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Age and sex determine the phenology and biometrics of migratory Common Quail (*Coturnix coturnix*) at Eilat, Israel

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We analysed data for the Common Quail (*Coturnix coturnix)* caught by the ringing program at Eilat, Southern Israel, to understand age and sex related phenology of migration and biometric differences in the only long-distance migratory Phasianidae in the western Palaearctic. The numbers of Quail caught during spring were higher than in the autumn seasons. We found great variation in the numbers of trapped birds between years both in spring and in autumn season. Furthermore, in spring, males were ringed significantly earlier than female Quail and adults of both sexes arrived significantly earlier than juveniles. Moreover, adult females had longer wing chords than had adult males, but we found no differences between first-year birds. We retrapped 22.4% of Quail during the spring migration seasons, which is a relatively large proportion in comparison with other species studied in Eilat. Our results indicate that Eilat is an important stopover site for the Quail populations crossing the Sahara desert during spring migration. This finding is supported by the fact that recaptured birds were in better condition than at their first capture, indicating staging behaviour by migrant Quails at Eilat.

1. Introduction

The Common Quail (*Coturnix coturnix*) is the only long-distance migrant of all the western Palaearctic Phasianidae (Snow & Perrins 1998*)*. The species is of special concern because of excessive hunting when on migration, especially in the Mediterranean basin (Hagemeijer & Blair 1997).

The Common Quail winters in the Sahel zone, but little is known about their wintering ecology (Snow & Perrins 1998). The migration ecology of the Common Quail has been studied in Europe (e.g., Rodriguez-Teijeiro *et al.* 2005), in North Africa (e.g., Forbes 1942, Zuckerbrot *et al.* 1980) and in southern Africa (Graham *et al.* 2000), but many questions remain unanswered. Snow and Perrins (1998) considered Common Quail an enigmatic species with as many unresolved questions about migration as about other aspects of its life history.

The Common Quail crosses the Mediterranean Sea in the autumn in large numbers, and several 100s of thousands are netted annually along the

North African and Sinai coastlines (Zuckerbrot *et al.* 1980, Paz 1987, Madge & McGowan 2002). During the spring migration period, birds fly across the Mediterranean on a very broad front (Shirihai 1996, Snow & Perrins 1998). Furthermore, Guyomarc'h (2003) described four routes of spring passage for European Quail population, three of them crossing the Mediterranean Sea. It is important to note that, owing to the fact that to date only the European population has been studied, only the Mediterranean flyways are mentioned and little is known about the migration of the Quail in the east.

Eilat, Israel, is located at the northern edge of the combined Sahel, Sahara and Sinai deserts. During spring migration, the Quails reach this region after a long and arduous journey. Many spring migrants returning from their wintering grounds in Africa to the Palaearctic breeding grounds are unable to store enough energy to complete the migration without refuelling at Eilat (e.g., Yosef & Tryjanowski 2002a, b; Yosef *et al.* 2003). Israel in general and Eilat in particular are at the eastern extremes of the known Quail migration routes in the spring (Snow & Perrins 1998). Most authors, however, have studied populations of Central and Western Europe (roughly 10–25% of the breeding range; Tucker & Heath 1994), while most ring returns or recoveries from Israel (Shirihai 1996, Bear & Nitzan 1999; see also Table 1) and NE Egypt (Zuckerbrot *et al.* 1980) are further east and are mostly from Bulgaria, Greece, Turkey, Armenia, Georgia, Ukraine and Russia.

Hence, to better understand the age- and sex-specific migration characteristics of this species, we analysed the data for all Common Quail caught randomly in the framework of the ringing program at the International Birding & Research Centre in Eilat (IBRCE) Bird Sanctuary. We hypothesized that, as the dataset includes information of this little known, more eastern population of Quail of the Western Palaearctic, the data would present a reliable picture of the migration ecology on the eastern extremities of the migration routes of Common Quail through the Middle East. In addition, most studies of Common Quail migration have been conducted in autumn, whereas our data were also collected in spring, when the potential breeding population is returning to their breeding grounds across Eurasia.

2. Material and methods

Data were collected during ten spring (February–June) and ten autumn (September–December) migration seasons during 1996–2005 at the "Bird Sanctuary" of the IBRCE (29°33' N, 34°57' E). The Sanctuary is a 64-ha plot recovered from the regional garbage dump and has been converted to a migratory bird-staging habitat (www.rolex-awards.com/laureates/laureate2.jsp?id=0065).

More than 150 species of xeric plants have been planted in an attempt to provide food for migrating birds that utilize the Eilat flyway.

In a larger geographic scope, the ringing station 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), but in recent decades human agricultural settlements have been established along the western side of the valley; a process that has produced green areas in the desert.

In addition, Eilat is situated at the northern edge of over 2,000 km of continuous Sahel, Sahara and Sinai deserts. In the north-northeast, however, there are still 650 km more of the Syrian Desert, and to the east lies the vast Arabian Desert. Hence, many birds land in the Eilat area in autumn to rest before, or in spring after, crossing these deserts (Safriel 1968, Yom-Tov 1993).

2.1. Catching and ringing

During 1996–1999 birds were trapped using mist nets (6 hr/d). Since 2000, birds were trapped using eight Helgoland/Rybachy traps located in the boundaries of the Eilat Bird Sanctuary. The trap entrances are built so that they cover the exact locations of the mist nets, resulting in a similar covered trapping area between the two periods of trapping. The total catching area of the eight trap entrances was 1536 m^2 and traps were kept open 24 hrs a day during the migration seasons.

We ringed all captured birds using standard aluminium rings, and sexed, aged and measured biometric parameters from them. We classified the birds into two age and/or sex classes based on plumage characteristics – adult male (EURING code 6), first-year male (5), adult female (6), first-

Table 1. Foreign ring recoveries of Common Quail (*Coturnix coturnix*) ringed at Eilat, Israel. Dates: day.month.year.

Date of ringing	Date of recapture	Place of recapture	Coordinates	Distance (km)
01.03.77	10.09.77	Tbilisi, Georgia	41°46'N, 44°44'E	1,610
22.03.78	09.10.79	Krasnodar, Russia	44°45'N, 37°48'E	1,690
22.03.78	30.09.79	Bakchisaray, Ukraine	44°44'N, 33°51'E	1,690
25.03.00	18.09.00	Gulripsh, Abkhaziya, Georgia	42°55'N, 41°06'E	1,586
28.02.01	21.08.01	Sungurlu, Yorum, Turkey	40°16'N, 34°59'E	1,193

year female (5; for details, see Saint Jalme & Guyomarc'h 1995, Waern 2002).

First-year birds can be distinguished from adults in the autumn by the moult of three outer primaries (Dementiev & Gladkov 1954, Geroudet 1978). These are not moulted in the post-juvenal or post-breeding moult. Moreover, scapulars remain unmoulted in the first-year birds (R. Yosef, unpubl. data), a pattern that has been used in Eilat for ageing in both seasons, though not mentioned in published literature. To date, this is the first study that uses scapular moult in Quail; others have mostly concentrated on the moult scores of secondaries, primaries and rectrices. Some have also used the percentage of moult on various regions of the Common Quail plumage: abdominal region, alula, head and throat (cf. Saint Jalme & Guyomarc'h 1995).

Common Quails can be easily sexed. Males but not females have an "anchor mark" on the throats (Saint Jalme & Guyomarc'h 1995, Waern 2002). Moreover, in adults, males have two distinct bands at the base of throat. Females and juveniles have diffuse banding that is more pronounced in older females (for Eilat, see Waern 2002).

Flattened maximum wing chord was measured to the nearest millimetre, and body mass was determined using digital scales to the nearest 0.1 g. We compared the relative body condition of the birds using a body condition index (body mass divided by wing length; cf. Yosef *et al.* 2003).

2.2. Data processing and analysis

We used data from both trapping seasons to describe seasonal variation in the number of birds caught. Because of insufficient data from autumn, however, we used only spring data in the in-depth analyses. Further, only individuals from the first captures, ascribed to one of the age/sex classes, were included in our analyses.

We analysed the simultaneous influence of sex and age on catching time, wing length and body condition of the ringed birds. In light of the hierarchical nature of the collected data, for all analysed variables we used seasonal averages calculated separately for each age/sex combination. Obtained mean values were compared using a factorial ANOVA (Zar 1999).

Furthermore, we studied the change of the body condition index of recaptured birds during spring passage. Data from the first and last catches were analysed.

We present the standardized trapping time in Julian dates. We calculated the relative catching time for each bird and season as being the residual from the seasonal median.

We used standard statistical methods to describe and analyse the data (Sokal & Rohlf 1995). All statistical tests were two-tailed. Throughout the text, we use the abbreviation CL for the 95% confidence limits.

3. Results

3.1. Trapping success, sex ratio and age ratio

We trapped a total of 737 Common Quails during 1996–2005 in Eilat. Only five of these (0.7%) have thus far been recovered or controlled elsewhere (Table 1). The number of birds caught strongly differed between the two seasons and was 714 in spring (mean per season = 71.4, CL:32.9–109.8, range: 2–160) and 23 in autumn (mean per season = 2.3, CL 0.4–4.2, range: 0–7). We found remarkable variance in the number of trapped birds between years in both spring and autumn (Fig. 1a, b).

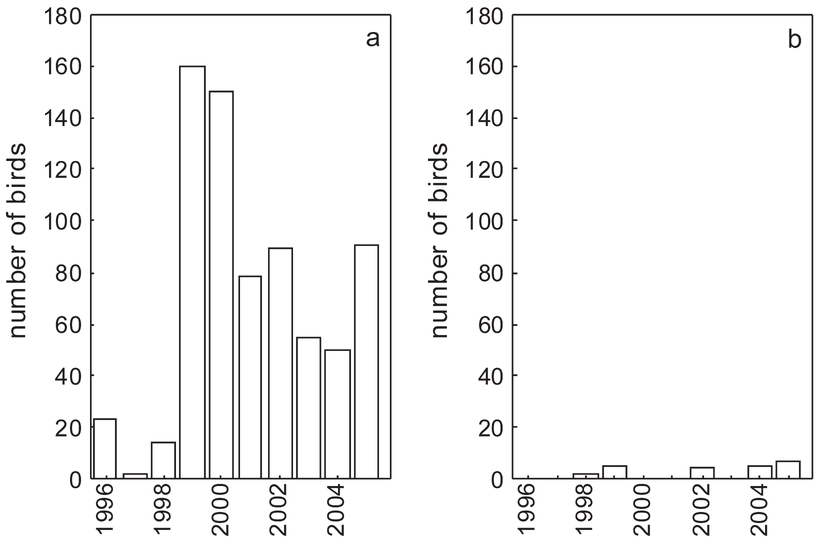

Fig. 1. The number of Common Quails ringed during 1996–2005 (a) during the spring (n = 714) and (b) autumn passage (n = 23) in Eilat, Israel.

Of the 714 individuals caught in spring, 664 (93.0%) were birds whose sex and age were determined. From this latter number, 272 (41%) were first-year and 392 (59.0%) were adult birds. Overall, the difference in the proportion of first-year to adult birds was significant (χ^2 = 10.93, df = 1, P < 0.001) and in individual years ranged from 0% in 1998 to 84.6% in 2003.

Furthermore, 204 (52.0%) adults were males and 188 (48.0%) females. In the case of first-year birds, 147 (54.0%) were males and 125 (46.0%) females. In both age classes, we did not find differences in the proportion of males to females (χ^2 = 0.33, df = 1, P = 0.57 and χ^2 = 0.89, df = 1, P = 0.34, respectively).

3.2. Phenology

The number of Quails ringed on migration peaked in March and April. The numbers of birds in autumn were low; all autumn birds were caught from September to November (Fig. 2).

In spring, males were ringed significantly earlier than females (factorial ANOVA, $F_{1.31}$ = 6.81, P = 0.014). Moreover, adults of both sexes arrived significantly earlier than first-year birds ($F_{1.31}$ = 8.81, P = 0.006; Fig. 3).

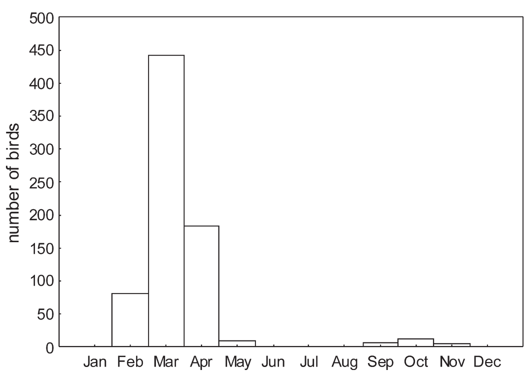

Fig. 2. Monthly changes in the numbers of Common Quails ringed at Eilat, Israel (n = 737).

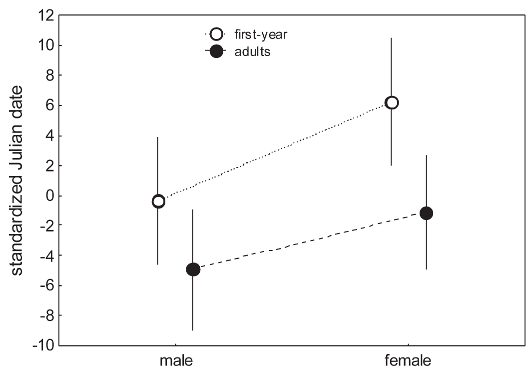

Fig. 3. Mean values and 95% confidence limits of ringing dates of male and female Common Quails of different age groups during the spring passage at Eilat, Israel.

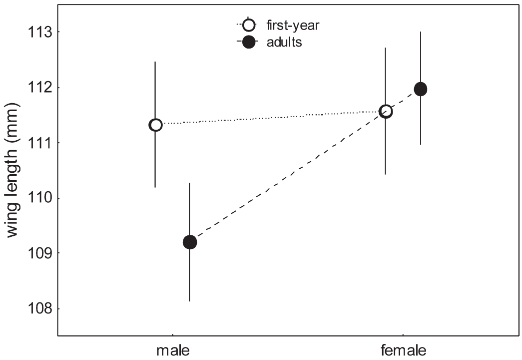

Fig. 4. Mean values and 95% confidence limits of wing length of male and female Common Quails of different age groups during the spring passage at Eilat, Israel.

3.3. Wing chord length and body condition in relation to sex and age

In general, females had longer wing-chord lengths than males (factorial ANOVA; $F_{1.31} = 7.82$, $P = 0.009$) but the difference occurred only in adults (age*sex interaction, $F_{1.31} = 5.54$, $P = 0.025$; Fig. 4). We did not find significant differences between first-year and adult birds ($F_{1.31} = 2.53$, $P = 0.12$; first-year males: $\bar{x} = 111.3$ mm, CL: 109.8–112.9, range for all individuals: 102–120; ad males: $\bar{x} = 109.2$ mm, CL: 108.1–110.3, range: 101–118; first-year females: $\bar{x} = 111.6$ mm, $\bar{x} = 110.3$–112.8, range: 100–118; ad females: $\bar{x} = 112.0$ mm, CL: 110.9–113.1, range: 103–123). Furthermore, we did not find significant influences of age and sex, nor interactions between these factors, on body condition (factorial ANOVA, $P > 0.21$).

3.4. Retrapping

We retrapped a total of 160 (22.4%) Common Quails during ten spring migration seasons. The proportion of retrapped specimens varied significantly among spring seasons ($\chi^2 = 34.41$, df = 9, $P < 0.001$) and ranged from 0% in years 1997–1998 to 40.0% in 2002. Birds stayed at the stopover site from 1 to 53 days. The median time was 5 days (lower and upper quartiles 2 and 13) and was not different among the spring seasons (Kruskal-Wallis test, $H_6 = 5.77$, $n = 122$, $P = 0.45$). We did not record differences in minimum length of stay on stopover site among birds from different age and sex classes (Kruskal-Wallis test, $H_3 = 4.77$, $n = 116$, $P = 0.19$).

Recaptured birds were in better body condition than at their first capture (body condition index, $\bar{x} = 0.707$, CL: 0.690–0.724 *vs* $\bar{x} = 0.786$, CL: 0.765–0.807, paired-samples *t*-test; $t = -7.92$, df = 117, $P < 0.001$). Moreover, we found a significant correlation between body condition of first capture and that of the recaptured birds ($r = 0.47$, $n = 118$, $P < 0.001$).

4. Discussion

4.1. Numbers, and sex and age ratio of trapped birds

We found great variance in the number of Common Quails trapped during the spring and autumn migration, which is typical for many migrants in Eilat (Morgan & Shirihai 1997; Meyrom *et al.* 2001; Yosef & Tryjanowski 2002a, b). The variance is attributed to general migratory strategies followed by most long-distance migrants. In spring, Eilat is the first suitable staging region encountered after crossing a hazardous desert, whereas in autumn, some birds (especially those in relatively good body condition) may depart for their flight across Sahara from other sites further north and overfly Eilat. In addition, Quails that cross the Mediterranean in the autumn and survive the trapping along the North African coast, cross the Sahara desert in non-stop flight into sub-Saharan Africa (Cramp 1998). Their return, however, in addition to being diffusive and widely distributed across the Mediterranean region, could also be one wherein the birds adopt a circum-Mediterranean route and avoid sea crossing altogether. This strategy could be true especially for the eastern populations that are oriented in a direct line to their breeding grounds, with Eilat being the traditional stopover site, as suggested by the ring-recoveries (Table 1). Goodman *et al.* (1989) put forward partial evidence for this line of thought and reported that along the Red Sea coast Quail was distinctly more common in spring than in autumn. Further, ringing recoveries from neighbouring Egypt display a more western distribution of the Common Quail, with recoveries from France, Austria, Italy, Bulgaria, Greece and Romania; the eastern recoveries are from Israel, Turkey, Syria and Ukraine and western Russia (Goodman *et al.* 1989).

We found remarkable variation in trapping success among years in both migration seasons. We suggest that the trapping success was influenced by fluctuations in the reproductive success of the breeding populations (Tucker & Heath 1994, Cramp 1998, Madge & McGowan 2002). For example, rainfall indirectly affects productivity and mortality, and influences the nomadic and migratory movements of Common Quail (Puigcerver *et al.* 1999). Also, stopover may reach greater numbers during years of drought (e.g., Baillie & Peach 1992, Bryant & Jones 1995) and habitat destruction (Morel & Morel 1992) in the Sahel region in Africa. Alternatively, in dry springs when winds are south-easterly, birds may migrate through more humid regions or be influenced by greater climatic forces and changes that are as yet not fully understood (e.g., Huppop & Huppop 2003, Peintinger & Schuster 2005). Cramp (1998) also found evidence for marked inter-seasonal movements, a shift of breeding grounds in dry springs, and displacements shown by ringing recoveries, all indicating that migration routes may vary from year to year. The cumulative effect of all of the above-mentioned factors could result in remarkable fluctuations that have been observed at the Eilat ringing station.

In spring, adults outnumbered first-year birds. Moreover, we found significant fluctuations in the proportion of first-year to adult birds in spring among the years of our study. These differences and fluctuations may result from lower survival rate of first-year birds, as compared with adults, during their first autumn migration, during the period spent in wintering grounds, and/or during spring migration across the Sahara and Sinai deserts. However, paucity of information from the breeding range, mortality during migration and survival rates on the wintering grounds prevent us from making predictions about population status and recruitment rates. Nevertheless, the observed fluctuations suggest that the survival during migration and at the breeding and wintering ranges vary greatly between years. Snow and Perrins (1998) thought that the capability of the Quail to produce large broods could possibly offset large losses during migration and over-wintering.

The survival rate reported for Common Quail in Italy is low (27–31%, Puigcerver *et al*. 1992) and may not be representative of our data, which indicate much higher survival rates for adults. However, one must take into account that Puigcerver *et al*. (1992) suggested their data should be interpreted cautiously because not only was their ringing station situated in an area with active hunting, but the authors also encouraged hunters to report ringed birds. They considered this to be an artefact that could have influenced their data, because at that point fledglings were dispersing and made up the majority of the bags of the hunters. The authors also found that some of the birds probably came from countries with different hunting pressures, resulting in varying survival rates. Hence, a reported survival rate in one part of the region may not necessarily hold for another part of the species distribution. The paucity of survival data in areas with reduced or no hunting pressure prevents us from evaluating the true survival rates of the Quail populations. This topic is especially relevant because the annual survival rate of male Bobwhite Quail (*Colinus virginianus*) was 19% in hunted populations but 48% in populations with no hunting pressure (Campbell *et al*. 1973, Pollock et al. 1989).

The species may also engage in a loop migration strategy, whereby the species crosses across the Mediterranean Sea in the autumn on a broad front but returns via the Rift Valley land-bridge route, resulting in greater numbers staging at Eilat. The fact that the data were collected randomly in the framework of a general ringing scheme and is thus not species specific strengthens our findings that a greater percentage of adults were found on the spring migration than elsewhere, such as in more western countries of the Mediterranean region. Also, the fact that only the European population has been intensively studied – even though it comprises less than a quarter of the global distribution of Common Quail (Burfield and Bommel 2004) – suggests that the few papers published to date on survival and longevity between adults (EURING 6) and juveniles (EURING 5) should be treated with caution and not be applied to all of the species range.

4.2. Phenology

During spring passage, in most species males have been ringed significantly earlier than have females. The fact that males migrate earlier than females is probably a result of the different evolutionary pressures faced by sexes. Males need to arrive early in order to reach the breeding grounds ahead of the females and to establish territories and moult into breeding plumage. The first individuals occupy territories of better quality and are preferred by females as breeding mates (eg. Møller 1994; Stolt & Fransson 1995; Kokko 1999; Yosef & Tryjanowski 2002a, b). The latter may also hold for Common Quail, whereby early-arriving males are able to mate with early-arriving females, resulting in early clutches, which in turn allows the hatchlings a better chance to prepare for the subsequent autumn migration.

Adults of both sexes arrived significantly earlier than first-year birds throughout the study years. This finding may simply result from the more experienced adults flying more efficiently due to the experience gained on previous migrations (cf. Yosef *et al.* 2006).

4.3. Differences in wing chord length

We found that females had significantly longer wing-chord length than males, but these differences occurred only in adults. These data are important in that they clarify the picture on the degree of overlap of measurements between sexes. This is not clear from the data presented in Snow and Perrins (1998) or in Madge and McGowan (2002), who present an almost similar wing-chord length for both sexes (males 107–117 mm, females 109–118 mm). We stress once again, however, that the data presented in these books come from the western Palaearctic, and it is possible that the Common Quail that migrate through Eilat are from a more eastern (west Asiatic?) origin, as indicated by the ring recoveries that have thus far all come from the Black Sea region.

This difference in wing chord could also suggest that females winter further to the south in sub-Saharan Africa than the males and the first-year individuals. This difference is similar to that described for passerine species (Møller 1994, Stolt & Fransson 1995, Kokko 1999) in which 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. Females might also migrate to different, yet unknown, wintering grounds using a different migratory route. Lack of information from breeding and wintering grounds of populations traversing Eilat impair our ability to make comparisons for this eastern west Palaearctic flyway.

4.4. Retraps

We retrapped 169 (22.4%) Common Quail individuals during the spring migration seasons. This is a relatively large proportion when compared with other species studied in Eilat. Yosef and Chernetsov (2004, 2005), who analyzed the data for Reed Warblers (*Acrocephalus scirpaceus*) and Sedge Warblers (*A. schoenobaenus*), recorded 9.2% and 14.7% retraps, respectively, in the spring. The present study suggests that Eilat is an important stopover site for the Common Quail populations crossing Sahara desert during spring migration. This pattern is substantiated also by the fact that, in general, the birds were in better body condition at the recapture than at the initial capture.

The difference in proportion of retrapped individuals between spring seasons was significant and possibly related to the habitat conditions prior to their onset of migration in Africa and enroute. The Common Quail might have to stay longer in Eilat during drought years in Africa in order to refuel prior to continuing their migrations to the breeding grounds.

Common Quail individuals stayed at the stopover site from 1 to 53 days. The median time was 5 days and was not different among the spring seasons. This lack of difference is indicative of a few, very weak birds that stayed at Eilat for a prolonged period.

We found a significant correlation between the body-condition index of the birds at the first capture and that when recaptured, which suggests that birds in better condition forage and gain weight more efficiently than do birds in poor body condition. Generally, for all seasons and species studied to date at Eilat (Meyrom *et al.* 2001; Yosef & Tryjanowski 2002a, b), birds in poor initial condition and those stopping over for a longer period, eventually gain more mass. This pattern suggests that the Eilat region is indeed used for refuelling, and the stopovers observed are not just a result of inclement weather or other migration inhibiting factors.

In summary, the key finding of this study is the contribution to our understanding of Common Quail migration ecology at the eastern extremities of the Western Palaearctic during the species spring migration. We showed that adults migrate earlier than first-year birds, and males earlier than females. Moreover, adult females had a longer wing chord than had adult males, though we did not find such difference for the first-year birds. We also supply biometric data from the east, a region that has previously been overlooked in this respect. In addition, the fact that a larger proportion of birds stages at Eilat stresses the importance of our understanding on the life cycle of this species of conservation priority. With such knowledge we can increase the chances of Common Quail survival in the near future.

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Ikä ja sukupuoli määräävät viiriäisen muuton ajoittumisen ja siipimorfologian Eilatissa Israelissa

Analysoimme eteläisessä Israelissa sijaitsevan Eilatin rengastusohjelmassa kerättyä viiriäisaineistoa (*Coturnix coturnix*) selvittääksemme ikä- ja sukupuoliriippuvaa muuton fenologiaa ja mittaeroavuuksia tällä länsipalearktisen alueen ainoalla muuttavalla kanalintulajilla. Viiriäisten keväiset pyyntimäärät olivat syksyisiä korkeampia. Molempina sesonkeina pyydetyt ja rengastetut yksilömäärät vaihtelivat huomattavasti vuodesta toiseen. Lisäksi keväisin koiraita rengastettiin keskimäärin merkitsevästi aiemmin kuin naaraita, ja molemmilla sukupuolilla aikuiset saapuivat yksivuotiaita aikaisemmin. Vanhoilla linnuilla naaraiden siipijänne oli koiraiden vastaavaa pidempi, mutta yksivuotiailla eroa ei todettu.

Kevätmuuton kuluessa viiriäisistä pyydystettiin uudelleen 22,4 %, mikä on korkeampi osuus kuin muilla Eilatissa tutkituilla lajeilla. Tulokset viittaavat siihen, että Eilat on merkittävä Saharan ylittäneiden viiriäisten kevätmuuton aikainen levähdyspaikka. Tätä tukee havainto, että uudelleenpyydetyt yksilöt olivat paremmassa kunnossa kuin ensipyytämisessä, mikä kertoo Eilatin olevan viiriäisille sovelias lepäilyalue.

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