

Population Dynamics of Small Mammal Species in Urbanized Areas

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Abstract—Population dynamics of small mammals was monitored in urbanized forest ecosystems on a long-term basis. Urban rodent communities had higher densities due to a large proportion of hemisynanthropic species of *Apodemus* (*Sylvemus*) genus. It was found that small mammals displayed similar population dynamics in the park-forests in the same type of forest, but the pattern broke down in the city. Urban stress proved to have a stronger influence on the structure and population dynamics of small mammals than site conditions. Transformation of lower plant layers disturbs habitat of some species and creates favorable conditions for others. Increasing species richness and thickness of shrub layer make site conditions more favorable for the wood mouse and the field mouse—species that do not normally inhabit coniferous forests.

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Biocenoses are known to adapt to the effect of a city by changing the rate and direction of their evolution. Urbanization transforms vegetation in ecosystems, and recreation transforms the soil. These changes eventually affect animal communities. Many authors have paid their attention to the ways small mammal communities form in the urban environment [1–19].

The long-term small mammal population study in various urbanized forest ecosystems contributes much to our understanding of biocenoses' response to stress. The data obtained can be used to evaluate the epidemiological situation with the infections that rodents and shrews actively carry and maintain. Urban park-forests favor the appearance of Anthropurgic nidi of infections of this kind. Small mammals are one of the three components of a natural nidus of infection [20]. Therefore, the knowledge of dynamics of small mammal communities and regularities of their formation should contribute to understanding and predicting epizooties.

MATERIALS AND METHODS

The studies were conducted in the park-forests of Yekaterinburg arranged according to the wind rose: the Kalinovskii park-forest in the northeast, the Shuvakish park-forest in the northwest, the Yugo-Zapadnyi park-forest in the southwest and Lesovodov Rossii (Russian Foresters') Park in the southeast, and the parks within the city: Central Recreation-and-Entertainment Park (CREP) and the Arboretum ("Dendrarium") of the Botanical Garden of the Ural Branch of the Russian Academy of Sciences—a conservation area without any recreation load. The control was a slightly disturbed

forest 50 km southeast of Yekaterinburg (56°36'04"N, 61°03'25"E).

In 2000–2007, small mammals were inventoried during the breeding season when population densities were high (late June–July). The animals were trapped in Lesovodov Rossii Park and the CREP in 2004–2007. At each site standard trap-lines were used (300 trap-days (td) per trapping session). Three plots were chosen in each site: one in the immediate vicinity of the city and two far in the park-forest. The forest site conditions of these sites and the natural forest were analyzed with standard forest inventory and geobotanical methods.

RESULTS AND DISCUSSION

According to the forest zonation by Kolesnikov [21] the study area belongs to the Transural piedmont province of the southern-taiga subzone. The edifier of the park-forests is mainly the pine. The recreation load in Yekaterinburg park-forests disturbs litter, soil, and plant communities, and facilitates invasion of synanthropic plants [18, 22, and 23]. Trail network covers 5 to 25% of a site area. The park-forests are sodded, up to 30–70%. All these factors impede forest regeneration. The introduced shrub species increase the species richness in the understory of the park-forests as compared with the forest, whereas the species richness of grass-subshrub layer is lower. In Arboretum the species richness of the understory and grass-subshrub layer is intermediate.

In the Yugo-Zapadnyi park-forest, CREP, and the control plot trap lines were set on the tops of low uplands and gentle slopes with mountain-forest sod-podzolic loam skeleton soils. Moisture regime of the soils is

permanently fresh. The stands are berry forest: berry-pine forest in the city and green moss-berry-pine forest in the control. Although regenerative capacity in such forest is usually good, young growth in the park-forests and parks is very sparse and mostly nonviable or absent. In the forest young viable growth is thick or moderately thick. Understory is very thick in the Yugo-Zapadni park-forest and CREP and sparse in the control. Thirteen understory species, mostly introduced, were described in the park-forests and five in the control. Degradation is moderate or weak in the Yugo-Zapadni park-forest, moderate in the CREP, and weak or absent in the natural pine forest.

Trap lines in the Shuvakish and Kalininskii park-forests, Lesovodov Rossii Park, and the Arboretum were set on gentle slopes with loam sod-podzolic soils underlain by loam eluviodeluvium. The moisture regime of the soils is fresh, periodically moist. The stands are grass pine forests. The densest is the Kalinovskii park-forest, the second densest is the Shuvakish, followed by the Arboretum, and the sparsest is Lesovodov Rossii Park.

There is no young growth of the edicator in the Arboretum, and it is very scarce in Lesovodov Rossii Park; in the Kalinovskii and Shuvakish park-forests there is only birch young growth. The understory is composed of 11 species, 8 of which are synanthropic and ecemic to this forest type. In Lesovodov Rossii Park the understory is the thickest, it is medium-thick in the Arboretum and Shuvakish park-forest, absent or medium-thick in the Kalinovskii park-forest. Degradation is weak to moderate on all sites except the Arboretum, where it is weak or absent.

Thus, the park-forests are characterized by low regenerative capacity of the stands, thicker understory and its richer species composition. The understory affects growth conditions of herbs, subshrubs, and moss, favoring some vegetation groups and suppressing others. Meadow grasses, subshrubs, and weeds invade the stands. The litter degrades and the soil becomes compacted. The trail network covers up to 25% of area of some sites. The surveyed sites are grouped into two categories according to the forest site conditions irrespective of location and distance between them.

Species composition of small mammal communities. Ten nonsynanthropic rodent species in five genera were recorded in the city and natural pine forest: *Clethrionomys glareolus*, *C. rutilus*, *C. rufocanus*, *Microtus arvalis*, *M. oeconomus*, and *M. agrestis*; *Apodemus agrarius*, *A. uralensis*, *Sicista betulina*, and *Micromys minutus*. All species, except *Micromys minutus* (absent in the city), were recorded both in the control and anthropogenically disturbed biotopes. Note that the density of *Sicista betulina*, a fairly rare species in the southern-taiga subzone and in our control site, in the park-forests was high (up to 1/3 of all rodents trapped in the years of low vole abundance).

Mus musculus was found only in the city and at the sites adjacent to city buildings. Its numbers were very low varying from year to year and were unevenly distributed during the study years (Figs. 1–3). In some years only one or two individuals were caught. I exclude *M. musculus* from my analysis as it is a specialist synanthropic species.

Three red-toothed shrew species were recorded in the investigated sites: *Sorex araneus* (Linnaeus, 1758), *S. caecutiens*, and *S. minutus*. *S. araneus* dominated everywhere, averaging from 85 to 97% of all red-toothed shrews trapped in the city and about 75% in the control. In the control forest all the three species were present [19], with *S. araneus* dominating and *S. caecutiens* being the second in abundance. In the city and its surroundings the three species were found only in the Yugo-Zapadni and Kalinovskii park-forests. Likewise, *S. araneus* dominated, but, contrary to the control, the role of the codominant shifted from *S. caecutiens* to *S. minutus*. Only two species, *S. araneus* and *S. minutus*, were found in the city: in the Arboretum and CREP, and in two of four park-forests: in the Shuvakish park-forest and Lesovodov Rossii Park. *S. caecutiens* and *S. minutus* numbers were low in all sites, yet these species were trapped even in the years of low abundances of shrews decreasing mainly due to *S. araneus*.

Population dynamics. Rodents and shrews displayed similar patterns of population dynamics. Mostly, the peaks of abundance of their species coincided in time, so did the lowest extremes of the abundance (see Figs. 1–3), only in some years the number of insectivores and rodents being out of phase. All the examined sites can be grouped into three categories according to population dynamics of the small mammals. Communities of the Yugo-Zapadni park-forest and the control site (with forest site conditions of the same type) had three peaks of rodent abundance. The second group includes small mammal communities of the Shuvakish and Kalinovskii park-forests (with different forest site conditions) also had three peaks of rodent abundance but of different range and in other years. Only in 2006 communities of all the park-forests, as well as in the undisturbed forest, showed synchronous highs, but there were differences in their levels in the first and second groups.

For the study period from 2004 to 2007, the second group also includes rodents and red-toothed shrew communities of Lesovodov Rossii Park that has the same site conditions as the Kalinovskii and Shuvakish park-forests, although it is situated across the city. However, some details were revealed in the species composition of animal communities: the Kalinovskii and Shuvakish park-forests were dominated by *C. glareolus*, whereas Lesovodov Rossii Park was dominated by *C. rutilus*.

The third group includes the Arboretum and CREP. Although the two parks have different forest site conditions, their small mammal communities showed similar

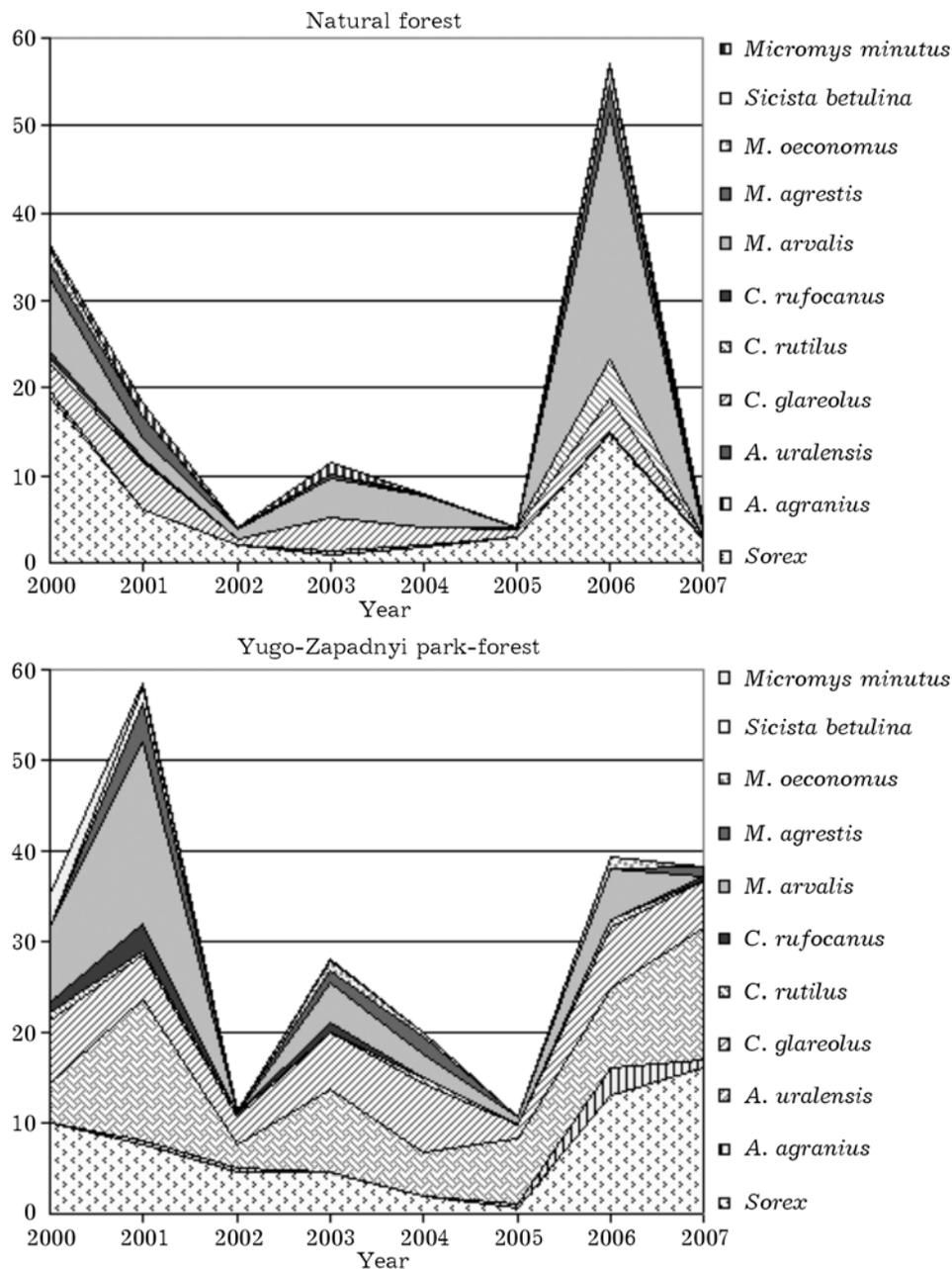


Fig. 1. Small mammal population dynamics in the control and Yugo-Zapadnyi park-forest. In Figures 1–3 the Y axis represents catch per 100 trap-days.

patterns of population dynamics. The Arboretum rodent communities displayed a single population peak; their dynamics is synchronous with that of the CREP in 2004 to 2007.

Although 2002 and 2005 were the years of the low numbers of the small mammals in all the Middle Ural forests (including our control site) we did not observe this decline in the communities of the park-forests. Even though the number of rodents decreased in all habitats, densities in the park-forests and the Arboretum remained stable at quite high levels.

Rodent abundances in the city were quite stable due to a large proportion of hemisynanthropic species. While rodent communities of the pine forests consist of usual southern-taiga species: *Clethrionomys* and *Microtus* genera, in urban communities the endemic species of the genus *Apodemus* (*Sylveus*) appeared: *A. uralensis* and *A. agrarius*. These species form the basis of the rodent community in the Arboretum. Transformation of lower layers in urban ecotones disturbs habitats of some species and creates favorable conditions for others. Richer species composition and higher

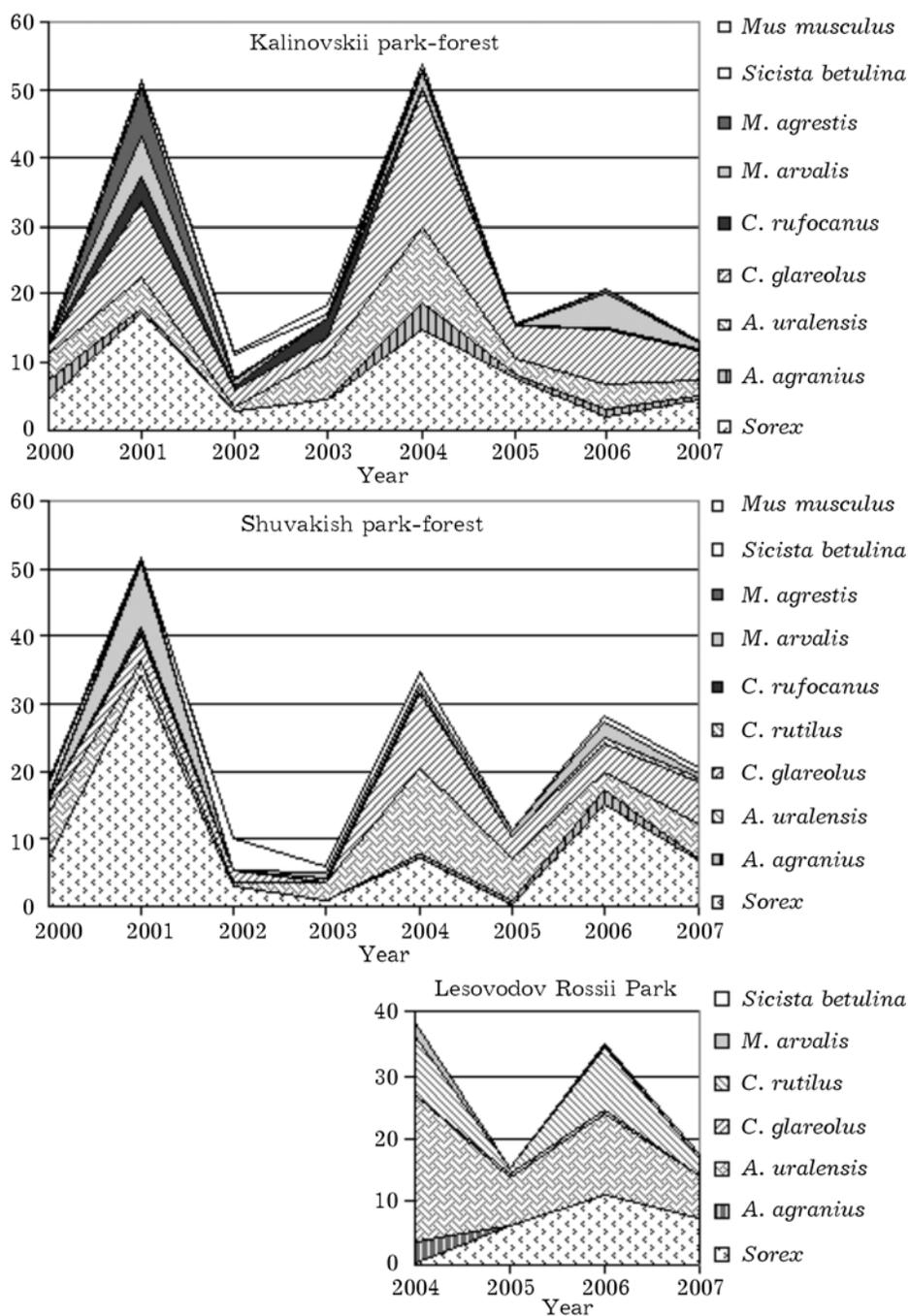


Fig. 2. Small mammal community dynamics in Shuvakish, Kalinovskii, and Lesovodov Rossii park-forests.

thickness of the underbrush makes the habitat more favorable for these mice species that do not normally inhabit coniferous forests. When we began our studies in 1989, *A. uralensis* was absent in the city, and the genus was presented by *A. agrarius* only. In 1991, the wood mouse appeared first in the Arboretum, and only in 1996, in the park-forests. Since then *A. agrarius* began to decrease reaching its lows in the recent years, along with high numbers of *A. uralensis*. Increase in the wood mouse numbers may be a function of recent warm win-

ters which facilitate its overwintering as they are species of more southern areas. The wood mouse is numerous in urban communities of cities located more to the south [1, 2, 8–12].

Since 1990, during the study period in our control forest only one *A. uralensis* individual was trapped at the first line set not far from road; occasional *A. agrarius* individuals also occurred only at the same line. As I mentioned above, red-toothed shrew communities are also divided into three groups according to population

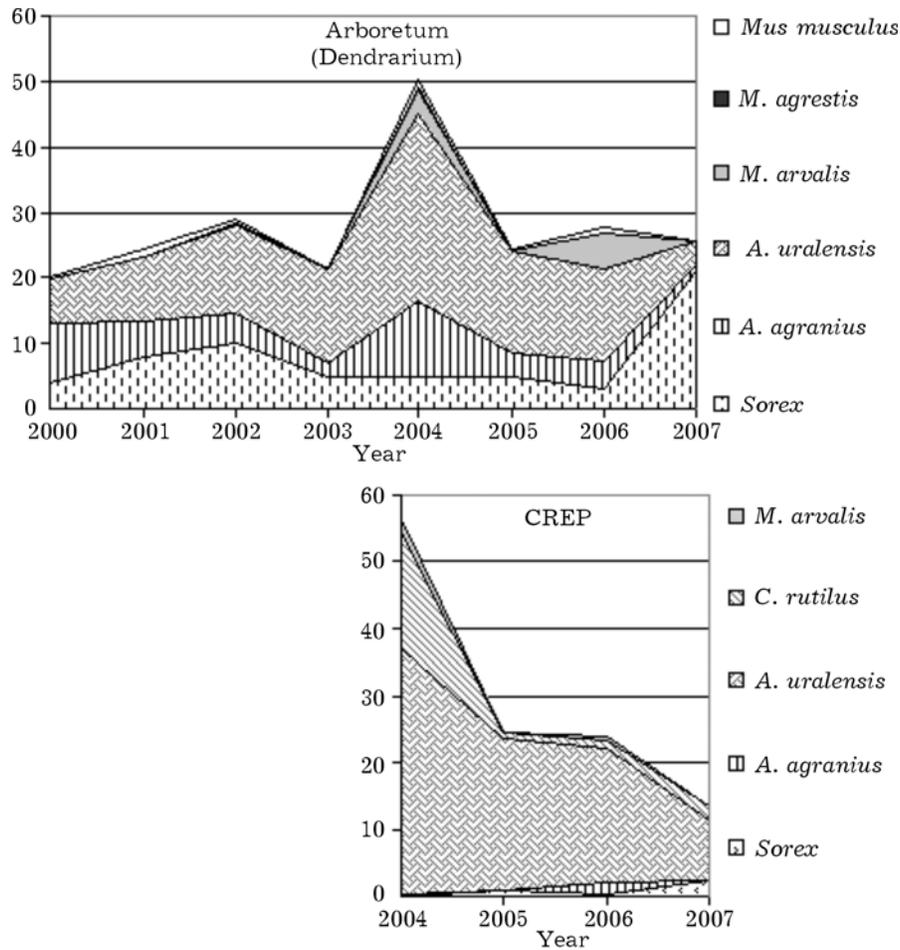


Fig. 3. Small mammal community dynamics in the Arboretum and Central Recreation-and-Entertainment Park.

dynamics: 1) the Yugo-Zapadnyi park-forest and control forest; 2) the Kalinovskii and Shuvakish park-forests. In 2004 and 2005 Lesovodov Rossii Park population dynamics was slightly different. The Arboretum and CREP red-toothed shrew abundances were low, but higher in the former. The Arboretum abundance index averaged about 2 ind/100 td, whereas in the park we trapped 0 to 2 ind/100 td on average. In 2007 seven individuals per 100 trap-days were trapped in the Dendrarium; in the CREP abundance index was 2 ind/100 td, which was the highest number for the four study years.

CONCLUSIONS

Small mammals displayed similar patterns of population dynamics in forest site conditions of the same type, but the pattern broke down in the city. Urban stress has a much stronger influence on the structure and dynamics of small mammal communities than forest site conditions. Urban communities have higher numbers of rodents due to a large proportion of species of *Apodemus* genus, which is mainly the consequence

of higher species richness and thicker underbrush that make habitats more favorable for species that do not normally inhabit coniferous forests: *A. uralensis* and *A. agrarius*. Ecotone processes on the city-forest interface result in transformation of phytocenoses and consequent changes in the structure and dynamics of small mammal communities.

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