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SHORT COMMUNICATIONS

Specific Features of Population Dynamics and Species Diversity of Shrews in Urbanized Areas

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The most interesting and important processes stimulated by urbanization take place at the periphery of urban agglomerations expanding into natural ecosystems. The zone of contact between natural and urbanized landscapes is characterized by a highly specific environment, which Neronov (2001) named "urbanoecotone." Studies on the role of urbanoecotones in the maintenance of biodiversity are important in theoretical terms. Moreover, knowledge of the events that take place in immediate proximity to populated areas is obviously of practical significance. The systematic monitoring of the buffer zones between natural and transformed ecosystems is relevant from both standpoints.

Small mammals rapidly respond to changes in the environment and, hence, are regarded as reliable indicators of the state of ecosystems. Rodents are the most common and best known component of the small mammal community, whereas shrews, being no less interesting, have not been studied in sufficient detail under conditions of urbanization.

The communities of shrews usually consist of three to five species that are close to each other both morphologically and ecologically. As in the case of rodents (Chernousova, 1996), the species diversity of shrews should reflect their living conditions in a biotope and the degree of its anthropogenic disturbance: as anthropogenic impact increases, the species most sensitive to changes in the environment should disappear. Shrews as a component of the small mammal community play an important role in a biogeocenosis: unlike rodents, they are second-order consumers that feed mainly on invertebrates, and, therefore, the abundance of shrews may indirectly indicate the abundance of small invertebrates in a given biotope. However, vegetable food is also important for shrews, especially in the winter period (Dokuchaev, 1980, 1990; Ivanter and Makarov, 2001). Shrews are involved in the circulation of some natural epizootic diseases such as hemorrhagic fever with renal syndrome. In recent years, outbreaks of this disease were recorded in several regions of Russia, including the Urals (*Informatsionnyi sbornik…*, 1997; *Epizootologicheskii monitoring…*, 2002).

Thus, research on the dynamics of abundance and species composition of shrews in the anthropogenically transformed area within the limits of a large city, such as Yekaterinburg (the Middle Urals), is of certain theoretical and practical significance.

In our study of the urban theriofauna, we refrained from the zonal approach commonly used by specialists working in urbanized areas (Karaseva et al., 1995; Tikhonova et al., 2001) but assessed the abundance and species composition of shrew communities in large peripheral park forests (Northeastern, Northwestern, and Southwestern) differing in location relative to the prevailing wind direction and within the city, in the arboretum of the Botanical Garden of the Ural Division, Russian Academy of Sciences. The control area was in a natural forest stand located 50 km from Yekaterinburg. The material was collected in midsummer (late June and July) over six years, from 2000 to 2005, by the standard trap-line method. Traps were of a modified design that ensured success in catching shrews (probably except for the smallest individuals). As all localities were surveyed using the standard procedure, the results were suitable for comparative analysis.

We trapped a total of 1056 shrews (the genus *Sorex*) of three species: *S. araneus* L. 1758, *S. minutus* L. 1766, and *S. caecutiens* Laxm. 1788. Most of them were young of the year. The communities of surveyed areas were compared with respect to their relative abundance and indices of species diversity and uniformity of distribution.

The relative abundance of shrews reached the highest value (over the study period) in the Northwestern Park Forest (Fig. 1). It was also high in the Northeastern

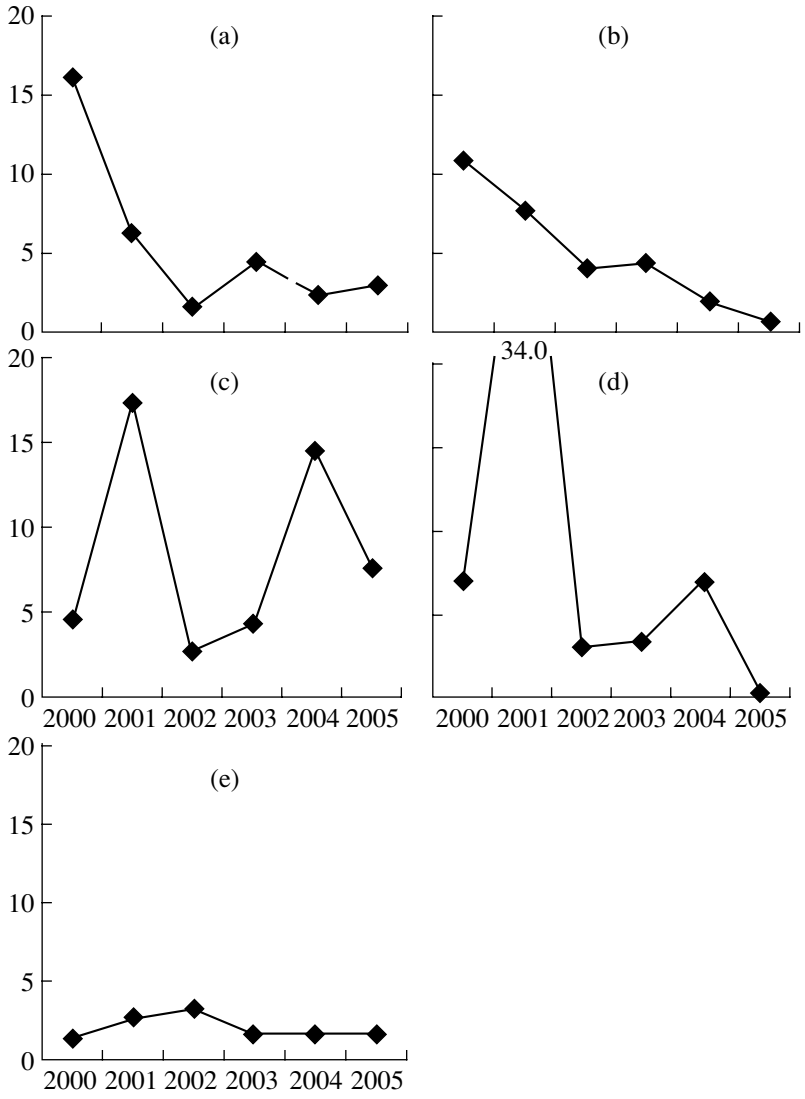

Fig. 1. Population dynamics of shrews (ind./100 trap–days) in (a) control area, (b) Southwestern Park Forest, (c) Northeastern Park Forest, (d) Northwestern Park Forest, and (e) arboretum of the Botanical Garden, UD RAS.

Park Forest, and the lowest abundance was observed in the arboretum.

With respect to population dynamics, shrew communities could be divided into three groups (Fig. 1): (1) a peak in 2000 and gradual decline by 2005 (the control area and the Southwestern Park Forest), (2) two peaks in 2001 and 2004 (the Northwestern and Northeastern park forests), and (3) no distinct dynamics (the arboretum).

The population dynamics of shrews in the control differed from those in urban localities. Although their direction in the control and Southwestern Park Forest was generally the same, changes observed in the control area were more abrupt: the abundance of shrews in the forest community decreased to a minimum in 2002 and subsequently fluctuated at this level, whereas that in the Southwestern Park Forest decreased gradually, with a minimum recorded in 2005. The dynamics of shrew communities in the Northwestern and Northeastern park forests were also similar, but their peaks differed in magnitude: at the first peak (2001), the relative abundance of shrews in the former was two times higher than in the latter (and the highest over the observation period); at the second peak (2004), the situation was inverse.

Sorex araneus prevailed in catches both in the control and in anthropogenically disturbed areas. The proportion of this species reached 92.5% in the city center (the arboretum), 91% in park forests, and 83.5% in the control area. Such a pattern of dominance markedly differs from that in rodent communities of the same areas (Chernousova, 1996, 2000). The prevalence of *S. araneus* as the most eurytopic species in the fauna of shrews is characteristic of the entire forest zone of the

Table 1. Indexes of diversity and proportion of rare species in communities of shrews

Index	Locality				
	Control	Southwestern Park Forest	Northeastern Park Forest	Northwestern Park Forest	Arboretum
μ	2.30 ± 0.11	1.99 ± 0.15	1.77 ± 0.12	1.27 ± 0.08	1.45 ± 0.15
h	0.23 ± 0.04	0.34 ± 0.05	0.41 ± 0.04	0.36 ± 0.04	0.27 ± 0.07

Middle Urals (Shvarts et al., 1992; Bol'shakov et al., 1996; Bobretsov et al., 2004); in our case, however, the degree of its dominance tends to be higher in anthropogenic than in natural landscapes. *Sorex minutus* was the second most abundant species in urbanized habitats, whereas its abundance in the control area was only half that of *S. caecutiens*. In addition to the control area, *S. caecutiens* shrews were also recorded in the Southwestern and Northeastern park forests, where they were scarce and occurred only in years of high abundance of shrews.

To compare shrew communities with respect to species diversity and uniformity, we used the index of species diversity μ and the index characterizing the proportion of rare species *h* (analogous to Simpson's index of uniformity), their errors, and coefficients of significance. Calculations were made according to Zhivotovsky (1980).

As follows from Tables 1 and 2 and Fig. 2, the index of species diversity in the control had the highest value and significantly differed from indices for other areas, except for the Southwestern Park Forest inhabited by a shrew community with the same type of population dynamics. Among urban areas, the highest species diversity was observed in the Southwestern Park Forest, with differences from other areas (except the Northeastern Park Forest) being statistically significant. As the total abundance of shrews in the arboretum was very low, the presence of only three *S. minutus* shrews in the corresponding sample had a strong effect on the diversity index: it was fairly high and did not differ significantly from those for the Northwestern and Northeastern park forests (Table 2). In the Northwestern Park Forest, two shrew species were recorded, *S. araneus* and *S. minutus.* The abundance of dominant *S. araneus* in the year of population peak reached 34 ind./100 trap–days and was significantly higher than in other areas (Fig. 1). Over the study period, a total of 153 shrews were trapped there, and only three of them were *S. minutus*. This is why the index of species diversity in the Northwestern Park Forest proved to be even lower than in the arboretum.

Cluster analysis with respect to the index of species diversity divided shrew communities into groups (clusters) slightly differing from those revealed by analyzing population dynamics (Fig. 3). One cluster was formed by communities of the control area and the Southwestern Park Forest, as in the previous case. Another cluster, however, comprised the Northwestern Park Forest and the arboretum located in the southern part of the city. The Northeastern Park Forest was segregated into an individual cluster.

The arboretum has a special place in our study due to its unique location and status: being located within the city limits, it is inaccessible to the general public and largely isolated from the park-forest zone. With respect to the state of the herb–dwarf shrub layer and undergrowth, the arboretum is intermediate between park forests and the natural forest stand in the control area. The absence of recreational load is favorable for small mammals inhabiting the arboretum, and the low abundance of shrews in it is apparently explained by its relatively small area (about 50 ha) and isolation from forests. Unlike the arboretum, peripheral park forests cover large areas with a variety of biotopes capable of accommodating a great number of small mammals, but

Table 2. Comparison of shrew communities with respect to index of diversity

Communities compared	Test value
Control vs. arboretum	**4.64****
Control vs. Northeastern Park Forest	**3.27****
Control vs. Northwestern Park Forest	**7.68****
Control vs. Southwestern Park Forest	1.66
Arboretum vs. Northeastern Park Forest	1.69
Arboretum vs. Northwestern Park Forest	1.07
Arboretum vs. Southwestern Park Forest	**2.54***
Northeastern Park Forest vs. Northwestern Park Forest	**3.51****
Northeastern Park Forest vs. Southwestern Park Forest	1.12
Northwestern Park Forest vs. Southwestern Park Forest	**4.19****

Note: Boldfaced values indicate differences significant at $*p < 0.05$ and $**p < 0.05$.

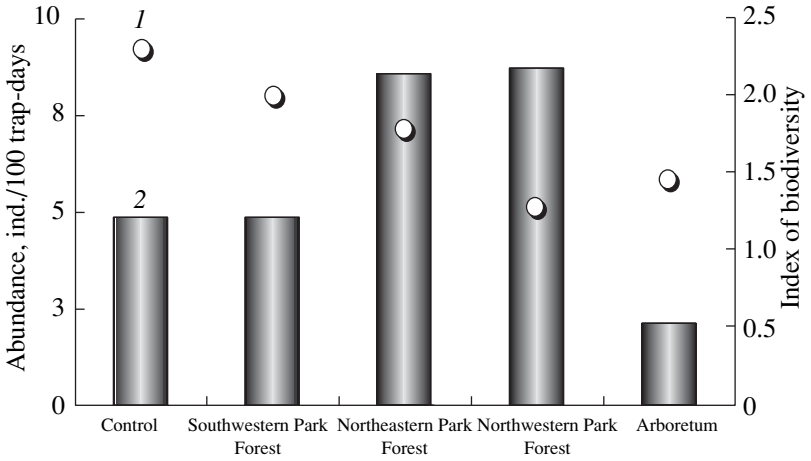

Fig. 2. Average abundance (*1*) and indices of species diversity (*2*) of shrew communities.

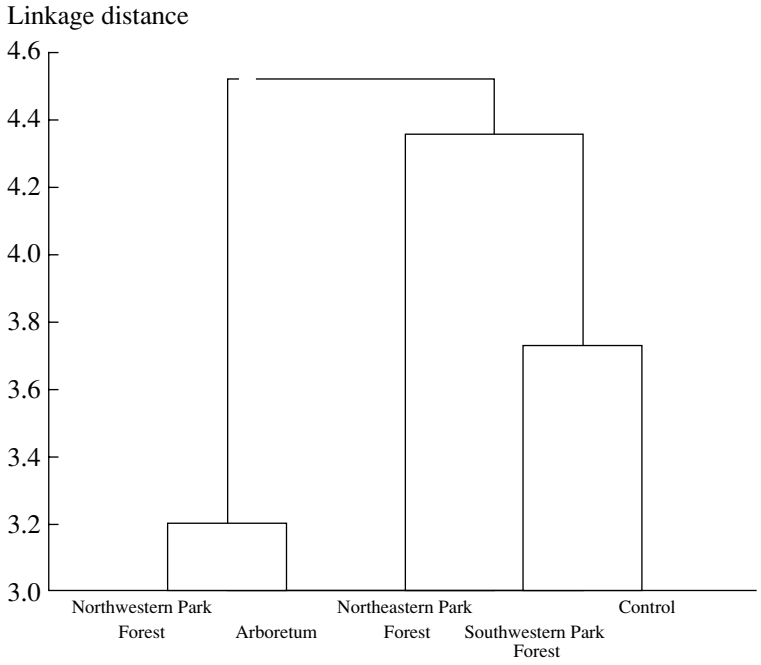

Fig. 3. Diagram of similarity between the indices of species diversity of shrew communities in different habitats.

the species diversity of these animals is lower than in the control area because of heavy recreational load.

Thus, the communities of shrews living in a mosaic urbanized environment develop different types of dynamics that allow optimal adaptation of these animals to local conditions in each habitat. The species diversity of shrews in urbanized areas decreases, and the distribution of species in communities becomes less uniform, being displaced toward dominance of *S. araneus*, the most ecologically flexible species. The species diversity of shrew communities in park forests decreases, although their abundance in these areas is higher and the diversity of biotopes is greater in the control natural forest. This is evidence that the ecosystems of urbanoecotones undergo degradation that is largely dependent on the degree of recreational impact on park forests.

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