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To cite this article: A A Ananin and I A Aiurzanaeva 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **908** 012012

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Dependence of floodplain birds' dynamics on the spring flood height and duration in the middle Ob River

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Abstract. Inter-annual variations in the total number of birds in floodplains of rivers are mainly associated with their flooding. The minimum population density during the nesting period was in a year with high and prolonged spring floods. The restoration and maximum development of shrubs took place with a significant simultaneous increase in the abundance of birds in subsequent years. Drying and simplification of vegetation cover were noted in all floodplain bird habitats during low-water periods. This process was accompanied by a decline in the number of birds. We identified four groups of bird species according to the criterion of the relationship “abundance – level and duration of the flood”. In the first group of bird species, abundance increased during high floods (3 species). In the second group, the abundance decreased sharply during high and prolonged floods (7 species). In the third group, the level and duration of the spring flood did not affect the abundance (9 species). In the fourth group, a very weak tendency of the negative flood level impact on the abundance of birds was noted (6 species).

1. Introduction

Degradation and extinction threaten floodplain ecosystems of large rivers worldwide due to changes in their hydrodynamic regime. These transformations are due to the activities of water resources management and climate change [1]. All organisms inhabiting river floodplain ecosystems inevitably respond to constant changes in the habitat due to seasonal and interannual fluctuations in river water levels [2]. Knowledge of the causes and mechanisms of organisms' response to constant fluctuations in environmental conditions can contribute to understanding the importance of environmental dynamics for maintaining floodplain biodiversity [3-6].

Birds are one of the most prominent and numerous vertebrates of river floodplains and a convenient model group for studying the conservation processes of these ecosystems [7, 8]. However, studies of the relationship between bird species and hydrological regimes are insufficient [2, 3, 9, 10]. Some authors have found that different species of birds use the mosaic of the environment of floodplains in different ways following their changing dynamics [11]. Hydrological fluctuations cause changes in bird habitat [12-14] which affects the availability of resources and the number of birds [9, 15, 16]. The high mobility of birds allows them to leave floodplains during floods. The species richness of birds during floods may decrease due to the inaccessibility of floodplain habitats, especially for flood-intolerant species [9, 17]. This leads to a reversible change in bird species during periods of high-water levels on the floodplain. Changes in the frequency, height, and duration



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of floods can occur due to changes in the attractiveness of floodplain habitats and cause restructuring in the composition of bird communities [3]. The long-term studies of bird populations at the altitude gradient of the Barguzin Range showed that various aspects of the inter-annual dynamics of habitat properties also explained long-term changes in bird communities [18]. The results of our studies of birds in the Ob river' floodplain also demonstrated a dependence of the bird numbers and the characteristics of their nesting ecology on the spring flood [8, 19].

This research aims to assess the influences of water level fluctuations and the flooding duration on the abundance and distribution of birds on the floodplain. These relationships and habitat preferences can explain and quantify the regularities of inter-annual variations in the species composition and abundance of the bird population on river floodplains.

2. Materials and methods

The study area was in the Krivosheinsky district of the Tomsk region (Western Siberia), 57°21' N; 83°56' E. The river in the study area has a well-developed floodplain, consisting of canals and lakes, and seasonally flooded areas between them. In the flooded areas, we saw a vegetation gradient from the highest areas dominated by deciduous forests (aspen and birch forests), shrubs, grasses, and open water. Our counting routes included woodlands, shrubs, herbaceous plant communities (meadows), and bushy swamps. We used data on the water level on the floodplain as a measure of hydrological fluctuations. The highest and longest spring flood with complete flooding was registered in 1979. A less high but lasting flood was in 1978. In 1980 and 1982 the flood was low and short-term, and in 1983 it was low but long-term. In 1981, the floodplain was not flooded; water reached only its lowest areas [8]. To assess the effect of the spring flood on the abundance of bird species, we used the indicator of effective flooding of the floodplain (table 1), which took into account the water level duration in its various parts [20].

The degree of degradation of the lower layers of vegetation in the flooding zone and the simplification of the structure of herb-shrub layers was assessed by the index of vegetation structure using the point method (5 points – the maximum degree of development, 1 point – the minimum degree of development). We used indicators of the total density, height, and degree of the vertical projective cover of the herbaceous layer, the degree of foliage development of the shrub layer, and undergrowth in the model areas of the forest-meadow floodplain (table 1).

Table 1. Floodplain Flood Index in 1978-1983.

Year	1978	1979	1980	1981	1982	1983
Effective flooding index	18.4	25.3	8.2	4.0	6.2	12.8
Vegetation structure index	3	2	3	4	5	3

We carried out bird censuses on permanent routes every ten days using the linear transect method [21] from May to July in 1978-1983. The total length of census routes for six years was 1,748 km. We used nonparametric statistical methods using the Statistica 6.0 software package. We used the Kendall tau rank correlation coefficient as a measure of association between the species number dynamics and effective flooding index, and cluster analysis of these coefficients (Euclidian distance, nearest neighbour algorithm).

3. Results

We recorded the highest average long-term number of birds in unmown meadows and aspen forests and the lowest in hay meadows and bush bogs (table 2). The water content of the floodplain corrected the inter-annual differences in the total number of birds. The minimum bird population density during the nesting period was in 1979. Significant degradation of the lower layers of vegetation in the flooded zones, simplification of the structure of grass-shrub layers occurred at the maximum height and duration of spring floods (table 1). For this reason, the area suitable for nesting was reduced and, as a result, the number of birds was minimal. After a high-water year, the vegetation structure simplified, but the number of birds increased.

Table 2. Population density of birds in the Middle Ob floodplain during the nesting period, 1978-1983, individuals / km².

Habitat	1978	1979	1980	1981	1982	1983	Average
Flooded floodplain	1,728.9	819.5	1,098.6	1,414.0	1,452.0	1,297.7	1,301.8 ± 128.0
Hay meadows	–	477.9	835.7	1,091.9	1,272.0	967.5	929.0 ± 133.6
No hay meadows	–	792.6	1700.7	1,573.0	1,766.4	2,019.0	1,570.4 ± 208.0
Shrubs	–	647.5	1,246.8	1,284.1	1,595.9	1,212.8	1,197.4 ± 153.5
Shrubs-swamps	–	658.8	772.8	1,235.3	1,296.2	769.2	946.5 ± 132.4
Aspen forests	–	530.6	1,273.1	1,564.0	1,790.6	1,476.1	1,329.6 ± 215.9
Birch forests	–	521.6	748.2	844.7	1,262.0	1,176.0	910.5 ± 137.1

We recorded the highest growth rates of the bird number in aspen forests, meadows, and shrubs. We noted a process of restoration and maximum development of shrubs and, at the same time and a significant increase in the density of the bird population in 1981 and 1982. A process of drying out and simplifying the vegetation cover, a decrease in the height and density of the herbage, and a decrease in the development of leaves on shrubs was in 1983. Habitat conditions for floodplain species have deteriorated significantly; we recorded a decline in the bird number in all floodplain habitats after a long period of dry years. This decline was not registered only in non-mowing meadows.

Table 3. Characteristics of the relationship strength between changes in the abundance of common bird species on the floodplain and the effective flooding index.

Assessment of bond strength, Kendall tau rank correlation coefficient			
Positive average correlation: 0,5 < τ ≤ 0,7	Negative high correlation: –0,7 < τ ≤ –0,9	Negative weak correlation: –0,2 < τ ≤ –0,5	Negative very weak correlation 0 < τ ≤ –0,2
Bird species			
Lesser Whitethroat (<i>Sylvia curruca</i>)	Yellow-breasted Bunting (<i>Ocyris aureolus</i>)	Common Magpie (<i>Pica pica</i>)	Common Chiffchaff (<i>Phylloscopus collybita</i>)
Fieldfare (<i>Turdus pilaris</i>)	Common Rosefinch (<i>Carpodacus erythrinus</i>)	Common Whitethroat (<i>Sylvia communis</i>)	Siberian Rubythroat (<i>Luscinia calliope</i>)
Sedge Warbler (<i>Acrocephalus schoenobaenus</i>)	Blyth's Reed-warbler (<i>Acrocephalus dumetorum</i>)	Yellow Wagtail (<i>Motacilla flava</i>)	Lesser Spotted Woodpecker (<i>Dendrocopos minor</i>)
	Long-tailed Rosefinch (<i>Uragus sibiricus</i>)	Common Starling (<i>Sturnus vulgaris</i>)	Long-tailed Tit (<i>Aegithalos caudatus</i>)
	Eurasian Cuckoo (<i>Cuculus canorus</i>)	Great Tit (<i>Parus major</i>)	Yellowhammer (<i>Emberiza citrinella</i>)
	Siberian Stonechat (<i>Saxicola maurus</i>)	Willow Tit (<i>Parus montanus</i>)	Hooded Crow (<i>Corvus cornix</i>)
	Eurasian Tree Sparrow (<i>Passer montanus</i>)	European Pied Flycatcher (<i>Ficedula hypoleuca</i>)	
		Pallas's Grasshopper Warbler (<i>Locustella certhiola</i>)	
		Lanceolated Grasshopper Warbler (<i>Locustella lanceolata</i>)	

A significant negative correlation ($r = -0.8$; $p > 0.95$) was between the total number of birds on the floodplain and the indicator of effective flooding of the floodplain, which accounts for the level and duration of the spring flood. The same regular changes in the number of birds were in separate floodplain biotopes (table 2). Fluctuations in abundance of common bird species at one site in different periods of the floodplain cycle were 2-5-fold, and for uncommon and rare bird species, they were much higher.

The dynamics of the common bird abundance on the floodplain differed significantly between years. We chose a site of a forest-meadow flooded floodplain as a model area. It included willow forests, aspen forests, birch-aspen forests, as well as hay meadows, no hay meadows, and shrubs. The dynamics of 25 bird species with an average long-term abundance of more than five individuals / km² were considered. The comparison of species was according to the long-term dynamics of their numbers. The similarity of the annual changes in the number of species indicated the similarity of their reactions to the same changes in the environment. In relation to the level and duration of the spring flood, the analysed community was divided into 4 groups (table 3).

In the first group, we noted a positive statistically significant relationship with the indicator of effective flooding of the floodplain. In the second cluster, we found a statistically significant negative correlation between long-term changes in the number of bird species with spring floods. The third and fourth groups had a weak and very weak negative correlation, which indicated the presence of a trend towards a negative impact of the flood level.

4. Discussion

Found patterns of long-term changes in the bird population of the Ob river floodplain made it possible to assess the relationship between the long-term dynamics of the number of individual bird species with local changes in the quality of habitats. Habitat quality is associated with the transformation of habitat suitability for nesting and food supply. Both suitability for nesting and food supply were determined by changes in the structure of vegetation under the influence of floodplain water. We have identified three groups of bird species, the dynamics of the number of which are closely related to changes in the indicator of effective flooding of the floodplain.

For bird species of the first group (Lesser Whitethroat, Sedge Warbler, and Fieldfare) there was a trend towards a positive impact of the level and duration of spring floods on the floodplain of the Ob river. A high level of watering of the area was positive for these species, had no significant effect on the suitability of the territory for nesting and did not reduce its supply of forage.

The species of the second group showed the maximum negative attitude to high and lasting floods. They are associated with shrubs during the nesting period.

The level and duration of the spring flood did not significantly affect the species of the third group. It includes omnivorous species (Common Magpie), species that fed on semi-aquatic invertebrates along the shores of floodplain lakes and canals (Yellow Wagtail and Common Starling), birds' hollow nest (European Pied Flycatcher, Great Tit and Willow Tit), late nesting species of birds of herbal tier (Pallas's Grasshopper Warbler and Lanceolated Grasshopper Warbler), as well as species preferring meadows with shrubs (Common Whitethroat). These birds had a neutral attitude to the parameters of the spring flood. The fourth group of species with a weakly expressed negative tendency for the relationship between changes in abundance and the indicator of effective flooding of the floodplain is close to them.

The long-term dynamics of the number of birds are synchronous in all floodplain biotopes. The 3-4 year flood cycle is favourable for floodplain birds. At the same time, a year with a high spring flood is followed by 2 or 3 years with a low and short-term flood. Nest suitability of the floodplain in the summer after a year with high and lasting floods remained low; the final restoration of the herbaceous and shrub layers took place only in the 3rd and 4th years of the floodplain cycle. Such differences were determined by the fact that in different habitats during the floodplain cycle, unequal conditions of suitability for nesting and food supply were formed.

Our previous studies of long-term changes in bird populations were carried out in the mountains, in habitats from the lower part of the montane-forest belt of vegetation to ridges. They showed that each bird species annually chooses habitats for settlement and use that are most favourable for this species in the current year [17]. A similar bird preference for the most favourable places for settling, the formation of nesting areas (especially those most suitable for nesting and chick feeding), has led to the annual redistribution of the population of bird species throughout the floodplain.

Annual changes in floodplain vegetation leading to changes in nesting suitability and food availability have contributed to periodic changes in the composition and structure of the bird population of the floodplain and its separate areas.

This indicated that the height and duration of the spring flood were the leading factors in changes in the bird population on the floodplain. The influence of the floodplain hydrological regime determined the differences in the structure and timing of vegetation development, and determined the redistribution of birds across habitats at different stages of floodplain local succession.

5. Conclusions

The level and duration of the spring flood influenced the development of shrub and grass vegetation on the floodplain. The simplest structure of herbaceous and shrub vegetation was recorded in the year with the maximal level and duration of spring floods.

The bird abundance increased during the decrease in flooding of the floodplain in the first 2-3 years. The number of birds decreased after several years in the absence of flood or its low level and short duration. The maximum population of birds on the floodplain was recorded in the intermediate years between the highest and the lowest water years. There were synchronous changes in the number of birds in different habitats of the floodplain.

The common bird species of the floodplain reacted differently to the level and duration of the spring flood. Several bird species have shown a positive correlation with spring floods. Other species showed a negative correlation with this factor. For some species, long-term changes in abundance were unrelated to flood characteristics.

Acknowledgments

The study was partially carried out within the framework of the state assignment of Institute of General and Experimental Biology SB RAS No. 121030900138-8.

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