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Trends and temperature effects in the arrival of spring migrants in Portland (United Kingdom) 1959–2005

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Abstract. This paper examines the first arrival dates of 25 migrant bird species recorded at Portland, Dorset, UK, for the period 1959–2005. To determine if trends over time existed, linear regression of first arrival dates on year was used; initially for the whole period and subsequently separately for 1959–1981 and 1982–2005. First arrival dates were compared to spring temperatures along migration routes in southern Europe and France and in the UK. The arrival of 11 species (e.g. Sand Martin, Blackcap and Pied Flycatcher) was significantly earlier with the mean trend for all species showing an advance of 1.6 days/decade over the study period. Over all species, trends in first arrival date were not significantly different between the two time periods but there were differences for Turtle Dove, Whitethroat and Lesser Whitethroat. Monthly mean temperatures along the European part of the birds' migration route were generally negatively correlated with, but can only explain < 30% of the variability in, first arrival dates. The consequences of both a changed phenology and differential phenological changes between species require urgent investigation.

Key words: phenology, birds, migration, climate change

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INTRODUCTION

The World Meteorological Organization (WMO) has reported that the 1990s were, globally, the warmest decade since instrumental measurement started in the 1860s and that the ten warmest years on record have all occurred since 1983. In recent years there has been a growing literature on analyses of bird migration phenology from countries as diverse as France (Sueur & Triplet 2001), Russia (Sokolov et al. 1998), and the USA (e.g. Butler 2003). Lehikoinen et al. (2004) summarised available data on European migration phenology and concluded that about 40% of first arrival series were getting significantly earlier but only 2% significantly later. A changing phenology has proved to be important in demonstrating effects of rising temperatures on the natural world, but, with a few exceptions, has largely unknown consequences on population dynamics and distributions. Because of its relative abundance and longevity, data on migration phenology are frequently examined for evidence of climate impacts.

In the UK there are many phenological data collected by a range of different interest groups ranging from individual ornithologists, through Bird Clubs to coastal bird observatories. Portland Bird Observatory is located on the southern coast of England on a headland (Portland Bill) extending nine km into the sea. As a point of entry, it is therefore uniquely placed to examine the effects of temperatures further south on migration into the UK. The bird observatory at Portland has been running for several decades and comprehensive records are available for all years from 1959 onwards. A comparison with two other observatories using data up to 1998 was included in Loxton & Sparks (1999). In this paper we extend the data up to 2005 and examine for changing trends in arrival phenology and the influence of temperatures on the European part of the migration routes.

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MATERIAL AND METHODS

All bird observations were recorded on a daily basis and systematic records entered into logbooks. We abstracted the dates of first spring records from 1959–2005 for 25 species of migrant birds (those observed in all or most years) from the grounds of the Portland Bird Observatory, Dorset, UK (50.31°N, 2.27°W). Dates were converted to days post December 31 prior to analysis. The species and their scientific names are listed in Table 1. Most of these species can be considered as long distance migrants wintering in Africa. The majority of species had complete records for the 47 years of the study; the exceptions missing some first arrival dates were Hobby *Falco subutteo* (41 years), Garden Warbler *Sylvia borin* (46 years) and Pied Flycatcher *Ficedula hypoleuca* (45 years). Recently, there has been a tendency for over wintering of Blackcap *Sylvia atricapilla* and Chiffchaff *Phylloscopus collybita*. For these species we have taken the first date of observations which were considered to be of migratory birds.

Central England mean monthly temperatures (CET) for January, February, March and April of each calendar year were obtained from the UK Met Office website (www.met-office.gov.uk). Mean monthly temperatures anomalies for the same months for Spain, Italy and France were obtained from the 5° gridded CRUTEM2v dataset (www.cru.uea.ac.uk). Temperatures for Spain were approximated by the average of the four grid boxes 35–45°N 10–0°W, Italian temperatures were approximated by the grid box 40–45°N 10–15°E, and French temperatures by the average of two grid boxes 45–50°N 5°W–5°E.

Evidence for a trend in first arrival date (FAD) was determined by linear regression of FAD on year. Because some trends appeared to vary over time, these regressions were repeated using two approximately equal but otherwise arbitrary time periods: 1959–1981 and 1982–2005. Differences between trends in the two periods (equality of slopes) were assessed by testing the interaction between period and slope in an ANCOVA. A recent paper (Tryjanowski et al. 2005) suggested that trends in FAD may be influenced by changes in population. Therefore, we have derived a population change index from descriptions in Baillie et al. (2006) as a five point scale from -2 (rapid decline) through zero (uncertain/stable) to +2 (rapid increase). This was available for all but one species (see final column of Table 1) and was compared to trends in FAD.

Since most species use the western flyway through Spain and France (Wernham et al. 2002), FADs were compared to mean monthly temperatures for Central England, France and Spain i.e. for temperatures in the UK and further south on the migration route. For two species (Cuckoo *Cuculus canorus* and Lesser Whitethroat *Sylvia curruca*) known to use the central flyway across the Mediterranean, Italian temperatures were substituted for Spanish temperatures. Species whose mean FAD occurred in March were not compared to April temperatures.

RESULTS

First arrival dates

Eight species had a mean FAD in March; the remaining 17 in April (Table 1). Unlike Tryjanowski et al. (2002) and other authors we found no correlation between mean FAD and its SD ($r = 0.08$, $p = 0.72$).

Trends in first arrival dates

Negative values of regression coefficients of FAD on year indicate an advance in arrival and positive values a delay (Table 1). Thus, for example, the largest coefficient of -0.529 for Blackcap indicates an earlier arrival by 0.529 days per annum, equating to 5.3 days per decade or 25 days over the period of the study. Of the 25 species, 21 have negative coefficients, indicating a trend to earliness, and of these 11 are statistically significant. A further two species had marginally significant ($0.05 < p < 0.10$) advances. The ratio of 21 negative to 4 positive values is extremely unlikely to occur by chance (sign test; $p < 0.001$). The mean trend was an advance of 1.6 days / decade. The mean trend ± SE for the eight species with a mean FAD in March (-0.26 ± 0.06) was almost significantly different from the mean trend of the species with a mean FAD in April (-0.12 ± 0.04; $t = -2.03$, $p = 0.065$).

Trends for each species were examined for differences between the "halves" (1959–1981 and 1982–2005, Table 1). During the period 1959–1981, 17 of the 25 species showed a trend to earlier arrival (six statistically significant). A further single species had a marginally significant trend to earlier arrival. None of the positive trends (delays) were significant. For the later period, 1982–2005, 17 species had negative coefficients (four statistically significant), and a further species was marginally significant. None of the positive

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Table 1. Mean (and standard deviation — SD), earliest and latest first arrival date (FAD; in days after December 31) of the 25 migrant bird species recorded at Portland Bird Observatory from 1959–2005. Regression coefficients (days/year) for the whole period (1959–2005) and two approximately equal "halves", 1959–1981 and 1982–2005 are given. The Interaction column indicates whether the trends in the two halves differed. Significance * — $p < 0.05$, + — $0.05 < p < 0.10$. Population trends are derived from Baillie et al. (2006), see text for details. Species are arranged in order of mean FAD.

	FAD				Trend: Whole period	Trend: First half	Trend: Second half	Interaction	Population
	Mean	SD	Earliest	Latest	1959–2005	1959–1981	1982–2005	p	trend
Species with mean FAD in March									
Oenanthe oenanthe	70.3	5.1	63	84	-0.134*	0.074	-0.046	0.564	-1
Phylloscopus collybita	71.2	6.9	60	87	-0.203*	-0.290	0.015	0.276	1
Riparia riparia	82.7	10.2	60	101	-0.463*	-0.494+	-0.446	0.893	0
Sterna sandvicensis	84.7	9.9	65	113	-0.177	-0.479*	-0.210	0.527	No info
Hirundo rustica	86.6	7.9	60	99	-0.236*	-0.118	-0.667*	0.077	0
Turdus torquatus	86.7	7.0	75	104	-0.045	-0.093	-0.332	0.433	-1
Sylvia atricapilla	88.3	9.5	51	111	-0.529*	-0.593*	-0.807*	0.419	2
Phylloscopus trochilus	88.6	5.2	76	98	-0.259*	-0.122	-0.342*	0.196	-2
Species with mean FAD in April									
Phoenicurus phoenicurus	94.7	6.9	74	108	-0.147*	0.156	-0.325	0.096	0
Anthus trivialis	95.5	6.3	79	107	-0.204*	-0.199	-0.086	0.657	-2
Motacilla flava	96.1	6.5	74	110	-0.136+	-0.341	-0.038	0.276	-2
Delichion urbica	96.7	8.1	79	114	-0.331*	-0.395	-0.366+	0.922	0
Locustella naevia	102.9	5.7	89	123	-0.077	0.040	0.057	0.945	-2
Actitis hypoleucos	104.3	9.4	75	133	-0.022	-0.559*	-0.119	0.274	-1
Sylvia communis	104.6	5.5	92	115	0.017	0.146	-0.354*	0.033*	-2
Acrocephalus schoenbaenus	105.7	6.9	88	134	-0.085	-0.086	-0.172	0.776	0
Saxicola rubetra	106.5	6.9	87	121	0.061	0.035	0.098	0.838	-1
Ficedula hypoleuca	107.7	9.0	91	141	-0.402*	-0.715*	-0.336	0.232	0
Cuculus canorus	109.4	8.7	86	127	-0.004	0.031	0.469	0.240	-2
Sylvia borin	110.3	6.1	96	120	0.071	0.155	0.164	0.976	-1
Streptopelia turtur	110.6	7.3	88	129	0.007	-0.705*	0.250	0.002*	-2
Apus apus	112.6	6.1	94	124	-0.077	0.238	-0.099	0.195	0
Sylvia curruca	112.9	5.8	102	138	-0.119+	-0.447*	0.045	0.043*	-1
Falco subutteo	116.1	13.1	92	160	-0.447*	-0.970	0.079	0.082	1
Muscicapa striata	117.9	6.6	98	129	-0.087	-0.181	-0.003	0.540	-2

trends was significant. The mean trends in the two periods were advances of 2.4 and 1.4 days/decade respectively but, on average, did not differ significantly (paired t test: $t = -1.16$, $p = 0.26$). There was no significant relationship between mean FAD and trend in FAD for the whole period ($r = 0.32$, $p = 0.12$) or for 1959–1981 ($r = -0.15$, $p = 0.46$), but this was apparent for the 1982–2005 period ($r = 0.49$, $p = 0.012$).

The Sand Martin *Riparia riparia*, House Martin *Delichon urbica* and Swallow *Hirundo rustica* all showed an advance in arrival date with the Sand Martin being especially responsive and advancing by 21 days during the study period. The arrival dates of both martins have been advancing steadily over the whole study period (Fig. 1) whereas the Swallow advanced only 1.2 days per decade from 1959–1981 but 6.7 days per decade during the second period (Fig. 1). The Swift *Apus apus*, however, showed no sign of arriving earlier (Fig. 1). Some species such as the Hobby advanced considerably during 1959–81 (9.4 days per decade) and became less variable, whereas since then there has been no noticeable advance in timing (Fig. 1).

The change in Blackcap arrivals was very marked during both periods and advanced by 25 days over the study period (Fig. 1).

Historically always an early visitor, the arrival date of Chiffchaff advanced on average by 2.9 days per decade during 1959–1981 (Fig. 1) but has remained fairly constant since (Fig. 1, Table 1). The Willow Warbler *Phylloscopus trochilus* (Fig. 1) has also advanced by 2.6 days per decade on average but the more rapid advance in arrival dates occurred during 1982–2005.

The difference in trends between the 1959–1981 and 1982–2005 time periods (Table 1) was significant only for Turtle Dove *Streptopelia turtur*, Whitethroat *Sylvia communis* and Lesser

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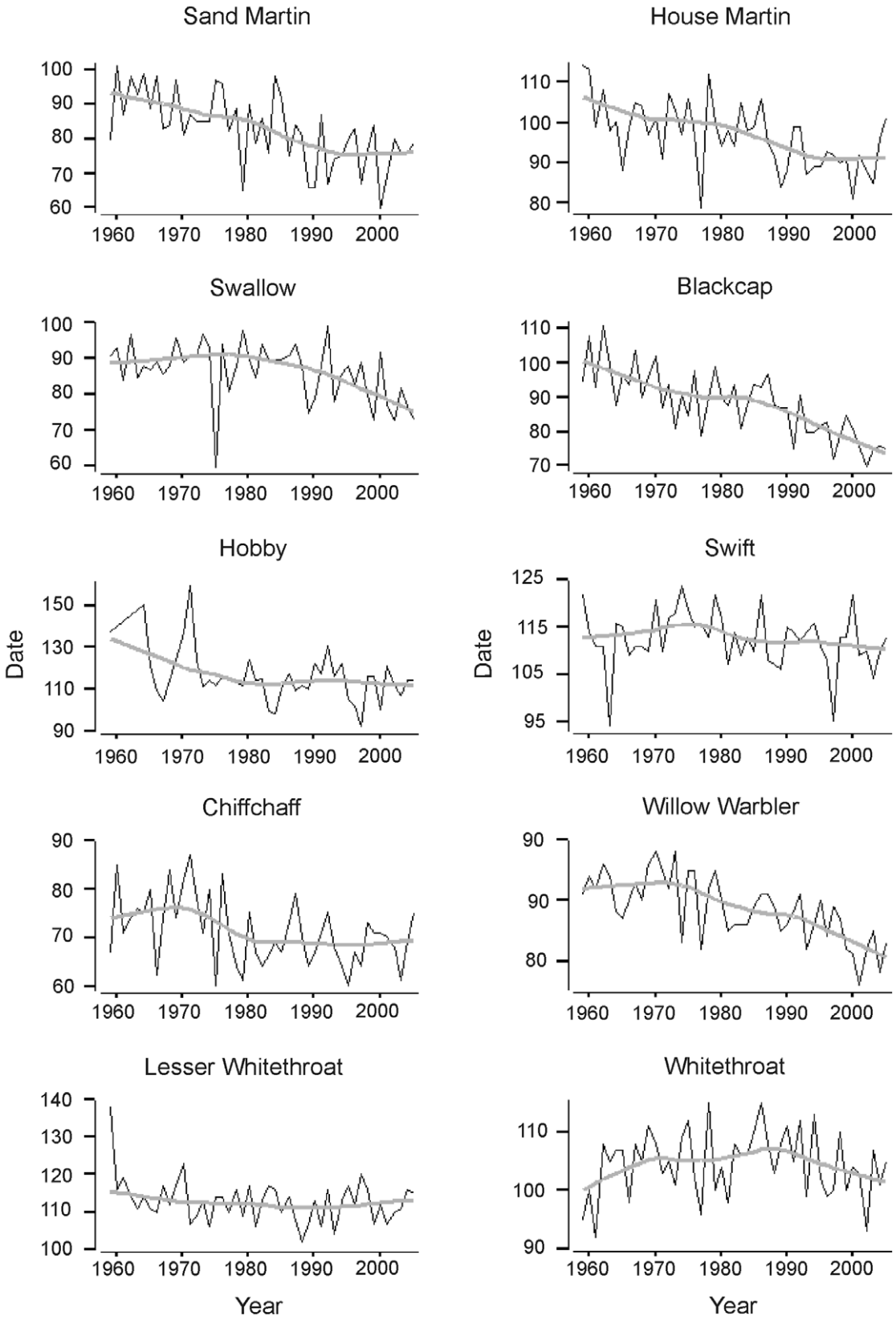


Fig. 1. First arrival dates (day of the year) for ten selected species. The smoothed lines represent the underlying trend as determined by locally weighted scatterplot smoothing (LOWESS).

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Whitethroat. Lesser Whitethroat (Fig. 1) and Turtle Dove revealed a greater trend to earlier arrival in the first period than the second, whilst Whitethroat (Fig. 1) revealed the reverse. There was a significant correlation between trends in FAD and trends in population ($r = 0.65$, $p = 0.001$) such that species undergoing decline and rapid decline showed less trend towards earlier FAD (Fig. 2).

The influence of temperature on first arrival dates

We calculated, for each species, correlations between FAD and the monthly temperatures of Spain (Italy in the case of Cuckoo and Lesser Whitethroat), France and Central England (Table 2). Of the 25 species examined, 18 had significant ($p < 0.05$) negative correlations with one or more of the national monthly temperatures. 79% of all correlations shown in Table 2 are negative. An additional species, Turtle Dove, had a significant positive correlation with temperature. For most of the species, significant correlations most often occurred with the month in which mean FAD occurred. Fourteen of the species had a marginally significant or significant correlation ($p < 0.1$) with Spanish (or Italian) temperatures in the month in which mean FAD occurred, 12 with French temperatures and 10 with Central England Temperature.

With one exception the monthly temperatures used were highly correlated ($p < 0.001$) between countries. English and French temperatures between January and April had correlations coefficients between 0.76 and 0.84, and those between France and Spain between 0.52 and 0.84. There was no significant correlation between January temperature in England and Spain ($r = 0.11$) but the correlations for February to April ranged from 0.60 to 0.65. It is therefore difficult to definitively identify the temperatures in one particular region as influential on the FAD of birds in the UK.

Because all but two species have a migration route across Spain we decided to see how temperatures in Spain, and then further north, influenced FAD. We calculated two regression models of FAD on temperature for each species (Table 3). The first is the best model based only on the monthly Spanish (or Italian) temperatures. The second is an extension of the first model to include any French or English temperatures that significantly improve the explanatory power of the model. Fourteen of the 25 species had a significant model based on Spanish temperature alone, of which all but the Turtle Dove model associated warmer temperatures with earlier arrival. For these 13 models the percentage variation explained by monthly temperatures was low (between 11% and 29%) and a 1°C increase in temperature was associated with a 2.2 to 4.6 day advance in FAD. Five of the species models were significantly improved by the addition of French or English temperatures and a further three species generated a significant model not achieved by Spanish temperatures. For eight species (Sandwich Tern *Sterna sandvicensis*, Ring Ouzel *Turdus torquatus*, Yellow Wagtail *Motacilla flava*, Common Sandpiper *Actitis hypoleucos*, Whinchat *Saxicola rubetra*, Cuckoo, Lesser Whitethroat and Spotted Flycatcher *Muscicapa striata*) no significant relationship with the examined temperatures was found.

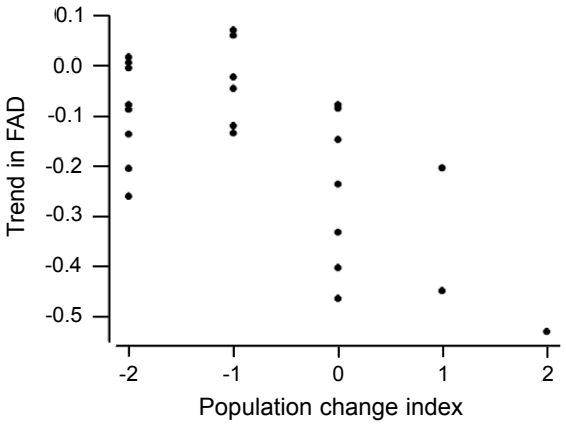


Fig. 2. Trends in first arrival dates (FAD) plotted against changes in population for 24 species, see text for details.

DISCUSSION

Portland, situated in the southwest of the UK, is the most southerly of the UK bird observatories. Its long history of bird observation has produced the record of first arrival dates over 47 years that we have examined here. Our analysis shows that many species are arriving at Portland earlier in the year and that, in many cases, this advance in timing correlates with an increase in spring temperatures. Similar changes in phenology have been reported across Europe (review in Lehikoinen et al. 2004) and in North America (e.g. Butler 2003). In our study, 11 (44%)

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Table 2. Correlation coefficients of arrival dates against mean monthly Spanish, French and Central England (CET) spring temperatures. For Cuckoo and Lesser Whitethroat, correlations are with Italian rather than Spanish temperatures (see text for details). Significance * — $p < 0.05$, + — $0.05 < p < 0.10$. Species order as in Table 1.

	Spain				France				CET			
	Jan	Feb	Mar	Apr	Jan	Feb	Mar	Apr	Jan	Feb	Mar	Apr
Species with mean FAD in March												
Oenanthe oenanthe	0.05	-0.25+	-0.54*		-0.01	-0.30*	-0.47*		-0.06	-0.20	-0.36*	
Phylloscopus collybita	-0.36*	-0.29*	-0.34*		-0.16	-0.27	-0.34*		-0.03	-0.13	-0.30*	
Riparia riparia	-0.06	-0.25+	-0.53*		-0.12	-0.16	-0.48*		-0.13	-0.22	-0.51*	
Sterna sandvicensis	0.05	-0.05	-0.11		-0.02	0.05	-0.17		-0.06	0.07	-0.15	
Hirundo rustica	-0.21	-0.13	-0.25+		-0.39*	-0.18	-0.32*		-0.40*	-0.27+	-0.32*	
Turdus torquatus	-0.03	0.00	0.02		-0.21	0.03	-0.01		-0.22	-0.11	0.06	
Sylvia atricapilla	-0.17	-0.15	-0.41*		-0.29+	-0.21	-0.46*		-0.36*	-0.29+	-0.50*	
Phylloscopus trochilus	-0.20	-0.10	-0.50*		-0.34*	-0.16	-0.48*		-0.26+	-0.29+	-0.41*	
Species with mean FAD in April												
Phoenicurus phoenicurus	-0.19	-0.10	-0.31*	-0.33*	-0.16	-0.16	-0.30*	-0.39*	-0.15	-0.29*	-0.29+	-0.30*
Anthus trivialis	-0.08	-0.34*	-0.48*	-0.26+	-0.15	-0.31*	-0.47*	-0.09	-0.07	-0.34*	-0.44*	-0.02
Motacilla flava	-0.10	-0.06	-0.15	0.08	-0.29*	-0.02	-0.17	-0.05	-0.39*	-0.09	-0.22	-0.02
Delichion urbica	-0.08	-0.28+	-0.39*	-0.24+	-0.13	-0.31*	-0.28+	-0.18	-0.17	-0.39*	-0.25+	-0.16
Locustella naevia	-0.03	-0.16	-0.16	-0.19	-0.13	-0.21	-0.11	-0.19	-0.17	-0.34*	-0.25+	-0.12
Actitis hypoleucos	0.24	-0.16	-0.01	0.02	-0.06	-0.10	0.07	0.26+	0.18	0.03	0.20	0.27+
Sylvia communis	-0.18	-0.12	-0.16	-0.39*	-0.05	-0.25	-0.22	-0.50*	0.10	-0.31*	-0.26+	-0.42*
Acrocephalus schoenbaenus	-0.28+	-0.27+	-0.18	-0.09	-0.24	-0.28+	-0.05	-0.05	-0.16	-0.33*	-0.17	-0.06
Saxicola rubetra	-0.06	-0.23	-0.05	-0.05	0.10	-0.25	0.00	-0.26+	-0.04	-0.19	0.06	-0.05
Ficedula hypoleuca	-0.22	-0.35*	-0.26+	-0.26+	-0.24	-0.31*	-0.14	-0.19	-0.29+	-0.40*	-0.24	-0.16
Cuculus canorus	0.02	0.10	-0.11	0.09	-0.01	-0.14	-0.16	-0.10	-0.10	-0.14	-0.15	0.05
Sylvia borin	0.09	0.04	0.09	-0.38*	0.02	0.03	0.08	-0.37*	0.05	-0.09	0.01	-0.11
Streptopelia turtur	0.21	0.03	0.30*	-0.05	0.29+	0.02	0.28+	0.10	0.12	0.06	0.13	0.20
Apus apus	-0.03	0.02	-0.37*	-0.49*	0.27+	0.09	-0.25+	-0.46*	0.18	0.02	-0.18	-0.24+
Sylvia curruca	0.03	0.06	0.03	-0.12	-0.05	0.08	-0.03	-0.03	-0.12	0.07	-0.01	0.06
Falco subutteo	-0.12	-0.10	-0.37*	-0.30+	-0.12	-0.09	-0.28+	-0.10	-0.09	-0.05	-0.25	-0.01
Muscicapa striata	-0.01	-0.01	-0.13	-0.13	-0.05	0.00	0.08	-0.21	-0.16	-0.08	-0.03	-0.01

species arrived significantly earlier; a figure highly compatible with the summary of Lehikoinen et al. (2004). Unlike other studies (e.g. Tryjanowski et al. 2002, Sparks et al. 2005) the variability in bird arrivals did not appear to be greater in earlier arriving species. The reasons for this are unclear. One possible explanation is that early species may skim the southern coastline of the UK (or even return to France) without penetrating the interior if conditions are not yet suitable. Thus, arrival dates may be more consistent that those from the interior of land masses.

The rate of change in FAD varied between species, for example the advance was almost significantly greater in species whose mean date occurred in March than those whose mean date occurred in April. Both martins (Fig. 1) showed a steady advance in FAD, whilst Swift (Fig. 1) showed little in the way of change. In other studies later arrival species have typically shown less variability in arrival date (e.g. Tryjanowski et al. 2002) which may reflect reduced phenological plasticity and thus less opportunity to adapt or select towards earlier arrival. Population expansion or contraction could affect first arrival dates (Sparks et al. 2001), principally through reduced likelihood of (and hence later) observation in declining populations. This was confirmed by Tryjanowski et al. (2005) and in the data set presented here. Thus, declines in species such as Common Sandpiper, Whitethroat and Turtle Dove may mask changes in their phenology (see Table 1). Given the general decline in European bird populations the trends in FAD in Table 1 may be an underestimate of the true change.

We arbitrarily divided the long series into two approximately equal parts to examine for change in each half, suspecting that change may have been greater in the second half. This was not the case. Had our primary interest been in looking for turning points in the arrival phenology of migrants any fixed division would have been be sub-optimal since such changes will inevitably be species specific. Long data series such as these might be better examined for abrupt changes in phenology using the change point technique reported by Dose & Menzel (2004).

The recently milder winters and springs have been associated with the earlier arrival of many of the species we have examined. These conditions also appear to be associated with an increased incidence in the overwintering of both Blackcap and Chiffchaff and may well be

Table 3. Regression models of first arrival date (FAD) on mean monthly Spanish temperatures from January to April (coded J, F, M and A), and an indication of whether these models can be improved by adding French (subscript Fr) or English (subscript CET) temperatures. For each regression model the variables included (or added) are indicated, together with the variation explained by the regression model (R^2), and the overall model significance (p). The combined coefficient indicates the change in FAD associated with a 1° C increase in the variables included in the model. Eight species for which no significant model could be constructed are omitted, see text for details. Species order as in Table 1. † — no significant model, ‡ — no significant improvement to model.

	Model on Spanish temperature				Extended model to include French and English temperature			
	Month(s) Included	R^2	p	Combined coefficient	Month(s) added	R^2	p	Combined coefficient
Oenanthe oenanthe	M	29.2	0.000	-2.35		‡		
Phylloscopus collybita	J, M	22.9	0.003	-4.33		‡		
Riparia riparia	M	27.7	< 0.001	-4.60		‡		
Hirundo rustica		†			J_{CET}	15.9	0.005	-1.73
Sylvia atricapilla	M	16.8	0.004	-3.30	J_{CET} , M_{CET}	32.9	0.001	-4.86
Phylloscopus trochilus	M	24.7	0.000	-2.21	J_{Fr}	33.2	0.000	-3.00
Phoenicurus phoenicurus	A	10.6	0.026	-2.40		‡		
Anthus trivialis	M	23.4	0.001	-2.62		‡		
Delichion urbica	M	15.2	0.007	-2.70	F_{CET}	22.0	0.004	-3.14
Locustella naevia		†			F_{CET}	11.6	0.019	-1.00
Sylvia communis	A	15.5	0.006	-2.34	A_{Fr}	25.1	0.002	-3.01
Acrocephalus schoenbaenus		†			F_{CET}	11.0	0.022	-1.17
Ficedula hypoleuca	F	12.2	0.019	-2.70	F_{CET}	17.3	0.018	-2.65
Sylvia borin	A	14.2	0.010	-2.46		‡		
Streptopelia turtur	M	9.2	0.038	1.90		‡		
Apus apus	A	24.3	0.000	-3.22		‡		
Falco subutteo	M	13.4	0.019	-4.00		‡		

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encouraging winter vagrant records of other migrants. Temperatures across Europe are correlated at the monthly scale and it is to be expected that warmer migration route temperatures would encourage earlier arrival in the UK through 1) earlier vegetation development 2) earlier insect appearance and 3) southerly tail winds and hence faster migration (Huin & Sparks 1998, 2000, Hüppop & Winkel 2006). Some bird species examined here, e.g. Pied Flycatcher, correlate with temperatures well before their arrival. In these circumstances we assume that early warmth is necessary to encourage early plant and invertebrate development. It is no great surprise that the UK temperatures used here were not as correlated with FAD as those from further south. Portland is on the south coast of Britain and birds arriving here will not have crossed any part of the UK mainland. The majority of UK species use the western flyway up through Spain (Wernham et al. 2002) and so it is appropriate to examine FAD in Portland with temperatures in Spain, and further north in France. The results we have shown here (Tables 2, 3) show clear associations between FAD and temperatures for more than half the species examined. However, explanatory power in these temperature models is low, generally less than 30%. Reasons for this may include the (unexamined) influence of environmental conditions over the (usually greater) African portion of their migration journey, the rather crude nature of monthly temperature data for birds that can cover several hundred kilometres each day, an inexact knowledge on the exact migration route of the species and the possibility that the route may vary from year to year (Huin & Sparks 1998). Explanatory power in our results is generally lower than those reported by Ahola et al. (2004). However they analysed median arrival dates, which have been shown (Sparks et al. 2005) to be less variable than FADs, and from a time series of shorter duration.

Our study has confirmed 1) earlier arrival, 2) a temperature response in arrivals, 3) a response to temperatures along the European part of the migration route, 4) an influence of population change on trend in first arrival, and, partly, 5) greater trends in earlier arriving species. It does not, however, confirm greater variability in earlier arriving species and greater change in more recent years. The reasons for the latter two are unclear, but the influence of population changes in change on FAD, as we have confirmed, should not be ignored.

Differential phenological change in migrants could affect species in a number of ways. Those species demonstrating phenological plasticity are likely to be the more adaptable species better able to cope with varying climatic conditions and benefiting from earlier arrival (Kokko 1999, Visser et al. 2004) and hence presumably earlier breeding. For eight of the species examined here no significant relationship with examined temperature variables could be found. Birds that do not display phenological plasticity may be unable to synchronise arrival (and breeding) with invertebrate availability and may be unable to successfully adapt to changing climatic conditions (Visser et al. 2004, Both et al. 2006). In our study we show a clear relationship between population change and change in arrival phenology. We have assumed that this is a consequence of reduced likelihood of observing species as populations decrease. But an alternative hypothesis could be that species that show little phenological plasticity have, in consequence, undergone population declines. Which is the chicken and which is the egg (which is cause and which is effect)? An examination of data from sites able to provide both mean migration times and population change estimates for many species could answer this question. Although, so far, there have only been modest increases in temperature the effects on migrant phenology are already clear. The task of understanding the consequences of a changed phenology is now becoming increasingly urgent.

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STRESZCZENIE

[Trendy i wpływ temperatury na daty przylotu migrantów wiosennych w Portland (Wielka Brytania) w latach 1959–2005]

W pracy przeanalizowano zmiany dat przylotów wiosennych 25 gatunków migrujących stwierdzanych w Portland (Wielka Brytania) w okresie 1959–2005. Istnienie trendów i ich istotność w czasie badano metodą regresji liniowej; analizy przeprowadzono dla całego okresu badań, jak i dla dwóch pod-okresów: 1959–1981 i 1982–2005. Daty pierwszych stwierdzeń odnoszono do temperatur stwierdzanych na trasach migracji ptaków: w południowej Europie, Francji i w Wielkiej Brytanii. Przyloty 11 gatunków (np. brzegówki, kapturki i muchołówki żałobnej) były istotnie wcześniejsze w trakcie badań (Tab. 1, Fig. 1). Wykazano przeciętny trend wcześniejszego przylotu wynoszący 1,6 dnia/10 lat. Stwierdzono istotną korelację pomiędzy zmianami dat przylotu poszczególnych gatunków a trendami zmian liczebności ich populacji (Fig. 2). Średnie miesięczne temperatury badań w różnych punktach migracji były generalnie negatywnie skorelowane z terminami przylotów, tj. im wyższą temperaturę notowano, tym badane gatunki przylatywały do Portland wcześniej (Tab. 2, 3). Jednakże korelacje z temperaturą wyjaśniają tylko do 30% zmienności dat pierwszych obserwacji migrantów wiosennych. Choć istnieje wiele danych z całej półkuli północnej wykazujących zmiany fenologiczne u migrujących ptaków, to niewiele wciąż wiadomo o konsekwencji tych zmian, jak i różnicach pomiędzy gatunkami. Jako, że zagadnienia te są ważne dla zrozumienia wpływu ostatnich szybkich zmian klimatycznych na populacje ptaków, to będą zapewne intensywnie badane w najbliższej przyszłości.

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