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Spring migration timing of *Sylvia* warblers in Tatarstan (Russia) 1957-2008

Research Article

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Abstract: The timing of when migrant birds return to breed is a key component of studies of the impact of climate change upon bird populations. However, such data are not distributed evenly across the World, and in the Northern Hemisphere are underrepresented in Asia and the east of Europe. Therefore, to help rectify this bias, we analysed first arrival dates (FAD) of four species of *Sylvia* warblers (Blackcap *Sylvia atricapilla*, Whitethroat *S.communis*, Lesser Whitethroat *S.curruca* and Garden Warbler *S.borin*) collected in the Tatarstan Republic of Russia between 1957 and 2008. Over the whole period the species returned to their breeding sites between three and six days earlier; these trends were significant except for Whitethroat. Advances in arrival were especially apparent in the two earlier species, Blackcap and Lesser Whitethroat, mainly because local temperatures for March had risen substantially. Except for Whitethroat, FADs were significantly related to temperatures in the African wintering ground and/or in Tatarstan. Whilst significant correlations occurred between FADs of some of the species, there was considerable variability in these relationships indicating a species-specific response to rising temperatures. Changes in FADs in this eastern extremity of Europe were smaller than in Central and Western Europe.

Keywords: *Arrivals • Co-fluctuation • Phenology • Temperature • Russia • Sylvia • Wintering areas*

1. Introduction

The timing of when migrant birds return to their breeding area is a key component of studies of the impact of climate change upon bird populations [1-3]. Moreover, research on the arrival timing of birds from wintering grounds to breeding locations is an important component of many phenological studies [1]. However, a geographical bias exists in studies on bird phenology; the majority of which being conducted in Western Europe or North America [2,3].

In general, spring arrival dates of birds to their breeding areas have been shown to correlate with local temperatures, as well as with temperatures on migratory routes and in wintering grounds [1,4,5]. However, in some parts of the world temperature has not increased significantly or has increased only in periods (months) of relatively minor importance to the migration of birds. A previous study on *Phylloscopus* warblers [6] suggested

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that changes in winter conditions may stimulate some long-term changes in arrival pattern, even if springtime temperature changes in the breeding grounds were small. Other recent studies suggest that temperature in the wintering grounds and along migratory routes may affect bird populations, even if the temperature in breeding areas has not changed very much [7]. The extent to which migration phenology is affected by climate warming is thus likely to be influenced by the timing and magnitude of change in the three zones (wintering, passage, breeding) experienced by each species. Furthermore, earlier arrival at breeding grounds may have no advantages, and may even be detrimental, unless plant and insect development there had advanced sufficiently to permit earlier breeding.

In the current paper we extend the geographical coverage of migration phenology studies by examining data from one location in central Euroasia surrounding Kazan in the Tatarstan Republic (Russia). At this location, increases in spring temperature have not been as obvious as other regions from which phenological shifts have been reported [2,3]. We studied four species of warblers from the genus *Sylvia* which are common in Tatarstan [8,9]. All these species are long-distance migrants with wintering areas in Africa (for maps of distributions and basic biological information see [10,11]) and data were collected over a 52 year study period. Therefore, this study provides a great opportunity to test co-fluctuations between morphologically and habitat-similar bird species. If conditions on wintering grounds are important (as we assume, see above and [1,4,5]), and provide a clear environmental signal to commence migration from Africa to their breeding grounds, the warblers should show similar arrival patterns [12, but see also 13].

In this paper we (1) document changes in the arrival timing of four *Sylvia* warblers in the 1957-2008 period, (2) identify relationships between timing of arrival and air temperature in the breeding site in Tatarstan, and in the wintering areas and (3) examine the co-fluctuations between the arrival timing of the four studied species.

2. Experimental Procedures

Observations of birds were carried out in the Kazan region of the Tatarstan Republic, Russia. This region covers a large area of c. 2500 km^2 around the city of Kazan (55°45′ N, 49°08′ E), and includes various habitats, such as sub-taiga coniferous–deciduous mixed forests, farmland, rivers, lakes, and human settlements. Between 1925 and 2004 the average annual temperature of Kazan was 3.6°C and monthly mean temperatures ranged from -12.1°C in January to 19.4°C in July. The lowest temperature recorded in our study period was -52°C, and the maximum 39°C. Average annual precipitation was *c.*530 mm and snow cover lasted for 141–164 days.

From 1957–1979, dates of the observations of the first occurrence of *Sylvia* warblers (for English and scientific names see Table 1) were recorded by Kazan scientists (V.A. Popov, B.V. Nekrasov, R.A. Zatcepina, A.V. Popov, V.G. Ivliev) and these records were extracted from the archive of the former Laboratory of Biomonitoring at the Institute of Natural Systems Ecology, now the Institute of Problems in Ecology and Mineral Wealth. Some data were published in [8]. Observations from 1980 to 2008 were continued by two of the authors (I.A. and O.A.) of this paper who were originally students of the previous recorders. It is considered that recorder effort and bird populations were relatively constant over the study period, although exact details are not known for the whole period. In just four cases first arrival dates are absent because recorders considered that they had missed the first arrivals. Data are included in the appendix.

Temperatures for January to May immediately south of Kazan (50-55°N, 45-55°E; 2 grid squares) and in the likely wintering grounds in Africa (0-15°N, 10-40°E; 18 grid squares) were extracted from the CRUTEM2v dataset (www.cru.uea.ac.uk/cru/data/). This dataset summarises monthly temperatures globally in 5°x5° grid squares as anomalies from the 1961-1990 average. In the case of our African temperatures some data (17% overall) were missing and an adjusted mean value was calculated using least squares methods; essentially a two way ANOVA with i) 5° grid square and ii) year/month combinations as the two factors.

Calendar dates of first arrivals were transformed into days after December 31 (e.g. 1 for 1 January *etc.*) prior to analysis. Trends were calculated by regression of day number on year, and correlations with and regressions on monthly mean temperature (African temperatures for February to April and Tatarstan temperatures for March to May) were used to examine for temperature influences. All statistical analyses were conducted using MINITAB v.15.

3. Results

3.1 Arrival date

All four studied warblers arrived in Tatarstan, on average, in the first half of May, and three of the species significantly advanced their first arrival dates over

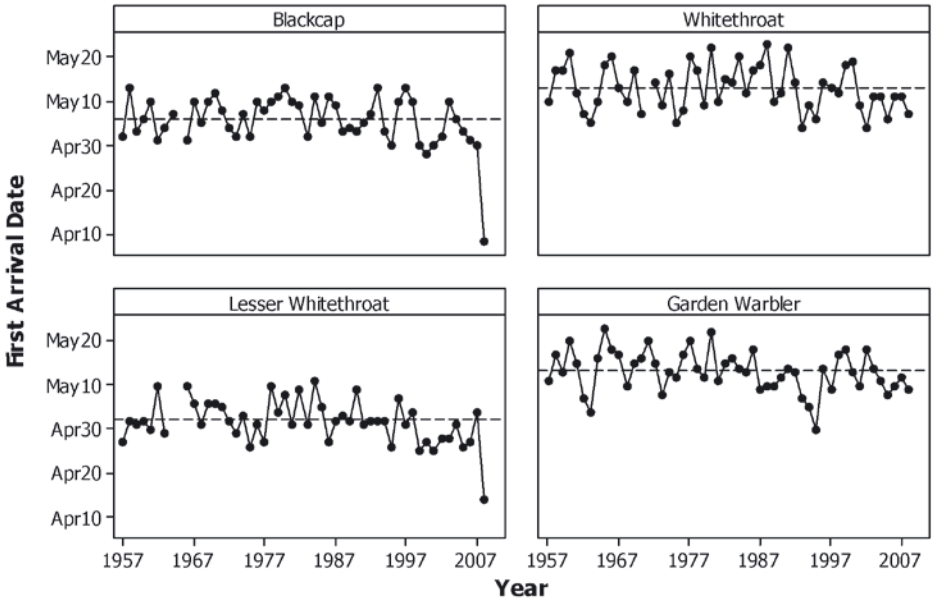

Figure 1. Patterns of first arrival dates of the four *Sylvia* warblers 1957-2008. Horizontal lines represent mean dates.

Common name	Scientific name	Mean	SD	n	b±SE	P
Blackcap	*Sylvia atricapilla*	May 6	5.8	51	-0.115±0.052	0.032
Whitethroat	*Sylvia communis*	May 13	5.2	51	-0.058±0.048	0.233
Lesser Whitethroat	*Sylvia curruca*	May 2	5.0	50	-0.117±0.045	0.012
Garden Warbler	*Sylvia borin*	May 13	4.6	52	-0.086±0.041	0.040

Table 1. Mean and standard deviation (SD) of first arrival dates, numbers of years of records (n), trends over time (slope from regression analysis, b±SE) and the significance of trends (P) of four *Sylvia* warblers in Tatarstan over the period 1957-2008.

the whole study period (Figure 1, Table 1). It may be worthy of note that for the single species yielding a nonsignificant trend, Whitethroat, the most recent eight years of observations were all earlier than the average date. However, the changes may be driven by the year 2008, when two species were recorded exceptionally early: Blackcap 20 days, and Lesser Whitethroat 11 days, earlier than anything previously recorded. The local temperature anomaly for March 2008 was 7.1°C higher than the 1961-1990 mean. However, rank correlation of first arrival date on year (to downweight the influence of 2008) yielded significance levels of 0.087, 0.27, 0.033 and 0.029 for the four species listed in Table 1.

3.2 The influence of temperatures

An examination of southern Tatarstan March temperatures in the 1957-2008 period revealed a consistent trend towards warmer conditions (b=0.066, P=0.021) by an estimated 3.4°C over the 52 years. There was also a significant increase in January temperature (b=0.080, P=0.025) equating to 4.2°C over 52 years. There was no significant change in February (b=0.041, P=0.20), April (b=0.025, P=0.31) or May (b=-0.010, P=0.57) temperatures. Wintering area temperatures for the months January to May rose significantly in each case and the estimated warming over 52 years and significance were as follows: January 0.8°C (b=0.016, P=0.031), February 1.7°C (b=0.033, P<0.001), March 1.5°C (b=0.028, P<0.001), April 1.9°C (b=0.036, P<0.001 and May 1.2°C (b=0.024, P<0.001). The increased level of significance despite lower temperature increases is undoubtedly due to the signal to noise ratio for the African temperatures being improved by averaging over 18 5° x 5° grid boxes rather than just the two for southern Tatarstan. Correlations between first arrival dates and mean monthly temperatures are shown in Table 2. Figure 2 shows the relationship with local temperatures for the most significant month. Blackcap arrivals were significantly negatively correlated with African March temperatures and with Tatarstan March and April temperatures. Whitethroat arrivals were not significantly correlated with any of the examined

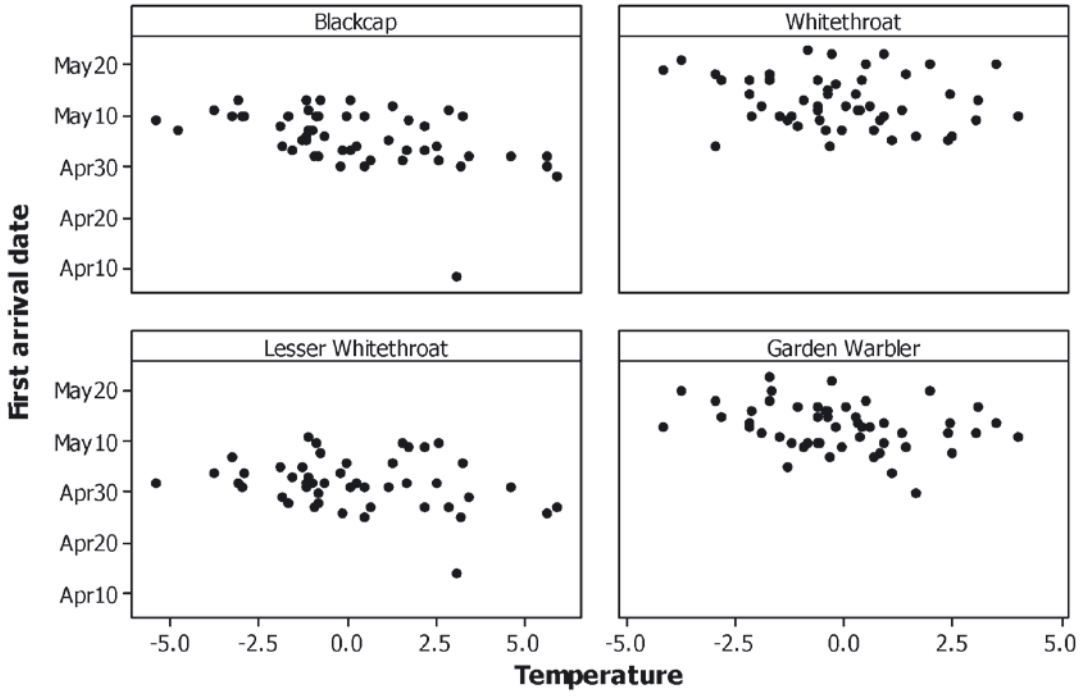

Figure 2. Relationships between first arrival date and local temperatures. For each species the most significant month was used (Blackcap, Lesser Whitethroat – April; Whitethroat, Garden Warbler – May). Temperatures are anomalies in °C from the 1961-1990 mean.

	Central Africa			Southern Tatarstan		
	Feb	Mar	Apr	Mar	Apr	May
Blackcap	-0.13	-0.29 *	-0.14	-0.45 **	-0.47 ***	0.03
Whitethroat	-0.03	-0.14	-0.08	-0.21	-0.10	-0.20
Lesser Whitethroat	-0.21	-0.34 *	-0.24 +	-0.19	-0.29 *	0.04
Garden Warbler	-0.03	-0.19	-0.12	-0.17	-0.17	-0.30 *

Table 2. Correlations between first arrival dates and mean monthly temperatures. Sample sizes as Table 1. *** P<0.001, ** P<0.01, * P<0.05, + P<0.1

months. Lesser Whitethroat was significantly negatively correlated with African March and Tatarstan April temperatures and Garden Warbler was only significantly correlated (negatively) with Tatarstan May temperatures. Table 3 summarises a forwards stepwise regression with African temperatures for February to April and Tatarstan temperatures for March to May as potential explanatory variables. Only for Blackcap and Lesser Whitethroat were models with more than one explanatory variables created. In both cases the magnitude of the coefficients of the African temperatures were greater than those for Tatarstan.

3.3 Co-fluctuation among species

Figure 3 shows the relationships between first arrival dates of the four species. The significance of correlations between arrival dates of the species were as follows: Blackcap with Whitethroat (r_{48}=0.22, P=0.13), Lesser Whitethroat (r_{48}=0.58, P<0.001) and Garden Warbler (r_{49}=0.34, P=0.016); Whitethroat with Lesser Whitethroat (r_{47}=0.32, P=0.023) and Garden Warbler (r_{49}=0.56, P<0.001); Lesser Whitethroat with Garden Warbler (r_{48}=0.26, P=0.067). The very early year of 2008 did not seem to be very influential in the significance levels since rank correlation produced very similar significance levels.

	March (Africa)	April (Tatarstan)	May (Tatarstan)	R^2	P
Blackcap	-3.0	-1.1		32.4	<0.001
Whitethroat				No model	
Lesser Whitethroat	-2.8	-0.6		20.6	0.004
Garden Warbler			-0.7	8.7	0.034

Table 3. Stepwise regression of first arrival dates in Tatarstan on African temperatures (February-April) and Southern Tatarstan temperatures (March to May). Sample sizes as Table 1. Only significant terms shown.

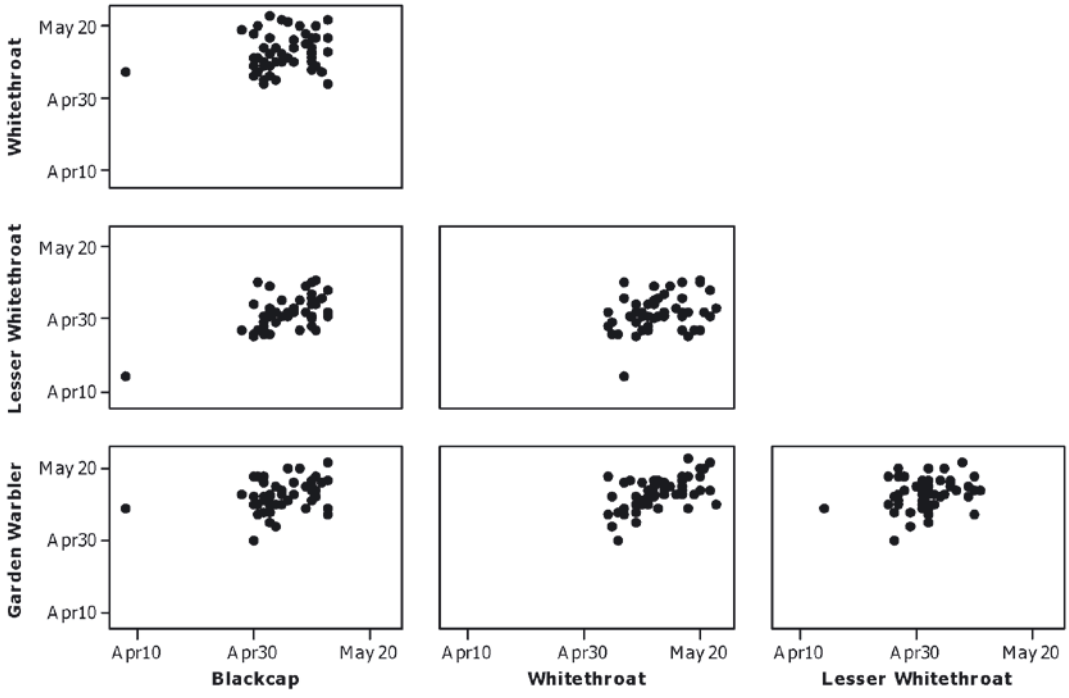

Figure 3. Relationships between the first arrival dates of the four *Sylvia* species.

4. Discussion

The *Sylvia* warblers belong to a group of birds very popular for migratory studies, including phenology [2,7,14] and this paper extends results for these species to the eastern extremity of Europe. In general, our results are in contrast with Western and Central European studies, for example in [14-16], where trends in first arrival seem much greater than reported here. There is an increasing body of evidence that these species are returning earlier throughout their range [2,7,14,17]. In these *Sylvia* warbler species there was less obvious earlier arrival in Tatarstan, which may be a consequence of the harsh winters the area experiences (supra zero temperatures only usually from April onwards) and the need for small birds to adopt a cautionary approach in such environments. However, the dramatically earlier arrival in 2008 in two of the species, and indeed in Skylark *Alauda arvensis* [18], suggest that there may be a critical temperature in these harsh environments above which phenological advance may become much more rapid. This was apparent in the much longer record of Skylark for the area [18] where an extremely long-term dataset allowed nonlinearity in temperature relationships to be explored.

Some records of Blackcap arrival in western Europe are now "contaminated" by records of birds overwintering thus making that species no longer useful for migration phenology. The very early arrival of Blackcap in Tatarstan in 2008 might indicate a bird overwintering within Europe rather than in Africa, although the exceptional temperatures of March 2008 and concurrent very early

arrival of other species (see above) suggest this may not be the case here.

It is clear from the current work that migration timing is likely to be influenced by temperatures on both the wintering grounds and the breeding grounds (see also e.g. [5,7,12,17]). For our study species we do not have reliable information about their passage route so have not examined temperatures in those areas. We have also taken temperatures from a large geographical area in Africa since their wintering grounds are only approximately known.

There was less correlation between species in first arrival dates than might have been expected. The results suggested that species arriving, on average, at a similar time (Blackcap and Lesser Whitethroat; Whitethroat and Garden Warbler) had stronger positive correlations in first arrival time between them. The low level of correlation suggests that migratory decisions taken by these birds tend to be species-specific. In this paper we use first arrival dates (the only data available) which may be criticised as unrepresentative of the population [14,19] but the authors' (I.A. and O.A.) experience suggests that, in Tatarstan, birds do not tend to arrive singly and first arrival dates are less likely to be influenced by abnormally early individual birds.

In conclusion, our results suggest that thermal conditions in the wintering quarters, as well as close to the breeding grounds, can influence interannual variation in migration phenology of trans-Saharan migratory birds, although the ecological mechanisms that link meteorological conditions to the timing of migration remain a matter of speculation.

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Appendix

First arrival dates (day of the year, 1 = Jan 1 *etc*.) of the four *Sylvia* species. Missing data represented by an asterisk.

Year	Blackcap	Whitethroat	Lesser Whitethroat	Garden Warbler
1957	122	130	117	131
1958	133	137	122	137
1959	123	137	121	133
1960	126	141	122	140
1961	130	132	120	135
1962	121	127	130	127
1963	124	125	119	124
1964	127	130	*	136
1965	*	138	*	143
1966	121	140	130	138
1967	130	133	126	137
1968	125	130	121	130
1969	130	137	126	135
1970	132	127	126	136
1971	128	*	125	140
1972	124	134	122	135
1973	122	129	119	128
1974	127	136	123	133
1975	122	125	116	132
1976	130	128	121	137
1977	128	140	117	140
1978	130	137	130	134
1979	131	129	124	132
1980	133	142	128	142
1981	130	130	121	131
1982	129	135	129	135
1983	122	134	121	136
1984	131	140	131	134
1985	125	132	125	133
1986	131	137	117	138
1987	129	138	122	129
1988	123	143	123	130
1989	124	130	122	130
1990	123	132	129	132
1991	125	142	121	134
1992	127	134	122	133
1993	133	124	122	127
1994	123	129	122	125
1995	120	126	116	120
1996	130	134	127	134
1997	133	133	121	129
1998	130	132	124	137
1999	120	138	115	138
2000	118	139	117	133
2001	120	129	115	130
2002	122	124	118	138
2003	130	131	118	134
2004	126	131	121	131
2005	123	126	116	128
2006	121	131	117	130
2007	120	131	124	132
2008	98	127	104	129