

# Specific Features of the Dynamics of Murine Rodent Communities under the Effects of Urbanization:

## 2. Maintenance of Population Size

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**Abstract**—The reproduction dynamics of nonsynanthropic rodents living in urbanized areas was compared with that of rodents from natural communities. The number of females in a community and the number of embryos and placental spots per female were estimated. The mechanisms providing for the maintenance of population size were different in different habitats. In particular, the urban communities of murine rodents proved to have a higher reproductive potential.

*Key words:* rodents, reproduction, dynamics, urbanization.

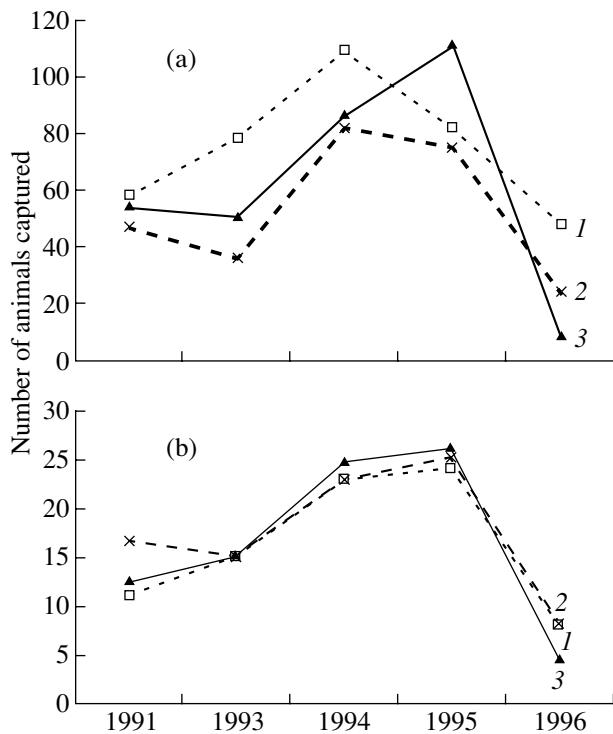
It is now evident that urbanization, which is an important aspect of the anthropogenic impact on ecosystems, creates conditions that accelerate the evolution of communities. Communities of small mammals such as rodents are necessary components of many ecosystems; however, these animals may sometimes be an epidemiological hazard. In the first part of my work (Chernousova, 2001), I noted that tick-borne encephalitis has become a serious problem for the city of Yekaterinburg and the entire region. Rodents, as well as birds, are known to serve as hosts for nymphs of ticks, which are vectors of encephalitis.

Studies on the dynamics of species composition (Chernousova, 2001) demonstrated that the main species constituting the communities of murine rodents in park forests of Yekaterinburg are voles of the genera *Clethrionomys* (mainly, the bank vole) and *Microtus* (mainly the common vole). Within the city, species of the genus *Apodemus* dominate. Population dynamics of these rodents are characterized by the prevalence of different species in different years. However, if we regard park forests as the foci of epizootics, then asynchronous oscillations of the numbers of different species lead to pathogen transmission from one host species to another, the one that is dominant in the given year. Therefore, if the numbers of one species decrease, another species takes up the infection and becomes its vector and carrier. It is known that most endoparasites of voles of the genera *Clethrionomys* and *Microtus* and mice of the genus *Apodemus* are common to all the three genera (Yushkov, 1995). Thus, infection and invasion are links within the rodent community that allow us to consider these rodents as a single unit of an ecosystem (small rodents). Within this unit, all species

are interrelated through both common habitat and common infections and parasites.

On the basis of this unifying principle, I regarded different rodent species living in the same area as a single community and estimated its reproduction as a whole; i.e., all reproducing females were pooled, and their fecundity was calculated as a mean value for the entire community. I believe that this approach is justified. Indeed, it is common practice to estimate the average birthrate even in human communities, where this parameter is determined by social rather than biological factors. For example, consider a settlement in Central Asia where the population consists of representatives of various ethnic and social groups differing from one another in their approaches to family planning. The average number of children per family may vary from one to twelve (or even more) in different groups. However, estimation of an average population growth in a given area or settlement may be considered acceptable. The differences in birthrate between the aforementioned genera are even smaller: the rodents of the genera *Clethrionomys*, *Microtus*, and *Apodemus* typically have three to four litters with an average of five to six, five to six, and five to seven newborns per litter, respectively (Sokolov, 1977). This led me to pool the data on different species and genera and deal with the average individual female fecundity in the community and related parameters.

As I noted before (Chernousova, 2001), the considerable population depression that periodically occurs in natural communities has not been observed in the city. The numbers of dominant species vary synchronously, and the total rodent population size is maintained due to an increase in the numbers of species of the genus *Apo-*



**Fig. 1.** Population dynamics of (a) abundant species of rodents and (b) reproducing females: (1) the arboretum, (2) park forests, and (3) the natural control.

*demus*, which are untypical of coniferous forests at this latitude.

It would undoubtedly be interesting to know the mechanisms that maintain the size of rodent communities and ensure their existence in the disturbed urban environment. In contrast to most studies, which usually concern the dynamics of one species (Andrzejewski *et al.*, 1978; Babinska-Werka *et al.*, 1979; Liro, 1985) or the distribution of species among different biotopes in a city (Stepanova, 1978; Karaseva *et al.*, 1995; Dickman, 1987; Dickman and Doncaster, 1987, 1989), my study dealt with the dynamics of several abundant species. The contributions of each species to the total size and reproduction of the rodent community may be different in different years. The purpose of this study was to clarify the mechanisms providing for the maintenance of the murine rodent community as a whole at different stages of population dynamics in an urban environment as compared to natural communities.

## MATERIAL AND METHODS

Reproductive potential was studied in the communities of murine rodents in five park forests on the outskirts of Yekaterinburg, which, in places, are only separated from surrounding forests by a road. The park forests are located in a circle around the city and experience a considerable recreational load. In the built-up area, the arboretum of the Botanical Garden of the Ural

Division of the Russian Academy of Sciences was studied. The arboretum is a section of a pine forest with well-developed lower layers; it is closed to visitors. On the one hand, this area is located within the city and is exposed to all kinds of emissions; on the other hand, it does not suffer from recreational load. The urban environment was compared with the environment of a natural community, which served as a control. A detailed description of the species compositions of all the communities studied and a map of the city showing the study areas were published earlier (Chernousova, 1996). I found that the species *Microtus arvalis*, *Apodemus agrarius*, and *Clethrionomys glareolus* were dominant in the city; *M. agrestis* was also abundant in some years. *Clethrionomys rutilus* was abundant in the north-eastern park forest in some years, and *A. uralensis* has recently become dominant in the arboretum of the Botanical Garden.

The rodents were captured by the standard trap-line method in late June and July. The details of trap arrangement and capturing were described earlier (Chernousova, 1996). The annual amount of work at each sampling point was 300 trap days.

The data on park forests were pooled, and all parameters were calculated per average park forest. Thus, we will hereinafter consider three habitats: an average park forest, the Botanical Garden, and the control area. The changes in the average female fecundity from year to year and the corresponding population dynamics were estimated in each area. For this purpose, I estimated the average fecundity of all reproducing females of the abundant species that determined the size of the total community in a given year. The mean numbers of embryos and placental spots per female were calculated, and the total and relative numbers of reproducing females (average numbers among ten animals) of abundant rodent species were estimated. Deviations from the actual total number were insignificant, because only in some years were there an additional one to four reproducing females of rare species, such as the harvest mouse and the birch mouse.

## RESULTS AND DISCUSSION

The estimation of population dynamics yielded the following results. During the study period (six years), I observed a population increase followed by a peak and then a depression. This depression occurred throughout the region in 1996 and was less pronounced in the city and on the outskirts than in the surrounding forests (Fig. 1a). The peaks of rodent abundance in individual habitats did not coincide. The peak occurred in 1995 in the natural community; in different park forests of the city, the peak was observed in 1994 and 1995 (the average numbers for all park forests and the Botanical Garden peaked in 1994; i.e., the peak shifted relative to the control). The numbers of rodents in the Botanical Garden were greater than in the park forests and the control community, whereas their numbers in the latter two

types of communities were almost the same (for more detail, see Chernousova, 2001).

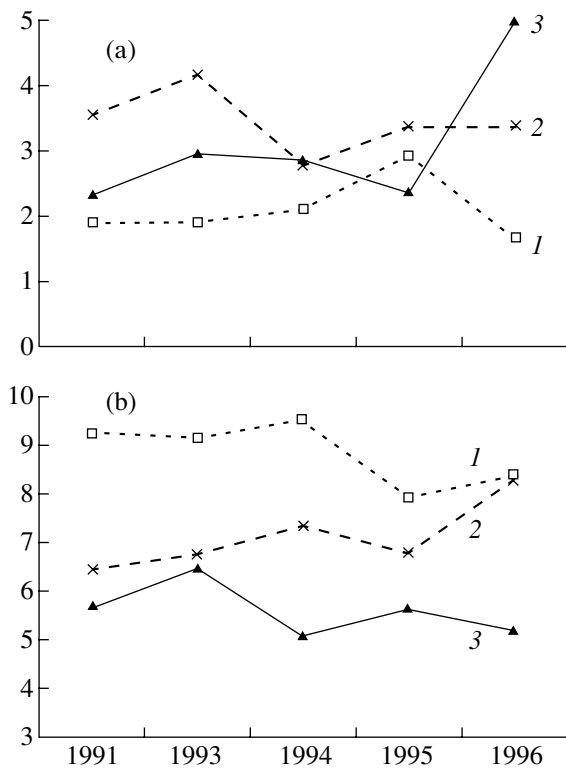
The total numbers of reproducing females in different communities were almost the same in each year (Fig. 1b); however, these numbers considerably changed from year to year, the differences between the peak and depression years being statistically significant ( $\chi^2$  was higher than 11 in all cases).

The average relative number of reproducing females among ten animals of a given community exhibited another dynamics (Fig. 2a). In all years, the relative number of reproducing females was minimum in the Botanical Garden. Conversely, the relative numbers of reproducing females in park forests were somewhat greater than in the control except for the peak and depression years, whereas the total number of rodents in the park forests and the control community were almost the same.

Female fecundity had no distinct dynamics in any habitat studied (Fig. 2b). The smallest variations in this parameter from year to year were observed in the Botanical Garden. Although the values of fecundity in different years did not significantly differ from one another in this habitat, a trend toward a higher fecundity was observed in the year of the peak (1994). In the park forests, female fecundity was significantly higher in the depression year (1996), when the numbers of rodents was 3.5 times lower than in the peak year. Although the number of rodents in the control habitat decreased in the year of the depression considerably more drastically than in the city (by a factor of 10 as compared to the peak), the average female fecundity in this year was almost the same as in other years in this habitat. Only in 1993, before an increase in population size, was the average female fecundity in the control habitat significantly higher than both in the next year and in the year of the depression.

Figure 2b shows data on the fecundity of females from different habitats studied. As is seen from the figure, the fecundity of females from the arboretum was the highest in all years except for the year of the depression, when it was the same as in the park forests. At all stages of population dynamics, the female fecundity in the control rodent community was the lowest and that in park-forest communities was intermediate between the corresponding values in the control and in the arboretum rodent community. The differences between these values were always significant, except for the years 1991 and 1993, when the fecundity in the park-forest communities did not differ significantly from the control value, and 1996, when it did not differ from that in the rodent community of the Botanical Garden.

Taking into account that the number of females in the habitats studied were different, the estimations of fecundity do not adequately reflect the communities' reproductive potentials. To estimate the reproductive potential of each community at least approximately, I calculated an index analogous to the gross number of



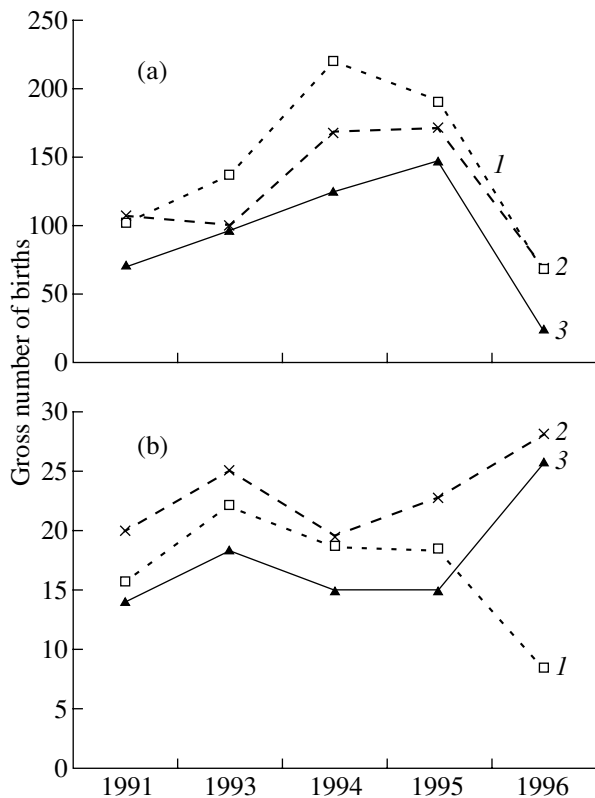
**Fig. 2.** Dynamics of (a) the relative number of reproducing females (per ten animals of the community) and (b) the average individual fecundity (the number of embryos and placental spots per female). Designations 1–3 are the same as in Fig. 1.

births ( $\sum m_x$ ) usually used for game animals (Pianka, 1981). The potential gross number of births for all reproductive females captured was calculated as follows:

$$\sum m_x = m_x N_F,$$

where  $m_x$  is the average individual fecundity and  $N_F$  is the number of reproductive females in the community.

This parameter was the highest in the rodent community of the arboretum of the Botanical Garden (Fig. 3a) and the lowest in the control (except for the years of depression and low population size). The variation of the potential gross number of births in the small-rodent communities of the park forests was intermediate between those in the control and the rodent community of the arboretum. During the entire study period, the gross number of births was the greatest in the years of maximum population size and the smallest in the year of the depression in all communities. Estimation of the relative (calculated for ten animals) potential gross number of births (birthrate) yielded opposite results (Fig. 3b). First, the gross birthrate was the lowest in the years of large population size and the highest in the year of the depression (except for the rodent community of the arboretum). Second, in con-



**Fig. 3.** Potential gross number of births (a) for all reproducing females and (b) calculated per ten animals of the community. Designations 1–3 are the same as in Fig. 1.

trast to the total gross number of births, which was higher in the arboretum, the relative birthrate (per ten animals) under urban conditions was higher in the park forests in all years.

Thus, the gross number of births in the control habitat (a nonurbanized area) was considerably smaller than in the urban habitats in all years except for the year of the depression, whereas the total number of rodents in the control community was practically the same as in the rodent communities of the park forests. This obviously indicates that mortality among the offspring at all developmental stages is higher under the urban conditions. The Botanical Garden is surrounded by industrial buildings, houses, and roads; therefore, it is exposed to industrial emissions and automobile exhaust to a higher degree than other habitats studied. However, the recreational load is completely absent there. The greater numbers of rodents in the Botanical Garden than in the park forests and the natural forest, along with the higher potential gross number of births, indicate that atmospheric pollution with industrial and exhaust emissions is not decisive for the survival of rodents. Therefore, the results of this work agree with the idea of Polish zoologists (Babinska-Werka *et al.*, 1979) that anxiety (which is directly related to recreation), rather than environmental pollution, is the leading factor affecting the abundance of small mammals.

The data obtained make it possible to put forward a hypothesis concerning the mechanisms providing for the maintenance of population size under different conditions. Although the total number of rodents in the control area and the park forests were almost the same, the rodent communities used different reproduction strategies in these habitats. The relative number of females in the community, the gross number of births, and the gross birthrate in the control habitat were lower than in the city park forests. Under different urban conditions, different components of the index  $\sum m_x$  are responsible for the maintenance of the rodent community; these are components  $N_F$  and  $m_x$  in the park forests and the arboretum of the Botanical Garden, respectively. In natural communities, population size is apparently maintained owing to a lower mortality among young animals, accounted for by a lower anxiety, compared to the rodent communities of park forests. In the park forests, where animals are under more stressful conditions because of the anxiety factor (Babinska-Werka *et al.*, 1979), female fecundity is significantly lower than in the Botanical Garden. However, since the relative number of females is higher, the potential total amount of the offspring in these communities is higher than in the control habitat, although it is still less than in the Botanical Garden. Thus, urban communities of murine rodents have a higher potential for maintaining their population size.

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#### REFERENCES

- Andrzejewski, R., Babinska-Werka, J., Gliwicz, J., and Goszczynski, J., Synurbanization Processes in Population of *Apodemus agrarius*: 1. Characteristics of Populations in an Urbanization Gradient, *Acta Theriol.*, 1978, vol. 23, pp. 341–358.
- Babinska-Werka, J., Gliwicz, J., and Goszczynski, J., Synurbanization Processes in Population of *Apodemus agrarius*: 2. Habitats of the Striped Field Mouse in Town, *Acta Theriol.*, 1979, vol. 24, pp. 405–415.
- Chernousova, N.F., Effect of Urbanization on the Communities of Small Mammals in Park–Forests in a Large Industrial Center, *Ekologiya*, 1996, vol. 27, no. 4, pp. 286–292.
- Chernousova, N.F., Specific Features of the Dynamics of Murine Rodent Communities under the Effects of Urbanization: 1. Dynamics of Species Composition and Abundance, *Ekologiya*, 2001, vol. 32, no. 3, pp. 186–192.
- Dickman, C.R., Habitat Fragmentation and Vertebrate Species in an Urban Environment, *J. Appl. Ecol.*, 1987, vol. 24, pp. 337–351.

- Dickman, C.R. and Doncaster, C.P., The Ecology of Small Mammals in Urban Habitats: 1. Populations in a Patchy Environment, *J. Anim. Ecol.*, 1987, vol. 56, pp. 629–640.
- Dickman, C.R. and Doncaster, C.P., The Ecology of Small Mammals in Urban Habitats: 2. Demography and Dispersal, *J. Anim. Ecol.*, 1989, vol. 58, pp. 119–127.
- Karaseva, E.V., Kulikov, V.F., Melkova, V.K., Tikhonova, G.N., Stepanova, N.V., Samoilo, B.L., and Molchanov, A.E., Ecological Forms of Mammals in a Large City: An Example of Moscow, in *Ekologicheskie issledovaniya v Moskve i Moskovskoi oblasti* (Ecological Studies in the City of Moscow and Moscow Oblast), Moscow: Nauka, 1995, pp. 78–96.
- Liro, A., Variation in Weight of Body and Internal Organs of the Field Mouse in Gradient of Urban Habitats, *Acta Theriol.*, 1985, vol. 30, pp. 359–377.
- Pianka, E.R., *Evolutionary Ecology*, New York: Harper and Row, 1978. Translated under the title *Evolutsionnaya ekologiya*, Moscow: Mir, 1981.
- Sokolov, V.E., *Sistematika mlekopitayushchikh. Otryady zaitseobraznykh, gryzunov* (Systematics of Mammals: Lagomorphs and Rodents), Moscow: Vysshaya Shkola, 1977.
- Stepanova, N.V., Distribution of Small Rodents over the Landscaped Territories of Moscow, in *Rastitel'nost' i zhivotnoe naselenie Moskvy i Podmoskov'ya* (The Flora and Fauna of the City of Moscow and Moscow Region), Moscow: Nauka, 1978, pp. 30–32.
- Yushkov, V.F., *Fauna Evropeiskogo Severo-Vostoka* (The Fauna of Northeastern Europe), vol. 3: *Gel'minty mlekopitayushchikh* (Helminths of Mammals), St. Petersburg: Nauka, 1995.