

## DIVERSITY OF BIRDS COMMUNITIES IN THE VYHRAIVSKI DACHI TRACT ON THE GRADIENT OF FOREST TRANSFORMATION

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### Abstract

The material was collected in June 2020 in the forest-steppe zone. A total of 42 species of nesting birds have been identified. Their relative abundance averaged  $2.1 \pm 0.42$  pairs/km. 34 species ( $2.8 \pm 0.53$ ) nest in the reserve, 19 ( $3.4 \pm 0.70$ ) in the forest not protected by the conservation status, 21 ( $7.7 \pm 0.88$ ) in the camping area, recreation centre – 33 species ( $5.5 \pm 0.62$  pairs/km). All dominants of communities are hemisynanthropes: *Fringilla coelebs*, *Turdus merula*, *Phylloscopus collybita*, *Passer montanus*. On the gradient of recreational transformation, the synanthropization index of bird communities and the relative abundance of synanthropes increase. The main factor in the formation of  $\alpha$ - and  $\beta$ -diversity of bird communities is the regulation of human activity. The living conditions associated with the culture of human behaviour and the protection of the territory at the recreation centre increase the diversity of nesting stations of birds (nests in buildings and in nest boxes), ensuring protection of birds from ruining nests. There is a redistribution of nesting species in favour of protected forest areas, an increase in the  $\alpha$ -diversity of their communities, which results in the similarity of the bird communities of the reserve with the community of the recreation centre, but not with the community of forestry sites.

**Key words:** indexes of  $\beta$ -diversity, synanthropization of birds communities, nesting birds, diversity recreational transformation by forests

### INTRODUCTION

The current level of anthropogenic impact brings multiple changes to all landscapes (Lavrov et al. 2016), which is reflected on the living conditions of animals (Grimm et al. 2008, Moreno Rueda and Pizzaro 2009). The estimation of the animal population of the region's natural forest ecosystems, deviations from which will be considered developmental defects that appeared under the influence of anthropogenic

conditions, will make it possible to control the city's green spaces to maintain their balanced functioning (Chaplygina et al. 2016, Blinkova and Shupova 2018, Blinkova et al. 2020, Everard 2008). The study of bird communities is one of the best diagnostic techniques, as birds are easy to observe and diagnose (visually and acoustically) (Fischer et al. 2007, Sekercioğlu 2006, Whelan et al. 2008, Gardner et al. 2008), they belong to a wide range of ecological groups, are sensitive to changes in plant communities (Paker et al. 2014, Shupova 2017, Blinkova and Shupova 2017) and to stress caused by humans and domestic animals (Blinkova and Shupova 2018, Shupova and Konyakin 2020). Despite all the deviations from a normally functioning natural forest ecosystem, tree plantings of the settlements are important links that unite forests into a single network, creating centers of greenery in large areas of urban development. Smart planning of plantings distribution in urban areas contributes to preservation of species diversity of biota, which is one of the research priorities of biological sciences development in the late XX – early XXI centuries (Seymour et al. 2015), justified by the loss of animal habitats and in particular birds (Lawlor and Meng 2019). Changes discovered in the diversity of birds will indicate qualitative changes in the functioning of the entire ecosystem (Palomino and Carrascal 2005, Kurosawa 2009). We studied changes in the faunogenetic and ecological structure of bird communities on the gradient of the forest-park transformation and found the exclusion of dendrophilic birds typical for the forest-steppe zone of the European nemoral complex by synanthropic sclerophiles, which are representatives of the desert-mountain complex (Gaychenko and Shupova 2019). On the example of the Boyarka forest research station we showed that the  $\alpha$ -diversity of bird communities is associated with anthropogenic load, rather than with the ratio of the floristic composition of main forest-forming tree species (*Pinus sylvestris* L. and *Quercus robur* L.) (Gaychenko and Shupova 2020).

The goal of this study: to research the changes in nesting bird communities on the forest transformation gradient under the recreational load pressure in culture phyto-coenoses based on *Pinus sylvestris* and *Quercus robur*.

## STUDY AREA

The study was conducted in the “Vyhrayivskie Dachi” tract, which is a complex of various biotopes, making it valuable for monitoring studies of forest-steppe biota. It is located in the forest-steppe zone (Marchenko 2004) in the north of Cherkasy region on the bank of river Ros. Forests are represented by oak-pine and oak-ash groves, pine monocultures, young plantings of *P. sylvestris* and *Q. rubra*. are also present. For the research in the “Vyhrayivskie Dachi” tract we chose plots based on *P. sylvestris* and *Q. robur*. Fragments of the forest were examined in the “Lysianka forestry station” State Institution (49°26'32.0"N; 31°04'57.1"E), in the “Vyhrayivsky” zoological reserve (49°26'28.0"N; 31°05'41.7"E), on the recreational camping area on the bank of the Ros river (49°26'41.1"N; 31°03'55.0"E), in the tree plantings of the recreation centre “Vyhrayivskie Dachi” (49°26'35.8"N; 31°04'16.2"E) (Fig. 1). The list of plots is provided according to the scale of forest biotope transformation. All the plantings are subject to recreational load pressure. Residents of local villages regu-

larly gather forest berries and mushrooms even on the area of the reserve. In summer they are joined by vacationers who come to recreation centre from cities. Unpaved roads are established on the area of the forestry station, consequences of sanitation cuttings were noted. On the bank of the river Ros a camping area of about 0.5 km<sup>2</sup> is designated. There is a beach, a table, a safe fire pit, several tent sites, a place for garbage collection, etc. In 2019, the campsite was actively used: about 10 tent camps were noted. In 2020 no tents were pitched, only the use of the campfire and the beach was observed. The guards of the recreation centre supervised the rules of handling of fire in the forest of the camping area. On the territory of the recreation centre stationary brick and wooden houses, restrooms and a shop are built, electricity supply and pathways are laid, as well as a 24-hour guarding of the area is organized. Some vacationers come with their animals, which are an additional threat to the birds of this biotope. The plantings of the centre are maintained, artificial nests are hung for birds.

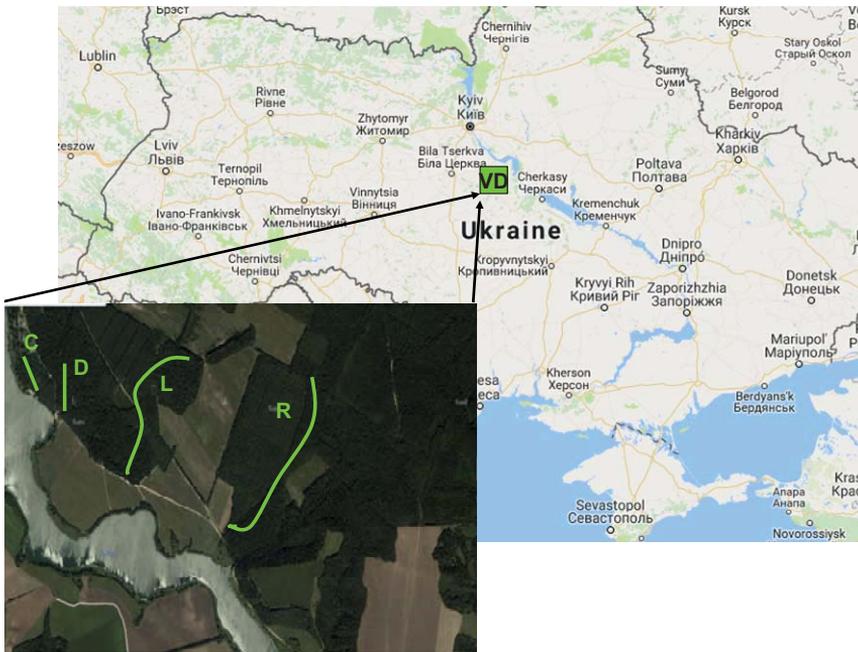


Fig. 1. Model plots of bird communities study in the “Vyhrayivskie Dachi” tract: R – “Vyhrayivsky” zoological reserve, L – forest of the “Lysianka forestry station” State Institution, C – forest of the camping area, D – plantings of the recreation centre

## MATERIAL AND METHODS

Baseline studies were conducted in September 2019. 4 routes were mapped, ranging in 200 m (C), 400 m (D), 900 m (L) and 1500 m (R) (see Fig. 1). The total length of the routes adds up to 3 km. The species composition of sedentary and migratory

birds was assessed. Comparative observations of nesting bird communities were conducted on June 21–26, 2020. The peak of the nesting period was observed: the birds actively sang and fed their hatchlings. The bird distribution was determined by the standard transect method (Bibby et al. 2000). At each plot, 2 countings were conducted (morning – starting at 6<sup>00</sup>, and evening – after 18<sup>00</sup>). The standard deviation was calculated to get the data about average number of birds. We analyzed the species composition of birds communities, their relative abundance (pairs/km), calculated indices (Magurran 1992): diversity: Menchinick index  $D_{Mn} = S/\sqrt{N}$ ; Margalef index  $D_{Mg} = (S-1)/\ln N$ ; Shannon index  $H' = -\sum (P_i \times \ln P_i)$ ; Simpson index  $U_s = 1/D_s$ ; dominance: Simpson index  $D = \sum (P_i \times (N_i - 1)/(N - 1))$ ; Berger–Parker index  $D_{bp} = N_{imax}^2/N$ ; McIntosh index  $D_m = (N - \sqrt{\sum N_i})/(N - \sqrt{N})$ ; Pielou evenness index:  $Ep = H'/\ln S$ , where:  $S$  – the number of species,  $N$  – the total number of birds in communities,  $N_i$  – the number of each species,  $N_{imax}$  – the number of the most numerous species,  $P_i = N_i/N$  – the ratio of each species in community. The synantropization index of birds communities was determined according to Jedryczkowski (Klausnitzer 1990):  $W_s = L_s/L_o$ , where  $L_s$  – is the number of synanthropic species,  $L_o$  – is the total number of species. The standard deviation and logarithmic trends of value changes were set during the graphical processing of data. By using the “Origin Pro 15.0” software, a cluster analysis of the studied habitats avifauna was conducted to estimate the similarity of bird communities. The data of the average number and  $\alpha$ -diversity indices of the birds communities were used during the analysis.

## RESULTS

In total, 42 species of birds with a relative abundance of  $2.1 \pm 0.42$  pairs/km were found in the forests of the “Vyhrayivskie Dachi” tract. Of these, 34 species nest in the reserve, numbering  $2.8 \pm 0.53$  pairs/km, 19 species – in the part of the forest that is not protected by the conservation status ( $3.4 \pm 0.70$  pairs/km), 21 species – in the forest of the camping area ( $7.7 \pm 0.88$  pairs/km). 33 bird species are nesting in the tree plantings of the recreation centre ( $5.5 \pm 0.62$  pairs/km). The species composition of sedentary birds that are on autumn migration in the forests of the tract is 29 species of 5 orders. In nesting birds communities in all biotopes dominated by chaffinch *Fringilla coelebs* Linnaeus, 1758 and common blackbird *Turdus merula* Linnaeus, 1758, and in most cases also common chiffchaff *Phylloscopus collybita* (Vieillot, 1817). In biotopes with a significant anthropogenic load (camping and recreation centre) the list of dominant species is expanded by tree sparrow *Passer montanus* (Linnaeus, 1758). (Table 1). In general, all dominants of communities are hemisynanthropes. Alien bird species in the forest areas are absent, although 1 pair of serin *Serinus serinus* (Linnaeus, 1766) has been noticed in the recreation centre.

In the tree plantings of the recreation centre the values of species diversity indexes are increasing. We attribute this to the fact that the territory of the centre creates specific conditions related to the culture of recreation and protection of the centre, thereby increasing the diversity of bird habitats through additional nesting sites in the cavities of buildings and in nest boxes.

Table 1.

Dominants of bird communities “Vyhrayivskie Dachi” tract  
on the forest transformation gradient

Model plots	Species	Relative abundance (pairs/km)	The ratio of species in community ( $P_i$ )
R	<i>Fringilla coelebs</i>	16.0	0.167
	<i>Phylloscopus collybita</i>	11.33	0.118
	<i>Turdus merula</i>	5.33	0.056
L	<i>Phylloscopus collybita</i>	1.11	0.172
	<i>Turdus merula</i>	8.89	0.138
	<i>Fringilla coelebs</i>	7.78	0.121
	<i>Turdus philomelos</i> Brehm, 1831	6.67	0.102
C	<i>Turdus merula</i>	15.0	0.091
	<i>Passer montanus</i>	15.0	0.091
	<i>Fringilla coelebs</i>	15.0	0.091
	<i>Carduelis carduelis</i> Linnaeus, 1758	15.0	0.091
D	<i>Passer montanus</i>	15.0	0.083
	<i>Fringilla coelebs</i>	15.0	0.083
	<i>Turdus merula</i>	12.5	0.069
	<i>Phylloscopus collybita</i>	10.0	0.056

\* R – “Vyhrayivsky” reserve, L – forest of the “Lysianka forestry station” State Institution, C – forest of the camping, D – plantings of the recreation centre

The species composition of subdominants differs more than that of dominants, and the biotopes of the reserve and forest of “Lysianka forestry station” State Institution include also *Streptopelia turtur* L., which is a species not prone to synanthropization. The species diversity of bird communities in the reserve is much higher than in the part of the forest that is not protected by conservation status. The degree of dominance and evenness of species by number are similar (Fig. 2).

The influence of recreational transformation on bird communities is best shown by ranked curves (dominance-diversity) of communities’ species composition, as well as logarithmic trends of the synanthropization index and the partial number of synanthropic species in communities (Fig. 3). According to the ranked curves, the birds community of the “Vyhraivsky” reserve is the most balanced in terms of the partial number of bird species in a community. A proper evenness of species is noted in the part of the forest, which is subject to anthropogenic activity, although the species composition of the community is lower. The distribution of species in communities is much worse in the forests that are subject to recreational load pressure by vacationers during the nesting period: there is a low number of species, including dominant, the angled shape of the curve indicates a significant gap in the partial number of dominant species from subdominants in the community, and the latter from the common species (Fig. 3a). From 12 to 23 synanthropic species were observed in each of the

model plots. The synanthropization index of bird communities and the share of synanthropic individuals in these communities increases on the gradient of recreational transformation of the forest of the tract. We attribute the decrease in the number of synanthropic species in bird communities in the plantings of the recreation centre (Fig. 3b) to the fact that due to the protection and controlled behaviour of people in the centre, non-synanthropic birds from neighbouring habitats – from the camping area and riverside forests – move here to nest. The absolute value of the observed synanthropic species is the largest here (n=23). Besides, obligate synanthropes settled only on the territory of the recreation centre ((2 species: *Passer domesticus* (Linnaeus, 1758) and *S. serinus*)).

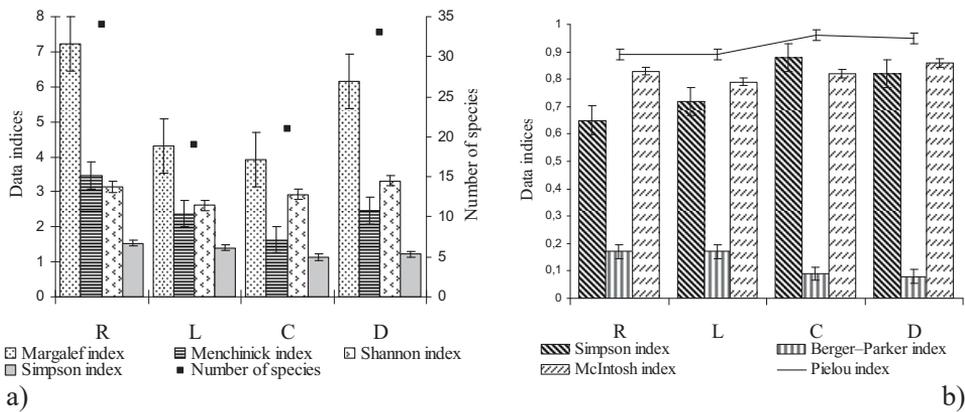


Fig. 2.  $\alpha$ -diversity of bird communities of the “Vyhrayivskie Dachi” tract: a) diversity indices; b) dominance and evenness indices; R – “Vyhrayivsky” reserve, L – forest of the “Lysianka forestry station” State Institution, C – forest of the camping, D – plantings of the recreation center

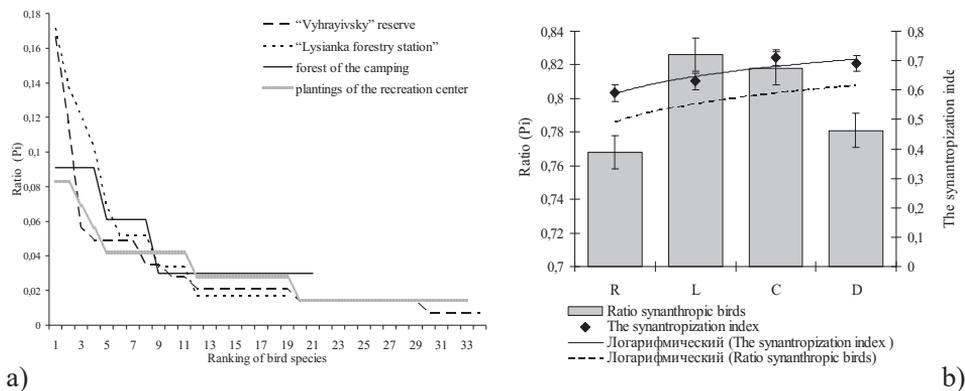


Fig. 3. Response of bird communities of model plots of “Vyhrayivskie Dachi” tract forests to recreational transformation: a) dominance-diversity curves; б) synanthropization of communities

According to the results of cluster analysis, conducted on the basis of bird communities  $\alpha$ -diversity indexes and their average number, bird communities of forest model plots of the “Vyhrayivskie Dachi” tract were divided into 2 groups of similarity: “reserve – recreation centre” and “forestry station – camping”. We believe that the main factor in the formation of the similarity principle of bird communities is the regulation of human activities, as groups of birds of the first group of the dendrogram exist in the presence of a particular protection (Fig. 4), in contrast to the other pair. The ecological distance between the two pairs of model plots is quite large.

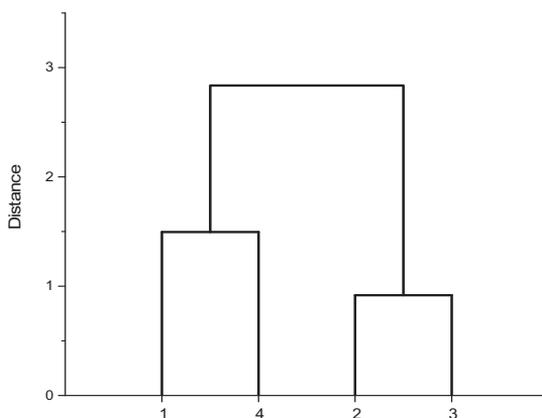


Fig. 4. Similarity of bird communities of forest model plots of the “Vyhrayivskie Dachi” tract: 1 – “Vyhrayivsky” zoological reserve, 2 – forest of the “Lysianka forestry station” State Institution, 3 – forest of the camping area, 4 – plantings of the recreation centre

## DISCUSSION

As in the forests of the Boyarka forest research station (Gaychenko and Shupova 2020), the largest species composition of birds of the “Vyhraivski Dachi” tract lives in the reserve. The lists of bird communities also include vulnerable species that nest on the ground: the woodlark *Lullula arborea* (Linnaeus, 1758), the tree pipit *Anthus trivialis* (Linnaeus, 1758), the wood warbler (*Phylloscopus sibilatrix* (Bechstein, 1793). Their nesting is a good sign that indicates the safety of herbaceous and shrub layers (Blinkova, Shupova, 2017). Nesting of predatory birds and owls is also a positive characteristic of forests: northern goshawk *Accipiter gentilis* (Linnaeus, 1758), sparrowhawk *Accipiter nisus* (Linnaeus, 1758), long-legged buzzard *Buteo rufinus* (Cretzschmar, 1829), common buzzard *Buteo buteo* (Linnaeus, 1758), long-eared owl *Asio otus* (Linnaeus, 1758), little owl *Athene noctua* (Scopoli, 1769). These birds are consumers of higher levels of food chains, thus indicating good productivity in the forest and surrounding landscapes. Their presence in nesting is an indicator of habitat quality (Donázar et al. 2016). The mosaic structure of the landscapes increases the species richness of birds (Tews et al. 2004), while

predatory birds mostly need different habitats for nesting and foraging, which are available in the studied area.

It was also found that the increase of the synanthropization index of bird communities on the biotope transformation gradient is smoother outside settlements, in contrast to the tree plantings of large cities (Gaychenko and Shupova 2019, 2020), which is also validated by this study. The absence of alien bird species is a good indicator for the forests of the tract, as their presence is an important sign of deteriorations of the natural ecosystem. Although birds are not dangerous habitat transformers, the integration of new species into the community leads to changes in its structure and functioning, and a significant imbalance of further development in ornithocoenoses with a low species composition is possible (Koshelev et al. 2009, Gutiérrez et al. 2014). Our previous work with cluster analysis showed that the analysis of  $\alpha$ -diversity data of bird communities reveals more significant differences in avifauna than the comparison of the number of species (Gaychenko and Shupova 2020), so in this study we focused on the data of  $\alpha$ -diversity of communities. The results of the analysis revealed the regulation of impact of recreational load by protective measures of any kind as a factor of the greatest importance.

## CONCLUSION

In total, 42 species of birds nest in the forests of the “Vyhraivski Dachi” tract, most of which live in the reserve: 34 species, numbering  $2.8 \pm 0.53$  pairs/km. The species composition of sedentary birds that are on autumn migration in the forests of the tract is 29 species of 5 orders. All species that dominate in number are hemisynanthropes: *Fringilla coelebs*, *Turdus merula*, *Phylloscopus collybita*, *Passer montanus*. Alien species are absent in the forest; *Serinus serinus* was spotted on the territory of the recreation centre. Living conditions, related to the culture of recreation and protection of the centre, lead to the increase of diversity of bird habitats through additional nesting sites in the cavities of buildings and in nest boxes, thus provide protection from nest destruction for birds. There is a distribution of nesting species in favour of protected forest areas, an increase in the  $\alpha$ -diversity of their bird communities, resulting in a greater similarity of the bird community in the reserve with the community of the recreation centre than that of the forestry station.

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W GRADIENTCIE TRANSFORMACJI REKREACYJNEJ LASU

**Streszczenie**

Badania przeprowadzono w uroczysku Wyhrajiwsi Dacze, które stanowi kompleks różnorodnych biotopów. Miejscowość znajduje się w strefie leśno-stepowej na północy obwodu czerkaskiego (Ukraina), nad brzegiem rzeki Roś. Lasy reprezentowane są przez gaje dębowo-sosnowe (49°26'32,0"N; 31°04'57,1"E) i dębowo-jesionowe (49°26'28,0"N; 31°05'41,7"E), monokultury sosnowe (49°26'41,1"N; 31°03'55,0"E). Występują również młode nasadzenia sosny i dęba czerwonego *Quercus rubra* L. (49°26'35,8"N; 31°04'16,2"E).

Wszystkie biocenozy poddawane są obciążeniu rekreacyjnemu. Mieszkańcy okolicznych wsi i wczasowicze regularnie zbierają leśne jagody i grzyby, nawet na terenie rezerwatu. Na terenie nadleśnictwa są nieutwardzone drogi, odnotowano konsekwencje cięć sanitarnych. Na brzegu rzeki Roś znajduje się pole biwakowe o powierzchni około 0,5 km<sup>2</sup>. W roku 2020 nie rozbijano na nim namiotów, obserwowano jedynie korzystanie z ogniska i plaży. Nasadzenia ośrodka są zadbane, wieszane są sztuczne gniazda dla ptaków.

Materiał zebrano w czerwcu roku 2020. W sumie zidentyfikowano 42 gatunki ptaków lęgowych. Ich względna liczebność wynosiła średnio  $2,1 \pm 0,42$  par/km. W rezerwacie gniazdują 34 gatunki ( $2,8 \pm 0,53$ ), 19 ( $3,4 \pm 0,70$ ) w lesie nieobjętym ochroną, 21 ( $7,7 \pm 0,88$ ) na terenie biwakowym, ośrodek rekreacyjny – 33 gatunki ( $5,5 \pm 0,62$  pary/km). Wszystkie dominanty zgrupowań są hemizynantropami: zięba *Fringilla coelebs*, kos *Turdus merula*, pierwiosnek *Phylloscopus collybita*, mazurek *Passer montanus*. W gradientcie transformacji rekreacyjnej wzrasta wskaźnik synantropizacji zgrupowań ptaków i względna liczebność synantropów. Głównym czynnikiem kształtującym różnorodność  $\alpha$  i  $\beta$  zgrupowań ptaków jest intensywność działalności człowieka.

Warunki bytowania ptaków są związane z kulturą ludzkich zachowań oraz ochroną terenu w ośrodku wypoczynkowym. Ochrona zwiększa różnorodność stanowisk lęgowych ptaków (gniazd w budynkach i budkach lęgowych), zapewniając ptakom ochronę przed rujnowaniem gniazd.

Następuje redystrybucja gatunków lęgowych na rzecz chronionych obszarów leśnych, wzrost różnorodności  $\alpha$  ich zgrupowań, co skutkuje większym podobieństwem ptasich zgrupowań rezerwatu do zgrupowań ośrodka rekreacyjnego, lecz nie do zgrupowań terenów leśnych.

**Słowa kluczowe:** wskaźniki  $\beta$ -różnorodności, synantropizacja zgrupowań ptaków, ptaki lęgowe, różnorodność