

Retrospective taxonomic analysis of avifauna of the Republic of Tatarstan

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Abstract. A retrospective analysis of the dynamics of the species diversity of the avifauna of the Republic of Tatarstan over a period of more than a century - from the end of the 19th century to 2022 has been carried out. Based on the analysis of literature and our own data, in which faunistic lists of different times were presented, an increase in the number of species in the modern territory of the republic was revealed. When comparing data on the status of species and the nature of their presence in the territory, it is revealed that the increase in the number of species occurs due to an increase in very rarely or rarely occurring vagrant species. An analysis of the nature of the stay of species on the territory of the republic showed an increase in the number of nesting species in a number of authors and an almost twofold increase in the number of vagrant species. According to the results of comparing the level of faunistic similarity of ornithological lists, it turns out that the farther the compared faunistic lists are from each other on the time scale, the less similar they are in terms of species diversity.

1 Introduction

The study of the composition of the avifauna of specific territories makes it possible not only to identify and analyze the main trends in the change in the number of certain species but also state various changes in the faunal composition of the region. It should be noted that, in general, periodic inventories of fauna are topical issues of modern zoology, and the data obtained can be used in forecasting and implementing various environmental protection measures.

This article presents the results of a retrospective analysis of the dynamics of species diversity of avifauna of the Republic of Tatarstan for more than a century - from the late XIX century to 2022. The work given represents part of the theoretical foundation for further study of bird zoogeography with the aim of clarifying and detailing the diversity of the causes of spatiotemporal changes in the regional bird fauna. It is generally admitted that birds have an active mode of distribution, which is flight. However, despite this, they still cannot settle everywhere and this is hindered by a number of environmental, geographical, and anthropogenic factors, which have recently become increasingly important. Moreover, environmental factors determine the character of the flora, with which the fauna is directly associated.

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The recently accumulated materials on the avifauna of the region require systematization, in-depth analysis and generalization. In fact, even the modern faunistic list is dynamically changing and needs to be constantly updated. A review of the avifauna of the Republic of Tatarstan has not previously been conducted in such a volume and form, which determines the academic novelty of the amount of research conducted.

2 Materials and methods

Based on both literature data presenting faunal lists and our own observations made over a number of years, we carried out a retrospective analysis of species diversity in the modern territory of the Republic of Tatarstan for the period of more than a century. The research stemmed from the works of the following authors which contain the most complete faunistic reports of their time: M.D. Ruzsky [1], A.A. Pershakov [2], V.A. Popov [3, 4], I.V. Askeev, O.V. Askeev [5], I.I. Rakhimov [6]. The names of bird species in Russian and Latin, the order of their location and supraspecific taxonomic categories are given according to L.S. Stepanyan [7]. The status and the nature of the presence of all bird species in the territory of the republic within the corresponding period were determined in accordance with generally accepted methods. The nature of the presence of the species in the territory was assessed according to the following categories: the species is absent in the given territory, vagrant, migratory, nesting, wintering. The following categories were used in determining the status of species in the territory: very rare, rare, common, numerous. The level of faunistic similarity of the ornithological lists of different authors was determined with the help of the Sørensen-Čekanowski similarity coefficient (1):

$$I_{cs} = \frac{2a}{(a+b) + (a+c)}, \quad (1)$$

where a is the number of species found in two lists;
 b is the number of species found only in the second list;
 c is the number of species found only in the first list.

To characterize the dynamics of the bird species diversity in the Republic of Tatarstan, we also calculated the indicators that characterize the processes of transformation of the avifauna, which are the rate of disappearance and the emergence of new species in the territory, according to G.V. Grishanov [8].

The rate of disappearance of species in the studies territory (2):

$$E = 2e / (t(c+d)) \times 100\%, \quad (2)$$

where e is the number of species that went extinct during t ;
 t is the duration (in years) of the studied period;
 c is the original number of species;
 d is the number of species at the end of the studied period.

The rate of the emergence of new species (3):

$$J = 2j / (t(c+d)) \times 100\%, \quad (3)$$

where j is the number of new species that appeared during t .

To do this, the period under study was conditionally divided into the following time periods: the end of the 19th century, the beginning of the 20th century, the 70s of the 20th century, the end of the 20th century and the beginning of the 21st century, according to the presence of corresponding faunal lists of different authors (Table 1).

The Republic of Tatarstan is a constituent entity of the Russian Federation, located in the eastern part of the East European Plain at the confluence of the Volga and Kama rivers. Most of the territory lies between 54.5° and 56° N. and 48° and 53.5° E (Fig. 1). The territory of the republic stretches 400 km from west to east and 250 km from north to south, and its total area is 68 thousand km². The relief has a general flat character, the average absolute height is about 170 m [9].

Table 1. Number of bird species according to literature data.

Time period	The end of the 19 th c.	The beginning of the 20 th c.	The 70s of the 20 th c.	The end of the 20 th c.	The beginning of the 21 st c.
Total number of species	251	270	277	320	317

The climate of the republic is mainly influenced by continental air masses of temperate latitudes. The average temperature in January is 14°C, in July – 19°C. The annual rainfall is 460-540 mm. During the warm period (April - October), 65-70% of precipitation occurs.

The soil landscape is diverse, dominated by grey forest soils (about 40% of the entire territory) and chernozem (32%). Forests occupy about 17% of the territory, massifs of pine forests have been preserved in the north, spruce and fir forests are present in some areas, and broad-leaved forests are found in the southern part [10].



Fig.1. The Republic of Tatarstan on the map of Russia. (according to mapsworld.ru).

3 Results and discussion

Quantitative analysis in the above table showed a trend towards an increase in the total number of registered species. When comparing the analyses of the data on the status of species and the nature of their presence in the territory, it was revealed that the increase in the number of species occurred due to an increase in very rarely or rarely occurring vagrant species.

Having analyzed the data on the status of species in the territory, we revealed a tendency to increase the total number of very rare and rare species. While at the end of the 19th century Ruzsky [1] reported the total of 109 species (43%) – (47 very rare and 62 rare),

at the beginning of the 20th century, Pershakov [2] already mentioned 120 species (44%) – (59 very rare and 61 rare), and in the 70s of the 20th century, Popov [3,4] wrote about 157 species (57%) – (73 very rare and 84 rare). At the end of the 20th century, the Askeevs [5] counted the total of 182 (57) – (51 very rare and 131 rare), and at the beginning of the 21st century, the final list by Rakhimov [6] already contained 201 species (63%) – (106 very rare and 95 rare). No clear trends were found for common, numerous and very numerous species.

Analyzing the nature of the presence of species in the territory of the republic, some of the authors noticed an increase in the number of nesting species and an almost twofold increase in the number of vagrant species. If in quantitative terms there was an increase in the number of nesting species, then in percentage terms the total number of species saw a slight decrease at the end of the studied time interval. At the end of the 19th century, Ruzsky [1] noted 178 breeding species (71%), whilst at the beginning of the 20th century, Pershakov [2] observed nesting in 195 species (72%). In the 70s of the 20th century, Popov [3, 4] registered 204 species (74%). The Askeevs [5] found 206 species (64%) nesting at the end of the 20th century, and Rakhimov [6] documented 207 (65%) nesting species at the beginning of the 21st century. The number of vagrant species also increased among the authors. There were 29 vagrant species (11%) mentioned by Ruzsky [1], 39 species (14%) by Pershakov [2], 37 species (13%) by Popov [3, 4], 63 species (20%) by the Askeevs [5] and 68 vagrant species (21%) by Rakhimov [6]. The upward trend of migrant species is also interesting due to the hypothetical possibility of their transition to the category of nesting species after a certain amount of time, that is, migrant species demonstrate a probabilistic potential of nesting species. As mentioned above, there was an increase in the number of nesting and vagrant species, and the last two authors explain a slight decrease in the percentage of nesting species relative to the total number by an almost twofold increase in the number of vagrant species. As for wintering and migratory species, their numbers were relatively stable and no certain trends were found.

Based on the data provided by different authors and the analysis of the similarity matrix of avifauna species in the Republic of Tatarstan at different historical times, it was revealed that the closer the periods under study were to each other, the higher the Sørensen-Čekanowski coefficient of similarity of species among the faunistic lists of authors. For example, when comparing the lists of Ruzsky [1] and Pershakov [2], this indicator was 0.96. The maximum similarity was revealed when we compared the Askeevs' data [5] with the list by Rakhimov [6], with our additions, and this very indicator was 0.97, which in this case could be explained by the minimum time interval between the two compared faunal lists (21 years). The minimum similarity figures were obtained between the lists of Ruzsky (the end of the 19th century) [1] and the Askeevs (the end of the 20th century) [5] and comprised 0.87, and also between the lists of Ruzsky (the end of the 19th century) [1] and Rakhimov (the beginning of the 21st century) [6] amounting to 0.88. Thus, according to our results, the farther the compared faunal lists are from each other on the time scale, the less similar they are in terms of species diversity (Table 2).

Table 2. The similarity matrix of avifauna species of the Republic of Tatarstan at different historical times according to faunal lists compiled by different authors.

	Ruzsky, 1893	Pershakov, 1929	Popov, 1977, 1978	Askeev, Askeev, 1999	Rakhimov, 2002, our data, 2022
Ruzsky, 1893	1	0.963	0.909	0.872	0.88
Pershakov, 1929	0.963	1	0.936	0.905	0.916
Popov, 1977, 1978	0.909	0.936	1	0.914	0.929

Askeev, Askeev, 1999	0.872	0.905	0.914	1	0.976
Rakhimov, 2002, our data, 2022	0.88	0.916	0.929	0.976	1

The annual rate of species extinction remains stably low within 0.06-0.1% per year for the entire study period. The rate of emergence of new species has two segments of acceleration: 0.2% per year from the end of the 19th century to the beginning of the 20th century and 0.75% per year from the 70s of the 20th century until the end of the 20th century, that is, it increased almost by 4 times. It is rather difficult to unambiguously interpret the data obtained in this case. Among the reasons there is the intensification of human economic activity, the decrease in the forest cover in the region, large areas of cultivated land, the creation of new reservoirs and other forms of environmental impact (Table 3).

Table 3. The dynamics of the number of avifauna species in the Republic of Tatarstan over the past 130 years.

Time period	The end of the 19 th c.	The beginning of the 20 th c.	The 70s of the 20 th c.	The end of the 20 th c.	The beginning of the 21 st c.
Author, publication year	Ruzsky , 1893	Pershakov, 1929	Popov, 1977, 1978	Askeev, Askeev, 1999	Rakhimov, 2002, our data, 2022
Considered period of time, years	0	36	49	21	23
Total number of species	251	270	277	320	317
Number of extinct species, pcs	0	0	14	4	9
Number of emerging species, pcs	0	19	21	47	6
The rate of disappearance of species in year (<i>E</i>), %	0	0	0.1	0.06	0.12
The rate of the emergence of new species in year (<i>J</i>), %	0	0.2	0.15	0.75	0.08

We should also mention the features of the geographical location of the region, which can act as prerequisites for the formation of a special avifauna to some extent. First of all, it is significant that the region is located at the junction of two zoogeographic zones – the forest zone and the steppe zone. That is why there one can encounter such typical forest birds as the capercaillie (*Tetrao urogallus*), the hazel grouse (*Tetrastes bonasia*), the three-toed woodpecker (*Picoides tridactylus*), the bullfinch (*Pyrrhula pyrrhula*) and others. At the same time, there are such representatives of the steppes as the quail (*Coturnix coturnix*), the ortolan bunting (*Emberiza hortulana*), the whinchat (*Saxicola rubetra*) and others. It is also worth noting the birds typical of broad-leaved forests, which arrived from the west, such as the stock dove (*Columba oenas*), the jay (*Garrulus glandarius*), the common starling (*Sturnus vulgaris*), the linnet (*Acanthis cannabina*) and others. There are also smaller quantities of species that entered the region from the east, such as the oriental cuckoo (*Cuculus saturatus*), the yellow-breasted bunting (*Emberiza aureola*) and a number of others [3].

Thus, in general, the avifauna of the region is quite complex in its composition, consisting of both representatives of taiga coniferous forests and the birds characteristic of such open spaces as steppes and fields, as well as some representatives of broad-leaved forests. In many locations the elements of both forest and steppe bird fauna are present. It

should also be noted that such intrazonal elements as river valleys and created reservoirs also complicate the mosaic nature of landscapes [11].

Another feature determining the nature of the bird fauna of the region is that there are the boundaries of the ranges of many species throughout its territory. There lies the southern boundary of the habitat of such a rare species as the wigeon (*Anas penelope*), the jacksnipe (*Lymnocyptes minimus*), the ruff (*Philomachus pugnax*), the oriental cuckoo (*Cuculus saturatus*), the hawk owl (*Surnia ulula*), the boreal owl (*Aegolius funereus*), etc. A number of species are found on the northern border of the range: the saker falcon (*Falco cherrug*), the lesser kestrel (*Falco naumanni*), the little owl (*Athene noctua*), the collared dove (*Streptopelia decaocto*), etc. The eastern border of the distribution of the green woodpecker (*Picus viridis*) is also located there.

One of the main reasons for the changes in the avifauna is the intensive human economic activity, which has especially intensified over the past century. In the context of the processes associated with the active development of the territory of the region, destabilization of the bird fauna is also occurring. The landscape of the territory has significantly changed as a result of deforestation, ploughing, the creation of reservoirs, the growth and expansion of urban settlements, the predominance of monocultures in agriculture, a significant expansion of the areas of shelter forest belts, including the creation of uniform-aged monocultural forest plantations.

4 Conclusion

Thus, during the studied period beginning from the end of the 19th century, in the territory of the Republic of Tatarstan, we can observe two seemingly opposite processes occurring simultaneously. On the one hand, due to the agricultural and industrial intensification, there is an ever-increasing pressure on the environment. On the other hand, despite the profound changes in the landscape of the region, we see an increase in the number of bird species. One of the reasons for this phenomenon is the emergence of new ecological niches in the conditions of anthropogenically created mosaicity and diversity of landscapes, which has intensified the processes of ecological adaptation of birds. Undoubtedly, the processes of natural range expansion provoke both unique and more and more frequently repeated migrations of species not previously recorded in the territory. At the same time, we do not rule out the role of the processes associated with climate change issues, which are widely discussed in modern society.

References

1. M.D. Ruzsky, Proc. Soc. Nat. KSU, **6**, 292 (1893)
2. A.A. Pershakov, Proc. St. Sc. Cl. "Nat. Lov.", **3**, 3-68 (1929)
3. V.A. Popov, *Birds of the Volga-Kama region: Non-passerines*, 296 (Moscow, Nauka, 1977)
4. V.A. Popov, *Birds of the Volga-Kama region: Passerines*, 247 (Moscow, Nauka, 1978)
5. I.V. Askeev, O.V. Askeev, *Avifauna of the Republic of Tatarstan (synopsis of the current state)*, 124 (Kazan, 1999)
6. I.I. Rakhimov, *The avifauna of the Middle Volga region under the anthropogenic transformation of natural landscapes*, 272 (Kazan, ZAO Novoe Znanie, 2002)
7. L.S. Stepanyan, *Synopsis of the ornithological fauna of the USSR*, 728 (Moscow, Nauka, 1990)

8. G.V. Grishanov, *Anthropogenic transformation of the fauna of nesting birds on the example of the Kaliningrad region*, 219 (Kaliningrad, 1988)
9. A.S. Taisin, *Geography of the Tatar ASSR*, 223 (Kazan, Tatknigoizdat, 1986)
10. *Atlas of the Republic of Tatarstan*, 211 (Moscow, Kartographiya, 2005)
11. R.A. Ulengov, *Int. Bus. Manage.* **10**, 5151-5154 (2016)