

THE MIGRATION OF THE LESSER KESTREL *Falco naumanni* IN EASTERN EUROPE – A RINGING RECOVERY AND DIRECT OBSERVATION APPROACH

Selitev južnih postovk *Falco naumanni* v vzhodni Evropi – pristop z analizo obročkovaških najdb in neposrednim opazovanjem

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We examined ringing recovery data of the Lesser Kestrel *Falco naumanni* in order to analyse its migration patterns and philopatry rates in Eastern Europe. In addition, we extracted counts of migrating birds from online databases and studied the use of the flyway as well as the phenology of both spring and autumn migrations through Greece. Birds appeared to migrate in the same mean direction in spring and autumn through the Italian and Balkan Peninsulas. During spring, movements took place on a broad front from March until mid-May with a peak in mid-April; in autumn, birds migrated through Greece on a narrower front from early August to early October, with most of individuals passing through Greece in mid-September. Finally, philopatry rates were higher for adults, while juvenile birds dispersed more often and at longer distances, up to 974 km away. Our results on migration patterns generally agree with those in other studies, but we found some evidence of long-distance premigratory movements towards mainland Greece that could also shape the narrower front migration in autumn. In addition, long distance dispersal movements of juveniles in southeastern Europe, where Lesser Kestrel populations show a fragmented distribution, could facilitate gene flow between populations, thus avoiding the negative effects of mating with genetically similar individuals.

Keywords: Lesser Kestrel, *Falco naumanni*, Greece, bird migration, ringing recoveries

Ključne besede: južna postovka, *Falco naumanni*, Grčija, selitev ptic, obročkovaške najdbe

1. Introduction

A vast number of birds, including many raptors, move between the western Palearctic and Africa (BERTHOLD 2001). Birds migrating through Greece face a large ecological barrier, the Mediterranean Sea, the shortest distance between Greece (Crete Island) and Africa being approximately 280 km. The length of the barrier leads the main flyways of several species to converge through the Balkans and in the Eastern Mediterranean

(PANUCCIO *et al.* 2012, SCHINDLER *et al.* 2015) with only a few raptor species attempting the long water crossing between Greece and Africa (LUCIA *et al.* 2011, PANUCCIO *et al.* 2013).

Bird ringing has provided undeniable insight into the biology of birds over the years, especially on their movements and migration routes (BAIRLEIN 2001). The increasing number of ringing schemes in Europe provides useful data and the process of handling large datasets has been facilitated in the last

decades (FRANSSON 2001). As a result, bird ringing is widely used in many studies concerning the ecology, behaviour, migration and conservation of bird populations (BAILLIE 2001). In addition, emerging citizen science platforms can provide a wealth of information that can be used in ecological and conservation studies, including the study of migration flyways and general phenology (DICKINSON *et al.* 2010, HURLBERT & LIANG 2012).

The Lesser Kestrel *Falco naumanni* is a small migratory falcon that breeds in southern Europe and winters in sub-Saharan Africa (CRAMP & SIMMONS 1980). The species disperses from the breeding grounds in late July and August, and migrates on a broad front from August to October. In spring it migrates in small groups, reaching southern Europe during March – April (FORSMAN 1999). The species regularly crosses the Mediterranean Sea during both autumn and spring migrations (MEYER *et al.* 2003). Additionally, the species is highly philopatric, with the majority of first time breeders returning within 10 km from their natal colony in Spain (NEGRO *et al.*

1997, SERRANO *et al.* 2003). However, there is evidence of long-distance dispersal events (PRUGNOLLE *et al.* 2003) and the importance of such movements is reflected in the low genetic differentiation between geographically distant populations (ALCAIDE *et al.* 2009).

In the Balkans and Central Europe, the species underwent a decline that led to the extinction of several national populations (e.g. in Bulgaria, Serbia, Slovenia, and Ukraine) and also of several colonies in all other countries (INIGO & BAROV 2010). This process resulted in a fragmented distribution of the species in the Balkan Peninsula. Currently, Greece is still among the most populated areas in southern Europe, hosting 2–3% of the European population with approximately 2,600–3,300 pairs in 140 recorded breeding colonies, most of them concentrated in the Thessaly region, Central Greece (LEGAKIS & MARAGOU 2009).

In this study we utilised the recoveries of Lesser Kestrels ringed in Eastern Europe, data from two bird observation databases, and data from raptor counts in Greece in order to study the phenology, migration

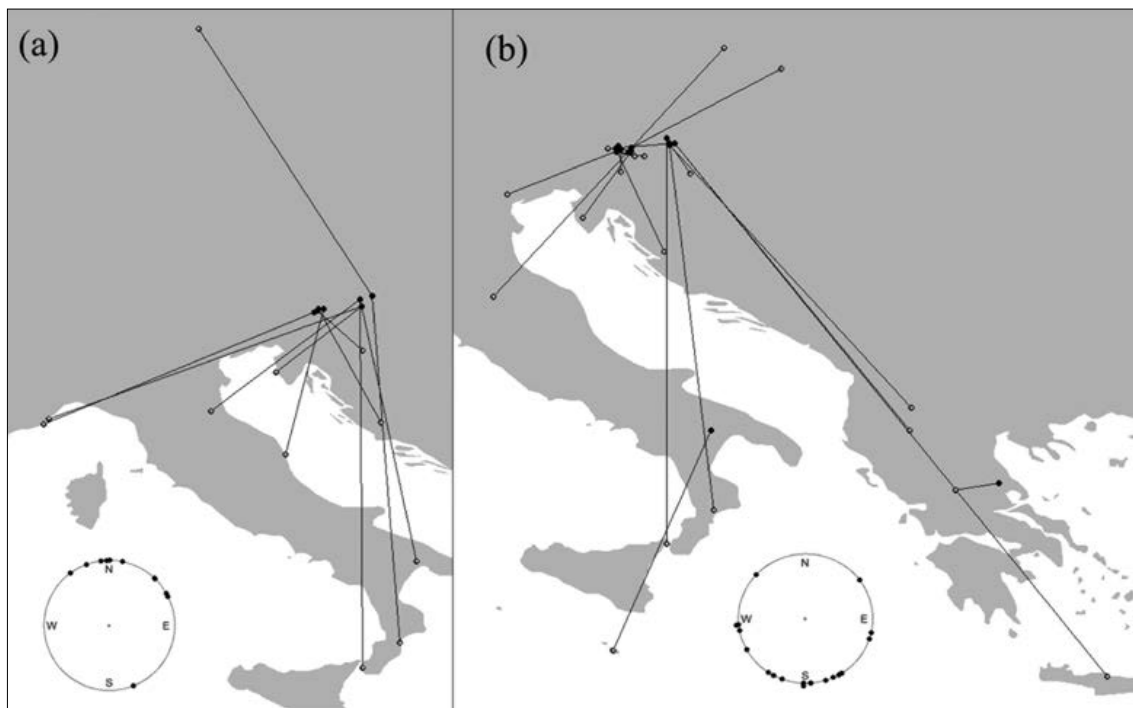


Figure 1: Recoveries of Lesser Kestrels *Falco naumanni* ringed between 1947 and 2002 and their movement directions during (a) Spring migration (February–April, $n = 11$ recoveries) and (b) Autumn migration (August–October, $n = 19$ recoveries). Filled black and open dots represent ringing and recovery locations, respectively. Lines connect ringing with recovery locations.

Slika 1: Najdbe južnih postovk *Falco naumanni*, obročkanih med letoma 1947 in 2002, in smer premikov med (a) spomladansko selitvijo (februar–april, $n = 11$ najdb) in (b) jesensko selitvijo (avgust–oktober, $n = 19$ najdb). Polni krožci ponazarjajo kraj obročkanja, prazni pa kraj najdbe. Črte povezujejo oba kraja.

patterns and flyways over Greece and Eastern Europe. We also provided an estimate of philopatry rates using ringing recovery data. These analyses are aimed to improve the knowledge of the migration behaviour in the region as well as the potential connectivity of populations through breeding and natal dispersal movements. Such information can have an impact on future conservation actions and genetic studies in the region.

2. Methods

For the migration pattern analysis we used data from 30 individuals ringed and recovered between 1947 and 2002 across 10 countries (Albania, Austria, Croatia, Czech Republic, The Former Yugoslav Republic of Macedonia, Germany, Greece, Italy, Malta and Slovenia). 19 of these individuals were recovered during autumn migration, and 11 recoveries were used for spring migration patterns. Regarding philopatry, our dataset consists of 22 recovered juveniles and 16 adult birds originating from Austria, France, Greece, Italy and Poland.

These observations were extracted from a total of 966 recoveries of ringed Lesser Kestrels provided by the EURING Data Bank (DU FEU *et al.* 2009) and spanning 79 years from 1934 to 2013. For our migration pattern analyses recoveries from birds ringed in Spain and France were discarded, since we were interested in the eastern European range of the species, thus resulting in 77 recoveries relevant for the region. These 77

recoveries were subsequently filtered in order to study the migration patterns of the species. We included birds that had a recovery date accurate to within two weeks at the most and ringing and recovery coordinates that were accurate within 50 km. For autumn migration we used records of birds ringed in the breeding season between April and July and recovered between late August and October in the same or subsequent years. We excluded recoveries with less than 30 km between ringing and recovery sites in order to eliminate local pre-migration gatherings but to keep possible long-distance pre-migratory movements. Spring migration movements were considered from records of birds ringed between April and July and recovered between February and April of the same or consecutive years after eliminating observations where recovery distance was less than 50 km in order to avoid bias from birds that could have dispersed and bred in nearby colonies. All data manipulation and analyses were performed in R 3.2.2 (R CORE TEAM 2015) using the package “birdring” (KORNER-NIEVERGELT & ROBINSON 2014). Direction and distances were provided with the EURING dataset. Movement directions were plotted and analysed using the R package “circular” (AGOSTINELLI & LUND 2011). In order to visualize the inverse movements in spring migration we transformed the directions by adding 180° to the calculated values. The non-parametric Mardia-Watson-Wheeler test was used to test for differences in the mean or variance of migration directions between spring and autumn. In order to examine whether Lesser Kestrels migrate on

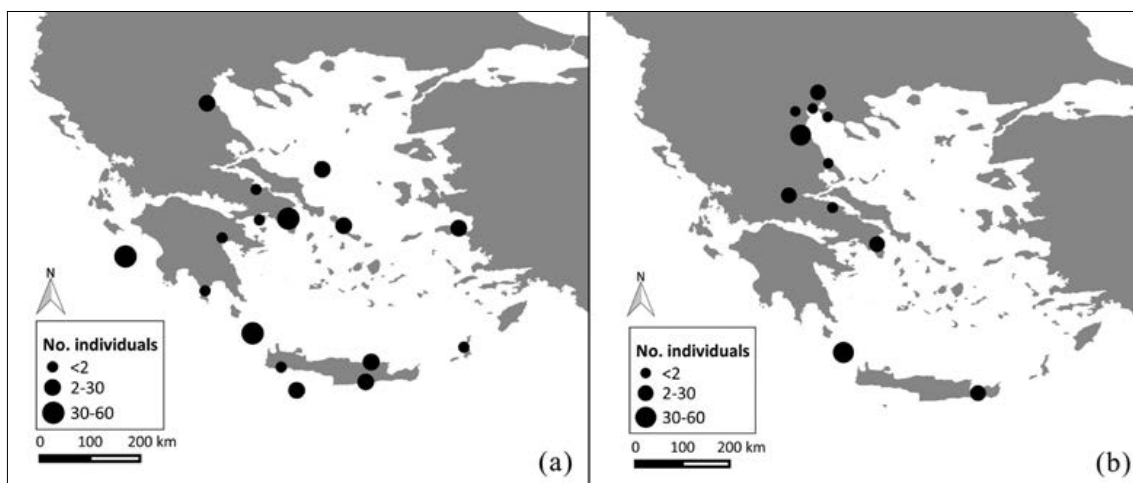


Figure 2: Observations of Lesser Kestrels *Falco naumanni* migrating over Greece from 1958 to 2013. (a) Spring migration, (b) Autumn migration.

Slika 2: Opazovanje južnih postovk *Falco naumanni* selečih se čez Grčijo med letoma 1958 in 2013. (a) spomladanska selitev, (b) jesenska selitev.

a broad front or through specific bottleneck areas over Greece, we extracted observations of migrating birds in spring (February to May) and autumn (August to October), during the 2001–2013 period from Ornithotopos database (HELLENIC ORNITHOLOGICAL SOCIETY 2009), data supplied by Observation.org (<https://observation.org>), observations reported in the literature (VAUGHAN 1960, PANUCCIO *et al.* 2011) as well as observations obtained from personal communications. We considered these observations to be of migrating birds since they were made far from breeding colonies of the species in Greece. In addition, these birds were observed in active migration during the migratory periods mentioned above and were moving in the expected direction of migration. Maps were designed with Qgis (v. 2.12.3.). The description of the migratory phenology of the species is based on raptor count data through the 2006–2015 period, from Antikythira Bird Observatory, Spata (Attica) and Olympus Mountain for the autumn migration, and Spata (Attica) for the spring migration. Values are presented as median and interquartile range. Plots were prepared using the R package “ggplot2” (WICKHAM & CHANG 2009).

We examined the philopatry of Lesser Kestrels in two age classes: birds ringed as fledglings or juveniles that returned to breed after one or subsequent years and birds ringed after their first year (subadults and adults) returning to breed after one or more years (natal and breeding philopatry, respectively). We considered birds to be dispersed if they did not return to breed around their natal colony (≤ 1 km). We filtered the EURING

data taking into account the ringing location (birds ringed in Spain were not included), date of ringing and recovery (defining the breeding season from April to June), accuracy of coordinates (accurate within 10 km) and condition and circumstances of recovered birds (since a part of recoveries includes dead birds, we eliminated observations that did not have information on how recently the birds had died). We used data from birds ringed in France in this analysis in order to examine possible eastward dispersal. Recoveries that included recently dead birds in a radius of 5 km from the place where they were ringed were double checked on the map and placed in the nearest breeding site, since the distance may indicate a feeding movement of a bird when it died. Additionally, we included eight recoveries of marked individuals from all over Greece that were a part of an ongoing genetic sampling project.

3. Results

The mapping of ringing recoveries shows movements of birds through both the Italian and Balkan Peninsulas in autumn, while in spring migrating individuals were only recovered through the Italian Peninsula (Figure 1). Some birds moved in northeasterly or westerly directions in early August, probably indicating some long distance premigratory movements. The mean directions for migrating birds in autumn and spring were $185.5^\circ \pm 31^\circ$ (95% CI) and $28.2^\circ \pm 36.5^\circ$ (95% CI), respectively. No significant differences were found in the mean migration axis or in the variance between spring and autumn migration (Mardia-

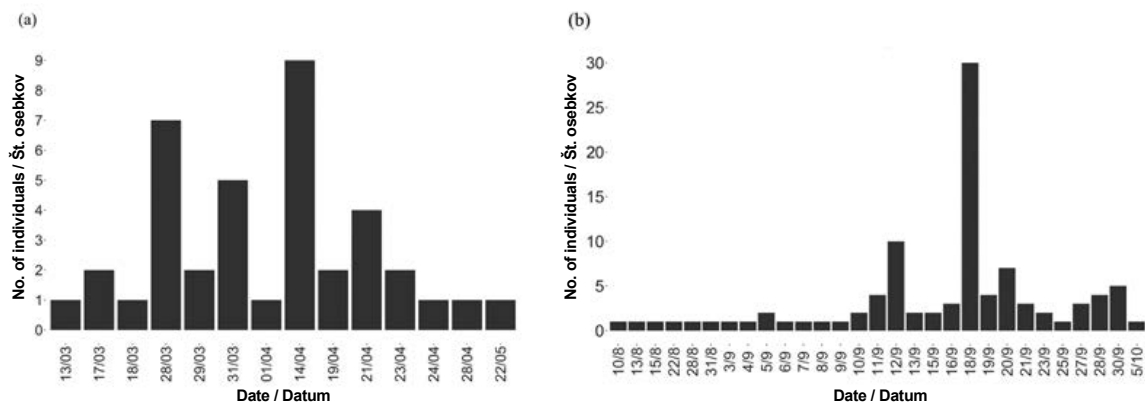


Figure 3: Phenology of individuals migrating through Greece between the years 2006 and 2015. (a) Spring migration, (b) Autumn migration.

Slika 3: Fenologija osebkov, selečih se skozi Grčijo, med letoma 2006 in 2015. (a) spomladanska selitev, (b) jesenska selitev.

Watson-Wheeler test: $W = 1.4$, $df = 2$, $P = 0.49$). Observations were gathered of 181 migrating Lesser Kestrels from 13 different locations during spring and of 115 individuals from 10 locations in autumn. Birds appear to migrate on a broad front, especially in spring when birds were recorded in both western and eastern Greece as well as through the Aegean Sea on various islands (Figure 2a). Migration in autumn appears to take place on a narrower front, with most birds flying over mainland Greece, Antikythira Island and Crete (Figure 2b). From the standardized counts, spring migration over Greece occurs from March till mid-May with a peak in mid-April ($n = 39$, median = 14 April, interquartile range: 28 Mar to 19 Apr; Figure 3a). Autumn migration extends from early August to early October, peaking in mid-September ($n = 101$, median = 18 Sep, interquartile range: 12 to 20 Sep; Figure 3b).

Of the 22 juveniles recovered, 15 showed natal philopatry and 7 dispersed. A long-distance dispersal was observed to the west. 2 birds ringed in Austria were recovered breeding in Italy (974 km and 684 km away) and 2 birds ringed in France were recovered breeding in Spain (464 km and 369 km away). The remainder dispersed closer to their natal colonies (23 km, 28 km and 60 km). Of the 16 adults, only one dispersed at a distance of 17 km, while 15 returned to breed on the same grounds. Thus, philopatry rates for adults and for juveniles differed significantly ($\chi^2 = 3.643$, $df = 1$, $P < 0.05$).

4. Discussion

4.1. Migration patterns

A combination of available ringing recovery data and direct observations was used in order to describe the migration patterns of Lesser Kestrels in Eastern Europe. No differences were found in the mean migration axis between autumn and spring, but birds appear to migrate through the region on a narrower front during autumn. In addition, the range of the migration period was defined as well as peak days of the species' migration in autumn and spring.

No evidence was found that birds used different migration routes in spring and autumn (loop migration) in the region. In autumn, birds migrated through both the Italian and Balkan Peninsulas, and some important movements were identified during this period. In particular, a juvenile ringed in Austria was recovered after 54 days 793 km away in Albania in mid-August, an adult female ringed in Austria was recovered in the Former Yugoslav Republic of Macedonia (FYROM) on 20 July of the same year having moved 750 km, and a

juvenile ringed in central Greece moved to the west and was recovered in mid-July 100 km away from its natal colony. Since the dates of recoveries are too early for full migration and the recovery sites host well-known large premigratory roosts (THORPE & HOLMES 1936, MINIAS *et al.* 2009, BOUNAS *et al.* 2016), we suggest that these individual-specific movements reflect the gathering of birds at pre-migratory sites. Such movements (even some northward ones) have already been reported in studies from the Iberian Peninsula (BUSTAMANTE & NEGRO 1994, OLEA 2001, CATRY *et al.* 2011).

Counts of migrating birds in Greece confirmed the broad-front migration strategy that is known for the species in other areas (MEYER *et al.* 2003, ALON *et al.* 2004). Although in spring birds migrated all across Greece, in autumn birds appeared to migrate on a narrower front. This result is in agreement with counts reported in the Central Mediterranean area. In Italy, Lesser Kestrels are commonly observed during spring in small numbers at different watch-sites, also on the small islands of the Tyrrhenian Sea, and along the Adriatic coast en route for the Balkan Peninsula (PANUCCIO *et al.* 2004, PREMUDA *et al.* 2004). On the other hand, in autumn, observations of actively migrating Lesser Kestrels are concentrated at the Strait of Messina where up to 753 individuals per season were estimated (AGOSTINI *et al.* 2015). Part of the same migratory flow is subsequently detected over Malta en route to Libya (SAMMUT & BONAVIA 2004). Conversely, birds tracked from Spain migrated on a broad-front in autumn and concentrated through Gibraltar in spring (LIMIÑANA *et al.* 2012). The apparent narrower front during autumn migration in Greece could again be a result of the premigratory gatherings in the Balkans, with birds concentrating in areas of mainland Greece and then converging along the “mainland Greece-Antikythira-Crete” flyway.

Estimation of the migration period and peak of the Lesser Kestrel in the region generally conformed to studies in the Italian Peninsula, where the spring migration begins in March, peaks from early to mid-April with some variation of the peaking date between years (CORSO 2001, GIORDANO *et al.* 2008, PREMUDA *et al.* 2008) and lasts till early May. In the Iberian Peninsula birds appear to arrive earlier, migrating from the first half of February till mid-April (RODRIGUEZ *et al.* 2009, CATRY *et al.* 2011). Late migrants observed from late April to mid-May could include non-breeding individuals as well as birds reaching their northern breeding grounds where breeding occurs later (MIKULIĆ *et al.* 2013). In autumn, Lesser Kestrels migrated over Greece from August to early October, peaking in mid-September, a little earlier than in Spain

(RODRIGUEZ *et al.* 2009, LIMINANA *et al.* 2012) but in the same period, with the closest migration routes in central Mediterranean (GALEA & MASSA 1985) and western Black Sea (MICHEV *et al.* 2011).

Analyses based on ringing recovery data can be biased due to the low recovery rates and irregular spatial distribution (PERDECK 1977, STRANDBERG *et al.* 2009). Thus, they do not provide a complete picture of bird migration but rather a general view of migration patterns. In our study, we had relatively few ringing recoveries so we used observations and counts of migrating birds in order to describe the species migration patterns in the region. Ringing recoveries were used to provide supplementary information on the long-distance movements of individuals. Despite that, information on migration of the species in the region can still be relevant for conservation actions.

4.2. Philopatry

According to our results, philopatry is higher in adult birds than in juveniles. Juveniles that dispersed did so on long distances, while adults showed much higher fidelity on their breeding grounds. There is evidence that the probability of dispersal decreases with age (SERRANO *et al.* 2001, CALABUIG *et al.* 2008) while such long distance dispersal movements exist but could be underestimated (PRUGNOLLE *et al.* 2003). A reason for that could be that estimating philopatry rates from ringing recovery data has its drawbacks since ringing intensity varies with locations and long-distance dispersal movements of individuals could be difficult to detect. Various reasons have been proposed for such dispersive behaviour in juvenile birds such as the increase of population density that leads to an increased dispersal (NEGRO *et al.* 1997). Moreover, high natal dispersal of juveniles (83%) has been observed in more isolated populations (SERRANO *et al.* 2003). In Southeastern Europe, where Lesser Kestrel populations show a fragmented distribution, such dispersal movements could facilitate gene flow between populations, thus avoiding the negative effects of mating with genetically similar individuals.

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5. Povzetek

Za analizo selitvenih vzorcev in stopnje filopatrije južne postovke *Falco naumanni* v vzhodni Evropi smo preučili podatke o obročkovalskih najdbah. Dodatno smo iz spletnih podatkovnih baz pridobili še podatke o opazovanih selečih se ptic, da bi preučili selitvene poti in fenologijo spomladanske ter jesenske selitve skozi Grčijo. Ptice so se tako spomladi kot jeseni selile v isti povprečni smeri vzdolž Apeninskega in Balkanskega polotoka. Spomladi so se selile v široki fronti med marcem in majem z viškom sredi aprila, jeseni pa je bila selitev v Grčiji prostorsko bolj zgoščena med začetkom avgusta in začetkom oktobra z viškom sredi septembra. Stopnja filopatrije je bila večja pri odraslih osebkih, medtem ko je bila pri mladih osebkih disperzija pogostejša in daljša, do 974 km. Naše ugotovitve o selitvenih vzorcih se v splošnem ujemajo z drugimi raziskavami, vendar smo opazili daljše preselitvene premike proti celinski Grčiji, ki bi lahko bili vzrok za prostorsko bolj zgoščeno jesensko selitev. V jugovzhodni Evropi, kjer so populacije južnih postovk daleč vsaksebi, bi bili dolgi disperzijski premiki mladih osebkov pomembni za genski pretok med populacijami, ki bi preprečil negativne učinke parjenja med sorodnimi osebki.

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