

CLIMATIC INFLUENCE ON YEAR-TO-YEAR VARIATION IN TIMING OF MIGRATION AND BREEDING PHENOLOGY IN PASSERINES ON THE COURISH SPIT

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ABSTRACT

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Long-term monitoring of the timing of spring and autumn migrations, breeding and juvenile dispersal in various birds species on the Courish Spit (the Baltic Sea) showed that during two decades (1960s and 1980s) early migration and breeding prevailed, and during two other decades (1970s and 1990s) late migration and breeding were recorded more frequently. A comparison of timing of spring migration, hatching date and timing of juvenile dispersal with mean monthly temperatures showed a significant relationship between this seasonal events and the temperature (primarily in April and May) in many species. On the basis of the presented material the following conclusions were derived. In eastern Baltic, some long-term trends in the timing of spring and autumn migrations, breeding and juvenile dispersal occurred over the 20th century in passerines. These trends were caused primarily by climate fluctuations in the northern hemisphere. Warming in the 1960s and 1980s led to significant shifts in mean arrival dates, timing of breeding and autumn migration towards earlier dates. Conversely, colder periods, especially in spring, during the 1970s and partly in the 1990s caused a shift towards later migration and breeding as well in short- as in long-distance migrants.

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INTRODUCTION

Recently, long-term trends in the timing of spring and autumn migration have been reported for a number of bird species in Europe. Some researchers suggested that these trends could be explained primarily by climatic fluctuations in the northern hemisphere (Moritz 1993, Mason 1995, Vogel and Moritz 1995, Berthold 1996, Bairlein and Winkel 1998, Moss 1998).

Much information concerning timing of breeding in many bird species has been published, but the results of long-term monitoring (over 10 years) are presented infrequently (Kania 1994).

A number of authors suggests that in short-distance migrants (in contrast to those migrating longer distance), the onset of autumn departure may be to a large extent shaped by the weather (Curry-Lindahl 1975, Alerstam 1990). However, the impact of the weather on the onset of autumn migration is insufficiently studied.

Such data have been collected at the Biological Station Rybachy by a long-term trapping project (from 1958 up to now) in an area very favourable for migration and breeding research. This study may give some new insights into the pattern of the most important phases of the annual cycle in passerines, as well as into the influence of external and endogenous factors on the regulation of the natural populations.

MATERIAL AND METHODS

Annual trapping of migrating and breeding passerines has been done using Rybachy-type traps. Traps have been oriented along the NE-SW axis, which corresponds to the main direction of migration in the Baltic region. The trapping was conducted from 1 April to 1 November, although in some years it started in late March. The timing of spring migration was characterised by the mean trapping date in the traps during the period between 1 April and 1 June (Sokolov *et al.* 1998). The arrival date of local birds was defined as the date of first capture of birds ringed in the study area in previous years. The timing of autumn migration was characterised by the mean trapping date in the traps during the period between 15 August and 1 November (Sokolov *et al.* 1999). Weather data were analysed in Kaliningrad Region, as well as in other sites in European Russia (from Smolensk to Kola Peninsula). Mean monthly air temperatures were included in the analysis (Sokolov *et al.* 1998).

Average hatching dates were used as estimates of timing of birds breeding. Timing of juvenile dispersal was estimated on the basis of trapping in large traps. The dates of first catches and the average trapping dates of the young birds of local origin (trapped before 15 August) were used (Sokolov and Payevsky 1998). For the analysis of temperature influence on the breeding phenology, average spring and summer air temperatures were used. Correlation analysis was conducted to reveal relationships between timing of migration, breeding, dispersal, and air temperature (Lloyd and Ledermann 1984).

RESULTS

Timing of spring migration

The analysis of dates of the first captures and the mean dates of spring migration in 33 species revealed the fact that the earlier a species migrates through the Cour-

ish Spit, the greater is the inter-annual variation in the timing of passage (Busse 1974, Sokolov *et al.* 1998). The annual fluctuations in the mean arrival dates did not depend on the length of migratory route. In some long-distance migrants that arrive considerably early, the fluctuations of the mean passage date are significant (Fig. 1B).

In the early migrants (arriving in April), two decades were recorded (1960s and 1980s) when earlier migration prevailed, and two decades with late migration (1970s and 1990s). In migrants that arrive late (in May), only one period with early migration was recorded (1980s), except for the very late migrants, in which no trends were found (Fig. 1B). The analysis revealed that the average timing of spring

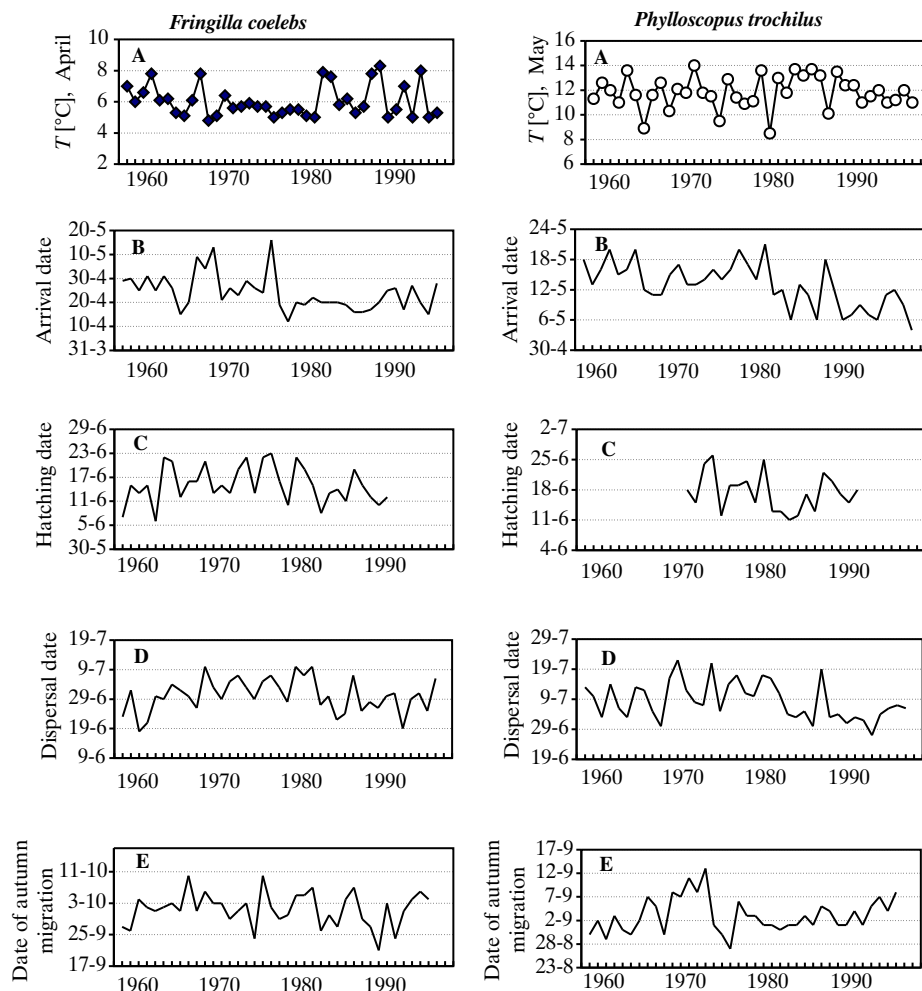


Fig.1. Changes of mean monthly air temperature in spring (A), arrival date (B), hatching date (C), date of post-fledging dispersal (D) and date of autumn migration of young birds of medium-distance migrant – Chaffinch (*Fringilla coelebs*) and long-distance migrant – Willow Warbler (*Phylloscopus trochilus*) on the Courish Spit.

migration in many species was significantly earlier in the 1960s and 1980s compared to the 1970s and 1990s (Sokolov *et al.* 1998).

A comparison of the timing of spring migration in 15 species with the mean monthly temperatures showed a significant relationship between the mean arrival date and the mean temperature in 9 species that migrate primarily in April and May (Table 1). Higher temperatures in these months were associated with earlier migration as well in short- as in long-distance migrants. An analysis of year-to-year fluctuations in mean April temperatures in the Kaliningrad Region revealed two significant rises in the temperature – in the 1960s and 1980s (Fig. 1A). Mean May temperature was increasing only between 1974 and 1986. Mean temperatures in our region were well correlated with similar data from various Russian sites (from Smolensk to Kola Peninsula) in April and May (Sokolov *et al.* 1998). In these spring months, similar weather conditions dominate a large area, at least from Belarus and Poland to Finland and Kola Peninsula.

Table 1

Correlation between mean dates of spring and autumn migrations, hatching dates, timing of juvenile dispersal (mean date of five first captures of juveniles) and air temperature in spring and in summer on the Courish Spit (Spearman's rank correlation coefficient; + $-p < 0.10$, * $-p < 0.05$, ** $-p < 0.01$, *** $-p < 0.001$)

	Period	N (years)	t (°C) April	t (°C) May	t (°C) June
<i>Parus major</i>	spring	32	-0.01		
	summer: Pull.	20	-0.42+	-0.58*	-0.53*
	summer: Juv.	32	-0.67***	-0.27	0.01
	autumn	32	-0.26	-0.26	-0.31+
<i>Parus caeruleus</i>	spring	32	-0.10		
	summer: Juv.	32	-0.63***	-0.07	-0.33+
	autumn	32	-0.27	-0.17	-0.08
<i>Erithacus rubecula</i>	spring	32	-0.35*		
	summer: Juv.	32	-0.39*	-0.33+	0.04
	autumn	32	-0.39*	-0.21	-0.31+
<i>Fringilla coelebs</i>	spring	32	-0.03	-0.37*	
	summer: Pull.	29	-0.40*	-0.66***	-0.22
	summer: Juv.	32	-0.63***	-0.40*	-0.18
	autumn	32	-0.38*	-0.35*	-0.17
<i>Phylloscopus collybita</i>	spring	32	-0.58**	-0.06	
	summer: Juv.	32	-0.40*	-0.19	0.21
	autumn	32	-0.33+	-0.15	-0.36*
<i>Anthus trivialis</i>	spring	32	-0.42*	-0.34	
	summer: Juv.	32	-0.60***	-0.22	-0.21
	autumn	32	-0.37*	-0.19	-0.16
<i>Phoenicurus phoenicurus</i>	spring	32	-0.68***	-0.30	
	autumn	32	-0.39*	-0.15	-0.02

	Period	N (years)	t (°C) April	t (°C) May	t (°C) June
<i>Phylloscopus trochilus</i>	spring	32	-0.30	-0.72***	
	summer: Pull.	20	-0.28	-0.61**	-0.03
	summer: Juv.	32	-0.63***	-0.49**	-0.24
	autumn	32	-0.44*	-0.12	0.16
<i>Phylloscopus sibilatrix</i>	spring	32	0.17	0.04	
	summer: Pull.	18	-0.61*	-0.49*	0.12
	summer: Juv.	32	-0.68***	-0.46**	-0.19
	autumn	32	-0.33+	-0.06	-0.20
<i>Ficedula hypoleuca</i>	spring	32	-0.26	-0.60***	
	summer: Pull.	20	-0.45*	-0.59**	-0.23
	summer: Juv.	32	-0.59***	-0.46**	-0.13
	autumn	32	-0.27	-0.01	-0.19
<i>Sylvia atricapilla</i>	spring	32	-0.01	-0.60***	
	summer: Pull.	18	-0.40+	-0.26	-0.02
	summer: Juv.	32	-0.46**	-0.62***	0.01
	autumn	32	-0.08	-0.10	-0.14
<i>Sylvia curruca</i>	spring	32		-0.35*	
	summer: Pull.	20	-0.45*	-0.33	-0.37
	summer: Juv.	32	-0.56**	-0.16	-0.06
	autumn	32	-0.30+	-0.08	0.06
<i>Sylvia communis</i>	spring	32		-0.05	
	summer: Pull.	16	-0.07	-0.38	-0.62*
	summer: Juv.	32	-0.68***	-0.39*	-0.05
	autumn	32	-0.30+	-0.23	-0.09
<i>Sylvia borin</i>	spring	32		0.13	
	summer: Pull.	20	-0.16	-0.51*	-0.26
	summer: Juv.	32	-0.60***	-0.50**	-0.09
	autumn	32	-0.18	0.04	-0.16
<i>Hippolais icterina</i>	spring	32		0.07	
	summer: Pull.	16	-0.24	-0.34	-0.28
	summer: Juv.	32	-0.68***	-0.43*	-0.06
	autumn	32	-0.19	-0.28	-0.16

Timing of breeding

First, it was necessary to find out whether catching during the period of juveniles dispersal can be used to estimate the timing of breeding. If so, it would be possible to estimate the timing of breeding in a number of species over four decades, as large traps supplied data on the timing of juvenile dispersal over this period for more than 30 passerine species. A significant positive correlation between the average hatching dates and the mean catching dates of local juveniles in stationary traps on the Courish Spit was revealed in 10 bird species (Sokolov and Payevsky 1998). This relationship suggests that early hatching is followed by earlier post-fledging movements (Fig. 1C-D). Thus, the timing of juvenile dispersal may be used for estimation of the timing of breeding in migratory and sedentary species.

An analysis of the annual fluctuations of average dates of the first five catches and of all the catches in 19 species revealed a trend towards later breeding in the 1970s and 1990s compared to the 1960s and 1980s (Fig. 1D).

We compared the timing of breeding and juvenile dispersal in 36 species with the monthly average temperatures in spring and summer (Sokolov and Payevsky 1998). Early arriving species showed a significant negative correlation with the average March and April temperatures, as did late arriving long-distance migrants with the mean temperatures of April and May (Table 1). In two of the earliest breeders – Crossbill (*Loxia curvirostra*) and Siskin (*Carduelis spinus*), similar relationships with February and March temperatures were found (Sokolov and Payevsky 1998). For some species, a relationship with the temperature of June was revealed (Table 1).

Five species showed a positive correlation between the arrival dates and the timing of juvenile dispersal. This suggests that in years, when these species arrive early, they start breeding earlier, what causes earlier juvenile dispersal. No such relationship was revealed in birds arriving late – the timing of their breeding and juvenile dispersal showed no correlation with the timing of arrival (Sokolov and Payevsky 1998).

Timing of autumn migration

The question arises: did the early breeding of the populations lead to a shift in the timing of the autumn migration? In some species, a more significant shift of autumn migration towards earlier period was recorded in the 1960s and 1980s compared to the 1970s (Fig. 1E). A positive relationship was found, *i.e.* the earlier breeding was followed by the earlier migration through the Courish Spit (Sokolov *et al.* 1999).

A comparison of the timing of autumn migration in 15 species with the mean monthly temperatures showed a significant relationship between the mean dates of migration and the mean temperatures of April and May other than correlation with autumn temperatures in majority of species (Table 1). Higher spring temperatures were associated with earlier autumn migration.

The analysis of relationships between the timing of autumn migration of young birds and the ambient temperature revealed a significant negative correlation with August values for the Chaffinch (*Fringilla coelebs*) and Brambling (*F. montifringilla*). In not a single species there was a correlation with September or October temperatures recorded (Sokolov *et al.* 1999).

In nine species out of 13 studied, a significant or nearly significant correlation between the timing of autumn passage of northern populations and the timing of post-fledging movements of local juveniles was revealed (Sokolov *et al.* 1999). This relationship was found in both short- and long-distance migrants.

The mean dates of autumn migration did not show higher variation for the short-distance migrants than for those migrating longer distances, although such situation occurred in the spring (Sokolov *et al.* 1999).

DISCUSSION

On the basis of our own data and available literature we concluded that over the 20th century some long-term trends in the timing of spring bird migration occurred, especially in passerines (Sokolov *et al.* 1998). These trends were caused primarily by climate fluctuations in the northern hemisphere. Warming in the 1930s-1940s, and then in the 1960s and 1980s led to significant shifts in the timing of spring migration towards earlier dates. Conversely, colder periods during the 1950s, 1970s and partially 1990s, caused later passage. Climate change influenced the migration of species wintering both within Europe and in Africa. However, this does not mean that the onset of spring migration from Africa occurred earlier. Onset of migration is thought to be stable, controlled primarily by endogenous stimuli (Dolnik 1975, Berthold 1996, Gwinner 1996). More likely, the progress of passage within Europe was affected. It has been suggested that unfavourable weather conditions in spring may result in arrested migration (Alerstam 1990, Raudonikis 1990), whereas early warm spring conditions may be a stimulus to migration in Europe.

Our data suggest that the long-term trends in the timing of breeding and dispersal for migratory passerines that were recorded in the 20th century, were also caused mainly by climatic fluctuations in the northern hemisphere (Sokolov and Payevsky 1998). These fluctuations occurred in the form of inter-annual variations of spring air temperatures and various phenological events, including the timing of spring migration and breeding. We would like to emphasise the following. The rising of spring temperatures in the 1960s and 1980s caused not only a significant shift towards earlier spring migration, but also towards earlier breeding and juveniles dispersal or even earlier autumn migration in many passerines in Europe. Colder periods in the 1970s and partly in the 1990s caused a shift towards later migration and breeding in both short- and long-distance migrants.

Some authors believe that highly variable timing of autumn migration in short-distance migrants, in comparison with those migrating over large distances, is explained by the impact of unpredictable weather conditions. Our data do not confirm higher variation in the mean date of autumn migration for the short-distance migrants (Sokolov *et al.* 1999). Variation is roughly the same in both groups. In spring, we indeed recorded higher variation in short- and medium-distance migrants, as opposed to long-distance migrants (Sokolov *et al.* 1998). This is caused by earlier arrival of birds that spend their winter within Europe, when temperature is variable and unpredictable.

The prognosis of future trends in the timing of migrations and breeding phenology in birds in Europe and in other regions depends on the forecast of future climatic change. If climate in the northern hemisphere is getting warmer, then spring migration, breeding and autumn migration will occur earlier. A colder climate will result later arrival, breeding and departure of birds in our region.

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