Ecology of the avifauna of the Voronezh upland oak forest

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Abstract. The article presents the results of the analysis of changes in the fauna, population and ecology of the dominant and background bird species of the Voronezh upland oak forest, depending on the level of the recreational load. The object of research is the Voronezh upland oak grove, a unique natural landscape complex located within the city of Voronezh in the Central Federal District. The research period is 2014-2018. The census was carried out according to the standard method of counting birds according to the spring mating song with a fixed width of the counting strip equal to 50 m. The length of each route was 10,000 m. The results of the study showed that on the territory of the Voronezh upland oak forest, background and dominant bird species are represented by 38 species belonging to 5 orders. Most of the species belong to the order Passeriformes. In areas with a high degree of recreation, the number of synanthropic species and birds with a mixed type of diet increases. The consequences of the recreational impact are reflected in the number and species composition of birds.

1. Introduction

For centuries, mankind has been waging a war of conquest against nature, taking away large territories, creating a comfortable habitat for itself. Rapid urban growth has become a characteristic feature of modernity. Many animals are deprived of their habitual habitat and are forced to adapt. Some species are ecologically plastic, others, on the contrary, survive with great difficulty and can forever leave their familiar territories. In the territories transformed by humans, birds surpass other vertebrates in quantity and species diversity, being an indicator of the state of the urbanized landscape. Rapidly expanding cities lead to the formation of new biotopes, which change the composition of bird communities.

The combination of the action of various recreational factors inevitably entails changes in the qualitative and quantitative indicators of nesting birds in forest ecosystems [1]. The species composition of the avifauna is very sensitive to changes in nesting conditions. The impact of a complex of various recreational factors leads to a decrease in the species diversity of nesting birds and, as a result, species that could not adapt do not find refuge and leave the territory [2].

Species diversity at the biocenotic level is most evident. Areas of the recreational forest that have undergone various degrees of digression leave the avifauna species that have not adapted to changes, but at the same time become attractive to various bird species at different levels of urbanization. In urban parks and forest parks, there is a greater variety of species of nesting birds than in the surrounding forests [3].
While urbanization threatens biodiversity around the world, expanding urban green spaces can attract a variety of bird species. How to maintain biodiversity in an urban ecosystem is critical to sustainable urban planning and management, taking into account the climatic characteristics of the regions. The species richness, phylogenetic and functional structure of bird aggregations depends on the diversity of plant species, modern climate and anthropogenic factors [4].

The natural landscape of recreational areas affects the number of bird species. The development of bird communities in artificially created habitats and the development of bird communities in transformed habitats occurs in different ways and in different directions [5].

The purpose of the study is to identify changes in the ecology, fauna and population of background and dominant bird species taking place in connection with the degree of recreation using the example of the Voronezh upland oak forest.

2. Methods and materials

The research was carried out on the territory of the Voronezh upland oak forest, which is a natural landscape complex located on the border of a city with a million inhabitants. In connection with the increasing recreational impact, the issues of observation deserve special importance, namely, the diversity of species of avifauna [6]. The Voronezh upland oak grove is located in the eastern part of the Don-Voronezh watershed. The natural borders for it in the south and east are the Voronezh river bed and the Voronezh reservoir, in the west – the Don river. The northern border coincides with the administrative border of the Voronezh region and is drawn conditionally. A vast forest area stretches from the northern outskirts of Voronezh to the village of Ramon, covering an area within the Pravoberezhnoe forestry over 3000 hectares.

The object of the study was the representatives of the avifauna of the Voronezh upland oak forest, belonging to the dominant and background species.

Field studies were carried out from 2014 to 2018 on the territory of the Voronezh upland oak forest. In the areas of forest ecosystems selected for the survey, the route registration of all birds encountered at the nesting sites was carried out according to the mating song [7]. Also, during the route survey of forest areas, such characteristics as found nests, features of the structure of the ecological niche and the degree of its study were recorded. Analysis of the data obtained from the results of the survey makes it possible to determine the population density of each species and the total population density. To calculate the density, the formula was used.

Within the ecological groups of birds, the density of birds of each species and the proportion of the total density were determined. Within the groups, a classification was made according to the preferred locations for nesting.

1. Birds nesting at a height of up to 2.0 m: birds nesting at a height of up to 2.0 m deep in the forest; birds nesting at a height of up to 2.0 m on forest edges and areas with sparse stands; birds nesting on the ground; birds nesting at a height of up to 2.0 m in undergrowth and bushes.
2. Birds nesting above 2.0 m.
3. Birds nesting in shelters (hollows and half-hollows).

Also, the density and percentage of participation were calculated for all birds that prefer to arrange nesting sites on forest edges and areas with sparse stands.

When studying the influence of recreational pressure on nesting birds of different ecological groups, such indicators as: population density, the proportion of participation of individual groups by population density and by the number of species were averaged for each site, separately at sites with constant recreational exposure and separately at sites with rare visits by people.

One of the main parts of the fieldwork was the selection of sites for work. Selection algorithm:

For the research, we selected the forest areas most similar in terms of the composition of the species, the age of the stand and geomorphology.

The sites selected for the study were of the same size. The route laid along them had a length of at least 10 km, and the counting bandwidth was at least 0.05 km.
The compared sites differed, first of all, in the consequences of the impact of the recreational influence on them at a given time.

To carry out the route counting and compare the results obtained, areas with different degrees of recreational load were taken. The territory of the route with the branched path network located on it, sanatoriums with recreation areas – was taken for recreational. And the route running through rarely visited areas of the forest was considered non-recreational.

Accounting methods.
In the studied territories, birds were counted by votes during the mating season. Each route was 10,000 meters long, with a fixed width of 50 meters.

In the early morning hours, the censor traversed the route and recorded all the singing males encountered. Each of them was subsequently taken as a couple. Analysis of the data obtained from the results of the survey makes it possible to determine the population density of each species and the total population density. To calculate the density, the formula (1) was used:

\[ A = \frac{B}{C \cdot D} \]  

where \( A \) – the number of pairs of a particular bird species per 1 km²; \( B \) – the number of males registered on the route; \( C \) – is the length of the route tape, km; \( D \) – is the width of the route tape, km.

Based on the established density of bird species and the total population density, the density and proportion of the participation of nesting birds of various ecological groups was established.

The counts were carried out 3 times in a certain period under the same weather conditions (20.04-20.05 – spring time, 21.05-20.06 – early summer time, 21.06-20.07 – late summer time).

When analyzing the data collected as a result of the registration, first of all, the total population density of the avifauna and the population density of each specific species were determined. The generalized results were extrapolated to the entire area.

The point scale of the number and dominance of A P Kuzyakina [8] was used to characterize the population of forest birds. Birds, the number of which is 5 pairs / km or more, were taken as dominant species. Those species, the number of which is not less than 1 individual/km², were considered background. In the surveyed areas with different levels of recreation, in order to compare the results and obtain qualitative indicators, the conditional population density of one species was adopted, calculated. During the reproductive period, the population density of nesting species was determined.

Based on the specific species and total population density, the density and proportion of nesting birds belonging to separate ecological groups were calculated.

Statistical processing of the research results was carried out using the programs ‘STATISTICS’, ‘STATAN’, Microsoft Windows EXCEL.

3. Results and discussion
From the results of counts in the studied areas, one can see an increase in the species diversity of the avifauna during the reproductive period. This can be clearly seen in the background and dominant species. The general species diversity of background and dominant bird species is greater in the recreational area.

The population density of background species in the non-recreational and recreational areas increases in the early summer period (21 May-20 June). The abundance and density of dominant species increases throughout the nesting season.

The study also shows that the background and dominant groups of birds are formed from representatives of 5 taxonomic groups. The leading role here belongs to the orders of the Passeriformes, Columbiformes and Piciformes. The results are shown in table 1.
Table 1. Composition/density of the population of representatives of bird orders in the reproductive period.

| Systematic position | Spring period (20 April-20 May) | Early summer period (21 May-20 June) | Late summer period (21 June-20 July) |
|---------------------|----------------------------------|--------------------------------------|--------------------------------------|
|                     | non-recreational site | recreational site | non-recreational site | recreational site | non-recreational site | recreational site |
| Columbiformes        | 2/3.43* | 4/7.53 | 3/4.46 | 4/7.62 | 2/4.61 | 4/8.47 |
| Cuculiformes         | 1/2.91 | 1/2.05 | 1/2.88 | 1/2.10 | 1/3.77 | 1/1.92 |
| Apodiformes          | 1/0.67 | 1/1.25 | 1/1.06 | 1/1.80 | 1/1.33 | 1/2.76 |
| Piciformes           | 8/14.12 | 8/16.55 | 8/14.31 | 8/16.11 | 7/20.98 | 7/18.76 |
| Passeriformes        | 44/127.5 | 46/151.8 | 51/139.9 | 50/142.0 | 53/171.0 | 53/178.0 |

*In the numerator – the number of species, in the denominator - the population density.

Two species, the finch (*Fringilla coelebs*) and the great tit (*Parus major*), were dominant during the entire reproductive period in the surveyed areas (table 2). During the nesting period, the abundance of the fieldfare thrush (*Turdus pilaris*) prevailed only in the recreational area. The song thrush (*Turdus philomelos*) was included in the dominant group in the spring period at two sites, and in early and late summer it had a numerical advantage at the site with a low recreational load. House sparrow (*Passer domesticus*) and rook were dominant in spring and summer only in the recreational area. The number of the hooded crow (*Corvus cornix*) prevailed in the late summer at two sites. The dominant group at different periods included the Great Spotted Woodpecker (*Dendrocopos major*) and Common Bunting (*Emberiza citrinella*) only in the non-recreational area.

Table 2. Dominant species of birds of the mixed forest at different times of the reproductive period (density of pairs/km²).

| Bird species          | Spring period (20 April-20 May) | Early summer period (21 May-20 June) | Late summer period (21 June-20 July) |
|-----------------------|----------------------------------|--------------------------------------|--------------------------------------|
|                       | non-recreational site | recreational site | non-recreational site | recreational site | non-recreational site | recreational site |
| *Fringilla coelebs*    | 10.48 | 8.76 | 10.26 | 9.00 | 13.97 | 12.37 |
| *Parus major*          | 7.70 | 10.95 | 6.30 | 7.73 | 8.79 | 10.03 |
| *Turdus pilaris*       | - | 8.76 | - | 7.92 | - | 9.61 |
| *Passer domesticus*    | - | 9.35 | - | 8.04 | - | 7.19 |
| *Turdus philomelos*    | 7.70 | 7.05 | 7.35 | 6.11 | 9.13 | 7.12 |
| *Corvus frugilegus*    | - | 7.80 | - | 7.30 | - | 7.68 |
| *Emberiza citrinella*  | 6.29 | - | 5.97 | - | - | - |
| *Corvus cornix*        | - | 5.0 | - | 6.64 | 7.93 | 9.08 |
| *Muscicapa striata*    | - | - | - | 7.66 | 8.67 |
| *Dendrocopos major*    | 5.56 | 6.52 | 5.35 | 6.40 | 8.77 | 8.55 |

Dominant species for each site are underlined; dash – this species does not belong to the dominant species in this area.

Studies of the distribution of bird fauna and population by longline at different stages of the reproductive period show that the number of crown nesting birds in the recreational area increases from the spring to the early summer period. The numerical values of species nesting in hollows vary minimally during the entire nesting period. The number of bush-nesting species was constant (5 species in spring in two plots and 6 in early summer and late summer). The most stable indicators...
were found for the group of terrestrial nesting species; in two plots, their species diversity remained unchanged throughout the observation period.

The minimum indices of the population density of crown-nesting birds at the recreational site were observed in the late summer time, while in the spring and, especially, in the early summer time, they increased. In the area with low recreation, the highest density was in the early summer time. The maximum density of hollow-nesting birds in the non-recreational area was observed in late summer. High rates for this group can be traced in the recreational area in the same period. From spring to summer, the density of the population of birds nesting in the bushes has increased. The density of birds nesting on the ground decreased in the early summer, but increased significantly in the late summer. The results are shown in table 3.

**Table 3.** Changes in the fauna and population of birds of different ecological groups.

| Ecological groups of birds (number of species/population density) | Spring period (20 April -20 May) | Early summer period (21 May-20 June) | Late summer period (21 June -20 July) |
|---------------------------------------------------------------|---------------------------------|-------------------------------------|--------------------------------------|
|                                                               | recreational site | non-recreational site | non-recreational site | recreational site | non-recreational site | recreational site |
| Ecological group of birds nesting in a crown and on a tree trunk | 10/38.32          | 11/51.02               | 12/43.31               | 13/58.74            | 9/37.69               | 9/50.87           |
| Ecological group of birds nesting in hollows                   | 9/27.79           | 12/57.79               | 9/27.92               | 11/50.79            | 10/4.84               | 13/67.05          |
| Ecological group of birds nesting in the bushes               | 5/11.74           | 5/8.43                 | 6/15.93               | 6/11.12             | 6/17.84               | 6/11.65           |
| Ecological group of birds nesting on the earth                | 8/28.84           | 8/18.92                | 8/27.05               | 8/16.19             | 8/34.70               | 8/28.42           |

The use of forest areas for the purpose of carrying out recreational activities benefits the urban population, and on the other hand leads to certain costs [9]. In intensively visited recreational forests, changes occur in forest ecosystems: vegetation is damaged, the renewal of forest-forming species is disturbed, the soil is compacted, the quantitative and qualitative composition of the forest fauna, the existing internal connections are disrupted [10].

Avifauna is one of the vulnerable components of the biogeocenosis. Because the constant presence of a person in the same place leads to a reduction in the species diversity of birds, their number, the replacement of some species with others, a change in the quantitative relationships between species [11]. The degree of species conservation is directly proportional to the amount of recreational loads [12]. As they increase, the disturbance factor for forest birds increases, they lose the necessary camouflage, the food supply becomes impoverished and disappears. In forests with a high level of recreational load, the decrease in bird species diversity is mainly due to terrestrial nesting (forest pipit (*Anthus trivialis*), warblers (*Phylloscopus*)), common hunting (*Emberiza citrinella*) and some bird species nesting in tree crowns (black kite (*Milvus migrans*) and hobbyist (*Falco subbuteo*)). The opposite process is also observed – expansion of the faunal spectrum due to hollow nests (woodpeckers (*Picidae*), great tit (*Parus major*)), pied flycatcher (*Ficedula hypoleuca*), gray flycatcher (*Muscicapa striata*)). In all recreational forests, there is an increase in the population of birds of the synanthropic group (dove (*Columba livia*), ringed dove (*Streptopelia decaocto*), black swift (*Apus apus*), hooded crow (*Corvus cornix*), magpie (*Pica pica*), sparrows (*Passer*)), a decrease
in the proportion of birds of prey and an increase in the number of species with a mixed type of diet. There is a decrease in the nesting density and reproductive success, the range of nest placement methods decreases, the clutch size increases, and the height of the nest location increases.

The current level of human impact on recreational forests does not lead to profound changes in the fauna and population of forest birds [13]. At the same time, adaptive changes take place in the nesting ecology of a significant part of the species that make up the basis of the city's avifauna.

4. Conclusions

On the territory of the Voronezh upland oak forest, background and dominant bird species are represented by 38 species belonging to five orders. The largest number belongs to the order Passeriformes. In areas with a high degree of recreation, the number of synanthropic species and birds that prefer mixed food increases. The result of the recreational impact on the natural habitats of birds is a change in the qualitative and quantitative composition of the avifauna. This is expressed, in particular, in the change in the ratio of the total density of the bird population, in the quantitative ratio in the density and diversity of species in the ecological groups of birds.

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