

Spring bird migration phenology in Eilat, Israel

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Academic editor: E. Neubert, S. Taiti | Received 30 November 2008 | Accepted 14 August 2009 | Published 28 December 2009

Citation: Yosef R, Markovets M (2009) Spring bird migration phenology in Eilat, Israel. In: Neubert E, Amr Z, Taiti S, Gümüs B (Eds) *Animal Biodiversity in the Middle East. Proceedings of the First Middle Eastern Biodiversity Congress, Aqaba, Jordan, 20–23 October 2008*. ZooKeys 31: 193–210. doi: 10.3897/zookeys.31.107

Abstract

Analysis of the mean date of first captures and median arrival dates of spring migration for 34 species of birds at Eilat, Israel, revealed that the earlier a species migrates through Eilat, the greater is the inter-annual variation in the total time of its passage. Birds arrive during spring migration in Eilat in four structured and independent waves. The annual fluctuation in the initial arrival dates (initial capture dates) and median dates (median date of all captures), not including recaptures, did not depend on the length of the migratory route. This implies that migrants crossing the Sahara desert depart from their winter quarters on different Julian days in different years. We suggest that negative correlations between the median date of the spring migration of early and late migrants depends upon the easterly (Hamsin) wind period. Moreover, we believe that the phenology of all birds during spring migration in Eilat is possibly also determined by external factors such as weather conditions on the African continent or global climatic processes in the Northern hemisphere. Orphean Warblers (*Sylvia hortensis*) show a strong negative correlation ($r_s = -0.502$) of initial capture date with calendar years, whereas other species such as Barred Warbler (*S. nisoria*; $r_s = -0.391$) and Spotted Flycatcher (*Muscicapa striata*; $r_s = -0.398$) display an insignificant trend. The Dead Sea Sparrow (*Passer moabiticus*) and Red-Backed Shrike (*Lanius collurio*) are positively correlated regarding initial arrival date and medians of spring migration.

Keywords

Phenology, spring, migration, Eilat

Introduction

During the last two decades in many European countries, spring arrival for numerous bird species has been recorded earlier than during the 1970s. This includes both short-distance migrants and species wintering in Africa (Mason 1995; Sokolov et al.

1998; Sparks 1999; Barrett 2002; Hüppop and Hüppop 2003). The considerable shift in timing of spring migration towards earlier Julian dates has been associated with global warming and climatic change (Bairlein and Winkel 2001; Sokolov 2001; Sparks et al. 2001, 2003; Hüppop and Hüppop 2003). However, the way in which timing of migration actually affects the early stages of spring migration has yet to be defined.

For many migrating species, the Eilat oasis is the first stopover site encountered after crossing the combined geophysical barrier of the Sahel, Sahara and Sinai deserts (Yosef and Tryjanovski 2002a). In some passerines species, e.g., Blackcap *Sylvia atricapilla* (Izhaki and Maitiav 1998), Red-backed and Masked Shrikes (*Lanius collurio*, *nubicus* resp.; Yosef and Tryjanovski 2002b, c), and Ortolan and Cretzschmar's Bunting (*Emberiza hortulana*, *caesia* resp.; Yosef and Tryjanovski 2002d, e), a significant interannual variation of the timing of spring migration has been documented.

Here, we present an analysis of the initial arrival (capture) date and median date of migration of 34 avian species in order to better understand if any changes have occurred in the phenology during spring migration for the past 20 years at Eilat.

Materials and methods

From 1984–2003, the International Birding and Research Center in Eilat (IBRCE), Israel (29°33'N, 34°57'E) has trapped and ringed passerines in autumn and in spring. This has resulted in dataset containing information on more than 180.000 individual birds from 272 avian species. In most species, the numbers trapped in spring were higher than in the autumn. The IBRCE ringing program is aimed at three major groups of birds: raptors, waders, and passerines. Because the ringing program during spring began at different times of the month (between 1–15 February), we analyzed data from 15 February only.

In order to analyze the phenology of spring migration, we selected species based on the following criteria: (1) all species were caught in mist nets; (2) no special effort was made to capture individual species, e.g., swallows (*Hirundo* spp.) and wagtails (*Motacilla* spp.) at roost; (3) the species were captured in a minimum of 17 seasons; (4) in sufficient numbers (>20); and (5) the species was not sedentary. Based on these criteria, we included in our final analyses a total of 34 avian species comprising 32 passerine species, Quail (*Coturnix coturnix*) and Wryneck (*Jynx torquilla*) (Table 1).

For all individual birds from all species captured, we calculated the date of initial capture, and the average and median of all captures during the season. The average and median were calculated if the number of birds caught exceeded 20, and excluded all recaptures.

Because of Eilat's unique geographical location on the migratory flyway, our analysis focused on the date of the initial capture and the median date of all captures. It was assumed that the date of initial capture reflected the date of first arrival of the species in that season (Sokolov et al. 1998). The species' median arrival date was considered to be of major importance because the duration of spring migration in Eilat for many species exceeds 3.5 months (Morgan and Shirihai 1997). Further, in

Table 1. Phenology of spring migration of Eurasian bird populations at Eilat, Israel, 1984–2003.

Species	Mean of first capture	SD, days	Median	N, all years
<i>Coturnix coturnix</i>	27.2	19	20.3	971
<i>Jynx torquilla</i>	12.3	8	29.3	332
<i>Anthus trivialis</i>	24.3	8	13.4	1596
<i>Cercotrichas galactotes</i>	10.4	12	3.5	386
<i>Luscinia luscinia</i>	12.4	11	27.4	263
<i>Luscinia megarhynchos</i>	23.3	7	6.4	470
<i>Luscinia svecica</i>	9.2	16	23.3	873
<i>Phoenicurus phoenicurus</i>	19.3	17	31.3	451
<i>Oenanthe hispanica</i>	15.3	17	29.3	200
<i>Oenanthe oenanthe</i>	17.3	10	28.3	707
<i>Locustella luscinioides</i>	26.2	10	18.3	469
<i>Acrocephalus arundinaceus</i>	1.4	17	21.4	315
<i>Acrocephalus schoenobaenus</i>	17.2	11	27.3	2356
<i>Acrocephalus scirpaceus</i>	26.2	10	13.4	3496
<i>Hippolais pallida</i>	11.3	11	27.4	4599
<i>Sylvia atricapilla</i>	3.3	17	23.4	17835
<i>Sylvia borin</i>	22.4	6	12.5	2104
<i>Sylvia communis</i>	26.2	16	28.3	1756
<i>Sylvia curruca</i>	25.2	8	1.4	13691
<i>Sylvia hortensis</i>	20.3	15	28.3	490
<i>Sylvia melanocephala</i>	15.2	11	12.3	737
<i>Sylvia nisoria</i>	28.4	11	13.5	260
<i>Phylloscopus bonelli</i>	11.3	8	26.3	1293
<i>Phylloscopus collybita</i>	11.2	13	18.3	6042
<i>Phylloscopus sibilatrix</i>	11.4	12	21.4	98
<i>Phylloscopus trochilus</i>	25.3	9	22.4	682
<i>Muscicapa striata</i>	22.4	12	3.5	210
<i>Lanius collurio</i>	22.4	12	8.5	217
<i>Lanius nubicus</i>	21.3	8	29.4	1038
<i>Lanius senator</i>	11.3	13	26.3	317
<i>Passer hispaniolensis</i>	11.2	17	26.3	2935
<i>Passer moabiticus</i>	18.2	13	9.3	756
<i>Emberiza caesia</i>	11.3	7	18.3	489
<i>Emberiza hortulana</i>	27.3	6	15.4	2188

many species there are several geographically distinct subspecies, many of which have not been identified to date, which constitute the species population for the season (Morgan and Shirihai 1997).

To corroborate our conjectures, we conducted a correlation analysis between initial and median captures of the 34 species included in our study from 1984–

2003. We also compared dates of initial capture of these species for the two decades from 1984–1993 and from 1994–2003. Standard statistical methods were used to characterize and analyze the data (Sokal and Rohlf 1995). Calculations were made using the STATISTICA v.5 package.

Results

Analysis of the phenology in 34 species at Eilat showed a large inter-annual variation (Table 1). More specifically, early migrants showed large inter-annual variation regarding initial capture date resulting in no statistically significant trends overall ($r_s = -0.2547$, $n = 34$, $p = 0.146$).

Correlation analyses of initial capture date during the past 20 years revealed that in the studied species, change in initial captures ranged from a strong positive influence to results that were statistically insignificant (Table 2). Correlation analyses of median capture dates of the individuals during the past 20 years highlighted groups of species that had similar spring migration timing and phenology (Table 3).

Initial captures of the 34 species confirmed that the first of the spring arrivals are the long-distance migrants, and that they are already present in Eilat by mid-February. Owing to its geophysical position in relation to African winter quarters, one of the important characteristics for Eilat is the simultaneous occurrence of groupings of species (Fig. 1). Combining the results of the correlations analysis of first arrival date and median data of spring migration in Eilat for 20 years showed that there are at least four such waves of arrival.

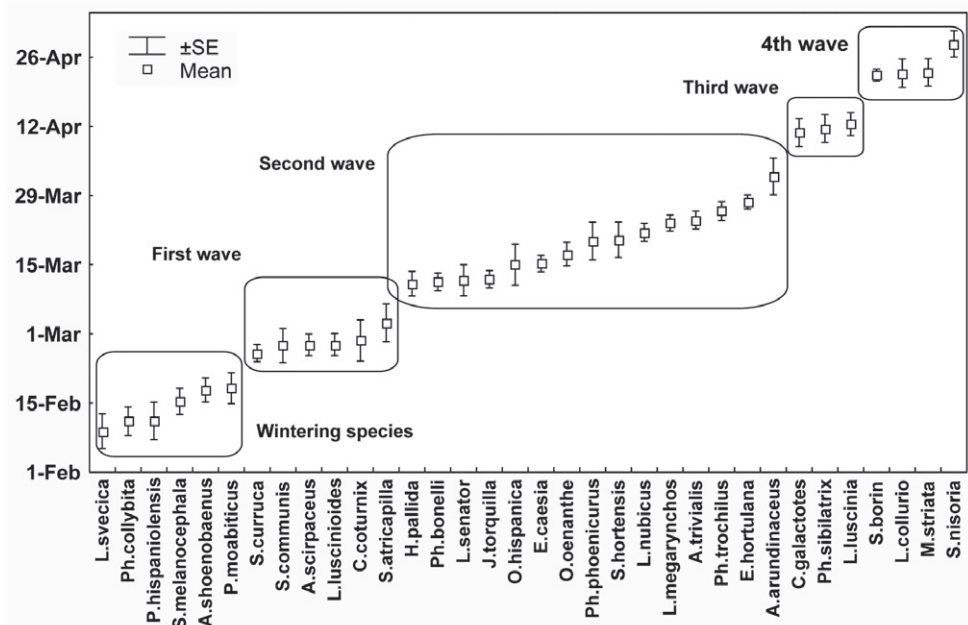


Figure 1. Data of first capture of 34 species of birds in Eilat in 1984–2003.

Table 2. The correlation between first arrival dates of 34 species in the spring in Eilat during 1984–2003. (Spearman's rank correlation 0.701, $p < 0.001$; 0.542, $p < 0.01$; 0.449, $p < 0.05$; 0.413, $p < 0.1$)

Species	<i>Coturnix coturnix</i>	<i>Jynx torquilla</i>	<i>Anthus trivialis</i>	<i>Cercotrichas galactotes</i>	<i>Luscinia luscinia</i>	<i>Luscinia megarhynchos</i>	<i>Luscinia svecica</i>	<i>Phoenicurus phoenicurus</i>
<i>Emberiza hortulana</i>								
<i>Emberiza caesia</i>								
<i>Passer moabiticus</i>								
<i>Passer hispaniolensis</i>								
<i>Lanius senator</i>								
<i>Lanius nubicus</i>								
<i>Lanius collurio</i>								
<i>Muscicapa striata</i>								
<i>Phylloscopus trochilus</i>								
<i>Phylloscopus sibilatrix</i>								
<i>Phylloscopus collybita</i>								
<i>Phylloscopus bonelli</i>								
<i>Sylvia nisoria</i>								
<i>Sylvia melanocephala</i>								
<i>Sylvia hortensis</i>								
<i>Sylvia curruca</i>								
<i>Sylvia communis</i>								
<i>Sylvia borin</i>								
<i>Sylvia atricapilla</i>								
<i>Hippolais pallida</i>								
<i>Acrocephalus scirpaceus</i>								
<i>A. schoenobaenus</i>								
<i>Acrocephalus arundinaceus</i>								
<i>Locustella luscinioides</i>								
<i>Oenanthe oenanthe</i>								
<i>Oenanthe hispanica</i>								
<i>Phoenicurus phoenicurus</i>								
<i>Luscinia svecica</i>								
<i>Luscinia megarhynchos</i>								0.618
<i>Luscinia luscinia</i>								
<i>Cercotrichas galactotes</i>						0.461		
<i>Anthus trivialis</i>				0.466				
<i>Jynx torquilla</i>							0.464	
<i>Coturnix coturnix</i>				0.483			0.509	0.414

Species	Oenanthe hispanica	Oenanthe oenanthe	Locustella luscinioides	A. arundinaceus	A. schoenobaenus	Acrocephalus scirpaceus	Hippolais pallida	Sylvia atricapilla	Sylvia borin
<i>Emberiza hortulana</i>									
<i>Emberiza caesia</i>									
<i>Passer moabiticus</i>									
<i>Passer hispaniolensis</i>									
<i>Lanius senator</i>									
<i>Lanius nubicus</i>									
<i>Lanius collurio</i>									
<i>Muscicapa striata</i>									
<i>Phylloscopus trochilus</i>									
<i>Phylloscopus sibilatrix</i>									
<i>Phylloscopus collybita</i>									
<i>Phylloscopus bonelli</i>									
<i>Sylvia nisoria</i>									
<i>Sylvia melanocephala</i>									
<i>Sylvia hortensis</i>									
<i>Sylvia curruca</i>									
<i>Sylvia communis</i>									
<i>Sylvia borin</i>									
<i>Sylvia atricapilla</i>									
<i>Hippolais pallida</i>									
<i>Acrocephalus scirpaceus</i>									
<i>A. schoenobaenus</i>						0.572			
<i>Acrocephalus arundinaceus</i>									
<i>Locustella luscinioides</i>					0.547	0.508			
<i>Oenanthe oenanthe</i>									0.498
<i>Oenanthe hispanica</i>						0.585	0.407		
<i>Phoenicurus phoenicurus</i>							0.470		
<i>Luscinia svecica</i>					0.445				
<i>Luscinia megarhynchos</i>							0.413		
<i>Luscinia luscinia</i>									
<i>Cercotrichas galactotes</i>				0.556					
<i>Anthus trivialis</i>		0.504	0.449						
<i>Jynx torquilla</i>				0.440	0.550				
<i>Coturnix coturnix</i>			0.424	0.500	0.688	0.588			

Species	<i>Sylvia communis</i>	<i>Sylvia curruca</i>	<i>Sylvia hortensis</i>	<i>Sylvia melanocephala</i>	<i>Sylvia nisoria</i>	<i>Phylloscopus bonelli</i>	<i>Phylloscopus collybita</i>	<i>Phylloscopus sibilatrix</i>	<i>Phylloscopus trochilus</i>
<i>Emberiza hortulana</i>									
<i>Emberiza caesia</i>									
<i>Passer moabiticus</i>									
<i>Passer hispaniolensis</i>									
<i>Lanius senator</i>									
<i>Lanius nubicus</i>									
<i>Lanius collurio</i>									
<i>Muscicapa striata</i>									
<i>Phylloscopus trochilus</i>									
<i>Phylloscopus sibilatrix</i>									
<i>Phylloscopus collybita</i>									-0.462
<i>Phylloscopus bonelli</i>								<u>0.717</u>	0.431
<i>Sylvia nisoria</i>									
<i>Sylvia melanocephala</i>							<u>0.721</u>		
<i>Sylvia hortensis</i>						0.498			
<i>Sylvia curruca</i>									
<i>Sylvia communis</i>		<u>0.717</u>	0.516						
<i>Sylvia borin</i>									
<i>Sylvia atricapilla</i>	0.486	0.542		0.523			0.480		
<i>Hippolais pallida</i>			0.525						
<i>Acrocephalus scirpaceus</i>	<u>0.747</u>		0.503						
<i>A. schoenobaenus</i>	0.567			0.534			<u>0.706</u>		
<i>Acrocephalus arundinaceus</i>	0.445		<u>0.719</u>						0.488
<i>Locustella luscinioides</i>	<u>0.729</u>	0.671							
<i>Oenanthe oenanthe</i>									0.514
<i>Oenanthe hispanica</i>				0.406			0.517		
<i>Phoenicurus phoenicurus</i>									
<i>Luscinia svecica</i>				0.580			0.585		
<i>Luscinia megarhynchos</i>						0.467			
<i>Luscinia luscinia</i>					0.445				
<i>Cercotrichas galactotes</i>									
<i>Anthus trivialis</i>		0.526							
<i>Jynx torquilla</i>	0.418					0.481		0.548	
<i>Coturnix coturnix</i>	0.538			0.615					

Species	<i>Muscicapa striata</i>	<i>Lanius collurio</i>	<i>Lanius nubicus</i>	<i>Lanius senator</i>	<i>Passer hispaniolensis</i>	<i>Passer moabiticus</i>	<i>Emberiza caesia</i>	<i>Emberiza hortulana</i>
<i>Emberiza hortulana</i>								
<i>Emberiza caesia</i>								
<i>Passer moabiticus</i>								
<i>Passer hispaniolensis</i>							-0.484	
<i>Lanius senator</i>								0.482
<i>Lanius nubicus</i>								
<i>Lanius collurio</i>			0.566		0.422			
<i>Muscicapa striata</i>								
<i>Phylloscopus trochilus</i>								
<i>Phylloscopus sibilatrix</i>								
<i>Phylloscopus collybita</i>					0.576			
<i>Phylloscopus bonelli</i>				0.415				
<i>Sylvia nisoria</i>	0.598					0.579		
<i>Sylvia melanocephala</i>					0.484	0.525		0.578
<i>Sylvia hortensis</i>		0.656	0.479	0.400	0.422			
<i>Sylvia curruca</i>			0.593					
<i>Sylvia communis</i>		0.405						
<i>Sylvia borin</i>		0.413						0.497
<i>Sylvia atricapilla</i>								
<i>Hippolais pallida</i>				0.457				
<i>Acrocephalus scirpaceus</i>								
<i>A. schoenobaenus</i>		0.474	0.435		0.406			0.408
<i>Acrocephalus arundinaceus</i>		0.662		0.497				
<i>Locustella luscinioides</i>			0.405					
<i>Oenanthe oenanthe</i>		0.416	0.522					0.544
<i>Oenanthe hispanica</i>								
<i>Phoenicurus phoenicurus</i>							0.414	
<i>Luscinia svecica</i>					0.729			
<i>Luscinia megarhynchos</i>				0.473				
<i>Luscinia luscinia</i>						0.572		
<i>Cercotrichas galactotes</i>								
<i>Anthus trivialis</i>			0.607					
<i>Jynx torquilla</i>								
<i>Coturnix coturnix</i>		0.570						0.485

Table 3. Correlation between medians of all captures dates of 34 species in the spring in Eilat during 1984–2003. (Spearman's rank correlation **0.701**, $p < 0.001$; **0.542**, $p < 0.01$; **0.449**, $p < 0.05$; **0.413**, $p < 0.1$)

Species	<i>Coturnix coturnix</i>	<i>Jynx torquilla</i>	<i>Anthus trivialis</i>	<i>Cercotrichas galactotes</i>	<i>Luscinia luscinia</i>	<i>Luscinia megarhynchos</i>	<i>Luscinia svecica</i>
<i>Emberiza hortulana</i>							
<i>Emberiza caesia</i>							
<i>Passer moabiticus</i>							
<i>Passer hispaniolensis</i>							
<i>Lanius senator</i>							
<i>Lanius nubicus</i>							
<i>Lanius collurio</i>							
<i>Muscicapa striata</i>							
<i>Phylloscopus trochilus</i>							
<i>Phylloscopus sibilatrix</i>							
<i>Phylloscopus collybita</i>							
<i>Phylloscopus bonelli</i>							
<i>Sylvia nisoria</i>							
<i>Sylvia melanocephala</i>							
<i>Sylvia hortensis</i>							
<i>Sylvia curruca</i>							
<i>Sylvia communis</i>							
<i>Sylvia borin</i>							
<i>Sylvia atricapilla</i>							
<i>Hippolais pallida</i>							
<i>Acrocephalus scirpaceus</i>							
<i>A. schoenobaenus</i>							
<i>Acrocephalus arundinaceus</i>							
<i>Locustella luscinioides</i>							
<i>Oenanthe oenanthe</i>							
<i>Oenanthe hispanica</i>							
<i>Phoenicurus phoenicurus</i>							
<i>Luscinia svecica</i>							
<i>Luscinia megarhynchos</i>							
<i>Luscinia luscinia</i>							
<i>Cercotrichas galactotes</i>							-0.589
<i>Anthus trivialis</i>				0.552	0.819		
<i>Jynx torquilla</i>				-0.652			
<i>Coturnix coturnix</i>							

Species	<i>Sylvia atricapilla</i>	<i>Sylvia borin</i>	<i>Sylvia communis</i>	<i>Sylvia curruca</i>	<i>Sylvia hortensis</i>	<i>Sylvia melanocephala</i>	<i>Sylvia nisororia</i>	<i>Phylloscopus bonelli</i>
<i>Emberiza hortulana</i>								
<i>Emberiza caesia</i>								
<i>Passer moabiticus</i>								
<i>Passer hispaniolensis</i>								
<i>Lanius senator</i>								
<i>Lanius nubicus</i>								
<i>Lanius collurio</i>								
<i>Muscicapa striata</i>								
<i>Phylloscopus trochilus</i>								
<i>Phylloscopus sibilatrix</i>								
<i>Phylloscopus collybita</i>								
<i>Phylloscopus bonelli</i>								
<i>Sylvia nisororia</i>								-0.851
<i>Sylvia melanocephala</i>								
<i>Sylvia hortensis</i>								0.608
<i>Sylvia curruca</i>								
<i>Sylvia communis</i>				0.634				
<i>Sylvia borin</i>							0.881	-0.596
<i>Sylvia atricapilla</i>			0.512	0.438				
<i>Hippolais pallida</i>	0.505							
<i>Acrocephalus scirpaceus</i>	0.577							
<i>A. schoenobaenus</i>								
<i>Acrocephalus arundinaceus</i>								
<i>Locustella luscinioides</i>	0.558	-0.450	0.525	0.746				
<i>Oenanthe oenanthe</i>			0.761	0.614				
<i>Oenanthe hispanica</i>	0.918	-0.667	0.718					0.743
<i>Phoenicurus phoenicurus</i>	0.929	-0.586		0.647	0.723			0.750
<i>Luscinia svecica</i>		-0.487						
<i>Luscinia megarhynchos</i>								
<i>Luscinia luscinia</i>	0.778	0.790					0.750	
<i>Cercotrichas galactotes</i>							0.727	
<i>Anthus trivialis</i>								
<i>Jynx torquilla</i>								
<i>Coturnix coturnix</i>				0.540	0.648			

Species	<i>Passer moabiticus</i>	<i>Emberiza caesia</i>	<i>Emberiza hortulana</i>
<i>Emberiza hortulana</i>			
<i>Emberiza caesia</i>			
<i>Passer moabiticus</i>			
<i>Passer hispaniolensis</i>			
<i>Lanius senator</i>			
<i>Lanius nubicus</i>			
<i>Lanius collurio</i>			
<i>Muscicapa striata</i>			
<i>Phylloscopus trochilus</i>			
<i>Phylloscopus sibilatrix</i>			
<i>Phylloscopus collybita</i>			
<i>Phylloscopus bonelli</i>			
<i>Sylvia nisoria</i>			
<i>Sylvia melanocephala</i>			
<i>Sylvia hortensis</i>			
<i>Sylvia curruca</i>			
<i>Sylvia communis</i>			
<i>Sylvia borin</i>			
<i>Sylvia atricapilla</i>			
<i>Hippolais pallida</i>		-0.761	
<i>Acrocephalus scirpaceus</i>			
<i>A. schoenobaenus</i>			
<i>Acrocephalus arundinaceus</i>			
<i>Locustella luscinioides</i>			
<i>Oenanthe oenanthe</i>			
<i>Oenanthe hispanica</i>			
<i>Phoenicurus phoenicurus</i>			
<i>Luscinia svecica</i>			
<i>Luscinia megarhynchos</i>			
<i>Luscinia luscinia</i>			
<i>Cercotrichas galactotes</i>			
<i>Anthus trivialis</i>			
<i>Jynx torquilla</i>		0.697	
<i>Coturnix coturnix</i>			

The first species to arrive in the spring are Quail, Reed Warbler (*A. scirpaceus*), Savi's Warbler (*Locustella luscinioides*), Blackcap (*S. atricapilla*), Common Whitethroat (*S. communis*), and Lesser Whitethroat (*S. curruca*). These species usually appear in Eilat in the second half of February (Table 1); their initial captures are positively and

Table 4. Mean of first capture in two consecutive decades – 1984–1993 and 1994–2003 (comparison by Mann-Whitney U test).

Species	1984–1993	1994–2003	Difference, days	P
<i>Coturnix coturnix</i>	29.2	24.2	6	0.150937
<i>Jynx torquilla</i>	13.3	10.3	3	0.324116
<i>Anthus trivialis</i>	21.3	26.3	-5	0.130583
<i>Cercotrichas galactotes</i>	11.4	10.4	1	0.4871
<i>Luscinia luscinia</i>	14.4	10.4	5	0.544293
<i>Luscinia megarhynchos</i>	24.3	22.3	2	0.939607
<i>Luscinia svecica</i>	19.2	29.1	21	0.0010
<i>Phoenicurus phoenicurus</i>	14.3	25.3	-11	0.161034
<i>Oenanthe hispanica</i>	10.3	20.3	-10	0.206919
<i>Oenanthe oenanthe</i>	15.3	18.3	-3	0.413402
<i>Locustella luscinioides</i>	24.2	1.3	-4	0.622787
<i>Acrocephalus arundinaceus</i>	3.4	31.3	3	0.676899
<i>A. schoenobaenus</i>	19.2	15.2	4	0.426839
<i>Acrocephalus scirpaceus</i>	25.2	27.2	-2	0.820265
<i>Hippolais pallida</i>	12.3	9.3	3	1
<i>Sylvia atricapilla</i>	7.3	26.2	9	0.343985
<i>Sylvia borin</i>	23.4	20.4	3	0.181392
<i>Sylvia communis</i>	23.2	2.3	-7	0.8
<i>Sylvia curruca</i>	24.2	26.2	-2	0.647795
<i>Sylvia hortensis</i>	25.3	16.3	8	0.37949
<i>Sylvia melanocephala</i>	19.2	10.2	9	0.121515
<i>Sylvia nisoria</i>	3.5	24.4	9	0.228487
<i>Phylloscopus bonelli</i>	11.3	11.3	0	0.703217
<i>Phylloscopus collybita</i>	16.2	6.2	10	0.110933
<i>Phylloscopus sibilatrix</i>	13.4	9.4	4	0.688823
<i>Phylloscopus trochilus</i>	23.3	28.3	-5	0.271235
<i>Muscicapa striata</i>	27.4	18.4	9	0.170445
<i>Lanius collurio</i>	26.4	18.4	8	0.191198
<i>Lanius nubicus</i>	21.3	21.3	0	0.733346
<i>Lanius senator</i>	12.3	11.3	1	0.964528
<i>Passer hispaniolensis</i>	22.2	31.1	22	0.002471
<i>Passer moabiticus</i>	22.2	14.2	8	0.229376
<i>Emberiza caesia</i>	11.3	19.3	-8	0.02255
<i>Emberiza hortulana</i>	28.3	26.3	2	0.279794

significantly correlated among themselves (Table 2). The second wave of migrants arrives in the second 10 days of March. The initial capture of Wryneck, Black-eared Wheatear (*Oenanthe hispanica*), Northern Wheatear (*O. oenanthe*), Bonelli's Warbler (*P. bonelli*), Olivaceous Warbler (*H. pallida*), Woodchat Shrike (*L. senator*), Cretzschmar's Bunting (*E. ceasia*) occurs almost simultaneously (Table 1). During the next 7–10 days, waves of Tree Pipit (*Anthus trivialis*), Redstart (*Phoenicurus phoenicurus*), Common Nightingale (*Luscinia megarhynchos*), Great Reed Warbler (*A. arundinaceus*), Orphee Warbler (*S. hortensis*), Willow Warbler (*P. trochilus*), Masked Shrike (*L. nubicus*), and Ortolan Bunting (*E. hortulana*) come through. In early April, mixed with the tail end of the third wave, Thrush Nightingale (*L. luscinia*), Rufous Bush Robin (*Cercotrichas galactotes*), Wood Warbler (*P. sibilatrix*), Garden Warbler (*S. borin*), Barred Warbler (*S. nisoria*), Spotted Flycatcher (*Muscicapa striata*), and Red-backed Shrike (*L. collurio*) constitute the last wave of initial arrivals at Eilat.

By correlation analyses, we found a strong and positive correlation among the medians of all species that arrive together (Table 3). However, there are significant negative correlations between the median date of spring migration among early migrants and those that migrate late (e.g., between the medians of spring migration of Garden Warbler and six early migrants).

In several species we found a significant correlation between initial capture dates in the spring and in the calendar years (Bluethroat, *L. svecica*, $r_s = -0.648$, $p = 0.002$; Orphee Warbler $r_s = -0.502$, $p = 0.0403$; Spanish Sparrow $r_s = -0.702$, $p = 0.0006$; Cretzschmar's Bunting $r_s = 0.6974$, $p = 0.0009$). In contrast, no such connection was found for Barred Warbler ($r_s = -0.391$, $p = 0.1203$), Spotted Flycatcher ($r_s = -0.398$, $p = 0.102$), Red-backed Shrike ($r_s = -0.419$, $p = 0.094$), and Dead Sea Sparrow ($r_s = -0.40124$, $p = 0.0989$). Further, we found a marked correlation between the medians of all capture dates in spring and in calendar years (Red-backed Shrike $r_s = -0.886$, $p = 0.01885$; Dead Sea Sparrow $r_s = -0.6946$, $p = 0.005$; Cretzschmar's Bunting $r_s = 0.6549$, $p = 0.0268$).

A comparison of mean data regarding initial capture dates during the two consecutive decades indicated that all 34 species arrived on average three days earlier from 1984–1993 than from 1994–2003 (17 vs 14 of March). However, the difference is not statistically significant (Mann-Whitney U Test, $U = 563$, $Z = 0.184$, $p = 0.854$).

Discussions

The beginning of spring migration for birds is controlled by the photoperiod or by means of special endogenous programs that are initiated in the breeding areas, and are specific for species that winter in the equatorial regions or further south (Gwinner 1996; Berthold 2001). Following this concept, many researchers believe that spring migration in Africa begins approximately at the same time, and that this is specific for each species, subspecies or separate population. Alerstam (1990) suggested that weather conditions determine the speed of spring migration, but not the timing of its

initiation. Sparks et al. (2001) and Hüppop and Hüppop (2003) found that weather conditions on the European continent determined strong interannual fluctuations in the timing of arrival of long-distance migrants in breeding areas.

To date, Eilat is the southernmost site for which there exists a long-term monitoring data set of spring migration phenology, and is closest to the wintering grounds. Of the 34 species chosen for analyses, the majority (24) were long-distance migrants from Africa to Europe and Asia, some (9) breed in the Mediterranean basin, and one, the Rufous Bush-Robin, is a summer visitor that breeds in the Eilat region and the Negev desert. The initial capture dates and median for many species varied considerably between years. The median date of spring migration (median of all captures) for some species also varied greatly between years (Table 1). Moreover, initial arrival dates and the median date of spring migration were very positively connected with each other, though the median dates of early migrants were very negatively associated with median dates of late migrants (Tables 2, 3). Assuming that birds do not stop over for longer periods in the desert, we infer that crossing the Sahara occurs on variable dates. It also suggests that the spring migration phenology at Eilat is strongly connected to extrinsic factors such as weather conditions in Africa or global climatic processes in the Northern hemisphere. The concomitant arrival of the same groups of species also suggests that weather influences the initiation of spring migration of those birds arriving at Eilat. A major weather pattern observed to have an effect on the medians of migration is known as the Hamsin. A Hamsin weather pattern consists of days (sometimes up to a week) of very hot, dry weather due to strong easterly winds occurring mostly in the spring. The Hamsin winds delay migration in late-migrating species such as the Garden and Barred Warbler and the Spotted Flycatcher (pers. obs.).

For several species of birds we found a connection between dates of initial capture and the calendar year. Some of these can be attributed to the influence of global warming on avian spring migration, as shown by several studies (Bairlein and Winkel 2001; Sokolov 2001; Sparks et al. 2001; Hüppop and Hüppop 2003; Butler 2003). Only the Orphean Warbler showed a strong positive correlation of initial capture with the calendar year, whereas the Barred Warbler and Grey Flycatcher displayed insignificant trends. The Dead Sea Sparrow and Red-Backed Shrike showed positive correlations of initial arrival date with the medians of spring migration.

Similar to long-term studies by Sokolov (2001; 43 years) and Butler (2003; 90 years), we concluded that it is imperative that the long-term ringing program at Eilat continues in such a way that the influence of environmental pressures on phenological trends of migratory birds will be evident in future decades.

Acknowledgments

We thank the European Union's BIRD Fund for optimal migration of EUEP for support to MM during his post-doctoral study at IBRCE, Eilat. We thank Mrs.

L. Mitchell, Mrs. B. Bausch, Swarovski Optics, and Earthwatch for their support of the ringing program in Eilat. Ms. Susan Craig improved an earlier draft of the manuscript.

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