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ORNITHOCOMPLEX CHANGES OF THE PINE-OAK FOREST DUE TO THE PARTICIPATION OF THE INTRODUCED POPULATION OF *QUERCUS RUBRA* L.

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Abstract

To date, the issues of the *Quercus rubra* L. ecological niche formation, adaptation of its introduced populations, competition with populations of native trees in the secondary range forests remain open. Purpose: to conduct an inventory of the pine-oak forests ornithocomplex with the participation of the population of *Q. rubra* on the territory of the Boyarka Forestry Research Station (Ukraine), to give a comparative analysis of the pine-oak forests ornithocomplexes with *Q. rubra* and *Q. robur* as a result of the participation of the introduced species in the conditions transformation of birds habitats. It was revealed that because of the replacement of native *Q. robur* with adventive *Q. rubra* in pine-oak plantations, a significant decrease in the species composition (from 24 to 15 species) occurs in ornithocomplexes during the nesting period. The value of the Sorensen index for model ornithocomplexes is 0.62. The average number of birds in both cultural phytocenoses is similar: 2.59 ± 0.50 individuals/km of the account line in subors with *Q. robur* and 2.51 ± 0.57 individuals/km with *Q. rubra*. The replacement of *Q. robur* with *Q. rubra* does not significantly affect the value of the synanthropization index (0.46 with *Q. robur* and 0.47 with *Q. rubra*); does not adversely affect ground-nesting species (*L. arborea*, *A. trivialis*, *T. troglodytes*, *Ph. trochilus*, *Ph. sibilatrix*), indicating the presence of nesting stations for vulnerable species. *Parus major* L., *Phylloscopus collybita Vieillot*, *Ph. sibilatrix* species dominate in the forest without introduced trees; with *Q. rubra* – species *Turdus pilaris* L., *P. major*, *Anthus trivialis* L. predominate. Both types of pine-oak plantations provide a full-fledged food resource for birds feeding on invertebrates and mixed feeds. The absence of predator birds, especially hawks, in the forest with *Q. rubra* is most likely due to the depletion of the food supply due to a smaller species composition and a smaller number of prey. As a result, predators visit subors with *Q. rubra* less often. The data of all species diversity indices are significantly higher for ornithocomplexes of model pine-oak forests with *Q. robur*. Dominance indexes data do not include synchrony (Simpson index data are stable, Berger–Parker index is higher in stands with *Q. rubra*, and McIntosh index – with *Q. robur* respectively). The data for the indices of species distribution uniformity are close.

Key words: α-diversity indices, ornithocomplex, pine-oak plantation, *Quercus rubra* L.

INTRODUCTION

Every year, the relevance of studies of the influence of adventitious biota species on the communities into which they were introduced increases. Despite the fact that sometimes the diversity of cultural phytocenoses, for example, park ecosystems, increases due to adventitious species (Miroshnyk et al. 2021), the problem of the negative impact of non-native species on the environment by disrupting structural and functional relationships in ecosystems does not fade away. Invasive plants can also lead to biodiversity loss (Wilcove et al. 1998, Ayup et al. 2014, Dragomir et al. 2017), reduced ecosystem resilience and degradation (Kumagai et al. 2015, Pyšek and Richardson 2010). To this day, the issues of the influence of populations of *Quercus rubra* L. on the native biota of communities remain not researched enough. In ornamental plantings in Ukraine, this species was introduced in the 40s of the 19th century, and 100 years later (in the 40-50s of the 20th century) into forest cultures (Ivchenko 2002). High winter hardiness, undemanding to soils, degree of illumination, humidity, intensive growth and productivity allowed the plant to adapt well to new habitat conditions (Poliakova 1997). The formation of the fundamental ecological niche of *Q. rubra*, the adaptation of its introduced populations, and their competition with native trees in natural forests and cultural phytocenoses have been identified as a promising area of research (Blinkova 2013).
In the process of studying the adaptation of *Q. rubra* populations to new habitat conditions, the ornithocomplex associated with plantations of introduced trees during the nesting period was studied. Birds are one of the most influential faunistic components of communities (Fischer et al. 2007, Robledano et al. 2010), they are sensitive to any environmental disturbances (Blair and Johnson 2008), which affect their species composition, abundance, and spatial distribution (Blinkova and Shupova 2017, 2018). The ornithocomplex analysis of the experimental site and the identification of its differences from the complex of birds inhabiting the natural site makes it possible to show the differences in the group of important consorts of tree plantations. Purpose: to carry out an inventory of the ornithocomplex of pine-oak plantations with the participation of the population of *Q. rubra* on the territory of the Boyarka Forestry Research Station, to give a comparative analysis of the subor's ornithocomplexes with *Q. rubra* and *Q. robur* as a result of the introduced species participation in the transformation of bird habitats.
The Boyarka Forestry Research Station was organized in 1925. The station is located in the Kiev highland region. High rainfall and relatively high average annual temperatures characterize the climate. The soils are soddy-weakly podzolic clayey-sandy (General geography atlas… 2004). The most common type of forest here is fresh hornbeam-oak-pine sudubraves (53.3% of the area) and fresh oak-pine subors (29.4%). The average age of stands is 50-70 years (Rybak et al. 2005). The territory of the station is 21,100 hectares, of which 2,275 hectares are occupied by cultural phytocenoses with *Q. rubra*. The material was collected on the territory of quarters 281 and 287 of the Plesetsk forestry of the Boyarka Forestry Research Station (50°17′34.6″N; 30°08′50.0″E). These are cultural phytocenoses (fresh subor) based on *Pinus sylvestris* L. with *Q. robur* L. and *P. sylvestris* with *Q. rubra*. A detailed analysis of plant communities in the studied areas is given in the work of O. Blinkova (2013).

MATERIAL AND METHODS

Birds were observed in the nesting period in June 2013 (3 controls observations). The bird distribution was determined by the standard transect method (Bibby et al. 2000). The length of transects was 1,400 m, in each model pine-oak plantation. Width of the transects 100 m. The examination was carried out in the morning (from 7 to 11 am); 27 species of birds from 5 orders were counted. The total number of recorded animals was 100 specimens.

We analyzed the species composition of birds communities, their relative abundance (individuals/km transect), calculated α-diversity indices (Magurran 1992). Diversity indices: Menchinick $D_{Mn} = S/\sqrt{N}$; Marhalef $D_{Mg} = (S-1)/lnN$; Shannon $H' = -\Sigma(P_i \times lnP_i)$; McIntosh $U = \sqrt{\Sigma N_i^2}$; dominance indices: Simpson $D_s = \Sigma(P_i \times (N_i-1)/(N-1))$; Berger–Parker $D_{bp} = Ni_{max}/N$; McIntosh $D_m = (N-\sqrt{\Sigma N_i})/(N-\sqrt{N})$; evenness indices: Pielou $E_p = H'/LnS$; McIntosh $E_m = (N-U)/(N-N/\sqrt{S})$, where: S – the number of species, N_i – the abundance of each species (individuals/km), N – the total abundance of birds, N_{max} – the abundance of the most numerous species, $P_i = N_i/N$ – the ratio of species in community.

Similarity of species composition in two ornithocomplexes was calculated by the formula (Sorensen index): $Cs = 2j/(a+b)$, where a – the number of ornithocomplex species present in the first list, b – the number of ornithocomplex species, present in the second list, j – the number of species common to both lists.

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.

Distribution of species in ornithocomplexes by feeding type analyzed by V. P. Belik classification (2006): predatory – birds that feed on vertebrates, entomophage – feed on invertebrates, phytophages – feed on fruits and green parts of plants, mixed feeding type – equally eat invertebrates and plant foods, polyphages – feed on all types of food (Corvidae).

RESULTS

On the territory of the model plantation of the Plesetsk forestry of the Boyarka Forestry Research Station with *Q. rubra* 15 species of birds of 2 orders were counted, with *Q. robur* – 24 species of 5 orders, respectively. The average abundance of birds in both cultural phytocenoses is similar: 2.59 ± 0.50 individuals/km in subors with *Q. robur* and 2.51 ± 0.57 individuals/km with *Q. rubra*. The presence of *Dryocopus martius* L., *Lullula arborea* L., *Anthus trivialis* L., *Troglodytes troglodytes* L., *Phylloscopus trochilus* L., *Phylloscopus sibilatrix* Bechstein in the ornithocomplex can be noted as a positive characteristic of stands with *Q. rubra* (Table 1). *L. arborea*, *A. trivialis*, *T. troglodytes*, *Ph. trochilus*, *Ph. sibilatrix* vocalized actively, indicating that they were nesting. The woodpeckers were feeding, which does not exclude the possibility of their nesting. The value of the Sorensen index for ornithocomplexes is 0.62.

In terms of numbers, the forest without introduced oaks, the following species dominate *Parus major* L., *Phylloscopus collybita* Vieillot, *Ph. Sibilatrix*; with *Q. rubra – Turdus pilaris* L., *P. major*, *Anthus trivialis* L. predominate.

Table 1

Species composition of ornithocomplexes in model pine-oak plantation

Species	Pine-oak plantation with			
	Q. robur		*Q. rubra*	
	N_i	P_i	N_i	P_i
Pernis apivorus (L. 1758)	0.71	0.011	0.00	0.000
Accipiter gentilis (L. 1758)	0.71	0.011	0.00	0.000
Columba palumbus L. 1758	0.71	0.011	0.00	0.000
Cuculus canorus L. 1758	0.71	0.011	0.00	0.000
Dryocopus martius (L. 1758)	1.43	0.023	0.77	0.020
Dendrocopos major (L. 1758)	1.43	0.023	1.54	0.041
Leiopicus medius (L. 1758)	1.43	0.023	0.00	0.000
Lullula arborea (L. 1758)	0.00	0.000	0.77	0.020
Anthus trivialis (L. 1758)	4.29	0.069	5.38	0.143
Oriolus oriolus (L. 1758)	0.71	0.011	0.00	0.000
Garrulus glandarius (L. 1758)	0.71	0.011	0.00	0.000
Corvus corax L. 1758	0.71	0.011	0.00	0.000
Troglodytes troglodytes (L. 1758)	0.00	0.000	1.54	0.041
Phylloscopus trochilus (L. 1758)	2.14	0.034	1.54	0.041
Phylloscopus collybita (Vieillot, 1817)	7.14	0.115	0.00	0.000
Phylloscopus sibilatrix (Bechstein, 1793)	5.71	0.092	3.08	0.082
Erithacus rubecula (L. 1758)	2.14	0.034	0.77	0.020
Luscinia luscinia (L. 1758)	1.43	0.023	0.00	0.000
Turdus pilaris L. 1758	2.14	0.034	7.69	0.204
Turdus merula L. 1758	3.57	0.057	0.77	0.020
Turdus philomelos C. L. Brehm, 1831	1.43	0.023	0.00	0.000
Poecile palustris L. 1758	0.00	0.000	0.77	0.020
Cyanistes caeruleus L. 1758	1.43	0.023	0.00	0.000
Parus major L. 1758	10.7	0.172	6.15	0.163
Sitta europaea L. 1758	3.57	0.057	3.08	0.082
Certhia familiaris L. 1758	2.86	0.046	1.54	0.041
Fringilla coelebs L. 1758	4.29	0.069	2.31	0.061

* N_i – the abundance of each species (individuals/km transect); P_i – the ratio of species in ornithocomplex

Feeding in the territory of both subors of *D. martius* and *Dendrocopos major* L., *Parus major* L., *Sitta europaea* L., *Certhia familiaris* L., i.e. gathering food on the trunks and branches of woody vegetation indicates an equivalent food resource of the forest stand. A high total abundance of thrushes (*Turdus*; see Table 1) is possible with a good forage base in forest litter. Other birds have a wider range of feeding stations, and they are less dependent on individual characteristics of the phytocenosis. Predator birds were not recorded in plantations with *Q. rubra*.

In both ornithocomplexes, entomophages and birds with a mixed diet are most widely represented (Fig. 1). The ornithocomplex of the forest with native *Q. robur* is supplemented by 1 species of phytophage, the granivorous *Columba palumbus* L., 1 myophage, *Accipiter gentilis* L., and 2 polyphages (*Garrulus glandarius* L., *Corvus corax* L.). Thus, birds with a mixed diet in stands with *Q. robur* make up 49.99% in total.

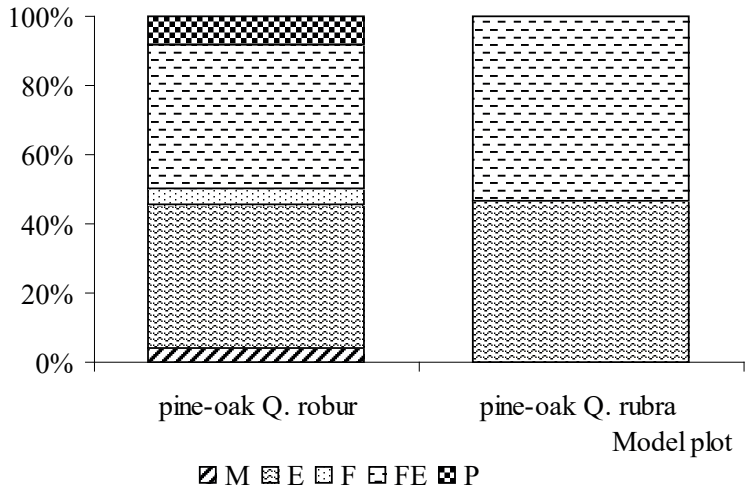

Fig. 1. Distribution of species in ornithocomplexes by feeding type: M – predatory birds, E – entomophages, F – phytophages, FE – mixed feeding, P – polyphages

The synanthropization index of the forest bird complex with an adventitious oak is slightly higher than that with the native oak: 0.47 and 0.46, respectively. The data of all indices of species diversity are significantly higher for the ornithocomplexes of model subors with *Q. robur* (Table 2). Dominance indexes data do not include synchrony (Simpson index data are stable, Berger–Parker index is higher in stands with *Q. rubra*, and McIntosh index – with *Q. robur*, respectively). The data for the indices of species distribution uniformity are close.

In the forest area with introduced oaks, the ranged curves of the abundance of bird species show a less balanced state of the ornithocomplex than in forest stands of native trees: a greater pressure of dominant species and a disturbed uniformity of species distribution (Fig. 2).

Table 2

α-diversity of ornithocomplexes in model plots

Indices		Index data in pine-oak plantation with	
		Q. robur	*Q. rubra*
Diversity indices	Marhalef	5.57	3.86
	Menchinick	3.04	2.44
	Shannon	2.84	2.40
	McIntosh	17.28	12.76
Dominance indices	Simpson	0.62	0.62
	Berger–Parker	0.17	0.20
	McIntosh	0.83	0.79
Evenness indices	McIntosh	0.91	0.89
	Pielou	0.89	0.89

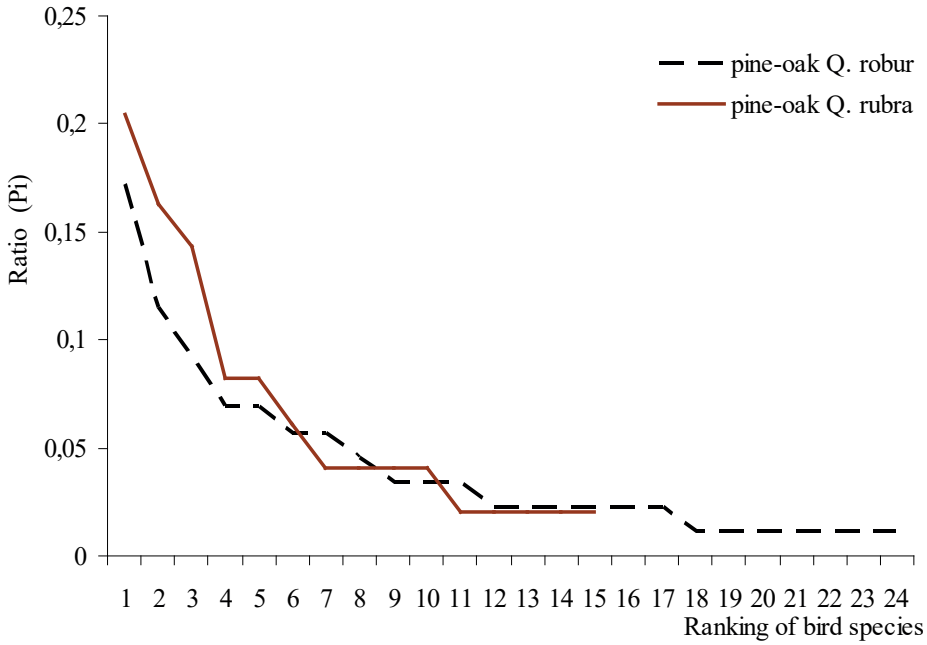

Fig. 2. Ranked curves of the relative abundance of species in ornithocomplexes of model plots

DISCUSSION

A total of 65 species of birds of 11 orders, of which 52 species are in forest plantations, 21 in adjacent meadows and fields were recorded on the territory of the Boyarka Forestry Research Station. Adventive bird species have not been registered (Gaychenko and Shupova 2020). Botanical studies of pine-oak plantations of the station showed that in some areas there was a replacement of tree species, a change in the sanitary condition of the forest. For introduced populations of *Q. rubra*, a high reproductive potential was revealed, the culmination of growth in height occurs at 8-15 years, diameter – 15-25 years, for the period 1995-2013 the sanitary condition of *Q. rubra* populations is indicated as "healthy", significant seed renewal is described, rapid growth, early ripeness, competitiveness with *P. sylvestris* and suppression of the latter (Blinkova 2013). All these adaptive characteristics allow the introduced species to quickly form a forest stand of sufficient structural complexity, which is a significant phytocenosis factor for bird life (James and Wamer 1982, Gabbe et al. 2002, Walther 2002).

Due to the large number of species and wide ecological valence, birds master the changed biotopes (Walther 2002) and adapt to existence in new conditions, creating consortative bonds, including with alien plants (Shupova 2021). Typical dominants of the ornithocomplexes of natural forests of the region were noted by us (Blinkova and Shupova 2017) in subori with native *Q. robur*, while in plantations with *Q. rubra*, *A. trivialis* was found in the list of dominant bird species, which has become rare in the natural forests of Ukraine (Chaplyhyna et al. 2016). The presence of the *A. trivialis* in the list of dominants is a good sign, since for birds nesting on the ground, a significant focus that affects their presence is the state of the herbaceous and shrub layer (Heyman 2010, Šalek et al. 2010), during the degradation of which ground-nesting species are decreasing or disappearing (Blinkova and Shupova 2017, 2018). Synanthropic bird species prefer the outskirts of the forest area of the Boyarka Station and the synanthropization index of communities in various forest fragments ranged from 0.40 to 0.65 (Gaychenko and Shupova 2020). The value of the synanthropization index of ornithocomplexes of the surveyed pine-oak plantations is relatively low, although in the forest with *Q. rubra* it is slightly higher: 0.47 and 0.46.

Habitat transformation often leads to a decrease in bird species diversity (Graham et al. 2014). As a rule, this is facilitated by the process of habitat fragmentation (Norton et al. 2000, Zannette 2001, Bélisle and Clair 2002). Our studies have shown a decrease in species diversity according to 4 indices (Margalef, Menchinick, Shannon, McIntosh) as a result of the introduction of an alien species into the ecosystem, violation of the species uniform distribution and dominant relationships.

CONCLUSION

There is a significant decrease in the species composition (from 24 to 15 species) and species diversity, a violation of the uniform distribution of species in terms of numbers, strengthening the pressure of the dominant species as a result of the *Q. robur*

replacement in native to Ukraine pine-oak plantations with adventive *Q. rubra* during the nesting period in the ornithocomplexes associated with this type of forest. At the same time, the replacement of *Q. robur* with *Q. rubra* does not significantly affect the value of the synanthropization index and does not negatively affect species nesting on the ground (*L. arborea*, *A. trivialis*, *T. troglodytes*, *Ph. trochilus*, *Ph. sibilatrix*), which indicates the presence of a complete complex of nesting stations for forests. The absence of predator birds (hawks) in the registration band is most likely because of a poorer food supply: due to the smaller species composition of the ornithocomplex and the lower number of birds (2.59 ± 0.50 and 2.51 ± 0.57 individuals/km), predators less often visit the subor with *Q. rubra*. Invertebrate-eating birds (with *Q. robur* – 41.67%, with *Q. rubra* – 46.67%), and mixed-ration species (with *Q. robur* – 49.99%, *with Q. rubra* – 53.33%) in the studied forests are equally represented.

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ZMIANY ORNITOKOMPLEKSU BORU SOSNOWO-DĘBOWEGO ZWIĄZANE Z UDZIAŁEM WPROWADZONEJ POPULACJI *QUERCUS RUBRA* L.

Streszczenie

Do chwili obecnej otwarte pozostają kwestie kształtowania się niszy ekologicznej dęba czerwonego (*Quercus rubra* Linnaeus, 1753), adaptacji jego populacji, konkurencji z populacjami rodzimych gatunków drzew w lasach o zasięgu wtórnym.

Cele badań: inwentaryzacja ornitokompleksów boru sosnowo-dębowego z udziałem populacji dęba czerwonego na terenie Leśnej Stacji Doświadczalnej Bojar (Ukraina). Wykonanie analizy porównawczej ornitokompleksów boru sosnowo-dębowego z dębem czerwonym oraz dębem szypułkowym (*Quercus robur* Linnaeus, 1753), aby ustalić wpływ gatunku inwazyjnego na przekształcenie warunków siedliskowych ptaków.

Stwierdzono, że w okresie lęgowym na plantacjach sosnowo-dębowych zastąpienie rodzimego dębu szypułkowego przez zawleczony dąb czerwony w ornitokompleksach prowadzi do znacznego zubożenia składu gatunkowego ptaków: z 24 do 15 gatunków. Wartość wskaźnika Sorensena dla modelowych ornitokompleksów wynosi 0,62.

Średnia liczebność ptaków w obu fitocenozach sztucznych jest zbliżona: 2,59±0,50 osobników/km z dębem szypułkowym oraz 2,51±0,57 osobników/km z dębem czerwonym.

Zastąpienie dębu szypułkowego przez czerwony nie zmienia istotnie wartości wskaźnika synantropizacji (0,46 z udziałem dębu szypułkowego oraz 0,47 z udziałem dębu czerwonego) oraz nie wpływa niekorzystnie na gatunki gniazdujące na ziemi (*L. arborea*, *A. trivialis*, *T. troglodytes*, *Ph. trochilus*, *Ph. sibilatrix*), co wskazuje na obecność stanowisk lęgowych gatunków wrażliwych.

Pod względem liczebności w lesie z dębem szypułkowym dominują: *Parus major L.*, *Phylloscopus collybita* Vieillot, *Ph. sybilatrix*; w lesie z udziałem dębu czerwonego: *Turdus pilaris L.*, *P. major*, *Anthus trivialis L.*

Obydwa typy plantacji sosnowo-dębowych dostarczają pełnowartościowych zasobów pokarmowych ptakom żywiącym się bezkręgowcami i pokarmem mieszanym. Brak ptaków drapieżnych, zwłaszcza jastrzębi, w lesie z dębem czerwonym jest najprawdopodobniej spowodowany uszczupleniem zasobów pokarmowych z powodu uboższego składu gatunkowego i mniejszej liczebności ofiar. Z tego wynika, że drapieżniki rzadziej odwiedzają plantacje z udziałem dębu czerwonego.

Wartości wszystkich wskaźników różnorodności gatunkowej są istotnie wyższe dla ornitokompleksów modelowych borów sosnowo-dębowych z udziałem dębu czerwonego. Wartości wskaźników dominacji nie wykazują synchroniczności: wartości wskaźnika Simpsona są stabilne, wskaźnik Bergera-Parkera jest wyższy w drzewostanach z dębem czerwonym, lecz wskaźnik McIntosh – w drzewostanach z dębem szypułkowym. Wartości wskaźników równomierności rozmieszczenia gatunków są zbliżone.