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Specific Features of the Dynamics of Murine Rodent Communities under the Effects of Urbanization: 1. Dynamics of Species Composition and Abundance

N. F. Chernousova

Institute of Plant and Animal Ecology, Ural Division, Russian Academy of Sciences, ul. Vos'mogo Marta 202, Yekaterinburg, 620144 Russia

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Abstract—The long-term population dynamics of rodent communities in park forests of Yekaterinburg was studied. The results showed that deep population depressions occurring in natural communities are not characteristic of the urban communities. In the urban environment, the density of rodents is always maintained at a relatively high level due to the appearance of species that are atypical for the natural communities. This fact deserves attention in view of the increasing risk of tick-borne encephalitis (TBE) in the region, as a high rodent abundance may provide for the maintenance of a stable TBE focus in the city.

Key words: murine rodents, urbanization, species composition, numbers.

The process of urbanization leads to the spatial reduction of the natural environment, which remains in the city as a small green area significantly transformed due to landscape development. In addition, forests in the green belt of the city are exposed to a significant impact accounted for by industrial and automobile emissions and recreation. All these factors naturally affect plant and animal communities, accelerating their evolution and leading to the formation of structures that prove to be stable in urban park forests exposed to a heavy recreation load. As was shown in several studies (Andrzejewski *et al.*, 1978; Korneeva and Shpilkin, 1978; Babinska-Verka *et al.*, 1979; Lisin, 1983, 1984, 1987; Chernousova, 1996), recreation in a large city is the main factor affecting small mammals, rodents in particular. Rodents, being an important component of any natural community, may sometimes be harmful for people by playing a role in the maintenance and spread of infections with natural focality.

Tick-borne encephalitis (TBE) has recently become widespread in the forest zone. Rodents, together with birds, are the main hosts of the larvae of ixodid ticks, the main TBE vectors. Therefore, the population dynamics of nonsynanthropic rodent species in the city is of both scientific and practical interest. The city of Yekaterinburg, a large industrial center of the Middle Urals, is a convenient location for studying the effects of urbanization on the communities of nonsynanthropic rodents inhabiting forest stands in the city and its suburbs.

MATERIALS AND METHODS

Long-term studies (1990–1998) were performed in four large park forests growing in the northern, northeastern, southern, and southwestern suburbs of Yekaterinburg (the forest zone of the Middle Urals) and in the arboretum of the Botanical Garden of the Ural Division of the Russian Academy of Sciences (approximately 50 ha in area) located within the city limits. The arboretum is closed to the public. The plots of artificial stands on its territory adjoin a coniferous forest with well-developed lower layers. Rodents were captured in this forest plot. The park forests form a green belt at the periphery of the city and spread to the residential areas in some places. They developed on the basis of coniferous forests characteristic of this region, which were included within the city limits. Depending on the proximity of housing tracts, the park forests have more or less developed lower layers interspersed with introduced plant species. Control catches were made near the biological station of Ural State University, 50 km southeast of Yekaterinburg, in a coniferous forest typical for the forest zone of the Middle Urals.

Small mammals were caught by the conventional trap-line method (300–400 trap-days per year in each sampling area). The distribution of the species of small mammals over park forests was described earlier (Chernousova, 1996). In this paper, we regard all the park forests as a single green belt at the periphery of the city, with more or less the same pattern and level of recreational load resulting from the proximity of urbanized territories. The arboretum is exposed to a specific type of urban effects because it is located within the city limits but is completely free from a recreational load.

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RESULTS AND DISCUSSION

In the period of studies, an increase, a peak, and a decline were observed in the rodent population dynamics (Figs. 1a, 1b). The pattern of the dynamics was similar in all areas. A high rodent abundance in the city and in the natural community was recorded in 1994 and 1995, while 1996 was the year of a depression; the peak of abundance in the northern and northeastern park forests and in the arboretum was in 1994; in the southern and southwestern park forests and in the control, this peak was in 1995. Note that, in the entire forest zone of the Middle Urals, 1994 and 1995 were the years of high rodent abundance, and 1996 was the year of depression. However, although the patterns of rodent population dynamics in the study sites were similar, animal abundance in the year of the depression decreased more drastically in the control area (approximately ten times) than in the city (3.2 times in park forests and 2.3 times in the arboretum). As estimated by the χ^2 test, differences in the decrease of rodent abundance in the period of the depression (relative to the peak period) between the study sites were statistically significant (table). Therefore, the numbers of nonsynanthropic rodents in the city fluctuate less sharply than in natural communities.

Since 1952, specialists of the city sanitary–epidemiological station have been monitoring rodent populations in park forests. The data kindly supplied by them are shown in Fig. 2 to illustrate the long-term dynamics of rodent abundance in Yekaterinburg. Although the sites, time, and methods of census used in our studies were different, the pattern of population dynamics in the same years proved to be similar. This fact confirmed that the trends revealed in four park forests are characteristic of all other park forests of the city. It follows from Fig. 2 that the fluctuating abundance of rodents tended to increase in the recent period, even in the years of population depression.

As was noted previously (Chernousova, 1996), the communities of murine rodents in the park forests, the Botanical Garden, and the surrounding forests differ in their species composition and abundance. Studies on the dynamics of species composition indicated that in the park forests, similarly to natural communities, voles of the genera *Clethrionomys* and *Microtus* usually prevailed in numbers (Figs. 3b, 3c); among them, *C. glareolus* and *M. arvalis* were dominant. Periodically, population outbreaks occurred in *M. agrestis*. However, the urban rodent community differed from the natural forest communities in the presence of *Apodemus agrarius.* In the Middle Urals, the latter species rarely occurs in coniferous forests (single specimens in some years) and mainly inhabits fields and brushwoods (Bol'shakov, 1977). Within the city limits, in the arboretum, this species mainly remained dominant and accounted for 70 to almost 90% of the total rodent abundance in some years (Fig. 3a). Another specific feature of park forests is that, in addition to *C. glareolus*, other species of this genus (*C. rutilus* and *C. rufocanus*) occurred there in greater numbers than in the control area throughout the study period. Owing to these species, the decrease of rodent abundance in the year of the depression was less pronounced in park forests than in the surrounding forests.

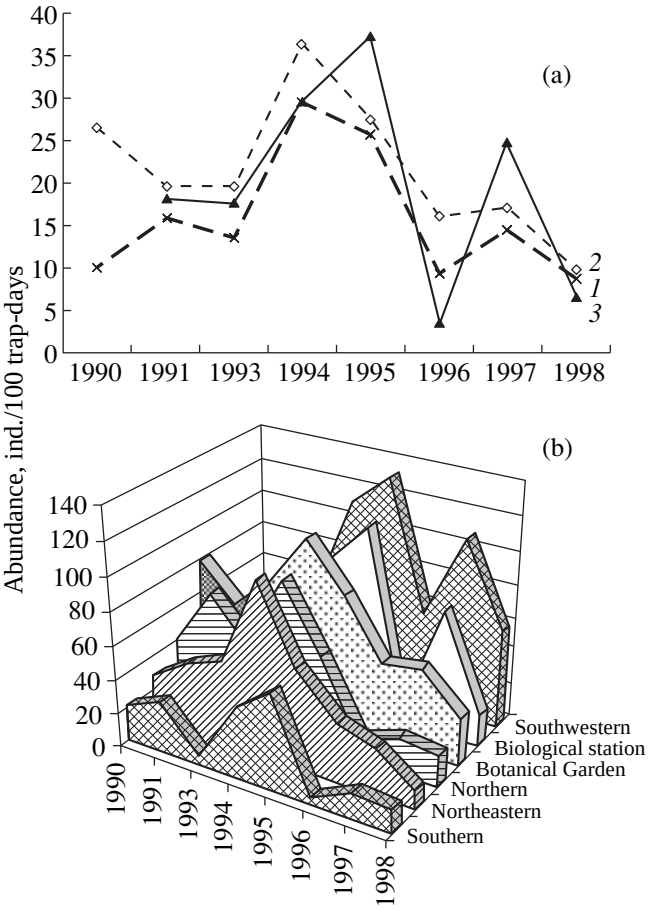

Fig. 1. Dynamics of the total rodent abundance (a) averaged over the green belt of the city (per 100 trap-days) and (b) in individual park forests (300 trap-days in each): (*1*) park forests, (*2*) botanical garden, (*3*) biological station.

The quantitative composition of the nonsynanthropic rodent community within the city limits (in the arboretum) had similar dynamics (Figs. 1, 3a). However, *A. agrarius* was the most abundant species in this community (excluding the years after the population depression), and *M. arvalis* was codominant. The remaining

Values of the chi-square test for the decrease of rodent abundance during the depression

Groups compared	χ^2 values
Arboretum–park forests	8.6*
Park forests–control	15.8**
Arboretum–control	29.3**

*Differences at 99% significance level.
**Differences at 99.9% significance level.

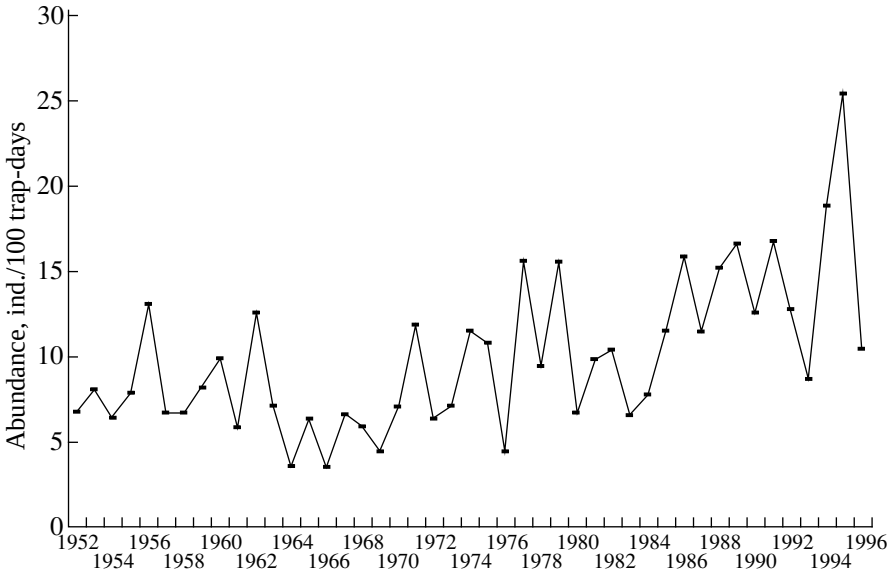

Fig. 2. Long-term dynamics of rodent abundance in park forests (according to the data of the city sanitary–epidemiological station).

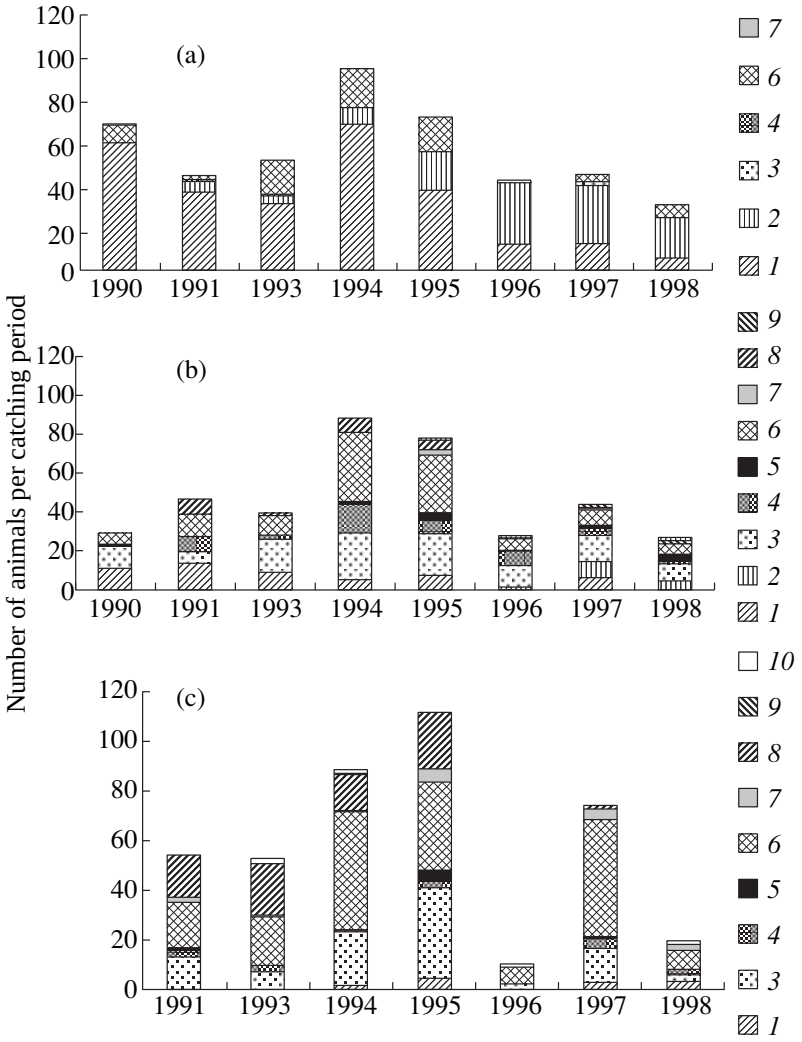

Fig. 3. Dynamics of the species composition of rodents in (a) the arboretum of the Botanical Garden, (b) park forests, and (c) the control area: (*1*) *A. agrarius*, (*2*) *A. sylvaticus*, (*3*) *C. glareolus*, (*4*) *C. rutilus*, (*5*) *C. rufocanus*, (*6*) *M. arvalis*, (*7*) *M. oeconomus*, (*8*) *M. agrestis*, (*9*) *Sicista betulina*, (*10*) *Micromys minutus*.

species occurred as single specimens (*M. oeconomus* in 1990, *C. glareolus* in 1991 and 1997, and *C. rutilus* in 1993). In the first two years of studies (the work actually began in 1989, but the data are not presented because the methods of trapping were slightly different), *A. sylvaticus* mice were never found in catches, although other studies on urbanized territories (Stepanova, 1978; Lisin, 1983, 1984, 1987: Dickman, 1987; Dickman and Doncaster, 1987, 1989; Karaseva *et al.*, 1995) provided convincing evidence for their presence in the city. However, *A. sylvaticus* appeared in the arboretum in 1991. The initially small number of these mice gradually increased, and, in the year of the depression, this species became dominant in the arboretum, accounting for almost 70% of the total rodent abundance (Fig. 3a). Owing to the presence of two mouse species, *A. agrarius* and *A. sylvaticus*, the abundance of rodents in the period of the depression was higher in the arboretum than in the other communities studied.

The increase of abundance in 1997, after the depression of 1996, was very prominent in natural communities; however, it was followed by a new decrease because of unfavorable weather in the spring of 1998 (a thick snow cover, initially rapid snow melting followed by the formation of an ice crust, and a prolonged late spring that caused a late onset of reproduction). In the years following the depression (1996–1998), *A. sylvaticus* appeared in park forests and increased in numbers; in the arboretum, this species became dominant (see above).

In the aggregate, these data allow the conclusion that the dynamics of species composition in the rodent communities of park forests and the surrounding forests are similar; some differences in quantitative ratios are mainly accounted for by rare species. As was shown previously (Chernousova, 1996), recreation is the main factor exerting an adverse effect on the size of the total small mammal community. The arboretum has a special place among the habitats studied. Being located within the city limits, it is free from the recreational load, and this fact apparently provided for a slightly higher abundance of rodents on its territory, compared to that in park forests. On the other hand, this territory is relatively small and isolated, which apparently accounted for a lower species diversity (probably due to stronger interspecific competition).

The dynamics of rodent abundance in the city and in the surrounding forests are similar, but population depression in natural communities is deeper. In the urban environment, the abundance of rodents is always maintained at a relatively high level due to the appearance of species that are atypical for the natural communities. This fact deserves attention in view of the increasing risk of TBE in the region, as a high abundance of rodents may provide for the maintenance of a stable TBE focus in the city.

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