Online ISSN: 2588-3526

Journal of Wildlife and Biodiversity

Volume 6 (Suppl. 1): 33-62 (2022) (http://www.wildlife-biodiversity.com/)

Scientific Reports

Population trends of Anseriformes and Charadriiformes on the west coast of the middle Caspian Sea

Evgeny Viktorovich Vilkov

Precaspian Institute of Biological Resources of the Daghestan Federal Research Center of the Russian Academy of Sciences, Ph.D., Leading Researcher. 367000 Makhachkala, Daghestan, Russia

Email: evberkut@mail.ru

Received: 13 August 2022 / Revised: 16 October 2022 / Accepted: 08 October 2022/ Published online: 13 November 2022.

How to cite: Vilkov, E.V. (2022). Population trends of Anseriformes and Charadriiformes on the west coast of the middle Caspian Sea, Journal of Wildlife and biodiversity, 6 (Suppl. 1), 33-62. **DOI**: https://doi.org/10.5281/zenodo.7316905

Abstract

The decline in the number of waterfowl and water birds is related to the reduction of wetlands during a warming climate. Most of the world's waterfowl and birds nest in Russia, but there is little accurate data on their population dynamics. This study presents long-term data on migratory populations of Anseriformes and Charadriiformes from an important Eurasian flyway where European and Asian migrants meet. Using data from 1995–2020 counts conducted at two Ramsar sites on the western coast of the Caspian Sea in Dagestan, the geography of regularly migrating populations of Anseriformes and waders was determined, with population trends established for 28 species. The results of the correlation analysis indicated that, of 18 anatids species, the number of 12 decreased significantly and 2 increased, in 4 it remained at a relatively previous level, and of 10 wader species, number – 3 decreased and 2 – increased, while the other model species' numbers stayed the former level. We observed a correlation between air temperature changes and long-term fluctuations in abundance of the model group of birds. Three main factors affecting population dynamics are discussed: hydroclimatic conditions, anthropogenic influence, and foraging. It is recommended to introduce a temporary ban on the hunting removal of 13 species of anatids and waders with a negative trend in abundance or to determine the removal standards that do not exceed 30–40% of their populations.

Keywords: Anatids, lagoons of Dagestan, migration area, population dynamics, waders

Introduction

In recent decades, due to global warming, there has been a dramatic increase in scientists' interest in the impact of climate on the biosphere. The first climatic shifts were noted as early as the mid-1970s in the Northern and Southern Hemispheres (Krivenko, 2021; Sokolov 2007), to which birds were among the first to react. As a result, dozens, if not hundreds, of new articles dedicated to the study of this important problem have been published monthly in scientific journals. There is increasing evidence of the impact of climate on bird populations and changes in habitats (Howard et al. 2018; James and Sarah et al. 2015; Krivenko and Vinogradov 2008; Krivenko, 2021; Schmaljohann and Both 2017; Sparks et al. 2005). Publications on changes in bird populations in different regions of Europe and America in the second half of the 20th century are often quite contradictory (Chamberlaen et al. 2000; Rutschke 1980; Schmaljohann and Both 2017). Some authors point to a significant, sometimes catastrophic, decline in the numbers of many bird species and, above all, of long-distance migrants associated with inland wetlands (Crick 2004; Erwin 2009; Mason and Green et al. 2019; Robinson et al. 2009; Sparks et al. 2005), which is explained by the influence of global warming and severe droughts in high and temperate latitudes (Lehikoinen and Jaatinen 2012; Roach and Griffith 2015; Schmaljohann and Both 2017; Van Eerden et al. 2005), and also by the worsening conditions on the flyways and wintering grounds of European migrants in the African continent (Both et al. 2010; Stephens et al. 2016). Other authors link the decline in the numbers of waterfowl and water birds to the impact of various anthropogenic factors (Andres and Smith et al. 2012; Delany and Scott et al. 2009; Fox and Leafloor et al. 2018). The third group of authors testifies that the number of many bird species, including distant migrants, in the last two decades not only has not decreased but also has significantly increased (Fox and Ebbinge et al. 2010; Guillemain and Poysa et al. 2013; Mason and Green et al. 2019). At the same time, the trends in bird abundance in the Americas are less pronounced than in Europe (combinations and Green et al. 2019). Although bird population trends are mixed, they all represent important baseline information underpinning international conservation commitments, including the identification of wetlands of international importance (Frost and Graham et al. 2019). To identify globally threatened bird species (populations) in decline, a comparison of all the accumulated data from different parts of their range is essential (BirdLife International 2017; BirdLife International 2021; State of nature in the EU, 2020; IPBES 2019; Woodward and Aebischer et al. 2020). Such an algorithm for population size estimation contributes not only to predict the response of birds to further climate warming (Mason and Green et al. 2019), but also to integrate the efforts of different countries in developing conservation projects to conserve threatened species on a macro-scale (Frost and Graham et al. 2019). It is important to emphasize that the conservation of biodiversity in the context of the dynamics of natural factors and, in particular, global warming, can only be ensured on the basis of long-term observations of the state of the bird population, carried out within the framework of biological monitoring, applicable to individual territories and specific species. At the same time, avifauna is an important natural resource and, therefore, forecasting its development in territories with different histories of formation, different combinations of natural conditions and the level of anthropogenic pressures is very relevant (Crick 2004).

Under the conditions of global climate warming, accompanied by a steady rise in sea level (Grant and Naish et al. 2019) and simultaneous reduction in the area of continental wetlands (Erwin 2009; Krivenko and Vinogradov 2008; Krivenko, 2021; Robinson et al. 2009; Thorup and Tottrup et al. 2017), the conservation of coastal-marine wetland ecosystems and waterbirds, whose numbers have declined over the past 25 years (Andres and Smith et al. 2012; Fox and Leafloor et al. 2018; Kharitonov 2019; Krivenko and Vinogradov 2008) became critical. It is practically impossible to estimate the absolute number of waterfowl birds in the forest, forest-steppe, and steppe zones of the European part of Russia (Krivenko and Vinogradov 2008), but it is quite acceptable to determine the status of migrating populations at the level of trends at nodal points during migration (Sokolov 2007). At the same time, population trends are the most effective indicators of national monitoring programs necessary to solve research (BirdLife International, 2017; BirdLife International, 2021; Estimation of numbers, 2017; State of nature in the EU, 2020; IPBES 2019), sanitary-epidemiological (Alekseev and Murashkina et al. 2019) and conservation tasks, which is especially relevant for Russia (Kharitonov 2019; Woodward and Aebischer et al. 2020), where most of the world populations of waterfowl birds are concentrated.

In order to diagnose the status of Palearctic migrant populations, two groups of waterfowl, the Anseriformes (anatids) and the Charadriiformes (waders), were chosen by us as models. The advantage of representatives of these taxonomic groups is that, firstly, being a priori indicators of the hydrothermal state of wetland ecosystems, they are able to respond by dynamics of numbers and species composition to qualitative transformations of wetland habitats within their entire migratory range. Secondly, anatids and waders constitute an important component of hunting and fishery resources, in this connection, long-term monitoring of the status of their populations acquires special relevance not only in the applied sphere but also in academic, sanitary-epidemiological and nature conservation aspects.

The above-mentioned trends determined the goals and tasks of our studies, consisting in determining the species composition of the model group of birds (among Anseriformes and Charadriiformes), their residence status, faunogenetic and population structures, boundaries of their migration range, population trends and factors determining these dependencies. The solution of these problems can serve to form a scientific approach not only in the management, but also in the conservation of resource species of Anseriformes and waders in a large part of the Palaearctic.

Material and methods

To determine changes in the ornithological situation, the western coast of the Middle Caspian Sea was chosen as a model territory. In the last quarter of the 20th century as a result of the sharp transgression of the Caspian Sea (Svitoch 1998), a complex of coastal lagoons was formed here (Vilkov 2014a), through which one of the largest movements of Palearctic migrants passes (Mikheev 1997) within the West Siberian-East African migration flyway (Boere and Stroud 2006). There is also a narrow (4–5 km wide) migration corridor – a "bottleneck", bounded from the west by a barrier of advanced ridges of the Eastern Caucasus (up to 1000 m high), extending at a 45° angle to the Caspian lowland, and from the east by the Caspian Sea coast itself (Fig. 1).

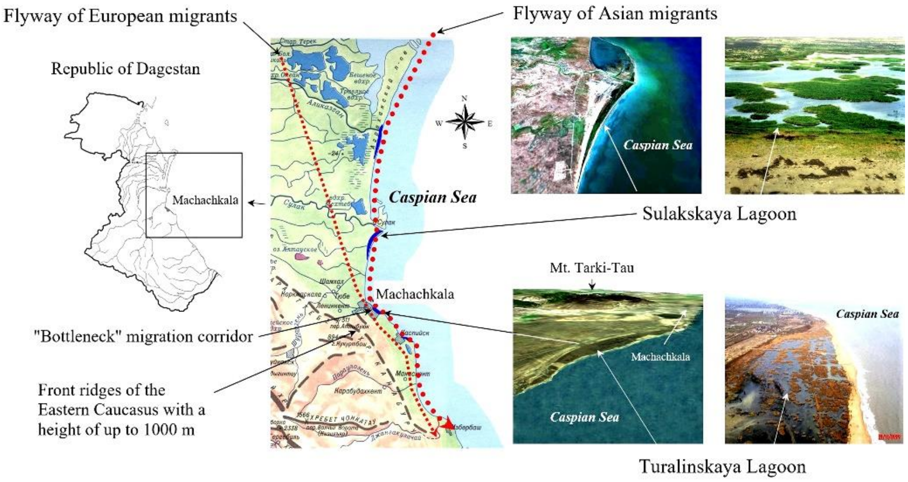

Figure 1. Layout of model lagoons, migration corridor and flight routes for European and Asian migrants

Of the four lagoons of Dagestan, the Sulakskaya and Turalinskaya lagoons were the most important for birds (Key… 2009), which motivated their selection as model wetland ecosystems for the Caspian Sea. The Turalinskaya lagoon, unlike the Sulakskaya lagoon, is located in a narrow migration corridor – a "bottleneck", where the flyways of Asian and European migrants cross, which determined its priority as a place to collect the main faunistic material (Vilkov 2013).

The faunistic material is summarized according to weekly year-round counts conducted in 1995–2020 in the Sulakskaya (47°31′16.42" N, 43°13′58.46" E) and Turalinskaya (42°56′00.53" N, 47°35′19.27" E) lagoons of Dagestan, which have the status of key ornithological territories of Russia that meet the Ramsar Convention criteria (Key… 2009). Routes passed along the perimeter of the lagoons, which allowed observation not only of their continental parts (from the coasts to the front mountain ridges) and coastlines along the Caspian shoreline (including the sea area up to the limit of binocular visibility (binoculars – Olympus 10-30×25 ZOOM PC I field 3.2–1.9°), but also up to 50–80% of the water surface. During the 25-year monitoring period, totally 1097 counts were performed (108 in Sulakskaya and 989 in Turalinskaya lagoons), 5952 km were covered, 4417.5 hours of recording time were spent, and over 70 thousand photos of birds and adjacent landscapes were taken.

Model bird species among Anseriformes and Charadriiformes were chosen based on the vastness of their ranges, relatively stable numbers, and regularity of their migration encounters (predominantly background species). Bird counts were conducted by the same researcher during the daytime on permanent pedestrian routes without limitation of the transect width, followed by separate recalculation of the area according to average group detection ranges (Ravkin 1967). According to the above methodology, on each route, the following was recorded: date, time of start and end of counting, all bird species seen or heard, distance from the observer to each individual at the time of detection, transient or resident individual, and kilometrage. The bird population density was calculated using the formula:

$$\frac{N_1 \cdot 40 + N_2 \cdot 10 + N_3 \cdot 3 + N_4}{L},$$

where $N_1 \ldots N_4$ – number of individuals recorded at distances: 1 – 0–25 m, 2 – 26–100 m, 3 – 101–300 m, 4 – 301–1000 m; 40, 10, 3 – coefficients expanding the recording strip to 1 km; L – distance traveled with recording along the biotope in kilometers. For birds in transit, the distance covered was replaced by the time of counts in hours multiplied by the average flight speed of birds, 30 km/h. If it was difficult to determine the species of fast-flying birds, or migrating at a long distance from the observer, the flock was photographed at 65x magnification (camera – Canon full HD 65×OPTICAL ZOOM). Then, the picture was displayed on the computer monitor and at high magnification, the species composition of migrating birds was reliably identified. The faunal-genetic structure was based on the classification of Shtegman (1938). In this case, in the category of faunistic complexes, the species with an extensive range and an unclear centre of origin were taken as widespread species. The systematic position of birds and volumes of species taxa are taken according to Stepanyan (2003). The territorial dispersion of the populations of Anseriformes and Charadriiformes migrating along the western Caspian Sea was determined according to the data of the Russian Bird Ringing Center of IPE RAS using the author's methodology (Vilkov 2014b). In order to identify the leading species among Anseriformes and Charadriiformes, both taxonomic groups were differentiated according to decreasing numbers of all individuals of each species encountered during the entire study period. The resulting abundance groups combined the species according to the following criteria: Anseriformes – numerous species – more than 4000 individuals, common – 900–3000 individuals, small – 300–800 individuals; Charadriiformes – numerous species – 2000–4000 individuals, common – 700–2000 individuals. In order to identify the core of the leading species, the proportion of each species to the sum of all individuals encountered in each bird taxonomic group was determined. The empirical material was processed using the statistical software package Excel and Statistica.

Using correlation analysis, model bird species were subdivided into 2 groups (global models) depending on the trend direction of their multiyear numbers. To avoid clutter, each of the figures includes 1–4 species with corresponding linear trends. The systematic order of birds in the figures was not observed, as the taxonomic group was selected according to similar quantitative parameters (sums of observed individuals) rather than the systematic sequence of the species.

In identifying patterns of lower rank within the two global models, a model group of birds with a reliable relationship with one of the key environmental factors, temperature, was identified using correlation analysis (Fig. 2 a, b).

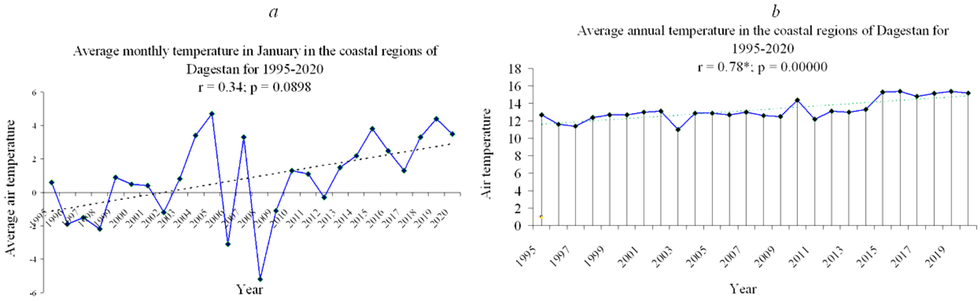

Figure 2 a, b. *a* – the average monthly temperature in January for 1995–2020; *b* – the average annual temperature in the coastal regions of Dagestan for 1995–2020 (according to the Dagestan Hydrometeorological Center) with correlation coefficient (*– recorded correlation of reliability at $p<0.05$ level of significance)

The concept of population trends of Anseriformes and Charadriiformes is based on four integrated principles: first, general flyways are relatively stable in space and time (Boere and Stroud 2006; Mikheev 1997); second, populations rather than "species" migrate (Isakov 1967); third, migrating bird populations have a genetic link to historically established flyways (Sokolov 2007); fourth, the status of migrating bird populations are estimated by long-term population trends at nodal points in one place (Sokolov 2007).

Results and discussion

At the turn of the 20th and 21st centuries, notable climatic shifts occurred in the Northern Hemisphere, which significantly affected populations of many migratory bird species (Howard and Stephens et al. 2018; James and Sarah et al.2015; Krivenko 2021; Rusanov 2015; Schmaljohann and Both 2017; Sparks and Bairlein et al. 2005). Species of the wetland complex making long-distance migrations from high and temperate latitudes turned out to be especially vulnerable to the consequences of climate warming (Lehikoinen and Jaatinen 2012; Roach and Griffith 2015; Schmaljohann and Both 2017; Van Eerden and Drent 2005), during which, first of all, the productivity of wetland ecosystems decreased (Schricke, 2001 Erwin 2009; Robinson and Crick et al. 2009; Thorup and Tottrup et al. 2017). At the same time, the success of migrations of waterfowl is primarily due to the presence of highly productive wetland ecosystems along their flyways (Nankinov 2017). In this sense, the shores of the Caspian Sea, stretching in the meridional direction and crossing the moderately continental, moderately warm and subtropical climate zones, serve as a good guide for the migrating bird populations from their nesting places in the north to the wintering places in the south. At the same time, the western coast of the Caspian Sea, which is more than 1200 km long, is the most favorable route for the mass migration of ecologically different groups of birds, including waterfowl by its ecological parameters (the presence of large sea bays, large river deltas, lagoons, and lake systems). For example, up to 86 bird species can be seen in the Turalinskaya lagoon during 4 hours of counting at the peak of migration activity, which cannot be observed at any other tract or along migration routes within Russia. In turn, the Caucasus Mountains, stretched meridionally at an angle of 30–35º between the Black and Caspian Seas, form a global migration corridor arranged like a "bottle-neck" (Fig. 3).

Figure 3. Caucasian-Caspian migration corridor – "bottleneck"

As a result, the tandem of the specific location of the Caucasus mountains and favorable environmental conditions of the West Caspian coast determine the spatial localization of migration flows of European and Asian migrants exactly in the area of the West Caspian Sea area. Confirming the above-mentioned, we note that more than 12 mln. Birds (Mikheev 1997) of 116 regularly migrating species (Vilkov 2013) migrate along the western Caspian Sea region, which is 14.9 times higher than on the eastern coast (Mikheev 1997). Out of the total number of migrants 6–7 mln. account for Anseriformes (56%) and Charadriiformes (Gistsov 2001), some of which stay in model lagoons for migration, wintering, summering, and nesting. At the same time, the southern location of the Caspian Sea determines the presence here of large wintering grounds of waterfowl birds (Mikheev 1997; Vilkov 2013) which along with the intense route of migration and places of their intermediate stops largely determines the preservation of populations of regular migrants. On this basis, the lagoons of Dagestan are assigned an important role of temporary reserves, contributing to the conservation of migrating and wintering birds of the Palearctic (Key ornithological territories of Russia…2009; Vilkov 2001, 2019).

With the emergence of the lagoons, the breeding fauna in their vicinity increased by 39 species, including 7 species of geese and 7 species of waders (Vilkov 2017, 2019). On the whole, during the 25-year monitoring period, a total of 299 bird species have been recorded in the Sulakskaya and Turalinskaya lagoons, 47 of which are game birds, and 53 are listed as endangered species in the IUCN and Red Data Books of Russia and Dagestan, including 135 species with different conservation statuses in Europe (Vilkov 2017, 2019). There are 31 species of Anseriformes (18 selected as model species) and 42 species of Charadriiformes (10 selected as model species) of the total diversity of avifauna of the lagoons (Table 1, columns I–II).

Table 1, columns I–II**:** Model species of Anseriformes and Charadriiformes of the studied lagoons with an indication of the residence status and faunogenetic group; columns III–IV**:** Coefficient of correlation between the abundance of the model group of birds and mean annual air temperature for 1995–2020 (*– marked correlations are valid at p<0.05 level of significance)

№	Species	I Residence status	II Faunogenetic group	III r — coefficient of correlation	IV p — level of reliability
		Order — Anseriformes			
1	*Anser anser* Linnaeus, 1758	P, IW	widespread	-0.14	0.5130
2	*Cygnus olor* Gmelin, 1789	Ø, P, N, W	European-Chinese	-0.57*	0.0032
3	*Cygnus cygnus* Linnaeus, 1758	P, W	Arctic	-0.61*	0.0014
4	*Tadorna ferruginea* Pallas, 1764	P	Mongolian	-0.50*	0.0102
5	*Tadorna tadorna* Linnaeus, 1758	Ø, P	Mongolian	-0.22	0.2887
6	*Anas platyrhynchos* Linnaeus, 1758	B, P, N, W	widespread	0.59*	0.0021
7	*Anas crecca* Linnaeus, 1758	P, W	widespread	-0.29	0.1607
8	*Anas strepera* Linnaeus, 1758	Ø, P, WT	widespread	-0.71*	0.0001
9	*Anas penelope* Linnaeus, 1758	P, W	Siberian	-0.69*	0.0001
10	*Anas acuta* Linnaeus, 1758	P, W	Siberian	-0.62*	0.0009
11	*Anas querquedula* Linnaeus, 1758	P, W	widespread	-0.54*	0.0051
12	*Anas clypeata* Linnaeus, 1758	P, WT	widespread	-0.59*	0.0020
13	*Netta rufina* Pallas, 1773	B, P, N, W	Mediterranean	-0.45*	0.0245
14	*Aythya ferina* Linnaeus, 1758	P, W	European-Chinese	-0.68*	0.0002
15	*Aythya nyroca* Güldenstädt, 1770	Ø, P, W	widespread	-0.61*	0.0012
16	*Aythya fuligula* Linnaeus, 1758	Ø, P, N, W	widespread	0.10	0.6494
17	*Bucephala clangula* Linnaeus, 1758	P, W	Siberian	0.53*	0.0060

18	*Mergus albellus* Linnaeus, 1758	P, W	Siberian	-0.41*	0.0410
	Order — Charadriiformes				
1	*Charadrius dubius* Scopoli, 1786	B, P	widespread	0.14	0.4956
2	*Vanellus vanellus* Linnaeus, 1758	B, P, IW	widespread	-0.05	0.8236
3	*Himantopus himantopus* Linnaeus, 1758	B, P, IW	Mongolian	0.15	0.4748
4	*Tringa ochropus* Linnaeus, 1758	N, P, W	widespread	0.45*	0.0231
5	*Tringa glareola* Linnaeus, 1758	P	widespread	-0.10	0.6175
6	*Tringa totanus* Linnaeus, 1758	B, P, IW	widespread	-0.52*	0.0071
7	*Actitis hypoleucos* Linnaeus, 1758	B, P	widespread	0.80*	0,0000
8	*Phylomachus pugnax* Linnaeus, 1758	P	Siberian	0.34	0.1008
9	*Gallinago gallinago* Linnaeus, 1758	P, W	widespread	-0.57*	0.0032
10	*Limosa limosa* Linnaeus, 1758	P, IW	widespread	-0.53*	0.0062

Note: residence status (code): B – nesting migratory; Ø – nesting in the early stages of lagoon successions; P – occurs on migration (individuals of the local population were not taken into account); W – wintering (stays on wintering for more than 10 days); IW – does not occur every year in winter; N – flying (meets during nesting time, but definitely does not nest)

The faunogenetic ranking of all species of Anseriformes and Charadriiformes recorded in the model lagoons showed that the study area occupies an area predominantly within the "sphere of influence" of widely distributed, Arctic and Siberian fauna types. Representatives of other faunal groups, however, do not regularly, but noticeably expand the range of zoogeography of migrating populations of anatids and waders, as they are also genetically related to historically established flyways (Fig. 4).

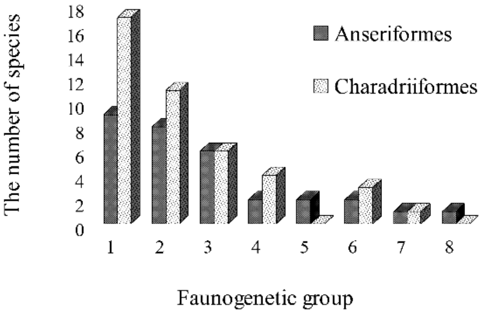

Figure 4. Faunogenetic structure of Anseriformes and Charadriiformes lagoons of Dagestan. **Note:** Anseriformes: 1. widespread – 9 species (29%); 2. Arctic – 8 species (26%); 3. Siberian – 6 species (19%); 4. Mediterranean – 2 species (7%); 5. European-Chinese – 2 species (7%); 6. Mongolian – 2 species (7%); 7. Central Asian-Mediterranean – 1 species (3%); 8. Boreal-Arctic – 1 species (3%). Charadriiformes: 1. widespread – 17 species (41%); 2. Arctic – 11 species (26%); 3. Siberian – 6 species (14%); 4. Mediterranean – 4 species (10%); 5. European-Chinese – 0 species (0%); 6. Mongolian – 3 species (7%); 7. Central Asian-Mediterranean – 1 species (2%); 8. Boreal-Arctic – 0 species (0%)

A spatial model of territorial dispersion of the populations of Anseriformes and Charadriiformes migrating along the western Caspian Sea area was built based on data from the Russian Bird Ringing Center of IPE RAS and the author's methodology (Vilkov 2014b). A conditional contour of the migratory range was determined for the peripherally dispersed populations, which allowed specification of the boundaries of the West Siberian-East African migratory range (Boere and Stroud 2006) for 18 species of Anseriformes and 5 species of waders (Fig. 5 a, b).

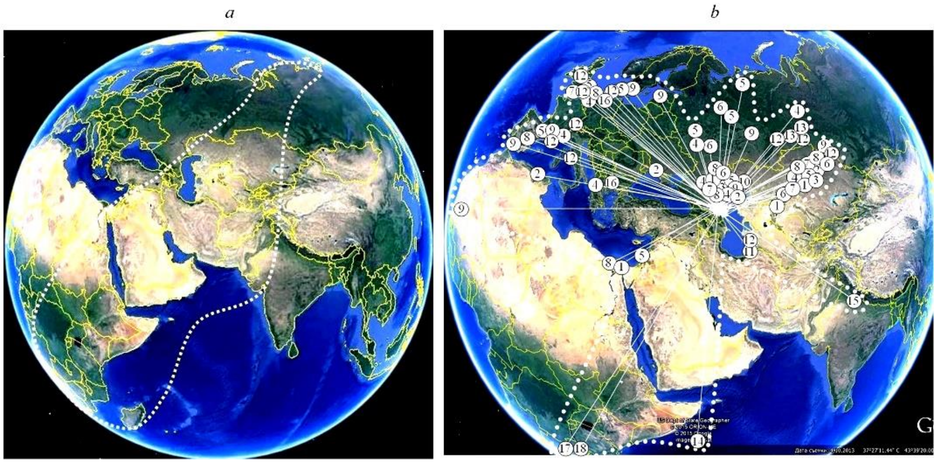

Figure 5 a, b. Geographic dispersion of Anseriformes and Charadriiformes populations migrating along the western coast of the Caspian Sea. Note: *a* – West Siberian-East African migratory area (Boere, Stroud, 2006); *b* – the boundaries of the dispersion of Anseriformes and Charadriiformes populations with indication of the conditional contour of the migration range and the vector of the passage of anatids and veders along the western Caspian. Species (populations). Species (populations): 1. *Tadorna tadorna;* 2. *Anser anser;* 3. *Cygnus olor;* 4. *Anas platyrhynchos;* 5. *Anas crecca;* 6. *Anas strepera;* 7. *Anas penelope;* 8. *Anas acuta;* 9. *Anas querquedula;* 10. *Anas clypeata;* 11. *Netta rufina;* 12. *Aythya ferina;* 13. *Bucephala clangula;* 14. *Arenaria interpres;* 15. *Himantopus himantopus;* 16. *Phylomachus pugnax;* 17. *Calidris ferruginea;* 18. *Calidris alba*

As a result, the total geographical dispersion of Anseriformes and Charadriiformes populations covered the space from the British Isles in the western Palearctic to the east of the West Siberian Plain, including the northwestern part of India, the Seychelles, northwest, east and extreme south of Africa.

The principle of extending the boundaries of territorial dispersion of waterfowl populations to the west of Europe is reliably confirmed by the ringing data for *Anas crecca* and *A. querquedula* (Katz et al., 1997; Nankinov, 2017) and that is illustrated by figure 5 b. Thus, a part of *A. crecca* and *A. querquedula* which are breeding in the European part of Russia and migrates for wintering along the western Caspian Sea to Africa together with the teals of the Ural-West Siberian population (Katz and Krivonosov et al. 1997; Zavyalov and Shlyakhtin et al. 2005; Zavyalov and Matrosov et al. 2008; Nankinov, 2017). On the African wintering grounds, there is a transition within the European geographic population from its western European part to the central northern European and Ural-Western Siberian parts (Katz and Krivonosov et al. 1997). At the same time, males, after the formation of pairs on wintering grounds, are carried away by females to the territories removed from places of their breeding at various distances, while separate individuals change their breeding and wintering ranges. Such territorial redistribution leads to a change of migration routes and expansion of geographical dispersion of anatids populations in the western direction (Katz and Krivonosov et al. 1997; Maclean and Rehfisch et al. 2008; Zavyalov and Shlyakhtin et al. 2005; Nankinov, 2017). The spring migration of the European (Volga) population of teals and garganeys usually passes through the territory of Italy, the Balkans, France, Belgium, and the Netherlands, while for the Ural-West Siberian populations it acquires a loop-like configuration (Katz and Krivonosov et al. 1997; Nankinov, 2017). A similar loop-like migration is characteristic of a number of Charadriiformes species (Delany and Scott et al. 2009). In the context of the above, it is important to emphasize that migratory birds, including the group of birds of the wetland complex, are known as carriers of subtype H5 and H7 viruses (Alekseev and Murashkina et al. 2019). Recent cases indicate that some migratory birds directly spread the virus H5N1 in a highly pathogenic form. Type "A" influenza viruses are most important to public health because they have the potential to cause an influenza pandemic (e.g., avian influenza virus H5N1 and H9N2 subtypes). In addition, outbreaks of highly pathogenic strains of avian influenza viruses (AIV) can also cause significant economic losses to the poultry industry. Therefore, the predicted spread of viral infections spread by migratory birds to various regions of the Palearctic acquires particular relevance on an international scale (Alekseev and Murashkina et al. 2019).

We conducted a correlation analysis, which showed an unreliable weakly negative trend in the total numbers of Anseriformes and Charadriiformes encountered in the study area over a 25-year period to determine possible changes in the populations of the model bird species (Fig. 6 a, b).

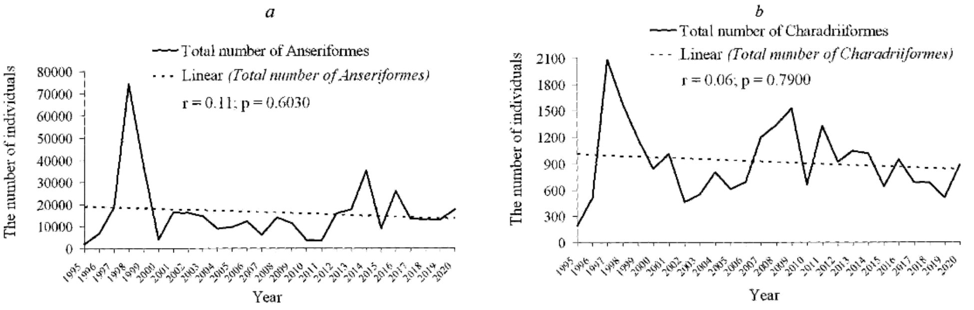

Figure 6 a, b. Dynamics of the total number of Anseriformes *(a)* and Charadriiformes *(b)* in model lagoons in 1995–2020

I summarized the numbers of model species of anatids and waders registered in the lagoons during the entire study period and subdivided them into their respective abundance groups (Table 2).

Table 2. Number groups and the share of model species Anseriformes and Charadriiformes in the studied lagoons in 1995–2020

№	Species	Species encountered	Share (%)

	Anseriformes		
	Numerous species		
1	*Aythya fuligula*	276318	67.1
2	*Anas platyrhynchos*	74133	18
3	*Anas crecca*	19391	4.7
4	*Anas querquedula*	9863	2.4
5	*Cygnus olor*	7749	1.9
6	*Anser anser*	4826	1.2
7	*Netta rufina*	4401	1.1
	Common species		
1	*Aythya nyroca*	2261	0.6
2	*Anas clypeata*	2226	0.5
3	*Cygnus cygnus*	2200	0.5
4	*Bucephala clangula*	2170	0.5
5	*Aythya ferina*	1871	0.4
6	*Mergus albellus*	987	0.2
7	*Anas acuta*	982	0.2
	Small species		
1	*Tadorna tadorna*	839	0.2
2	*Anas penelope*	757	0.2
3	*Anas strepera*	531	0.1
4	*Tadorna ferruginea*	303	0.1
	Charadriiformes		
	Numerous species		
1	*Gallinago gallinago*	4010	17
2	*Tringa ochropus*	3513	14.9
3	*Actitis hypoleucos*	3472	14.6
4	*Himantopus himantopus*	3145	13.4
5	*Tringa glareola*	2651	11.3
6	*Tringa totanus*	2171	9.2
	Common species		
1	*Vanellus vanellus*	1832	7.8
2	*Charadrius dubius*	1082	4.6
3	*Phylomachus pugnax*	857	3.6
4	*Limosa limosa*	798	3.4

The algorithm used made it possible to determine the nucleus of the leading species in terms of abundance from the number of model taxa, establishing the proportion of each species in the sums of individuals registered.

To identify trends of lower rank and, in particular, trends of Anseriformes and Charadriiformes abundance for the whole period of works, we used long series of observations in nodal points of flight (our study area), where migration activity is traced for 9.0–10.5 months per year (Fig. 7 a – h; 8 a – d).

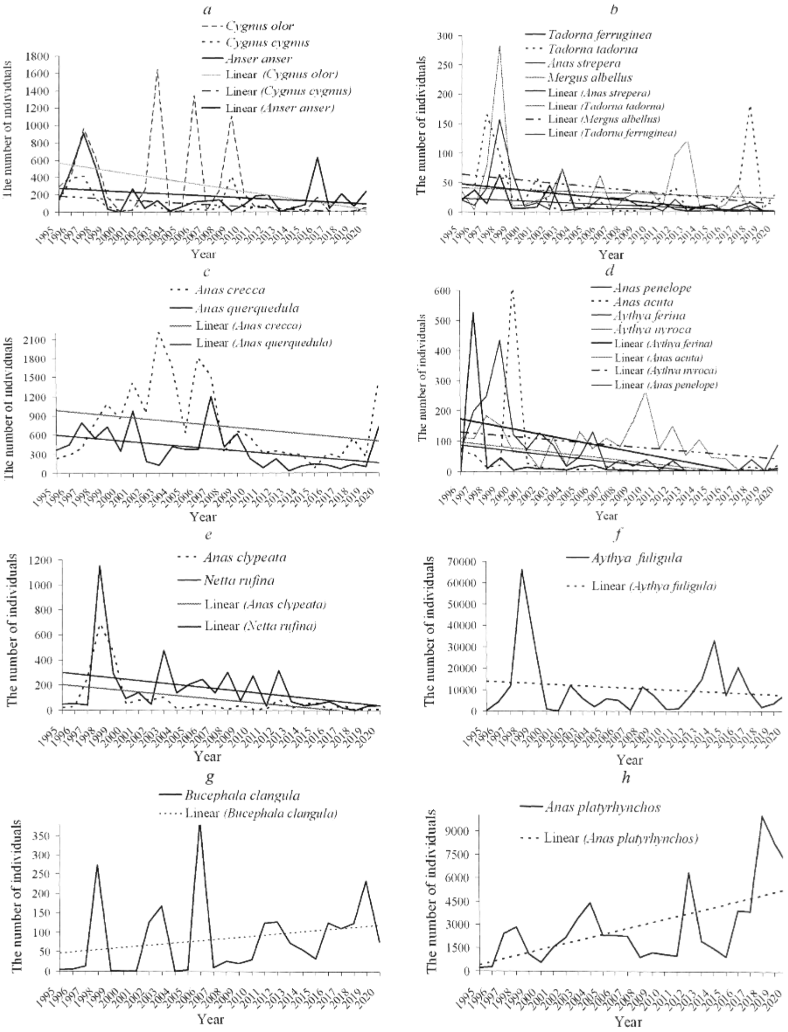

Figure 7 a – h. Anseriformes population trends in numbers: *a* – *f* – with a negative trend in numbers; *g*, *h* – with a positive trend in numbers

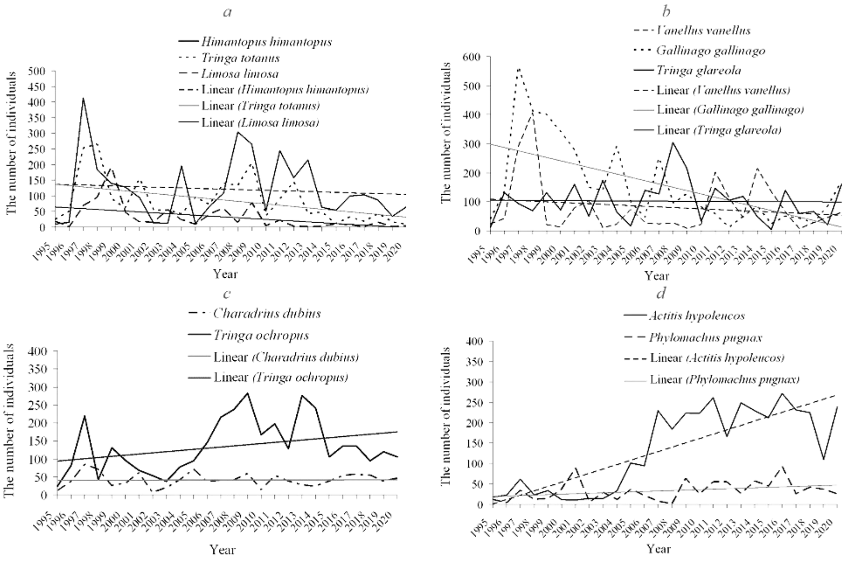

Figure 8 a – d. Charadriiformes population trends in numbers: *a* – *b* – with a negative trend in numbers; *c* – *d* – with a positive or relatively stable trend in numbers

A correlation analysis with the annual average air temperature (Table 1, columns III–IV) was conducted to determine the statistical validity of the resulting population trends (Figures 7 a – h; 8 a – d).

Analysis of the data in figures 7 a – h; 8 a – d and Table 1, columns III–IV, showed that, despite some cyclicity, out of 18 tested species of anatids, in 12 the abundance significantly decreased, in 2 it increased, in 4 it remained at a relatively former level. Of the 10 model species of Charadriiformes, 3 significantly decreased in abundance, two increased in abundance and 5 remained at the same level.

The obtained population trends should seem to correspond to all geographic populations, representatives of which were found in the area of our study and confirmed by the ringing data (Fig. 5 b). However, the established trends can only reflect the population dynamics of those geographic populations of anatids and waders that regularly migrate along the western Caspian Sea. And since, a priori, only populations regularly migrate along the western Caspian regularly from the Boreal-Arctic, northeastern and western Siberian regions of Russia, the Urals, Volga, northwestern Caspian, and northern Kazakhstan (Delany and Scott et al. 2009; Karri-Lindahl 1984; Mikheev 1997; Zavyalov and Scott et al. 2008), it is these geographic populations that correspond to the abundance trends we obtained at the nodal points of the flight in our observation area.

For the correctness of the presented concept, as well as for the purpose of revealing the reasons causing a negative population trend in the model group of birds, we synchronized the information from literature sources with the data of our studies (Figures 7 a – h; 8 a – d; Table 1, columns III–IV). Thus, despite a slightly negative trend (Figure 7 a; Table 1, columns III–IV), stable decrease of *Anser anser* numbers on the flyways along the western Caspian Sea is caused, first, by a deterioration of conditions of its wintering grounds in the south of the Caspian Sea (Koshelev and Dannik 2001), where as early as in 1960–1970 the grain crops in the Araksin plain in Azerbaijan began to be replaced by cotton and grapes (Sultanov 2001). Secondly, as a result of the latest Caspian Sea transgression (Svitoch 1998), which caused an increase in the groundwater level, cereal-ephemeral semi-deserts of the western Caspian Sea region began to be replaced by sagebrush and saltwort, which worsened the forage base not only for the Greylag Goose but also for other anatids species on their migration routes (Krivenko and Vinogradov 2008). Thirdly, due to increased depth of the Volga River avandelta in the end of XX-th century (Krivenko 2021), feeding conditions for nesting and migrating populations of the Greylag Geese worsened, which caused a sharp decrease in their numbers (Rusanov 2015). Fourth, the decline in the numbers of Graylag Geese nesting in Western Siberia, Kazakhstan, the southern Urals, and the Volga basin was influenced by climate warming, which disrupted the natural hydrological regime of wetlands and increased desertification of territories (Erokhov and Berezovikov et al. 2011; Tarasov 2015). Fifth, the reduction of the number of southern Greylag Geese nesting in the Southern Federal District, Stavropol Krai, and Dagestan was caused not only by the loss of breeding habitats but also by the pressure of spring hunting, which coincided with the beginning of the nesting period of this species (Lebedeva and Lomadze 2016; Rosenfeld 2015). Sixth, under the conditions of a warming climate, part of the Greylag Geese population shortened their migration routes, adapting to "cold" wintering in their breeding grounds (Gordo 2007; Lebedeva and Lomadze 2016). As a result, all the abovementioned tendencies also had an effect on the decrease of the number of the Greylag Goose in our study area, where only during the last 20 years during the passage in 1997 it was noted 910 individuals, in 2007 – 129, and in 2017 – 40 (Fig. 7 a). And, since, based on ringing data (Fig. 5 a), populations of Graylag Geese flying from Western Siberia, Northern Kazakhstan, Astrakhan, Volgograd regions and Dagestan regularly migrate along the western Caspian flyway, it is these populations that are characterized by a steady negative trend in numbers. The numbers of Greylag Geese in England have not changed significantly, while those in Europe have increased (BirdLife International, 2017; Frost and Graham et al. 2019; State of nature in the EU, 2020). In the area of our studies, a decrease in *Anas strepera* numbers is also clearly visible, where on a passage in 1998 was noted 156 individuals, in 2009 – 9, in 2020 – 1 individual (Fig. 7 b; Table 1, columns III–IV). The sharp decline in numbers of the Gadwall flying along the western Caspian Sea from the Voronezh, Volgograd, Astrakhan regions and Kazakhstan (Fig. 5 b) is associated with a depression in the numbers of this species in the optimal forest-steppe and steppe regions of Russia, except for the southern Pre-Urals (Fedosov 2015). At the same time, its dispersal to the taiga zone, Vologda and Arkhangelsk Regions, as a result of which the general tendency of growth of a number of this species in the south of Eastern Siberia is traced (Fedosov 2015; Melnikov 2015). At present, the *A. strepera* range has expanded far to the north of East Siberia up to the southern outskirts of Yakutia, which is caused by progressive climate warming and eviction of this species from the southern parts of the range covered by severe droughts (Melnikov 2015). In parallel, there has been an increase in *A. strepera* in England and in Europe (State of nature in the EU, 2020; Frost and Graham et al. 2019), that, is probably, also linked to its eviction from the forest-steppe and steppe regions of Russia to the west. With a view of the preservation of the southern population, we included it in the new edition of the Red Book of Dagestan (Red Book of the Republic…2020) as a vulnerable species with decreasing numbers and distribution.

The Ferruginous Duck *Aythya nyroca* is in an even more vulnerable position. Until recently it was a hunted species, but at the beginning of the 21st century, the Ferruginous Duck was already listed in the Red Book of Russia (Koblik 2001; Red Book of the Russian …2001). In the European part of Russia, its main nesting places are on the eastern coast of the Azov Sea and the western coast of the Caspian Sea in Dagestan (Snow and Perrins 1998), where in the early 2000s the share of *A. nyroca* in the bag of local hunters was on average 8.8% (Dzhamirzoev and Bukreev 2013). In 2000, we estimated the number of this species at 550–600 specimens in the Arakum reservoirs alone in Dagestan (Vilkov 2001). And, in the area of the Turalinskaya lagoon in 1998–1999, the number of its migrating flocks reached 25–34 individuals, while during the wintering period in the same tract in 1997–1998, a concentration of 73 individuals was constantly maintained (data of our observations). A sharp decrease in the number of *A. nyroca* was caused by climate warming and large-scale irrigation and drainage work throughout the area, which resulted in changes in the structure of biotopes, disturbance of their successional cycles and fragmentation of the range (Fedosov 2015; Kazakov and Lomadze et al. 2004; Krivenko and Vinogradov 2008; Red…2001). As a result, *A. nyroca* ceased to occur in the Volga delta during the last 5 years of the 20th century (Rusanov 2006). However, the number of this species at the beginning of the 21st century was estimated at 300–450 breeding pairs and more than 2,000 individuals on the trans-migration (Kazakov and Lomadze et al. 2004). However, already in 2001 only 190–230 pairs (Kazakov and Lomadze et al. 2004) were counted in Dagestan water bodies while the total number of this species in Russia at the beginning of the 21st century was estimated at 800–1200 pairs (Banik and Dzhamirzoev 2003). The widespread depression in the abundance of *A. nyroca* populations mirrored its flyways in the area of the Turalinskaya Lagoon, where it was observed in 1998 as 183 individuals, in 2008 – 82, in 2020 – 3 (Fig. 7 d; Table 1, columns III–IV).

According to 9–10-year abundance slices obtained by us in model lagoons (Fig. 7 c – e; Table 1, columns III–IV), a decrease in numbers is well traced in: *A. crecca* – in 1999 – 1081 individuals, in 2009 – 650, in 2019 – 256 (at the same time, the abundance of this species in England has increased (Frost, Graham et al. 2019); *A. penelope* – in 1999 – 45 individuals, in 2009 – 3, in 2019 – 0; *A. acuta* – in 2000 – 619 individuals, in 2010 – 2, in 2019 – 0 (at *A. acuta* numbers down by 38% in Europe (BirdLife International… 2017; BirdLife International… 2021); *A. querquedula* – in 1999 – 731 individuals, in 2010 – 226, in 2019 – 94 (abundance of *A. querquedula* number remaining stable in England (BirdLife International… 2019), while in most European countries it has decreased (Schricke, 2001)); *A. clypeata* – in 1999 – 465 individuals, in 2009 – 37, in 2019 – 4 (number of this species in Europe is steadily declining, while in England it has increased (Frost, Graham et al. 2019; European Environment Agency... 2020)); *Netta rufina* – in 1999 – 294 individuals, in 2009 – 76, in 2019 – 36 (abundance of this species in England has increased (Frost, Graham et al. 2019)); *Aythya ferina* in 1999 – 434 individuals, in 2009 – 17, in 2019 – 1 (at the same time, a clear decrease in the abundance of this species was noted in England (Frost, Graham et al. 2019), in Europe (BirdLife International … 2019) and in Russia (Estimation of numbers… 2017)). According to ringing data (Fig. 5 b) and information from literary sources (Fedosov 2015; Zavyalov and Matrosov et al. 2008), all the above species are part of the Volga, South Ural, West Siberian and Kazakh populations that regularly migrate along the western Caspian Sea. Accordingly, these same populations also exhibit the above negative population trends. Thus, the population of *A. crecca* has disappeared from the southern part of the range (Fedosov 2015). In the last five years of the 20th century and at the beginning of the current century, the numbers of all species of dabbling and diving ducks in the avandelta of the Volga River decreased by 27%, while *A. penelope* has disappeared on passage at all (Rusanov 2006; Rusanov 2015). Against this background, the number of West Siberian populations of *A. acuta, A. penelope, A. clypeata, A. querquedula* and *Aythya fuligula* wintering in the Caspian Sea and Nile delta decreased 3-fold in 2010–2013 due to extremely low water levels (Antipov 2010; Golovatin and Paschalnyi 2015). The decrease in the numbers of the West Siberian population of *A. acuta* and *A. clypeata* is also evidenced by the fact that these species in recent years have become less frequent on trans-migration (passage) in the area of the Western Manych, where a major migration route of the West Siberian population of these species passes (Lebedeva and Lomadze 2016). Compared to previous years, the number of the most mass-breeding duck species in Dagestan *N. rufina* has also drastically decreased (Bukreev and Dzhamirzoev et al. 2013). At the same time, the decline in the numbers of the West Siberian population of *A. crecca, A. querquuedula,* and *Ay. ferina* is associated with poorly controlled shooting in their nesting places and on flyways (Korobitsyn and Tyutenkov et al. 2018; Mikheev 1997), which has sharply increased as a result of the shift of the beginning of autumn hunting to earlier dates (Mishchenko and Kharitonov 2018). In addition, since the mid-2000s, with the development of the next dry phase of the hydrological cycle, the number of the most numerous species of ducks nesting in Western Siberia has decreased by 3–5 times. Another reason for the decline in duck numbers in this region was the extensive breeding of plankton-eating fish species and benthophages, which led to the depletion of plankton and benthos biomass. Fishermen face the problem of scaring these birds away from their reservoirs by shooting them on unprotected lakes, while on protected ones (in game reserves) they are scared away by various noise-making means. The reduction of the area of grain crops, located near large reedbed lakes also led to a decrease in the number of ducks and Graylag Geese in Western Siberia (Tarasov 2015). At the same time, sharp depression in the numbers of *Ay. ferina* occurs mainly in the most numerous – West European-West Siberian population (Mishchenko and Kharitonov 2018), part of which (West Siberian) regularly migrates along the western Caspian Sea (Antipov 2010). In turn, increasing depths in the avandelta of the Volga River and the deterioration of feeding and molting conditions for migrating populations of various duck species, was another reason for the sharp decline in their numbers in the northern Caspian Sea (Rusanov 2015), as we mentioned above. It is likely that the same factor also contributed to the fact that some of the migrating duck populations began to periodically use the Kizlyar Bay in the western Caspian for molting (Dzhamirzoev and Perevozov et al. 2014).

The first increase in abundance of most model species occurred during the cold winters of 1996–1998 (Fig. 2; Fig. 7 a – h; 8 a – d), which coincided with the end of the cool-to-wet to a warm-to-dry phase of the century (Krivenko and Vinogradov 2008). It is axiomatic that when the polarity of hydroclimatic cycles reversed, there was an upsurge in the numbers of almost all waterfowl birds in the maximum possible geographic areas, because the area of wetlands reaches its maximum during cool-wet climatic phases (Krivenko and Vinogradov 2008). Accordingly, in 1996, the water content of model lagoons also approached the full profile (Vilkov 2014a), coinciding with the peak of the last transgression of the Caspian Sea, which resulted in the flooding of vast areas of the western Caspian Sea, which subsequently transformed into new habitats for waterfowl birds (Chernichko 2016). Against this background, anatids and waders are redistributed along the newly expanded range boundaries, which was accompanied by an increase in their numbers (Vilkov 2014a).

Periodic fluctuations in the abundance of model species observed in subsequent years (Fig. 7 a – h; 8 a – d) are associated with more frequent warm years (winters) 2000–2002, 2004–2006, 2010–2011, 2013–2015 and 2018–2019 (Fig. 2). In such years, the trans-migration of the model group of birds along the western Caspian fades ("erodes"), as some of Charadriiformes change their flight routes and places of permanent stops (Chernichko 2016), while some Anseriformes (*C. olor, C. cygnus*, *T. ferruginea*, *T. tadorna*), remain for wintering in more distant areas of northern latitudes, including breeding sites (*A. anser*) (Gordo 2007; Lebedeva and Lomadze et al. 2018; Rusanov 2001; Schmaljohann and Both 2017). Correlation analysis showed a reliable negative relationship between the increase in mean annual and autumn-winter temperatures in the Caspian lowland of Dagestan (Fig. 2) and the long-term fluctuations in abundance of *C. olor* (r = -0.54; p = 0.004), *C. cygnus* (r = -0.53; p = 0.005), *A. anser* (r = -0.16; p = 0.43), *T. tadorna* (r = -0.44; p = 0.03), *T. ferruginea* (r = -0.59; p = 0.002), *A. querquedula* (r = -0.49; p = 0.01), *N. rufina* (r = -0.55; p = 0.004), *Ay. ferina* (r = -0.54; p = 0.005), *B. clangula* (r = -0.44; p = 0.024), Mergus *albellus* (r = -0.40; p = 0.04) and *Limosa limosa* (r = -0.40; p = 0.04) (Fig. 7 a – e; 8 a). On the contrary, in cold years, such as in 2020, there was an intense passage of migrants along the western Caspian Sea, as well as their organized flight to winter, which was accompanied by an increase in their abundance (Fig. 2; Fig. 7 a – h; 8 a – d). The established pattern is confirmed by the presence of a reliable positive relationship between the increase in abundance of *Ay. nyroca* (r = 0.55; p = 0.003) and a decrease in average annual temperatures in the Caspian lowlands of the Republic (Fig. 7 d). At the same time, multidirectional temperature trends that appear on migrants' flyways during seasonal migrations can only affect changes in their wintering places (Anseriformes) and flyways (Charadriiformes), but not on the number of populations themselves.

As for Charadriiformes, from 1998 to 2019, there is a steady decline in the numbers of *Vanellus vanellus* that were counted on the flyway in 1998 in the number of 408 individuals, in 2009 – 8, in 2018 – 27 (despite the weak trend shown in Table 1, columns III–IV, a decadal cross-section showed a steady decline in *V. vanellus* abundance not only in our study area, but also in Russia as a whole (Estimation of numbers… 2017), as well as in England and Europe (BirdLife International… 2017; State of nature in the EU, 2020); *Tringa totanus* in 1998 – 266, in 2008 – 133, in 2019 – 17 (with *T. totanus* number in Europe down by 30% (BirdLife International… 2021), as it continues to decline in England (BirdLife International… 2017)); *Gallinago gallinago* in 1999 – 401, in 2009 – 127, in 2019 – 88 (the population of *G. gallinago* in Russia as a whole is steadily declining (Estimation of numbers… 2017), already down 36% in Europe (BirdLife International… 2021) and continues to decline in England (BirdLife International… 2017)) and *L. limosa* in 1999 – 192, in 2009 – 79, in 2019 – 0 (with multidirectional trends characteristic of Russia as a whole (Estimation of numbers… 2017), whereas in Europe, *L. limosa* number has already declined by 45% (BirdLife International… 2021) and continues to decline in England (BirdLife International… 2017) (Fig. 8 a, b; Table 1, columns III–IV). The depressed populations of these species are associated with a warming climate, degradation of most wetlands, and fragmentation of their habitats not only in Eurasia but also in the wintering grounds in Africa (Delany and Scott et al. 2009; Krivenko and Vinogradov 2008; Sokolov 2018; Sokolov and Numerov et al. 2019). The response to the deterioration of habitats of the above species in their breeding grounds (Delany and Scott et al. 2009; Sokolov 2018; Sokolov and Numerov et al. 2019) mirrored the decline in their abundance on the flyways in our study area (Fig. 8 a, b). In addition, the subsequent regression of the Caspian Sea, in which the sea level decreased again from 1996 to 2019 by 1 m (Gavrilov 2019), led to the overgrowth of shallow marine macrophytes (Rusanov 2015). Taken together, the above trends worsened the recreational and foraging habitat of waders in their breeding grounds and along their flyways along the western Caspian Sea (Vilkov 2013). In general, the decline in numbers of a number of model wader species was caused by the widespread intensification of agricultural production in different parts of their habitat, which was noted already in 1983–1990 (Delany and Scott et al. 2009). At the same time, the decrease in numbers of most species began to appear not in the period of intensive agriculture, but only in subsequent years, which, together with the large-scale anthropogenic transformation of natural ecosystems against the background of climate warming, gave a negative trend in subsequent years (Delany and Scott et al. 2009; Sviridova 2003; Zavyalov and Shlyakhtin et al. 2005). It is interesting that such a lag in the response of birds to the integrated impact of the above factors is shown on three dozen species with extensive data in England (Chamberlaen and Fuller et al. 2000) and other European countries (Delany and Scott et al. 2009). Let us add to the above, that the modern regression of the Caspian Sea has also negatively affected the decline of water levels in the model lagoons, destroying some of the underwater meadows formed by *Ceratophýllum demérsum* and *Vallisneria spiralis*. And because these plants accumulate the main stock of *Chironomus plumosus* Linnaeus, 1758 larvae, and other hydrobionts, which form the basis of the diet of most wader species, their large-scale destruction also worsened the habitat conditions of the model group of birds on the routes of their flight along the western Caspian Sea. In principle, the above example of biotic destruction in model lagoons caused by another regression of the Caspian Sea can be taken as a reliable model, demonstrating similar processes of biota degradation in other wetlands of the Caspian Sea.

Another set of factors worsening the ecological attractiveness of the Caspian region for anatids and waders is related to the total development of the West Caspian coast by various types of anthropogenic infrastructures. Anthropogenic transformation of the natural environment noticeably intensified in 2000 and has been steadily increasing since then against the background of a sharp depression (up to 40–90%) of the Caspian Sea forage as a result of the active destruction of various components of the Caspian biota by the Black Sea invader – *Mnemiopsis leidyi* A. Agassiz 1865 (Aladdin and Plotnikov 2000; Shiganova and Musaeva et al. 2005; Vostokov and Gadgiev et al. 2020). Simultaneously, there is a more than tenfold reduction in the areas of wintering waterfowl tracts in Azerbaijan (Polivanova 1990), which is also reflected in the deterioration of conditions of anatids and waders wintering in the Caspian Sea. In addition, the depression of bioresources in the Caspian Sea occurs in conditions of intensive petrochemical and organochlorine pollution, accompanied by a decrease in the percentage of oxygen in the water (Aladdin and Plotnikov 2000), which in combination with the above factors worsens the environmental significance of the Caspian Sea for Anseriformes and Charadriiformes for the whole. However, in October 2020, in the waters of the Dagestan shelf, the presence of a new pest – *Beroe* cf. *ovata* – was recorded in plankton. Its emergence and development in the Caspian Sea, occurred on the wave of general warming, after a number of warm winters (Vostokov and Gadgiev et al. 2020). At the same time, there were signs of the impact of the new invader, *B. ovata*, on the population of *M. leidyi*, which it feeds on selectively. This event could be the beginning of a new stage in the evolution of the Caspian Sea ecosystem and the restoration of its bioresources that were affected by the invasion of *M. leidyi*, which will presumably also affect the regeneration of the Caspian Sea's ecological attractiveness for migrating and wintering birds, including Anseriformes and Charadriiformes.

At the biological level, according to Eremchenko and Bolotnikov (1986), the disturbance factor, which, similar to the press of predators, causes significant elimination of clutches of anatids and waders in their breeding grounds, is of particular importance nowadays. Repeated clutches increase the reproductive period, leading to increased mortality of broods and, consequently, decreased numbers of waterfowl at general population levels. Finally, for migrating populations of Anseriformes and Charadriiformes, the anthropogenic impact is quite reasonably ranked among the above-mentioned causes of decline in their numbers (Butyev 2006; Nankinov 2017). The latter leads to an increased degree of environmental mosaicism (Delany and Scott et al. 2009; Krivenko and Vinogradov 2008), fragmentation of habitats and depressed populations of waterfowl birds in different parts of the Palearctic. In spite of all above mentioned anthropogenic and natural factors, hunting pressure was and still is among the leading anthropogenic impacts, which decreases population sizes of the majority of Anseriformes and Charadriiformes birds within the whole migrating range (Atlas…2010; Delany and Scott et al. 2009; Fox and Leafloor 2018; Kharitonov 2019; Krivenko and Vinogradov 2008; Nankinov 2017; Rosenfeld 2015).

In conclusion, we state that the proposed concept of evaluation criteria obtained in the nodal points of the flyway (model lagoons) in the form of multiyear population trends reflects the real status of specific geographic populations of Anseriformes and Charadriiformes regularly migrating along the western Caspian Sea region. The coincidence of the number trends (Fig. 7 a – f; 8 a, b; Table 1, columns III–IV) we obtained with the data from literature sources is explained by the commonality of factors influencing the number of populations of model species in different parts of their migratory range. The concept of the state of populations reasonably suggests introducing either a temporary ban on the hunting of such resource species as: *A. anser*, *A. crecca*, *A. strepera*, *A. penelope*, *A. acuta*, *A. querquedula*, *A. clypeata*, *Ay. nyroca*, *Ay. ferina*, *V. vanellus*, *T. totanus*, *G. gallinago* и *L. limosa* (Fig. 7 a – f; 8 a, b; Table 1, columns III–IV) until their sustainable recovery, or establish removal rates not exceeding 30–40% of their populations. For "targeted" management of the populations of the above-mentioned bird species these measures could be implemented not only in Dagestan but also in Boreal-Arctic, North-Eastern, and West Siberian regions of Russia, Priuralie (cis-Uralia or the Urals region), Volga region and in the North-Western Caspian Sea region, where populations of model species regularly migrate along the historically formed and genetically fixed West-Caspian flyway. However, for such bird species as *A. acuta, A. clypeata, Ay. ferina, V. vanellus, T. totanus, G. gallinago* and *L. limosa*, similar conservation measures should be applied in Europe and England (except for *A. clypeata* in England), where numbers of these species are also steadily declining (BirdLife International… 2017; BirdLife International… 2021; Delany et al., 2009; State…2020). On the basis of the above, the system of hunting regulation should cover not only all entities of the Russian Federation but also those states of the near and far abroad were "Russian" waterfowl winter (Isakov 1972).

In order to preserve model lagoons and their biodiversity, the Ministry of Natural Resources and Environment of the Republic of Dagestan used our long-term monitoring data when creating a specially protected natural area (SPNA) of international importance – EU–RU260 "Sulakskaya Lagoon" (Decree of the Government of the Republic of Dagestan, order № 296 from 22.12.2017) (Vilkov 2017). Based on the same data an innovative socio-ecological project of the natural park – "Ornithopark – Turalinskaya Lagoon" (Vilkov 2019) was also developed. The creation of a network of SPNAs along the western Caspian Sea region will contribute to the conservation not only of the regional avifauna but also of an extensive group of Palearctic migrants, as the Sulakskaya and Turalinskaya lagoons combined with 16 SPNAs (Alekseev and Murashkina et al. 2019), form a single supporting framework of wetlands cascading in the arid semi-deserts of the western Caspian Sea.

Conclusions

1. The reasons (factors) that determine the concentration of European and Asian migrant flyways in the area on the west coast of the Caspian Sea have been identified. This is associated, firstly, with the presence of a global Caucasian-Caspian migration corridor – "bottleneck" formed by the Greater Caucasus Mountains, stretched meridionally at an angle of 30–35° between the Black and Caspian Seas and the favorable environmental conditions of the Western Caspian Sea area (large sea bays, lagoons, large river deltas, and lake systems). Secondly, the second, narrowest (4–5 km wide) migration corridor, the "bottleneck", formed by the leading ridges of the Eastern Caucasus and the Caspian Sea shoreline itself, is located on the western coast of the Middle Caspian. The key model ecosystem – the Turalinskaya Lagoon – is also located here, where the flyways of Asian and European migrants, which form a concentrated migration flow, intersect.

2. Spatial model of territorial dispersion of the populations of Anseriformes and Charadriiformes migrating along the western Caspian was built on the basis of the data of the Center for Bird Ringing of Russia IPE RAS and the author's methodology. According to the peripherally dispersed populations, a conditional contour of the migratory range, covering the space from the British Isles in the west of the Palearctic to the east of the West Siberian Plain, including the northwestern part of India, the Seychelles, northwest, east and the extreme south of Africa, has been determined.

3. The basis of the faunogenetic structure of Anseriformes and Charadriiformes noted in the model lagoons consists of widely distributed, Arctic and Siberian representatives of faunal types.

Representatives of other faunal groups are not regularly, but noticeably expand the range of zoogeography of migrating populations of anatids and waders, as they are also genetically related to historically established flyways.

4. The interpopulation exchange of Teal individuals occurring on African wintering grounds within the European geographic population from its western European part to the central northern European and Ural-Western Siberian parts, is not only important in understanding the principles of expanding zoogeographic dispersion of populations to western Europe, but also in the sanitary and epidemiological aspect since Anseriformes belong to important spreaders of viral infections and, in particular, of all flu group "A" strains.

5. The correlation analysis showed an unreliable, weakly negative trend in the total numbers of Anseriformes and Charadriiformes encountered in the study area over a 25-year period. The nucleus of the dominant species was identified and the proportion of each species to the sums of individuals registered was determined.

6. The correlation analysis showed that, despite a certain cyclicity, out of 18 tested species of anatids, in 12 the abundance significantly decreased, in 2 it increased, in 4 it remained at a relatively former level. Of the 10 model species of Charadriiformes, 3 significantly decreased in abundance, two increased in abundance and 5 remained at the same level.

7. The number trends of the model species of Anseriformes and Charadriiformes obtained in one place in the nodal points of the flight in the area of the lagoons of the western coast of the Middle Caspian Sea area can be taken as a reliable assessment of the status of specific geographic populations (Boreal-Arctic, north-east, west Siberian, Volga, Ural, north-western Caspian and north Kazakhstan), which was confirmed by ringing data and synchronized with the data from the literature.

8. The concept of the state of populations reasonably suggests introducing either a temporary ban on the hunting of such resource species as *A. anser*, *A. crecca, A. strepera, A. penelope, A. acuta, A. querquedula, A. clypeata, Ay. nyroca, Ay. ferina, V. vanellus, T. totanus, G. gallinago* and *L. limosa* until their sustainable recovery, or establish removal rates not exceeding 30–40% of their populations. The concept can be used for the conservation of these species not only in Dagestan but also in the Boreal-Arctic, northeastern and western Siberian regions of Russia, the Urals, the Volga, and the northwestern Caspian, from where these species (populations) regularly migrate along the historically formed and genetically fixed Western-Caspian flyway. For bird species such as *A. acuta, A. clypeata, Ay. ferina, V. vanellus, T. totanus, G. gallinago* and *L. limosa* similar conservation measures would be appropriate in Europe and England (except for *A. clypeata* in England), where numbers of these species are also steadily declining. The system of hunting regulation should cover

not only all constituent entities of the Russian Federation but also all neighboring and far-abroad countries where "Russian" populations of Anseriformes and Charadriiformes overwinter. At the same time, spring hunting for all species of birds should be closed everywhere.

9. Correlation analysis revealed a reliable relation between air temperature changes in the Caspian lowland of Dagestan and long-term fluctuations of the numbers of 12 model species of Anseriformes and Charadriiformes. It was proved that in cold years the abundance of migrating populations of anatids and waders on their flyways increases, and in warm years it decreases due to changes in flyways of Charadriiformes and redistribution of wintering areas of Anseriformes. At the same time, the number of populations themselves remains unchanged.

10. The present status of populations of Anseriformes and Charadriiformes is the result of the integrated effect of 3 regulating factors: hydroclimatic (change of the range boundaries depending on the direction of phases of the hydro-climatic cycle; deterioration of wetlands and fragmentation of ranges), anthropogenic (redistribution of birds across the range depending on the destruction of natural landscapes; hunting pressure; disturbance factor); foraging (reduction of forage availability in continental wetlands and depression of bioresources in the Caspian Sea region).

11. The data obtained may serve as a basis for the creation of a Russian monitoring database of Anseriformes and Charadriiformes with its subsequent integration with already existing Eurasian databases.

12. According to the data of the ornithological monitoring carried out by the author, the SPNA of – EU–RU260 "Sulakskaya Lagoon" with the status of international importance has already been created and an innovative socio-ecological project of the natural park "Ornithopark – Turalinskaya Lagoon" has been developed. The creation of a network of SPNAs along the western Caspian Sea will contribute to the conservation not only of the regional avifauna but also of an extensive group of Palearctic migrants.

13. In order to preserve resource bird species, we consider it rational to develop and disseminate among hunters within the authority of hunting farms of Russia a mobile application with photos and information about birds, which are supposed to be banned from hunting (including legal liability for illegal hunting of one species), as well as with photos and information about birds, which are open for hunting, but in accordance with the established norms of hunting takeover.

Acknowledgment

This work was carried out within the framework of the program of fundamental scientific research of the Caspian Institute of Biological Resources, a separate subdivision of the Dagestan Federal Research Center of the Russian Academy of Sciences, registration number AAAA-A20-120062990013-5

References

Aladdin NV, Plotnikov IS (2000) Threat of a large-scale ecological disaster in the Caspian Sea (Comparative analysis of the causes and consequences of ecological crises in the Aral and the Caspian Sea). Bulletin of the Caspian Sea 4:112–126 [In Russian]

Alekseev AYu, Murashkina TA, Dzhamalutdinov JM, Abdullaev SS, Akhmedrabadanov KhA, Sharshov KA (2019) Analysis of bird migrations of the water and near-water complex in the Republic of Dagestan and the rationale for the selection of key points for monitoring influenza type A. South of Russia: ecology, development 14(1):137–149. https://doi: 10.18470 / 1992-1098-2019-1-137-149 [In Russian]

Andres BA, Smith PA, Morrison RIG, Gratto-Trevor CL, Brown SC & Friis CA (2012) Population estimates of North American shorebirds. Wader Study Group Bull 119(3):178–194

Antipov AM (2010) Waterfowl of the Khanty-Mansiysk Autonomous Okrug – Ugra and adjacent territories: distribution patterns, numbers, migration, hunting, protection measures. Khanty-Mansiysk: Publishing house "Bibliography", Surgut [In Russian]

Atlas of Duck Populations in Eastern Europe (2010) Vilnius, Akstis:199

Banik MV, Dzhamirzoev GS (2003) New data on the ecology of the white-eyed duck in Dagestan. Current state of populations, resource management and protection of anseriformes in Northern Eurasia: Abstracts. Report of International Symposium. Petrozavodsk:10–11 [In Russian]

Boere GC & Stroud DA (2006) The flyway concept: what it is and what it isn't. Waterbirds around the world. Eds. GC Boere, CA Galbraith & DA Stroud. The Stationery Office, Edinburgh, UK 40–47. ISBN 0 11 497333 4

Both, Van Turnhout CA, Bijlsma RG, Siepel H, Van Strien AJ, Foppen RP (2010) Avian population consequences of climate change are most severe for long-distance migrants in seasonal habitats. Proc R Soc B BiolSci 277:1259–1266

BirdLife International (2017) European birds of conservation concern: populations, trends and national responsibilities. Cambridge, UK: BirdLife Int ISBN 978-1-912086-00-9

BirdLife International (2021) European Red List of Birds. Luxembourg: Publications Office of the European Union

Bukreev SA, Dzhamirzoev GS, Perevozov AG (2013) Interesting ornithological observations in Dagestan in 2012. Non-Passeriformes. Birds of the Caucasus: history of study and life in an urbanized environment. Stavropol:5–25 [In Russian]

Butyev VT (2006) Dynamics of bird habitats and ornithogeographic regionalization. Ornithological research in Northern Eurasia. Stavropol. SSU Publishing House:104–105 [In Russian]

Chamberlaen DE, Fuller RJ, Bunce RGH, Duckworth JC, Shrubb M (2000) Changes in abundance of farmland birds in relation to the timing of agricultural intensification in England and Wales. Jour of Appl Ecol 37(5):771–785

Chernichko II (2016) The value of the Azov-Black Sea coast of Ukraine in maintaining the structure of inland flyways of waders in Eastern Europe. Bulletin of Zoology. Institute of Zoology. I.I. Schmalhausen National Academy of Sciences of Ukraine. Kiev 2(33):126–258 [In Russian]

Crick HQP (2004) The impact of climate change on birds. Ibis 146:48–56. https://doi: 10.1111 / j.1474-919X.2004.00327.x

Delany S, Scott D, Dodman T & Stroud D (eds) (2009) An Atlas of Wader Populations in Africa and Western Eurasia. Wet Int, Wageningen, The Netherlands

Dzhamirzoev GS, Bukreev SA (2013) Rare vertebrates of Reserve Dagestansky. Proceedings of Reserve "Dagestansky". Makhachkala (6):145–149 [In Russian]

Dzhamirzoev GS, Perevozov AG, Komarov YuE, Tilba PA, Mnatsekanov RA, Karavaev AA et al. (2014) Birds of nature reserves and national parks of the North Caucasus. Proceedings of Reserve "Dagestansky". Makhachkala 8(1):428 [In Russian]

Erokhov SN, Berezovikov NN, Timoshenko AYu, Koshkin AV (2011) The current state of the nesting population of the gray goose *(Cygnus cygnus)*. Abstracts of the International conference "Anseriformes of Northern Eurasia: geography, dynamics and population management". Elista:28 [In Russian]

Eremchenko MI, Bolotnikov AM (1986) Influence of the disturbance factor on the reproductive potential of biotopic populations of pintail. Nesting life of birds. Perm:29–34 [In Russian]

Erwin KL (2009) Wetlands and global climate change: the role of wetland restoration in a changing world. Wetl Ecol and management 17(1):71–84. https://doi: 10.1007/s11273-008-9119-1

Estimation of numbers and trends for birds of the European Russia ("European Red List of Birds") (2017) Mischenko, A.L. (ed.). Moscow, Russian Society for Bird Cons and Study 63. ISBN 978-5-9907592-8-2 [In Russian]

European Environment Agency. State of nature in the EU – Results from reporting under the nature directives 2013–2018. EEA. 2020. 142 p. https://www.eea.europa.eu/publications/state-of-nature-in-the-eu-2020

State of nature in the EU (2020) Results from reporting under the nature directives 2013-2018. EEA (10) 142. https://doi:10.2800/088178

Fedosov VN (2015) Results of studying the habitats of waterfowl based on the materials of the project for creating an atlas of nesting birds of European Russia. International conference "Anseriformes of Northern Eurasia: study, conservation and rational use". Salekhard:92–93 [In Russian]

Fox AD, Ebbinge BS, Mitchell C, Heinicke T, Aarvak T, Colhoun K et al. (2010) Current estimates of goose population sizes in western Europe, a gap analysis and an assessment of trends. OrnisSvecica 20 (3–4), (Oct. 2010):115–127. https://doi.org/10.34080/os.v20.19922

Fox AD & Leafloor JO (eds.) (2018) A Global audit of the status and trends of Arctic and Northern Hemisphere goose population. Cons of Arct Flora and Fauna Int Secretariat, Akureyri, Iceland, 31

Frost T, Graham A, Hearn R, McAvoy S, Robinson A, Stroud D et al. (2019) Population estimates of wintering waterbirds in Great Britain. Brit Bir 112:130–145

Gavrilov NN (2019) Dependence of geoclimatic indicators on the succession of habitats in the Volga delta in the process of intrasecular climate variability. Natural ecosystems of the Caspian region: past, present, future: Proceedings of the All-Russian scientific conference with international participation, dedicated to the 100th anniversary of the Astrakhan State Reserve. Astrakhan. MIR printing house:16–17. ISBN 978-5-6043340-2-7 [In Russian]

Gistsov AP (2001) The number of birds of the wetland complex on the north-eastern coast of the Caspian. Actual problems of the study and protection of birds in Eastern Europe and Northern Asia. Materials of the International Conference (XI Ornithological Conference). Kazan. From "Matbugat Yorty" 174–176. ISBN 5-89120-156-9 [In Russian]

Golovatin MG, Paschalnyi SP (2015) The current state of the resources of anseriformes in the lower Ob' floodplain and their spatial distribution. In: International conference "Anseriformes of Northern Eurasia: study, conservation and rational use". Salekhard:23–24 [In Russian]

Gordo O (2007) Why are bird migration dates shifting? A review of weather and climate effects on avian migratory phenology. Clim res 35(1–2):37–58. https://doi:10.3354/cr00713

Grant GR, Naish TR, Dunbar GB, Stocchi P, Kominz MA, Kamp PJJ et al. (2019) The amplitude and origin of sea-level variability during the Pliocene epoch. Nature 574:237–241. https://doi: 10.1038/s41586-019-1619-z

Guillemain M, Poysa H, Fox AD, Arzel C, Dessborn L et al. (2013) Effects of climate change on European ducks: what we know and what do we need to know? Wild Biol (19):404–419

Howard C, Stephens PA, Tobias JA, Sheard C, Butchart SH, Willis SG (2018) Flight range, fuel load and the impact of climate change on the journeys of migrant birds. Proceedings of the Royal Society B: Biol Sci 285(1873): 20172329. https://doi: 10.1098/rspb.2017.2329

IPBES (2019) Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Diaz, and H. T. Ngo (ed.). Bonn, Germany: IPBES secretariat 1148. https://doi.org/10.5281/zenodo.3831673

Isakov YA (1967) Proceedings of the Second European Meeting on Wildfowl Conservation, Noordwijk aan Zee, The Netherlands, 9–14 May 1966:125–138

James W, Pearce-Higgins, Sarah M Eglington, Blaise Martay and Dan E Chamberlain (2015) Drivers of climate change impacts on bird communities. Journal of Animal Ecology, 84:943–954. https://doi: 10.1111/1365-2656.12364

Isakov YuA (1972) Red-breasted goose – a species requiring full protection. Geese in the USSR. Proceedings of the interdepartmental meeting, Estonia, May 1970. AN Est SSR. Institute of Zoology and Botany. Tartu:127–130 [In Russian]

Karri-Lindahl K (1984) Birds over Land and Sea: A Global Overview of Bird Migration. Moscow: Thought. 204. BBK 28.693.35 [In Russian]

Katz EB, Krivonosov GA, Reutskiy ND (1997) Garganey - *Anas querquedula* L. Bird migration of Eastern Europe and North Asia: Lamellar-billed. River ducks. Moscow: 246–296 [In Russian]

Kazakov BA, Lomadze NKh, Belik VP, Khokhlov AN, Tilba PA, Pishvanov YuV et al. (2004) Birds of the North Caucasus. Volume 1: Loons, Grebes, Trumpets, Copepods, Storks, Flamingos, Anseriformes. Rostov-on-Don: Publishing house of the Russian State Pedagogical University: 398. ISBN 5-8480-0216-9 [In Russian]

Key ornithological territories of Russia (2009) Key ornithological territories of international importance in the Caucasian ecoregion, Moscow: Union for the Conservation of Birds of Russia (3) 197–199. ISBN 978-5-8125-1342-9 [In Russian]

Kharitonov SP (2019) On the rational (non-depleting) use of waterfowl resources: demographic well-being of the population and rates of withdrawal. Zoological journal 98(8):903–914. https://doi: 10.1134 / S0044513419080063 [In Russian]

Koblik EA (2001) Variety of birds (based on the materials of the Zoological Museum of Moscow State University). Moscow: Moscow State University (1): 384. ISBN 5-211-04072-4 [In Russian]

Korobitsyn IG, Tyutenkov OYu, Moskvitin SS (2018) Sex ratio of birds as an indicator of the state of populations of waterfowl. In: Dynamics of populations of game animals in Northern Europe: Abstracts. VII International Symposium. September 24–28, 2018, Petrozavodsk, Republic of Karelia, Russia, Petrozavodsk, KarRC RAS:61–62 [In Russian]

Koshelev AI, Dannik OYu (2001) Local foraging flights of wintering geese in the Northern Azov region. Problems of the study and protection of birds in Eastern Europe and Northern Asia. Moscow:72–73 [In Russian]

Krivenko VG, Vinogradov VG (2008) Birds of the aquatic environment and the rhythms of the climate of Northern Eurasia. Moscow, Science. ISBN 978-5-02-036669-5 [In Russian]

Krivenko VG (2021) Global climate warming from the standpoint of the cosmogenic theory of the dynamics of habitats and the number of animals in the Northern Hemisphere // Social-scientific journal "Bulletin" of the Russian Academy of Natural Sciences, V.3. pp. 96–106. DOI: 10.52531/1682-1696-2021-21-3-96-106 [In Russian]

Lebedeva NV, Lomadze NKh (2016) The population of the gray goose (Anser anser) in the Western Manych at the beginning of the XXI century. Science of the South of Russia 12(2): 68–81. UDC 598.252.2(282.247.366)"20" [In Russian]

Lebedeva NV, Lomadze NKh, Kolomeitsev SG (2018) Migration of Anseriformes (Anseriformes) in Western Manych in 2016. Science of the South of Russia 14(1):97–115. https://doi: 10.23885/2500-0640-2018-14-1-97-115 [In Russian]

Lehikoinen A, Jaatinen K. (2012) Delayed autumn migration in northern European waterfowl. J. Ornith 153(2): 563–570. https://doi: 10.1007/s10336-011-0777-z

Maclean IMD, Rehfisch MM, Delany S, Robinson RA (2008) The effects of climate change on migratory waterbirds within African-Eurasian flyways. AEWA technical series (21). Bonn, Germany

Mason LR, Green RE, Howard C, Stephens PA, Willis SG, Aunins A et al. (2019) Population responses of bird populations to climate change on two continents vary with species' ecological traits but not with direction of changeinclimatesuitability. ClimChan 157, 3(1):337–354. https://doi: 10.1007/s10584-019-02549-9

Melnikov YuI (2015) Gray duck in Eastern Siberia: habitat dynamics and current state of abundance. In: International conference "Anseriformes of Northern Eurasia: study, conservation and rational use". Salekhard:52–53 [In Russian]

Mikheev AV (1997) Visible daytime passage of aquatic and waterbirds along the western coast of the Caspian Sea. Stavropol [In Russian]

Mishchenko AL, Kharitonov SP (2018) The current state of populations of red-headed diving in Russia and Europe: reasons for the decline. First All-Russian Ornithological Congress (Tver, Russia, January 29 – February 4, 2018). Abstracts of reports. Tver: 226–227 [In Russian]

Nankinov DN (2017) Birds of Russia and neighboring countries: teal cod *Anas querquedula* Linnaeus, 1758. // Russian Journal of Ornithology. Vol. 26, Express Iss. 1460: 2505-2553 ISSN 0869-4362 [In Russian]

Polivanova NN (1990) Migration and wintering of birds of the North Caucasus. Stavropol. Book. publishing house, 11, pp 5–6 [In Russian]

Ravkin YuS (1967) To the method of counting birds in forest landscapes. Nature of foci of tick-borne encephalitis in Altai. Novosibirsk:66–75 [In Russian]

Red Book of the Russian Federation (2001) Animals. Moscow: AST-Astrel [In Russian]

Red Book of the Republic of Dagestan (2020) Makhachkala: Printing house A4 (IP Dzhamaludinov) [In Russian]

Roach JK, Griffith B (2015) Climate-induced lake drying causes heterogeneous reductions in waterfowl species richness. Landsc Ecol 30(6):1005–1022. https://doi: 10.1007/s10980-015-0207-3

Robinson RA, Crick HQP, Learmonth JA, Maclean IMD, Thomas ChD, Bairlein F et al. (2009) Travelling through a warming world: climate change and migratory species. Endang spec res 7(2): 87–99. https://doi: 10.3354/esr00095

Rosenfeld SB (2015) Prospects for the conservation of gray goose populations by artificial breeding. International conference "Anseriformes of Northern Eurasia: study, conservation and rational use". Salekhard:73–74 [In Russian]

Rusanov GM (2001) The number of waterfowl in the Volga delta under conditions of an unstable water regime (1968-1999). Bulletin of the Working Group on geese in Eastern Europe and North Asia 7:365–383 [In Russian]

Rusanov GM (2006) Changes in the avian population of the Volga delta in the second half of the XX century. Development of modern ornithology in Northern Eurasia: Proceedings of the XII International Ornithological Conference of Northern Eurasia. Stavropol, SSU Publishing House: 210–228 [In Russian]

Rusanov GM (2015) Dynamics of populations of waterfowl in the Volga delta in the twentieth century. Russian Ornithological Journal 24(1171):2674–2694 [In Russian]

Rutschke E (1980) Der Wandel der Vogelwelt in der DDR unter dem Einfluss veranderter Umweltbedingungen. Falke 27(10):329–341

Schmaljohann H, Both C (2017) The limits of modifying migration speed to adjust to climate change. Nat Clim Chan 7(8): 573–576. https://.doi: 10.1038/nclimate3336

Schricke V (2001) Elements for a Garganey *(Anas querquedula)* management plan // *Game and Wildlife Sci*. 18, 1: 9–41.

Shiganova TA, Musaeva EI, Pautova LA, Bulgakova YuV (2005) The problem of invaders in the Caspian Sea in connection with new finds in it of the Black Sea species of zoo- and phytoplankton. Izv. RAS. Biol. Series 1:78–87 [In Russian]

Shtegman BK (1938) Fundamentals of ornithogeographic division of the Palaearctic. Fauna of the USSR. Birds. Moscow – Leningrad: Publishing House of the Academy of Sciences of the USSR 1(2) [In Russian]

Snow DW and Perrins CM (1998) The Birds of the Western Palearctic. Concise Edition. Oxford - New York. Oxford University Press (1):242–244. ISBN 0 19 850187 0

Sokolov LV (2007) Bird population dynamics due to climate fluctuations and autochthonous population processes. Dynamics of the bird’s density in terrestrial landscarpes. Proceedings of the Russian Scientific conference. Moscow, Russia, February 21–22 2007. Moscow:8–24. ISBN 5-94018-016-7 [In Russian]

Sokolov AYu (2018) The dependence of the nesting fauna of Charadriiformes on changes in the state of agrocenoses in the south of the Central Black Earth Region. First All-Russian Ornitol. congress. Abstracts. Tver:307. ISBN 978-5-9793-1324-5 [In Russian]

Sokolov AYu, Numerov AD, Vengerov PD (2019) Status and change in the number of waders in the Voronezh region since the middle of the twentieth century. Topical issues of studying waders in Northern Eurasia: materials of the XI International scientific-practical conf., Minsk, January 29-2 Feb. 2019 Minsk, BSU:113–121. ISBN 978-985-566-685-2 [In Russian]

Sparks TH, Bairlein F, Bojarinova JG, Huppop O, Lehikoinen EA, Rainio K et al. (2005) Examining the total arrival distribution of migratory birds. Glob Chan Biol 11(1): 22–30. https://doi: 10.1111/j.1365-2486.2004.00887x

Stepanyan LS (2003) Synopsis of the ornithological fauna of Russia and adjacent territories (within the boundaries of the USSR as a historical region). Moscow, Academbook [In Russian]

Stephens PA, Mason LR, Green RE, Gregory RD, Sauer JR, Alison J et al. (2016) Consistent response of bird populations to climate change on two continents. Science 352:84–87

Sultanov EG (2001) Status of Lesser White-fronted Goose (Anser erythropus) in Azerbaijan. Focus on the Caspian Sea. Regional program for the conservation of Lesser White-fronted Goose in the Caspian region. Regional Environmental Agency Häme. Finland, Hameenlinna:1–5

Sviridova TV (2003) Studying the history of nature management is an important tool for monitoring and preserving key bird areas (on the example of agricultural lands in the Moscow region). Key ornithological territories of Russia. Moscow 2 (18):24–27 [In Russian]

Svitoch AA (1998) Geoecological disaster in the coastal cities of Dagestan. Nature 5 (993):16–17 [In Russian]

Tarasov VV (2015) The current state of the resources of anseriformes in the Tobol-Ishim forest-steppe. International conference "Anseriformes of Northern Eurasia: study, conservation and rational use". Salekhard:89–90 [In Russian]

Thorup K, Tottrup AP, Willemoes M, Klaassen RHG, Strandberg R, Vega ML et al. (2017) Resource tracking within and across continents in long-distance bird migrants. Sci Adv 3(1): e1601360. https://doi: 10.1126/sciadv.1601360

Van Eerden MR, Drent RH, Stahl J, Bakker JP (2005) Connecting seas: western Palaearctic continental flyway for water birds in the perspective of changing land use and climate. Glob Chan Biol 11(6): 894–908. https://doi: 10.1111/j.1365-2486.2005.00940x

Vilkov EV (2001) Ornithological significance, features of ecology, fauna and bird population of inland water bodies of the Arakum lowland. Herald of the Daghestan Scientific Center of the Russian Academy of Sciences 10:67–74 [In Russian]

Vilkov EV (2013) Population Trends in Regular Migrants as the Basis for a Prediction Model for Conservation of the Birds of Eurasia. Russian Journal of Ecology. Pleiades Publishing, Ltd. 44(2): 142–157. https://doi: 10.1134/S106741361301013X

Vilkov EV (2014a) Genesis and evolution of the Caspian lagoons as important reserves of bird fauna in the western Caspian. Problems of regional ecology. Moscow: Publishing house "Kamerton" 2:191–197. UDC 598.2:574.3/.91(470·67) [In Russian]

Vilkov EV (2014b) Express-methodology for computer reconstruction of large-scale maps based on limited geographic parameters. In: Problems of regional ecology. Moscow: Publishing House "Kamerton":138–140. UDC 598·2:574·3/·91(470·67) [In Russian]

Vilkov EV (2017) Ornithological significance of the specially protected natural area "Sulak Lagoon". Sustainable development of specially protected areas. Collection of articles of the IV All-Russian Scientific and Practical Conference (November 1–3, 2017, Sochi). Sochi: GKU CC "Natural Ornithological Park in the Imeretinskaya Lowland", Donizdat (4):67–79. ISBN 978-5-904079-80-6 [In Russian]

Vilkov EV (2019) Socio-ecological project of the natural park "Ornithopark – Turalinskaya lagoon". Sustainable development of specially protected natural areas. Collection of articles of the VI All-Russian Scientific and Practical Conference (October 2-4, 2019, Sochi). Sochi: GKU KK "Natural Ornithological Park in the Imeretinskaya Lowland", Donskoy Publishing Center (6):111–122. ISBN 978-5-904079-75-8 [In Russian]

Vostokov SV, Gadgiev AA, Vostokova AS, Rabazanov NI (2020) The ctenophore *Beroe* cf. *ovata* in the Caspian Sea. The beginning of a new stage in the evolution of the Caspian ecosystem? South of Russia: ecology, development 15(4):21–35. https://.doi:10.18470/1992-1098-2020-4-21-35 [In Russian]

Woodward I, Aebischer N, Burnell D, Eaton M, Frost T, Hall C et al. (2020) Population estimates of birds in GreatBritain and the United Kingdom. British Birds 113:69–104. https://britishbirds.co.uk

Zavyalov EV, Shlyakhtin GV, Tabachishin VG. et al. (2005) Birds of the North of the Lower Volga region. Book I. History of the study, general characteristics and composition of the avifauna. Saratov: Publishing house of Saratov University. ISBN 5-292-03351-0 [In Russian]

Zavyalov EV, Matrosov AN, Tabachishin VG, Kutyrev IV, Popov NV, Yakushev NN et al. (2008) The role of seasonal migrations of limnophilic bird species in the possibility of the introduction of the influenza A (H5N1) virus into the north of the Lower Volga region. Povolzhskiy ecological journal (1):3–19. UDC [592.8: 591.543.4: 578.832.1] (470.44 /.47) [In Russian]