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ORIGINAL PAPER

Differential sex- and age-related migration of Bluethroats *Luscinia svecica* at Eilat, Israel

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Abstract This paper examines the phenology and biometrics of Bluethroats staging in the Eilat region. This is of special interest because of the extreme conditions with which this temperate zone breeding species has to contend because Eilat is a desert habitat and is the last green area before the crossing of the deserts in autumn or after it in spring. Data were collected during 20 spring and 18 autumn migration seasons in the years 1984–2003, and a total of 7,464 Bluethroat were recorded. The number of trapped birds was much higher in autumn than in spring. The majority of Bluethroats caught in both the autumn and spring migrations were juveniles. We found differences in sex ratio in the individual age classes only in the autumn wherein among both adults and juveniles, males were in greater numbers. We also found significant differences in the dates of ringed birds from different sex–age classes in the spring and in autumn migrations. In spring, males from both age classes were caught earlier than females. In autumn, adult birds arrived earlier than juveniles. We think that it is important to identify and conserve the high quality stopover habitats such as Eilat wherein not only Bluethroats have been shown to stopover but also several hundred other species.

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Introduction

Ever-increasing understanding of the processes that govern migration is being achieved by direct observations of migratory flyways, studies of stopover ecology and behaviour and research of orientation and navigational abilities (Alerstam 1990; Berthold 1996). The least studied component of the annual migration cycle, especially of the long-distance species, is their staging ecology (Ellegren and Staav 1990).

The Bluethroat *Luscinia svecica* is a polytypic species, widespread in the Northern Palearctic from Scandinavia to Alaska and from the Siberian arctic tundra to the Himalayan Mountains. There is limited knowledge of their migration strategies and behaviour (Cramp and Perrins 1994). Most of the studies published to date on Bluethroat migration ecology are from Western Europe (Bergman 1987; Ellegren 1990, 1992; Ellegren and Staav 1990; Ellegren and Wallin 1991; Peiro 1997; Lindstrom and Lind 2001; Hernandez et al. 2003; Lindstrom et al. 1990, 1994), and there is no data for the more eastern subspecies that migrate on the circum Mediterranean flyway that passes through Eilat, Israel.

Eilat, Israel is situated at the northern edge of the combined Sahel, Sahara and Sinai deserts and, in the spring, is reached after a long and arduous journey. Eilat is located at the southern tip of the Arava Valley, i.e. the section of the Rift Valley between the Red and Dead Seas. The region is mostly desert, as defined by annual rainfall (Miller 1961). Many spring migrants returning from their wintering grounds in Africa to the Palearctic breeding grounds are unable to store enough energy to complete the migration without refueling at Eilat (e.g. Yosef and Tryjanowski 2002b, c, d; Yosef and Chernetsov 2004, 2005).

In Israel, Bluethroats have two distinct populations: one that migrates through the region and winters to the south and the other that winters in Israel. The wintering areas of the Bluethroat in Israel are well known (Shirihai 1996). The Bluethroat winters in low-lying areas of damp habitat near water in the northern valleys of Israel, along the Jordan River, in the desert near sewage plants in oases and at Eilat (see Markovets and Yosef 2005). The aim of this paper is to examine the phenology of migration, biometrics and the age- and sex-related strategies of the Bluethroat in the Eilat region.

Material and methods

Trapping and banding of birds have been conducted at the International Birding and Research Centre (IBRCE) in Eilat, Israel (29°33′ N, 34°57′ E) for the past 20 years. Eilat is located at the southernmost tip of Israel and lies within the Saharo-Arabian desert, characterised by extreme temperatures and very low precipitation (average annual rain 17 mm).

The site of the trapping station was changed three times during the course of this 20-year study (Morgan and Shirihai 1997). From the spring of 1996 to the present, birds have been trapped in the 68-hectare Bird Sanctuary (IBRCE), which is positioned equidistant from the two earlier study areas used from 1984 to1995. In all of the study years, Bluethroats were captured in large numbers. Hence, we assumed that the precise location of the trapping station was not a factor that influenced this study.

The data analysed in this study were collected in the normal process of the trapping work conducted at the IBRCE ringing station and no special efforts were made to trap the study species. Hence, the data are a random sample of Bluethroats and we consider them to be representative of migration at Eilat, Israel. However, because the study area is also where Bluethroats winter, we separated the data from that of the migration seasons. For the purpose of this study, an over-wintering Bluethroat was defined in one of two categories: those that were trapped for the first time between 1 December and 1 March and those individuals trapped prior to 1 December but were re-trapped at least 60 days after their first capture in Eilat. Hence, we analysed only data of first caught birds between March and June (spring passage) and between September and November (autumn passage).

Catching and biometrics

Data were collected during 20 spring and 18 autumn migration seasons in the years 1984–spring 2003 (no ringing in autumn 1987). Birds were trapped during the day only (average 4.6±1.2 h, 500 m of mist-nets, details in Yosef and Tryjanowski 2002a). A total of 7,464 Bluethroats have, to date, been recorded at Eilat and none recovered or controlled elsewhere. All birds trapped were ringed, sexed and aged; also, biometric parameters were measured. We classified the birds into four age or sex classes based on plumage characteristics wherein the colouration of the tips of the greater coverts have light brown edges in juveniles and dark edges in adults: (1) first-year male, (2) first-year female, (3) adult male, (4) adult female (see Svensson 1992). Flattened maximum wing chord was measured to the nearest millimetre, and body mass was determined with a Pesola 50-g spring balance to the nearest 0.1 g. The relative body condition of the birds was compared using a body condition index (body mass divided by wing length; Yosef and Tryjanowski 2002a, b, c, d).

Data processing and analysis

We analysed possible differences in arrival time, wing chord length and body condition index among trapped birds from different age and sex classes in both trapping seasons. For all analysed variables, we used seasonal averages calculated separately for each age and sex class. We compared the mean values using one-way analysis of variance (ANOVA). Furthermore, we analysed possible relationships and differences between passage seasons, which concerned the number of birds caught, age and sex ratio and the biometrics features of each of the individual age and sex classes. Our comparisons were between autumn and the subsequent spring season.

Analysis of possible changes of body dimensions and body condition in relation to ringing date were separately conducted for birds from individual age–sex classes. In this case, the Bonferroni corrections were applied to adjust the alpha values for the increased probability of obtaining statistical significance from multiple testing.

Only individuals ascribed to one of the age and sex classes were included in the in-depth analysis. However, data on wing chord length, body mass and thereby body condition of birds were not available for all individuals and for all age and sex classes in each season and has resulted in different sample sizes.

Additionally, to avoid pseudoreplication, only data from the first captures were used to calculate phenology and biometric characteristics. For each season, the relative catching date (RCD) for each bird was calculated and is presented in Julian dates. The RCD was estimated by subtracting the median Julian date of catching time for each trapping season from each catching date in that trapping season.

Standard statistical methods were used to describe and analyse the data (Sokal and Rohlf 1995). The calculations were performed using STATISTICA for Windows (StatSoft Inc. 2005). All statistical tests were two-tailed. Throughout the text, we use the abbreviation CL for the 95% confidence limits.

Results

Trapping success, sex ratio and age ratio

During 20 springs and 18 autumns in the years 1984–2003, a total of 7,464 (mean per year=411.8, CL 307.9–515.7, n=18) Bluethroat were trapped. Great variance in number of trapped birds was found between spring (mean per season=42.8, CL 31.8–53.8, n=20) and autumn season (mean=367.1, CL 267.0–467.2, n=18) and between years in both seasons (Fig. 1a,b). We did not find the relationship between the total number of ringed birds in autumn and the following spring (Pearson's correlation, r=0.16, n=18, p=0.51).

Of 7,464 individuals, 6,875 (92.1%) were birds whose sex and age were determined. From this latter number, 1,762 (25.6%) were adults and 5,113 (74.4%) juvenile birds. 1,075 (61.0%) adults were males and 687 (39.0%) females. In the case of juveniles, 3,052 (59.7%) were males and 2,061 (40.3%) females.

We analysed possible differences in sex ratio in individual age classes in both migration seasons. We did not record any differences in the proportion of males to females in spring passage when adult as well as juveniles were analysed (adult, χ^2=1.11, df=1, p=0.29; juveniles, χ^2=1.14, df=1, p=0.29). In autumn passage in both age classes, we found male-skewed sex ratio (adults, χ^2=44.76, df=1, p<0.001 and juveniles, χ^2=99.66, df=1, p<0.001). Males comprised 62.1% of all adults and 60.3% of all juvenile birds. We did not find any relationship between the sex ratio in autumn and the following spring passage in both age groups (adults, r=0.12, n=17, p=0.63; juveniles, r=0.12, n=17, p=0.65).

In addition, we compared age ratio in both migration seasons. We found a significant difference in the proportion of juvenile to adult birds trapped in spring (χ^2=25.89, df=1, p<0.001), where juveniles comprised 63.4% of all caught birds. Also in autumn passage age ratio was juvenile-skewed (χ^2=867.32, df=1, p<0.001). In this case, juveniles comprised 75.6% of all ringed birds. Furthermore, we observed differences among years in the proportion of juveniles to adults in autumn (χ^2=319.39, df=17, p<0.001), when the percentage of juveniles ranged in individual seasons from 44.6% in 1984 to 90.7% in 1999. Such differences were not recorded between spring seasons (χ^2=27.52, df=18, p=0.07, data from 1995 were excluded from analysis because of insufficient sample size). Moreover, we did not find any relationship between the age ratio in autumn and the following spring passage also taking into consideration the total number of birds recorded during autumn passage (partial correlation, r=−0.13, n=17, p=0.60).

Phenology

In spring, the transient Bluethroats were observed form March to the end of April and from October to the end of December in autumn passage. The largest numbers of

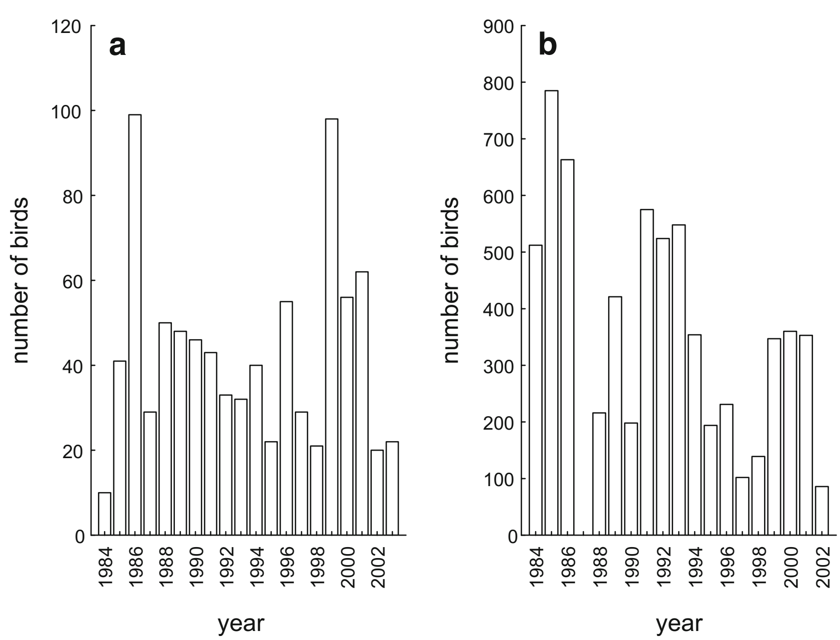

Fig. 1 The number of Bluethroat ringed during the study period in spring (**a**, n=856) and autumn passage (**b**, n=6,608), 1984–2002; no autumn trapping in 1987

individuals were ringed towards the end of March in the spring and at the end of October or beginning of November in the autumn (Fig. 2).

We found significant differences in the dates of ringed birds from different sex–age classes in the spring (one-way ANOVA, $F_{3,71}=4.53$, $p=0.006$) and in autumn passage ($F_{3,68}=9.78$, $p<0.001$). In spring, males from both age classes were caught earlier than females (Fig. 3a). In autumn, adult birds arrived earlier than juveniles (Fig. 3b).

Differences in wing chord length and body condition index in relation to sex, age and migration season

We found differences in wing length between birds from different sex–age classes both in spring (one-way ANOVA, $F_{3,71}=64.93$, $p<0.001$) and autumn season ($F_{3,64}=100.51$, $p<0.001$). In both age classes, males had longer wings than females in both migration seasons and in both sexes, adults had longer wings than juveniles in both migration seasons (Fig. 4a). Overall, mean wing length was not longer in autumn than in the following spring passage (Paired Student's *t*-test, juvenile males $t=1.57$, $df=15$, $p=0.138$; adult males $t=1.16$, $df=15$, $p=0.264$; adult females $t=1.90$, $df=16$, $p=0.076$). The exception was juvenile females ($t=2.35$, $df=16$, $p=0.032$), which had gotten longer wings in autumn (mean=70.7 mm, CL 70.5–70.9, $n=17$) than in spring (mean=70.3 mm, CL 69.9–70.7, $n=17$).

We did not find differences in body condition between age and sex classes in spring (one-way ANOVA, $F_{3,66}=0.80$, $p=0.49$, Fig. 4b). Such differences occurred in autumn passage ($F_{3,64}=3.22$, $p=0.028$) and concerned only juvenile females and adult males (Fig. 4b). No differences were found between autumn and the following spring for all analysed age–sex classes (Paired Student's *t*-test, in all cases $p=0.30$).

Wing length and body condition in relation to date of migration

We did not record any changes in the wing length for any age–sex classes during both the spring and autumn passage (range of Spearman correlation coefficient, spring, −0.11 to 0.06, in all cases $p>0.08$; autumn, 0.01 to 0.05, in all cases $p>0.11$; in both cases, alpha value after the Bonferroni correction for four comparisons is $\alpha=0.012$).

Only in autumn passage was there a significant relationship between body condition index and date of ringing. We found a significant decrease in body condition during autumn for juvenile males ($r_s=-0.06$, $n=2{,}605$, $p=0.001$) and juvenile females ($r_s=-0.12$, $n=1{,}717$, $p<0.001$). The same was recorded for adult males ($r_s=-0.19$, $n=863$, $p<0.001$) but not for adult females ($r_s=-0.08$, $n=522$ $p=0.054$; in all cases, alpha value after the Bonferroni correction for four comparisons is $\alpha=0.012$).

Discussion

The numbers of migrants were higher in autumn than in spring by a factor of 8.2 (6,608 vs 805). This is not typical of most passerine migrants in Eilat (e.g. Meyrom et al. 2001; Yosef and Tryjanowski 2002b, c, d; Yosef and

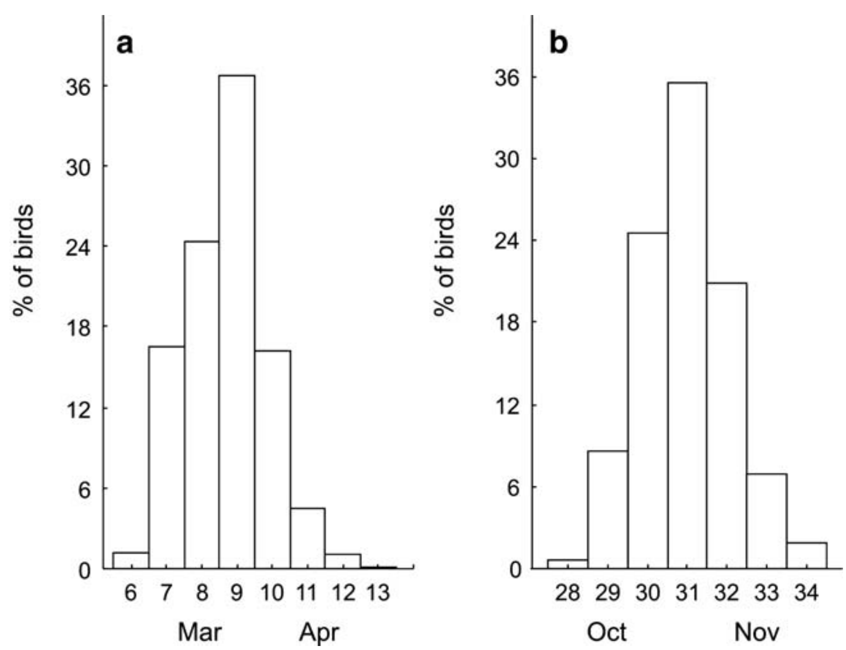

Fig. 2 Phenology of Bluethroats during the spring (**a**, $n=856$) and autumn (**b**, $n=6{,}608$) migration seasons at Eilat, 1984–2002, data presented in 10-day periods

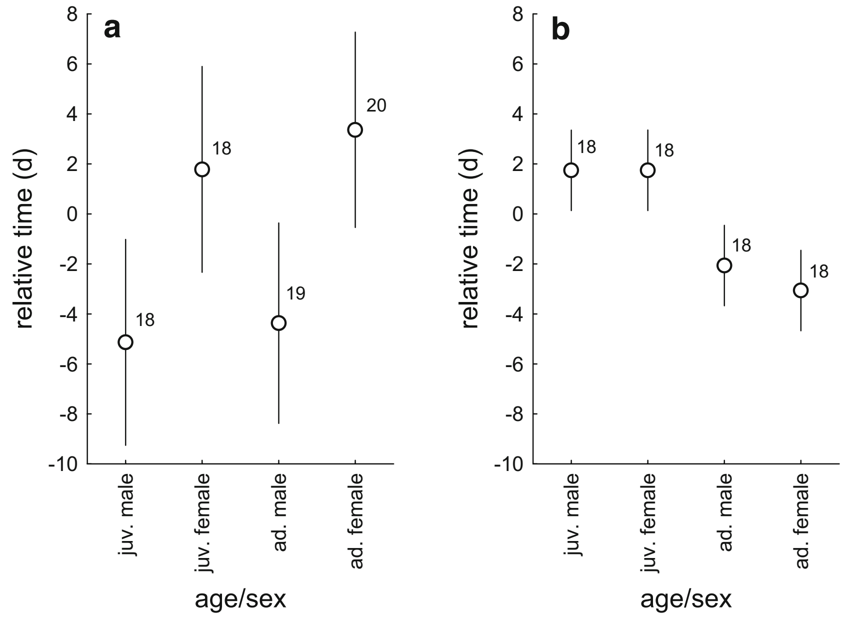

Fig. 3 Differences in date of passage (mean with 95% CL) between birds from different sex-age classes in spring (**a**) and autumn (**b**); *numbers* represent the sample sizes

Chernetsov 2004, 2005) whose general migratory strategies follow those of most long-distance, trans-Saharan migrants. In spring, Eilat is the first suitable staging region encountered after a hazardous desert crossing. In autumn, some birds (especially those in relatively good body condition) may depart for their flight across the Sahara from sites further north. The Bluethroat*,* on the other hand, is not a trans-Saharan migrant; west Palearctic populations winter in the Mediterranean and North African regions (Peiro 1997; Snow and Perrins 1998; Hernandez et al. 2003). This could explain why larger numbers are trapped in winter when most Bluethroat are at the southern fringes of their wintering grounds when at Eilat. In spring, Bluethroats either over-fly the region on the way to their breeding grounds or alternatively loop migrates further to the east of Eilat (Markovets and Yosef 2005). This might also explain why we did not find a relationship between the total number of ringed birds in autumn and the following spring. Inter-annual variation observed in our study has also been reported for several passerine species (e.g. Meyrom et al. 2001; Yosef and Tryjanowski 2002b, c, d; Yosef and Chernetsov 2004, 2005) and appears to be a general rule for the Eilat stopover site.

The majority of Bluethroats trapped in both the autumn and spring migrations are juveniles. This suggests that the less-experienced juveniles are forced to stage at Eilat more often than adults, who are also capable of over-flying the region if in better body condition. These findings are similar to Ellegren (1991) who reported that in Eastern Sweden, even though adults and juveniles migrated simultaneously, adults had a more concentrated migration period, carried more fat and stopped over for a shorter time.

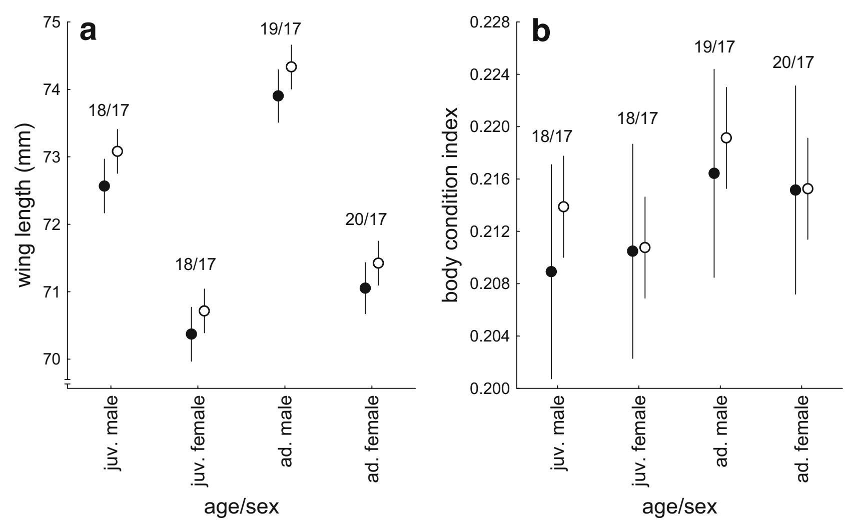

Fig. 4 Mean values with 95% confidence limits of wing length (**a**) and body condition index (**b**) of Bluethroats from different sex–age classes ringed during spring (*solid symbols*) and autumn (*open symbols*) passage seasons at Eilat, Israel; *numbers* represent the sample sizes for spring/autumn season, respectively

Further, adults did not loose mass after arrival and accumulated fat earlier than juveniles. Ellegren (1990) found that adults also migrate at a higher speed. Thus, Ellegren (1991) regarded adult Bluethroats as more efficient migrants.

In addition, we observed significant differences among years in the proportion of juveniles to adults only in the autumn migration seasons and is similar to that reported by Peiro (1997) for Southeastern Spain. This could be representative of the Bluethroat's annual breeding success and population fluctuations as they migrate through Eilat (cf. Hussell and Ralph 1996). Lack of corroborative data from the breeding grounds of the populations that migrate through Eilat prevents us from making any comparisons or reaching conclusions as to the importance of the data or their interpretation.

We found differences in sex ratio in individual age classes only in the autumn migration seasons. Overall, 62.5% of adults and 60.3% of juveniles were males. The discrepancy in age was also observed by Peiro (1997) in Southeastern Spain; however, the sex ratio was not skewed and was 1:1. Moreover, we did not find any relationship between the age ratio in autumn and the subsequent spring passage when also taking into consideration the total number of birds recorded during autumn passage. This suggests that Bluethroats have a strategy similar to that described for other passerine species (Møller 1994; Stolt and Fransson 1995; Kokko 1999) wherein it has been suggested that males winter closer to the breeding grounds because early arrival is important among territorial species, with early arrivals occupying optimal territories. It is also possible that females migrate to different, as yet unknown, wintering grounds using a different migratory route. Lack of information from the breeding and wintering grounds of populations traversing Eilat impair our ability to make comparisons for this eastern west Palearctic flyway.

It is of interest that we found significant differences in the dates of ringed birds from different sex–age classes in the spring and in autumn passage. In spring, males from both age classes were caught earlier than females. These data suggest that in spring males possible adapt a time-minimising strategy in order to get to the breeding grounds before the females. Of further interest is the fact that we found that in autumn adults arrived significantly earlier than juveniles. This suggests that in the East Western Palearctic, either adults leave the breeding grounds earlier than the juveniles or the lack of experience of the juveniles costs them the extra passage time if they do leave at the same time. This is of interest following the observations of Ellegren (1992) at much northerly latitude, in Sweden, that adults and juveniles migrated simultaneously but that adults were more concentrated.

Adults had longer wings than juveniles, which are in post-fledging plumage in both migration seasons. This is a result of the complete post-breeding moult achieved prior to the initiation of the autumn migration (Jenni and Winkler 1994). However, unlike Svensson (1992), we did not find a difference in the overall mean wing length between the autumn and spring migrations. This is surprising because Bluethroat are known to undertake a complete summer moult that results in a longer wing chord in the autumn than in the spring, when as a result of abrasion of the remiges and rectrices in the wintering quarters, the wing is considerably shorter. We are unable to explain this result owing to lack of information from the breeding or wintering grounds of the populations that migrate through Eilat.

Analyses of body condition between seasons and age and sex classes did not show any particular differences. However, we did find a relationship in autumn between body condition and date of migration when birds that arrived later were in reduced body condition. However, the obtained relationships are weak and its statistical significance is most probably a result of the huge sample size.

The possibility that migration of Bluethroats, and many other avian species, depend extensively on staging habitats in the region has previously been suggested and requires further study (e.g. Yosef and Tryjanowski 2002b, c, d; Markovets and Yosef 2005). Fransson et al. (2005) found that birds from large breeding areas converge to confined areas to stage before and after ecological barriers and that individuals of the same species have to follow different migratory directions depending on the location of their starting point. This stresses the importance of this study because most previous studies have been conducted in Western Europe and the paucity of data on the eastern flyways is of conservation concern. In addition, Russell et al. (1994) showed the importance and effects of a staging area on the migratory Rufous Hummingbird (*Selasphorus rufus*) wherein in years when stopover habitat quality was poor, incoming body masses were low and stopover durations were long. They reported important effects on the physiological, behavioural and population ecology of the migrating hummingbirds. They recommended that high quality stopover habitats are critical links between breeding and wintering areas for many species, and their preservation should be an essential component of strategies aiming to conserve migratory bird populations. The above mentioned is very true for Eilat wherein not only Bluethroats have been shown to stopover but also couple of hundred other species (e.g. Yosef and Tryjanowski 2002b, c, d; Yosef and Chernetsov 2004, 2005). The low conservation priority afforded to these habitats in Middle Eastern and other countries spanning the Syrio-African Rift Valley could endanger migratory species stopping over in this region. It is important to identify at the earliest those areas that are important as staging or wintering areas for the Palearctic migratory avian fauna and to convince the authorities involved of the importance of the preservation of the priority habitats and areas such that the migrations can continue through the Middle East with minimal human impact.

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