

BIOLOGICAL DIVERSITY OF THE SPIDERS HERPETOBIONT POPULATION OF DEGRADED BIOTOPES IN VOLGOGRAD CITY AND ITS SURROUNDINGS

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БИОЛОГИЧЕСКОЕ РАЗНООБРАЗИЕ ГЕРПЕТОБИОНТНОГО НАСЕЛЕНИЯ ПАУКОВ В ГОРОДЕ ВОЛГОГРАД И ЕГО ОКРЕСТНОСТЯХ

Abstract. The article deals with exposed to strong anthropogenic impact of biotopes spiders species community on the territory of Volgograd (South of the European territory of Russia). The material was collected using Barber's open soil traps with a fixing solution. Using the Simpson diversity index, the state of biotopes was evaluated, and the comparison of the species composition of spiders using cluster analysis based on the qualitative and quantitative aspects of the Jaccard index was carried out. In the course of the exploring, it was found out that the steppe biotopes of this region are least susceptible to anthropogenic load. In urban environment species are replaced with those that are more resistant to anthropogenic stress, but biological diversity is restored over time. The species composition of the near-aquatic biotopes most susceptible to the influence of the environment microclimatic conditions.

Keywords: Spiders, Volgograd region, biodiversity, biotopes, cluster analysis

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Аннотация. В статье представлен анализ сообщества нескольких видов пауков, распространенных на территории Волгограда (юг европейской территории России). Исследуемые местообитания были подвержены сильному антропогенному воздействию. Материал собран с помощью открытых почвенных ловушек Барбера с фиксирующим раствором. С помощью индекса разнообразия Симпсона было оценено состояние биотопов и проведено сравнение видового состава пауков с использованием кластерного анализа, основанного на качественных и количественных аспектах индекса Жаккара. В процессе исследования было установлено, что степные биотопы этого региона наименее подвержены антропогенной нагрузке. В городской среде виды заменяются более устойчивыми к антропогенному стрессу, но биологическое разнообразие со временем восстанавливается. Видовой состав приводных биотопов наиболее подвержен влиянию микроклиматических условий окружающей среды.

Ключевые слова: пауки, Волгоградская область, биоразнообразие, биотопы, кластерный анализ.

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Introduction. The experience of recent years shows that the research of entomological communities as an integral part of biological monitoring is relevant in the constant anthropogenic transformation of the natural environment conditions. Many regions of the world in general and Russia in particular are poorly affected by arachnological research or are not affected at all. On the Russian Federation territory, the spider fauna of the Urals, Siberia, the Far East, and Dagestan is actively studied [1; 3; 4; 6]. The araneofauna of the Rostov region and the Dzhanybek research station (the border of the Volgograd Region and the Republic of Kazakhstan) have been sufficiently studied among the territories nearby to the research region [7; 8; 9]. Earlier studies of spider biodiversity [2; 5; 11; 12] do not take into account the dry-steppe zone of the Russia's European territory conditions, or the research objects are other living organisms, which indicates the relevance of the Lower Volga region araneofauna research. There are only a few publications related to ecological and faunal studies of this region: an annotated list of spiders of the Volgograd region is presented in the article by Ponomarev A.V., Khnykin A. S. [9]; seasonal changes in the species composition of the forest araneofauna of the Volgograd region and near-water biotopes of the Volgograd agglomeration are considered in own publications [11; 12].

Materials and methods. Territories with varying degrees of disturbance were selected as study polygons to assess the degree of spider communities transformation (Fig. 1). Terrain inhomogeneities, such as

the Ergeninskaya Upland, which retains a significant part of the JSC “Khimprom” emissions on its slopes, can act as geochemical barriers to pollutants.

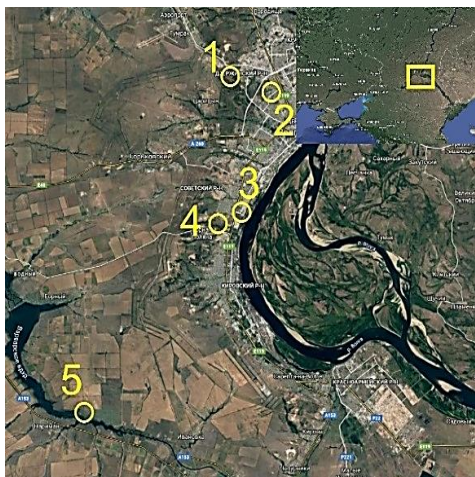


Fig. 1. Research area and key points

location: 1 – location near the Volgograd plant of drilling equipment in Dzerzhinskij district of the Volgograd city; 2 – Prolomnyj ravine in Dzerzhinskij district of the Volgograd city; 3 – hydrological complex of the FSC of Agroecology of RAS (former VNIALMI) in Sovetskij district of the Volgograd city; 4 – Grigorova ravine together the Lysaya Gora natural boundary in Sovetskij district of the Volgograd city; 5 – location near the Varvarovskoye water reservoir inside the Volga-Don navigation canal named after Lenin in Gorodishenskij district of the Volgograd city

number of captured individuals of each species) aspects of the species composition of biotopes. The Jacquard index was calculated using the formula:

$$I_J = \frac{C}{A + B} \times 100,$$

where C is the total population of species in both plots; A is the number of species that live only in the first plot; B is the number of species that live only in the second plot.

Results and discussion. Data on the Simpson Diversity index (D_s) are presented in Table, and on the Jacquard coefficient in Figures 1-4.

As can be seen from Table, the values of the Simpson index for steppe and forest biotopes are close to each other, but the degree of individual species dominance in steppe biotopes is slightly higher. In ravines and balkas, the value of the species diversity indicator reaches its maximum. The average number of species in different biotopes, as shown by our research, was almost the same, but the number of captured individuals in near-water biotopes was much higher.

In the steppe biotopes conditions, the highest values of the Jacquard coefficient were noted – 0.26–0.47 (Fig. 2). Taking into account the values of the diversity index, it can be concluded that the araneofauna of steppe biotopes experiences the least stress, and, consequently, is the most resistant to anthropogenic changes.

The steppe areas near the VZBT and the area adjacent to the Prolomny ravine are qualitatively quite similar in terms of the araneofauna species composition, but in quantitative terms, the differences are noticeable. The other parameters of biological diversity (the number of species detected, the Simpson dominance index) are approximately at the same level, with the exception of the number of captured individuals.

The qualitative and qualitative-quantitative values of the Jacquard coefficient in the the VZBT and Grigorova Balka sites are close to each other (0,39 and 0,34), which is probably due to similar environmental processes occurring in both sections: in the first case, it is an abandoned and dead garden, and in the other – an almost shrunken forest belt. In both cases, there is a change of forest microclimatic conditions to steppe

The division of these polygons by transformation levels was carried out as follows:

- the impact zone includes the Prolomny ravine;
- the buffer zone includes the area near the Volgograd Drilling Equipment Plant (VZBT) and the hydrological complex of the FSC of agroecology RAS;
- the background zone includes Grigorova Balka with the Lysaya Gora tract and the area near the Varvarovskiy reservoir.

The material was collected using open Barber traps with a diameter of 10 cm without bait with a fixing liquid (6% acetic acid solution). The species identification carried out according to national [2; 10] and foreign determinants, using Internet resources and together with A.V. Ponomaryov, Senior Researcher of the Department of Terrestrial Ecosystems of the Institute of Arid Zones of the Federal Research Centre The Southern Scientific Centre of the Russian Academy of The Sciences (SSC RAS).

The Simpson Index of Biological Diversity (D_s), a dimensionless indicator used in biology to determine the degree of the sampling objects features distribution uniformity, was calculated based on actual data:

$$D_s = \frac{1}{\sum_{i=1}^S \left(\frac{n_i}{N}\right)^2},$$

where S is the number of species, n_i is the number of individuals of the i-th species, and N is the total number of individuals.

In the computer application “Cluster Analysis”, dendrograms of the biotopes similarity by the Jacquard coefficient were constructed, taking into account the qualitative (presence or absence of a species) and qualitative-quantitative (presence and absence of a species) aspects of the species composition of biotopes. The Jacquard

ones. The araneofauna biological diversity in these areas is almost identical, but the territory of the VZBT is characterized by a higher ecological capacity.

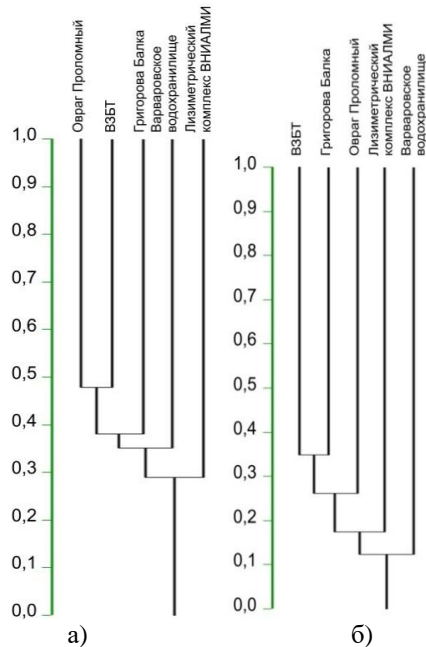


Fig. 2. Qualitive (a) and Quality-quantitive (b) Jaccard indexes for steppe biotopes

Varvarovsky reservoir and lysimetric complex of the FSC of agroecology RAS maximally differs from the rest a key polygons and between each other, both in qualitative and in qualitative-quantitative terms. According to the main indicators of biological diversity, these key sites have the least similarity among the entire group of biotopes (if we exclude the open and poorly overgrown sands of Lysaya Gora). For the lysimetric complex, this is due to the peculiar ecological conditions of the urban landscape. The situation with the Varvarovsky reservoir developed in a similar way, presumably due to the island status of this biotope (the key site is adjacent to the uncultivated potyazhina, surrounded on all sides by arable land).

Among the steppe biotopes, the area of open and poorly overgrown sands on Lysaya Gora stands out sharply with the values of both indices of biological diversity. Here, the diversity index has the lowest value (0,5). The number of species and captured individuals here is minimal, and the species composition also differs significantly from the other sites. All of these facts indicate a strong stress experienced by the spider community in this area. However, this situation is most likely due to the extreme natural conditions of the area (in summer, for example, the soil surface can heat up to

+70°C). The overall set of environmental and microclimatic factors of Lysaya Gora is unique for the study area. The highest diversity index values are for the open steppe area near Grigorova Balka and its anthropogenic counterpart – the courtyard of the FSC of agroecology RAS. This suggests that the biological diversity of disturbed areas returns to its previous values over time, but the community species composition can change significantly. Close to each other steppe population and number of species of spiders Grigorova Balka and wheatgrass facia of FSC of agroecology RAS lysimetric complex. However, the species composition of these two key points differs significantly in both qualitative and quantitative aspects. Based on these facts, it is should be concluded that a relatively stable araneocomplex was formed on the wheatgrass facia of the lysimetric complex during its existence.

On average, forest biotopes have one of the lowest values of the Simpson diversity Index. The estimated reason for this was the relatively small area of forest stands on the territory of the Volgograd agglomeration. In addition, one of the surveyed research sites (the courtyard of the lysimetric complex of the Federal Research Center for Agroecology of the Russian Academy of Sciences) is surrounded by urbanized territories. For the same reason, the average value of the species diversity of spiders is the lowest, and the number of captured individuals is high. It is worth noting the high qualitative and very low quantitative similarity between the majorities of biotopes (Fig. 3).

With a general relatively similar species composition, different species of spiders turned out to be massive. In the courtyard of the FSC of agroecology RAS lysimetric complex, this is *Harpactea rubicunda* (96 individuals/100 trap-days), for Grigorova Balka it is *Pardosa alacris* (329 individuals/100 trap-days). In the other biotopes, several species are often found in the dominant, but they also differ, as evidenced by a rather large difference (almost 1,5 times) between the qualitative and quantitative values of the Jacquard coefficient, which indicates that the forest biotopes considered differ greatly in their abiotic conditions.

Despite the completely different species composition of woody and herbaceous plants, the maximum similarity of the araneofauna of tree stands near the Prolomny ravine and pine plantings in the area of the VZBT was noted (the value of the Jacquard coefficient is 0,38 in qualitative and 0,26 in quantitative aspects). In terms of the number of species living here, these two biotopes are ahead of the others, but the situation is very different in terms of the number of captured individuals. 517 individuals were caught in forest landings near the Prolomny ravine (this is the second result among forest biotopes), and 201 individuals were caught in pine stands (the smallest number in this category). The situation is very ambiguous; the ecological and microclimatic conditions of these biotopes differ significantly from each other, but the biodiversity indicators of spider community are generally close to each other. It can be assumed that this situation is the result of a large fire, which almost completely destroyed the pine stands on the territory near the VZBT.

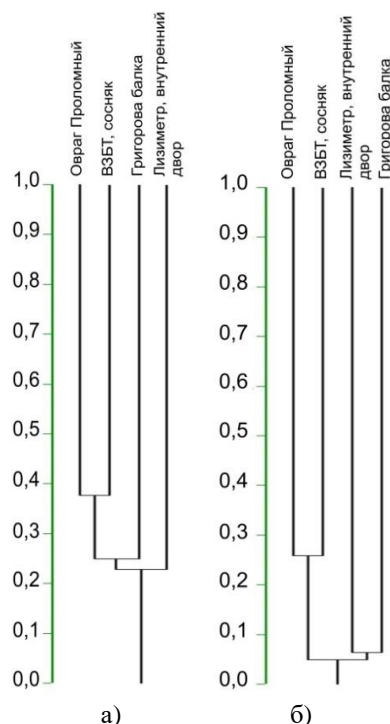


Fig. 3. Qualitative (a) and Quality-quantitative (b) Jaccard indexes for forest biotopes

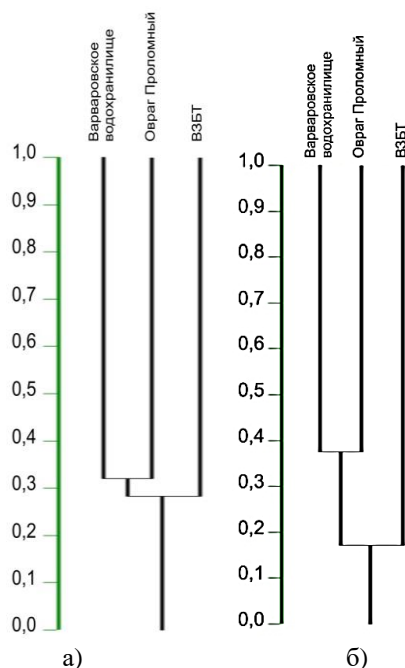


Fig. 4. Qualitative (a) and Quality-quantitative (b) Jaccard indexes for ravine biotopes

Similar values has an index of dominance of the inner courtyard of the FSC of agroecology RAS lisymeric complex and the Grigorova Balka’s forest, but the species composition of these habitats has the least degree of similarity. The index of dominance in the Grigorova Balka was very strongly influenced by the species *Pardosa alacris*, whose population is very high here. Obviously, the natural conditions of the Grigorova Balka were optimal for this species. It was not found in other examined biotopes. For the number of species and the number of captured individuals, the situation is very different. In the forest area of Grigorova Balka, 46 species of spiders live, which is only 1 species less than in the pine plantations near the VZBT, and in terms of the captured individuals number, this biotope is in the first place (705 spiders). According to the set of indicators, courtyard territory of the FSC of agroecology RAS lisymeric complex differs the least biological diversity. Obviously, the size of this biotope (in contrast to the wheatgrass facies here) was not enough for the complete flow of successional processes in disturbed urban habitat conditions and for the formation of a stable araneocomplex.

Biotopes of ravines and balkas. The araneofauna of ravines and balkas is characterized by the greatest biodiversity among all the studied biotopes. As can be seen from Figure 4, in qualitative terms, all three biotopes are quite close to each other; the value of the Jacquard coefficient varies from 0,27 to 0,32.

However, in quantitative terms, there is a great similarity between the potyazhina on the Varvarovsky reservoir and the Prolomny ravine (0,375), and the ravine near the VZBT differs significantly from them (0,172 and 0,17, respectively). An average of 515 individuals from 65 species were captured at each key site. Such a high level of biodiversity indicates that the ecological conditions of ravines and balkas, which have individual characteristics, inherent in ecotones, when the dry steppe conditions are replaced by softer grasslands conditions, are the optimal habitat for species living in the adjacent territories.

In the Prolomny ravine and at the bottom of the potyazhina near the Varvarovsky reservoir, the species composition of mass species is more similar, while in the species composition of rare species there are significant differences, as indicated by the values of the Simpson coefficient. The dominance of other spider species is almost the same at both key points, and the population indicators of araneofauna are quite different. Therefore, in the Prolomny ravine, 457 individuals from 55 species were caught, while at the bottom of the potyazhina near the Varvarovsky reservoir 234 individuals from 49 species were captured. Apparently,

these differences are caused by the different genesis of both biotopes: the potyazhina of the Varvarovsky reservoir has an island status, while the Prolomny ravine flows into the floodplain of the Volga Tsaritsa River, i.e. it is part of a larger landscape formation.

The species composition of spiders ravine near VZBT in qualitative terms in equal measure coincides the habitats of other ravines, but in quantitative terms, much differs from them, that is, with a large percentage of the same types, the dominants are different, despite the strong similarity of the natural environment with a Prolomny ravine and species composition with other habitats. There is no sharp dominance of any one species. As can be seen from the data given in Table, the araneofauna of the ravine near the VZBT has the most optimal natural conditions complex among all the key points considered in this work. The presence of a spring and

isolation from the nearest sources of anthropogenic press by a large wood mass led to the fact that, despite the relatively small distance from the city borders, a community of spiders close to the natural one remained in this ravine.

Table

Diversity (*D_s*) index of Simpson and spiders biological diversity

Biotopes	Key points	Ds	Number of species	Number of captured specimens
Steppes	Grigorova balka, step'	13,9	41	268
	Lysaya Gora, pesok	0,5	22	162
	Ovrag Prolomnyi, brovka	9,2	53	324
	VZBT, brovka	11,6	57	522
	Varvarovskoe vdkhr., brovka potyazhiny	8,5	34	148
	Lizimetr, pyreinaya fatsiya	11,8	45	230
	Average	9,3	50	330
Forests	Grigorova balka, les	3,9	46	705
	Ovrag Prolomnyi, posadki	13,5	59	517
	VZBT, osnovnye posadki	14,4	47	201
	Lizimetr, vnutrennii dvor	4,5	31	224
	Average	9,1	46	412
Ravines and balkas	Ovrag Prolomnyi, dno ovraga	13,2	55	457
	Varvarovskoe vdkhr., dno potyazhiny	13,4	49	234
	VZBT, rodnik	28,3	91	854
	Average	18,3	65	515
Springs and near-aquatic biotopes	Grigorova balka, rodnik	2,4	41	1879
	Ovrag Prolomnyi, rodnik	7,7	40	350
	Varvarovskoe vdkhr., bereg kanala	5,2	36	576
	Average	5,1	39	935

Springs, near-water biotopes. The values of the Simpson index of near-water biotopes are close to the average (Fig. 5). Without taking into account the spring near the VZBT, the Simpson diversity index is 5,1.

According to the degree of similarity of the species composition, they differ from each other as much as possible. The qualitative values of the Jacquard index are 0,17–0,25, and the quantitative values are 0,03–0,13.

It was also decided to include the ravine near the VZBT in this group of studied biotopes because of the water source (spring) flowing here. The species composition of araneofauna in this area significantly differs from the others compare habitats, which is explainable by the abiotic conditions difference: the springs in the Prolomny ravine and Grigorova Balka surround arrays of large trees, while the spring near VZBT is located in the ravine, almost devoid of woody vegetation. However, the ravine itself is located in the center of a large tree plantation. In addition, some of the traps are located above the current of the spring, which allows us to attribute the results to both the ravines biotopes and the spring's biotopes. The investigated area has the highest indicators of biological diversity among near-water biotopes. In addition to the fact that the value of the diversity index is the highest among all the key points surveyed, the maximum number of species (91 species) was also found here and a significant number (854 individuals) of spiders were captured.

The spring in Grigorova Balka is characterized by the lowest biodiversity of spider species according to

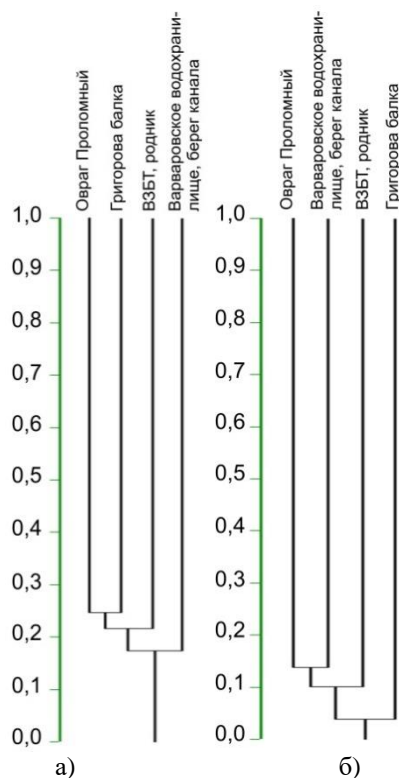


Fig. 5. Qualitive (a) and Quality-quantitive (b) Jaccard indexes for springs and near-aquatic

Simpson coefficient (2.4), which is associated with the presence of the superdominant *Pardosa alacris*, the main part of the population of which lives here (during the study period, 834 individuals of this species were caught in this biotope), only a lesser part inhabited in the forest biotope. According to the species composition Grigorova Balka and Prolomny ravine territories are the closest to each other, but the ratio of the number of species is the lowest among all biotopes (the qualitative-quantitative value of the Jacquard coefficient is 0.03).

The values of Simpson index in Prolomny ravine spring and on the Varvarovsky reservoir shore are close to average, which may mean an equal degree of impoverishment of the spider community, caused in the first case by the extreme depression of the biotope, and in the second – by the natural monotony of environmental conditions (studies were carried out in reed beds). This assumption is partially supported by the population indicators of both key sites. The total number of spiders on the bank of the Volga-Don shipping channel is more than 1.5 times higher than in the Prolomny ravine.

Conclusions. 1. The araneofauna of the steppe biotopes adjacent to Volgograd is the most resistant to anthropogenic changes in ecosystems, since on average the species diversity here is one of the highest without a sharp dominance of individual species.

2. The biological diversity of disturbed areas eventually returns to the previous parameters with a new species composition, which is confirmed by the population characteristics and the diversity index of individual biotopes.

3. Large woodlands are a reliable buffer zone between sources of anthropogenic pressure and natural complexes, as evidenced by the close to natural community of spiders in the ravine near the VZBT.

4. Microclimatic differences between near-water biotopes affect the species composition of araneofauna to a greater extent than other biotopes.

5. Spiders adapt to anthropogenic environmental changes at the community level. In disturbed ecosystems, spider species that are sensitive to changes in environmental conditions are replaced by more stable or synanthropic ones.

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