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INFLUENCE OF GLOBAL WEATHER CONDITIONS ON TIMING OF THE SPRING MIGRATION OF BIRDS IN THE KANIV NATURE RESERVE (CENTRAL UKRAINE)

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Influence of Global Weather Conditions on Timing of the Spring Migration of Birds in the Kaniv Nature Reserve (Central Ukraine). Grishchenko, V. N. — I studied the effect of North Atlantic Oscillation (NAO) on the phenology of spring migration of birds in Central Ukraine. Data for arrival and departure of 92 species collected in 1987 to 2018 were used. The statistically significant correlation was found for 33 (35.9 %) bird species. 50 coefficients were negative (82.0 %) and 11 ones — positive (18.0 %). The majority of relationships have been shown in February (12) and March (22). In April, they became more rarely (5). There was only one significant value for January and May. For 20 species correlations were found with averaged indices including three months (January to March). The relationships with NAO indices were much commoner for the short-distance migrants (63.3 % of studied species) than for birds wintering in tropical and Southern Africa (20.5 %) and the intermediate group (18.8 %). Wintering birds showed 8 significant coefficients in 3 species (42.9 %). Statistically significant coefficients of correlation ranged in absolute values from 0.35 to 0.80. The average absolute values were very close for different groups of species. The overall mean made 0.50 ± 0.01 (n = 61).
Key words: first arrival date, last departure date, short-distance migrant, long-distance migrant, weather, North Atlantic Oscillation.

Introduction

Migrations of birds are strongly influenced by weather conditions. Timing of arrival and departure depends on the air temperature, the direction and the strength of wind, precipitations, ice and snow cover, etc. But as against of plants, for birds is necessary not only local weather in points of observations. Conditions in wintering grounds and migration routes can be more important (Newton, 2008). It is very complicate to analyse different weather variables in many localities in order to the study of bird migration patterns. Large-scale climate indices are much more useful. They summarise weather conditions over a large area and a long time span in a single value (Haest et al., 2018). The North Atlantic Oscillation (NAO) is one of the most known such characteristics. This phenomenon affects the climatic and ecological dynamics over very large areas, including North America, Europe and Africa. There is a significant positive correlation between winter air temperatures and winter NAO indices in a large area, from the British Isles to Sakhalin (Sokolov et al., 2003; Sokolov, 2010).

The NAO index is defined as the difference in the normalized atmospheric sea-level pressure between the Azores High and the Icelandic Low. These fluctuations between the subtropical and the subpolar centres affect the speed and direction of winds. Positive NAO indices mean the intensification of the zonal circulation.

Westerly winds bring the moist and warm air from Atlantic Ocean into Europe. Negative values indicate the stronger influence of meridional flow. In Northern Europe, positive NAO indices correlate with mild winters and early springs, while negative ones indicate the cold and dry weather (Ottersen et al., 2001; Hurrell et al., 2003; Sokolov, 2010).

Many researchers analysed the relation of NAO to different aspects of bird ecology, especially migrations (Forchhammer et al., 2002; Nott et al., 2002; Hubálek, 2003; Hüppop & Hüppop, 2003; Sokolov et al., 2003; Vähätalo et al., 2004; Stervander et al., 2005; Boyd, Petersen, 2006; Rainio et al., 2006; Sokolov, 2006; Palm et al., 2009; Žalakevičius et al., 2009; Tøttrup et al., 2010; Gordo et al., 2011; Kim et al., 2015, etc.). However, the influence of weather variables and climate changes is very manifold and polysemantic. The published results show a large variety of relations between spring migration phenology and NAO indices (Haest et al., 2018). Therefore, it is necessary to store our knowledge for the better understanding these events. In Ukraine, the influence of NAO on the bird migration is studied very poorly. At the same time, such information is important because the country is located farther deep into the continent than West and Central Europe. Lithuanian ornithologists wrote that 'the role of NAO index values in various European regions at different distances from the Atlantic Ocean still remains obscure' (Zalakevicius et al., 2006, p. 338).

The aim of this paper is to determine correlations between monthly NAO indices and timing of spring migration of birds in Central Ukraine.

Material and methods

The Kaniv Nature Reserve is located on the Dnipro near the town of Kaniv in Cherkasy Region (49.724 N, 31.535 E). It has an area of 2027 ha.

I have studied bird migrations during 32 years: in 1987 to 2018. Phenological observation was conducted on the territory of the reserve and in its environs. In spring, the first arrival dates of spring migrants and the last departure dates of winter visitors were registered. A part of these data was published (Grishchenko & Gavrilyuk, 2000).

For the analysis, 92 species have been chosen, for which there are 10 and more phenological dates during the period of research. 7 from them are the northern birds wintering in the study area (winter visitors). Calendar dates were transformed into sequential numbers since 1st February. All the arriving species (summer visitors) were divided into 3 groups depending on their main wintering areas. 30 species belong to short-distance migrants wintering within Europe and in Turkey. 16 medium-distance migrants winter mainly in Mediterranean, Northern Africa and in the Middle East. 39 species are long-distance migrants with main wintering grounds in Africa to the south from Sahara. For this grouping, I used the actual data about the distribution of birds at the site of the IUCN Red List of Threatened Species (http://www.iucnredlist.org/) and results of such division in other publications (Hubalek, 2003; Rainio et al., 2006; Newton, 2008; Haest et al., 2018).

There are many variants of NAO indices (annual, seasonal, monthly, daily) and different methods of their calculation. I have used for this study the monthly indices published at the site of Climate Prediction Center (http://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/nao.shtml). Summarised JFM index was calculated as average value for three months (January to March).

Pearson's correlation coefficient was used to examine relationships between avian spring phenological events and NAO indices.

The NAO indices did not show a significant trend during the study period (linear regression analysis, $p > 0.1$ for all cases).

Results

In total, the reliable correlation was found for 33 (35.9 %) bird species (table 1). This is the relationship with the first arrival dates for 30 from them and with the last departure dates for 3 species (wintering birds). 50 statistically significant coefficients of correlation were negative (82.0 %) and 11 ones — positive (18.0 %).

The majority of relationships have been shown in February (12) and March (22). In April, they became more rarely (5). There were only one significant value for January and May. For 20 species correlations were found with averaged indices including three months (January to March). In 5 from them the timing of spring migration related only to these summarised values.

Birds responded to the NAO differently. It depended on the month and the phenological event (arrival or departure). For both winter months, timing of migration correlated with NAO indices negatively. Negative correlations prevailed also in March (18 of 22, 81.2 %) but for this month there were 4 positive coefficients. They predominated in April (4 of 5,

Table 1. Correlation between monthly NAO indices and the timing of spring migration of birds in the Kaniv Nature Reserve

Species	n	January	February	March	April	May	JFM
First arrival dates							
Acanthis cannabina (Linnaeus, 1758)	26	–0.32	–0.42*	–0.48*	–	–	–0.53**
Acrocephalus arundinaceus (Linnaeus, 1758)	15	–	–0.17	–0.22	–0.18	–	–0.17
Acrocephalus schoenobaenus (Linnaeus, 1758)	10	0.35	–0.09	–0.21	–0.09	–0.44	–
Actitis hypoleucos (Linnaeus, 1758)	12	0.44	–0.16	–0.23	–0.26	–	–
Alauda arvensis Linnaeus, 1758	32	–0.10	–0.41*	–0.59***	–	–	–0.53**
Anas acuta Linnaeus, 1758	14	–0.48	–0.59*	–0.31	0.27	–	–0.58*
Anas crecca Linnaeus, 1758	11	0.32	0.40	–0.52**	–0.15	–	–0.04
Anas penelope Linnaeus, 1758	26	–0.31	–0.36	–0.50**	0.27	–	–0.52**
Anas querquedula Linnaeus, 1758	22	–0.32	–0.19	0.08	0.01	–	–0.17
Anser sp.	32	0.04	–0.34	–0.52**	0.19	–	–0.41*
Anthus trivialis (Linnaeus, 1758)	29	–0.10	0.01	0.05	–0.31	–	–0.01
Apus apus (Linnaeus, 1758)	18	–0.09	–0.38	0.05	0.11	0.38	–0.19
Ardea cinerea Linnaeus, 1758	32	–0.25	–0.56***	–0.47**	0.02	–	–0.60***
Aythya ferina (Linnaeus, 1758)	22	–0.13	–0.29	–0.49*	–0.04	–	–0.40
Aythya fuligula (Linnaeus, 1758)	15	–0.26	–0.42	–0.57*	–0.10	–	–0.51
Buteo buteo (Linnaeus, 1758)	26	–0.28	–0.15	–0.17	0.16	–	–0.27
Casmerodius albus (Linnaeus, 1758)	15	–0.32	–0.23	–0.32	0.26	–	–0.39
Charadrius dubius Scopoli, 1786	11	0.12	–0.29	0.29	0.52	–	0.08
Chloris chloris (Linnaeus, 1758)	23	–0.29	–0.40	–0.29	0.20	–	–0.42*
Ciconia ciconia (Linnaeus, 1758)	26	0.07	–0.05	–0.01	–0.26	–	–
Circus aeruginosus (Linnaeus, 1758)	16	0.06	0.29	0.25	0.29	–	0.25
Circus cyaneus (Linnaeus, 1766)	13	0.09	0.01	0.22	–0.36	–	0.15
Circus pygargus (Linnaeus, 1758)	11	0.36	–0.11	–0.18	0.22	–	–
Coccothraustes coccothraustes (Linnaeus, 1758)	22	0.19	–0.20	–0.42*	–0.05	–	–0.23
Columba oenas Linnaeus, 1758	11	–0.19	–0.61*	–0.31	0.20	–	–0.56
Columba palumbus Linnaeus, 1758	30	–0.17	–0.13	–	–	–	–0.13
Corvus frugilegus Linnaeus, 1758	11	–0.20	–0.47	–0.68*	0.18	–	–0.69*
Coturnix coturnix (Linnaeus, 1758)	10	–0.18	0.29	–0.10	0.25	0.06	0.03
Crex crex (Linnaeus, 1758)	18	0.09	0.22	0.49*	0.50*	–0.12	0.36
Cuculus canorus Linnaeus, 1758	32	–0.23	–0.06	0.20	–0.12	–	–0.01
Cygnus olor (J.F. Gmelin, 1789)	23	–0.23	–0.36	–0.33	0.14	–	–0.43*
Delichon urbica (Linnaeus, 1758)	26	–0.34	–0.19	0.08	0.07	–	–0.19
Emberiza schoeniclus (Linnaeus, 1758)	14	–0.09	–0.28	–0.29	–0.10	–	–0.26
Erithacus rubecula (Linnaeus, 1758)	32	–0.25	–0.28	–0.23	0.02	–	–0.35
Falco tinnunculus Linnaeus, 1758	14	0.02	–0.20	–0.11	0.15	–	–0.13
Ficedula albicollis (Temminck, 1815)	25	0.04	0.35	0.45*	0.46*	–	0.43*
Ficedula hypoleuca (Pallas, 1764)	10	0.02	0.35	0.02	–0.65*	–	0.18
Ficedula parva (Bechstein, 1794)	14	0.10	–0.09	–0.06	0.16	0.33	–0.03
Fringilla coelebs Linnaeus, 1758	32	–0.13	–0.38*	–0.36*	0.16	–	–0.41*
Fringilla montifringilla Linnaeus, 1758	15	–0.22	0.19	–0.15	0.35	–	–0.06
Fulica atra Linnaeus, 1758	14	–	0.05	0.01	0.15	–	–0.01
Gallinago gallinago (Linnaeus, 1758)	11	0.31	0.27	–0.39	0.15	–	0.07
Grus grus (Linnaeus, 1758)	30	–0.01	–0.05	–0.31	0.05	–	–0.18
Haematopus ostralegus Linnaeus, 1758	20	0.27	0.31	0.33	0.36	–	0.45*
Hirundo rustica Linnaeus, 1758	31	–0.09	0.18	0.36*	0.35*	–	0.23
Jynx torquilla Linnaeus, 1758	29	0.05	–	0.05	–0.13	–	0.05
Lanius collurio Linnaeus, 1758	25	0.05	–0.04	–	0.22	–	0.01
Larus canus Linnaeus, 1758	15	–0.02	0.17	–0.25	0.20	–	–0.06
Larus ridibundus Linnaeus, 1758	27	–0.12	–0.23	–0.16	–0.02	–	–0.25

Table 1 (Continued)

Lullula arborea (Linnaeus, 1758)	26	0.05	–0.16	–0.29	0.27	–	–0.19
Luscinia luscinia (Linnaeus, 1758)	29	–0.19	0.02	0.13	0.34	–	–
Luscinia svecica (Linnaeus, 1758)	12	–0.27	–0.17	0.09	0.23	–	–0.15
Merops apiaster Linnaeus, 1758	29	0.04	0.08	–0.11	0.22	–0.25	–
Milvus migrans (Boddaert, 1783)	19	–0.24	–0.20	–	0.14	–	–0.18
Motacilla alba Linnaeus, 1758	32	–0.16	–0.34	–0.31	–0.11	–	–0.38*
Motacilla flava Linnaeus, 1758	15	–0.11	–0.34	–0.54*	–0.15	–	–0.42
Motacilla werae Buturlin, 1908	13	0.41	0.26	0.20	–	–	0.36
Muscicapa striata (Pallas, 1764)	17	–0.08	0.05	0.14	0.22	–0.26	0.06
Oenanthe oenanthe (Linnaeus, 1758)	19	0.33	0.09	0.16	–0.09	–	0.23
Oriolus oriolus (Linnaeus, 1758)	30	0.03	0.15	0.32	0.21	0.02	0.23
Phalacrocorax carbo (Linnaeus, 1758)	20	0.01	–0.03	–0.18	–0.02	–	–0.11
Philomachus pugnax (Linnaeus, 1758)	10	–0.25	0.12	0.04	0.19	–	–0.02
Phoenicurus ochruros (S.G. Gmelin, 1774)	23	–0.19	–0.22	–0.08	0.15	–	–0.23
Phylloscopus collybita (Vieillot, 1817)	31	0.04	–0.17	–0.16	–0.07	–	–0.15
Phylloscopus sibilatrix (Bechstein, 1793)	31	–0.10	0.04	0.13	–0.04	–	0.05
Phylloscopus trochilus (Linnaeus, 1758)	30	–0.29	0.06	0.18	–0.15	–	–
Podiceps cristatus (Linnaeus, 1758)	20	–0.29	–0.08	–0.12	0.09	–	–0.20
Remiz pendulinus (Linnaeus, 1758)	10	–0.49	–0.66*	–0.67*	–	–	–0.80**
Riparia riparia (Linnaeus, 1758)	14	–	0.12	0.20	0.01	–	0.13
Saxicola rubetra (Linnaeus, 1758)	23	0.11	–0.32	–	–0.29	–	–0.11
Saxicola torquata (Linnaeus, 1758)	13	–0.27	–0.11	0.03	0.39	–	–0.14
Scolopax rusticola Linnaeus, 1758	26	0.15	–0.12	–0.34	0.04	–	–0.17
Sterna albifrons Pallas, 1764	13	–	0.40	–0.34	–0.33	–0.04	–0.08
Sterna hirundo Linnaeus, 1758	31	–0.11	–0.08	0.21	0.04	–	0.02
Streptopelia turtur (Linnaeus, 1758)	23	0.13	–0.10	–0.43*	0.22	0.47*	–0.18
Sturnus vulgaris Linnaeus, 1758	27	–0.20	–0.48*	–0.42*	0.20	–	–0.49**
Sylvia atricapilla (Linnaeus, 1758)	29	0.15	0.16	–0.02	–0.08	–	0.12
Sylvia communis Latham, 1787	14	–0.30	0.04	0.02	0.62*	0.21	–0.09
Sylvia curruca (Linnaeus, 1758)	13	–0.22	–0.06	0.02	0.41	0.42	–0.10
Tringa ochropus Linnaeus, 1758	12	0.01	–0.22	–0.01	–0.10	–	–0.10
Turdus iliacus Linnaeus, 1766	13	–0.34	–0.38	–0.33	–0.13	–	–0.48
Turdus merula Linnaeus, 1758	32	–0.31	–0.45**	–0.39*	0.11	–	–0.53**
Turdus philomelos C. L. Brehm, 1831	32	–0.21	–0.22	–0.32	0.19	–	–0.35*
Upupa epops Linnaeus, 1758	23	0.15	0.28	0.45*	0.34	–	0.38
Vanellus vanellus (Linnaeus, 1758)	24	–0.08	–0.37	–0.65***	0.19	–	–0.47*
Last departure dates of wintering birds							
Bombycilla garrulus (Linnaeus, 1758)	20	–0.17	–0.45*	–0.47*	0.27	–	–0.59**
Bucephala clangula (Linnaeus, 1758)	18	–0.28	–0.27	–0.17	–0.13	–	–0.31
Lanius excubitor Linnaeus, 1758	16	0.10	0.31	0.22	0.40	–	0.29
Mergus albellus Linnaeus, 1758	13	0.07	–0.09	–0.07	–0.44	–	–0.05
Mergus merganser Linnaeus, 1758	20	–0.25	–0.45*	–0.48*	0.11	–	–0.53*
Pyrrhula pyrrhula (Linnaeus, 1758)	32	–0.29	–0.21	–0.20	0.10	–	–0.31
Regulus regulus (Linnaeus, 1758)	14	–0.55*	–0.56*	0.17	–0.21	–	–0.40

JFM — averaged values of indices for three months (January to March).
Pearson's correlation coefficients are given.
Significance level: * — $p < 0.05$, ** — $p < 0.01$, *** — $p < 0.001$.
Anser sp. — mainly *A. anser* (Linnaeus, 1758) and *A. albifrons* (Scopoli, 1769).

80.0 %) and in May (only one). Negative correlations were also more typical for JFM index (18 of 20, 90.0 %).

The relationship is revealed as a rule with NAO indices for the month of arrival (departure) or previous one and for summarised JFM index.

For short-distance migrants, the significant correlations were found for 19 species (63.3 %). All the coefficients have negative values (38, 1 to 3 for the species). The obtained data demonstrated clearly the relationship to weather conditions in winter and early spring. The correlation with February, March and JFM indices was the most frequently variant (7 species: *Acanthis cannabina* (Linnaeus, 1758), *Alauda arvensis* Linnaeus, 1758, *Ardea cinerea* Linnaeus, 1758, *Fringilla coelebs* Linnaeus, 1758, *Remiz pendulinus* (Linnaeus, 1758), *Sturnus vulgaris* Linnaeus, 1758 and *Turdus merula* Linnaeus, 1758). In 4 species, arrival dates correlated with March and JFM indices (*Anas penelope* Linnaeus, 1758, *Anser* sp., *Corvus frugilegus* Linnaeus, 1758 and *Vanellus vanellus* (Linnaeus, 1758)), in *Anas acuta* Linnaeus, 1758 — with February and JFM indices. 7 species had the significant correlation only with one index: *Columba oenas* Linnaeus, 1758 — February; *Anas crecca* Linnaeus, 1758, *Aythya ferina* (Linnaeus, 1758), *Aythya fuligula* (Linnaeus, 1758) and *Coccothraustes coccothraustes* (Linnaeus, 1758) — March; *Chloris chloris* (Linnaeus, 1758) and *Cygnus olor* (J. F. Gmelin, 1789) — JFM.

Data on the departure of wintering birds confirmed this pattern. All 8 coefficients of correlation in 3 species (42.9 %) were negative, departure dates depended mainly on the winter weather. In *Bombycilla garrulus* (Linnaeus, 1758) and *Mergus merganser* Linnaeus, 1758 they correlated with February, March and JFM indices, in *Regulus regulus* (Linnaeus, 1758) — with January and February indices.

The group of medium-distance migrants had relationship only with JFM index in 3 species (18.8 %). Here appeared the first positive value. Arrival dates of *Motacilla alba* Linnaeus, 1758 and *Turdus philomelos* C. L. Brehm, 1831 correlated negatively, *Haematopus ostralegus* Linnaeus, 1758 — positively.

Long-distance migrants showed the inconsistency of tendencies. Only 8 species (20.5 %, 13 significant coefficients) had correlations. For 5 of them, the positive relationships (1 to 3 values) were found (*Crex crex* (Linnaeus, 1758), *Ficedula albicollis* (Temminck, 1815), *Hirundo rustica* Linnaeus, 1758, *Sylvia communis* Latham, 1787, *Upupa epops* Linnaeus, 1758). Arrival dates correlated with March (4 significant coefficients), April (4) and JFM (1) indices. Two species had negative relationships: *Motacilla flava* Linnaeus, 1758 to March index and *Ficedula hypoleuca* (Pallas, 1764) to April index. In *Streptopelia turtur* (Linnaeus, 1758) arrival dates correlated negatively with March index but positively with May index.

The relationships with NAO indices were much commoner for the short-distance migrants (63.3 % of studied species) than for birds wintering in tropical and Southern Africa (20.5 %) and the intermediate group (18.8 %). Differences of proportions are significant (Fisher Exact Test: $p < 0.001$ and $p < 0.01$, respectively). The group of wintering birds is too small but it is possible to say that these species are closely related in this regard to the arriving short-distance migrants.

The closeness of relationship fluctuated widely. Statistically significant coefficients of correlation ranged in absolute values from 0.35 in *Hirundo rustica* and *Turdus philomelos* to 0.80 in *Remiz pendulinus*. The average absolute values were very close for different groups of species: 0.52 ± 0.02 ($n = 38$) in short-distance migrants, 0.51 ± 0.02 ($n = 8$) in wintering birds, 0.48 ± 0.03 ($n = 12$) in long-distance migrants, 0.39 ± 0.03 ($n = 3$) in medium-distance migrants. The overall mean made 0.50 ± 0.01 ($n = 61$). The average absolute values of negative and positive coefficients were also similar: 0.51 ± 0.01 ($n = 50$; range: 0.35–0.80) and 0.45 ± 0.02 ($n = 11$; range: 0.35–0.62). The difference was not significant.

Hence, the NAO is responsible for 12.2–64.0 % (R^2) of interannual variation in timing of spring migration of 33 bird species in the area of Kaniv Nature Reserve, on average for 25.0 %. Mean values for 4 above mentioned groups: 27.0 %, 26.0 %, 23.0 %, and 15.2 %, respectively.

Discussion

The negative relationship with NAO indices for late winter and early spring means that birds arrived earlier after or during periods with the warm and moist weather. In Central Ukraine, this is a characteristic feature first of all for short-distance migrants. Similar results were obtained in other countries: in Czechia (Hubálek, 2003, 2004; Hubálek & Čapek, 2008), Lithuania (Zalakevicius et al., 2006; Žalakevičius et al., 2009), Estonia (Palm et al., 2009), Northern Europe (Tøttrup et al., 2010;), Belarus (Pinchuk & Karlionova, 2011). Analysis of relationships between first arrival dates of dabbling ducks in Ukraine and NAO indices has shown the presence of statistically significant negative correlations in 4 species of 7 investigated, mainly in early arriving short-distance migrants (Grishchenko, 2014).

On the other hand, many authors did not find considerable differences between short- and long-distance migrants (Forchhammer et al., 2002; Hüppop & Hüppop, 2003; Sokolov & Kosarev, 2003; Vähätalo et al., 2004; Stervander et al., 2005). Furthermore, the opposite tendencies were discovered by the same authors in various observation sites (Jonzén et al., 2006; Rainio et al., 2006). Such instability can be explained rather by the distinctions of conditions in study areas and in migration routes of birds. Investigations have revealed the influence of the latitude on the relation between NAO and phenology of spring migration (Hubálek & Čapek, 2008; Haest et al., 2018). The longitude can also affect it. Observation sites farther eastwards in Europe are located in more continental climate, migration routes of birds are longer. Such contradictions evidence the importance of further investigations of NAO influence on the bird migration.

Reasons of earlier arrival of birds following high NAO winters are comprehensible. Positive values of indices imply better conditions of wintering and an advance of the spring. The warm and moist weather promotes migration. Among other things, westerly flow means the tailwind for birds passing to the east and north-east. The proposed mechanism for the effect of positive NAO values on migration is the improved environmental conditions for migratory progression across Europe in terms of both food availability and the weather (Gordo et al., 2011).

For Central Ukraine this mechanism explains the relationships with NAO in short-distance migrants and in a part of medium-distance ones. Early arriving birds wintering not far from breeding grounds are more dependent on the climate (Dolnik, 1975; Newton, 2008). Therefore, such relation is expected. The migration of long-distance migrants depend more on endogenous factors. Nevertheless, there are statistically significant correlations between NAO indices and first arrival dates of many bird species wintering in Africa to the south from Sahara. In our study 20.5% of species investigated have shown such relationships. Moreover, two opposite tendencies were discovered: positive and negative correlations with the same NAO indices. In that case the mechanism of influence is more complicated.

Timing of the arrival of migrating birds is determined by two factors: the onset of migration and the speed of movement (Gordo et al., 2011). It is known that timing of the departure of birds from the sub-Saharan winter grounds is unaffected by the weather system fluctuation at northern Atlantic latitudes (Both & Visser, 2001). Local factors play the key role. Gordo et al. (2005) showed that temperature and precipitation in Africa are likely to affect departure decision of wintering migrants through food availability and fat reserves. But NAO influences on the passage of trans-Saharan migrants en route. Positive NAO values enhance the migration across Europe but at the same time they are related to decrease in air temperatures and drought in the Mediterranean. They impair ecological conditions in Northern Africa and can delay the migration of birds (Gordo et al., 2011).

The distinction of tendencies in timing of the arrival can arise because of different behaviour of migrants. Their reaction depends on many factors: species-specific attitude to the same weather conditions, location of wintering areas and migration routes, time of migration, etc. The different migration strategy is also important. A part of birds stay in stopover sites waiting out the bad weather but other migrants can hasten the passing over an unfavourable area.

It is supposed that the influence of NAO on bird migration is more pronounced in western and northern parts of Europe (Forchhammer et al., 2002; Hüppop & Hüppop, 2003). Many studies in Southern Europe discovered no effect (Gordo et al., 2011). Tryjanowski et al. (2013) considered using NAO in studies of long-distance migrants breeding in Central and Eastern Europe to investigate relationships between climate and avian phenology as questionable. Our results for Central Ukraine show nevertheless that the effect of NAO on spring migration of birds is felt much more eastwards. Its influence reveals first of all on short-distance migrants but the arrival of long-distance migrants is also affected. For winter visitors, there is the well pronounced tendency to departure earlier after mild winters.

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