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Seasonal and interannual dynamics of the bird population of the Nizhny Novgorod International Airport

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Ninety-nine bird species has been registered on the territory of the Nizhny Novgorod International Airport in 2013–2014 and 2017–2018, 10 of which are listed in the regional Red List and 10 – in its Annex. There were changes in the bird population after carrying out construction work on the site improvement. The dominant species have changed; particularly, common whitethroat *Sylvia communis* Latham, 1787 was replaced by white wagtail *Motacilla alba* L., 1758 in the nesting period, and the Eurasian tree sparrow *Passer montanus* (L., 1758) became the dominant species instead of great tit *Parus major* L., 1758 in the post-nesting period. Birds feeding in shrubs and tall grasses have been replaced by land-feeding species, which was especially noticeable during the post-nesting period. The dynamics of bird abundance in summer has changed from emigration to equilibrium-dynamic. The interannual similarity of the summer ornithocomplexes of the airport and its similarity with other meadow avian communities in the region is low. The bird population of the airport stands out as a separate group, but is close to ornithocomplexes of different mosaic coppice meadows, as evidenced by cluster analysis. The characteristics of the airport bird population are preconditioned by several factors such as afforestation, development, and human activities.

Keywords: bird population, species richness, cumulative abundance, interannual similarity, meadow habitats, factors.

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Introduction

A modern airfield occupies a large territory. Here, the conditions are often favorable for the bird nesting; for example, they are the inaccessibility for most people, the formation of a mosaic landscape with forest, shrubbery and open areas, with temporary and permanent ponds, and various buildings. The fodder base is also well represented. Seeds of herbaceous plants in the open areas provide food for granivorous birds. The presence of rodents attracts predators, including corvids, which can form large flocks here. Well-heated runways

attract insects and, accordingly, insectivorous birds. Some birds themselves like to bask here in the sun. Buildings are convenient for synanthropes. The combination of all these factors contributes to the formation of a special biocenosis at the territory of airports (Chudnenko et al., 2018; Molodovsky and Zaloznykh, 1999; Zabashta, 2018; Yacobi, 1974).

A variety of environmental parameters, a mosaic landscape over a large area inside and around airports form favorable conditions for mass nesting and feeding of birds, especially in the summer (Surnina et al., 2018; Titkov, 2008). The airport security regime is especially important for them, providing the restricted access to the territory during the nesting period. Data on the status and dynamics of ornithocomplexes of airports can serve as source material for planning work to reduce the attractiveness of this area for birds. It is also possible to identify the features of ornithocomplexes formed on the territory of protected sites that occupy large areas in the vicinity of large megacities.

Nizhny Novgorod International Airport is located at the southern border of Nizhny Novgorod, in the lowland of the Volga-Oka interfluve, behind the left-bank floodplain of the Oka River. Lowland motley meadows prevail on its territory, surrounded by the mixed forests, represented mainly birch, alder, aspen, and oak. Groups of administrative buildings and hangars occupy a small area.

Until 2017, bush formation was observed at the airport, the periphery was covered with 15-year-old deciduous or coniferous new growth. The northern part of the airport was heavily flooded and had drainage channels and depressions for the accumulation of flood and drainage waters. In 2018, they cleared the territory: both the tree-shrub layer and the grass cover were completely reduced on large areas, abandoned buildings were pulled down, the northern part was mostly drained, and a new taxiway was built in the southern part. The territory has become completely open and landscaped. At the same time, extensive shallow puddles with low grass stand formed in the northern part of the airport.

In order to develop recommendations for ensuring the safety of aircraft flights, the bird population was monitored at the airport several times over the past two decades (Kolesova and Noskova, 2018; Kolesova and Strizhova, 2016; Molodovsky and Zaloznykh, 1999). The range of devices that scare birds has significantly replenished here over this period, including propane guns, bioacoustic installations, and various repelling dummies of predator birds. The latest bird counts at the airport were carried out both before and after the site improvement. The study aims to assess the changes of the ornithocomplex of the airport in a dynamically developing environment.

Materials and Methods

Materials on the bird population were collected during censuses at the airport from the second half of May 2013 to the second half of August 2014, and from September 2017 to the second half of August 2018. Birds were counted by the route method without a fixed accounting band with subsequent recalculation to the area according to the average group detection ranges (Ravkin, 1967). A correction was made for the walking speed of observer in order to calculate the abundance of flying individuals (Ravkin and Dobrokhotov, 1963). In the summer period (from the second half of May to the second half of August), seven censuses were performed, from September to April, eight censuses (once a month). The total route length of the summer censuses was about 240 km over three years (an average of 80 km each year), of which 137 km were made during in the nesting period (May 16 – July 15) and 103 km, during the post-nesting period (July 16 – August 31); during other periods, 65 km in autumn, 64 km in winter, and 44 km in spring (total for two years).

The species with the share in the community exceeding 10% by abundance have been defined as dominant; common species were the species, which abundance was at least 1 ind./km^2 (Kuzyakin, 1962). Primary data have been included into the database of the Laboratory of Zoological Monitoring, Institute of Systematics and Ecology of Animals, Siberian Branch, Russian Academy of Sciences (Novosibirsk, Russia). The data processing has been performed using the original software developed by this laboratory, as well as using the StatSoft Statistica v 6.0 software package. The Sørensen – Chekanovsky index (Pesenko, 1982) has been calculated in order to search for the similarity between the summer ornithocomplexes of the airport before and after the site development (in 2014 and 2018), as well as with other meadow bird communities of the Nizhny Novgorod Region. A total of 36 indicators were obtained, including own data (at the airport) for 2018 and the published materials collected in different years (Noskova et al., 2009).

Materials on other meadow ornithocomplexes were collected in the summer, from June 16 to July 31, in the valleys of medium-size and large rivers of the western and central Pre-Volga River region (Serezha River and P'yana River, respectively), as well as the southern Trans-Volga River region (Volga River, Vetluga River) in 2001 (data by A.V. Rokhmistrov), in 2002–2003 (data by O.S. Noskova and I.A. Skvortsova), and in 2004 (data by O.S. Noskova, O.A. Grigorieva, and E.V. Santsova). In each floodplain, several types of habitats were examined: mosaic coppice meadows and overgrown upland hayfields (Serezha River, Volga River), clover meadows (P'yana River, Volga River), upland pasture meadows (Serezha River, Vetluga River). In all

cases, birds were counted by the same route method (census) without a fixed band (Ravkin, 1967). In total, routes in the meadows covered about 200 km, at the territory of the Nizhny Novgorod International Airport, about 80 km. In order to make an objective comparison with the local meadow communities, the data of bird counts at the airport have been used only for the period of July 16–31, which coincided with the timing of counts in other habitats.

In addition, a cluster analysis was carried out to assess the degree of similarity between the ornithocomplexes of the airport and the bird communities of other meadow habitats in the region. The role of various characteristics (parameters) of habitats in shaping the summer bird population was evaluated separately by the number of species and cumulative abundance using factor analysis (Khalafyan, 2007). The parameters were evaluated by an expert method in a point system from 0 to 3, where 0 is the complete absence of the factor, 1 is a weakly expressed factor, 2 is the clearly expressed factor, 3 is the most pronounced factor. A total of five characteristics were identified: moisture, bush cover percent, forest cover percent, degree of development, and disturbance factor.

Results

At the territory of the Nizhny Novgorod International Airport, over the entire study period, 99 bird species from 33 families and 11 orders have been registered, which comprised 33% of the total bird species number of the Nizhny Novgorod Region (Bakka and Kiseleva, 2017).

Species richness

In summer, over three study years of research, a larger number of species has been registered, 95 species in total (79 species, in 2013; 62, in 2014, and 82, in 2018), of which 92 species have been noted during the nesting period, and 73, during post-breeding period. Moreover, 15 species were observed only in summer. The greatest species richness of the ornithocomplex, including the common species, has been observed during the nesting period (Fig. 1). In 2014, the number of species was slightly lower than in the other years. When comparing with other airport-associated bird communities, only 24 bird species from 4 orders nest on the territory of the Ivanovo airport, also located in the Volga-Oka interfluve, about 190 km from the Nizhny Novgorod International Airport (Chudnenko et al., 2018).

In the summer community, 10 species belonged to the Red List of the Nizhny Novgorod Region, and 10, to its Appendix (hereinafter, all these species were conditionally called rare; Krasnaja Kniga..., 2014; Prilozhenie..., 2014). Thus, corn crake *Crex crex* (L., 1758), the common gull *Larus canus* L., 1758 and the black-headed gull *L. ridibundus* L., 1766 were observed in all three study years; the common quail *Coturnix coturnix* (L., 1758) and the common redpoll *Acanthis flammea* (L., 1758), only in 2013 and 2014; and the common tern *Sterna hirundo* L., 1758, the common house martin *Delichon urbica* (L., 1758), and the hawfinch *Coccothraustes coccothraustes* (L., 1758), in 2013 and 2018. The other rare species were registered during a certain year only.

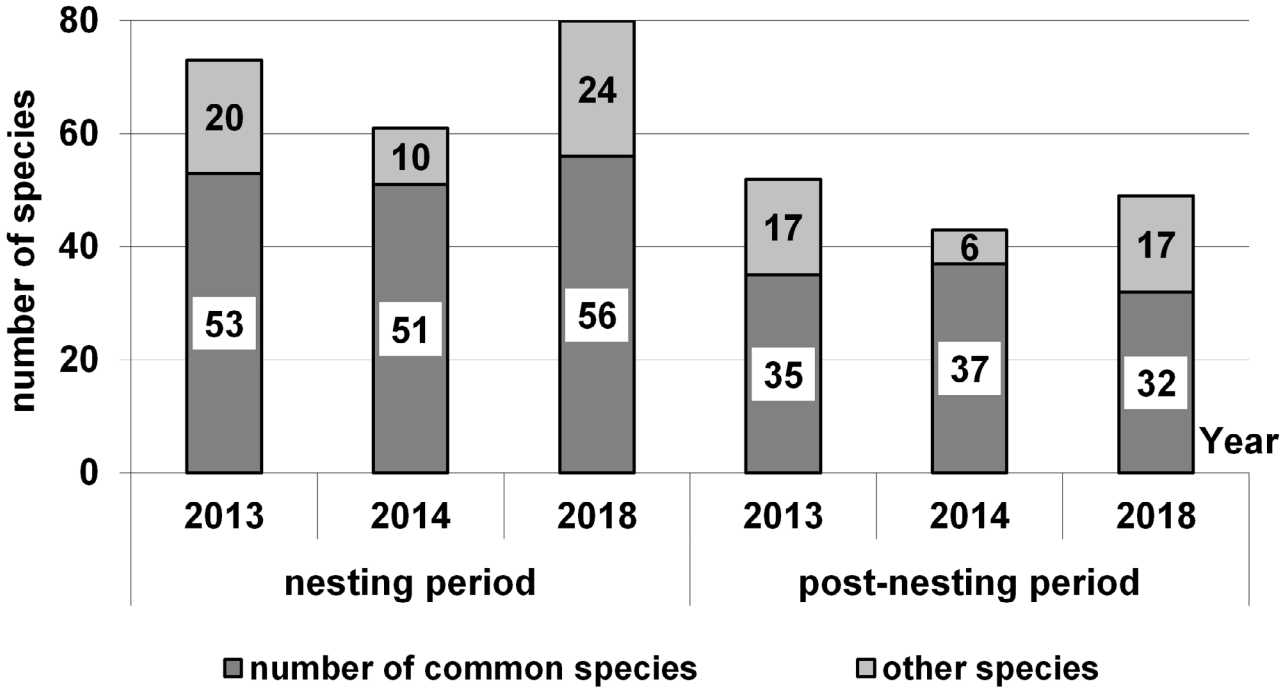

Fig. 1. The species richness of the summer bird population of the Nizhny Novgorod International Airport.

The abundance of most rare species did not exceed 5 ind./km^2. Only in the common redpoll, found in the post-nesting period, it reached 25 ind./km^2, and in the black-headed gull in the nesting period, up to 33 ind./km^2. In 2018, after finishing the site development, Montagu's harrier *Circus pygargus* (L., 1758), wood sandpiper *Tringa glareola* L., 1758, marsh sandpiper *Tringa stagnatilis* (Bechstein, 1803), ruff *Philomachus pugnax* (L., 1758), and the booted warbler *Hippolais caligata* (Lichtenstein, 1823) appeared on open moistened meadows of the airport during the nesting period (Fig. 2). The Eurasian oystercatcher *Haematopus ostralegus* L., 1758, was noted back in April of the same year. Many rare species of sandpipers were recorded both on the territory of the Ivanovo airport and its environs: obviously, under similar conditions of moisture and landscape openness (Chudnenko et al., 2018).

In the autumn, 40 bird species have been recorded; in the winter, they were 18, and in the spring, 50. The northern goshawk *Accipiter gentilis* (L., 1758) and the Eurasian treecreeper *Certhia familiaris* L., 1758 have been met only in autumn, the Eurasian oystercatcher, only in the spring; the Bohemian waxwing *Bombycilla garrulus* (L., 1758) was registered in all seasons except summer. In autumn, the largest number of species was recorded in September or October (up to 24 species in 2017), depending on autumn weather conditions (Fig. 3).

Fig. 2. Montagu's harrier *Circus pygargus* (L., 1758) (**A**) and northern lapwing *Vanellus vanellus* (L., 1758) (**B**) on the territory of the Nizhny Novgorod International Airport (photo by S.A. Baranov).

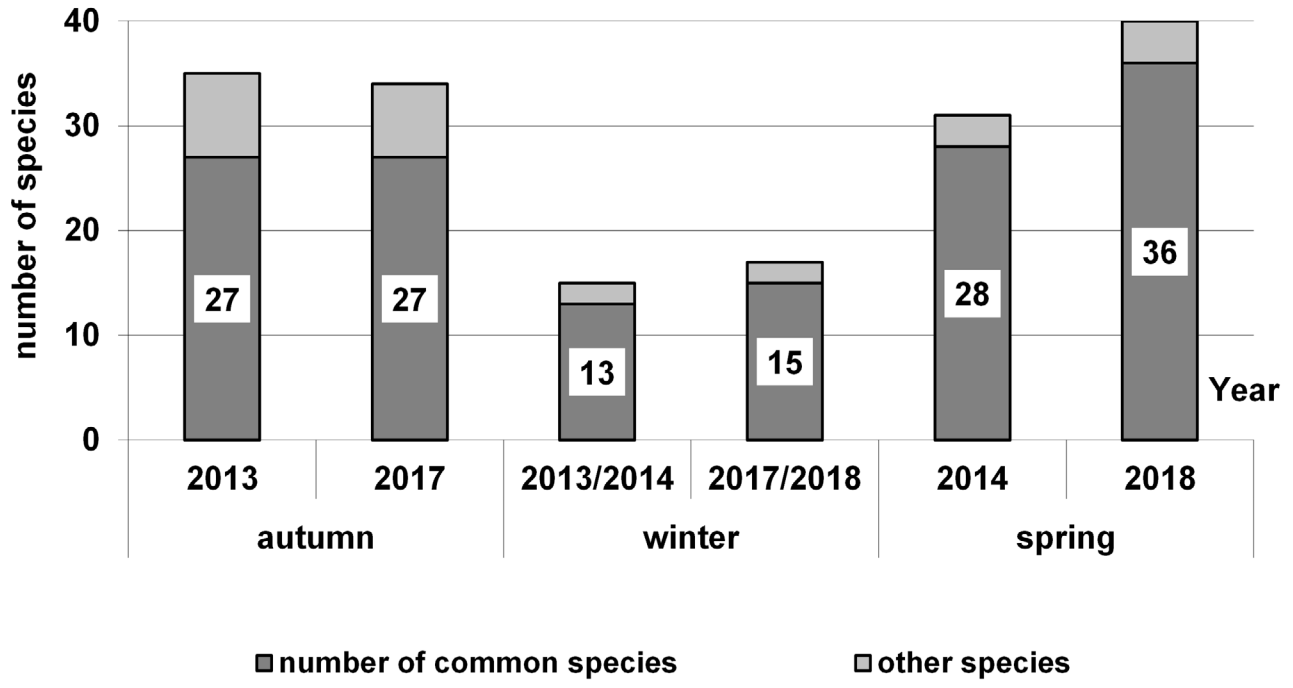

Fig. 3. The species richness of the autumn-winter-spring bird population of the Nizhny Novgorod International Airport.

In winter, at the airport, most birds belonged to the group of common species. The composition of the bird population was relatively stable, since only a few of them could survive harsh weather conditions, namely the Eurasian bullfinch *Pyrrhula pyrrhula* (L., 1758), the species of Paridae family, as well as Corvidae, fieldfare *Turdus pilaris* L., 1758 and Bohemian waxwing, which were dangerous for the aircraft flights.

In 2014, the number of bird species began to grow as early as February; on the contrary, it decreased in 2018. Active construction work at the airport, cutting down a significant part of the bushes made it less attractive for feeding birds in winter. In addition, vast treeless spaces did not provide protective shelter for birds during severe frosts.

In the spring, there was a sharp increase in both the total number of species and the number of common species, which was associated with the natural processes of bird migration to nesting sites.

Cumulative abundance and its dynamics

Dynamics of the summer abundance of the ornithocomplex was of an emigration type in 2013 and 2014, and of equilibrium-dynamic in 2018 (Fig. 4). Site development evolved new parameters of the environment for the birds, so they kept here mainly during the post-nesting migrations. Fledgling in the majority of species occurred every year in the first half of June, but the abundance of the bird population in 2018 was almost half as much comparing to the same period of 2013–2014. The cumulative abundance of the ornithocomplex in 2018 in the nesting period decreased almost one and a half times, and in the post-nesting, on the contrary, it increased by the same degree (Table 1).

The bird abundance increase, which is dangerous for aircraft, has been noted every year in summer, specifically, in the first half of the nesting period (II half of May and I half of June) and at the beginning of

Table 1. The main integral indicators of the summer bird population of the Nizhny Novgorod International Airport.

	Cumulative abundance, ind./km^2			Dominant species, % by abundance			Shannon index (H)			Pielou's evenness index (E)		
Period	2013	2014	2018	2013	2014	2018	2013	2014	2018	2013	2014	2018
Nesting	1582	1204	998	15	–	11	3.30	3.46	3.67	0.77	0.84	0.84
Post-nesting	688	641	1041	29	26	47	2.90	3.12	2.18	0.75	0.83	0.56

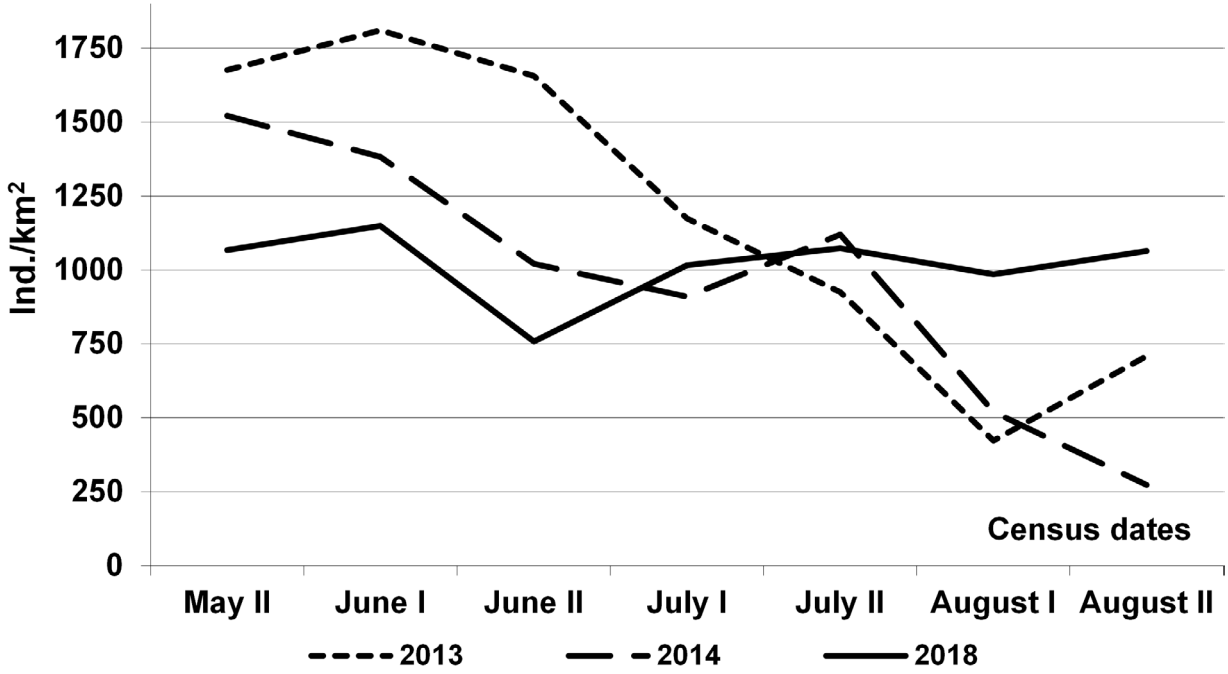

Fig. 4. The dynamics of the cumulative abundance of the summer bird population of the Nizhny Novgorod International Airport.

the post-nesting period (II half of July). In 2018, a high bird abundance has been keeping during August.

Large flocks of the birds of various sizes represented the greatest danger, namely Charadriidae (little ringed plover *Charadrius dubius* Scopoli, 1786, northern lapwing *Vanellus vanellus* (L., 1758), wood sandpiper, common greenshank *Tringa nebularia* (Gunnerus, 1767), common redshank *Tringa totanus* (L., 1758), marsh sandpiper, ruff, common snipe *Gallinago gallinago* (L., 1758)), Laridae (European herring gull *Larus argentatus* Pontoppidan, 1763, common gull, black-headed gull, common tern), Corvidae (common raven *Corvus corax* L., 1758, hooded crow *Corvus cornix* L., 1758, rook *Corvus frugilegus* L., 1758, western jackdaw *Corvus monedula* L., 1758, Eurasian magpie *Pica pica* (L., 1758), Turdidae (fieldfare, common blackbird *Turdus merula* L., 1758, song thrush *Turdus philomelos* C.L. Brehm, 1831, redwing *Turdus iliacus* L., 1758), Hirundinidae (barn swallow *Hirundo rustica* L., 1758 and common house martin), common swift *Apus apus* (L., 1758), common starling *Sturnus vulgaris* L., 1758, rock dove *Columba livia* Gmelin, 1789. This was also true for the large single predators hunting during daytime, namely Falconiformes (black kite *Milvus migrans* (Boddaert, 1783), common buzzard *Buteo buteo* (L., 1758), northern goshawk, Eurasian sparrowhawk *Accipiter nisus* (L., 1758), Montagu's harrier *Circus aeruginosus* (L., 1758), western marsh harrier, common kestrel *Falco tinnunculus* L., 1758, Eurasian hobby *Falco subbuteo* L., 1758). Small-size passerines (Fringillidae, Turdidae, etc.), gathering in flocks on migrations in the post-nesting period, were not included in this list, since they did not form flocks of especially large sizes.

The bird abundance generally decreased from September through January, but interannual shifts in the migration peaks were possible, depending on the weather conditions of a particular year. Thus, the warm September of 2017, when the air temperature exceeded 15 °C in the middle of the month, allowed the birds to extend the feeding period by almost a month. In addition, various types of construction work carried out at that time on the airport territory (cutting bushes, leveling the ground, etc.) attracted a significant number of white wagtails *Motacilla alba* L., 1758, common chaffinch *Fringilla coelebs* L., 1758, hooded crow, and western jackdaw. The newly formed open spaces with bare patches of soil have become very attractive to them.

In September–early October 2017, the emigration from local populations was changed by the bird immigration from the northern regions. The emigration occurred mainly in November, then the bird abundance decreased (Fig. 5). In autumn 2013, such an increase in bird abundance did not occur. By winter, it decreased gradually and remained low until spring.

In winter, the cumulative abundance of the bird population did not exceed 250 ind./km^2 on average (Table 2). The minimum abundance has been registered in February 2014 and December 2017.

A marked increase in bird abundance recorded in March 2014 was not observed in March 2017 due to prolonged cold weather. Therefore, in April 2017, this indicator amounted to only 350 ind./km^2, while in 2014 it was twice as much.

Dominant species (by abundance)

As a result of construction work, the composition of dominants in the bird population has changed significantly. In the nesting period, the common whitethroat *Sylvia communis* Latham, 1787, which nested on separate bushes and dominated earlier, was replaced by a land-nesting white wagtail (Table 3). At the same time, the share of dominants decreased, and the species diversity of the ornithocomplex (Shannon index) increased.

The interannual similarity of the airport's ornithocomplex before and after the construction works was 0.65 in the nesting period and 0.40 in the post-nesting period. This indicated a significant change in habitat.

In the post-nesting period, the great tit *Parus major* L., 1758 was no longer the dominant species of the ornithocomplex, and the share of the Eurasian tree sparrow *Passer montanus* (L., 1758) increased almost fourfold.

During the non-nesting period, the great tit played generally the leaing role in the ornithocomplex during the entire observation period (Table 4). On average, during the autumn and spring season, its share varied from 14 to 32% by abundance, while in winter it did not change and was about 35%. Moreover, different species were dominants in certain months; the changes in the composition of dominants occurred also in 2017 as a result of landscaping of the airport.

In the autumn and winter months of 2013–2014, the great tit constantly dominated the bird population, and in the autumn of 2017, it became a subdominant. The newly formed vast open areas of land attracted a white wagtail to feed, so it was the dominant species in September (32% by abundance); in October, the hooded crow dominated (25%), in November, the fieldfare (35%). In the winter months and in March 2017–2018, the great tit kept the leading role by abundance (up to 84% in December 2017), as it was observed in 2013–2014; in April, the migratory common chaffinch has replaced the great tit. In winter and spring, common redpoll was recorded here; in January, it dominated by abundance (up to 40%).

Other species were subdominants during the non-nesting season. Some of them posed a danger to the aircraft flights, namely, hooded crow, western jackdaw, and fieldfare.

On average, dominating species comprised from 38 to 65% by abundance in the ornithocomplex at that time, but in certain months their share could be even higher, for example, up to 97% in December 2017.

Table 2. The main integral indicators of the autumn-winter-spring bird population of the Nizhny Novgorod International Airport.

Year	Season	Cumulative abundance, ind./km^2	Dominant species, % by abundance	Shannon index (H)	Pielou's evenness index (E)
2013	Autumn	413	65	2.27	0.64
2017		546	62	2.57	0.73
2013/2014	Winter	198	57	1.96	0.73
2017/2018		246	57	2.11	0.74
2014	Spring	547	38	2.96	0.86
2018		313	42	2.81	0.76

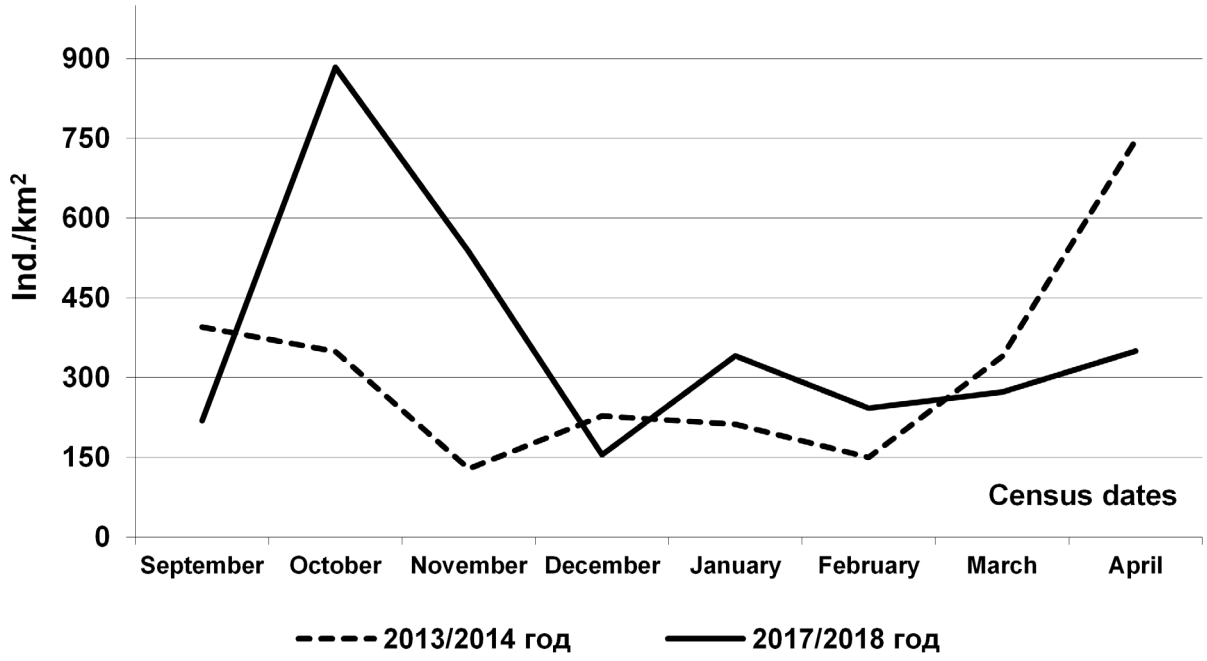

Fig. 5. Dynamics of the cumulative abundance of autumn-winter-spring bird population of the Nizhny Novgorod International Airport.

Distribution of the feeding birds in regard to the canopy level

The birds fed mostly on the soil surface, in the shrubs and tall grass, as well as in the tree crowns over the entire year (Fig. 6). In the summer of 2018, as a result of landscaping the airport, birds feeding on shrubs and tall grass replaced the land-feeding species. This was especially pronounced in the post-nesting period, when their share in the ornithocomplex increased twofold compared to previous years.

Less than 5% (by abundance) of ornithocomplex basically used the tree trunks, water space, and air during the year (Fig. 6, 7). Only in April and May the species feeding on the surface of the water (Anatidae, gulls, and sandpipers: northern lapwing and common redshank) accounted for up to 8%, and in July and August it was possible to note the common swift, the barn swallow, and common house martin feeding in the air (up to 15%). All of them posed a danger to aircraft operations.

In 2013–2014, the share of species feeding in the tree crowns gradually decreased from autumn to winter, and the share of birds collecting food on the soil surface and in tall grass increased (European goldfinch *Carduelis carduelis* (L., 1758), common redpoll, etc.) at the same time. By spring, the share of land-feeding species increased even more; on the contrary, the species feeding in the shrubs decreased again.

In the autumn of 2017, due to the clearing of the airport territory from shrubs and trees, as well as the removal of a layer of perennial turf and digging, the

Table 3. Dynamics of the most abundant species in the summer bird population of the Nizhny Novgorod International Airport. Asterisk * indicates the species prevailing in the bird population, but not exceeding 10% by abundance.

Period	Dominant species (% by abundance)		
	2013	2014	2018
Nesting	Common whitethroat (15)	Common whitethroat (9)*	White wagtail (11)
Post-nesting	Great tit (18), Eurasian tree sparrow (11)	Great tit (13), Eurasian tree sparrow (13)	Eurasian tree sparrow (47)

Table 4. Dynamics of the dominant species (by abundance) in the autumn-winter-spring bird population of the Nizhny Novgorod International Airport.

Year	Season	Dominant species (% by abundance)
2013	Autumn	Great tit (32), common chaffinch (15), Eurasian tree sparrow (14)
2017		Great tit (19), hooded crow (16), fieldfare (14), western jackdaw (12)
2013/2014	Winter	Great tit (34), Eurasian bullfinch (20)
2017/2018		Great tit (35), common redpoll (22)
2014	Spring	Great tit (14)
2018		Great tit (24), common redpoll (18)

proportion of the species feeding in shrubs and tree crowns decreased by 1.5–2.0 times. Throughout autumn, land-feeding birds prevailed, but since December, their share in ornithocomplexes did not exceed 15% in general. In winter and in March, birds feeding in the tree crowns (mainly tits) and species feeding in tall grasses (common redpoll, etc.) prevailed.

Territorial features of the summer bird population of the Nizhny Novgorod International Airport and the influencing factors

In order to assess the local features of the summer bird population of the Nizhny Novgorod International Airport, its similarity with ornithocomplexes of various meadow communities of the Nizhny Novgorod Region has been calculated (Noskova et al., 2009).

For the period from June 16 to July 31, 2018, seventy-one bird species was recorded on the territory of the Nizhny Novgorod International Airport. In the floodplain open and mosaic habitats of the Nizhny Novgorod Region, 111 bird species were recorded (Noskova et al., 2009). A total of 117 species were analyzed; the little ringed plover, ruff, icterine warbler *Hippolais icterina* Vieillot, 1817, booted warbler, the European pied flycatcher *Ficedula hypoleuca* Pallas, 1764, and hawfinch were noted only at the airport.

The similarity of the bird population of the airport with other meadow ornithocomplexes of the Nizhny Novgorod Region was low. The greatest similarity was noted for the bird population of the mosaic meadows of the Volga River floodplain (0.45) due to the similar abundance of great tit (50–68 ind./km^2), common linnet *Acanthis cannabina* L., 1758 (44–47 ind./km^2), willow warbler *Phylloscopus trochilus* L., 1758 (21–28 ind./km^2), hooded crow (17–25 ind./km^2) and, to some extent, tree pipit *Anthus trivialis* L., 1758 (20–27 ind./km^2). Most of these species preferred the transitional sites between transformed and natural habitats. The great tit and hooded crow are semi-synanthropes, willow warbler and tree pipit are forest species. The landscape structure of these sites is rather important to them.

The ornithocomplexes of clover meadows in the valley of P'yana River, consisting of only 17 species, exhibited maximum resemblance to the upland meadows-pastures of the valleys of the rivers P'yana and Vetluga (0.80) and Volga River clover meadows (0.65) when comparing the habitats. The two species, the whinchat *Saxicola rubetra* L., 1758 (70–87 ind./km^2) and the Eurasian skylark *Alauda arvensis* L., 1758 (34–68 ind./km^2) were the community-forming species; in the latter case, also yellowhammer *Emberiza citrinella* L., 1758 (20–33 ind./km^2). These three species mainly inhabited open spaces with rare curtains of lupine and nettle, where they made nests.

The cluster analysis (Khalafyan, 2007) made it possible to describe the bird population of the Nizhny Novgorod International Airport as a separate group (Fig. 8). The other meadow ornithocomplexes of the

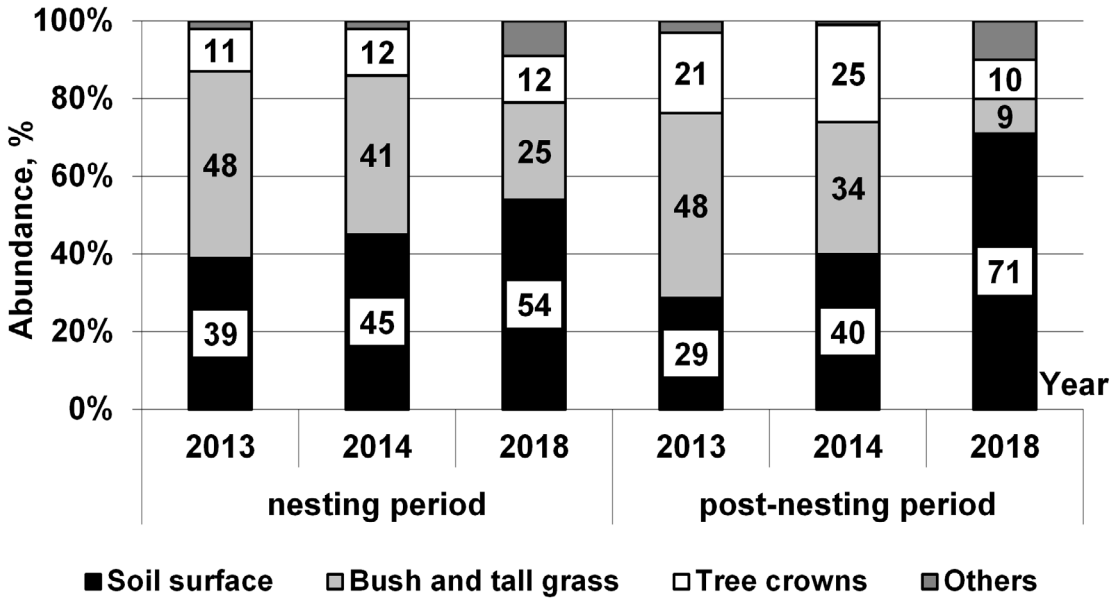

Fig. 6. The distribution of the summer bird population in regard to the canopy level during feeding at the Nizhny Novgorod International Airport.

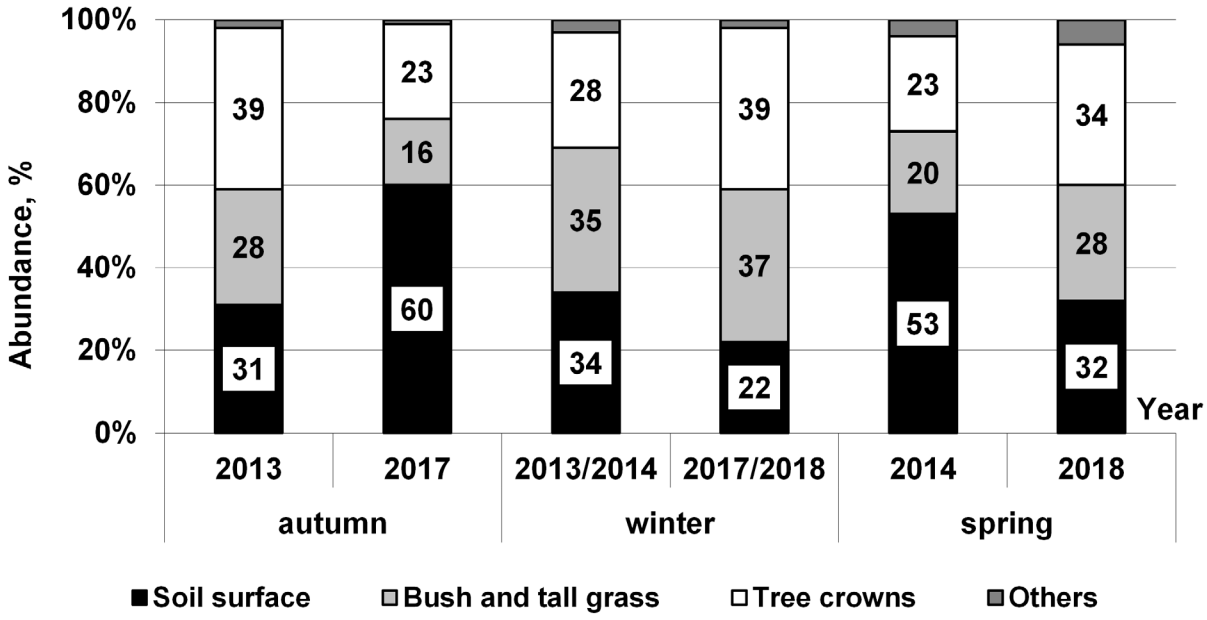

Fig. 7. The distribution of the autumn-winter-spring bird population in regard to the canopy level during feeding at the Nizhny Novgorod International Airport.

region belonged to the two groups, one of which was associated with mosaic coppice meadows, the second, with clover meadows, overgrown upland hayfields, and upland pasture meadows.

Three factors preconditioning the spatial structure of the summer bird population on the territory of the Nizhny Novgorod International Airport and in different meadow habitats of the region have been defined under factor analysis (Table 5). The main factors associated with the spatial heterogeneity of the number of species in ornithocomplexes are forest cover percent (factor 1, 46% of the variance) and bush cover percent (factor 2, 29%). Degree of development is less significant (factor 3).

The combination of moisture and bush cover percent (factor 1, 37%), as well as the influence of ecotone, combining characteristics such as forest cover percent, degree of development, and disturbance factor, i.e. human accessibility (factor 2, 32%) play the important role for the spatial distribution of birds at the airport and other meadow communities of the region (Table 6). Degree of development itself (factor 3), when considered separately as a factor, negatively affects the bird abundance.

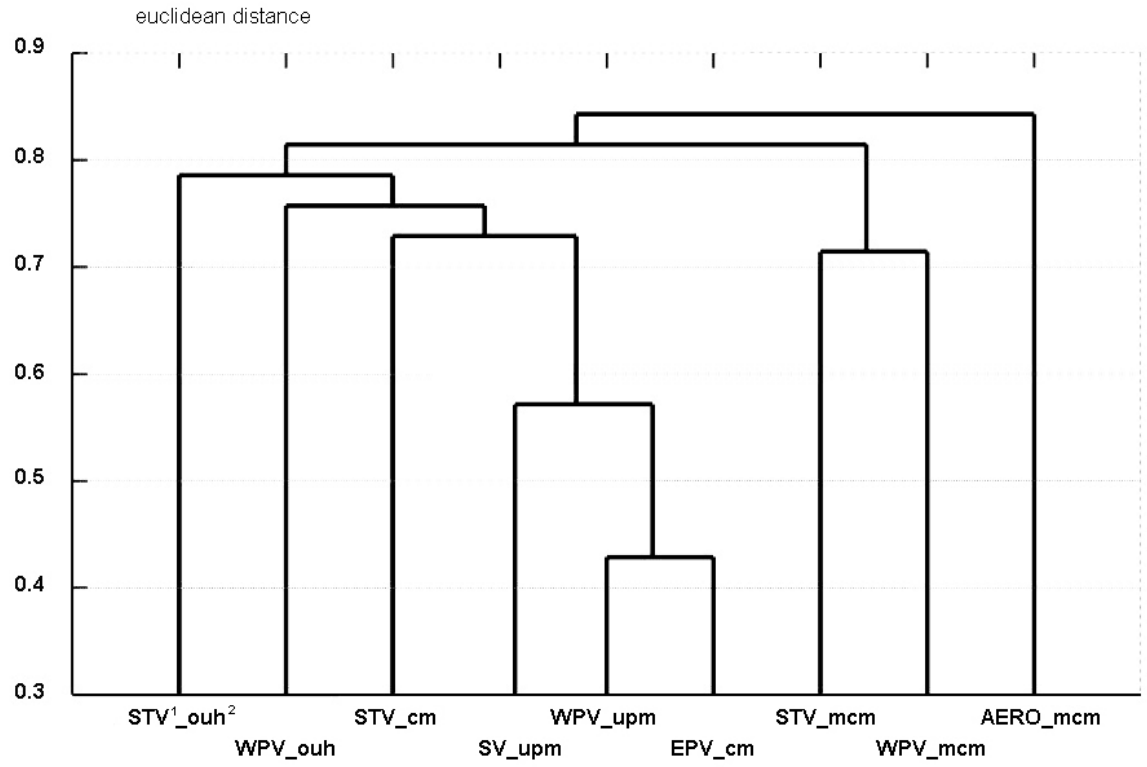

Fig. 8. Groups (clusters) of the summer bird population of the Nizhny Novgorod International Airport and meadow communities of the Nizhny Novgorod Region (materials from different researchers: Vetluga River, by A.V. Rokhmistrov, Seryozha River, by O.S. Noskova, P'yana River, by I.A. Skvortsova, Volga River, by O.S. Noskova, O.A. Grigorieva, and E.V. Santsova). Legend: 1 – a key sampling site: AERO – the territory of the Nizhny Novgorod International Airport, WPV – the western Pre-Volga River region, Serezha River, STV – southern trans-Volga River region, Volga River; SV – southern trans-Volga region, Vetluga River; EPV – Eastern Pre-Volga River region, P'yana River; 2 – habitats: mcm – mosaic coppice meadows, cm – clover meadows, oup – overgrown upland hayfields, upm – upland pasture meadows.

Table 5. Factors preconditioning the spatial heterogeneity of the species number in the summer bird population on the territory of the Nizhny Novgorod International Airport and various meadows of the Nizhny Novgorod Region. The most important indicators are highlighted in bold (> 0.7).

Parameters	Factors		
	1	2	3
Moisture	0.66	0.38	0.55
Bush cover percent	0.50	**0.82**	−0.19
Forest cover percent	**0.82**	−0.31	−0.40
Degree of development	0.29	−0.70	0.61
Disturbance factor	0.63	−0.56	−0.41

Table 6. Factors preconditioning the spatial heterogeneity of the cumulative abundance of the summer bird population on the territory of the Nizhny Novgorod International Airport and various meadows of the Nizhny Novgorod Region. The most important indicators are highlighted in bold (> 0.7).

Parameters	Factors		
	1	2	3
Moisture	**−0.71**	0.02	−0.54
Bush cover percent	**−0.84**	−0.40	0.23
Forest cover percent	−0.53	**0.73**	0.33
Degree of development	0.13	0.67	−0.68
Disturbance factor	−0.23	**0.85**	0.33

Therefore, the bird population of the territory of the Nizhny Novgorod International Airport (Table 7) is unique to a certain extent due to its specific landscape structure and security regime. The conditions here are favorable for birds, including for rare species. However, during certain periods of the year different species may be dangerous for the aircraft flights. Changes in habitat characteristics, preconditioning the composition of different meadow ornithocomplexes in the region, including the airport, will allow to control the dynamics of the bird population to some extent.

Table 7. List of bird species of the Nizhny Novgorod International Airport and the adjacent territory in 2013–2014 and 2017–2018.

No.	Common name	Latin name	Summer			Autumn-winter-spring	
			2013	2014	2018	2013/2014	2017/2018
		Order Ciconiiformes					
		Family Ardeidae					
1	Eurasian bittern	*Botaurus stellaris* (L., 1758)	+	–	–	–	–
2	Grey heron	*Ardea cinerea* L., 1758	–	–	+	–	–
		Order Anseriformes					
		Family Anatidae					
3	Mallard	*Anas platyrhynchos* L., 1758	+	+	+	+	+
		Order Falconiformes					
		Family Accipitridae					
4	Black kite	*Milvus migrans* (Boddaert, 1783)	+	+	+	–	–
5	Northern goshawk	*Accipiter gentilis* (L., 1758)	–	–	–	+	–
6	Eurasian sparrowhawk	*Accipiter nisus* (L., 1758)	+	–	+	–	–
7	Common buzzard	*Buteo buteo* (L., 1758)	+	–	–	+	+
8	Montagu's harrier	*Circus pygargus* (L., 1758)	–	–	+	–	–
9	Western marsh harrier	*Circus aeruginosus* (L., 1758)	+	–	–	–	+
		Family Falconidae					
10	Common kestrel	*Falco tinnunculus* L., 1758	+	–	+	–	+
11	Eurasian hobby	*Falco subbuteo* L., 1758	+	–	+	–	+
		Order Galliformes					
		Family Tetraonidae					
12	Black grouse	*Lyrurus tetrix* (L., 1758)	+	–	–	+	+
		Family Phasianidae					
13	Common quail	*Coturnix coturnix* (L., 1758)	+	+	–	–	–
		Order Gruiformes					
		Family Rallidae					
14	Corn crake	*Crex crex* (L., 1758)	+	+	+	–	–
		Order Charadriiformes					
		Family Charadriidae					
15	Little ringed plover	*Charadrius dubius* Scopoli, 1786	+	+	+	–	–
16	Northern lapwing	*Vanellus vanellus* (L., 1758)	+	+	+	–	+
		Family Haematopodidae					
17	Eurasian oystercatcher	*Haematopus ostralegus* L., 1758	–	–	–	–	+

No.	Common name	Latin name	Summer			Autumn-winter-spring	
			2013	2014	2018	2013/2014	2017/2018
		Family Scolopacidae					
18	Green sandpiper	*Tringa ochropus* L., 1758	+	–	–	–	–
19	Wood sandpiper	*Tringa glareola* L., 1758	–	–	+	–	+
20	Common greenshank	*Tringa nebularia* (Gunnerus, 1767)	–	–	+	–	+
21	Common redshank	*Tringa totanus* (L., 1758)	+	+	+	–	+
22	Marsh sandpiper	*Tringa stagnatilis* (Bechstein, 1803)	–	–	+	–	–
23	Common sandpiper	*Actitis hypoleucos* (L., 1758)	–	–	+	–	–
24	Ruff	*Philomachus pugnax* (L., 1758)	–	–	+	–	–
25	Common snipe	*Gallinago gallinago* (L., 1758)	+	+	+	–	–
		Family Laridae					
26	European herring gull	*Larus argentatus* Pontoppidan, 1763	–	–	+	–	–
27	Common gull	*Larus canus* L., 1758	+	+	+	–	+
28	Black-headed gull	*Larus ridibundus* L., 1766	+	+	+	+	+
29	White-winged tern	*Chlidonias leucopterus* (Temminck, 1815)	+	–	–	–	–
30	Common tern	*Sterna hirundo* L., 1758	+	–	+	–	–
		Order Columbiformes					
		Family Columbidae					
31	Rock dove	*Columba livia* Gmelin, 1789	+	+	+	+	+
		Order Cuculiformes					
		Family Cuculidae					
32	Common cuckoo	*Cuculus canorus* L., 1758	+	+	+	+	–
		Order Apodiformes					
		Family Apodidae					
33	Common swift	*Apus apus* (L., 1758)	+	+	+	–	–
		Order Piciformes					
		Family Picidae					
34	Eurasian wryneck	*Junx torquilla* L. , 1758	–	–	+	–	–
35	Great spotted woodpecker	*Dendrocopos major* (L., 1758)	+	+	+	+	+
36	White-backed woodpecker	*Dendrocopos leucotos* (Bechstein, 1803)	+	–	–	–	–
37	Lesser spotted woodpecker	*Dendrocopos minor* (L., 1758)	–	–	+	–	+
		Order Passeriformes					
		Family Hirundinidae					
38	Barn swallow	*Hirundo rustica* L., 1758	+	+	+	–	–
39	Common house martin	*Delichon urbica* (L., 1758)	+	–	+	–	–
		Family Alaudidae					
40	Eurasian skylark	*Alauda arvensis* L., 1758	+	+	+	+	+

No.	Common name	Latin name	Summer			Autumn-winter-spring	
			2013	2014	2018	2013/2014	2017/2018
		Family Motacillidae					
41	Tree pipit	*Anthus trivialis* (L., 1758)	+	+	+	+	+
42	White wagtail	*Motacilla alba* L., 1758	+	+	+	+	+
43	Western yellow wagtail	*Motacilla flava* L., 1758	+	+	+	+	–
44	Citrine wagtail	*Motacilla citreolla* Pallas, 1776	+	+	+	–	–
		Family Laniidae					
45	Red-backed shrike	*Lanius collurio* L., 1758	+	+	+	–	–
46	Great grey shrike	*Lanius excubitor* L., 1758	–	–	+	–	–
		Family Sturnidae					
47	Common starling	*Sturnus vulgaris* L., 1758	+	+	+	+	–
		Family Oriolidae					
48	Eurasian golden oriole	*Oriolus oriolus* (L., 1758)	+	+	+	–	–
		Family Corvidae					
49	Eurasian jay	*Garrulus glandarius* (L., 1758)	–	+	–	+	+
50	Eurasian magpie	*Pica pica* (L., 1758)	+	+	+	+	+
51	Western jackdaw	*Corvus monedula* L., 1758	+	–	+	+	+
52	Rook	*Corvus frugilegus* L., 1758	+	+	+	–	+
53	Hooded crow	*Corvus cornix* L., 1758	+	+	+	+	+
54	Common raven	*Corvus corax* L., 1758	+	+	+	+	+
		Family Bombycillidae					
55	Bohemian waxwing	*Bombycilla garrulus* (L., 1758)	–	–	–	+	+
		Family Sylviidae					
56	River warbler	*Locustella fluviatilis* (Wolf, 1810)	+	–	–	–	–
57	Blyth's reed warbler	*Acrocephalus dumetorum* Blyth, 1849	+	+	+	–	–
58	Marsh warbler	*Acrocephalus palustris* (Bechstein, 1798)	+	+	+	–	–
59	Icterine warbler	*Hippolais icterina* (Vieillot, 1817)	+	+	+	–	–
60	Booted warbler	*Hippolais caligata* (Lichtenstein, 1823)	–	–	+	–	–
61	Garden warbler	*Sylvia borin* (Boddaert, 1783)	+	+	+	–	–
62	Eurasian blackcap	*Sylvia atricapilla* (L., 1758)	+	+	+	+	–
63	Common whitethroat	*Sylvia communis* Latham, 1787	+	+	+	+	–
64	Willow warbler	*Phylloscopus trochilus* (L., 1758)	+	+	+	+	+
65	Common chiffchaff	*Phylloscopus collybita* (Vieillot, 1817)	+	+	+	+	+
66	Wood warbler	*Phylloscopus sibilatrix* (Bechstein, 1793)	+	+	+	+	–
67	Greenish warbler	*Phylloscopus trochiloides* (Sundevall, 1837)	+	–	+	–	–

No.	Common name	Latin name	Summer			Autumn-winter-spring	
			2013	2014	2018	2013/2014	2017/2018
		Family Muscicapidae					
68	Spotted flycatcher	*Muscicapa striata* (Pallas, 1764)	+	+	–	+	–
69	European pied flycatcher	*Ficedula hypoleuca* (Pallas, 1764)	+	+	+	–	–
70	Red-breasted flycatcher	*Ficedula parva* (Bechstein, 1794)	–	+	+	–	–
		Family Turdidae					
71	European robin	*Erithacus rubecula* (L., 1758)	+	+	+	+	+
72	Thrush nightingale	*Luscinia luscinia* (L., 1758)	+	+	+	+	–
73	Bluethroat	*Luscinia svecica* (L., 1758)	+	+	+	+	+
74	Common redstart	*Phoenicurus phoenicurus* (L., 1758)	+	–	+	+	+
75	Whinchat	*Saxicola rubetra* (L., 1758)	+	+	+	–	–
76	Northern wheatear	*Oenanthe oenanthe* (L., 1758)	+	+	+	–	+
77	Common blackbird	*Turdus merula* L., 1758	+	+	+	–	+
78	Fieldfare	*Turdus pilaris* L., 1758	+	+	+	+	+
79	Redwing	*Turdus iliacus* L., 1758	+	+	+	–	+
80	Song thrush	*Turdus philomelos* C.L. Brehm, 1831	+	+	+	–	–
		Family Aegithalidae					
81	Long-tailed tit	*Aegithalos caudatus* (L., 1758)	+	–	+	+	+
		Family Paridae					
82	Willow tit	*Parus montanus* Conrad von Baldenstein, 1827	–	–	+	–	+
83	Great tit	*Parus major* L., 1758	+	+	+	+	+
84	Eurasian blue tit	*Parus caeruleus* L., 1758	+	+	+	+	+
		Family Sittidae					
85	Eurasian nuthatch	*Sitta europaea* L., 1758	+	+	+	+	+
		Family Certhiidae					
86	Eurasian treecreeper	*Certhia familiaris* L., 1758	–	–	–	–	+
		Family Passeridae					
87	Eurasian tree sparrow	*Passer montanus* (L., 1758)	+	+	+	+	+
		Family Fringillidae					
88	Common chaffinch	*Fringilla coelebs* L., 1758	+	+	+	+	+
89	Brambling	*Fringilla montifringilla* L., 1758	–	–	+	–	+
90	European greenfinch	*Chloris chloris* (L., 1758)	+	+	+	+	+
91	Eurasian siskin	*Spinus spinus* (L., 1758)	+	+	+	–	+
92	European goldfinch	*Carduelis carduelis* (L., 1758)	+	+	+	+	+
93	Common rosefinch	*Carpodacus erythrinus* (Pallas, 1770)	+	+	+	+	–

No.	Common name	Latin name	Summer			Autumn-winter-spring	
			2013	2014	2018	2013/2014	2017/2018
		Family Fringillidae					
94	Common redpoll	*Acanthis flammea* (L., 1758)	+	+	–	+	+
95	Common linnet	*Acanthis cannabina* (L., 1758)	+	+	+	+	+
96	Eurasian bullfinch	*Pyrrhula pyrrhula* (L., 1758)	+	–	–	+	+
97	Hawfinch	*Coccothraustes coccothraustes* (L., 1758)	+	–	+	–	+
		Family Emberizidae					
98	Yellowhammer	*Emberiza citrinella* L., 1758	+	+	+	+	+
99	Common reed bunting	*Emberiza schoeniclus* (L., 1758)	+	+	+	–	+

Conclusions

Due to its geographical location and mosaic landscape, the territory of the Nizhny Novgorod International Airport provides favorable conditions for nesting and feeding of birds, including during the non-nesting season. The ornithocomplex of the airport area has a number of features related both to the specifics of its territory and to the recent territorial spatial transformations.

1. During the three years of study, 99 species of birds (33% of the regional species list) from 33 families and 11 orders have been recorded in the airport area. Twenty species from this list are indicated in the Red List of the Nizhny Novgorod Region and in the Annex. Such conditionally rare species, such as the corn crake, common gull, black-headed gull, were observed during the whole study period, while others (Montagu's harrier, Eurasian oystercatcher, wood sandpiper, marsh sandpiper, ruff, and the booted warbler) appeared only in 2018, after carrying out landscaping works.

2. The largest number of species (including common species) and the cumulative abundance of the bird population have been registered during the nesting period. Passerines formed the basis of the ornithocomplex throughout the year. During the periods of increasing of the bird abundance, the degree of a danger to the aircraft flights increased, namely, it was in the second half of May, the first half of June, and the second half of July each year. Abundant flocking species were represented by sandpipers, gulls, corvids, blackbirds, swallows, black swift, common starling, rock dove, and large single daytime predators.

3. After carrying out construction work at the airport, the composition of dominating species has changed in the ornithocomplex, which was especially obvious in summer. Species that preferred open spaces, nesting and/or feeding mainly on the ground began to dominate (white wagtail, Eurasian tree sparrow, etc.). The dynamics of the summer abundance of the ornithocomplex has also changed, when in 2013 and 2014 it was mostly emigration, but equilibrium-dynamic in 2018. Great tit, which was previously dominating constantly in the bird population, in some autumn months became a subdominant, yielding to a white wagtail, hooded crow, and fieldfare.

4. The bird feeding during the year was peformed mainly on the soil surface, in shrubs and tall grass, as well as in the tree crowns. After carrying out the construction work at the airport, the birds that were feeding in shrubs and tall grass were replaced by the land-feeding species. This was especially expressed in the summer in the post-nesting period, when their share in the ornithocomplex increased twofold compared to previous years.

5. An assessment of the degree of interannual similarity of summer ornithocomplexes of the Nizhny Novgorod International Airport evidenced that the composition of the bird population has changed as a result of the airfield deforestation. The similarity of ornithocomplexes in 2014 and 2018 was low.

6. The degree of similarity of the ornithocomplexes of the airport and different meadow bird communities of the Nizhny Novgorod Region was also low. The greatest similarity was observed with the bird population of the mosaic meadows of the Volga River floodplain, due to the great tit, common linnet, willow warbler, hooded crow, and tree pipit.

7. Due to the specific landscape structure and security regime of the Nizhny Novgorod International Airport, the bird population here is unique to a certain extent. This is due to factors such as forest cover percent, degree of development, and human activity. Moreover, the overall appearance of the ornithocomplex is close to the population of birds of various mosaic coppice meadows of the Nizhny Novgorod Region according to the results of cluster analysis, although it stands out as a separate group.

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