Post–breeding movements and migration patterns of western populations of common quail (*Coturnix coturnix*): from knowledge to hunting management

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Abstract

Post–breeding movements and migration patterns of western populations of common quail (Coturnix coturnix): from knowledge to hunting management.— We investigated the patterns of post–breeding movements of the common quail (*Coturnix coturnix*) in the Iberian peninsula with the aim of describing its migratory phenology and some physiological features of individuals. This information is needed to adjust hunting seasons in an optimal way. We worked with two data–sets: a) captures made in a non–breeding site (Garraf) from August to October in 2009 and 2010; b) post–breeding recoveries of individuals ringed in Europe and recaptured in Spain between 1933 and 2005. The results showed that post–breeding movements in Garraf occur in two waves: a first wave that occurs around 10 VIII and is mainly composed of non–sexually active yearlings that do not correspond physiologically to migrants, and a second much more intense wave, which occurs around 17 IX and is mainly composed of non–sexually active migrant yearlings. The hunting season in Spain takes place mainly during the first wave, preserving the passage of migrant individuals from Spain and other European countries. Information on the post–breeding movements in other Spanish regions and other European countries where the common quail is a popular game species would improve timing between the hunting season and migration by providing more precise recommendations for hunting management.

Key words: Hunting season, Game management, Ring recovery, Migration phenology, Iberian peninsula.

Resumen

*Patrones de movimientos y de migración postcría en la población occidental de codorniz común (*Coturnix coturnix*): algunas recomendaciones de gestión cinegética.*— Hemos investigado los patrones de los movimientos postcría de la codorniz común (*Coturnix coturnix*) en la península ibérica con el fin de describir su fenología de paso migratorio y algunas características fisiológicas de los individuos. Esta información es necesaria para un ajuste óptimo de los períodos de caza. Hemos trabajado a partir de dos conjuntos de datos: a) capturas efectuadas en una zona que no es de cría (Garraf) de agosto a octubre en 2009 y 2010; b) recuperaciones, posteriores a la presunta época de cría, de individuos anillados en Europa y recapturados en España durante el período 1933–2005. Los resultados obtenidos muestran que los movimientos postcría en Garraf están formados por dos oleadas: una primera, que se produce sobre el 10 VIII, formada principalmente por jóvenes del año inactivos sexualmente que no son fisiológicamente migrantes; y una segunda, mucho más intensa, que se produce sobre el 17 IX, formada principalmente por migrantes jóvenes del año inactivos sexualmente. La época de caza en España tiene lugar principalmente durante la primera oleada, preservando el paso de los migrantes provenientes de España y de otros países europeos. La información de los movimientos postcría en otras regiones españolas y en otros países europeos en los que la codorniz común es una especie cinegética popular, permitiría mejorar el ajuste entre el período de caza y la migración, proporcionando recomendaciones de gestión cinegética más precisas para esta especie.

Palabras clave: Media veda, Gestión cinegética, Recuperaciones de anillas, Fenología de la migración, Península ibérica.

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Introduction

The common quail (*Coturnix coturnix*) is a very abundant and widespread migratory galliform species whose distribution area encompasses the Western Palaearctic, and Western and Central Asia (Gallego et al., 1997). Its estimated population ranges from 35,000,000 to 300,000,000 individuals, with an extent of occurrence of 21,300,000 km^2 (Birdlife International, 2004). In Europe, a range of 2,800,000–4,700,000 breeding pairs has been estimated and, according to Gallego et al. (1997), 33–57% of the European Union pairs breed in Spain.

Currently, the species is considered to have an unfavourable conservation status in Europe (SPEC 3), with depleted populations and a large historical decline (Burfield, 2004). In spite of this, the species is also considered a game bird in many countries within its distribution range (Guyomarc'h, 2003). In Spain, in particular, it is a very popular game species, with a mean annual hunting bag of 1,381,503 individuals (standard deviation: 268,812; data calculated from the hunting bags of 1973–2008, collected from the *Yearbook of Agro–alimentary Statistics* of the Spanish Ministry of Agriculture, Fishing and Food). Moreover, 33–57% of the quails of the European Union breed in Spain (Perennou, 2009), a figure that is not surprising as Spain is a major pass way for individuals that are migrating to Africa from several Western European countries (unpub. data).

Therefore, data on both breeding pairs and hunting bags strongly suggest that management of the species and conservation measures that are adopted in Spain are extremely important for the entire quail population in Europe.

According to the European Union Management Plan for common quail for the period 2009–2011 (Perennou, 2009) and the European Birds Directive 2009 147/EC, hunting periods in EU member states should concord with information on the breeding period, and hunting activity should not affect late breeding birds or birds during spring migration. However, it is also necessary to know the post–breeding movements and the post–breeding migratory patterns to correctly adjust the hunting period. These movements and patterns are generally very poorly understood and more specifically, information concerning the Iberian Peninsula is extremely scarce (see however Guyomarc'h et al., 1989; Rodríguez–Teijeiro et al., 1996). The common quail shows not only migratory movements, but also nomadic movements (Sinclair, 1984) during the breeding season in search of suitable but ephemeral habitats, mainly winter cereal crops (Rodríguez–Teijeiro et al., 2009). These movements can be divided into latitudinal (or aestival) movements from northern Africa to Europe (Munteanu & Maties, 1974) and elevation (or transhumant) movements within Europe (Davis et al., 1966, Heim de Balsac & Mayaud, 1962; Puigcerver et al., 1989). Movements of males in search of females throughout the breeding season have also been described (Rodríguez–Teijeiro et al., 2006). These movements are not sporadic, but are part of the annual cycle of the species and, as Wernham et al. (2002) suggest, they seem to be firmly set to maximize the production of yearlings, in a remarkable sequential breeding strategy similar to that of some butterflies and moths.

This extremely high mobility of the species makes it more complicated to determine the current suitability of hunting periods and, not surprisingly, there are no data available concerning how the post–breeding movements and migration might be affected by the traditional hunting calendar.

This study aimed to provide new data concerning patterns of post–breeding movements in the Iberian peninsula and also to determine how the hunting season is related to these movements. The evaluation of how this could affect European quail populations would hopefully lead to the development of new management recommendations.

Material and methods

Data collection

The data presented here were collected from two sources, allowing two different approaches: (1) The capture and ringing of post–breeding moving individuals using mist–nets and electronic decoys in a non–breeding area in Garraf Natural Park, north–eastern Spain; this source of data provided information on the temporal migration patterns of the common quail at a local scale. (2) Quail ringing recovery data in Spain; analysis of the post–breeding recoveries of individuals ringed in Europe and recaptured in Spain during the period 1933–2005 provided information on the temporal migration patterns of the species at a large scale.

Captures of post–breeding moving individuals

The method used for collecting data on post–breeding individuals involved the use of mist nets and call playback in a non–breeding area. Fieldwork was carried out in Garraf Natural Park in the north–eastern coast of Spain. This area is characterised by rough landscape with typical Mediterranean sclerophyllous vegetation consisting mainly of shrubs and pine trees. The Garraf Natural Park is not a suitable place for breeding for the common quail (Rodríguez–Teijeiro et al., 2004). We selected a clear flat area at about 350 m from the edge of a 190 m cliff that drops to the sea (41º 15' N, 1º 52.7' E).

During 2009 and 2010, captures were carried out approximately once a week from 15 VII to the end of October, when quail migration finished in this area. A total of six mist nets, each one with 6 bags of 25 mm mesh, 12 m long and 3 m height, were set up in the study area in 2009, and 18 mist–nets with the same features were set up in 2010. The nets were placed around a digital, quail call playback device which could be heard within approximately a 2 km radius in optimal conditions. The call was played after sunset from 22:00 h at night to 8:00 h in the morning to attract post–breeding moving quails towards the nets.

The use of electronic decoys may result in some bias (see for example Weatherhead & Greenwood, 1981). For this reason, we checked that the sample of individuals captured in Garraf (presumably migrant individuals coming from northern areas) does not show bias in sex and age composition when compared to a sample of 302 individuals of known sex hunted during the same period in northern Spain (Llivia) and in France (Ariège and Cavalerie) and with a sample of 288 individuals of known age hunted in the same places. No statistical differences were found either in sex composition ($\chi_1^2 = 0.871$; $p = 0.35$) or in age composition ($\chi_1^2 = 1.80$; $p = 0.18$), thus indicating that no significant bias of sex and age composition was linked to the use of electronic decoys in the studied sample.

Quails captured in the nets were immediately collected, ringed, measured and released. Information about sex and age (following Saint–Jalme & Guyomarc'h, 1995) was recorded; individuals classified as EURING 3 age code are named hereafter yearlings, whereas individuals classified as EURING 5 and EURING 6 are named hereafter adults, due to the extreme sexual precocity of the common quail (Guyomarc'h, 2003). Measurements of the width of the pectoral lipid band, a good indicator of the migratory impulse according to Guyomarc'h & Belhamra (1998),were taken for all captured quails. Finally, the sexual development of the captured quails was assessed by the detection of presence or absence of the proctodeal foam (Seiwert & Adkins–Regan, 1998) and by measuring the length of the cloacal vent in a sample of 319 individuals; less than 4.5 mm would indicate that individuals are not sexually active (Fontoura et al., 2000; Guyomarc'h & Belhamra, 1998).

Quail ring recoveries in Spain

Data from ring recoveries in the Iberian peninsula of quails ringed in Europe (from 1933 until 2005) were provided by EURING Data Bank.

Most quail ring recoveries come from hunted birds. Quail hunting is a widespread tradition in the Iberian peninsula; the Spanish hunting law ('Ley de caza') regulating the hunting of migrating birds was enacted in 1902 and it stated that migrating birds could be hunted during any season of the year. This law was modified in 1970 to establish a hunting period for migrating birds (*Streptopelia turtur, Columba palumbus* and *Coturnix coturnix*) from 15 VIII to 15 IX; there may be small variations between years and regions. The general hunting season for all game species (including the common quail) opens again from 12 X until mid–February.

Every ring recovery has associated information about the ringing date in the usual format, which we transformed into days of the year (days elapsed since 1 I), the ringing location, and the recovery date and location. Unfortunately, information about the sex and age of the individuals is mostly incomplete. For the analysis, we only selected rings recovered in the Iberian peninsula within the same year of ringing. To ensure that wintering individuals were not included, all the recoveries subsequent to 30 X were excluded from the analysis.

These data were also divided in three groups: Spanish recoveries (quails ringed in Spain), international (quails ringed elsewhere in Europe) coastal recoveries (recoveries located in the Mediterranean slope, which is an area at less than 50 km from the shoreline and limited by Mediterranean coastal mountain chains), and international inland recoveries (the remaining recoveries). This division was made to explore the possible differences in quail migration patterns suggested in other studies (Rodríguez–Teijeiro et al., 2009; Zduniak & Yosef, 2008; Zuckerbrot et al., 1980).

Statistical analysis

We applied parametric tests (multi–way ANOVA, Student *t*–test, Chi–square test) and when conditions of application were not fulfilled, non–parametric tests were applied (Mann–Whitney *U*–test, median test and Fisher exact test). In this case, descriptive statistics of central trend and dispersion used were the median and quartiles, respectively. PASSW and Statistica software were used for calculations.

Results

Quail captures in Garraf

A total of 530 quails (85.10% were yearlings) were trapped in Garraf during the study periods in 2009 and 2010. Surprisingly, the number of quails trapped was higher in 2009 (N = 275) than in 2010 (N = 255), when the number of mist–nets was tripled.

Captured birds showed that there are two different movement waves in the post–breeding passage (figs. 1, 2). In both years, the first wave occurred in August (median: 13 VIII 2009, quartiles 25–75: 219–224 days, and 7 VIII 2010, quartiles 25–75: 217.25–219 days), whereas the second , more intense wave occurred in September and October (median: 13 IX 2009, quartiles 25–75: 254–263 days, and 22 IX 2010, quartiles 25–75: 255–276 days), this latter difference being statistically significant (Mann–Whitney *U*–test Z = 7.26; $N_1 = 280$; $N_2 = 269$; $p < 0.01$). No significant differences were found in sex composition of the first and second wave when analyzing them by age classes in the two years (Yearlings: $\chi_1^2 < 1.84$; $p > 0.33$; Adults: Fisher exact test; $p > 0.39$), or in the proportion of ages between waves in the two years ($\chi_1^2 < 0.43$; $p > 0.51$).

No differences were found in the cloacal vent between yearling and adult males in the two years of study (two–way ANOVA, year factor: $F_{(1,315)} = 0.036$; $p = 0.88$; age factor: $F_{(1,315)} = 4.14$; $p = 0.29$); interaction year x age: $F_{(1,315)} = 0.339$; $p = 0.56$). However, individuals belonging to the first wave had a higher cloacal vent (mean ± SE = 5.23 ± 0.17, n = 54) than those belonging to the second wave (mean ± SE = 4.39 ± 0.05, n = 262). None of the individuals in either wave showed proctodeal foam, indicating they were not sexually active (Guyomarc'h et al., 2001; Seiwert & Adkins–Regan, 1998).

In 2010, yearling females showed a delay in migration (fig. 2) when compared to yearling males (median day of yearling males: 266; quartiles 25–75%: 258–272; median day of yearling females: 272; quartiles 25–75:

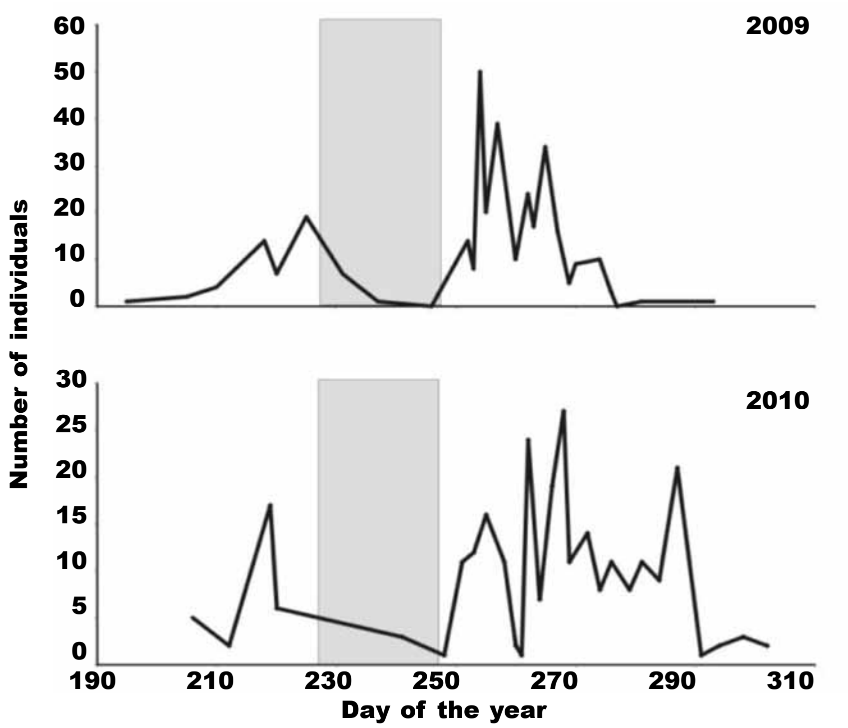

Fig. 1. Number of individuals captured from August to October in 2009 and 2010 in Garraf. The grey band shows the hunting season for migrant species in Barcelona province (15 VIII to 4 IX).

Fig. 1. Número de individuos capturados de agosto a octubre en 2009 y 2010 en Garraf. Las bandas grises corresponden a la época de caza de las especies migratorias en la provincia de Barcelona (15 VIII a 4 IX).

258–284; *U*–test Mann–Whitney $Z = 2.49$; $N_1 = 135$; $N_2 = 68$; $p = 0.01$). This phenological difference was, however, less clear in 2009 (median day of yearling males: 257; quartiles 25–75: 254–265; median day of yearling females: 255; quartiles 25–75: 253–262; Mann–Whitney *U*–test, $Z = 1.78$; $N_1 = 154$; $N_2 = 97$; $p = 0.08$). No differences were observed in the phenology of migration in adult individuals either in 2009 or in 2010 (Mann–Whitney *U*–test, $U < 189$; $p > 0.40$).

From a physiological point of view, the width of the lipid band in yearlings showed differences between 2009 and 2010, being wider in 2009 (three–way ANOVA, year factor: $F_{(1,436)} = 18.66$; $p < 0.01$). Differences were also found between waves, as individuals captured in the first wave showed a smaller lipid band than those captured in the second wave (wave factor: $F_{(1,436)} = 75.65$; $p < 0.001$; fig. 3). However, no differences were found between sexes (factor sex: $F_{(1,436)} = 3.27$; $p = 0.07$). Only the interaction between year and sex was significant; while males did not differ between years, females were less fat loaded in 2010 (interaction season x sex: $F_{(1,436)} = 6.59$; $p = 0.01$; fig. 3).

The width of the lipid band in adults showed non–significant differences between years (three–way ANOVA, year factor: $F_{(1,67)} = 30.67$; $p = 0.08$). However, significant differences appeared between waves (wave factor: $F_{(1,67)} = 33.49$; $p < 0.001$). As in yearlings, there were non–significant differences between sex (sex factor: $F_{(1,67)} = 0.46$; $p = 0.50$), and there was no interaction between factors ($p > 0.05$; fig. 3).

Ring recoveries

The distribution of ring recoveries in Spain showed that Spanish recoveries were captured very early (median: 20 VIII quartiles 25–75: 227–240, fig. 4).

Of a total of 189 international recoveries, 55 (29.1%) were coastal recoveries, whereas 134 (70.9%) were inland recoveries. In the former, 52 (94.5%) were obtained before 1970, before the law was amended to establish a hunting season for migrating bird species; in the second case, 102 birds (76.1%) were recovered before this date.

International recoveries show a first passage which mainly occurs inland, and a second passage which occurs along the Mediterranean coast (fig. 4).

There were significant differences (fig. 4) in the median day of capture in the three groups of recoveries analysed (Spanish recoveries, international coastal recoveries and international inland recoveries), together with the median day on which individuals of the second wave were captured in Garraf (Median test:

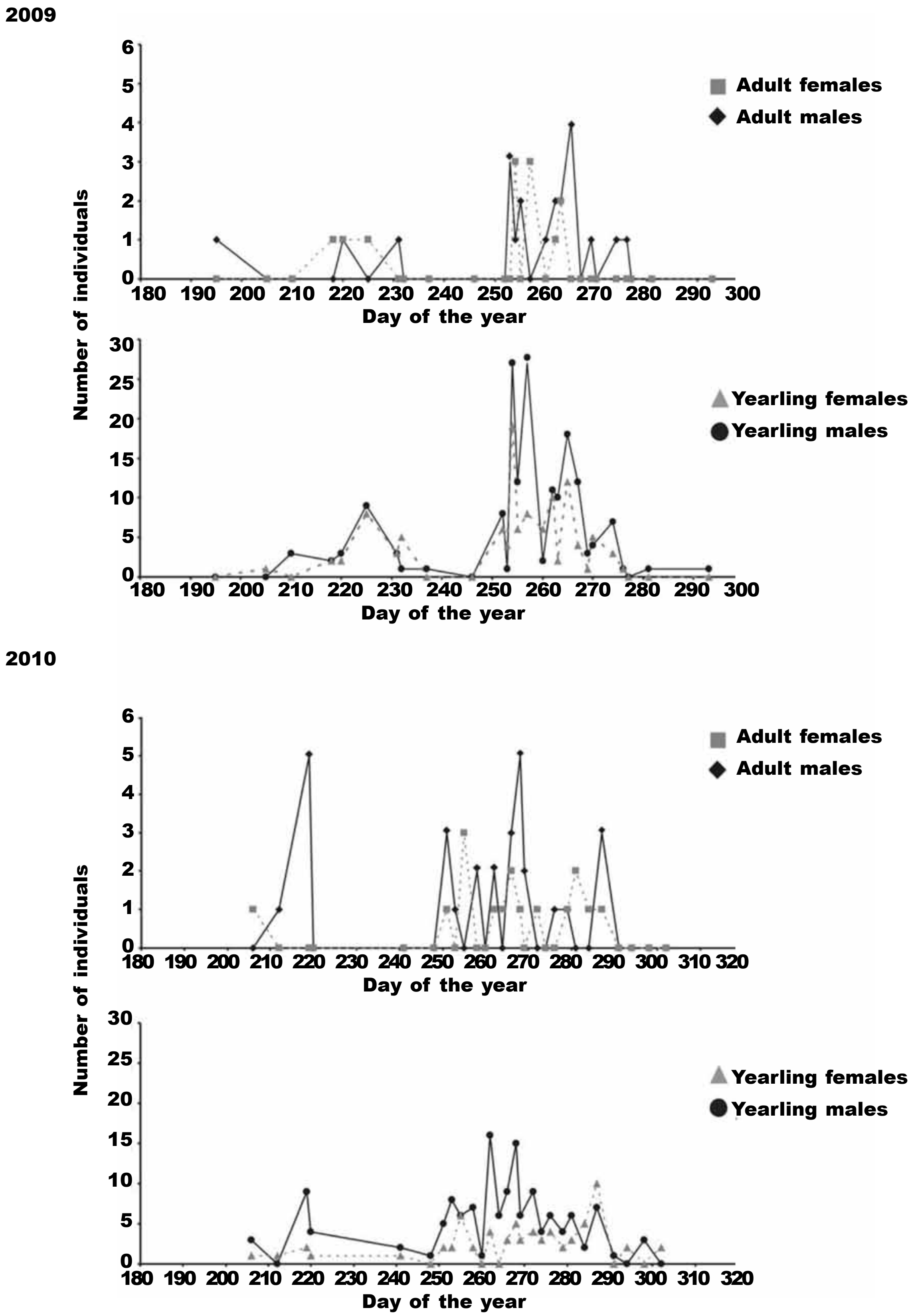

Fig. 2. Temporal migration patterns by sexes and ages in 2009 and 2010 in Garraf.

Fig. 2. Patrones de migración temporal por sexos y edades en 2009 y 2010 en Garraf.

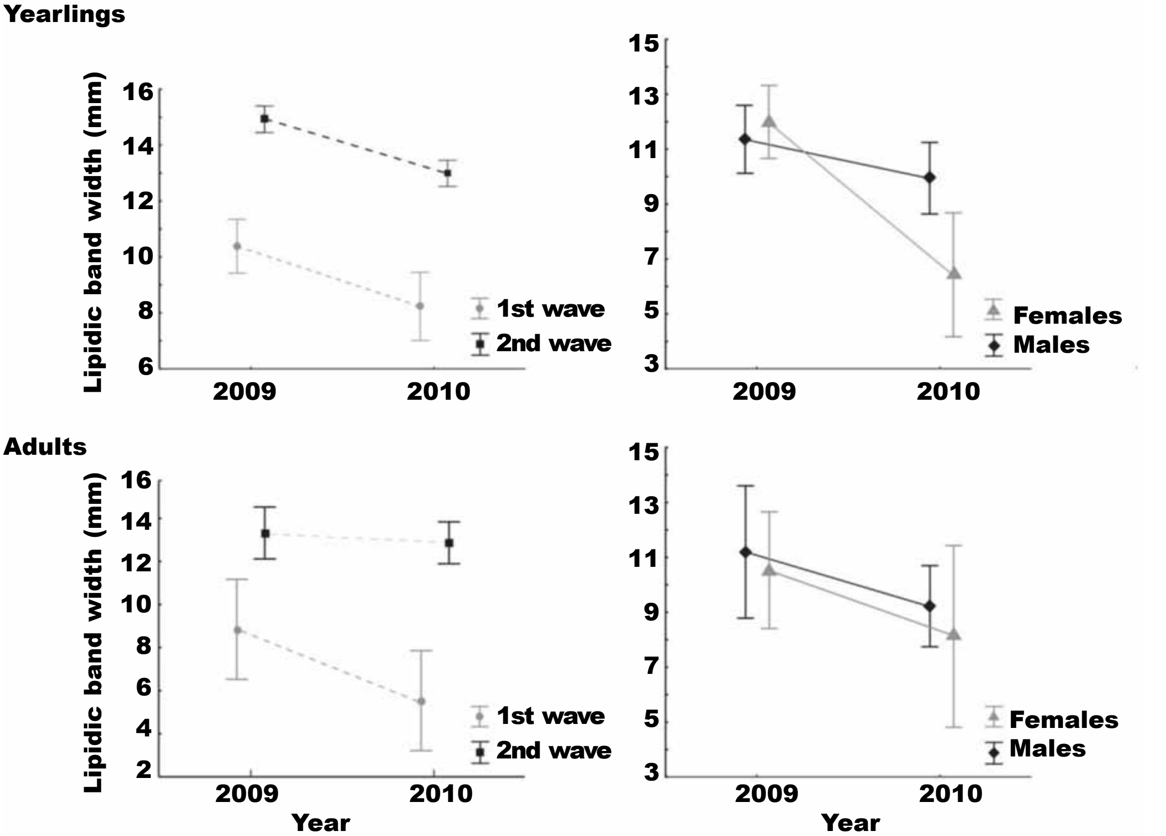

Fig. 3. Lipid bands of migrant quails in 2009 and 2010 in Garraf. Results on the left show whether the individuals belong to the first or second movement wave. Results on the right show interactions between year and sex factors. Mean and 95% confidence intervals are shown for yearling and adult males and females.

Fig. 3. Bandas lipídicas de codornices migrantes en 2009 y 2010 en Garraf. Los resultados de la izquierda muestran según si los individuos pertenecen a la primera o a la segunda ola migratoria. Los resultados de la derecha muestran las interacciones entre los factores año y sexo. Se muestran la media y los intervalos del 95% de confianza para jóvenes del año y machos y hembras adultos.

$\chi^2_{685} = 596.75$; $p < 0.01$). Moreover, a multiple post hoc comparison test showed differences ($p < 0.01$) in all the two–to–two comparisons with the exception of the comparison between the median day of capture of international coastal recoveries with regard to the median day on which individuals of the second wave were captured in Garraf ($p > 0.01$).

Discussion

The common quail post–breeding movement patterns through the Iberian peninsula were completely unknown to date. Our results in Garraf Natural Park, in the northeast of Iberian Peninsula, clearly suggest that an important movement flow occurs along the Mediterranean coast at latitude of 41ºN. Furthermore, they show that these movements are formed by two marked movement waves.

The first wave, which lasts from July to August (with a modal value of 13 VIII), is mainly composed of yearlings at the end of their sexually–active period (on the basis of their cloacal vent over 4.5 mm but, on the other hand, without proctodeal foam. According to their fat deposits, they cannot be considered physiologically as migrant individuals and should be considered more nomadic than migratory. This movement would belong, thus, to the movement patterns of the species during the breeding season (Munteanu & Maties, 1974; Puigcerver et al., 1989; Rodríguez–Teijeiro et al., 2006).The common quail is a farmland bird whose life cycle is mainly linked to winter cereal crops (wheat and barley mainly) and dense grassland (Guyomarc'h, 2003). However, during the breeding season, the species suffers massive habitat loss due to cereal harvesting. Thus, there is a radical landscape change in spring to the post–breeding migration passage, which induces common quail birds to move during the breeding season (Rodríguez–Tei-

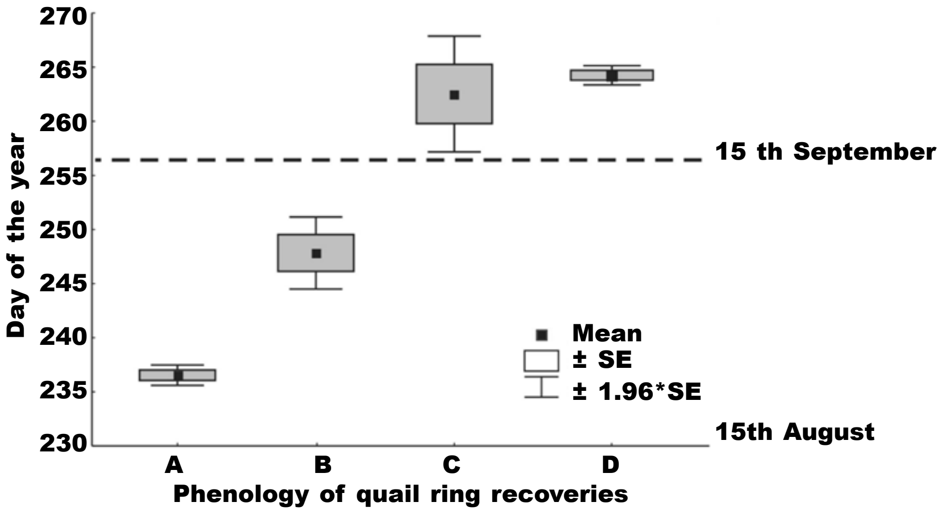

Fig. 4. Phenology of quail ring recoveries in Spain according to the ringing origin and recovery location. The hunting season for migrant species in Spain (15 VIII to 15 IX) after 1970 is shown: A. Spanish recoveries; B. International recoveries inland; C. International recoveries on the coast; D. Garraf second wave.

Fig. 4. Fenología de la recuperación de anillas en España, según el lugar de origen del anillamiento y la localidad de recuperación. Se muestra la época de caza de las especies migratorias en España (15 VIII a 15 IX) después de 1970: A. Recuperaciones españolas; B. Recuperaciones internacionales en el interior; C. Recuperaciones internacionales en la costa; D. Segunda oleada en Garraf.

jeiro et al., 2009) from south to north and from lower areas (harvested in June) to higher areas (harvested in August). Thus, at the end of the breeding season, quail population movements in the Iberian Peninsula present a complex scenario, and quails that breed in the Peninsula show nomadic movements in search of remaining suitable habitats to match habitat loss caused by cereal harvesting (Gallego et al., 1993; Puigcerver et al., 1989; Rodríguez–Teijeiro et al., 2009), rather than a true migratory movement (Rodríguez–Teijeiro et al., 2006).

The second wave is formed mainly of non–sexually active yearlings and occurs on average five weeks later. These birds have a cloacal vent under 4.5 mm, do not present proctodeal foam, and could be physiologically considered as migrants because of their lipid band. The passage of these common quails captured in Garraf during the second wave has a very similar phenology to that of international quails that were ringed and recovered on the Mediterranean coast (fig. 4) in a totally independent way. As the breeding cycle of the species in the Spanish strip between the Pyrenees and the Garraf Natural Park has finished by the time harvesting is over, and as the maximum passage is recorded one month later in Northeast Spain, the individuals belonging to this migratory wave must come mainly from the North of Europe.

This post–breeding migration passage has also been reported in Egypt (Zuckerbrot et al., 1980), whereas in Italy and Israel an important spring passage has been described, with the post–breeding flow being much less intense (Macchio et al., 1999; Zduniak & Yosef, 2008).

In the two years of the study, age and sex composition of the first and second wave remained fairly constant. However, the phenology of yearling females suffered a delay in the second year. Furthermore, yearling females in 2010 also showed less developed fat deposits, suggesting that they were physiologically less prepared for the migratory passage. As females invest alone in brood care, any delay in the breeding attempt would be reflected in the migratory condition of the female fraction of the population. On the other hand, the proportion of adults showed constancy in their migratory condition over the years of study.

Our results on the basis of the two years of study (which were very similar in terms of meteorological conditions) indicate that there is a set of nomadic movements at the end of the breeding season that coincides with the hunting season for migrant species in Spain. Moreover, it almost entirely respects the main migratory passage constituted by the coastal passage, probably affecting only individuals that breed in Spain and the international inland recoveries (fig. 1).This information should help to adjust timing between the hunting period and migration in coming years. However, as meteorological variability from year to year could affect the movements of individuals, data need to be collected over more years to clarify how the different meteorological conditions affect quail movements. This would provide more precise information and would permit reliable recommendations for adjusting hunting seasons to quail population movements. However, no efforts have been carried out to date in other Spanish regions, or in other European countries where the common quail is a popular game species, to study and describe its post–breeding migration patterns, which could vary from one country to another. Besides, the variability between years that could appear as a consequence of changes in meteorological conditions could have some influence on the movements of the individuals. Monitoring of post–breeding movements and post–breeding migration should thus be extended to all the regions and countries where the common quail is a game species. Furthermore, it should be carried out over years with varying meteorological conditions in order to improve adjustment between the hunting period and migration, thus complementing other measures described in Perennou (2009).Based on these findings we strongly suggest studies of this type should be conducted in other countries in coming years in order to gain further knowledge of the species and improve its management.

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