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Has Recent Climate Warming Affected the Dates of Bird Arrival to the Il'men Reserve in the Southern Urals?

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Abstract—The results of regression and correlation analyses of long-term data (1971–2005) on the dates of arrival of 16 bird species to the Il'men State Nature Reserve (the Southern Urals) show that they have not changed in most of these birds, unlike in many countries of Europe and North America. This is explained primarily by the absence of any significant trends in the dynamics of spring air temperatures in the study region. Only the herring gull *Larus argentatus* and the lapwing *Vanellus vanellus* have shown a significant tendency to arrive earlier, while the garganey *Anas querquedula* has shown a tendency to arrive on later dates in the past two decades. Nevertheless, interannual fluctuations in the dates of arrival are well manifested in both early arriving species wintering in Europe and late-arriving species wintering in Africa. These fluctuations largely depend on temperature conditions in spring. As a rule, almost all species studied—from waterbirds to passerines—appear in the Il'men Reserve earlier in years with early and warm springs than in cold years. Hence, spring weather is the key factor determining the dates of arrival of migratory birds to the study region.

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In the past two decades, compared to the 1970s, considerably earlier arrivals of many bird species that winter not only in Europe but also migrate to Africa have been recorded in different European countries and northwestern Russia (Moritz, 1993; Mason, 1995; Ahas, 1999; Sokolov et al., 1999a; Sparks, 1999; Barrett, 2002; Askeyev et al., 2002; Tryjanowski et al., 2002; Hüppop and Hüppop, 2003, 2005; Sokolov, 2006). Specialists usually explain the shift of spring migration to earlier dates by the current global climate warming (Sokolov et al., 1999b; Ahas et al., 2000; Bairlein and Winkel, 2001; Forchhammer et al., 2002; Sparks et al., 2003; Hüppop and Hüppop, 2003, 2005; Sokolov, 2006).

Long-term tendencies of changes in the dates of bird arrival to the central and eastern parts of Russia have been studied less. According to some authors (Ananin, 2002; Paskhalny, 2002; Golovatin and Paskhalny, 2003), these changes in different species are more differentiated than in Europe. For instance, in the Barguzin Reserve (the northeastern Baikal region), some bird species, mainly passerines, began to arrive considerably earlier; conversely, waterbirds and birds of prey began to arrive later; in many species, the dates of arrival remained unchanged. Ananin (2002) explains it by the fact that the response of different bird species to climatic changes may differ considerably. In addition, the trends of air temperatures at the beginning and end of spring may considerably differ in different regions of Russia.

In this context, it is interesting to find out how the dates of bird arrival have changed in different regions of Russia over a long period of time and what factors account for the ambiguous pattern of these changes.

The main purpose of this study was to reveal long-term tendencies of changes in the dates of bird arrival to the Il'men Reserve, the Southern Urals, and to estimate the effect of spring air temperatures on the dates of arrival of early and late-migrating species.

MATERIAL AND METHODS

Regular phenological observations on the dates of spring arrival of birds to the Il'men Reserve and its environs have been performed since 1971. The Il'men Reserve is located in the subzone of southern taiga pine–birch forests in the eastern foothills of the Southern Urals (54°58'–55°19' N, 60°–60°20' E). The area of the reserve is about 30000 ha.

Table 1. Dates of bird arrival to the Il'men Reserve between 1971 and 2005

Species	Number of years	Date of the first bird record			*SD*
		median	early	late	
Corvus frugilegus	32	March 21	March 4	April 1	7.3
Larus argentatus	18	March 31	March 20	April 8	5.3
Sturnus vulgaris	30	April 3	March 21	April 12	6.0
Anser anser	11	April 7	March 25	April 22	7.4
Alauda arvensis	18	April 7	March 29	April 20	5.2
Anas platyrhynchos	34	April 8	March 30	April 22	5.4
Motacilla alba	34	April 10	March 22	April 17	5.8
Vanellus vanellus	23	April 11	April 3	April 24	5.7
Grus grus	29	April 14	April 5	April 26	5.2
Anas querquedula	19	April 21	April 2	May 7	8.5
Aythya fuligula	17	April 24	April 13	May 1	5.7
Gavia arctica	33	April 29	April 20	May 12	5.2
Hirundo rustica	35	May 2	April 12	May 15	6.3
Cuculus canorus	33	May 5	April 18	May 13	5.7
Luscinia luscinia	33	May 11	April 21	May 19	6.6
Apus apus	28	May 19	May 2	May 27	6.0

Note: Species are listed in order of their arrival; *SD* is standard deviation.

The climate of the study area is moderately continental; the city of Miass belongs to the first agroclimatic region—moderately cool and humid, with sharp changes in temperature and precipitation, short summers, and snowy winters (Khitryakova, 1999). Temperature conditions change drastically depending on topography. In the study period, the average temperature of the warmest month (July) was 17.9°C, that of the coldest month (January) was –14.6°C, and the average annual temperature was 2.0°C. The area of the reserve is characterized by a moderate amount of precipitation averaging 444 mm per year.

The time of arrival of migrating birds was estimated from the date on which a certain species was first observed in the reserve. A total of 16 bird species belonging to short- and long-distance migrants were chosen as phenological indicators (Table 1). As shown by several authors (Sokolov et al., 1999a; Sparks et al., 2001), the dates of the first record (catch) of a bird provide objective evidence concerning the dates of migration of the corresponding species in the given year. Data on the dates of bird arrival were collected by specialists of the reserve: from 1971 to 1989, by V.I. Popov, V.G. Davydov, and V.D. Zakharov, as well as by rangers; from 1990 to 2005, by N.S. Gordienko (*Letopis' prirody…*, 1971–2004).

Information on average monthly and ten-day temperatures was obtained from the weather station located 8 km west of the reserve.

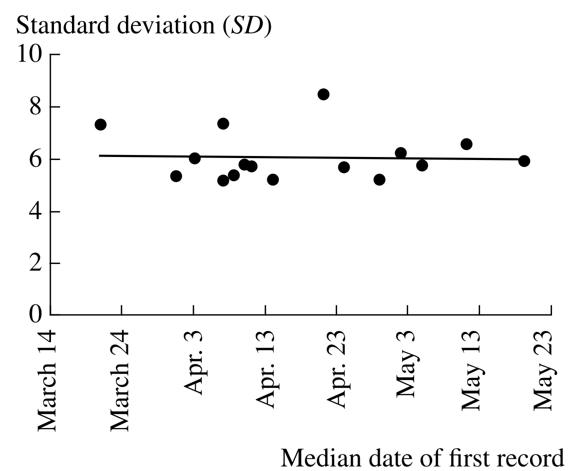

Fig. 1. Range of interannual fluctuations in the dates of first records of 16 bird species in the Il'men Reserve as a function of the time of their arrival.

Table 2. Trends in the dates of bird arrival to the Il'men Reserve between 1971 and 2005

Species	Parameters of linear regression		
	slope	*r*	*p*
Corvus frugilegus	–0.010	0.148	n.s.
Larus argentatus	–0.414	0.506	<0.05
Sturnus vulgaris	0.043	0.071	n.s.
Anser anser	–0.861	0.539	n.s.
Alauda arvensis	0.137	0.293	n.s.
Anas platyrhynchos	–0.156	0.284	n.s.
Motacilla alba	–0.042	0.071	n.s.
Vanellus vanellus	–0.209	0.422	<0.05
Grus grus	0.100	0.189	n.s.
Anas querquedula	0.569	0.594	<0.01
Aythya fuligula	–0.088	0.129	n.s.
Gavia arctica	0.108	0.197	n.s.
Hirundo rustica	–0.112	0.180	n.s.
Cuculus canorus	0.076	0.135	n.s.
Luscinia luscinia	0.064	0.099	n.s.
Apus apus	0.048	0.077	n.s.

To reveal trends in the dates of bird arrival and spring air temperatures and estimate the correlation between the first record date of a species and the average air temperature over a ten-day period, regression and correlation analyses were performed using the STATISTICA 5.0 program package.

RESULTS AND DISCUSSION

In most species studied, significant interannual fluctuations in the dates of arrival to the Il’men Reserve were revealed. It is important that these fluctuations, judging from the value of standard deviation (*SD*), were similar in both early and late-arriving species (Table 1, Fig. 1). The difference between the earliest and latest bird records over the study period in late-migrating species wintering in Africa (*Hirundo rustica, Luscinia luscinia, Cuculus canorus,* and *Apus apus*) was almost one month, being similar to that in early arriving intracontinental migrants such as *Corvus frugilegus* or *Alauda arvensis*. This is noteworthy, as considerable differences in the range of fluctuation in the dates of arrival between early and late-migrating birds are usually recorded in Europe (Mason, 1995; Sokolov et al., 1999a; Sparks and Mason, 2001; Hüppop and Hüppop, 2005): as a rule, this range is wider in early than in late-arriving birds, because air temperature is usually subject to stronger fluctuations at the beginning than at the end of spring, when most long-distance migrants arrive. In the Il’men Reserve, interannual fluctuations of ten-day average air temperatures between late March and late May were of similar magnitude, judging from *SD* values: 3.0 in the third ten-day period of March, 2.9 in the second ten-day period of April, and 3.1 in the third ten-day period of May. Apparently, this is the reason why we revealed no significant differences in the amplitude of fluctuation in the dates of arrival to the Il’men Reserve between early and late-migrating birds.

An analysis of trends in the dates of arrival of 16 bird species indicated that two species (*L. argentatus* and *V. vanellus*) are characterized by a significant tendency to arrive earlier and one species (*A. querquedula*) has a tendency to arrive later, with the dates of arrival of all other species remaining almost unchanged (Table 2; Figs. 2, 3). This obviously disagrees with the data obtained by researchers in several European countries, where significantly earlier bird arrival has been recorded (Peintinger and Schuster, 2005; Hüppop and Hüppop, 2005; Sokolov, 2006) in the past two decades even in late-migrating species such as *C. canorus, A. apus, Delichon urbica, Hippolais icterina,* and *Muscicapa striata.*

An analysis of trends of change in spring air temperatures in the study region allowed us to explain the fact that the arrival of most bird species to the Il’men Reserve has remained almost unchanged over the past three decades, despite distinct climate warm-

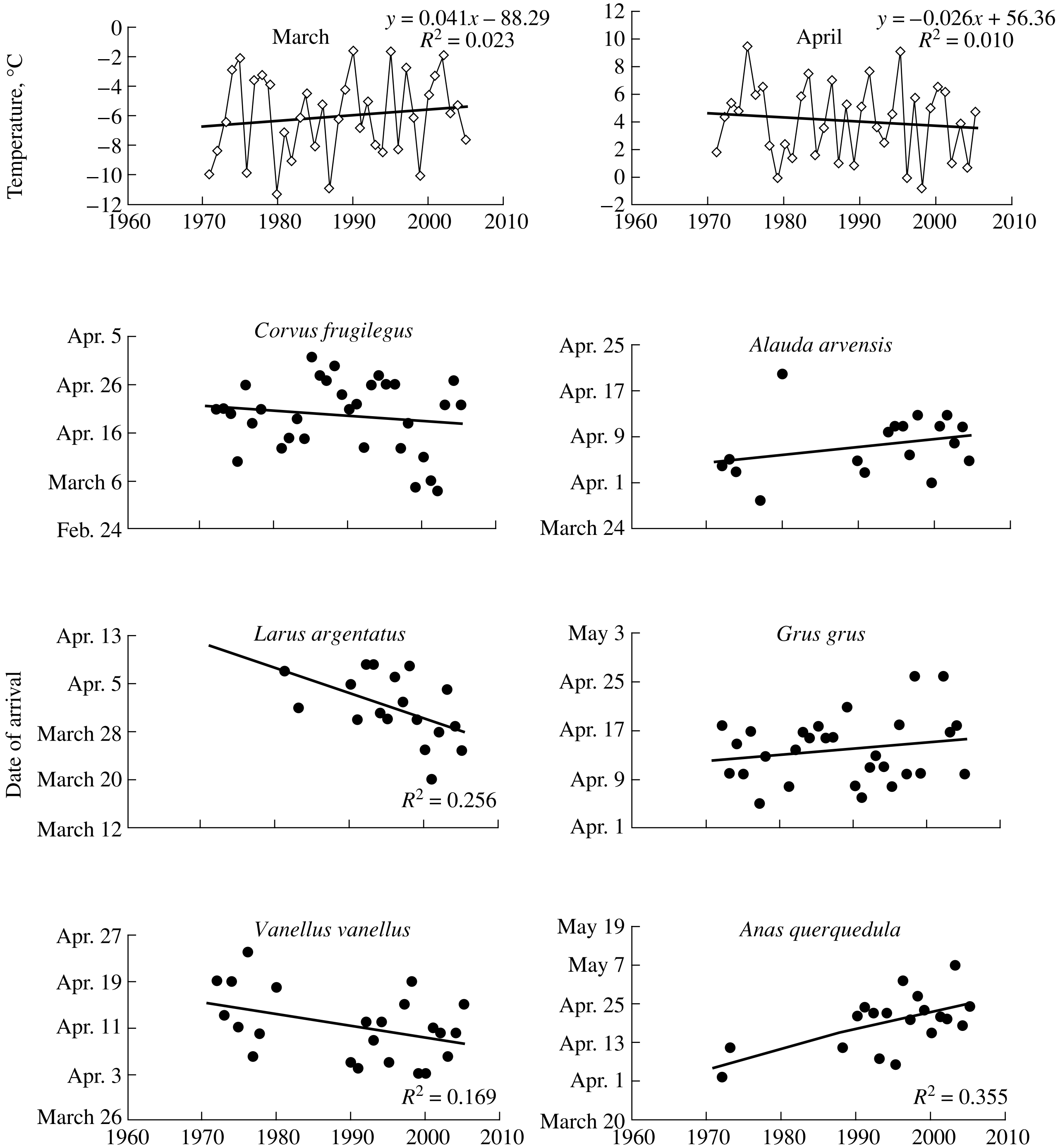

Fig. 2. Trends of March and April air temperatures and the dates of arrival of some early-migrating bird species to the Il'men Reserve.

ing recorded in many regions of the Northern Hemisphere. The dynamics of monthly or ten-day average air temperatures in spring showed no significant trends (Figs. 2, 3). A significant positive trend in air temperature was revealed only for the first two ten-day periods of January ($r = 0.479$, $p < 0.01$; $r = 0.379$, $p < 0.05$) and the last ten-day period of February ($r = 0.412$, $p < 0.05$), while both winter and spring air temperatures in many countries of Europe and North America have increased considerably during the past decades (Perevedentsev et al., 2002).

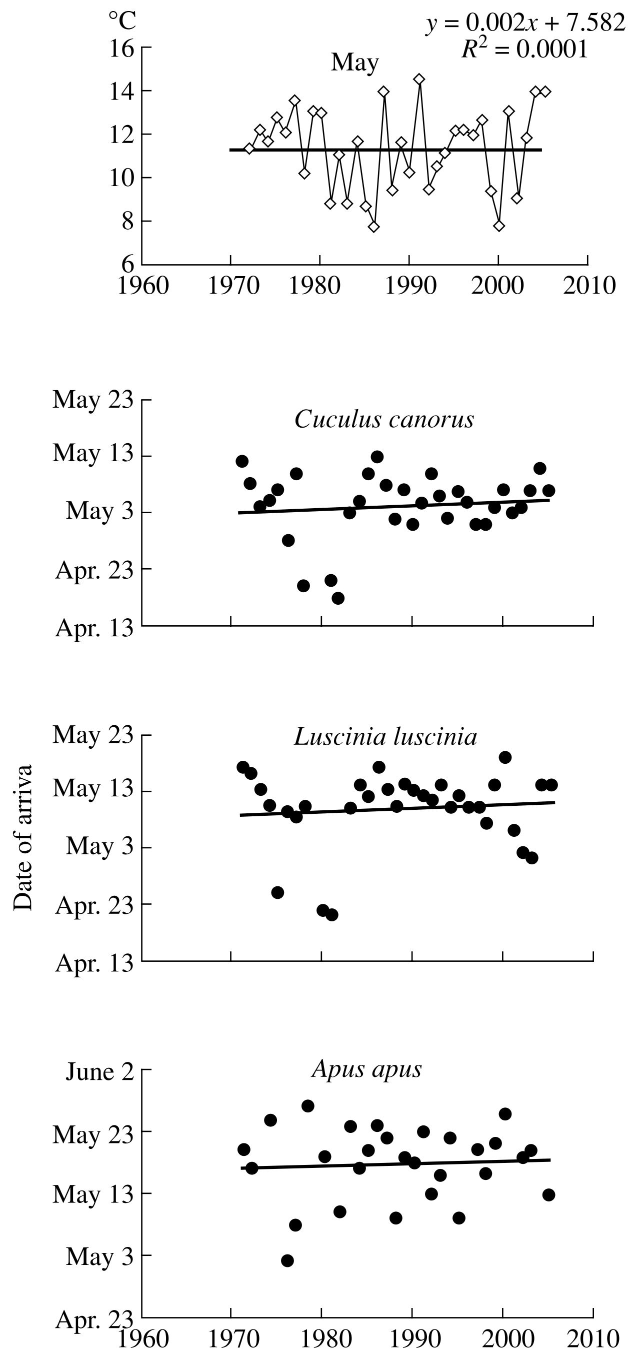

Fig. 3. Trends of May air temperature and the dates of arrival of some late-migrating bird species to the Il'men Reserve.

Thus, the absence of distinct trends in the dates of arrival of most species to the Il'men Reserve is explained primarily by the absence of such trends in the dynamics of spring air temperatures. A similar phenomenon was observed at the end of the 20th century in mountain areas of Slovakia, where bazn swallows began to arrive in spring later, rather than earlier (as in other barn countries), since no increase in spring air temperatures was recorded there (Sparks and Braslavská, 2001).

At the same time, as noted above, strong interannual fluctuations in the dates of arrival are observed in most species studied (Table 1). To answer the question concerning the environmental factors that can determine these annual fluctuations, we analyzed the relationship between the dates of bird arrival and air temperatures in winter and spring, having considered not only monthly average (as most researchers do in Europe) but also ten-day average values. As a result, a significant negative correlation between these parameters was revealed in all species, both in early arriving intracontinental migrants and in species wintering in Africa, including the latest arriving common swift *A. apus*. The only exception was the graylag goose (*Anser anser*): in this species, the correlation was at the limit of statistical significance, which could be explained by an insufficient observation period (Tables 1, 3).

These data indicate that the dates of bird arrival in the Southern Urals, as in other parts of Europe, strongly depend on spring temperatures. If the spring in some region is early and warm, many migratory species, from waterbirds to passerines, arrive markedly earlier than in years with late and cold springs. In several early arriving species, the dates of arrival significantly correlate with air temperature in February (Table 3). These are mainly species feeding in the fields, such as *C. frugilegus, S. vulgaris*, and *V. vanellus*. Apparently, higher temperatures in February provide for more rapid soil warming, which facilitates earlier arrival of these birds to the Il'men Reserve.

The relationship between the arrival of birds and changes in spring air temperatures was reported by researchers who observed birds in the 19th and early 20th centuries (Middendorff, 1855; Dixon, 1895; Kaigorodov, 1911; Menzbir, 1934). They noted that migratory birds usually arrive in spring upon the entrance of warm air masses, whereas a wave of cold air (e.g., from the Arctic) retards their movement to the north.

Thus, the dates of bird arrival to the Il'men Reserve significantly depend on temperature conditions in spring, irrespective of the taxonomic position of these birds and the time and distance of their migration: they arrive earlier in years with early and warm springs than in years with late and cold springs. This trend appears to be common to different regions of the Northern Hemisphere.

Table 3. Correlation between the dates of bird arrival and ten-day average spring air temperatures in the Il'men Reserve between 1971 and 2005

Species	Pearson's correlation coefficient by ten-day periods											
	February			March			April			May		
	1	2	3	1	2	3	1	2	3	1	2	3
Corvus frugilegus	–0.06	–0.56***	–0.21	–0.37*	–0.31	0.01	–	–	–	–	–	–
Larus argentatus	0.40	–0.29	–0.22	–0.15	–0.47*	0.17	–	–	–	–	–	–
Sturnus vulgaris	–0.28	–0.50**	–0.20	–0.22	–0.39*	–0.40*	–0.10	0.04	–0.07	–	–	–
Anser anser	–0.22	0.27	–0.53	–0.21	0.13	0.18	0.04	–0.07	–0.15	–	–	–
Alauda arvensis	–0.18	–0.06	0.35	–0.07	–0.34	–0.36	–0.62**	–0.35	–0.44	–	–	–
Anas platyrhynchos	–0.17	–0.42*	–0.02	–0.47**	–0.27	–0.40*	–0.08	–0.06	–0.01	–	–	–
Motacilla alba	–0.23	–0.25	0.02	–0.25	–0.20	–0.47**	–0.38*	–0.14	–0.08	–	–	–
Vanellus vanellus	–0.59**	–0.30	–0.26	–0.22	–0.32	–0.27	–0.27	–0.28	–0.34	–	–	–
Grus grus	–0.11	–0.12	0.22	–0.01	–0.04	–0.17	–0.56**	–0.56**	–0.43*	–	–	–
Anas querquedula	–0.21	–0.33	–0.14	–0.03	0.30	–0.52*	–0.40	–0.32	–0.21	–	–	–
Aythya fuligula	–0.07	–0.48	–0.37	–0.37	–0.34	–0.36	–0.24	–0.57*	–0.75***	–	–	–
Gavia arctica	0.06	–0.21	–0.11	–0.09	–0.16	–0.11	–0.55**	–0.66***	–0.46*	–	–	–
Hirundo rustica	–0.15	–0.18	–0.31	–0.38*	0.03	–0.23	–0.17	0.01	–0.33*	–0.17	0.17	–
Cuculus canorus	0.10	–0.18	–0.08	–0.23	0.25	0.11	0.06	0.04	0.07	–0.35*	0.19	0.29
Luscinia luscinia	0.05	0.03	–0.04	–0.10	0.04	0.01	–0.03	0.10	0.07	–0.38*	0.01	0.07
Apus apus	0.26	0.14	–0.09	–0.12	0.34	0.03	0.01	0.04	–0.22	–0.09	–0.41*	0.02

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

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