Original Research

Study on the First Arrival Date of Spring Avian Migrants to Eastern Poland

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Received: 9 July 2010
Accepted: 23 February 2011

Abstract

First arrival dates of birds to their breeding grounds can be a valuable biological trait reflecting global and local climate changes. Long-term trends in the first arrival dates of 28 common breeding bird species to Gułowskie Forests (eastern Poland) were studied for the period of 1970-2009. Only 6 species studied – Barn Swallow (18 days), Thrush Nightingale (28 days), Lesser Whitethroat (8 days), Golden Oriole (7 days), Common Blackbird (13 days), and Chaffinch (14 days) – demonstrated a statistically significant trend of earlier arrival. Short- and medium-distance migrants arrived significantly earlier (median date: March 22) than studied long-distance migrants (median: April 23).

Keywords: migration, phenology, first arrival dates, migrants, Gułowskie Forests, Poland

Introduction

Numerous species of vertebrates have advanced their phenology in recent decades. Many authors indicate that these processes are related to climate change [1-6]. Processes of advanced phenology are also observed among birds [7-10]. Phenological analyses show that the first arrival dates of birds to their breeding grounds can reflect climate changes.

Studies of the influence of climate change on birds in Europe generally present time series observations from continental edge zones [8, 10-14] that are characterized by avian populations existing in different environmental and climate conditions compared to the rest of the continent. Data related to eastern Europe are rarely published [15-17].

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The aim of this study is to analyze trends in the first arrival date (FAD) of 28 common breeding avian species to Gułowskie Forests (eastern Poland) from 1970 to 2009. These analyses were performed in the context of climatic factors. We tested whether trends in the FAD correlate with local climatic change.

Study Area and Methods

Observations were carried out in Gułowskie Forests (Lasy Gułowskie) (51º43'N, 22º20'E; approximate area of 36 km^2). The climate of Gułowskie Forests during winter and spring is both more stable and continental compared to that of western and central Poland [18, 19]. Following Piotrowicz [20], we defined average winter temperature as the mean temperature from the period of December through January to February, and average spring temperature from March to May. The average winter (December-February) and spring (March-May) temperatures for 1970-2009 were: -1.4ºC and 8.4ºC, respectively. All the temperature data applied in this study originated from the meteorological field station at the Institute of Soil Science and Plant Cultivation in Puławy, about 25 km from the study site.

The first arrival dates (FADs) for 28 common species of nesting birds to Gułowskie Forests from 1970 to 2009 were analyzed. The senior author (Biaduń W.) conducted observations from 1970 to 2009 as part of long-term faunal studies. Observations were started each year, in principle, from March 1 and finished by June 30. Two checks per week were made in optimal habitats for birds. Checks were not possible every day because of logistical reasons, especially in the 1970s and 1980s. Birds were recorded based on sightings and singing, depending on their ecology. There are some gaps in the data for years when a delay occurred in the first recording, or insufficient numbers of later inspections suggested that FADs might be less reliable. In some years data were also missing because particular species such as White Storks *Ciconia ciconia*, Barn Swallows *Hirundo rustica*, and Lapwings *Vanellus vanellus* did not breed in the study area. For some cases the first observations were made too late to stand them as the first arrival dates for particular species.

To find an effective tool for describing climate factors in wide context and known impact on biotas [21], the North Atlantic Oscillation (NAO) index for the winter period (January-March) was employed in the analysis. Data on the North Atlantic Oscillation were obtained from [22]. And winter and spring temperatures were employed to check potential impact on short-distance migrants. In order to check for possible changes in FADs over the past 20 years, the entire study period was arbitrarily divided into two stages: 1970-89 and 1990-2009 for comparison of the initial period of the most recent global warming with the later one. Because some papers [23-25] have suggested that the European climate has become warmer recently, which can lead to shorter snow cover and increase in mean winter temperature of even faster climatic changes compared to the years before.

Bird species were categorized as short/medium and long-distance migrants following Hubalek [7] and Tryjanowski et al. [26]. It is known that missing data values (years with no data) may potentially result in making species' first arrival dates incomparable, because some species may be recorded more times in a period of late arrival than others. To prevent this, adjusted mean FADs were calculated for the entire 1970-2009 period. For this purpose, missing values were estimated by interpolation using a "linear trend in point" procedure included in the statistical package SPSS v. 14.0 (SPSS Inc., Chicago, USA). This procedure was applied separately for each species and means were recalculated. However, the mean FAD differed from the adjusted mean FAD by more than one day for only 3 species (White Stork, Whitethroat *Sylvia communis,* and Thrush Nightingale *Luscinia luscinia*) and so the adjusted mean FADs are not presented. Mean FADs are provided with the ±SD. The FAD for each species was correlated with annual temperatures and NAO winter index value. Trends in FADs were ascertained using standard regression. Median data are presented with ±SE.

Results

Trends in the First Arrival Dates

The analysis of the collected data shows that a majority of the breeding bird species studied did not exhibit a significant acceleration of their arrival date to the Gułowskie Forests between 1970 and 2009 (Table 1). The birds accelerating the date of arrival comprised only 6 (21%) of all 28 analyzed species: Barn Swallow (18 days), Thrush Nightingale (28 days), Lesser Whitethroat *Sylvia curruca* (8 days), Golden Oriole *Oriolus oriolus* (7 days), Common Blackbird *Turdus merula* (13 days), and Chaffinch *Fringilla coelebs* (14 days) showed a significant tendency of advancing their arrival date. The above data were calculated based on the slope of a line (*a*) (Table 1). Among these, the first four are long-distance migrants. A trend of delaying the date of arrival was found only for the Whitethroat (20 days) (Table 1).

Short/medium distance migrants arrived earlier (median data: March 22±0.92) compared to long-distance migrants (median data: April 23±1.04). These differences were found to have high statistical significance according to the Mann-Whitney U test ($Z=14.28$, $n_1=277$, $n_2=192$, $p<0.0001$). Significant differences were also found in the mean FAD between the periods of 1970-1989 and 1990-2009 for 5 of the 6 species, for which a trend of earlier arrival date to the forests was statistically confirmed (Table 1). Significant differences in mean FAD values between both time periods also were found for the short/medium distance migrants (27 March ± 14.8 days vs. 23 March ± 15.8 days) (Table 1), but not for long-distance migrants (22 April ± 14.2 days vs. 19 April ± 14.5 days) (Table 1).

Local temperature had a greater influence on the first arrival date of short/medium distance migrants than that of long-distance migrants. A significant negative correlation was found for mean ambient temperature in January and April and FAD values for the Blackcap. Average ambient temperature in February significantly correlated with first arrival dates of the Robin, Starling *Sturnus vulgaris,* and Chiffchaff *Phylloscopus collybita*. No such dependence was found for March among any of the short/medium distance migrants. The mean winter temperature correlated only with the FAD of the Chiffchaff, while the mean spring temperature was related only to the FADs of the Lapwing and Blackcap (Table 2).

In the case of long-distance migrants, the only significant correlation was found between the FAD of the Icterine Warbler *Hippolais icterina* and January's mean temperature. Such a dependence was also found between the mean April temperature and the Barn Swallow, Common Cuckoo *Cuculus canorus,* and all long-distance migrants examined as a whole (Table 2). None of the first arrival dates of any of the long-distance migrant species reflected a significant relationship to changes in the mean temperature values of spring or winter (Table 2).

Table 1. Means and trends in first arrival date (FAD) in Gułowskie Forests, 1970-2009.

Species		N	Range of time series	Mean FAD	SD (days)	R^2 (%)	*a*	Trend	Student's t-test	
	Short/medium distance migrants								*t*	df
1	Skylark *Alauda arvensis*	24	1970-2008	March 10	10.3	0.02	0.014	0.016	0.337	22
2	Starling *Sturnus vulgaris*	19	1970-2008	March 10	10. 1	0.001	0.011	0.014	0.335	17
3	Lapwing *Vanellus vanellus*	21	1970-2003	March 14	7.9	0.00	0.010	0.014	0.034	19
4	Chaffinch *Fringilla coelebs*	23	1970-2008	March 18	8.3	20.88	-0.357	-0.457**	2.500**	21
5	Common Blackbird *Turdus merula*	22	1971-2009	March 18	11.4	17.60	-0.340	-0.420*	2.341*	20
6	Meadow Pipit *Anthus pratensis*	14	1977-2006	March 21	8.7	6.27	-0.250	-0.250	1.386	12
7	Song Thrush *Turdus philomelos*	25	1972-2008	March 22	9.8	1.38	-0.286	-0. 330	1.179	23
8	Wood Pigeon *Columba palumbus*	18	1973-2000	March 22	0.11	4.84	-0.209	-0.220	1.851	16
9	Pied Wagtail *Motacilla alba*	18	1970-2008	March 28	7.3	0.40	0.063	0.063	1.083	16
10	Black Redstart *Phoenicurus ochruros*	10	1972-2007	March 29	13.5	16.22	-0.401	-0.403	0.986	8
11	Robin *Erithacus rubecula*	19	1972-2006	March 29	6.4	14.12	0.244	0.376	0.950	17
12	Chiffchaff *Phylloscopus collybita*	19	1972-2006	April 5	8.2	3.91	-0.168	-0.198	1.756	17
13	Dunnock *Prunella modularis*	17	1977-2006	April 8	10.3	2.39	0.180	0.155	0.081	15
14	European Serin *Serinus serinus*	13	1972-2007	April 15	12.0	15.01	-0.403	-0.387	0.800	11
15	Blackcap *Sylvia atricapilla*	15	1976-2005	April 25	11.6	6.44	-0.295	-0.254	1.100	13
	Weighted mean of short/medium distance migrants	277	1970-2009	March 25	15.3	0.40	-0.117	-0.063	2.133*	275
	Long-distance migrants									
1	White Stork *Ciconia ciconia*	9	1972-1996	March 31	5.6	2.01	0.088	0.142	0.029	7
2	Woodlark *Lullula arborea*	18	1976-2008	March 23	10.1	0.51	-0.068	-0.071	0.540	16
3	Willow Warbler *Phylloscopus trochilus*	18	1976-2006	April 15	5. 4	0.44	-0.039	-0.070	0.113	16
4	Barn Swallow *Hirundo rustica*	18	1972-2007	April 16	10.5	24.0	-0.512	-0.489**	1.396	16
5	Tree Pipit *Anthus trivialis*	19	1976-2006	April 19	6.1	0.00	-0.001	-0.002	0.584	17
6	Lesser Whitethroat *Sylvia curruca*	13	1973-2005	April 21	4.4	53.28	-0.257	-0.730***	3.264***	11
7	Wood Warbler *Phylloscopus sibilatrix*	15	1973-2005	April 22	5.3	7.64	-0.140	-0.276	0.173	13
8	Pied Flycatcher *Ficedula hypoleuca*	12	1976-2004	April 25	7.9	1.38	-0.089	-0.118	1.354	10
9	Common Cuckoo *Cuculus canorus*	23	1972-2009	April 29	5.3	0. 10	-0.015	-0.031	0.866	21
10	Whitethroat *Sylvia communis*	9	1977-2009	April 29	9.0	52.35	0.626	0.724*	2.021	7
11	Thrush Nightingale *Luscinia luscinia*	9	1972-2003	May 1	10.1	55.42	-0.799	-0.744**	2.428*	7
12	Golden Oriole *Oriolus oriolus*	17	1972-2007	May 4	2.8	76.72	-0.211	-0.876***	5.882***	15
13	Icterine Warbler *Hippolais icterina*	12	1975-2005	May 9	3.9	5.86	-0.098	-0.242	1.776	10
	Weighted mean of long-distance migrants	192	1972-2009	April 20	14.3	0.83	-0.122	-0.092	1.150	190

N – number of years of data, R^2 – regression coefficient, *a* – the slope of a line, *p<0.05, **p<0.02, ***p<0.01.
Student's t-test show effects comparison between mean first arrival date of 1970-89 and 1990-2009 periods.

The relation between the first arrival date of birds and the NAO winter index was analyzed. Four (26.7%) of the 15 short/medium distance migrant species analyzed showed a statistically significant relation between the value of the North Atlantic Oscillation winter index and FAD. Such a correlation was also found when taking the short/medium migrants together as a whole (Table 2). None of the first arrival dates of any of the long-distance migrant species reflected a significant relationship to changes in the values of the North Atlantic Oscillation winter index (Table 2). Additionally, no correlation was found between North Atlantic Oscillation winter index values and mean ambient temperatures of the particular months studied and the mean temperatures of winter or spring. December: (r=0.123, n=38, P=0.459), January: (r=0.103, n=38, P=0.540), February (r=0.208, n=38, P=0.211), March (r=-0.149, n=38, P=0.371), May (r=-0.100, n=38, P=0. 274).

Table 2. Correlation between first arrival date of bird species to Gułowskie Forests and mean monthly air temperatures January-April, and proceeding winters and springs for 1970-2009. NAO January-March North Atlantic Oscillation index.

Species	N	January	February	March	April	Winter	Spring	NAO
Skylark *Alauda arvensis*	24	-0.130	-0.333	-0.099	-0.336	-0.230	0.041	-0.629***
Starling *Sturnus vulgaris*	19	0.093	-0.622***	-0.428	0.443	-0.239	0.056	-0.080
Lapwing *Vanellus vanellus*	21	0.279	0.177	0.379	0.401	0.065	0.491*	-0.362
Chaffinch *Fringilla coelebs*	23	0.325	-0.189	0.022	0.215	0.199	0.058	-0.052
Common Blackbird *Turdus merula*	22	-0.192	-0.116	-0.05	-0.097	-0.125	-0.235	-0.217
Meadow Pipit *Anthus pratensis*	14	0.163	-0.001	0.368	0.141	0.259	0.270	-0.344
Song Thrush *Turdus philomelos*	25	-0.029	-0.251	0.085	0.060	-0.063	0.078	-0.399*
Wood Pigeon *Columba palumbus*	18	-0.009	-0.247	-0.132	0.111	-0.069	0.025	-0.186
Pied Wagtail *Motacilla alba*	18	0.344	0.420	0.287	-0.076	0.325	0.081	0.153
Black Redstart *Phoenicurus ochruros*	10	-0.368	-0.182	0.538	-0.063	- 0.302	0.565	-0.478
Robin *Erithacus rubecula*	19	-0.578	-0.484*	-0.164	0.374	-0.242	0.091	-0.474*
Chiffchaff *Phylloscopus collybita*	19	-0.253	-0.477*	0.101	-0.413	- 0.494*	0.054	-0. 200
Dunnock *Prunella modularis*	17	-0.032	-0.391	-0.383	0.252	-0.221	0.144	-0.797***
European Serin *Serinus serinus*	13	-0.480	-0.078	0.155	-0.166	-.0277	-0.058	-0.286
Blackcap *Sylvia atricapilla*	15	-0.597**	-0.280	-0.316	-0.488*	-0.383	-0.582*	0.263
All short/medium distance migrants	277	0.016	-0.082	0.058	0.044	0.003	0.007	-0.166***
White Stork *Ciconia ciconia*	9	0.355	-0.202	-0.214	0.487	-0.053	0.080	-0.443
Woodlark *Lullula arborea*	18	0.143	0.145	0.243	0.176	0.193	0.214	-0.359
Willow Warbler *Phylloscopus trochilus*	18	-0.294	-0.135	-0.434	-0.218	-0.278	-0.383	-0.190
Barn Swallow *Hirundo rustica*	18	-0.369	0.119	0.087	-0.524*	-0.284	-0.238	-0.317
Tree Pipit *Anthus trivialis*	19	-0.065	0.087	0.185	-0.087	0.108	0.044	0.118
Lesser Whitethroat *Sylvia curruca*	13	-0.056	-0.021	-0.062	-0.422	0.181	-0.434	0.174
Wood Warbler *Phylloscopus sibilatrix*	15	-0.264	0.173	0.161	0.044	0.002	0.011	-0.216
Pied Flycatcher *Ficedula hypoleuca*	12	-0.416	-0.038	0.057	-0.078	-0.500	0.0813	0.001
Common Cuckoo *Cuculus canorus*	23	-0.039	-0.144	0.022	-0.439*	-0.127	-0.174	0.326
Whitethroat *Sylvia communis*	9	-0.003	0.171	-0.431	0.426	-0.083	0.057	0.614
Thrush nightingale *Luscinia luscinia*	9	-0.200	-0.289	0.033	-0.310	-0.500	-0.214	0.185
Golden Oriole *Oriolus oriolus*	17	-0.143	-0.118	0.369	-0.339	0.020	-0.148	-0.383
Icterine Warbler *Hippolais icterina*	12	-0.646*	-0.410	-0.310	-0.277	-0.538	-0.354	-0.161
All long-distance migrants	192	-0.033	0.041	0.092	-0.147*	-0.029	0.009	-0.080

N – number of years of data. *p<0.05, **p<0.02

Discussion

Novel studies have tended to show changes in the first arrival date to breeding grounds of many bird species, both short/medium and long-distance migrants [12, 23-25]. However, our study carried out in Gułowskie Forests only partially reflected these processes. Our research shows that only 6 (21%) of the 28 studied species exhibited a significantly earlier arrival to breeding sites 1970-2009. However, Whitethroat delayed statistically its arrival. This is an adequate time series to ascertain such a tendency [12, 13].

Short/medium distance migrants arrive on average 25 days earlier than long-distance migrants. This difference was 20 days for other studies in eastern Poland [17]. Non-passerine species breeding in the Zuvintas Biosphere Reserve during 1966-2000 exhibited a 24-day difference [26]. Other data from Lithuania [9] indicated 32 days as the average difference between the arrival dates of 16 short/medium migrant species and 24 long-distance migrant species.

Other studies, especially those from the verge areas of Europe along the continent's coast, clearly show a much higher percentage of birds arriving earlier to breeding sites in recent decades than the results we obtained. Sokolov [27] indicated that as many as 26 (62%) of 42 passerine birds shifted to earlier spring migration dates in the past two decades. Hüppop and Hüppop [28] presented data where an even greater proportion: 17 (71%), of 24 of species studied showed a statistically significant tendency of earlier spring passage. Zalakevicius et al. [9] indicated that as many as 28 (70%) of the 40 bird species studied in the environs of Vilnius (Lithuania) demonstrated significant trends of earlier arrival in spring from 1971 to 2004. This is almost the same time series as presented in our research. They examined 26 of the species from our study (Common Blackbird and Dunnock *Prunella modularis* being the exceptions). There, as in the case of birds from Gułowskie Forests, a statistically significant trend of earlier arrival was found for Barn Swallow, Lesser Whitethroat, Thrush Nightingale, and Golden Oriole. Among the birds studied in Lithuania that also are included in our research, only 7 did not exhibit trends of a quicker arrival to breeding grounds. These were: Chaffinch, Pied Wagtail *Motacilla alba*, Robin *Erithacus rubecula*, European Serin *Serinus serinus*, Woodlark *Lullula arborea*, Pied Flycatcher *Ficedula hypoleuca*, and Icterine Warbler. Another Lithuanian study on first arrival dates of non-passerine species in the Zuvintas Biosphere Reserve showed that earlier arrival was statistically significant for 10 (83.3%) of 12 studied short-distance migrants and for 5 (62.5%) long-distance migrants of 8 studied. Croxton et al. [12] showed first arrival date trends for 25 bird species observed from southwestern UK from 1982 to 2005. Among the species studied there, up to 25% were arriving significantly earlier. Rubolini et al. [13] analyzed trends for the period of first arrival dates from 1982 to 2006 for four long-distance migrants. Two, the Swift *Apus apus* and Barn Swallow, showed significant trends of earlier arrival to breeding grounds.

North Atlantic Oscillation (NAO) may be seen as a proxy for regulating forces in aquatic and terrestrial ecosystems. Available data suggests that the NAO influences ecological dynamics in both marine and terrestrial systems, and its effects may be seen in variation at the individual, population, and community levels. The ecological responses to the NAO encompass changes in timing of migration and reproduction [29, 30]. Using a time series of 1983-2003, 10 (33%) of 30 spring migrants were found to have trends of earlier arrival to their breeding areas in the Wielkopolska region of Poland (western Poland) [31]. This region is characterized by a less stable and warmer climate due to the greater impact of the North Atlantic Oscillation on air temperature as compared to eastern Poland [18, 19, 23]. We are aware that the biological interpretation of the above-mentioned differences in FAD between our results and results from other studies is very difficult. Different time periods were analyzed, and not the same species were considered. Therefore, the difference might be caused by geography (continental vs. coastal Europe), but it might also be caused by different time series and species analyzed with no biological difference.

Among the short/medium distant migrant species we studied, only 26.7% reflected an influence of the NAO winter index. And none of the long-distance migrant species' FAD reacted to changes in the NAO winter index. Researchers also have noticed that in Central Europe, the NAO winter index values can strongly influence the arrival dates of short/medium distance migrants to breeding areas compared to those of long-distance migrants. Zalakevicius et al. [32] reports a significant negative dependence between NAO winter index values and mean arrival dates for all 12 short/medium distance migrants and 3 of the 4 long-distance migrants in the Zuvintas Reserve. Their data [32] also showed a significant negative relation between mean winter air temperature and mean arrival dates for all 12 short/medium distance migrants and 3 of the 8 long-distance migrants considered in this case from the Zuvintas Reserve (Lazdijai environs).

In analyzing data on FADs of birds from southern Moravia (Czech Republic), Hubálek [33] took the stand that NAO conditions, especially in February and March, have a profound effect on many early spring migrants that usually winter in western Europe or Mediterranean areas. On the other hand, the NAO did not significantly affect the timing of arrivals of long-distance migrants with winter grounds largely in sub-Saharan Africa.

Jonzén et al. [8] also showed that European short-distance migrants wintering in temperate areas have been assumed to be more affected by climate changes in Europe than long-distance migrants wintering in tropical areas. However, they showed that long-distance migrants advanced their spring arrival to the Scandinavia Peninsula more than short-distance migrants. By analyzing a long-term data set from Italy, they showed that long-distance migrants also pass through the Mediterranean region earlier. They argue that this may reflect a climate-driven evolutionary change in the timing of spring migration and we can interpret our data in the light this hypothesis.

In summary, we believe that despite some expressed reservations [34], FADs and first egg laying dates continue to be important biological variables for detecting effects of climate change on avian phenology. And our observations confirm other studies [26, 28, 35] showing that changes in bird arrival dates are more explicit at the continental margins of Europe and the British Isles than in the interior of the continent. Our results suggest that the border based on climactic factors dividing Europe into two areas may run through Poland. The first is the verge zone (connected to the seas), where a high proportion of birds have accelerated their arrival dates to breeding grounds typical of western Europe and also noted in western Poland [5, 31]. The second area is where arrival dates have been more stable over the past decades and are less prone to fluctuation. This is typical for the heartland of Europe and its eastern parts [15]. It has also been noted for eastern Poland [17]. Our findings from eastern Poland correspond to those of Wesołowski and Maziarz [36] on first arrival dates of the Wood Warbler to Białowieża Forest (NE Poland), where even though temperatures of the arrival period (the second half of April) rose, neither males nor females significantly advanced their arrival date over 30 years.

Despite the fact that birds may be affected by climate change occurring not only at their destination sites but also along migration routes as well as at winter grounds [8, 32, 37, 38], the results of our analyses show a certain stabilization in first arrival dates to the breeding grounds of birds in eastern Poland.

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