

URBAN MAMMAL FAUNA UNDER CONDITIONS OF A LARGE CITY (ON THE EXAMPLE OF ULYANOVSK, MIDDLE VOLGA REGION)

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Urban mammal fauna under conditions of a large city (on the example of Ulyanovsk, Middle Volga Region). — E. Artemieva. — In this work, the topographic features of the spatial pattern of biodiversity of the urban fauna in general in the city are revealed: the number of urban fauna species has a maximum in the southern part of the city and a minimum in the western part. The mammal fauna as a component of urban fauna in general exhibits greater plasticity and adaptability in relation to humans compared to other groups of biota, for example, the insect fauna and avifauna. The urban mammal fauna in Ulyanovsk has historically formed due to the penetration of representatives of various faunal complexes that inhabit the region into the city area and its vicinities: (1) floodplain species associated with the river Sviyaga and its tributaries, 36.17%; (2) forest species living in pine-deciduous, deciduous-pine, and taiga forests, 46.81%; (3) upland-steppe species associated with Cretaceous landscapes of the right bank, 6.38%; (4) steppe species, including mammals of the left bank, common for the native feather grass–fescue steppes, 6.38%. Some animal species have remained in the city and in the region due to their spread by humans—introduced species and species kept in fur farms (10.64%). Synanthropic species are associated with human settlements (4.26%). The occurrence of species in different zones of the city (right bank and left bank) and habitats with an increase in the level of urbanization and a decrease in species diversity (1–5) are as follows: (1) green zones—parks and squares with woody vegetation, 31 species; (2) floodplain of the river Sviyaga within the city, 24 species; (3) summer cottages within the city, 15 species; (4) private sector with one-storey buildings, 5 species; (5) multi-storey buildings, 4 species. In general, in an urban environment, mammal species that coexist with humans make up 66.19% of the total number of mammal species in the region. At the same time, the number of rare mammal species listed in the regional Red Book is 12.68%. Thus, when conservation measures for the protection of animal habitats within the urban environment are observed, most species are able to maintain stable populations.

Key words: urban fauna, mammals, geoactive zones, population, Middle Volga Region.

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Introduction

Urban fauna is one of the most important zoological and ecological objects, the history of which is associated with the knowledge and development of the region's territory, its natural complexes, formation, and protection (Godlevskaya *et al.* 2006; Bradley & Altizer 2007; Schell *et al.* 2021). It is known that the preservation of urban fauna elements of different eras, their dynamics, changes in the entire ecozoic complex, which occur naturally or due to anthropogenic influence, reflect the state of separate landscapes and serve as a model of methodological approaches to understand the processes of development of natural complexes. The latter include changes in the nature of animal migrations, formation of habitats in natural environments and under the influence of human economic activity, allocation of reference zones for natural zonation, development of measures and ensuring the rational use of wildlife resources (Karaseva *et al.* 1990; Klausnitzer 1990; Kruskop 2002; Luniak 2004; Menkhorst & Loyn 2011).

This research topic and study are interesting and relevant, since urban fauna is an excellent indicator of human impact on natural complexes and their enclosing landscapes (Pickett *et al.* 2001; Lowry *et al.* 2013; Parry *et al.* 2014). The urban mammal fauna is of great interest as an indicator of the state of the environment (Tatarinov 1973; DeStefano & DeGraaf 2003; Savitsky *et al.* 2005; Gallo *et al.* 2017). Invasive species also periodically appear in the urban fauna as an indicator of its transformation, often of anthropogenic nature (Zorenko & Leontyeva 2003; Bulakhov & Pakhomov

2006; Godlevskaya *et al.* 2006). The most poorly studied aspects of the urban fauna include the compatibility of species with humans, presence of rare mammal species and their adaptability to living in a large city and protection, death of mammals on highways and its prevention, formation of urbocoenoses in megapolises, and protection of the population from rodents that carry pathogens of animal and human diseases (Makarov 2011). Similar studies of the urban fauna were carried out for the megalopolis of Kyiv in Ukraine by I. V. Zagorodniuk, the results of which showed a significant impoverishment and disappearance of native species, mainly predators and ungulates, and also that bats and murine rodents constitute the basis of the urban mammal fauna (Zagorodniuk 2003).

The aim of the present work is to reveal the current composition of the urban fauna of mammals in the city of Ulyanovsk and to assess its changes under the influence of human activity.

Materials and Methods

The territory of the city of Ulyanovsk has right-bank and left-bank parts, which are divided by the Volga River (Kuibyshev reservoir) (Stupishin 1964; Dedkov 1978). The following mammalian habitats were identified according to an increasing level of urbanization:

- (1) green zones such as parks and squares with woody vegetation;
- (2) the floodplain of the river Sviyaga within the city;
- (3) summer cottages within the city;
- (4) private sector with one-storey buildings;
- (5) multi-storey buildings.

In the course of the study, the methods of search and identification of tracks on snow, wet soil, and mud were used (summer and winter counts on tracks). The tracks on the routes were determined using literature sources; they were photographed, measurements were recorded, etc. (Rukovitsky 1984; Karjakin 1991; Formozov 2006, 2012). The following methods of detecting and counting mammals were used: route censuses and visual observations, trapping grooves, inspection of attics of one-storey and multi-storey buildings, traces of vital activity, droppings, and roadkill.

Shelters of mammals were also taken into account; camera traps were installed in places of accumulation and on routes and paths of mammals, recordings from surveillance cameras on highways were analyzed. Both direct and indirect collection of materials on mammals was carried out, including information from social networks, polls on blogs and forums, open Internet sources, media and population survey data (OSINT).

Direct and indirect observations and counts of mammals on the routes were carried out; the finds were recorded using camera and video camera. Burrows were also taken into account on the routes, photographs were taken, and measurements were determined. In addition to burrows, all traces of vital activity encountered were considered and determined: remains of molted wool, droppings and pellets, food remains, marks on individual sites and trails; for these purposes, methods of photography and video recording were used.

The capture and identification of murine rodents was carried out with Gero traps according to the standard technique (Karaseva & Telitsyna 1996; Bystrakova *et al.* 2008; Ravkin & Livanov 2008; Adamovich *et al.* 2016). The total volume of counting operations was 107 trap-days (23 trap-lines). The data on bats were processed using the works of Godlevskaya (2012; Godlevskaya *et al.* 2009) and Romashin (2015).

To identify bat species, a guide was used, forearm length was measured, and the venation of the wing was considered at light (Popov 1960; Dietz & Helvesen 2004).

For the analysis, we used data averaged over the years without taking into account the annual fluctuations in the abundance of rodents in separate habitats. Bats were counted in attics during wintering and in colonies in summer. We used survey data by M. A. Korolkov, F. M. Zeleev, S. G. Zeleeva, O. G. Saltykova, A. N. Moskvichev, M. M. Shashkin, G. V. Piliugina, M. V. Kalagin, and others (Moskvichev 2017).

The data of observations and counts of mammals are given in Table 1.

Table 1. Methods of observation and registration of mammals in the territory of the city and in its vicinities

Таблиця 1. Методи спостереження та обліку ссавців на території міста і його околиць

Years	Number of summer and winter counts by footprints	Number of direct and indirect observations on routes	Number of recorded burrows, traces of vital activity: wool remains, droppings, pellets, etc.	Number of inspection of attics of single-storey and multi-storey buildings	Number of corpses on roads (road-kill)	Number of photo and video registrations
Orders*	In La Ro Ca Ar	In La Ro Ca Ar	In Ch La Ro Ca Ar	Ch Ca	In La Ro Ca Ar	In Ch Ro Ca Ar
1986–1999	1	5	4	8	7	2
2000–2010	3	6	2	3	4	7
2011	7	23	32	37	5	13
2012	5	5	26	24	3	1
2013	14	19	21	21	6	8
2014	19	12	16	15	1	5
2015	8	7	9	19	2	2
2016	10	9	5	10	7	4
2017	12	15	5	11	5	6
2018	7	3	20	5	6	3
2019	15	5	6	3	4	5
2020	4	20	28	4	2	3
2021	2	3	5	2	6	4
Total	106	132	179	162	58	63

* Acronyms of orders: Insectivora, Chiroptera, Lagomorpha, Rodentia, Carnivora, Artiodactyla.

When characterizing the mammal fauna of parks, the ‘rule of thirds’ or ‘rule of three’ was used, that is three key typical mammal species common for the mammal fauna of each park were identified (Zagorodniuk 2003). In addition, the uniqueness of the biodiversity of each park was assessed by summing the number of species of each mammalian order (Table 2).

The research period episodically covers the years 1986 to 1999 and 2000 to 2010, but mainly the period from 2011 to 2021. Special trapping methods of mammals were not applied and the studied material was not deposited in collections. Dead mammals were counted on routes (highways and trails). Photos were used to illustrate the work. The catches and observations included rare and endangered species listed in the red data books of the Russian Federation and of the Ulyanovsk Region (2015), which are indicated in the text with asterisk (*); the numbering is continuous. The taxonomy is given according to Pavlinov and Lisovsky (2012) and Zagorodniuk and Emelyanov (2012).

A brief history of the study of vertebrates in the region

Zoological research in the territory occupied by the modern Ulyanovsk Region of Russia started in 1768 by the academic expedition of P. S. Pallas and I. I. Lepekhin. The researchers crossed the Simbirsk province of the Kazan Governorate from the side of the Penza Province near the village of Godaykino (now Godaykino, Bazarnosyzgan District, Ulyanovsk Region) in September 1768. In the winter and spring of 1768–1769, the expedition took place in Simbirsk. Scientists studied the fauna of the city's environs. In the spring of 1769, they left Simbirsk to Samara and Syzran. The information they collected was the first data on the flora and fauna of the investigated territory. In Ulyanovsk Region, vertebrate species new to science were discovered and described, including the thorn, beluga, blue tit, harvest mouse, and field mouse. In addition, I. I. Lepekhin observed here an ordinary lentil, which was later described by P. S. Pallas, indicating the territory of ‘Volga and Samara’ (Pallas 1809; Pallas 1811–1814).

The next stage in the study of the fauna of the Simbirsk Province was the research carried out by the famous zoologist and professor of Kazan University E. A. Eversmann. He studied in detail the fauna of the Orenburg Province, and he gave information about the fauna of the Ulyanovsk Re-

gion in his work *Natural History of the Orenburg Region* (Eversmann 1866). His student M. N. Bogdanov, in 1871, based on his ten-years-long research on the Volga region's fauna, published the book *Birds and Animals of the Chernozem Zone of Russia and the Valley of the Middle and Lower Volga*, which contains a complete summary of the avifauna and mammal fauna as of the mid-19th century. He was born in the village of Russkaya Bekshanka, Syzran District, Simbirsk Province (now it is the territory of Baryshsky District, Ulyanovsk Region), where he collected during 1860–1866 a number of factual materials, which is reflected in this book (Severtsov 1877).

According to the research carried out in the Surye Region by B. M. Zhitkov in 1898, the first full-fledged summary on the mammal fauna of the Simbirsk province was published as *Materials on the Mammal Fauna of the Simbirsk Province* (Zhitkov 1898). The childhood, youth and student years of the famous Russian zoologist and game expert B. M. Zhitkov passed nearby to the village of Mikhailovka, Ardatovsky District, Simbirsk Province (currently the territory of the Republic of Mordovia). In 1919–1921, together with S. A. Buturlin (the estate of the Buturlins was located in the villages of Lava and Bely Klyuch of Karsun District (now Sursky District, Ulyanovsk Region), where they jointly conducted research. In the same period, the Sura expedition was organized and excursed to the city of Karsun, the city of Alatyr, and explored the floodplain of the Barysh River. In the city of Alatyr, they founded the first and only Institute of Natural Science in the country. In 1926, the Society for the Study of the Ulyanovsk Region published its only collection, in which the work of the game expert A. N. Lentovsky about game animals of the Inzensky Region with information on fishes, birds, and mammals was published.

From the early 1930s to the 1970s–1980s, the fauna of the Middle Volga Region was studied on the basis of the Ulyanovsk State Pedagogical University (USPU) (Abrakhina *et al.* 1993). Over the past ten years, there have been changes in the species composition of the vertebrate fauna of the Middle Volga Region and new species have been found in the region's fauna. Some species were excluded from the faunal list, since their findings were not confirmed or their findings are highly dubious due to the lack of supporting facts (for example, the common dormouse). On the other hand, the list of species was supplemented with the brown long-eared bat, northern bat, sibling vole, southern birch mouse, corsac fox, and stone marten (Shemyatikhina 2010; Shemyatikhina *et al.* 2010a-b; Moskvichev *et al.* 2011).

At present, 71 mammal species are found in the region, of which 18 species are rare and endangered and listed in the red data books of the Russian Federation and of the Ulyanovsk Region (Artemieva *et al.* 2015): water shrew, Russian desman, whiskered bat, Leisler's bat, common pipistrelle, Kuhl's pipistrelle, northern bat, serotine bat, spotted souslik, fat dormouse, northern birch mouse, southern birch mouse, great jerboa, greater mole-rat, *Allocricetulus eversmanni*, *Lagurus lagurus*, brown bear, otter; 9 species are included into the orange list (Appendix 3, species requiring special attention): Brandt's bat, Nathusius' pipistrelle, parti-coloured bat, russet souslik, steppe marmot, forest dormouse, stoat, stone marten, lynx; 1 species is considered extinct (European mink) (Chernousova & Tolkachev 2011; Stolyarova & Vovkotech 2013). A summary of vertebrates of the region is given in the work by I. B. Abrakhina with colleagues (Abrakhina *et al.* 1993); for the city of Ulyanovsk such works are relevant. At present, information on the mammal fauna of the city of Ulyanovsk is scattered, fragmentary, and requires generalization and analysis (Borodin 2001; Korolkov *et al.* 2001; Fomina 2007; Moskvichev 2017). There are no special works on the urban fauna of mammals; most of the above works are related and they cover the region as a whole.

Results

Current species composition of the urban mammal fauna

For the period 1986–2021, 47 mammal species were found in the territory of Ulyanovsk, of including 9 rare and endangered species listed in the red data books of the Russian Federation and of the Ulyanovsk Region (Artemieva *et al.* 2015).

Order Insectivora

1. Northern white-breasted hedgehog *Erinaceus roumanicus* Barrett-Hamilton, 1900. A common species found in green zones of the city (parks), in the Ulyanovsk Regional Arboretum, in summer cottages (near the village of Karamzin), in private sectors (Zheleznodorozhny district of the city) and in the floodplain of the river Sviyaga. Based on counting of tracks in the morning, finding corpses on the roads and visual counting, its number is stable and rather high (four meetings per evening in July 2012). Hedgehog families—females with calves—are regularly observed. Dates of meetings (Moskvichev 2017): 2000–2004, 25.04.2011, 25.06.2015, and 09.06.2016. The total number of individuals encountered was 8 specimens.

2. Common mole *Talpa europaea* Linnaeus, 1758. A non-abundant species. In June–July occurs regularly in city parks and summer cottages (Parus and Solnyshko garden communities). The total number is 5 finds, including molehills on the surface. These findings are dated to 2000–2008.

3. Lesser white-toothed shrew *Crocidura suaveolens* Pallas, 1811. A rare synanthropic species. Occurs along the Volga slope, which is a steep slope of the right bank of the Kuibyshev Reservoir within the city, on the right bank of the city of Ulyanovsk, in a residential area. During the entire observation period, 2 animals were caught, 6 animals were recorded (Moskvichev 2017): winter 1991–1992, 28.06.1994, 24.11.1998, and 2005. Occurs in undeveloped areas, in the private sector, and in industrial zones. The right-bank part of the city (and the whole of the Ulyanovsk Region) differs from the left-bank (Trans-Volga): the right-bank part is raised, the bank is steep and clayey, whereas the left-bank part is flat, the bank is low and sandy, and there is a natural zoogeographic border of the species along the line of the Kuibyshev Reservoir.

4. Water shrew *Neomys fodiens* Pennant, 1771*. A rare species listed in the Red Book of Ulyanovsk Region (category 4) (2015). Visually recorded during 2001–2008 in the floodplain of the river Sviyaga (1 specimen), in the territory of Ulyanovsk Water Channel (1 specimen), at the treatment facilities in the southern part of the city (1 specimen), and a corpse was found in the Black Lake Ecopark.

5. Common shrew *Sorex* (gr. 'araneus') *araneus* Linnaeus, 1758. An abundant species. It inhabits sown fields (6 specimens), meadows (8 specimens), wastelands (2 specimens), in parks (13 specimens), etc. During the entire observation period, 29 animals were counted (in 2001–2006). On 11.11.2011, a dead animal was found in the snow in the western part of the city.

6. Pygmy shrew *Sorex* (gr. 'minutus') *minutus* Linnaeus, 1766. A non-abundant species found in parks on the left bank of the city of Ulyanovsk. During the entire observation period, 6 animals were counted (in 2001–2006).

Order Chiroptera (materials collected by V. A. Bezrukov)

7. Pond bat *Myotis dasycneme* Boie, 1825. A common species. Inhabits buildings in the floodplain of the river Sviyaga.

8. Daubenton's bat *Myotis daubentonii* Kuhl, 1817. A common species. Recorded in parks of the riverine and southern parts of the city.

9. Brandt's bat *Myotis brandtii* Eversmann, 1845*. Found by V. A. Bezrukov (pers. comm.). A rare species listed in the Red Data Book of Ulyanovsk Region (Appendix 3) (Artemieva *et al.* 2015). Within the city, it is rarely found in buildings, forested parks along the northern (right-bank) and eastern (left-bank) outskirts of the city.

10. Common noctule *Nyctalus noctula* Schreber, 1774. A non-abundant species. Inhabits parks of the riverine and eastern parts of the city and Paltsinsky Island. Wintering noctules (2–3 specimens) were observed in the attic and between window frames in the sports hall of the USPU (November 1986–1987).

11. Nathusius' pipistrelle *Pipistrellus nathusii* Keiserling et Blasius, 1839*. A rare species listed in the Red Book of Ulyanovsk Region (Appendix 3). Inhabits parks of the riverine, northern, southern, and eastern parts of the city. Five to seven specimens were encountered during 2001–2008.

12. Kuhl's pipistrelle *Pipistrellus kuhli* Kuhl, 1817*. A rare species listed in the Red Book of Ulyanovsk Region (2015). Discovered during repair works in one of the residential buildings (O. G. Saltykova, pers. comm.). A sedentary, wintering, and synanthropic species. Known for a single record on 29.09.2016.

13. Parti-coloured bat *Vespertilio murinus* Linnaeus, 1758*. A rare species listed in the Red Data Book of Ulyanovsk Region (Appendix 3) (Artemieva *et al.* 2015). In August 2006, one individual was found in an old nesting box at the edge of a pine forest in the territory of Bogdanovskiy Zakaznik. Inhabits attics of houses and city parks. Hibernates in buildings. On 8.02.2016, a wintering male was found at dusk on the wall at the entrance of a multi-storey building in the central part of the city. In late March 2017, one wintering bat was found at the entrance of a residential building (G. V. Piliugina, pers. comm.). On 13.09.2017, one individual recorded at the edge of a forest in the Zavolzhsy District of the city (left-bank) (M. V. Kalagin, pers. comm.).

Order Lagomorpha

14. Mountain hare *Lepus timidus* Linnaeus, 1758. A common species. Inhabits the forest edge, fields, meadows, parks, wastelands, and the Volga slope. Also enters gardens in winter and gnaws the bark of fruit trees. On 20.03.2016, one individual was recorded in a pine-mixed forest on May Mountain in the Zavolzhsy District of the city (left-bank). On 19.03.2017, one individual was recorded in the northern part of the city, in the Ulyanovsk Regional Arboretum and in the northern forest. No leverets were observed.

15. Brown hare *Lepus europaeus* Pallas, 1778. A common species. Inhabits the forest edges, fields, meadows, parks, wastelands, the Volga slope, floodplains of the rivers Seld and Sviyaga. In winter it occurs in gardens where gnaws the bark of fruit trees. Dates of meetings (Moskvichev 2017): 01.03.2013, 2014–2016; lines of footprints in the snow are often noted in winter. No leverets were observed.

Order Rodentia (non-muroid rodents)

16. Russet ground squirrel *Spermophilus* (gr. 'major') *major* Pallas, 1779*. A non-abundant species listed in the Red Data Book of Ulyanovsk Region (Appendix 3) (Artemieva *et al.* 2015). Inhabits meadows and wastelands along the western outskirts (nine individuals in surroundings of the village of Baratayevka on the right bank), the territory of Pribrezhny Park, steppe slopes along the eastern outskirts (322 individuals, left-bank), and Paltsinsky Island (50 individuals) (data from S. V. Titov, 2013–2014). Forms small, scattered settlements (Fig. 1 a). On 1.04.2010, 16.05.2010, 21.06.2012, 20.04.2013, 10.04.2014, and 15.04.2015, single specimens were found in the Trans-Volga Region. Burrows were found on 20.06.2011, 13.05.2012, 14.06.2012, 15.06.2014, 12.06.2017, and 02.08.2017 (Moskvichev 2017).

17. Garden dormouse *Eliomys quercinus* Linnaeus, 1766*. A rare species with declining abundance. Recommended for the regional red data book. Recorded in summer only once in a garden in the southern outskirts of the city, in the vicinity of Karamzin, on the right bank of the Volga River (Kuibyshev Reservoir). In the daytime, the animal feasted on berries of the buckthorn at a summer cottage. The author is aware of only one find in the surroundings of the village of Karamzin in the territory of her own dacha on 19.08.1987.

18. Fat dormouse *Myoxus glis* Linnaeus, 1766*. A very rare species. Inhabits the forest area of Victory Park and the Northern Forest Park; four individuals were recorded during 2001–2008. In the central part of the city, a young animal was found in one of the buildings in the summer of 2016 (Moskvichev 2017). On 18.06.2014, a sleeping dormouse was found in a hollow in an old poplar in a park in the northern part of the city. In many parts of the range, synanthropization of this species has been noted.

19. Red squirrel *Sciurus vulgaris* Linnaeus, 1758. Currently a common species; 200 individuals were released in the early 2000s in the Ulyanovsk Regional Arboretum, Northern Forest Park, and Victory Park (Fig. 1 b). Currently, the number of this species is estimated at 1700 individuals.

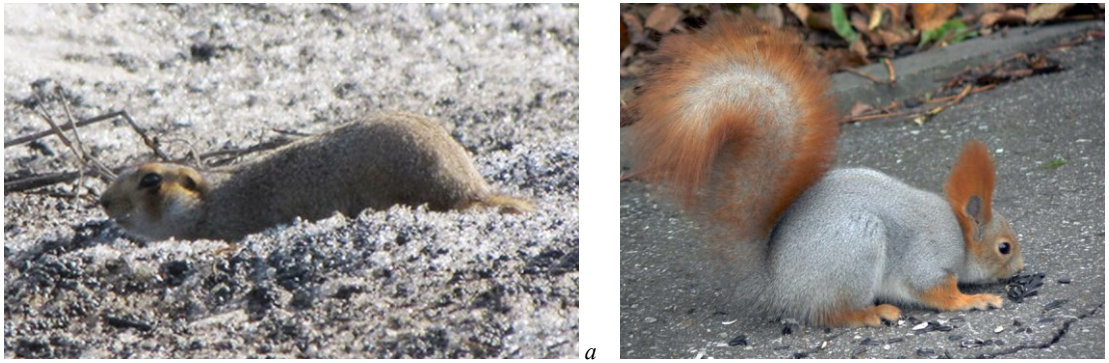


Fig. 1. Representatives of family Sciuridae in Ulyanovsk: *a*—*Spermophilus major* (photo by Sergej Titov), *b*—*Sciurus vulgaris*, form *teleutka* (photo by the author).

Рис. 1. Представники родини вивіркових в місті: *a* — ховрах рудуватий (фото Сергія Титова), *b* — вивірка звичайна, форма телеутка (фото автора).



Fig. 2. Traces of the life activity of *Castor fiber* in the city: *a*—a gnawed and felled tree, *b*—beaver droppings. Photo by the author.

Рис. 2. Сліди життєдіяльності бобра звичайного в місті: *a* — погриз і повалене дерево, *b* — послід бобра. Фото автора.

The squirrel is a relatively species in the fauna of the city, which occurred earlier only in the territory of Ulyanovsk Region. Individuals with usual red colouration of the fur are found. Another form—*teleutka*—is determined by the grey colour of the fur. On 18.11.2010, the species was recorded in the central part of the city, in a park near the building of USPU. On 26.09.2010, the red squirrel born in the home of and raised by Mikhail Shashkin was observed.

20. Eurasian beaver *Castor fiber* Linnaeus, 1758. Currently a common species. Inhabits the banks of the rivers Sviyaga and Seld within and beyond the limits of the city, along the western and southern outskirts, as well as the Black Lake Ecopark and surroundings of the villages Baratayevka and Prigorodny. Beaver settlements, burrows, above-water huts, fallen trees, gnawed trees, and droppings were noted (18.01.2009, 23.05.2013, and 26.10.2013). The species does not build dams; it fells willows, aspens, and poplars (Fig. 2 *a–b*). Animals are active both in the daytime and at night, throughout the entire year. Dates of records (Moskvichev 2017): 05.11.2012, 20.10.2013, 15.03.2014, 08.05.2014, 03.11.2014, 18.01.2015, 11.03.2015, 17.05.2015, 13.04.2016, 23.06.2016, and 26.06.2016. The abundance of this species in the city is estimated at 450 individuals.

Order Rodentia (muroid rodents)

21. Common hamster *Cricetus cricetus* Linnaeus, 1758. A non-abundant species. Inhabits meadows in the floodplain of the river Sviyaga within the city, also noted in gardens of the northern part of the city (08.07.1987, a melanistic individual), as well as in the southern outskirts of the city and at the summer cottage plot of Parus Garden Community (07.05.2017, an individual with a nor-

mal colouration). On 04.07.2016, the jaws of three individuals were found piled up in a wasteland near high voltage power line tower in the floodplain of the river Sviyaga. Presumably, they were preyed by Montagu's harrier, which nests in this area (Fig. 3 *a*). On 23.06.2021, a cat caught a young grey melanistic common hamster at an estate in the southern part of the city (suburban area of Spring Valley Garden Community).

Dates of records (Moskvichev 2017): 04.08.2012 (the body of a melanist in a meadow, near the village of Baratayevka), 11.10.2013 (a melanist in an uncleared sunflower field, floodplain of the Seld River). Meetings of melanistic individuals were recorded throughout the habitat of the common hamster (Samosh 1978). Melanistic forms have been also found among representatives of other mammal species (Zizda 2005; Malyshev 2010; Evdokimov & Sineva 2016).

22. Grey hamster *Cricetulus migratorius* Pallas, 1773. A non-abundant species, but more common than the common hamster. Inhabits gardens in the suburban area, in the right-bank part of the city. On 14.06.2020, two melanists were recorded in a brood of seven individuals in the southern part of the city (suburban area of Parus Garden Community).

23. Muskrat *Ondatra zibethicus* Linnaeus, 1766. An introduced species (native to America). In Russia, it began to acclimatize in 1929. It is noted in the region as early as 1946, when it was artificially released to water bodies of Cherdaklinsky, Staromainsky, Melekessky, and Kuzovatovsky regions (Abrakhina *et al.* 1993). The species has been noted regularly in the city since 1990. It is a common species. Occurs in meadows, in the floodplains of the Sviyaga and Seld rivers, in the Sviyaga ecological and recreational zone, in the Black Lake Ecopark, in Lake Osinovoe in the southern part of the city, near the park Primorsky and in the village of Baratayevka, as well as along the banks of various water bodies within the city and in its outskirts.

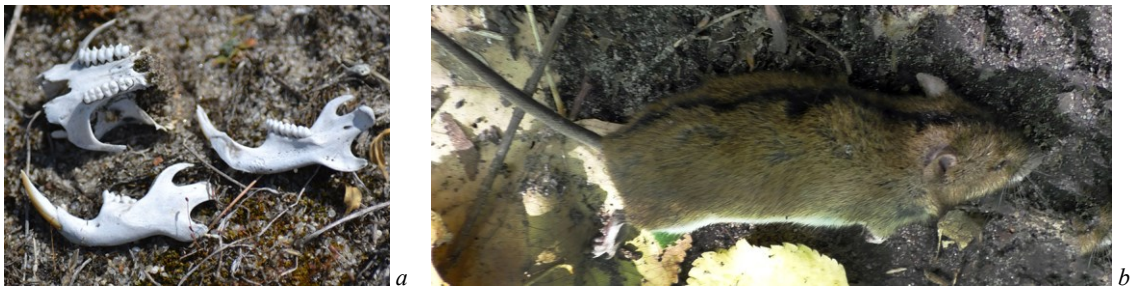


Fig. 3. Representatives of muroid rodents in the city: *a*—jaws of *Cricetus cricetus*, *b*—corpse of *Apodemus agrarius*. Photo by the author.

Рис. 3. Представники мишоподібних гризунів в місті: *a* — щелепи хом'яка звичайного, *b* — трупики польової миші. Фото автора.

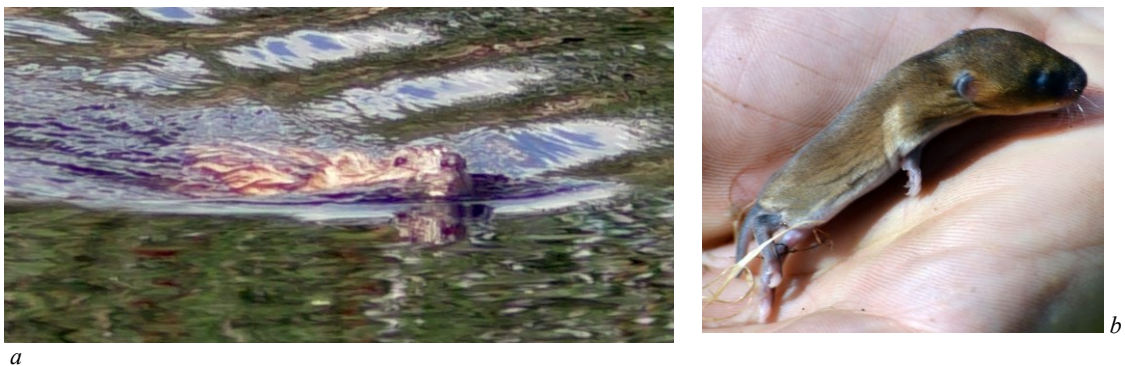


Fig. 4. Representatives of muroid rodents in the city: *a*—a swimming *Ondatra zibethicus*, *b*—a juvenile *Myodes glareolus*. Photo by the author.

Рис. 4. Представники мишоподібних в місті: *a* — пливе ондатра, *b* — дитинча нориці рудої. Фото автора.

Swimming specimens of the muskrat were recorded in an abandoned quarry near a residential multi-storey building in the western part of the city and in the Kuibyshev Reservoir near the right-bank within the city. On 12.07.2016, a swimming muskrat was photographed by the author in an artificial quarry nearby to a multi-storey building in the western part of the city, where the animal competed for food with mallard ducks. A feeding muskrat was found on 04.10.2014, and a swimming animal was recorded on 04.28.2013 in the river Sviyaga. No feeding stations were found (Fig. 4 a). Dates of records (Moskvichev. 2017): 10.04.2012, 15.04.2012, 16.05.2012, 03.04.2013, 25.03.2014, 27.04.2014, 02.05.2014, 28.05.2014, 20.06.2014, 25.06.2014, 15.08.2014, 09.04.2015, 20.05.2015, 25.05.2016, 31.08.2015, 30.04.2017, 28.04.2017, and 25.07.2017. The species' abundance in the city is estimated at 150 individuals.

24. Bank vole *Myodes glareolus* Schreber, 1780. An abundant species. Recorded in park areas of the city (23 individuals were counted), in wastelands (17 individuals were counted), and gardens (11 individuals were counted). On 19.07.2013, a bank vole nest with three juveniles was found (Fig. 4 b). On 17.03.2020, a crushed corpse of a bank vole was found under the snow on the track in the Vinnovskaya Roscha Park, where a snowmobile ride was working.

25. European water vole *Arvicola amphibius* Linnaeus, 1758. A common species. In 2000–2008, it was found to inhabit the floodplain of the river Sviyaga, the Black Lake Ecopark, the Sviyaga ecological-recreational zone, and banks of various water bodies in the western and northern parts of the city. Visually, 5 individuals were noted and numerous burrows.

26. Root vole *Alexandromys* (gr. 'oeconomus') *oeconomus* Pallas, 1776. An abundant species. In 2000–2008, it was found to inhabit city parks (15 individuals were counted) and the floodplain of the river Sviyaga (12 individuals were counted). On 27.04.2008, a corpse of a root vole was found in the northern outskirts of the city, in a mixed pine forest.

27. Southern vole *Microtus levis* Miller, 1908 form *obscurus* (Malygin *et al.* 2019). An abundant species. Inhabits park zones of the city (21 individuals were found and marked in pellets) and the floodplain of the river Sviyaga (24 individuals were counted). On 14.05.2017, a female southern vole was found in a meadow in the floodplain of the river Sviyaga. When trying to catch it, it quickly plunged into the dense, loose turf of a grassland with last year's dry grass (Fig. 5 a). On 02.05.2010, a southern vole was also found in a meadow in the floodplain, lured with a piece of dry rye bread.

28. Harvest mouse *Micromys minutus* Pallas, 1771*. A rare species with a declining abundance. Recommended for inclusion to the regional Red Data Book. Inhabits the parks of the eastern (left-bank, 'Zavolzhye') and western parts of the city; its nests (8.5 cm in diameter) were found in floodplain meadows of the river Sviyaga (Zasviyazhie, right-bank), and nearby to the village Bely Yar of Cherdaklinsky District (left-bank). The nest (10.5 cm in diameter) with five hairless mice was in high dense grass (found on 08.28.2004). The nest was located 70 cm above the soil.

29. Pygmy field mouse *Sylvaemus uralensis* Pallas, 1811. An abundant species. In 2000–2008, it was found to inhabit forested biotopes (43 individuals were counted), park zones of the city (36 individuals were counted) and the floodplain of the river Sviyaga River (39 individuals were counted).

30. Yellow-necked field mouse *Sylvaemus flavicollis* Melchior, 1834. A common species. Prefers thickets of bushes and large-fruited trees (hazel, oak, etc.) Inhabits forest parks in the northern and central parts of the city, as well as the floodplain of the river Sviyaga River, the Sviyaga ecological-recreational zone with woody vegetation and thickets of shrubs (wild rose, *Swida* sp., Tatar honeysuckle, loch silver, etc.). In parks, it prefers heaps of dead wood to nest. Seven individuals were counted during 2000–2008.

31. Striped field mouse *Apodemus agrarius* Pallas, 1771. A common species. Inhabits various biotopes such as meadows and wastelands, both with and without trees and buildings. It was recorded in park zones of the city (Fig. 3 b). On 07.07.2018, 15.07.2018, and 23.08.2019, corpses of the field mouse were found on forest paths in the Vinnovskaya Roshcha Park.

32. Eastern house mouse *Mus musculus* Linnaeus, 1758. A widespread species in the city. It occurs everywhere in park areas, near residential buildings, in summer cottages in different districts of the city and in the suburbs, as well as inside private residential buildings, apartments in multi-storey buildings, basements, etc.

33. Brown rat *Rattus* (gr. 'norvegicus') *norvegicus* Berkenhout, 1769. A widespread species in the city. An invasive species (Kucheruk 2000). In the late 19th century, it displaced the black rat in the region, which had occurred there before. A stuffed black rat specimen is in the Zoological Museum of Kazan State University (Abrakhina *et al.* 1993).

Order Carnivora

34. Raccoon dog *Nyctereutes procyonoides* Gray, 1834. An alien species native to Primorye, Ussuri Region. The species was introduced to the Volga Region in the 1930s. It also penetrated the region in the mid-1930s from the Republic of Tatarstan, where the species was released in 1934 and from where it successfully dispersed and became common in many areas (Abrakhina *et al.* 1993). Single finds of the species are known from the northern and western outskirts of the city, the floodplain of the river Sviyaga, the floodplain of the river Kamenka in the northern part of the city, and from outskirts of the village Bolshie Klyuchischi (territory of fish-breeding ponds). Footprints of the raccoon dog were noted on 09.28.2008 and 04.26.2009 on the wet soil along the banks of banks of fish-breeding ponds overgrown with reed in outskirts of the village Bolshie Klyuchischi.

35. Wolf *Canis lupus* Linnaeus, 1758. Cases of visits of the species to the outskirts of the city were noted. On 17.06.2016, tracks of a wolf were noted in a clear-cut on Mayskaya Mountain in the left-bank part of the city (Moskvichev 2017).

36. Red fox *Vulpes vulpes* Linnaeus, 1758. A common species. Inhabits parks and the floodplain of the river Sviyaga within the city. Adults, burrows, and broods of foxes were noted (Fig. 5 a). It regularly occurs in the western and central districts of the city, connected with the floodplains of the rivers Sviyaga and Seld, as well as in the Sviyaga ecological and recreational zone, the Black Lake Ecopark, the Prigorodny and Volga slopes (summer cottages, private sector, river port, Primorsky Park, and Friendship of Peoples Park). The species was also noted in the Pribrezhny Park, in the forest on Maiskaya Mountain in the Volga region of the city (left-bank), on Paltsinsky Island, in the Vinnovskaya Roshch Park, in vicinities of Bely Klyuch in the southern part of the city, and in forest areas of the Northern Forest Park and the Ulyanovsk Regional Arboretum in the northern part of the city. On 07.02.2008, a young fox was observed at the Young Naturalists Station (Fig. 5 a). It was found in the winter of 9.01.2011, in the night at the dump.

Burrows were found on 21.07.2013 and 06.08.2014 in the western and eastern districts of the city. Dates of meetings (Moskvichev 2017): summer 2013 (a family of foxes with two cubs was found on Paltsinsky Island), 31.12.2013, summer 2014 (cubs), 30.11.2014, 11.01.2015, February 2015, April 2015, May 2015, 23.05.2015 (burrow), 14.08.2015, 12.10.2015, 7.03.2016 (old burrow), 20.03.2016, 11.05.2016, 22.06.2016, 03.10.2016, 10.10.2016, 26.10.2016, 13.11.2016, 20.11.2016, 19.03.2017, 6.05.2017, 22.05.2017, 12.06.2017 (burrow), 28.06.2017, June 2017, July 2017, September 2017, 12.09.2017, and 08.10.2017. The species' abundance in the city and its suburbs is estimated at 80 individuals.

37. Pine marten *Martes martes* Linnaeus, 1758. Rarely found in the northern forest outskirts of the city, the Volga slope near the river port, in the Primorsky Park, in the neighbourhood of Bely Klyuch, in the floodplain of the river Herd, and in the neighborhood of the village Baratayevka. Dates of finds (Moskvichev 2017): summer 2012, autumn 2014, 23.04.2017, and 07.05.2017. The species was found in the Primorsky Park in the southern part of the city on 06.02.2013 and 04.15.2015.

38. Stone marten *Martes foina* Erxleben, 1777*. A non-abundant species, included to the Red Data Book of the Ulyanovsk Region in 2008 and listed in Appendix 3 of its new edition (Artemieva *et al.* 2015). An invasive species known to occur in the region since the early 1990s and it had been unknown in the Volga region before the 1970s (Borodin 2001).



Fig. 5. Representatives of Carnivora in the city: *a*—*Vulpes vulpes* (photo by Galina Piliugina); *b*—*Martes foina* (photo by Viacheslav Savinov).

Рис. 5. Представники ряду хижих в умовах міста: *a* — лисиця звичайна (фото Галини Пилогіної); *b* — куниця кам'яна (фото Вячеслава Савінова).

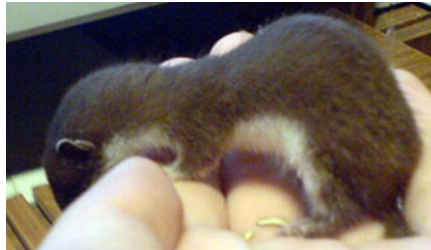
In 1971, it was recorded for the first time in the Saratov, Volgograd, and Tambov regions. In the winter of 1987–1988, it was recorded in Tatarstan. On 04.08.2001, the corpse of a stone marten was found on the roadside near the village Upper Belozerki in Stavropol District of Samara Region (Borodin 2001). On 14.10.2007, the corpse of a stone marten was found on an abandoned farm in the village Akshuat (Barysh District), in a transformer box (Fomina 2007). In the city, the species was found in the attic of 5–12-storey residential buildings, where it is known to attack nesting colonies of blue-grey pigeons and jackdaws, in particular in a multi-storey building in the western part of the city (Zasviyazhsky District). On 31.03.2010, a stone marten was noted on a high poplar near a school, where it was attacked by hooded crows. On 27.10.2012, in the park zone of the southern part of the city (in the specially protected natural area (SPNA) ‘Vinnovskaya Roshcha’), a stone marten was recorded rapidly climbing up the trunk of an old tall oak at the edge of a broad-leaved forest, with prey in its teeth and chased by a pair of hooded crows (Fig. 5 *b*). The species was also discovered in an old birdhouse in the western part of the city on 05.12.2014.

39. Weasel *Mustela nivalis* Linnaeus, 1766. A non-abundant species. Inhabits the park zone of the northern and eastern parts of the city, the floodplain of the river Sviyaga River, outskirts of the village Mostovaya, the southern outskirts of the city, summer cottages, the Victory Park in the northern part of the city, the Friendship of Peoples Park, the Primorsky Park, and the New City (left-bank part). The form ‘*vulgaris*’ has brown fur colouration on the paws up to the toes and on the lips. The form ‘*nivalis*’ has white fur on the upper and lower lips, white ‘mittens’ on the forepaws to the elbows, white chest, and white winter fur (Zagorodniuk 2015). In the studied individuals, fur colouration corresponds to that in the southern form of the ‘*vulgaris*’ group. On 03.02.2006, the remains of weasel prey (quail wing) were found in the yard of a multi-storey building in the southern part of the city. On 05.11.2011, remains of weasel prey (decapitated corpse of a fieldfare) were also found among garages in the territory of multi-storey buildings. Dates of finds (Moskvichev 2017): March–April 1993, summer 2012, March 2015, August 2017, and 25.08.2017 (Fig. 6).

40. Stoat *Mustela erminea* Linnaeus, 1758*. A non-abundant species. It was included to the Red Data Book of the Ulyanovsk Region (2008) and is now listed in Appendix 3 (2015). Inhabits park zones of the northern and eastern parts of the city, the floodplain of the river Sviyaga, the southern outskirts of the city, and also occurs near summer cottages. Winter fur is white. In winter, stoat traces in the snow were observed regularly in parks of the central and western parts of the city and in the garden community areas in the southern and northern districts of the city. Observations of the species occurred in 2000–2008.



a



b

Fig. 6. *Mustela nivalis*, the southern form 'vulgaris' in the city: a—front view; b—side view. Photo by Galina Piliugina.

Рис. 6. Ласка південної форми «vulgaris» в умовах міста: a — ласка, форма «vulgaris», вид спереду; b — ласка, форма «vulgaris», вид збоку. Фото Галини Пиліюгіної.

Fig. 7. *Mustela eversmanni* in the city. Photo by Vera Shtynda.

Рис. 7. Степовий тхір в умовах міста. Фото Віри Штинда.



41. Western polecat *Mustela putorius* Linnaeus, 1758. Single finds of the species are known from the floodplain of the river Sviyaga and park zones of the northern and eastern parts of the city. Cases of synanthropy of the species are known, in particular it was encountered in the territory of summer cottages and garden communities. Observations of the species occurred in 2000–2008.

42. Steppe polecat *Mustela eversmanni* Lesson, 1827. A non-abundant species. Single finds are dated to 14.05.2013 and 27.07.2013 and were reported from an area of summer cottages in the floodplain nearby to the village Karasevka (left-bank part) (Fig. 7).

43. American mink *Neogale vison* (Schreber, 1777). A non-abundant species. It was released into the hunting grounds of the Republic of Tatarstan in 1934. Then, along the rivers Bolshoy and Maly Chereyshan in the Trans-Volga region (left-bank), it penetrated into the studied region and city (Abrakhina *et al.* 1993). In the 1950s, in the territory of the settlement of Mostostroiteley in the eastern district of the city (left-bank), there was a state farm for breeding American minks. In the 1980s, it became abandoned and some animals escaped. Therefore, the species turned out to be confined to the right bank of the Volga River (Kuibyshev Reservoir), to the Volga slopes in the northern part of the city, to the area of the river port and the Primorsky Park, which is located not far from the former farm. The species occurs among concrete constructions and artificial embankments, breakwaters, in the floodplain of the river Sviyaga, in the neighborhood of Mostotryad (left-bank), and among the boulders. The dates of the finds are as follows (Moskvichev 2017): 18.01.2015, 03.11.2015, 10.11.2016, 06.04.2017 (a pair of minks), and 02.09.2017.

44. Badger *Meles meles* Linnaeus, 1758. A non-abundant species recorded in a forest on Maiskaya Gora (left-bank). On 24.09.2018, a fresh burrow was discovered with a site in a pine-mixed forest in the neighborhood of the village Krasny Yar in Cherdaklinsky District. The dates of the finds are as follows (Moskvichev 2017): 30.03.2013, 2016 (an old sett was discovered), and 13.05.2017.

Order Artiodactyla

45. Wild boar *Sus scrofa* Linnaeus, 1758. Regular visits of single individuals and small groups have been recorded in spring, autumn, and winter to the northern forested outskirts of the city (Ulyanovsk Regional Arboretum, Northern Forest Park, Victory Park, and summer cottages), to the floodplain of the river Sviyaga, Black Lake Ecopark, to the private sector of the western part of the city, to the Volga slope in the northern and central parts of the city (garden communities and river port), to forests of May Mountain and of the neighborhood of the village Arkhanel'skoe (Zavolzhsky District of the city, left-bank), and to the neighborhood of the village Bely Klyuch in the southern part of the city. Wild boars were also seen on major city highways.



Fig. 8. Elk *Alces alces* in the city. Photo by the author.

Рис. 8. Лось европейский в условиях міста. Фото автора.

Dates of records are as follows (Moskvichev 2017): October 1993, November 1994, October 2009, 11.11.2012, 02.10.2014, 27.09.2015, 20.10.2015, 06.12.2015, 12.04.2016, 14.05.2016, 15.06.2016, 21.08.2016, October 2016, 13.11.2016, 13.08.2017, 29.09.2017, 08.10.2017, and October 2017. The species' abundance in the city and its suburbs is estimated at 50 individuals.

46. Roe deer *Capreolus capreolus* Linnaeus, 1758. Regular visits of mainly single individuals (occasionally 2–3 individuals) are recorded in spring and autumn in the floodplain of the river Sviyaga, in the pine-mixed forest on the Upper Terrace, in the Park of the 40th Anniversary of the All-Union Leninist Young Communist League, New Gorod, in forests on Maiskaya Mountain in the Zavolzhsky District of the city (left-bank), in the Ulyanovsk Regional Arboretum in the northern part of the city, in the private sector in the neighborhood of the river port, and in the village Bely Klyuch in the southern part of the city. Dates of records are as follows (Moskvichev 2017): October 1993, 17.04.1994, winter 2001, 23.06.2001, 23.05.2016, 02.02.2016, 01.03.2016, 22.05.2016, 15.06.2016, 22.06.2016 (doe with fawn), 27.06.2016, 14.06.2016, and 16.10.2016. The species' abundance in the city and its suburbs is estimated at 30 individuals.

47. Elk *Alces alces* Linnaeus, 1758. Regular visits of single individuals to the northern forest outskirts of the city were recorded at different times of the year, as well as in the neighborhood of the Polytechnic State University, Victory Park, Northern Forest Park, Volga Slope, Isheevka Village, Regional Ulyanovsk Arboretum, floodplain of the river Seld near the village Baratayevka village in the western part of the city, confectionery factory 'Volzhanka' and the village Bely Klyuch in the southern part of the city, New Gorod in the Zavolzhsky District of the city and the highway in the neighborhood of the village Krasny Yar (left-bank) (Fig. 8). Dates of records are as follows (Moskvichev 2017): 12.03.1994, 06.05.1994, 04.06.2013, 11.05.2016, 21.05.2016, 24.05.2016, 31.05.2016, 03.06.2016, 12.07.2016, 13.08.2016, and 30.08.2016. The species' abundance in the city and its suburbs is estimated at 15 individuals.

Urban mammal fauna of parks and green areas

City parks, squares, and green zones play the most important role in the preservation of habitats of representatives of the urban mammal fauna. Such areas are similar to faunal reserves and refugia, in which rare species are preserved finding suitable habitats and food resources.

Northern district of the city (forest faunal complex)

The northern part of the city is characterized by the presence of mammals that represent the forest faunal complex. This part of the city includes seven park zones uniting large forests (pine-deciduous forests, floodplain forest areas along the river Kamenka) and vast areas of summer cottages and private sectors, harbouring the highest biodiversity within the city and suburbs (Victory Park).

Regional Ulyanovsk Arboretum. In total, 13 mammal species have been recorded in the park: *Erinaceus roumanicus*, *Talpa europaea*, *Pipistrellus nathusii**, *Lepus europaeus*, *Lepus timidus*, *Sciurus vulgaris*, *Sylvaemus uralensis*, *S. flavicollis*, *Rattus norvegicus*, *Mus musculus*, *Sus scrofa*, *Capreolus capreolus*, and *Alces alces*.

Victory Park. The park is inhabited by 20 mammal species: *Erinaceus roumanicus*, *Talpa europaea*, *Sorex araneus*, *Pipistrellus nathusii**, *Lepus europaeus*, *Myoxus glis**, *Sciurus vulgaris*, *Myodes glareolus*, *Microtus levis*, *Sylvaemus uralensis*, *S. flavicollis*, *Rattus norvegicus*, *Mus musculus*. The order Carnivora is represented here by five species: *Nyctereutes procyonoides*, *Vulpes vulpes*, *Mustella nivalis*, *M. erminea*, and *M. putorius*. *Sus scrofa* and *Alces alces* are common representatives of the order Artiodactyla in the park. Over the past 10 years, the number of wild boars has decreased and they have been recorded only occasionally in the park.

Youth Park. The mammal fauna of the park includes 12 species: *Erinaceus roumanicus*, *Talpa europaea*, *Sorex araneus*, *Pipistrellus nathusii**, *Lepus europaeus*, *Myodes glareolus*, *Microtus levis*, *Sylvaemus uralensis*, *S. flavicollis*, *Mus musculus*, *Mustela nivalis*, and *M. erminea**. Because of the construction of a new bridge across the Volga and the industrial zone, the latter has become very rare in the park.

Geological Milanovskiy section. The mammal fauna in this area is represented by ten species: *Erinaceus roumanicus*, *Talpa europaea*, *Sorex araneus*, *Lepus europaeus*, *Myodes glareolus*, *Sylvaemus uralensis*, *S. flavicollis*, *Mus musculus*, *Rattus norvegicus*, and *Vulpes vulpes*.

Peoples' Friendship Park. There are 12 mammal species in the park: *Erinaceus roumanicus*, *Talpa europaea*, *Pipistrellus nathusii**, *Lepus europaeus*, *Myodes glareolus*, *Microtus levis*, *Sylvaemus uralensis*, *S. flavicollis*, *Rattus norvegicus*, *Mus musculus*, *Vulpes vulpes*, and *Mustela nivalis*.

‘Vladimirsky Garden’ Park. Eight mammal species were found to inhabit the park: *Erinaceus roumanicus*, *Talpa europaea*, *Pipistrellus nathusii**, *Lepus europaeus*, *Microtus levis*, *Rattus norvegicus*, *Mus musculus*, and *Mustela nivalis*.

Children's Central Park. Only two synanthropic mammal species were recorded here: *Mus musculus* and *Rattus norvegicus*.

Southern district of the city (right-bank upland-steppe faunal complex)

The southern part of the city is characterized by the presence of mammals of the right-bank upland-steppe faunal complex. This area includes three park zones uniting large woodlands: upland broad-leaved forests with participation of the pedunculate oak, small-leaved linden, and Norway maple on the right bank of the Volga River, areas of chalk steppes and chalk outcrops, dry meadows on high Volga steep slopes. This part of the city also includes vast areas of riverine zones covered with forests, garden communities along the banks of the Volga River, the Volga slope and the private sector. It has a relatively high biodiversity within the city and its suburbs (SPNA ‘Vinnovskaya Roshcha’ and Primorsky Park).

SPNA ‘Vinnovskaya Roscha’. Twelve mammals species were recorded in the territory of the protected area: *Erinaceus roumanicus*, *Talpa europaea*, *Sorex araneus*, *Pipistrellus nathusii**, *Vespertilio murinus** (confined here to old hollow trees; listed in the Red Data Book of the Ulyanovsk Region), *Lepus timidus*, *Myodes glareolus*, *Microtus levis*, *Sylvaemus uralensis*, *Apodemus agrarius*, *Vulpes vulpes*, and *Martes foina**.

‘Vinnovskaya Roscha’ Park. Mammals are represented here by nine species: *Erinaceus roumanicus*, *Talpa europaea*, *Sorex araneus*, *Vespertilio murinus**, *Myodes glareolus*, *Microtus levis*, *Sylvaemus uralensis*, *Apodemus agrarius*, *Vulpes vulpes*, and *Martes foina**.

Primorsky Park. Twelve mammal species were recorded in the park: *Erinaceus roumanicus*, *Talpa europaea*, *Pipistrellus nathusii**, *Lepus europaeus*, *Ondatra zibethicus*, *Microtus levis*, *Myodes glareolus*, *Apodemus agrarius*, *Rattus norvegicus*, *Martes martes*, *Mustela nivalis*, and *Neogale vison*.

Western district of the city (Sviyazhsky floodplain faunal complex)

The western part of the city is characterized by the presence of mammals of the Sviyazhsky floodplain faunal complex, which is historically associated with the ancient valley of the river Sviyaga and its tributaries. The area includes four park zones uniting large floodplain areas and meadow complexes, riparian and reed thickets along the rivers Sviyaga and Seld, as well as territories of large summer cottages. This part of the city is characterized by a high level of biodiversity within the city and its suburbs (Sviyaga ecological and recreational zone).

Molodezhny Park. Only two mammal species were recorded in the park: *Erinaceus roumanicus* and *Mus musculus*.

‘Family’ Park. Only two mammal species were found: *Erinaceus roumanicus* and *Mus musculus*.

Sviyazhsky ecological and recreational zone. Mammals are represented here by 17 species: *Erinaceus roumanicus*, *Arvicola amphibius*, *Neomys fodiens**, *Cricetus cricetus*, *Ondatra zibethica*, *Sylvaemus uralensis*, *S. flavicollis*, *Alexandromys oeconomicus*, *Micromys minutus*, *Nyctereutes procyonoides*, *Vulpes vulpes*, *Mustela putorius*, *M. nivalis*, *M. erminea**, *Sus scrofa*, *Capreolus capreolus*, and *Alces alces*. The latter three species were regularly observed in the floodplain of the river Sviyaga in the 1970s–1980s, but at present they are known only by single records.

Black Lake Ecopark. In this area, 17 mammal species were recorded: *Erinaceus roumanicus*, *Neomys fodiens**, *Castor fiber*, *Arvicola amphibius*, *Ondatra zibethica*, *Cricetus cricetus*, *Myodes glareolus*, *Microtus levis*, *Sylvaemus uralensis*, *Micromys minutus*, *Vulpes vulpes*, *Mustela putorius*, *M. nivalis*, *M. erminea**, *Sus scrofa*, *Capreolus capreolus*, and *Alces alces*. In the 1980s, the elk regularly visited the area, but the current number of elks has decreased significantly and records are extremely rare.

Eastern district of the city (left-bank steppe faunal complex)

The eastern part of the city is characterized by the presence of mammals of the left-bank steppe faunal complex, which is historically associated with autochthonous communities of feather grass–fescue steppes and pine forests on sandy soils and relief depressions. This part of the city includes three park areas, uniting large pine forests and territories of summer cottages on the left bank of the Volga River. It has a high biodiversity within the city and its suburbs (Riverine Park).

Paltsinsky Island. Only one mammal species was found—*Spermophilus major**—, which have remained here after the Kuibyshev Reservoir was filled.

Riverine Park. Mammals are represented here by 15 species: *Erinaceus roumanicus*, *Crocidura suaveolens*, *Sorex araneus*, *Nyctalus noctula*, *Myotis daubentoni*, *Pipistrellus nathusii**, *Sylvaemus uralensis*, *Spermophilus major**, *Myodes glareolus*, *Micromys minutus*, *Lepus timidus*, *Vulpes vulpes*, *Mustela nivalis*, *Mustela erminea**, and *Alces alces*.

Eastern Park. In this area, 14 mammal species were recorded: *Erinaceus roumanicus*, *Crocidura suaveolens*, *Sorex araneus*, *Nyctalus noctula*, *Pipistrellus nathusii**, *Lepus timidus*, *Spermophilus major**, *Myodes glareolus*, *Sylvaemus uralensis*, *Vulpes vulpes* (burrows located in the Petrov ravine), *Mustela putorius*, *Mustela nivalis*, *Mustela erminea**, and *Capreolus capreolus*.

A comparative summary of the biodiversity of mammals of city parks is presented in Table 2.

Discussion

Geoecological features of the city

It was shown earlier that the geoecological uniqueness of the city of Ulyanovsk lies in its specific location between rivers flowing in opposite directions—the Volga River that flows to the south and the river Sviyaga that flows to the north. Both rivers as natural conductors produce powerful electromagnetic fields that interact with each other in a complex manner having a negative impact on the biota of the city. Spatial patterns in biodiversity of the urban fauna (on the example of the

entomofauna) in the city revealed that species richness is the highest in the southern part of the city and is the lowest in its western part (Artemieva & Zusmanovsky 2001).

In the present work, spatial patterns in species richness of the urban mammal fauna, which generally exhibits a larger plasticity and adaptability to humans compared to the entomofauna, have been revealed. The spatial distribution of representatives of the urban mammal fauna generally depends on the location of geoactive areas created by electromagnetic fields of the Volga and Sviyaga rivers in the territory of Ulyanovsk and in its immediate vicinities. Study results indicate that animals that represent various taxonomic groups try to avoid habitats in these areas.

To assess the heterogeneity and compare the similarity of the mammal fauna lists obtained for different city districts, the author applied the previously used analysis algorithm: separate lists were created for the five city districts and an analysis of their similarity was carried out based on the calculation of the correlation coefficient.

Table 2. Comparative data on biodiversity of the mammal fauna of city parks
Таблиця 2. Порівняльні дані з біорізноманіття фауни ссавців парків міста

Parts of the city	Parks	Typical mammal species selected according to the 'rule of threes'	Total number of species	Number of rare species	Total number of species by orders
Northern	Regional Ulyanovsk Arboretum	<i>Sciurus vulgaris</i> , <i>Sus scrofa</i> , <i>Alces alces</i>	13	1	2+1+2+5+3
Northern	Victory Park	<i>Myoxus glis</i> *, <i>Nyctereutes procyonoides</i> , <i>Mustela putorius</i>	20	2	3+1+1+8+5+2
Northern	Youth Park	<i>Sorex araneus</i> , <i>Pipistrellus nathusii</i> *, <i>Mustela erminea</i> *	12	2	3+1+1+5+2
Northern	Milanovsky Geological Section	<i>Sorex araneus</i> , <i>Lepus europaeus</i> , <i>Vulpes vulpes</i>	10	0	3+1+5+1
Northern	People's Friendship Park	<i>Pipistrellus nathusii</i> *, <i>Microtus levis</i> , <i>Mustela nivalis</i>	12	1	2+1+1+6+2
Northern	'Vladimirsky Garden' Park	<i>Talpa europaea</i> , <i>Pipistrellus nathusii</i> *, <i>Lepus europaeus</i>	8	1	2+1+3+1+1
Northern	Children's Central Park	<i>Mus musculus</i> , <i>Rattus norvegicus</i>	2	0	2
Southern	SPNA 'Vinnovskaya Roscha'	<i>Myodes glareolus</i> , <i>Lepus timidus</i> , <i>Martes foina</i> *	12	3	3+2+1+4+2
Southern	Vinnovskaya Roscha Park	<i>Vespertilio murinus</i> *, <i>Apodemus agrarius</i> , <i>Martes foina</i> *	9	2	3+1+4+2
Southern	Primorsky Park	<i>Ondatra zibethicus</i> , <i>Martes martes</i> , <i>Neogale vison</i>	12	1	2+1+1+5+3
Western	Molodezhny Park	<i>Erinaceus roumanicus</i> , <i>Mus musculus</i>	2	0	1+1
Western	Family Park	<i>Erinaceus roumanicus</i> , <i>Mus musculus</i>	2	0	1+1
Western	Sviyazhsky ecological and recreational zone	<i>Cricetus cricetus</i> , <i>Alexandromys oeconomicus</i> , <i>Capreolus capreolus</i>	17	2	2+7+5+3
Western	Black Lake Ecopark	<i>Neomys fodiens</i> *, <i>Castor fiber</i> , <i>Arvicola amphibius</i>	17	2	2+8+4+3
Eastern	Paltsinsky Island	<i>Spermophilus major</i> *	1	1	1
Eastern	Riverine Park	<i>Myotis daubentoni</i> , <i>Spermophilus major</i> *, <i>Micromys minutus</i>	15	3	3+3+1+4+3+1
Eastern	Eastern Park	<i>Nyctalus noctula</i> , <i>Vulpes vulpes</i> , <i>Mustela putorius</i>	14	3	3+2+1+3+4+1

Correlation was calculated for pairs of comparisons, in which the variables were the values of the number of species of each order (5 orders in total); the same was calculated for the number of families in each order. The five city districts for which the calculations were carried out are as follows: southern (p_1), northern (p_2), western (p_3), central (p_4), and eastern (p_5). Respectively, 10 pairs of comparisons were carried out in two series – according to the number of species of each order and according to the number of families of each order.

The results of such comparisons are presented in Figs 9–10, where areas with similar lists of fauna (i.e. with high correlation) are grouped by similarity ($r > 0.5$), including at the level of the number of families (Fig. 9) and the number of species (Fig. 10). There are three such groups at the family level: p_1+p_3 ($r = 0.95$), p_2+p_4 ($r = 0.97$), and p_5 (relationships with others within 0.72–0.90). At the species level, there are two such groups: $p_1+p_2+p_3$ ($r = 0.91$ –0.96), p_4+p_5 ($r = 0.98$) (connections between groups are 0.74–0.96). The levels of similarity–differences within groups and between groups in all cases are small, i.e. the groups identified are largely conditional due to the significant similarity of indicators of species richness.

A similar analysis, which we carried out earlier for butterflies, showed that at the family level, all five city districts (p_1 – p_5) are characterized by similar similarity scores. At the family level, correlation analysis allows distinguishing the same three clusters: p_1+p_3 , p_2+p_4 , and p_5 . At the species level, we have the same two clusters $p_1+p_2+p_3$ and p_4+p_5 (Artemieva & Zusmanovskiy 2001).

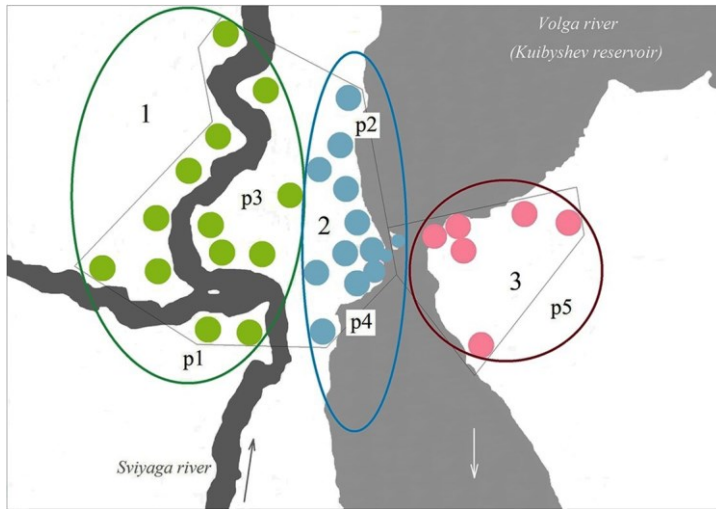


Fig. 9. Spatial structure of biodiversity of mammalian faunal complexes at family level in Ulyanovsk and its vicinities: 1—southern (p_1) and western (p_3) districts; 2—northern (p_2) and central (p_4) districts; 3—eastern (p_5) districts. The marks indicate record and census localities of mammals.

Рис. 9. Просторова структура біорізноманіття фауністичних комплексів ссавців на рівні родин на території м. Ульяновська та його околиць: 1 — південний (p_1) і західний (p_3) райони міста; 2 — північний (p_2) і центральний (p_4) райони міста; 3 — східний (p_5) район міста. Пуассонами позначено точки знахідок і обліку ссавців.

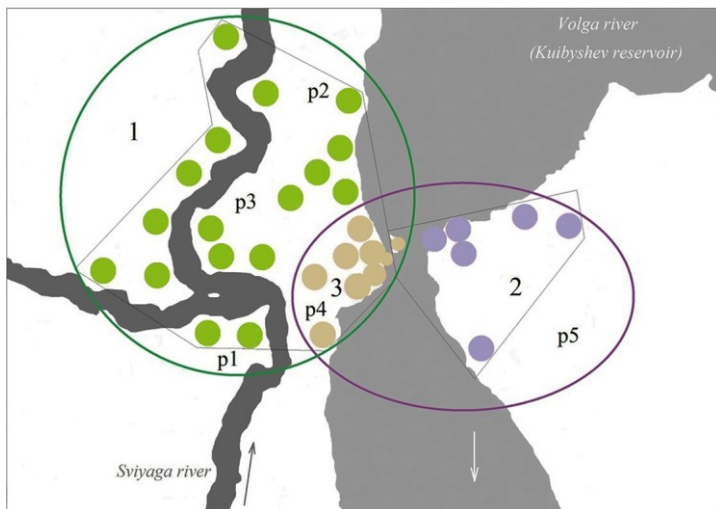


Fig. 10. Spatial structure of biodiversity of mammalian faunal complexes at species level in Ulyanovsk and its vicinities: 1–2—designated clusters; 3—geoactive area. The numbering of city districts (p_1 – p_5) is given in Fig. 9. The marks indicate record and census localities of mammals.

Рис. 10. Просторова структура біорізноманіття фауністичних комплексів ссавців на рівні видів на території м. Ульяновська та його околиць: 1–2 — виокремлені кластери; 3 — геоактивна зона. Нумерація районів як на рис. 9. Пуассонами позначено точки знахідок і обліку ссавців.

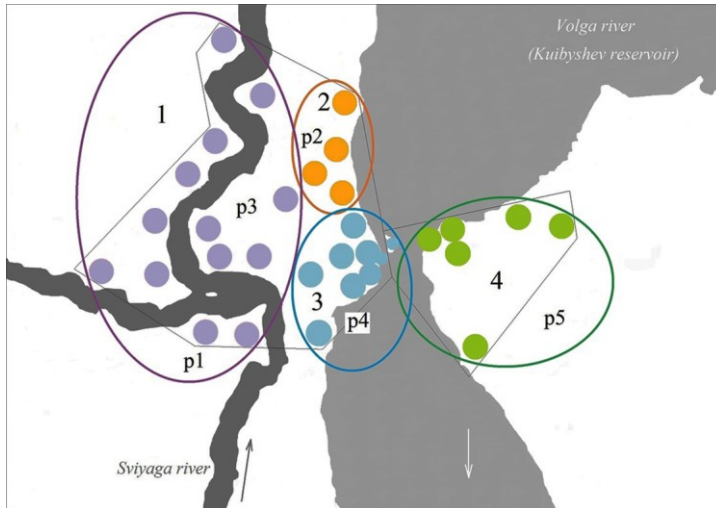


Fig. 11. Spatial structure of mammalian faunal complexes in Ulyanovsk and its vicinities: 1—floodplain complex of the river Sviyaga; 2—forest complex; 3—upland steppe complex; 4—left-bank steppe complex. The marks indicate record and census localities of mammals. Numbering of city districts (p1–p5) as in Figs. 9–10.

Рис. 11. Просторова структура фауністичних комплексів ссавців Ульяновська та околиць: 1 — заплавної комплекс р. Свіяга; 2 — лісовий комплекс; 3 — нагірно-степовий комплекс; 4 — лівобережний остепнений комплекс. Пуассони — точки знахідок та обліку ссавців. Нумерація районів як на рис. 9–10.

Regarding the five studied parts of the city, species richness has the following spatial trends: northern district (p₂)—25 species (4 rare species), central district (p₄)—13 species (1), western district (p₃)—27 species (6); southern district (p₁)—20 species (5); eastern district (p₅)—17 species (6 rare species). Low species richness of some parts of the city are consider to be situated in the geoactive zones, where low species richness as well as numerous developmental anomalies were registered. So, such results were obtained for Lepidoptera: anomalous development of the wing pattern are noted in geoactive areas of the city (floodplains of the Volga and Sviyaga rivers) in more than 24% specimens (Artemyeva & Zusmanovskiy 2001).

The urban mammal fauna of Ulyanovsk has historically developed due to the penetration of representatives of various faunal complexes common for the region into the territory of the city and its environs (Fig. 11). They include (1) floodplain species associated with the river Sviyaga and its tributaries, 36.17%; (2) forest-dwelling species common for pine-deciduous, deciduous-pine, and taiga forests, 46.81%; (3) upland-steppe species associated with cretaceous landscapes of the right-bank, 6.38%; (4) steppe species, including mammals from the left bank common for feather grass-fescue steppes, 6.38%. Some species have remained in the territory of the city and in the region due to their spread by humans—introduced species and species kept on fur farms (10.64%). Synanthropic species are associated with human settlements (4.26%) (Fig. 11).

Comparative analysis of park areas

A comparative analysis of the city's park zones showed that mammals of this regional centre with a high level of urbanization is adapted to the local ecological conditions. Comparative data on the biodiversity of mammals of city parks is presented in Table 2.

Analysis of the city's mammal fauna showed that biodiversity at the level of orders is the highest in the Pribrezhny and Eastern parks (eastern part of the city, left-bank) and in the Victory Park in the northern part of the city. This shows the level of urban development of these areas—these are the least developed areas of the city. On the contrary, the lowest level of biodiversity is revealed for parks located in the central (Children's Central Park, only Rodentia) and western (Family and Moloдеzhny parks, orders Insectivora and Rodentia) parts of the city.

Parks in the northern part of the city have the highest level of biodiversity (Victory Park, 20 species, including 2 rare species), while the lowest diversity was revealed for parks of the southern part of the city (Vinnovskaya Roshcha and Primorsky parks, 12 species in each, including 3 rare species). The parks 'Vinnovskaya Roscha', Primorsky, Riverine, and the Black Lake Ecopark have the most distinct mammal faunas, i.e. each park has features of landscape complexes that harbour such mammal faunas. Each park is characterized by only its particular set of species, three of which (the 'rule of the three') fully describe the features of its urban mammal fauna.

The infrastructure of park zones includes the elements as follows: a private zoo in the Eastern Park in Zavolzhye, a system of summer sports attractions in the Victory Park, a ski base in the Victory Park and in the Youth Park in the northern district of the city, winter attractions—slides, riding ATVs and winter banana—in the park ‘Vinnovskaya Roshcha’ (small mammals often die under the wheels of walking equipment). Negative factors affecting habitats of mammal species include noise and recreational load, felling of undergrowth and old trees, cleaning up the territory for the landfill and tennis courts in the ‘Vinnovskaya Roshcha’ Park, as well as clearing shrubs and cutting down trees in the Family Park, straightening and cleaning the channel and banks covered with thickets of bushes along the river Sviyaga and the entire Sviyazhsky ecological and recreational zone, and intensive urban development of empty sites within park zones.

The city reflects the urbanization process of the mammal fauna as follows: the number of synanthropic species of mouse-like rodents increases in all park and green zones; the number of rare mammal species decreases in all park and green areas; the level of preservation habitats suitable for mammals in parks and green areas decreases; the disturbance factor for most mammalian species increases; the behaviour of most mammal species changes—they become less cautious, which exposes them to an already increased danger on highways and in crowded areas.

General processes and patterns in the urbanization of mammal fauna are as follows: general decline of biodiversity in the city and its suburbs; general reduction of suitable habitats; decrease in the level of fragmentation of natural habitats and ecotones reducing selection options of suitable habitats; reduction and change of food supply in the city and suburbs. The geoactive site between the Volga and Sviyaga rivers, which is located partly in the southern and western regions of the city, has an additional negative impact on the biodiversity of mammal fauna affecting the general picture of urbanization.

The occurrence of species in different part of the city (right-bank and left-bank) and habitats according to an increasing level of urbanization and decreasing species diversity (1–5) is as follows:

- (1) green zones—parks and squares with woody vegetation, 31 species;
- (2) floodplain of the river Sviyaga within the city, 24 species;
- (3) summer cottages within the city, 15 species;
- (4) private sector with one-storey buildings, 5 species;
- (5) multi-storey buildings, 4 species.

In general, in an urban environment, mammal species that co-exist next to humans make up 66.19% of the total number of mammals occurring in the region. At the same time, the number of rare species listed in the regional Red Data Book (2015) is 12.68%. Thus, when conservation measures to protect habitats within the urban environment are observed, most mammal species are able to maintain stable populations.

During the entire study period, 47 mammal species representing 6 orders and 14 families were found in the territory of the city of Ulyanovsk and its suburban areas, of which 9 are listed in the Red Data Book of the Russian Federation and in the Red Data Book of the Ulyanovsk Region. The most common and abundant species are the northern white-breasted hedgehog, common shrew, bank vole, southern vole, pygmy field mouse, striped field mouse, eastern house mouse, and brown rat.

The rare and endangered species listed in the Red Data Books of the Russian Federation and of the Ulyanovsk Region (2015) include the water shrew, Brandt's bat, Nathusius' pipistrelle, Kuhl's pipistrelle, parti-coloured bat, russet ground squirrel, fat dormouse, stone marten, and stoat. Rare species with a declining abundance include the garden dormouse, and the harvest mouse.

Conclusions

The study revealed that the current composition of the urban mammal fauna of Ulyanovsk and its changes under the influence of human economic activity was assessed.

The limiting factors affecting the state of natural populations of most of the recorded mammal species and the level of biodiversity of the urban fauna in general include the topographic features of the city related to the presence of geoactive areas in its territory, wide development of urban out-

skirts and wastelands in the central part of the city, development of transport network, uncontrolled groups of stray dogs, as well as unauthorized solid waste dumps and installations of wind turbines (WPPs) in the city's immediate vicinity. Eurytopic species (brown rat, house mouse, etc.) and species with a secretive lifestyle and mixed type of diet (mainly insectivores, rodents, and bats) co-exist with humans the most comfortably.

Symbol species of the region include the steppe marmot, settlements of which preceded the settlement of ancient humans in the modern suburbs of the city of Ulyanovsk. Further research is needed to reveal general regional trends in the urban mammal fauna in a west-east direction, to predict global changes in the urban mammal fauna's composition, and to find approaches to its protection.

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