum density in 1993 (3.7 ind. per 100 trap-days) and the next peak was observed only after 10 years in 2003 (2.6 ind. per 100 trap-days). In forests the highest density of this species was in 1993, 1998 and in 2002 when the amplitude of cycles varied from three to 19 fold. Less expressed fluctuations was found for *Sorex* species. In the grassland habitats two peaks were observed for *S. araneus*, in 1998 and 2002, and with no remarkable low phase in that period. In forest habitat the population was almost stable until 1998 when a cycle occurred from 1999 to 2003, with minimum density 0.2 and maximum 5.2 individuals per 100 trap-days.

In forest habitats the average amplitude of the total small mammal density was nine fold varying from three to 19 fold. The minimum and maximum numbers of *C. glareolus* in woodland habitats were 0.5 in 1994 and 14.9 individuals per 100 trap-days in 1993 and the proportion of species in the community did not differ during the population peak and low years, varying from 70 % to 92 % of the total abundance.

No correlation was found between fluctuation of abundance of different species in the period of investigation. Each species reached their peak phases in different years and only low phases coincided for voles and shrews. Nevertheless, the mean density of the total number of small mammals in grassland habitats reached their maximum and minimum in the same years. Also, the total number of small mammals in the grassland and forest habitats fluctuated more or less synchronously (in "Lisiņa" and "Žūklis" in the period from 2002 to 2005 there was a positive correlation, and in "Apsalas", since 1991, $r = 0.69$, $p < 0.001$).

Small mammal species in the area exhibited spatial synchrony in population density fluctuations. For a four year period a perfect positive correlation was found for *M. arvalis* ($r = 1.00$), *M. agrestis* ($r = 0.95$, $p < 0.001$), *S. araneus* (in grasslands $r = 1$, in forest habitats $r = 0.95$, $p < 0.001$), *C. glareolus* ($r = 0.8$, $p < 0.01$) and *A. flavicollis* ($r = 0.8$, $p < 0.01$) was observed in two study areas "Apsalas" and "Lisiņa".

Discussion

Twelve small mammal species were recorded in the area inter alia all three species of family *Soricidae* and nine of 13 species of the *Murida* and *Cricetidae* registered in Latvia (Timm et al. 1998). On average voles prevailed in the area, forming 67.5 % of the small mammal community. A very similar proportion of voles (69.7 %) in small mammal communities as observed in NE Lithuania (Mažeikyte 2002).

In grasslands SMC were found to be monodominant with the dominant species *M. arvalis* and *A. agrarius* and *S. araneus* subdominating. The low diversity ($H = 1.084$, $c = 0.471$) and dominating species is similar to that observed in NE Lithuania in the anthropogenic habitats (Mažeikyte 2002). That might imply that even in the study area "Apsalas", where no agricultural activity has occurred already for 13 years, the impact of ipast land use is still present. The dominating plant species *Dactylis glomerata* and *Phleum pratense* in the habitat confirm this assumption. The other grassland habitats are still influenced by human activity, which might be the reason of low species diversity observed in the area.

The small mammal community in the forest habitats was monodominant with

C. glareolus prevailing, likewise it has been observed in NE Lithuania (Balčiauskas 2005). Subdominant species in the mixed type forests were Apodemus flavicollis and Sorex species subdominate in coniferous forest. A higher density of small mammals was observed in mixed forest on rich euthropic drained mineral soil.

Small mammal populations in eastern Latvia did not show clear cyclic dynamics. Although fluctuations of population density occurred in the period of investigation, no pronounced periodicity was observed and the amplitudes of fluctuations were low and variable. Future fluctuations of small mammal density cannot be predicted in the area. It is known that northern small mammal populations exhibit multiannual fluctuations in density (Hansson, Henttonen 1985; Hanski et al. 2001). However, not all of them can be considered to be cyclic. Hansson and Henttonen (1985) found that cyclicity of arvicoline rodents decreased from the north to south in the Fennoscandinavia, where populations below 59° N fluctuated mainly seasonally.

We also did not observe interspecific temporal synchrony among the small mammal populations in the region. However, synchrony occurs in Fennoscandinavia, for example, for voles and shrews (Hansson 1984; Henttonen 1985; Korpimaki et al. 2005), and there is also a decrease in the degree of interspecific synchrony in population oscilliations from northern latitudes to the south (Henttonen, Hansson 1986).

Spatial synchrony was observed among populations in the studied sample areas at distances of 10 to 25 km. Large-scale synchrony in population fluctuations of small mammals prevail in the northern Europe (Sundell et al 2004) whereas again the degree of synchrony decreases towards the south (Steen et al 1996). For *Microtus* voles a higher degree of spatial synchrony was found in a more agricultural landscape (Huitu et al. 2003), which is consistent with the positive correlation found in eastern Latvia, where trapping was conducted in the agricultural areas.

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Sīko zīdītājdzīvnieku sugu daudzveidība, sastopamības biežums un dinamika Austrumlatvijā

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Kopsavilkums

Šajā darbā apkopoti Austrumlatvijā veiktā sīko zīdītājdzīvnieku monitoringa rezultāti laika periodā no 1991. līdz 2005. gadam. Sīko grauzēju un ciršļu uzskaite veikta divas reizes sezonā, vasaras sākumā un rudenī izmantojot standarta slazdu līnijas veida metodi ar peļu sitamajām lamatiņām. Pētījumu laikā reģistrētas divpadsmit sīko zīdītājdzīvnieku sugas. Atklātā ainavā visbiežāk sastopamā suga bija *Microtus arvalis*, nedaudz retāk – *Apodemus agrarius* un *Sorex araneus*. Meža biotopos visbiežāk sastopamās sugas bija *Clethrionomys glareolus*, *Apodemus flavicollis* un *Sorex araneus*. Zālāju biotopos novēroja zemu sīko zīdītājdzīvnieku blīvumu un daudzveidību (17,1 ± 2,2 dzīvnieku 100 slazdu-diennaktīs; Šanona indekss H = 1,084; Simpsona indekss c = 0,471). Meža biotopos vidējais sīko zīdītājdzīvnieku blīvums bija 10,5 ± 1,4 ind. 100 slazdu-diennaktīs, bet sugu daudzveidība – H = 1,153; c = 0,407. Sīko zīdītājdzīvnieku skaits pa gadiem svārstījās, tomēr netika atrasts cikliskums to skaita izmaiņās, kā arī atsevišķu sugu skaita svārstības pa gadiem nesakrita. Tomēr konstatēja, ka sīko zīdītājdzīvnieku skaita svārstības pa gadiem sakrita dažādos uzskaites parauglaukumos 10 līdz 25 km attālumā.