Oleg V. Askeyev · Tim H. Sparks · Igor V. Askeyev · Piotr Tryjanowski

Is earlier spring migration of Tatarstan warblers expected under climate warming ?

O.V. Askeyev

The Institute of Natural Systems Ecology, Tatarstan Academy of Sciences, Kazan, Russia

T.H. Sparks (✉)

NERC Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire PE28 2LS, UK

e-mail: ths@ceh.ac.uk

I.V. Askeyev

The Federal Service for Veterinary, Fish, Game and Phytosanitary Control in the Tatarstan Republic, Kazan, Russia

P. Tryjanowski

Department of Behavioural Ecology, Adam Mickiewicz University, Umultowska 89, PL-61-614 Poznań, Poland

Abstract We analysed data on the arrival dates of four species of leaf warbler (genus *Phylloscopus*) collected in Tatarstan between 1957 and 2004. There was no evidence, over the whole period that the warblers returned to their breeding sites significantly earlier, mainly because local temperatures for April and May, months when the majority of birds arrived from their wintering grounds, did not increase significantly. However, arrival dates of two species (Chiffchaff *P.collybita* and Willow warbler *P.trochilus*) were strongly related to local temperature in April and Greenish warbler *P.trochiloides* to that in May. As expected, arrival dates for the three species wintering in Africa (Chiffchaff, Willow and Wood warblers *P.sibilatrix*) correlated positively with one another ($P<0.01$ in all cases), but were not correlated with arrival dates of Greenish warbler ($P>0.5$ in all cases), a species wintering in the Indian sub-continent.

Keywords co-fluctuation, phenology, temperature, migration route, Russia, *Phylloscopus*, wintering areas

Introduction

The timing of when birds return to their breeding area is a key component of studies of the impact of climate change upon bird populations (reviews in: Sparks et al. 2003; Lehikoinen et al. 2004). Moreover, research on the arrival time of birds from wintering grounds to breeding locations is an important part of many phenological studies (Sparks 1999; Walther et al. 2002; Sparks et al. 2003). However, a bias probably exists in studies on bird phenology, strongly focused on very well known species, which may limit our knowledge on the functioning of ecological systems. The same is true of the geographical locations of many studies; the majority of which have been conducted in Western Europe or North America (review in: Lehikoinen et al. 2004). The reported results fit very well with changes in climate during recent decades (Sparks et al. 2003; Lehikoinen et al. 2004; Root et al. 2006). Spring arrival dates of birds to their breeding places have been shown to correlate very well with local temperatures, as well as with temperatures on migratory routes and in wintering grounds (Sparks et al. 2003; Gordo et al. 2005; Mitrus et al. 2005). However in some parts of the world, temperature has not increased significantly, or increased only in periods (months) of relatively minor importance to migrating birds. If in such places birds still arrived earlier, how would this affect predictions of climate change influences on bird migration?

We tested this question with data from one location in central Euroasia surrounding Kazan in the Tatarstan Republic (Russia), where observed changes in surface temperature were relatively low (Karolay and Wu 2005) in comparison with other regions where phenological shifts have been reported (summary in: Walther et al. 2002; Lehikoinen et al. 2004). As the study subject we used four species of leaf warblers from the genus *Phylloscopus*. In the study area, five breeding species of *Phylloscopus* warblers are present (Askeyev and Askeyev 1999). These are Chiffchaff *Phylloscopus collybita*, Willow warbler *P.trochilus*, Wood warbler *P.sibilatrix*, Greenish warbler *P.trochiloides* and Arctic warbler *P.borealis*. In this paper we examine data on

the first four of these species, which are quite common breeding species in the study area. Due to lack of sufficient data, because the species is relatively rare, we excluded Arctic warbler from further analysis. All these species are long-distance migrants with wintering areas in Africa (Chiffchaff, Willow and Wood warblers) or the Indian sub-continent and China (Greenish warbler) – for maps of distributions and basic biological information see Katti and Price (2003). This study provides a great opportunity to test co-fluctuations between morphologically and habitually similar bird species, but which differ in their wintering grounds. If conditions on migratory routes and in wintering places are important (as we assume, see above and Sparks et al. 2003; Gordo et al. 2005; Mitrus et al. 2005), the three African warblers should show similar arrival patterns different from the Indian wintering species (Hubalek 2005).

Our purposes in this paper are (1) to document the changes in arrival time of the leaf warblers (genus *Phylloscopus*) in the 1957-2004 period, (2) to identify relationships between time of arrival and air temperature in the breeding site in Tatarstan, (3) to examine the potential co-fluctuations between the arrival time of the four studied species.

Materials and methods

Study area

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 centred on the city of Kazan (55°45′ N, 49°08′ E), and includes various habitats (sub-taiga coniferous–deciduous mixed forests, farmland, rivers, lakes, and town and villages). The relief is a mostly flat or undulating lowland (55 – 220 m a.s.l). The continental climate of the region is typical of Eastern Europe. The average annual temperature is 3.6°C and monthly mean temperatures range 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 is *c.*530 mm and snow cover lies for 141–164 days.

Phenological observations

From 1957–1979, dates of the observations of the first occurrence of warblers 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 Laboratory of Biomonitoring at INSE (Institute of Natural Systems Ecology). Some data were published in Zatcepina (1978). Observations from 1980 to 2004 were recorded by two of the authors (IA and OA) of this paper. Observations were made daily from transects across the Kazan region and the recorder effort has been similar throughout the 48 years of study.

Meteorological data

Monthly mean air temperature data for the period from 1957 to 2004 were calculated as the average of the Raifa (55°55' N, 48°43' E) and Kazan meteorological stations and collected according to standard WMO protocols.

Statistical analysis

Calendar dates were transformed into days after March 1 (e.g. 1 for 1 March etc) prior to analysis. Trends were calculated by regression methods. All statistical analyses were applied according to the recommendations of Sokal and Rohlf (1995) and were conducted using MINITAB v.13.

Results

Arrival date

None of the four species significantly changed their first arrival dates over the whole study period (Fig. 1), although Wood warbler was nearly significant (P=0.064).

The influence of temperatures

An examination of Kazan March temperatures in the 1957-2004 period (Fig. 2) do reveal a consistent trend towards warmer conditions (P=0.004) by an estimated 4.1ºC over the 48 years. However, there was nearly a significant decrease in May temperature (P=0.055) equating to 2.2ºC over 48 years. There was no significant change in February (P=0.14) or April (P=0.48) temperatures.

Regressions between first arrival dates and the mean monthly temperatures for the month of mean arrival and the preceding month are shown in Table 1. With the exception of Wood warbler, the species displayed a significant negative relationship with the temperature of the month of mean arrival (Fig. 3). The combined coefficients (Table 1) suggested a response to local temperatures of between 0.23 days/°C and 1.55 days/°C. Thus, fine tuning of arrival dates to local conditions (which may also reflect temperatures over a larger continental area) was apparent.

Co-fluctuation among species

Arrival dates of the three species wintering in Africa correlated very well (Fig. 4, $r = 0.41$ to 0.65, $n = 31$ to 45 years, $P < 0.008$ in all three cases) but they did not correlate significantly with arrival dates of Greenish warbler, wintering in the Indian subcontinent and China (Fig. 4; $r = -0.01$ to 0.11, $n = 39$ to 41 years, $P > 0.51$ in all three cases).

Discussion

The *Phylloscopus* warblers belong to a group of birds very popular for migratory studies, including phenology (Sparks 1999; Tryjanowski et al. 2002). However, European studies typically concern two, sometimes three species (mainly Chiffchaff and Willow Warbler), and to

date we have not found a paper that focuses on the arrival dates of Greenish warbler. Greenish warbler has a limited distributional range in Europe and is limited mainly to eastern and northern parts of the continent (Cramp 1992) and it overwinters in India, which is rather exceptional for European avifauna (Mitrus et al. 2005). However our results are in contrast with Western and Central European studies, where there is an increasing body of evidence that migrant birds are returning earlier (reviewed in Lehikoinen et al. 2004) including three *Phylloscopus* warblers e.g. Sokolov et al. 1998; Tryjanowski et al. 2005; Tøttrup et al. 2006). In this paper we examined first arrival dates since information on the complete migration distribution is not available from this part of Russia. Tryjanowski et al. (2005) and others have warned about possible dangers in using this measure of phenology, although Sparks et al. (2005) and others have shown broad agreement between first and mean arrival dates. In this part of Russia the arrival period is relatively short so that first birds are rapidly followed by others and we believe the first arrival date to be representative.

In the analysed leaf warbler species we did not find significantly earlier arrival in Tatarstan, which is not such a great surprise because local temperatures in the spring months did not consistently increase. Indeed, the contrast between rising March and falling May temperatures would be expected to affect fauna and fauna in different ways depending on the key months driving their phenology. However, because arrival dates of three of the analysed species correlated very well with local temperatures we predict that warblers can be good phenological indicators in the case of increasing temperatures. We have used a unique data set of observations that could be useful in understanding the reaction of birds to climate change, even where temperature changes are not detected. Three species' (Chiffchaff, Willow and Greenish warblers) arrival dates correlated well with April or May temperatures, an appropriate period for arrivals in Tatarstan. That for Wood warbler didn't quite achieve significance (P=0.116) with April temperature, Table 1). As found by Marra et al. (2005) in North America the response to

temperature can be relatively modest, c. 1day/°C, in locations where temperatures have not consistently risen. Greater responses have been found elsewhere in Europe (e.g. Lehikoinen et al. 2004).

Interestingly, the arrival dates of the African migrants co-fluctuated in a similar way (*sensu* Hubalek 2005), completely independent of the Indian migrant, the Greenish warbler. This supports earlier suggestions that birds react not only to temperature in the breeding ground, but on the whole migration route (e.g. Gordo 2005; Hubalek 2005; Mitrus et al. 2005; Tøttrup et al. 2006). They probably start migration to breeding places from different wintering places according to local signals, and just experience similar conditions at the end of their migratory route. However, part of our explanation is of a speculative nature, because knowledge about the cues used by birds in the wintering grounds is very scarce, especially in the Indian sub-continent whose wintering species are of relatively low research interest in Europe (c.f. Mitrus et al 2005).

Acknowledgements We would like to thank V.G. Ivliev for data from the archive of the Laboratory of Biomonitoring at INSE.

References

Askeyev IV, Askeyev OV (1999) Birds of the Tatarstan Republic. Akademia Nauk Tatarstana, Kazan (in Russian).

Cramp S (ed) (1992) The Birds of the Western Palearctic. Vol VI. Oxford University Press, Oxford

Gordo O, Brotons L, Ferrer X, Comas P (2005) Do changes in climate patterns in wintering areas affect the timing of the spring arrival of trans-Saharan migrant birds? Global Change Biology 11: 12-21

Hubalek Z (2005) Co-fluctuation among bird species in their migration timing. Folia zool. 54: 159-164

Karoly DJ, Wu Q (2005) Detection of regional surface temperature trends. J Climate 18: 4337-4343

Katti M, Price TD (2003) Latitudinal trends in body size among over-wintering leaf warblers (genus *Phylloscopus*). Ecography 26: 69-79

Lehikoinen E, Sparks TH, Zalakevicius M (2004) Arrival and departure dates. Adv Ecol Res 35: 1-21

Marra PP, Francis CM, Mulvihill RS, Moore FR (2005) The influence of climate on the timing and rate of spring bird migration. Oecologia 142: 307-315.

Mitrus C, Sparks TH, Tryjanowski P (2005) First evidence of phenological change in a transcontinental migrant overwintering in the Indian sub-continent: the Red-breasted Flycatcher *Ficedula parva*. Ornis Fenn 82: 13-19

Root TL, MacMynowski DP, Mastrandrea MD, Schneider SH (2006) Human-modified temperatures induce species changes: joint attribution. Proc Natl Acad Sci USA 102: 7465-7469

Sokal RR, Rohlf FJ (1995) Biometry. 3rd ed. Freeman, New York

Sokolov LV, Markovets MYu, Shapoval AP, Morozov YuG (1998) Long-term trends in the timing of spring migration of passerines on the Courish Spit of the Baltic Sea. Avian Ecol Behav 1: 1-21

Sparks TH (1999) Phenology and the changing pattern of bird migration in Britain. Int J Biometeorol 42: 134-138

Sparks TH, Crick HQP, Dunn PO, Sokolov LV (2003) Birds. In: Schwatz MD (ed) Phenology: An Integrative Environmental Science. Kluwer, New York, pp 421-436

Sparks TH, Bairlein F, Bojarinova JG, Hüppop O, Lehikoinen EA, Rainio K, Sokolov LV, Walker D (2005) Examining the total arrival distribution of migratory birds. Global Change Biology 11: 22-30

Tøttrup AP, Thorup K, Rahbek C (2006) Patterns of change in timing of spring migration in North European songbird populations. J Avian Biol 37: 84-92

Tryjanowski, P, Kuzniak S, Sparks T (2002) Earlier arrival of some farmland migrants in western Poland. Ibis 144: 62-68

Tryjanowski P, Kuzniak S, Sparks TH (2005) What affects the magnitude of change in first arrival dates of migrant birds? J Ornithol 146: 200-205

Walther GR, Post E, Convey P, Menzel A, Parmesan C, Beebee TJ, Fromentin JH, Hoegh-Guldberg O, Bairlein F (2002) Ecological responses to recent climate change. Nature 416: 389-395

Zatcepina RA (1978) Sylividae family. In: The birds of Volga-Kama region. Moscow, pp 94–134 (in Russian).

Table 1 Summary of regression models between first arrival dates and mean monthly temperatures of the month of mean arrival and the preceding month. Significant coefficients ($P < 0.05$) are shown in bold.

	Regression coefficients ±SE					
	March	April	May	Sum of coefficients	R^2	P
Chiffchaff	-0.18±0.25	**-1.40±0.29**		-1.55	40.7	<0.001
Willow warbler	0.13±0.18	**-1.17±0.20**		-1.04	44.8	<0.001
Wood warbler		-0.56±0.35	0.33±0.38	-0.23	8.1	0.20
Greenish warbler		-0.33±0.28	**-0.92±0.30**	-1.25	21.2	0.011

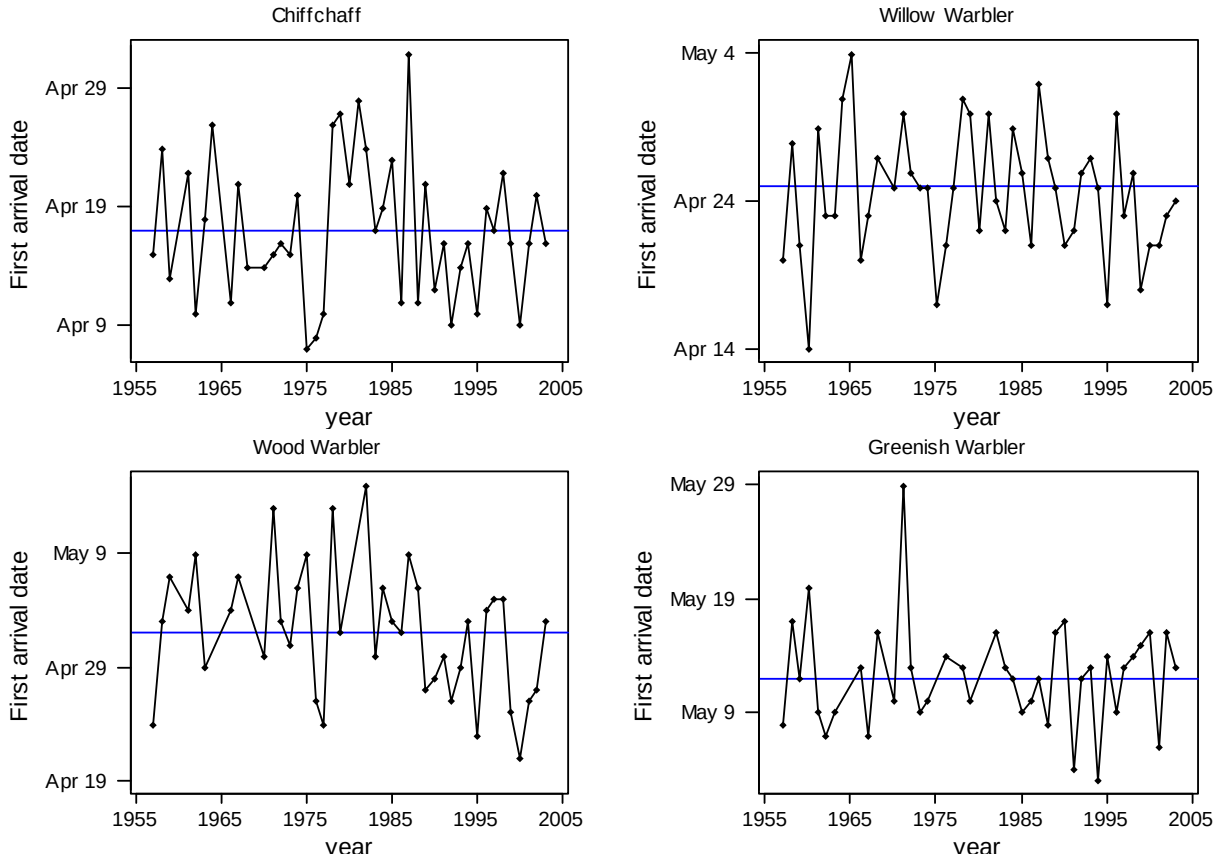

Fig. 1 Patterns of first arrival dates of the four *Phylloscopus* warblers 1957-2004. Horizontal lines represent mean dates

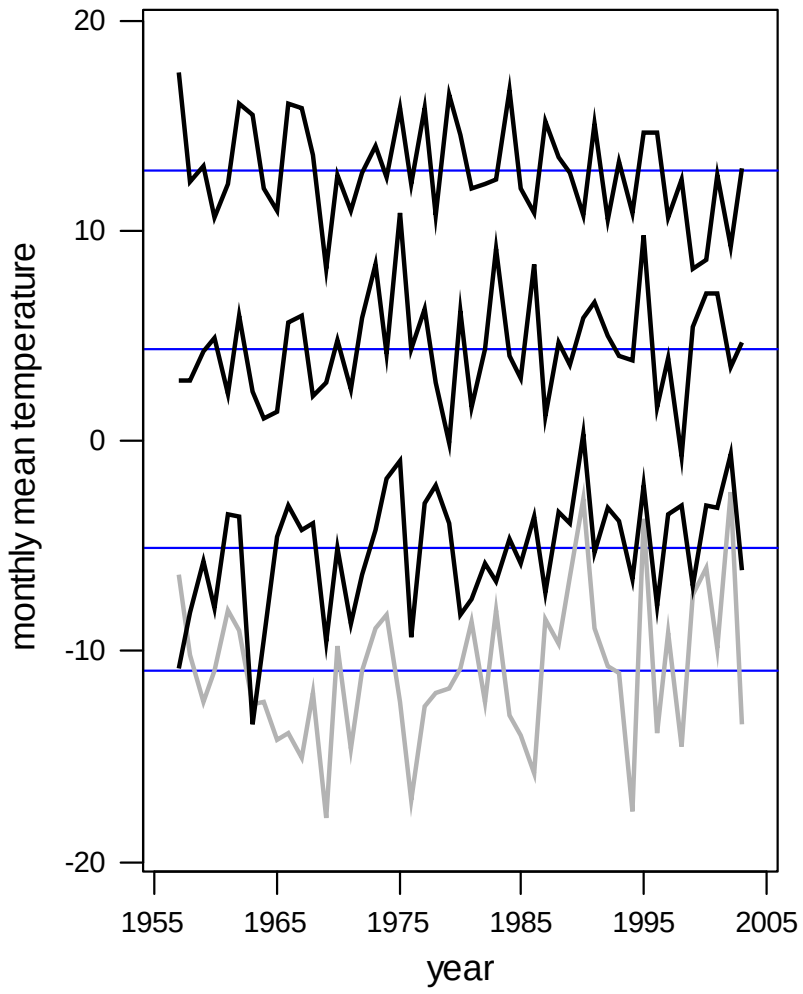

Fig. 2 Patterns in mean monthly temperatures from February (lower) to May (upper). A significant increase in March and an almost significant decrease in May temperatures were apparent in the time frame. Horizontal lines represent mean temperatures in the 1957-2004 period

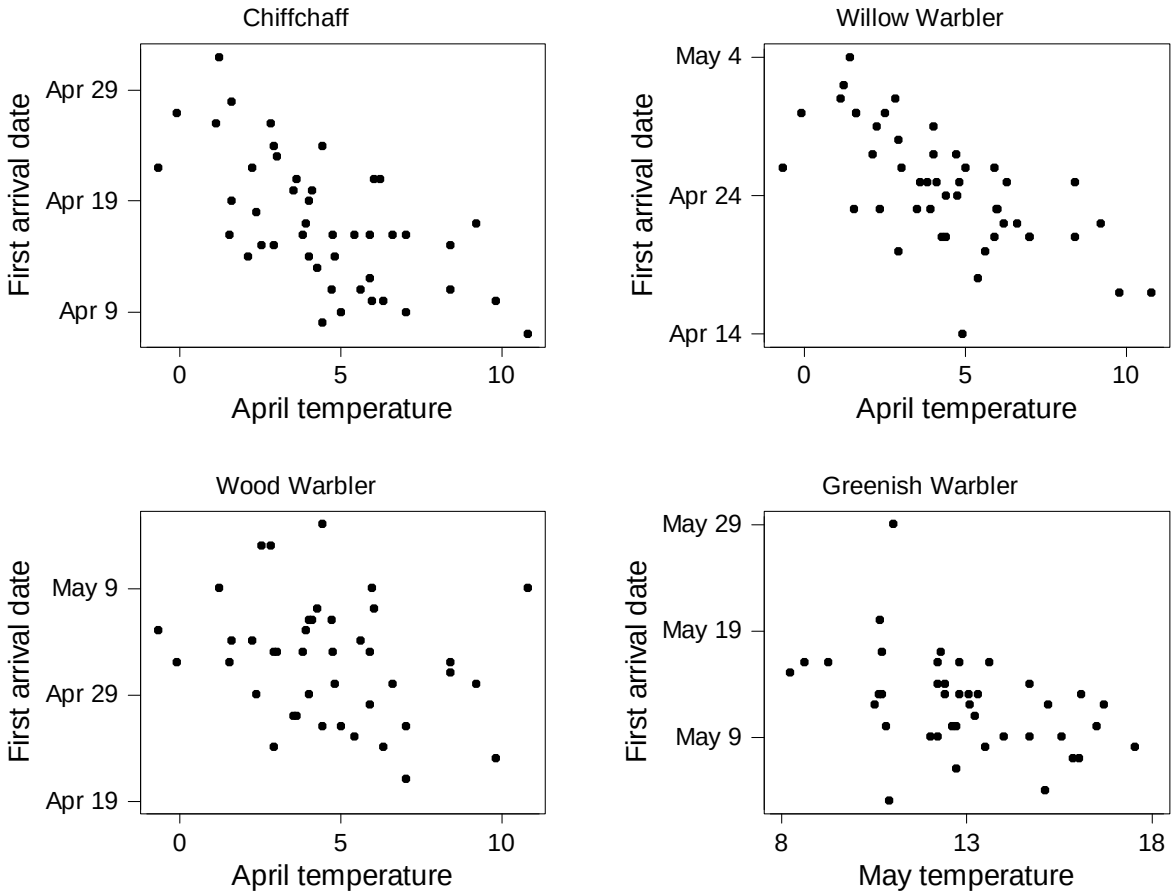

Fig. 3 Relationships between first arrival date and local temperatures in the most significant of either the month of mean first arrival or the preceding month

Fig. 4 A matrixplot showing the relationship between the first arrival dates of the four *Phylloscopus* warblers