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Influence of point-of-departure climate variables on the passage dates of two long-distance migrants in Eilat

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ABSTRACT: We examined the influence of point-of-departure climatic variables in autumn, namely surface ambient temperature, the number of wet days and growing season length (GSL), and the influence of the point-of-departure surface ambient temperature in spring on the passage dates of 2 long-distance migrant passerine species, the lesser whitethroat *Sylvia curruca* and the bluethroat *Luscinia svecica*, at Eilat, Israel, from 1985 to 2004. Ambient temperature at the breeding grounds of the lesser whitethroat increased at a rate of 0.147°C yr^{-1}. There was no significant change in the ambient temperature at the breeding grounds of bluethroat, nor was there a change in the number of wet days or GSL at the breeding grounds of either species. We found that the median autumn passage date of lesser whitethroat in Eilat was delayed by 21.5 d, or by 5.43 d for every 1°C increase in ambient temperature at their breeding grounds. We found no change in the median autumn passage date of bluethroat in Eilat. The median spring passage date and the ambient temperature at the wintering grounds of both species did not change significantly. We found no significant correlation between the median spring passage dates of birds of either species and the ambient temperature at their wintering grounds. We conclude that migration phenology of long-distance migrants can be strongly correlated with fluctuations in climatic variables, especially the ambient temperature at the breeding grounds of a species.

KEYWORDS: Migration timing · Migration phenology · Bluethroat · Lesser whitethroat

1. INTRODUCTION

In the last 100 yr, average global surface temperatures have increased by 0.4 to 0.8°C. Most of this increase has occurred during 2 distinct periods, from 1910 to 1945 and from 1976 to the present (Jones et al. 1999, Brohan et al. 2006). To date, the mid and high latitudes of the Northern Hemisphere continue to show the largest rates of temperature increase of about 0.8°C $decade^{-1}$ (Jones et al. 1999). Along with the temperature rise in the mid and high latitudes, an increase in precipitation, especially during autumn and winter, has also been documented (Hulme et al. 1998). This increase in temperature, coupled with increased precipitation, has caused an increase in growing season length (GSL) by an average of 10 d in the last 4 decades (Menzel & Fabian 1999, Sparks & Menzel 2002, Butler 2003).

For migratory birds, global warming poses complex challenges since resultant changes in food availability may have a significant impact on optimal passage dates for both north- and southbound birds. Both the physical condition on arrival at the breeding grounds and the timing of arrival are crucial for the bird's reproductive success and fitness (Marra et al. 1998, Alerstam & Lindström 1990). Across northern Europe, for example, spring events — such as the beginning of the growing season — start significantly earlier than the historical

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data suggests (Menzel 2000), a fact that may require phenology shifts by migratory birds. Indeed, both New World (Butler 2003) and northern European bird species have advanced their arrival time at their breeding grounds and changed their breeding phenology (e.g. Bradley et al. 1999, Inouye et al. 2000, Cotton 2003).

We investigated the relationships among the timing of migration of the lesser whitethroat *Sylvia curruca* and the bluethroat *Luscinia svecica* (as recorded at the International Birding and Research Center in Eilat [IBRCE] over the last 20 years) with surface temperature trends, changes in the number of wet days, and changes in growing season length in the species' wintering and breeding grounds. We hypothesized that since migration time must be kept short to save energy, and the use of 'fueling stations' is important for the success of the journey (Gill 1995), changes in timing of migration caused by climatic changes will be reflected in changes of passage dates in Eilat.

2. MATERIALS AND METHODS

2.1. Study site

Passage dates of the study species were retrieved from the archives of the IBRCE located at the southernmost point in Israel, at the northern tip of the Gulf of Eilat (29° 33′ N, 34° 57′ E). Research was conducted in accordance with institutional and national guidelines concerning the use of animals in research and under the ringing permit of R.Y.

2.2. Study species

We focused on 2 common migratory passerine species, the lesser whitethroat and the bluethroat, for 3 key reasons. (1) Ringing data at the IBRCE for both species were consistently collected over the last 20 yr (for information regarding data collection and standardizing capture rates by the number of net hours, see Yosef & Wineman 2010). (2) Both species breed over extensive areas throughout Europe, and most of the birds that stopover to 'refuel' at Eilat arrive from central and northern Europe and winter south of the Sahara desert (Shirihai 1996); thus they can be considered long-distance migrants. This fact is important since we wished to avoid background noise attributable to large-scale climatic systems such as the North Atlantic Oscillation (NAO) or the El Niño Southern Oscillation, and concentrate on changes in passage dates at Eilat with respect to climatic conditions at the departure sites of each species. (3) Ringing recoveries and the feather color and morph of both species indicate that the birds that stopover in Eilat originate from known areas of small geographic scale (Ożarowska et al. 2004, Markovets & Yosef 2005).

The breeding grounds of lesser whitethroat that pass through Eilat in autumn span from southern and central England, across the Netherlands to southwest Sweden (50° 36′ to 60° 18′ N and 01° 36′ to 13° 54′ E; Yosef 1997, Ożarowska et al. 2004). The breeding population of bluethroat that is known to pass through Eilat in autumn covers the region between central Europe and Russia, to north of the Volga River (50° to 60° N and 35° to 48° E; Cramp 1988, Markovets & Yosef 2005). The geographic area of the wintering grounds of both species includes the upper Nile region in southern Sudan and northern Ethiopia (12° 42′ to 06° 06′ N and 35° to 41° 12′ E; Cramp 1988, 1992).

2.3. Climatic data

We examined 3 climate variables at the breeding grounds of lesser whitethroat and bluethroat and one climate variable at their wintering grounds: mean monthly temperature anomalies, number of wet days and GSL. Mean monthly temperature anomalies from the 1961–1990 period were obtained from www.ncdc.noaa.gov/. Data were taken for the approximate center of the breeding and wintering grounds of each of the study species. The number of wet days was calculated as the number of days in which precipitation exceeded 1 mm. Data were downloaded from the European Climate Assessment and Dataset (http://eca.knmi.nl/), and were available only for Europe. Since, from banding recapture data, we knew the origin of many of the whitethroats and bluethroats passing through Eilat, we used the average number of wet days from June to August in Oxford, England, for lesser whitethroat, and the average of the number of wet days from September to November in Moscow, Russia, for bluethroat. GSL is the number of days between the first occurrence of 6 consecutive days in which the mean daily temperature was above 5°C and the first occurrence, after 1 July, of 6 consecutive days with mean daily temperature below 5°C. GSL data was downloaded from the European Climate Assessment and Dataset (http://eca.knmi.nl/), and was available only for Europe. For each species we used the same location as for wet days.

2.4. Data analysis

We investigated the trend in the passage dates of the lesser whitethroat and the bluethroat in Eilat in each season by regressing median passage date (day of year [DOY]) on year. We then examined trends of the 3 chosen climatic variables for both breeding grounds in Europe, and for temperature at the wintering grounds in Africa.

We investigated the association between the median passage dates for each species in each migration season with each of the climatic variables at the sites of departure using regression analysis. Passage dates were converted to DOY prior to analysis. Data analysis was done using SPSS software and graphs were prepared with SigmaPlot 6.0. The lowest acceptable level of significance was set at $p = 0.05$.

3. RESULTS

3.1. Autumn migration

During the 20 yr (1985–2004) covered in this analysis, 304 lesser whitethroat were banded in Eilat in autumn. The median passage date of these birds in Eilat became increasingly and significantly delayed by a total of 21.5 d, at a rate of 1.08 d yr^{-1} ($R^2 = 0.33$, $p = 0.01$, normality of residuals $p = 0.91$; Fig. 1). There was no significant change in the median passage date of the 6324 bluethroat that were banded in Eilat in autumn from 1985 to 2004 ($R^2 = 0.21$, $p = 0.06$).

Over the 20 yr study period at the breeding grounds of the lesser whitethroat, there was a significant increase in the ambient temperature in August of 0.147°C yr^{-1} ($R^2 = 0.36$, $p = 0.007$, normality of residuals $p = 0.95$; Fig. 2), the autumn departure month of this species (Cramp 1992). In contrast, there was no significant change in the ambient temperature for September, the departure month for bluethroat from the upper Volga region ($R^2 = 0.05$, $p = 0.38$).

The number of wet days at lesser whitethroat breeding grounds did not change significantly from 1985 to 2004 ($R^2 = 0.09$, $p = 0.18$). Similarly, the number of wet days at bluethroat breeding grounds did not change significantly during this period ($R^2 = 0.27$, $p = 0.08$). GSL at the breeding grounds of both species did not change significantly over the study period (lesser whitethroat, $R^2 = 0.15$, $p = 0.1$; bluethroat, $R^2 = 0.01$, $p = 0.78$).

Using regression analysis, we found a significant positive relationship between median passage date and August temperature at the species breeding grounds for lesser whitethroat, indicating a 5.43 d delay in the median passage date for every 1°C increase in temperature ($R^2 = 0.50$, $p = 0.001$, Fig. 3). We found no significant relationship between the number of wet days and GSL at the breeding grounds of lesser whitethroat and their passage date in Eilat (number of wet days, $R^2 = 0.28$, $p = 0.05$; GSL, $R^2 = 0.17$, $p = 0.49$).

There was no significant relationship between median passage dates of bluethroat and climatic variables at its breeding grounds (temperature, $R^2 = 0.01$, $p = 0.27$; number of wet days, $R^2 = 0.06$, $p = 0.85$; GSL, $R^2 = 0.03$, $p = 0.93$).

3.2. Spring migration

From 1985 to 2004, 10 805 lesser whitethroat and 1198 bluethroat were banded in Eilat in spring. We found no significant changes in the median spring passage dates of lesser whitethroat or bluethroat in Eilat (lesser whitethroat, $R^2 = 0.06$, $p = 0.32$; bluethroat, $R^2 = 0.08$, $p = 0.23$).

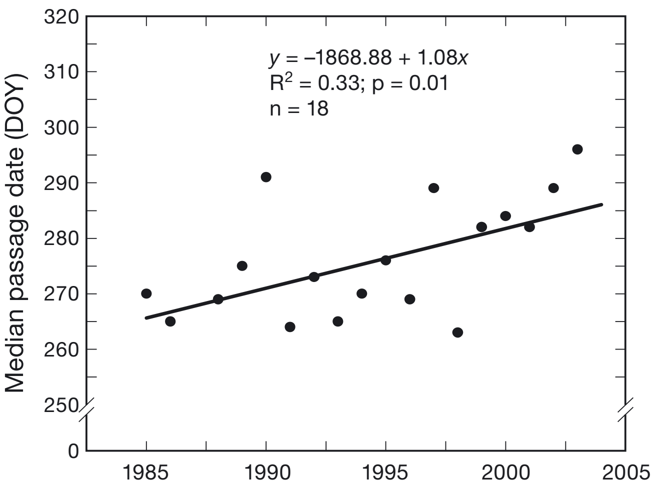

Fig. 1. Relationship between median autumn passage date (day of year, DOY) of lesser whitethroat *Sylvia curruca* and year of arrival in Eilat, Israel, from 1985 to 2004

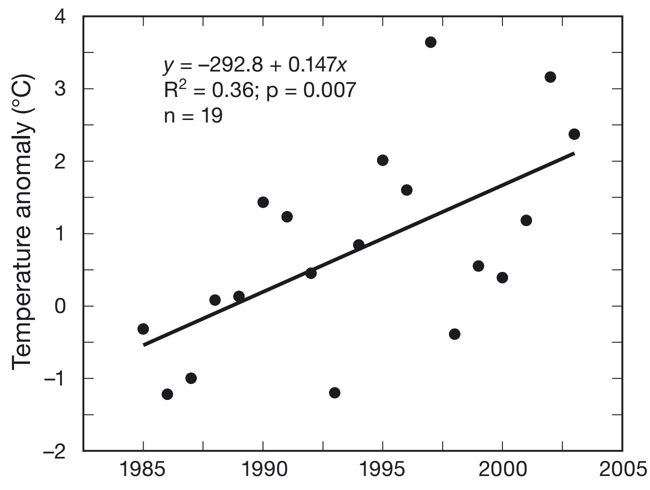

Fig. 2. Relationship between ambient temperature in August at breeding grounds of lesser whitethroat *Sylvia curruca* and year, from 1985 to 2004

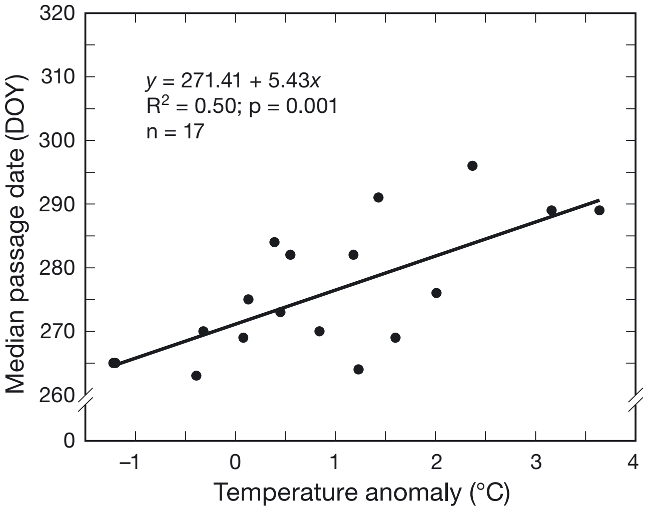

Fig. 3. Relationship between median autumn passage date (day of year, DOY) of lesser whitethroat *Sylvia curruca* (Eilat, Israel, 1985–2004) and ambient temperature at their breeding grounds in August

Temperatures in the upper Nile region, part of the wintering grounds of both species, did not change significantly from 1985 to 2004 ($R^2 = 0.027$, $p = 0.84$). We found no significant relationship between median passage date of either species with January temperature at the wintering grounds (lesser whitethroat, $R^2 = 0.007$, $p = 0.75$; bluethroat, $R^2 = 0.05$, $p = 0.35$).

4. DISCUSSION

The progressive delay in the passage dates of lesser whitethroat in Eilat in autumn, and the fact that ambient temperatures in their departure grounds have significantly increased over the past 20 yr support the hypothesis that local climate conditions at the site of departure affects the timing of these species' migration passage. The number of wet days and GSL at the site of departure had no obviously discernable effects on autumn passage dates in Eilat.

This relationship suggests that lesser whitethroat delay their departure dates in autumn, and thus take advantage of the increase in the length of the summer season. This may be beneficial to migratory birds due to the increased opportunity for adults, and more importantly for juvenile, first year migrants, to complete growth of their lean mass and to store fat (Bauchinger & Biebach 2001) before the onset of autumn migration.

In contrast, we did not find a significant change in passage dates of bluethroat in Eilat in their autumn migration over the last 2 decades. The fact that there was no significant change in any of the climatic variables at the usual autumn migration peak over the past 20 yr suggests that there has likely been no change in environmental conditions at the breeding grounds of this species, and thus no incentive for changing the timing of departure.

Local spring ambient temperatures at the departure site of both bluethroat and lesser whitethroat in Africa have not changed significantly over the past 20 yr. Therefore, there has apparently been no environmental stimulus to change the onset of spring migration. Indeed, spring passage dates of both species in Eilat have not significantly changed over the last 20 yr.

Changes in the arrival dates of migratory birds at their breeding grounds in spring have been reported in many studies (e.g. Cotton 2003, Hüppop & Hüppop 2003, Ahola et al. 2004, Crick 2004, Vähätalo et al. 2004). Of these, Cotton (2003) found that lesser whitethroat have significantly advanced their arrival dates at their breeding grounds over the last 30 yr. In addition, Hüppop & Hüppop (2003) found a significant advance in the arrival dates of this species at its breeding ground that were correlated significantly with the NAO over the last 40 yr, and Ahola et al. (2004) and Marra et al. (2005) found that the arrival date of spring migrants at their breeding grounds was significantly correlated with temperature fluctuations en route.

The NAO mainly affects climatic conditions across Europe in winter (Hurrell 1995). The positive trend in NAO index over the last 4 decades (Hurrell 1995) corresponds to an increase in surface temperature in the Northern Hemisphere, especially from April to June (Hurrell et al. 2001). However, the concurrent temperature increase across Europe from April to June may also be important in setting the scene for spring migration en route (Forchhammer et al. 2002). For example, Sparks et al. (2001) found that higher temperatures from March to June that follow higher NAO indices are associated with southwesterly or westerly winds from the Atlantic. These winds probably serve as tailwinds for birds migrating from Africa, enabling them to increase migration speed. Therefore, while no advance in spring arrival by lesser whitethroat is apparent in Eilat, it has occurred at their breeding grounds.

The present study adds to the growing body of knowledge showing the ability of migratory passerine species to exploit favorable environmental conditions by modifying their migration phenology (e.g. Forchhammer et al. 2002, Cotton 2003, Hubalek 2003, Hüppop & Hüppop 2003, Ahola et al. 2004, Crick 2004, Vähätalo et al. 2004). Our findings suggest that changes in migration phenology of long-distance migrants are not only associated with fluctuations at large climatic scales, but could be strongly correlated with fluctuations in local climatic variables, namely the ambient temperature at the breeding grounds of a species.

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