THE EXTENDING OF RANGES OF SOME BIRD SPECIES AT THE NORTH-EASTERN BORDER OF THEIR DISTRIBUTION DUE TO INTRA-CENTURY CLIMATE CHANGES

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The paper presents an overview of the phenomenon of range expanding of birds located at the northeastern limit of their range. The study area is located in the Volga-Kama Krai in the Chuvash Republic, adjacent to the River Volga. It is situated northwards and southwards of 56° N, and westwards and eastwards of 49° E, in a band of about 400 km. The problem is considered in aspect of the intra-century changes of climatic conditions in the region and in European Russia as a whole. The analysis of the relationship between the range expansion of some bird species and the intra-century climate changes was based on ornithological and climatological material available for the study area. We have used material on climate change in the Chuvashian Republic and Volga-Kama Krai since 1926, taking into account recent data of Roshydromet and Intergovernmental Panel on Climate Change. The idea of this study was based on the theory of climatic cycles of different periodicity, the theory of recent global climate change and the hypothesis of cyclic dynamics of the ranges of waterfowl in the context of centuries-old and intra-century climate change in Northern Eurasia. In the framework of the problem, we have studied ornithological material dated from the late 19th till the early 21st century, authored by Bogdanov, Ruzsky, Zhitkov, Buturlin, Artobolevsky, Volchanetsky, Pershakov, Popov, Glushenkov and others. As shown the intra-century climate changes do quite likely affect the northward and northeastward range expansion of such bird species as *Cygnus olor*, *Anas strepera*, *Aythya ferina*, *Hieraaetus pennatus*, *Aquila heliaca*, and *Fulica atra*. Climate changes can also be judged on the base of the shift in the arrival timing to earlier dates for some birds. It is most clearly manifested for early arriving species (*Grus grus*, *Ardea cinerea*, *Actitis hypoleucos*). It is also true for the later arriving *Pernis apivorus* and *Merops apiaster* whose existence depends on the emergence time of insects. Climate changes are not the only determining factors affecting the bird distribution. Ecological factors are also important, along with the mentioned above. The range expansion of species in anthropogenically disturbed landscapes occurs by means of complex chains of ecological relationships. Examples of *Haematopus ostralegus* and *Sterna albifrons* show the reasons for the reduction and restoration of species ranges due to the change in the effect of an anthropogenic factor. Thus, the range expansion of some bird species to the north and northeast is quite likely related to the centuries-old and intra-century climate changes. However, we do not consider climate warming as the only determining factor in the abundance increase and further range expanding for some birds at the range limits in temperate zone. In order to a better understanding of the impact of climate changes on birds, it is needed to investigate how modern climate changes in the temperate regions influence on the animals which serve as food for birds, and, as a consequence, how these processes impact the number of nesting pairs and the survival of young animals.

Key words: arrival timing, birds of prey, intra-century climate changes, range expanding, semi-aquatic birds, waterfowl

Introduction

The Chuvash Republic is located in the east of the Russian Plain, in the centre of the European part of Russia, between 54°38′ and 56°20′ N, and between 45°55′ and 48°26′ E. It reaches 190 km from the north to the south, and from 90 to 160 km from the west to the east.

Its small area and the flat relief result in quite monotonous climatic conditions. The Chuvash Republic is situated between the following annual isotherms: +2.5°C in the north and +3.6°C in the south (Karyagin, 2007a,b). Despite the abovementioned factors, the Chuvashia area is characterised by a high diversity of habitats and landscapes. These are presented by both well-preserved natural and anthropogenically altered ecosystems. This is a result of its geographical location in the centre of the Russian Plain at the border of the forest-steppe zone and the zone of mixed forests, at the border of the taiga forests in the north and the steppe ecosystems in the south.

The main part of the study area is located on the right bank of the River Volga, and it adjoins the north side to its latitudinal «river reach», stretching from west to east between 44°17′ E and 49°07′ E. After the creation of a continuous chain of reservoirs, the River Volga contributes to the formation of a more

humid microclimate along its course. The northern limit ranges of many species pass along the areas adjacent to the River Volga. The range boundaries are usually very diffuse. It is not by accident that we consider the problem of range expanding within a larger territory – the Volga-Kama region (Fig. 1).

The abundance of species depends mainly on the state of their populations in the optimum of the range and in its periphery. Therefore, the expanding of the range boundaries of (animal) species reflects the capabilities of their peripheral populations to adapt under new environmental conditions (Melnikov & Durnev, 2012). Climate changes also affect the status of species populations (Şekercioğlu et al., 2012; Velásquez-Tibatá et al., 2013) and, as a consequence, the dynamics of the boundaries of the natural distribution of birds (Crick, 2004; Araújo et al., 2011; Velásquez-Tibatá et al., 2013; Virkkala & Lehikoinen, 2017). For example, changes in the boundaries of bird ranges (Thomas & Lennon, 1999; Brommer, 2004; Kassal, 2017) or a change in the arrival timing of migratory birds (Kullberg et al., 2015; Courter, 2017) have been established under the influence of various climatic factors. In some cases, the climate impact on bird communities is observed through changes in the vegetation cover in these birds' habitats (Regos et al., 2017).

In Russia there are not numerous studies devoted to the changes in ranges of bird species under the influence of climatic factors. Therefore, the present work can serve as one of the few indicators of the climate change impact on the ranges of some bird species in European Russia. The examples of the penetration of separate most active bird species northwards and eastwards allow us to judge current trends in the range expanding, while the displacement depth of the range boundaries of some birds into more northern and eastern areas is an important indicator of climate warming.

Material and Methods

A thorough analysis of the secular trends within the framework of the extending of the species ranges within the Chuvash Republic and Volga-Kama Krai is based on data of Roshydromet (Second Assessment Report, 2014; Report on climate features, 2017) and the Intergovernmental Panel on Climate Change (IPCC, 2013), the theory of climatic cycles of various periodicity and the recent global climate change (Assessment Report, 2008, Second Assessment Report, 2014). Krivenko & Vinogradov (2008) proposed the concept of cyclic dynamics of waterfowl ranges in the context of the centuries-old and intra-century climate change in Northern Eurasia.

In the region, the avifauna is the most studied animal group. Since the end of the 19th century, its investigations in the Volga-Kama region in general, and in the Chuvash Republic in particular, have been carried out during the last three natural climatic cycles according to the classification of Krivenko & Vinogradov (2008). These periods are corresponding to the period of temperature growth in the European part of Russia in the early twentieth century, a period of cooling in the middle twentieth century and a period of warming again in the second half of the twentieth century which has continued till the beginning of the 21th century (IPCC, 2013; Second Assessment Report, 2014) (Fig. 2). For the Chuvash Republic there is a detailed climatic analysis from 1926, published in two volumes of the monograph «Modern Hydroclimatic Changes in Chuvashia» authored by Karyagin (2007a).

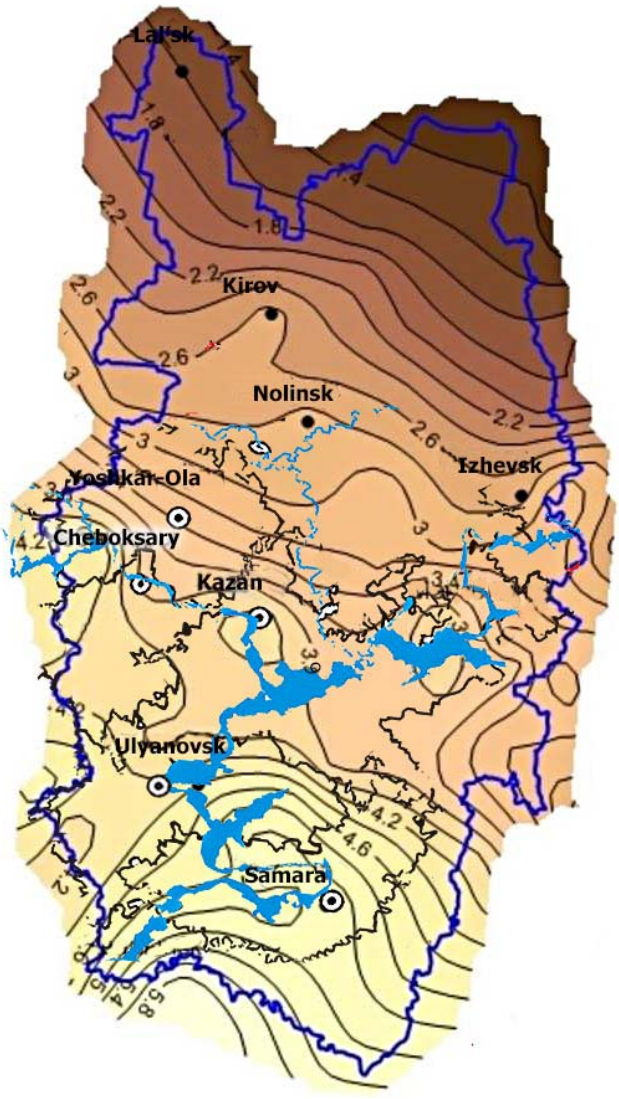

Fig. 1. The average annual temperature in the Volga-Kama region (according to Perevedentsev et al., 2011).

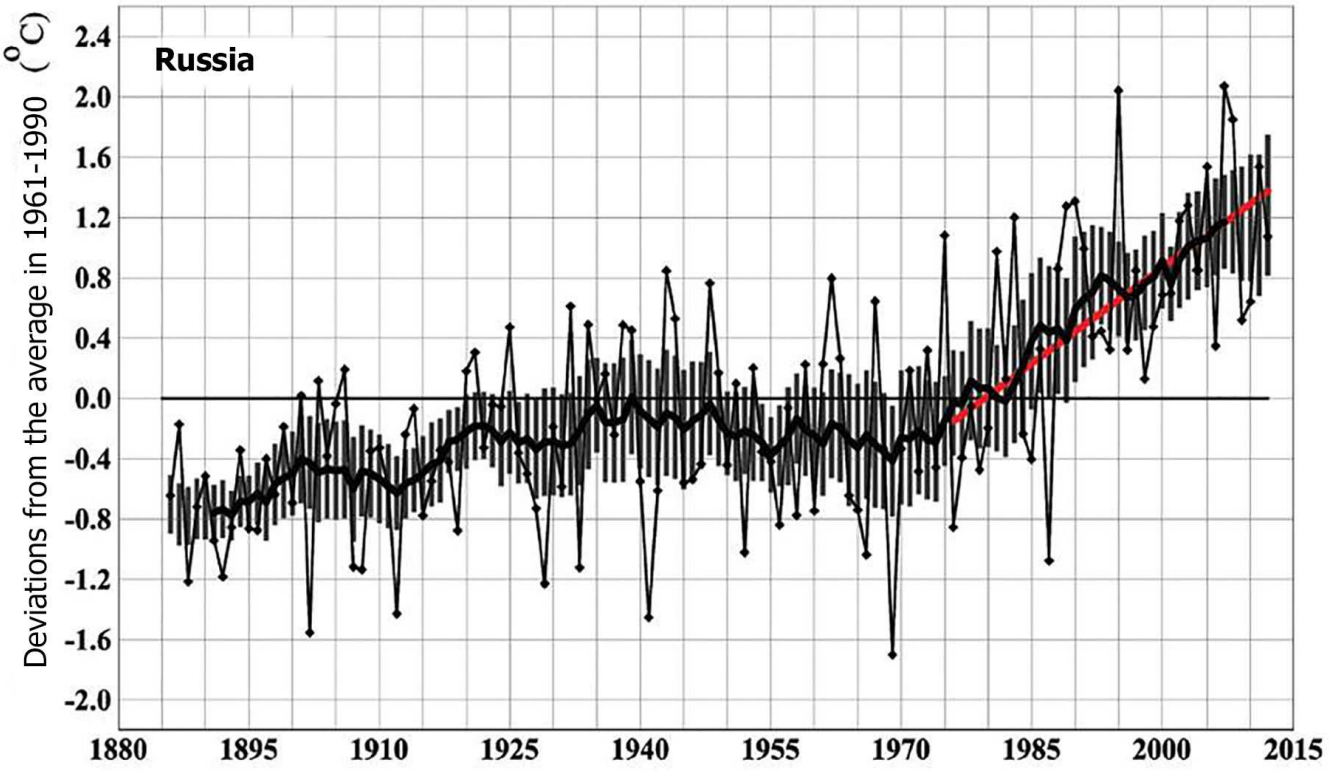

Fig. 2. Changes in anomalies of mean annual surface air temperature averaged in Russia during 1886–2012. The anomalies are calculated as deviations from the average value over 1961–1990. The bold curve shows the smoothed temperature (11-years moving averages). Vertical segments show 95% confidence interval for the 11-years average values (without taking into account errors of spatial averaging and dehomogenisations). The red line is a linear trend over 1976–2012 (Second Assessment Report, 2014).

Published analyses of climatic changes in Chuvashia since 1926 (Karyagin, 2007a,b) allow us to overview the issue within the area of 54–56° N and even slightly northwards. The polynomial trend of the average annual temperatures (according to the weather station in Cheboksary) showed a sharp increase of temperature from 2.5°C to 3.2°C from 1926 to 1932. Then there was a gradual decrease of temperature up to 2.8°C by 1950, and, finally, a following steady increase of temperature has been observed up to 1988 with a sharp rise up to 2000s and a further smooth motion at a high limit at 4.6°C (Fig. 3). The number of years with average annual temperatures above 4.5°C in the ten-year periods has increased from two to five in 2000, although this phenomenon was almost not observed until the 1970s. In addition, the average annual temperature was not below 2.7°C since 2007, whereas in the 1920s, 1940s, 1960s and 1970s at least 3–5 years in each ten-year period were characterised by an average air temperature of below 2.5°C.

In the last years (2013–2016), the average annual temperatures have been even higher (Fig. 4). So, they exceed +4°C in the coldest 2016, and these were higher than +5°C in the remaining years. For such a short period, the construction of a linear trend is impractical (Fig. 3).

If we compare our data with the climate change across Russia as a whole, Chuvashia is located in an area where since 1976 the air temperature has been growing with a rate of 0.5°C per 10 years. The growth is more noticeable (0.7–0.8°C per 10 years) in autumn, and it is weaker (0.2–0.3°C per 10 years) in winter (Fig. 5).

With regard to rainfall in the Chuvash Republic over the studied period, an average of 450–500 mm fell down annually. 2/3 Of the precipitation falls in summer and 1/3 in winter (Fig. 6). At the same time, over the whole century of observations (since 1920), a precipitation amount of less than 400 ml per year was observed only 8 times, and a precipitation amount lower than 350 ml was registered only twice (Fig.7).

Statistics of Roshydromet (Second Assessment Report, 2014) indicate a significant variegation of changes in the average annual precipitation amount in the European part of Russia. But for the study area it is characterised by a general increase of approximately 100 mm from 1936 to 2010 (Fig. 8).

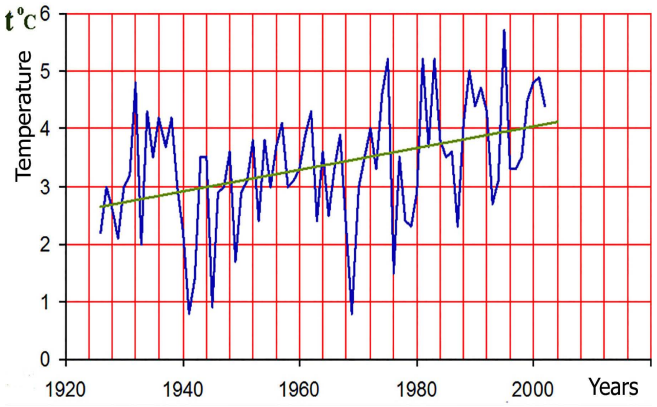

Fig. 3. The curve and the linear trend of average annual temperatures (Cheboksary) (according to Karyagin, 2007a,b).

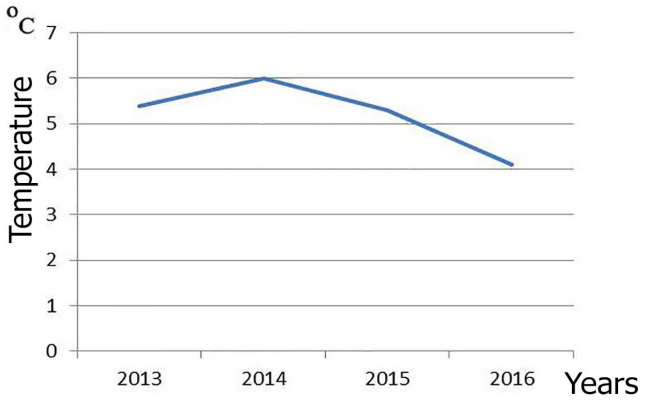

Fig. 4. The curve of average annual temperatures in Cheboksary (airport) (according to https://rp5.ru).

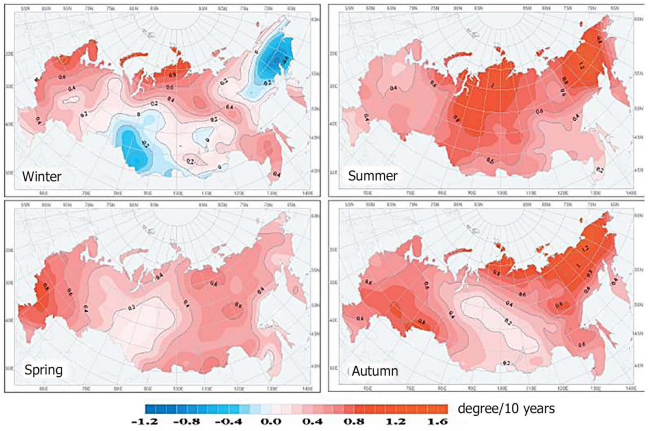

Fig. 5. The distribution of coefficients of linear trend of average seasonal air temperatures in Russia during 1976–2012 (according to Second Assessment Report, 2014).

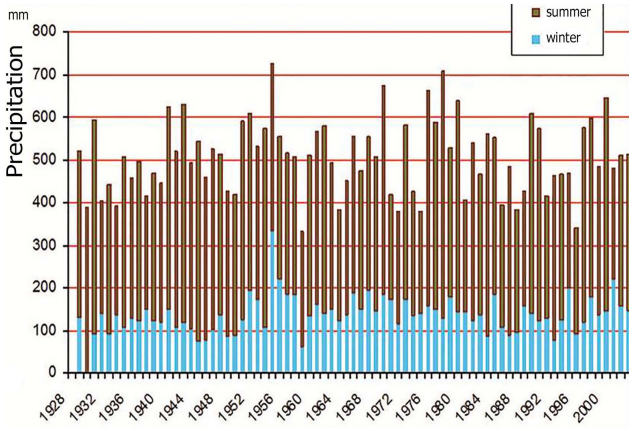

Fig. 6. The amount of winter and summer precipitation in Cheboksary (according to Karyagin, 2007a,b).

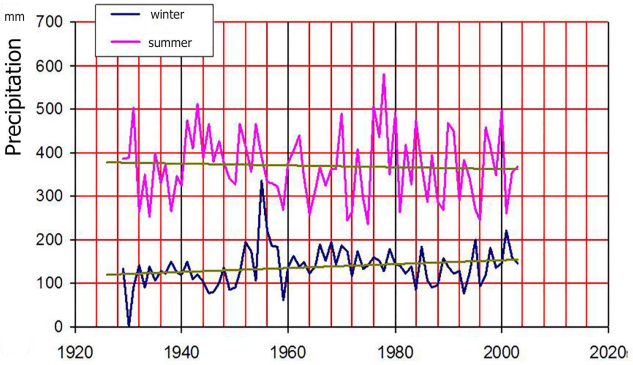

Fig. 7. Precipitation. The curve and the linear trend of winter and summer precipitation amount in Cheboksary over 1920–2020 (according to Karyagin, 2007a,b).

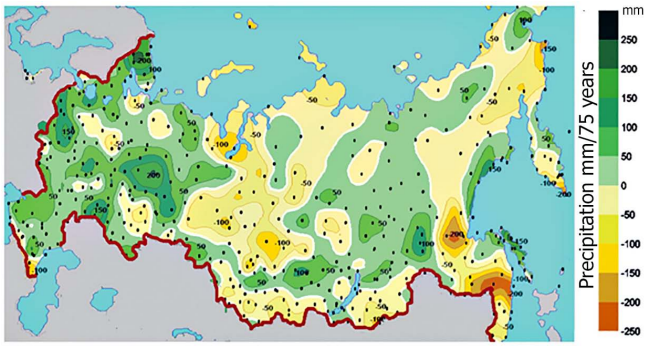

Fig. 8. Temporal changes of annual precipitation in Russia from 1936 till 2010; mm over 75 year (Second Assessment Report, 2014).

This indicates that the humidity can not be used to distinguish clear intra-century periods and phases. Gumilev (2002) had proposed his ethnogenesis theory (in «The Millenium around the Caspian Sea») long before the study of the influence of centuries-old and intra-century climate changes on the dynamics of animal ranges, based on the flooding rhythms of the Caspian Sea. He clearly noted that dry or wet periods in the southern steppe are the result of periodic displacements of the Atlantic cyclones southwards or northwards. Thus, if any cycle in arid regions is characterised by an age-old warm-dry phase, this means that in the temperate regions it will be characterised by an optionally warm but necessarily wet phase, and vice versa. In fact, in the temperate regions the entire twentieth century can be attributed to a wet phase.

The incomplete coincidence of the characteristics of the periods according to Krivenko & Vinogradov (2008) in the Chuvash Republic is a result of the difference in climatic processes taking place in arid and temperate regions. That is why a direct extrapolation of the conclusions made in southern regions to the more northern ones should be carried out very carefully.

Up to 1870, only the most general, non-specific information about the animal world of the study area can be found in some state documents. Nevertheless, by the late 18th century, archival data from the Kurmyshsky County of Simbirsk Province indicate the nesting of *Pelecanus crispus* (Bruch, 1832), *Phalacrocorax carbo* (Linnaeus, 1758) and *Lagopus lagopus* (Linnaeus, 1758) along the River Sura (Kirikov, 1959), although later these species disappeared from these places.

In the late 19th century, the study area was investigated by two complex expeditions aimed to study the vertebrate fauna. Both were organised by Kazan University under the leadership of M.N. Bogdanov and M.D. Ruzsky. As a result of long-term investigations, there were publications of Bogdanov (1871) and Ruzsky (1893, 1894) which contain data suitable for our study. From 1900 until 1920, Zhitkov & Buturlin (1906) captured and studied at least 6000 birds in the Lower Prisurye.

Volchanetsky (1925) made a significant contribution to the study of the fauna of the Chuvasian Republic. He studied nature in the neighbourhood of Alatyr City during his work at the Institute of Natural History in 1919–1922. Since 1917, Pershakov (1932), a docent of the Kazan Agricultural Institute, studied birds of the oak forests of Chuvashia. From 1931 until 1957, Professor V.A. Popov of Kazan University visited Chuvashia several times. Later he became ideological founder of the monograph «Birds of the Volga-Kama Krai», which contained a first list of bird species of Chuvashia in its present-day borders. The active ornithological research began in the 1980s. Summarised data of the last study period are in the publication «Birds of Chuvashia. Non-passerines» (Glushenkov, 2016c; Isakov, 2017).

Results and Discussion

Below there are data on how and when some southern bird species have reached the territory of the Chuvash Republic.

Changes in limits of ranges of bird species

***Anas strepera* Linnaeus, 1758**. For this species, the start of expanding its range from the Mediterranean is indicated for the warm-dry phase (1822–1850) of the first cycle (according to Krivenko & Vinogradov, 2008). And already in the 1860s, it was known over all river valleys, lakes and swamps of the Volga region (Bogdanov, 1871). This fact raises some doubts about determining the start of expanding its range from the Mediterranean. Perhaps, the researchers proceeded from later data because in the 1890s in the Kazan and Simbirsk Provinces, *Anas strepera* was observed on nesting non-often (Ruzsky, 1893, 1894). In the early 20th century, *Anas strepera* did not nest on all the rivers of the Province of Simbirsk, but it was not uncommon on the River Sura (Zhitkov & Buturlin, 1906). Volchanetsky (1925) observed this species in Middle Prisurye only during spring and autumn migrations. At present, the northern boundary of the species range within the Volga-Kama region lies at the latitude of Kirov (Sotnikov, 1999). In Chuvashia, the nesting of *Anas strepera* is confined to the elements of the water structures of the treatment facilities, to fish ponds and some lakes with a dense semi-aquatic and aquatic vegetation. But necessary or at least a partial element for the species' nesting is a nearby meadow coast and technogenic structures. In addition, *Anas strepera* is known in the Kuibyshev and Cheboksary reservoirs. The territory of Chuvashia is located at the northern limit of the breeding range of this species. So in the nesting period its abundance is low and unstable. (Isakov et al., 2013a).

***Netta rufina* (Pallas, 1773)**. This is another Mediterranean bird species which began expanding its range at the same time as *Anas strepera*. But it did not reach the Chuvashia area yet. Only in recent years there have been four visitations of *Netta rufina* in winter. The breeding range of this species is limited to the south of the Chuvashia territory. Its main nesting places are located in the zone of steppes and deserts of Eurasia. *Netta rufina* occasionally nests in the forest-steppe zone. The Tengushevo district of the Republic of Mordovia is the nearest place to Chuvashia where this species sometimes nests (Isakov et al., 2013a).

***Cygnus olor* (J.F. Gmelin, 1789)**. This is a representative of a more powerful colonisation wave in the next age-old warm-dry phase (1930–1940) (Krivenko & Vinogradov, 2008). For the

Chuvashia territory, *Cygnus olor* was first observed in 1979 as a vagrant species. A next record was only in 1984. In the 1990s, birds began to be observed regularly on summering. In the mid-1990s, the nesting of *Cygnus olor* was first observed in Alatyrsky, the most southern district of Chuvashia. At present, this species is observed on summerings and can irregularly nest in Chuvashia. Its abundance is estimated at 1–5 nesting pairs and at 20–50 individuals at summerings, taking into account that this species is observed mainly in the northern part of the Chuvash Republic (Glushenkov, 2016a).

***Fulica atra* (Linnaeus, 1758)**. This is another species which has widely distributed during the same powerful colonisation wave in the second age-old warm-dry phase (1930–1940) (Krivenko & Vinogradov, 2008). It was a quite common species both in the south and in the north of the Volga region in an earlier period (Bogdanov, 1871). *Fulica atra* was nesting in sufficient abundance everywhere, where there were swampy reed thickets along the banks of rivers and lakes, oxbows and mill ponds (Ruzsky, 1893, 1894). Probably the misconception about the start timing of its resettlement was caused by the lack of sufficient data over an earlier period and by the fact that the abundance of *Fulica atra* does permanently fluctuate with very large recessions and rises. So, in the early 20th century, Zhitkov & Buturlin (1906) pointed to its rarity in the River Alatyr floodplain and in all floodplain rivers of the Province of Simbirsk. They noted that *Fulica atra* nested here in a very small number with an abundance of convenient places. The same authors believed that a low abundance of *Fulica atra* could not be due to its secretive life pattern only, because the even more secretive and cautious *Gallinula chloropus* (Linnaeus, 1758) was incomparably more often found in the floodplains of the River Sura and the River Barysh. In the first quarter of the 20th century, *Fulica atra* was nesting very rarely in the Middle Prisurye region (Volchanetsky, 1925). In the middle and the beginning of the second half of the 20th century *Fulica atra* became a common nesting bird in western Bashkiria, Tatarstan and Chuvashia. The abundance of *Fulica atra* increased after the construction of reservoirs and the formation of thickets of emergent vegetation (Popov, 1977). In the last quarter of the 20th century, there was another decline in the abundance of *Fulica atra* in the region. Thus, in Chuvashia this species has become very rare. The only place of its permanent habitation at that time was the sewage constructions in Alatyr City. At the end of the 20th century, the northern limit of the species' range in the Volga-Kama Krai was indicated along the latitude of Kirov City (Sotnikov, 1999). At the early 21st century, the abundance of *Fulica atra* began to grow again. At present, this species is known from many water bodies of Chuvashia suitable for nesting. According to the censuses of the abundances of waterfowl through accounting of broods (data of the State hunting-fishing service of Chuvashia), 1318 individuals of *Fulica atra* were registered in 2009. The current population of *Fulica atra* in the Chuvash Republic counts 500–800 breeding pairs (Yakovlev et al., 2013).

***Aythya ferina* (Linnaeus, 1758)**. The situation for this species is the same as for *Fulica atra*. The powerful expansion of the range of *Aythya ferina* into the centre of the European part of Russia has been registered only for the last decades (Krivenko & Vinogradov, 2008).

The most obvious relationship between the expansion of the range and climate changes can be considered for daytime birds of prey. Until the last quarter of the 20th century such species as *Hieraaetus pennatus* (J.F. Gmelin, 1788) and *Aquila heliaca* Savigny, 1809 had not been seen in the Chuvash Republic.

***Hieraaetus pennatus* (J.F. Gmelin, 1788)**. This species appeared in Chuvashia in the 1990s. It nests in the steppefied oak forests located at the slopes of the terraces above the floodplain. To date, there are 25 nesting sites of *Hieraaetus pennatus* in Chuvashia. Karyakin (2007) suggests that in Chuvashia there are up to 80 nesting pairs of this species (Isakov et al., 2013b). At present, the extension of its range to the north-east is continuing. And the northern border of its range lies along the central part of the Republic of Mari El (Karyakin, 2007).

***Aquila heliaca* Savigny, 1809**. The current status of this bird in Chuvashia is a very rare nesting migratory species. In the late 19th – early 20th century, *Aquila heliaca* was not observed by previous researchers on the current territory of Chuvashia (Bogdanov, 1871; Zhitkov & Buturlin, 1906; Volchanetsky, 1924). The most northern site of an eagle capturing (according to Zhitkov & Buturlin, 1906) was located near the village Promzino (now it is the village Surskoe in the

Ulyanovsk region). This place is 20 km southwards of the Chuvashia border with Ulyanovsk region. Serebrovsky (1918) noted this species in the floodplain of the River Alatyr. Later, Artobolevsky (1923–1924) reported on the nesting of *Aquila heliaca* in the floodplain of the River Alatyr. The first data on the nesting of this bird in the Prisursky forest massif in the south-west of Chuvashia date back to 1986 (Glushenkov, 1991). In the late 20th century, it was supposed that 1–4 pairs of *Aquila heliaca* inhabited the Chuvash Republic in the floodplain of the River Sura from the southern borders of the region to the village Poretskoe in Poretsky district. Since 1998, this species is known in the National Park «Chavash Varmane» in the south-east of Chuvashia. But the nest was found only in 2005 (Isakov et al., 2013b). At present, the northern limit of its range on the right-bank of the River Volga passes through the south of the Nizhny Novgorod region, north of Chuvashia, southwest of Tatarstan (Karyakin, 2008). However, in case of its range expansion, it is impossible to consider the climatic factor as fundamental because Karyakin (1999a) showed the possibility of this species to restore and expand the range northwards due to the changing of the feeding basis from ground squirrels and hamsters to ravens. In Chuvashia we find the northern range limit of *Spermophilus suslicus* Guldenstaedt, 1770 (Spotted Souslik) and *Cricetus cricetus* Linnaeus, 1758 (Hamster). But to date, these species have become so rare that they are included in the Red Data Book of the Chuvash Republic. Therefore it is not possible to consider them as a feeding base for eagles. In contrast, *Lupus europaeus* Pallas, 1778 became a mammal species widely distributed in the agrolandscapes of the broad-leaved zone and the zone of mixed forests. In addition, in Chuvashia there is the most northern colony of *Marmota bobak* Muller, 1776 (Bobak Marmot). It is a source for a successful colonisation of this mammal in many forest-steppe districts of Chuvashia up to its northern border where these animals have well established. However, *Aquila heliaca* is observed extremely rare in the habitat of *Marmota bobak*.

***Pernis apivorus* (Linnaeus, 1758)**. In Russia, the nesting range of this species includes the forest and forest-steppe zones of the European part of Russia and Western Siberia east up to Altai. Previously *Pernis apivorus* was not numerous in the study area. Bogdanov (1871) considered this species as a mysteriously rare bird. Zhitkov & Buturlin (1906) saw it only a few times. But the apparent rarity of this species in the Middle Volga region can be (partly) explained by the high similarity, when flying, of *Pernis apivorus* with *Buteo buteo* Linnaeus, 1758. Ruzsky (1893) did not consider *Pernis apivorus* as a rare bird in the Province of Kazan. He observed this species annually during migration and nesting over the entire area of island forests. Volchanetsky (1925) did not indicate nesting of *Pernis apivorus* near Alatyr, because he usually observed this species during migration. Since the late 20th century this species has distributed everywhere and uniformly in the Chuvash Republic. Its nesting in the region has been proven. In the nesting period, *Pernis apivorus* is observed in almost all regions of Chuvashia. Its abundance is estimated at 100–150 pairs, and it is possibly increasing (Isakov et al., 2013b). There is a clear connection between the growth of its abundance and an increase in the populations of collective bees which in turn is a consequence of the mitigation of climatic conditions.

***Himantopus himantopus* (Linnaeus, 1758)**. In the middle belt of European Russia this species began to nest on technogenic water bodies (sewage constructions, fish farms). That allowed this species to shift its range northwards significantly. But the nesting of *Himantopus himantopus* at the northern limit of its range is locally due to a small number of technogenic water bodies (Isakov et al., 2017). Since the late 20th century cases of nesting of this species has become registered in the middle part of the Volga-Kama Krai. In 1996, the first case of nesting was registered at the sewage constructions in Saransk (Republic of Mordovia), in 1997 – in the Penza region, in 2001 – on the sewage constructions of Nizhny Novgorod. In the Ulyanovsk region this species was observed for the first time on 25.05.1997, where at present the nesting of 2–3 pairs is supposed (Isakov et al., 2017). Until 2009 only some vagrant birds were known in Chuvashia. In 2009, the first case of nesting of *Himantopus himantopus* in Chuvasia was recorded on the fish pond «Kirya» (Poretsky district in the south-west of the Chuvash Republic). In 2012, several nests were found in the north of Chuvashia (fish farm «Karamyshevsky» in the Kozlovsky district and biological stewage constructions of Novocheboksarsk City), after which the nesting of this

species has become regular. Thus, at the present time the northern limit of the nesting range of *Himantopus himantopus* passes through the north of Chuvashia (Isakov et al., 2017).

***Merops apiaster* Linnaeus, 1758**. The rhythmic nature of the range dynamics is well illustrated by the expansion of *Merops apiaster*'s range since the second half of the 19th century. Researchers of the late 19th century and early 20th century (Bogdanov, 1871; Ruzsky, 1893; Volchanetsky, 1925; Pershakov, 1932) did not indicate this species in the modern territory of Chuvashia. Based on the available literature data regarding to the central and northern regions of the Volga-Kama Krai, Sotnikov (2002) made the following conclusions: During the 19th century, the northern limit of *Merops apiaster*'s range fluctuated slightly. Many times it reached the mouth of the River Kama in the north and then retreated to the south. A northwards shift apparently occurred in the 1930s. (Isakov & Yakovlev, 2008). In 1939, 178 residential and about 200 non-residential burrows were registered in one of the colonies on the River Sura in the vicinity of the village Kurmysh in the Nizhny Novgorod region. By the late 1950s and early 1960s, *Merops apiaster* had colonised the southern parts of Tatarstan and the Gorky region, the whole of Chuvashia, while it had almost never crossed the River Volga nor the River Kama. In the 1970s, the northern boundary of the nesting range of this species shifted slightly southwards. As a result, in Chuvashia it passed through the central districts of the region. In the 1980–1990s, *Merops apiaster* was observed on nesting only along rivers of southern Chuvashia. These records are: in 1987, its abundance on the River Bezdna was 0.55 pairs per km; on the River Sura the abundance of birds was 0.04 individuals per km in 1985–1986, and 0.02 individuals per km in 1995–1996. In the late 20th century, the total abundance of this species in Chuvashia did not exceed 100 pairs. A new wave of *Merops apiaster*'s colonisation of northern Chuvashia began in 2000 by nesting of birds in single pairs. In 2002, the number of this species in the north of Chuvashia had increased. As a result, *Merops apiaster* colonised the majority of small rivers and adjacent gullies and ravines with an abundance of 0.38–0.46 pairs per km of riverbed. In recent years, the abundance of this species has grown continuously. So, in July 2004, 61 pairs of *Merops apiaster* (0.22 pairs per km of riverbed) were accounted throughout the Chuvashian part of the River Sura (280 km). In June 2006, 170 pairs (0.61 pairs per km of riverbed) were recorded in the same area. Thus, the abundance of this species along the River Sura had increased by 30 times in comparison with 1980–1990s. In different years, its abundance varied within 150–250 pairs in the lower reaches of the River Sura. In 2004–2008, 550 nesting pairs of this species were registered only in the surveyed colonies at the inner part of Chuvashia. The total number of *Merops apiaster* in Chuvashia is estimated at 1000–1500 pairs (Isakov & Yakovlev, 2008).

***Coracias garrulus* Linnaeus, 1758**. The resettlement of this bird can be considered as one of failed attempts to extend its range. Single records of this species on nesting in Chuvashia are known since the late 19th century (Ruzsky, 1893, 1984; Pershakov, 1932). *Coracias garrulus* was penetrating northwards up to Tsarevokokshaisky County and up to the village Oshurga in Cheboksary County (currently it belongs to the area of the Republic of Mari El). After that, there were no data about this species in Chuvashia until the 1980s. Then, in 1983, 1997 and 1998, *Coracias garrulus* was observed four times. Three of these observations were in the most northern part of Chuvashia, in the Trans-Volga region. (Isakov & Yakovlev, 2008).

***Upupa epops* Linnaeus, 1758**. The range extension of this species can be regarded as successful, but not optimal, because all the time this bird remains a rare species in all the newly-colonised areas. During the 19–20 centuries, the northern limit of *Upupa epops*'s range gradually shifted northward. Bogdanov (1871) observed this species near Penza. Then, in the summer of 1864, he found it in the Syzran County in the valley of the River Sura. It was believed that *Upupa epops* had reached the border of the Province of Kazan. Ruzsky (1893) captured a female bird in the Tetyushsky County on 27.07.1889. And in 1893 Ruzsky found the nest of this species in a hollow old apple tree in an orchard in the Ardatov County (Ruzsky, 1894). Volchanetsky (1925) observed *Upupa epops* both as single birds and in pairs in the middle course of the River Sura where in spring he heard their characteristic call. In the 1920s, these birds were already found in the Republic of Mari (Pershakov, 1932). Currently, the northern limit of its range passes through the southern districts of the Kirov region (Sotnikov,

2002). At present, *Upupa epops* is distributed throughout Chuvashia, but everywhere it is rare. Often, it inhabits pine and pine-spruce forests.

***Ciconia ciconia* (Linnaeus, 1758).** According to Krivenko & Vinogradov (2008), the range extension of a species does not always follow the changing temperature conditions (from the south to the north), but often it can be observed from the east to the west, and vice versa. «Vice versa» means from west to east. And in this case the basis for range extension is the same: «following changing temperature conditions». This species is an example of the type of range extension mentioned above: this is a species of western origin. Its expansion to the east occurred in the 1970–1990s. In the early 1980s the first observations of this bird were registered in the Chuvash Republic. In 1988–1992, this species nested in one of the central districts of Chuvashia (Lastukhin, 1997). Between 1989 and 2001, the largest number of observations of *Ciconia ciconia* (nine) was recorded in the southern and northern districts of the region. The highest number of observations occurred during the period of spring migration (from late April till early June). From 2002 till 2010, *Ciconia ciconia* was observed only two times. In recent years, this species has not been recorded. Perhaps, expanding of its range has stopped. (Glushenkov et al., 2013b).

***Dendrocopos medius* (Linnaeus, 1758).** The limit of this species' range lies much further west and south. There are only records of *Dendrocopos medius* in the north of the Chuvash Republic (Yakovlev et al., 2008).

***Ocyris aureolus* (Pallas, 1773)**. For Chuvashia, this is the only example of species' range expansion from east to west. In the late 19th century, *Ocyris aureolus* penetrated in the region on the right bank of the River Volga. And it was a common bird in the valleys of almost all the rivers of the Province of Kazan (Ruzsky, 1893) for at least 30 years (Volchanetsky, 1925). However, 20 years earlier, Bogdanov (1871) noticed that the middle reaches of the River Volga represent a sharp southwestern border of the distribution of the «meadow sparrow» [*Ocyris aureolus*]. After the construction of the Cheboksary reservoir this species gradually disappeared from the nesting sites in the Chuvash part on the right bank of the River Volga. Now, this species is being observed irregularly, sporadically in the coastal zone of the Kuybyshev reservoir (Isakov et al., 2009). The taiga component of the ornithofauna in the Prisurye forest massif (Yakovlev, 2012) cannot be considered as an example of expansion from east to west, because the remained spruce-broadleaved forests are relic ones.

Some southern species were observed (from one to three times) as migratory birds in the territory of Chuvashia during the last century. Of these, during the development of the age-old warm-dry climate phase (the wave of the 1930s), *Pelecanus crispus* (Bruch, 1832), *Tadorna tadorna* (Linnaeus, 1758) colonised the steppe regions of Western Siberia and Kazakhstan. In addition, the following species have extended the limits of their ranges northwards in the temperate climate zone of Eastern Europe: *Casmerodius albus* (Linnaeus, 1758), *Phoenicopterus roseus* Pallas, 1811, *Phalacrocorax carbo* (Linnaeus, 1758), *Tadorna ferruginea* (Pallas, 1764), *Recurvirostra avosetta* (Linnaeus, 1758), *Buteo rufinus* (Cretzschmar, 1827), *Gyps fulvus* (Hablizl, 1783), *Gypaetus barbatus* (Linnaeus, 1758) (Glushenkov, 2016c).

Shift in the timing of arrival of birds

Climate changes can also be judged on the basis of the shift in the timing of arrival of birds. This is most clearly manifested for early-arrival species: e.g., *Ardea cinerea* Linnaeus, 1758 (Glushenkov et al., 2013b) and *Grus grus* (Linnaeus, 1758) (Yakovlev et al., 2013).

***Grus grus* (Linnaeus, 1758)**. The beginning of the spring migration of this species in Chuvashia is in late March – the first half of April. It depends on the course of a spring and, first of all, on the timing of the transition of air temperature through 0°C. In the 1970–1980s, the average timing of arrival of *Grus grus* was on 10–12 April. In the 1990s it occurred on 4–5 April due to changes in climatic conditions (e.g., snowless winters, early snowmelt). Over the past decade, a shift of the timings of arrival has not been noted. The average date of registration of the first arriving birds in Chuvashia (n = 14, 1999–2012) is 7 April (27.03.2008–15.04.2012). During the last decade, the earliest observations of *Grus grus* in the north of Chuvashia were: 22.03.2002, 27.03.2008, 31.03.2004, 31.03.2007, 02.04.2009. In 2008 it was registered on 04.03.2008 in the south of the Shemurshinsky district of the Chuvash Republic. During intensive snowmelt (on the first 10–20 days of April), nesting birds appeared in the Lower Prisurye region. And this happened 2–7 days

before the main mass of *Grus grus* and geese transitory migrates through the Chuvash Republic (Yakovlev et al., 2013). The active phase of the migration begins in mid-April. Exactly at this time the most number of registrations and the largest flocks can be observed.

***Ardea cinerea* Linnaeus, 1758**. Late March – early April, the spring migration of this species begins. In the 1980s, the timings of arrival fluctuated insignificantly. These were observed for the first 10 days of April: 06.04.1981, 07.04.1982, 03.04.1984. From the 1990s to date, the arrival dates have shifted mainly to the third decade of March. So, the average date of registration of the first meetings (n = 16, 1993–2013) is 29 March (19.03.2002–06.04.2006) (Glushenkov et al., 2013b). The active phase of migration is observed in mid-April, and it ends by early May. In spring the flock size is from 3 to 15 individuals.

The shift in the timing of arrival is less obvious among waders who firstly arrive in the Chuvash Republic (*Vanellus vanellus* (Linnaeus, 1758), *Tringa totanus* (Linnaeus, 1758), *Tringa ochropus* Linnaeus, 1758) because dates of their arrival depend too significantly on the character of the spring in each year. Because of the return of cold weather, they are characterised by return migration southwards and westwards, that is not known either for *Ardea cinerea* nor for *Grus grus*. Clear conclusions on shifts in arrival dates of these species are not possible either because we have data on the migration timing of most species only over the last 20 years.

***Vanellus vanellus* (Linnaeus, 1758)**. This species is the first wader arriving in the Chuvash Republic. It happens when thawed patches appear in fields and on slopes of ravines. Sometimes it occurs under an average daily temperature below 0°C. Depending on the weather conditions, the first *Vanellus vanellus* individuals in Chuvashia more often appear late March (n = 10, 21.03.2002 – 31.03.1999) – early April (n = 9, 02.04.2000 – 06.04.2003). Even earlier meetings were recorded in 2012 (4 March, in the north of the region) and in 2014 (11 March, in the centre of the Chuvash Republic). The average date of arrival (n = 21, 1995–2016) is 28 March. By the 20th of April the migration of *Vanellus vanellus* ends. And late April only some single individuals can be recorded (Isakov et al., 2017).

***Tringa totanus* (Linnaeus, 1758)**. These birds arrive in Chuvashia on average seven days later than *Vanellus vanellus* under an average daily temperature of +4°C. In the early-spring years, the arrival of the first *Tringa totanus* is already observed at late March (25.03.2014, 27.03.2016, 28.03.2004, 29.03.2008). Migration most often begins in the first half of April (n = 13, 01.04.2001 – 13.04.2002). The average date of registration of the first individuals (n = 17, 2000–2016) is 4 April (Isakov et al., 2017). In the mid-twentieth century, a mass migration in the Volga-Kama Krai was observed late April (Plessky, 1977). Over the followed 40 years the dates of mass migration have shifted by ten days (Isakov, 2007)

***Tringa ochropus* Linnaeus, 1758**. These birds arrive in the Chuvash Republic as one of the first waders – usually after *Vanellus vanellus* and *Tringa totanus*. The first observations of *Tringa ochropus* in Chuvashia are recorded on the first 10 (n = 10, 02.04.2009–10.04.2004) – 20 (n = 8, 11.04.2001–19.04.2007) days of April. The average date of its arrival in the region (n = 19, 1995–2016) is 10 April (Isakov et al., 2017).

***Actitis hypoleucos* (Linnaeus, 1758)**. These birds arrive in Chuvashia even later than *Tringa ochropus* and *T. totanus*. The shift in the average dates of their arrival is most obvious. In 1998–2007, the first individuals of *Actitis hypoleucos* were observed from 15 April (2005) to 27 April (2003), and the average date of arrival (n = 10) was 22 April. In 2008–2016, the first individuals were observed from 9 April (2016) till 22 April (2010, 2011), and the average date of arrival (n = 9) shifted by 6 days to 16 April. Spring migration lasts 15–28 days (Isakov et al., 2017).

At the same time, there is not a shift in timing of migration of Arctic bird species. The spring migration of *Pluvialis squatarola* (Linnaeus, 1758), *Pluvialis apricaria* (Linnaeus, 1758), *Charadrius chiaticula* Linnaeus, 1758, *Philomachus pygnax* (Linnaeus, 1758) through Chuvashia is observed during late May – mid-June. Probably the climate warming is not so significant at high latitudes or, rather, it has not become a constant factor to determine the shift in the timing of optimal nesting.

***Merops apiaster* Linnaeus, 1758**. It is interesting that the shift in the timing of arrival has also happened to some other species, e.g., for *Merops apiaster*, which has expanded its range in recent years. In the 1990s, the first individuals of this bird were observed from 27 May till 21 May. According to the data of 2000–2014 (n = 16), the average date of arrival of the first *Merops*

apiaster into the north of Chuvashia was 18 May (Isakov & Yakovlev, 2008; pers. data).

***Hieraaetus pennatus* (J.F. Gmelin, 1788)**. In the early 2000s, its arrival was registered in the third decade of April: 27.04.2001, 28.04.2002, 25.04.2004, 23.04.2006. Later, *Hieraaetus pennatus* began to be registered approximately ten days earlier: 16.04.2005, 15.04.2007, 15.04.2009, 16.04.2011. In 2008 (early spring) the arrival of this species was registered on 6 April (Isakov et al., 2013b).

***Pernis apivorus* (Linnaeus, 1758)**. This bird depends on the activation of collective stinging insects. Therefore it arrives as one of the last among birds of prey. Over 14 years of study (1999–2012) the arrival of the first individuals of *Pernis apivorus* began to be frequently observed late April (19.04.2001, 22.04.2007, 23.04.2000, 27.04.2008, 28.04.2002). The average date of its arrival in the north of Chuvashia (n = 8) is 30 April (Isakov et al., 2013b).

The climate warming manifests in the increase of the frost-free period (Fig. 9); in the increase in the average winter temperatures; in the later dates of establishing the constant snow cover and earlier dates of snow cover loss; in weak soil freezing; in the decrease of the water contents in snow.

***Picus viridis* Linnaeus, 1758**. Changes, mentioned above, affect *Picus viridis* resistance to wintering at the northeastern limit of its range. Until the 1980s, this species regularly migrated southwards in winter. In the late 20th century, migration of this species was observed only both in rarely frosty winters and for a very short period of lowest temperatures (Yakovlev et al., 2008). On the base of observations in 1917–1932, Pershakov (1932) indicated that the range of this species north-eastwards ended at the area of steppefied oak forests. But a general trend of its range extension northwards and eastwards is not observed. Currently, the northern limit of its range passes through the Trans-Volga areas in the Nizhny Novgorod region and the Republic of Mari El. But only single records were noted there as it was in the Chuvash part of the Trans-Volga region.

***Perdix perdix* (Linnaeus, 1758)**. Despite the increase of the winter precipitation amount over the last years, the depth of the snow cover and its density were the lowest from 1980 till 2000 (Karyagin, 2007a,b). It contributed to an abundance increase of *Perdix perdix* in Chuvashia, because its survival in winter depends mainly on these indicators (Glushenkov et al., 2013a).

The range extension of some bird species northwards and north-eastwards is quite likely due to climate changes. However, climate changes are not the only determinant factor affecting the distribution of birds. Along with them, environmental factors are also important determinants.

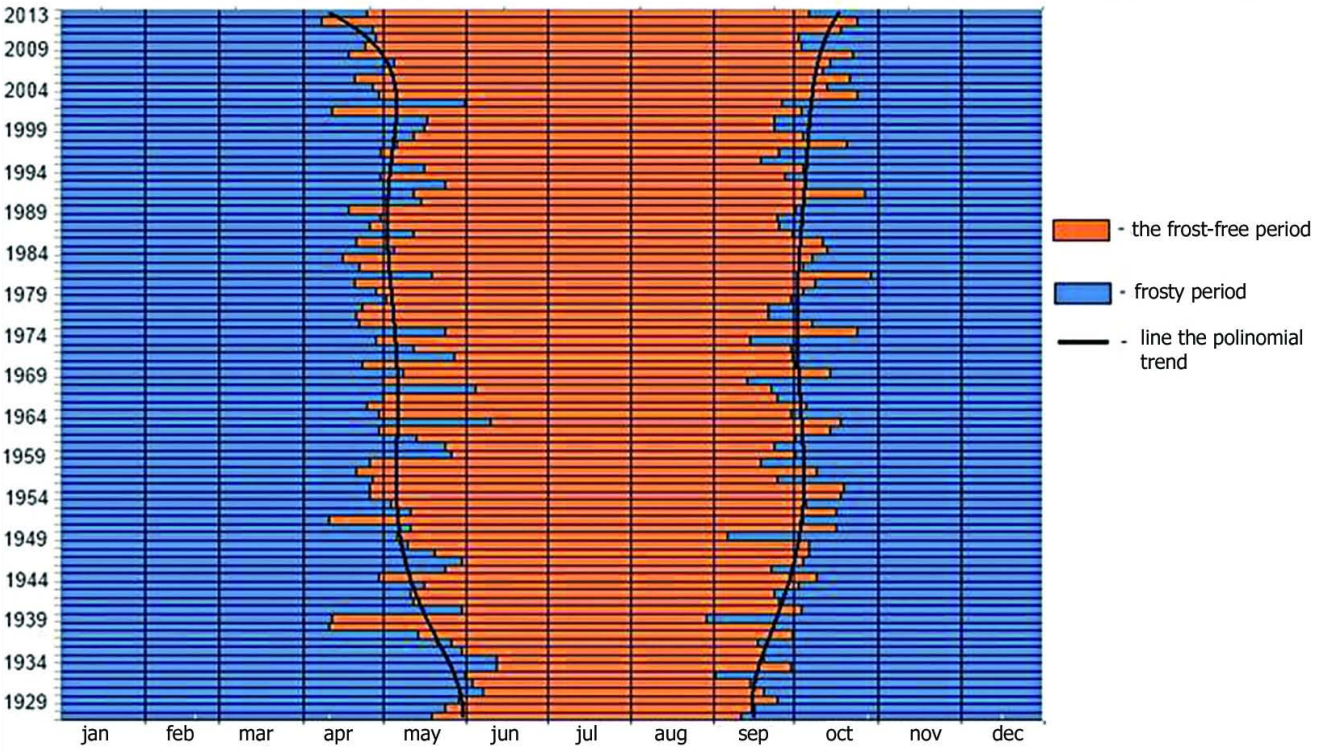

Fig. 9. Diagram of long-term fluctuations of the frost-free period (Cheboksary) (according to Karyagin, 2007a,b).

Anthropogenic impact on well-being of some bird species

Changes in the abundance waterfowl and semi-aquatic birds, the extension of ranges through deeply anthropogenically transformed landscapes have occurred through complexes of ecological relationships. Earlier we showed the effect of mentioned mechanisms on the example of the forming of bird communities in suburban areas (Glushenkov, 1995, 1997). The reaction of most bird species to any anthropogenic impact is approximately similar: a decrease of bird abundance and their migration to sites where the human impact is minimal.

***Haematopus ostralegus* Linnaeus, 1758**. In the late 19th – early 20th century, all ornithologists indicated that this species is a common bird along the River Kama, the River Sura and some other rivers of the Volga-Kama Krai (the River Ilovlya, the River Medveditsa) (Bogdanov,1871; Ruzsky,1893; Zhitkov & Buturlin, 1906). At the same time, *Haematopus ostralegus* was considered as vagrant species in the Upper Prisurye (Artobolevsky, 1926). Until the mid-20th century, the lower reaches of the River Sura remained one of the main nesting places of the continental subspecies of this bird in the Volga-Kama Krai (Plessky, 1977). In 1985–1986, the nesting density of *Haematopus ostralegus* in the Lower Prisurye was 0.4 pairs per km of riverbed. In 1995–1996 this value was 0.41 pairs per km of riverbed (Bochenkov & Glushenkov, 2001). In the late 1990s, the abundance of the species along the River Sura in Chuvashia was estimated at 100 pairs (Glushenkov et al., 1999). Such an abundance decrease was due to the navigation development in the Lower Prisurye. It required regular dredging and the organisation of passenger traffic using small-draft ships. Therefore these ships eroded sandy islands, sandy spits and washed up the banks of the River Sura. However, exactly in the late 20th century, the next stage of noticeable changes in the abundance and size of *Haematopus ostralegus*'s range began in the Volga-Kama Krai. The effect of the factors that led to the changes can be logically arranged in the following sequence. In early 1980s, the Cheboksary reservoir filled. It caused the flooding of the nesting sites of this species along the River Volga and the redistribution of the «Volga-confined» population along the tributaries. It should be noted that an abundance decrease along the River Volga and the River Kama within the Republic of Tatarstan and Ulyanovsk region has been observed even after the construction of the Kuybyshev reservoir. A significant abundance increase did not occur in the Lower Prisurye due to the flooding of its wellhead part and the continuing of intensive shipping. In the mid-1980s, apparently, a range extension of *Haematopus ostralegus* took place along the large tributaries of the River Sura. And its abundance in the Middle Prisurye increased until the limits of the natural size of communities. Also the Upper Prisurye has been colonised more densely (Isakov et al., 2017). In the late 20th – early 21st centuries, the abundance restoration, and its further increase in the Lower Prisurye occurred. It started with the complete collapse of navigation and the restoration of natural nesting sites of this species along the river. At present, the abundance of *Haematopus ostralegus* in Chuvashia is 305–370 pairs. This is 7.5–18.5% of the continental subspecies' population in European Russia. This means that the Chuvash Republic is one of the key habitats for this species (Isakov et al., 2017).

***Sterna albifrons* Pallas, 1764**. The last abundance fluctuations of this species are identical with those for *Haematopus ostralegus*, and were caused by the same reasons. But unlike *Haematopus ostralegus*, for *Sterna albifrons* there is a connection with climatic cycles. Even before the last quarter of the 19th century, Bogdanov (1871) and Ruzsky (1893) considered this species as a common bird throughout the river valleys of the Volga region. And nesting of this species together with *Sterna hirundo* (Linnaeus, 1758) were registered in numerous mixed colonies on sandy spits of the floodplains of the River Kama, the River Volga, the River Vyatka and other rivers. But already in the early 20th century Zhitkov & Buturlin (1906) did not find colonies of this bird along the River Sura and in the River Alatyr valley. In general, they did not observe *Sterna albifrons* along rivers of the western part of Simbirsk Province. Just 20 years later *Sterna albifrons* became again a common bird on nesting sites together with *Sterna hirundo* in the Middle Prisurye (Volchanetsky, 1925). In the last 30 years of the 20th century, we noticed an abundance decrease for th is species caused by climatic and anthropogenic factors under predominance of the latter. So, in July 1968, *Sterna albifrons* was observed in the middle reaches of the River Sura with an abun-

dance of 0.6 individuals per 1 km of riverbed. This value in the lower reaches of the River Sura was 0.15 pairs per 1 km of riverbed in 1985–1986 and 0.2 pair per km of riverbed in 1995–1996. In the early 20th century the abundance of *Sterna albifrons* began to increase. By 2006, the abundance of this species along the River Sura from the border of Chuvashia with the Ulyanovsk region to the mouth had increased almost by 6-fold in comparison to the period of 10–20-years before. Its values were from 1.15 to 1.5 pairs per km of riverbed (from Alatyr to Shumerlya – 115 km; 172 pairs). These results allow us to estimate the population of *Sterna albifrons* along the River Sura as one of the largest in European Russia (Glushenkov, 2016b). Such a significant abundance increase is explained by the numerous alluvial sandy islands and broad braids on the River Sura which have appeared after the complete cessation of navigation. In 2009, the abundance of *Sterna albifrons* began again to decrease in the area between Alatyr and Shumerlya (115 km) – 1.1 pairs per km of riverbed (110 pairs). And in 2012 it decreased by 2-fold – 0.6 pairs per km of riverbed (59 pairs). In 2011, this decrease (until 0.54 pairs per km of riverbed (110 km)) was recorded in the area from Shumerlya City to the bridge across the River Sura on the «M7» road (Isakov & Glushenkov, 2010). In this case, succession factors act together with the climatic cycle. This species is confined to large rivers. Its main colonies are located exclusively on sandy islands and spits, where this bird is often seen together with *Sterna hirundo*. The inconstancy of the location of the appeared and disappeared sandy islands and spits, the overgrowth of willows at more permanent sandy islands are main factors leading to the change in location of nesting sites and change in the size of the colonies.

Paradoxically, examples of abundance restoration of the previously displaced species within their ranges after the termination of anthropogenic factors can be considered as conclusive evidence of the importance of these factors in the expansion of ranges for highly adaptive species.

Conclusions

All typical periods and trends of climate changes of the 20th and 21st century can be observed in the Chuvash Republic located in the centre of European Russia. Of these are: 1) a warm period in the early 20th century, 2) a colder period in the mid-20th century, which has been replaced by 3) a warm period, which continues to the present day. The periods listed above are a consequence of the complex overlap of cycles of different periodicity and anthropogenic climate change noticeable since the 1970s (IPCC, 2013; Second Assessment Report, 2014). If the phases can quite clearly be distinguished on the basis of changes in the average annual temperature, then their correlation with a change in the precipitation amount is not traced. There can be noted its considerable interannual variability and general trend to increase during the 20th century (Second Assessment Report, 2014).

The authors of the concept of cyclic dynamics of waterfowl ranges in the context of the centuries-old and intra-century climate change in Northern Eurasia (Krivenko & Vinogradov, 2008) were faced with the need to select a model area due to the lack of completeness of material for such a global aim as a reconstruction of the natural environment and the bird population in the past and present. They selected the arid and semi-arid zones of Russia and Kazakhstan.

As a model area these territories have already been used earlier. For example, Shnitnikov (1969) used this area to establish the intra-century and general variability of humidification of the continents on the Northern Hemisphere. Changes in the animal world in natural zones were investigated by Kirikov (1959). As a result, this choice proved to be very successful in terms of reconstructing the picture of the intra-century and centuries-old variability of the hydrological regime of a number of water bodies in Northern Eurasia, confirmation of the existence and development of several periods of colder and warmer climate since the late 19th century, establishing the influence of centuries-old and intra-century climate cycles on the dynamics of animals' ranges (Krivenko & Vinogradov, 2008).

However, in our opinion, not a quite real picture of the reasons of dynamics of abundance and habitats, and the possibility of ranges expansion of waterfowl and semi-aquatic birds in the middle latitudes was shown «through the representation prism» obtained in model areas. Direct extrapolation of the obtained regularities for the arid and semiarid zones is not in all cases adequate for forest-steppe zone, taiga zone, and zone of mixed forests.

A lack of sufficient data on the fauna of a certain area for the earlier periods of the 19th century leads to difficulties in the establishment of connections between a particular climatic period and the beginning of a range expansion and its further continuation for a certain species. A lack of data on the species' abundance and its fluctuations do not allow us to reconcile this dynamics with periods of climate changes. Hence, there is an inconsistence in the conclusions of Krivenko & Vinogradov (2008) at the beginning and rate of range expansion for *Anas strepera* and *Fulica atra*.

In our analysis, among all birds which have expanded their natural range up to 56° N and northwards, the range expansion of *Merops apiaster* is within the framework of the concept of cyclic dynamics of ranges. This species is indeed characterised by some regularities. At first, it is the coincidence of the northward shift of the range boundary with abundance increase during warm-dry climatic phases. At second, it is the abundance decrease and southward shift of the range boundary during cool-wet climate phases. The abundance increase at the northern limit of the range and the shift of its boundaries for other species (*Anas strepera*, *Cygnus olor*, *Hieraaetus pennatus*, *Aquila heliaca*, *Pernis apivorus*, *Himantopus himantopus*) is more likely associated with the general trend of climate warming that began in the 20th century. In any case, there are attempts to expand the ranges with further establishment in more northern areas, but it is not a matter of dynamics caused by the change of climate phases.

The trend of climate warming is clearly traced in the change of the arrival timing to earlier dates for *Grus grus*, *Ardea cinerea* and *Actitis hypoleucos*. It is especially considerable for *Pernis apivorus* and *Merops apiaster* which depends on the emergence time of insects.

The range expansion of some bird species northwards and north-eastwards is quite likely associated with the centuries-old and intra-century climate changes. Nevertheless, we do not consider them to be the only determining factors affecting the bird distribution. Examples of *Haematopus ostralegus* and *Sterna albifrons* have shown that environment factors play no less an important role along with climatic factors.

A succession of aquatic habitats in middle latitudes proceeds according to completely different regularities which are not characteristic for the arid zone. The ecosystem watercut in the middle latitute does not depend so much on the sum precipitation amount as on the duration of the winter period, the depth and density of the snow cover and the water reserve in it. The replenishment of water bodies in summer is more or less due to the large evaporation. The winter period has reduced from 5.5 to 4–4.5 months due to the explicit warming that began in the mid-20th century and continued at the early 21st century (Karyagin, 2008a). The period of accumulation of solid precipitation (snow) was reduced. As a result, the water reserves in snow has become smaller. The water reserve in winter is not enough to supply the watershed karst lakes and interdunal lakes under conditions of early, gradual snowmelt and the weakly-frozen ground. Due to the same reason there is not enough water for abundant floods and full-scale flood in floodplain territories. Weak floods do not contribute to the washing of oxbow lakes from accumulated plant residues. A lack of floods leads to a lack in the water amount in these lakes. Thus, the succession of water bodies in the mid-latitudes has accelerated. But unlike arid regions, here this process is irreversible. In addition, lakes do not dry up. Instead of that, they get transformed into swamps. It has a completely different effect on the abundance and dynamics of waterfowl and semi-aquatic birds.

Modern climate changes and the change in the intra-century climatic phases in the temperate regions have influence on the organisms that are food for birds, and, as a consequence, these factors impact the number of nesting pairs and the survival of young animals. The study of the influence of these factors requires a separate approach.

In our opinion, the main factors determining these processes in the centre of European Russia for waterfowl and semi-aquatic birds are anthropogenic factors. For example, these are the regulation of river runoff, formation of large reservoirs, technogenic and artificial water bodies. As a result of adaptation to their action is the formation of new ecological niches with their food provision, regardless of any natural processes. In the future, urbanisation and synanthropisation of these ecological niches could lead to a further range expansion.

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РАСШИРЕНИЕ АРЕАЛОВ НЕКОТОРЫХ ВИДОВ ПТИЦ НА СЕВЕРО-ВОСТОЧНОЙ ГРАНИЦЕ РАСПРОСТРАНЕНИЯ В СВЯЗИ С ВНУТРИВЕКОВЫМИ ИЗМЕНЕНИЯМИ КЛИМАТА

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Проблема расширения ареалов птиц, имеющих северо-восточную границу распространения рассматривается в пределах территории Волжско-Камского края на приволжских территориях к северу и югу от 56° с.ш., к западу и востоку от 49° в.д., в полосе около 400 км. Проблема рассматривается в аспекте внутривековых изменений климатических условий в регионе и Европейской части России в целом. Анализ связи процессов расширения ареалов некоторых видов птиц на северо-восточной границе их распространения с внутривековыми изменениями климата опирается на орнитологические материалы и материалы по изменению климата рассматриваемой территории. Использованы материалы по климатическим изменениям в Чувашии с 1926 г., в рамках изменения климатических условий и ресурсов Волжско-Камского края, в контексте данных Росгидромета и Межправительственной группы экспертов об изменениях климата последних лет. Основой идеи явилась теория климатических циклов различной периодичности, теория современного глобального изменения климата и гипотеза циклической динамики ареалов водоплавающих птиц в связи с многовековыми и внутривековыми изменениями климата Северной Евразии В.Г. Кривенко и В.Г. Виноградова. По проблеме изучены орнитологические материалы конца 19 в. М.Н. Богданова и М.Д. Рузского; начала 20 в. Б.М. Житкова, С.А. Бутурлина, В.М. Артоболевского, И.М. Волчанецкого; второй четверти 20 в. А.А. Першакова; третьей четверти 20 века В.А. Попова; конца 20 – начала 21 вв. О.В. Глушенкова и др. В работе показано, что расширение ареалов на север и северо-восток таких видов птиц как лебедь-шипун (*Cygnus olor*), серая утка (*Anas strepera*), красноголовый нырок (*Aythya ferina*), орел-карлик (*Hieraaetus pennatus*), могильник (*Aquila heliaca*), лысуха (*Fulica atra*) вполне вероятно связано с внутривековыми изменениями климата. Об изменениях климата можно судить и по смещению сроков прилета птиц на более ранние. Наиболее наглядно это проявляется на раннеприлетных видах: серой цапле (*Ardea cinerea*), сером журавле (*Grus grus*), и на позднеприлетных видах, благополучное существование которых зависит от начала активности насекомых: обыкновенном осоеде (*Pernis apivorus*), золотистой щурке (*Merops apiaster*). Изменения климата не являются единственными определяющими факторами, влияющими на распространение птиц. Наряду с ними немаловажными факторами являются экологические. Расширение ареалов в ландшафтах глубоко трансформированных человеческой деятельностью, происходит через сложные цепи экологических взаимосвязей. На примере кулика-сороки (*Haematopus ostralegus*) и малой крачки (*Sterna albifrons*) показаны причины сокращения и восстановления ареалов в связи с изменением действия антропогенного фактора. Таким образом, расширение ареалов некоторых видов птиц на север и северо-восток вполне вероятно связано с вековыми и внутривековыми изменениями климата. Однако в умеренных широтах для ряда птиц, увеличивающих свою численность на границах своего ареала, мы не считаем потепление климата, единственными определяющими факторами увеличения численности и дальнейшего расширения ареалов. Для более глубокого понимания воздействия изменений климата на птиц необходимо провести исследования того, как в средних широтах современные изменения климата сказываются на количестве животных, являющихся кормом для птиц, и, как следствие, числе загнездившихся пар и выживаемости молодняка.

Ключевые слова: внутривековые изменения климата, водоплавающие и околоводные птицы, дневные хищные птицы, расширение ареалов, сроки прилета