Current Zoology, 2022, **XX**, 1–11
https://doi.org/10.1093/cz/zoac039
Advance access publication 18 May 2022
Original Article

The variability of juvenile dispersal in an opportunistic raptor

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Handling editor: Zhi-Yun Jia

Abstract

The juvenile dispersal of raptors is a crucial stage that stretches from parental independence to the establishment of the first breeding area. Between 2012 and 2020, 44 juvenile red kites *Milvus milvus* from the Spanish breeding population were tagged using GPS telemetry to study their dispersal. Juveniles left the parental breeding area at the end of their first summer and performed wandering movements throughout the Iberian Peninsula, returning to the parental breeding area the following year, repeating the same pattern until they settled in their first breeding area. We analyzed the mean distance from the nest, the maximum reached distances, and the traveled distances (daily and hourly) during the first 2 years of dispersal and compared them. Despite the high individual variability, variables describing the dispersal movements of juveniles showed a decreasing trend during the second dispersal year: 80% of individuals reached a shorter maximum distance in the second year, 70% decreased their mean distance to the nest, 65% decreased their hourly traveled distances, and 50% decreased their daily traveled distances. On the other hand, the red kites usually combined wandering movements with the establishment of temporary settlement areas (TSA). The average duration of settlement in the TSAs was 75 ± 40 days (up to 182 days) and was located at 182 ± 168 km from the nest. In those areas, juveniles used 781.0 ± 1895.0 km^2 (KDE 95%). Some of the TSAs were used by several individuals, which suggests that these areas might be good targets for conservation in future management plans

Key words: GPS telemetry, landfills, movement ecology, natal dispersal, red kite, spatial ecology.

The juveniles from both sedentary and migratory birds, after becoming independent from their parents, disperse from their birthplaces for months or years (Newton 2010). This period, known as "juvenile dispersal" or "natal dispersal", comprises the departure from the nest to the establishment of the first breeding area, when individuals become adults. Most of the movements performed by birds during this stage seem to occur randomly in all directions. Individuals range from one area to another, exploring territories and residing in TSAs, where food and clime are appropriate for a short period (Greenwood 1980; Ronce 2007; Newton 2010). Juvenile dispersal, despite being one of the most crucial stages in birds' life cycle (Gadgil 1971; Ferrer 1993; Soutullo et al. 2006; Penteriani and Del Mar Delgado 2009; Cadahía et al. 2010; Nemček et al. 2014, Urios et al. 2017), is often poorly known in comparison with breeding and migration events. However, juveniles' survival rates determine the settlement and distribution of later adults in their breeding areas; so high mortality rates during this period may affect population dynamics (Ferrer and Calderón 1990; Newton 1998; Penteriani and Del Mar Delgado 2009). Thus, the study of movements and settlement patterns of juveniles is indispensable for the correct design of management plans.

Opportunistic raptors such as the red kite (*Milvus milvus*, Accipitridae) are very interesting species for the study of juvenile dispersal. This species is a partial migratory raptor from Western Palearctic (Aebischer and Scherler 2021; Panuccio et al. 2021; Vidal-Mateo et al. 2021) and has high variability in its spatial strategies. Their breeding populations are mainly found in the west and center of Europe (BirdLife International 2021), but there are also more than 2,000 breeding pairs in Spain (Molina 2015). During the last decade, the Spanish breeding population has slightly increased (15.66% since 2004), but the species is far from being recovered in this country (Molina 2015), where it is categorized as "In Danger of Extinction" (MITECO 2020). Several reasons could explain this complicated situation in the southern limit of red kite's distribution. On the one hand, they have a generalist diet, being facultative scavengers (García et al. 1998), feeding on carrion (Knott et al. 2009); therefore, they are especially vulnerable to poison exposure (Monclus et al. 2018; Herrero-Villar et al. 2021; Viñuela et al. 2021). On the other hand, Spain is the limiting region in the southern distribution of the red kite (García-Macía et al. 2021, 2022); therefore, its climatic conditions may also explain the decrease in the Spanish population (Seoane et al. 2003; Wormworth and Mallon 2006). The rise

Received 18 January 2022; revised 10 May 2022; accepted 14 May 2022

of temperatures and global change may shift the distribution range of red kites toward the north, as it is happening with several species in the last decades (Visser et al. 2009; Heath et al. 2012; Martín et al. 2014).

Despite the importance of its conservation, the dispersal movements of the juvenile Spanish red kites are poorly known. This stage has been mainly studied in some European population based on rings and field observations (Newton et al. 1989; Bustamante 1993; Newton et al. 1994), but also on GPS telemetry in the last decade (Nemček 2013; Vidal-Mateo 2019; Literák et al. 2020; Literák et al. 2022), which provides more accurate information (López-López et al. 2010; Urios et al. 2015; López-López 2016; Mattsson et al. 2022). However, juvenile red kites from the Spanish breeding population seem to have distinct characteristics, so there are still many open questions about their dispersal: How do movements evolve? What are the characteristics of their TSAs? Where are their first breeding areas located after dispersal? Are there sex differences in dispersal distances, as is the case for some Central European populations (Literák et al. 2022)? More studies focused on these issues are necessary to improve the knowledge of this species and have good tools for its conservation.

In this study, we analyzed GPS telemetry data from 44 individuals of the Spanish breeding population, using dispersal periods from 7 months to 2 years. First, we hypothesize that juveniles' movements of the red kite decrease during the second year of dispersal, including less distances traveled and shorter mean distance to the nest. This process has been reported in other raptors, both during dispersal (Ferrer 1993) and migration (Mellone et al. 2013; García-Macía et al. 2021). Second, the juvenile dispersal throughout the Iberian Peninsula will not be sex dependent, because sex differences in the movement ecology of raptors often appear when individuals become adults (Newton et al. 1989; Walls and Kenward 1995; Real and Mañosa 2001; Balbontín and Ferrer 2009). Third, juveniles will tend to establish their breeding area near their natal nests. This philopatric behavior has already been demonstrated in many other raptors (Bustamante 1993; Ferrer 1993; Newton et al. 1994; Negro et al. 1997; Literák et al. 2022). Finally, we hypothesize that there will be a tendency to establish in TSAs, as often occurs in juvenile raptors (Ferrer 1993; Prommer and Bagyura 2007; Nemček et al. 2016; Vidal-Mateo 2019).

Materials and Methods

Area study and tagging

Forty-four chicks from the Spanish breeding population were tagged between 2012 and 2020 in different Spanish provinces (Supplementary Figure IA), mainly from the center and north of the Iberian Peninsula, trying to follow the distribution of the species in that territory: Madrid (22), León (5), Soria (4), Ávila (3), Zamora (2), Toledo (2), Álava (2), Guipúzcoa (2), Valladolid (1), and Mallorca (1).

Individuals were tagged with GPS transmitters while they were in the nest, unable to fly freely, but still able to be caught by hand. The GPS transmitter was fixed to the back of the juvenile with a non-abrasive material, a full-body Teflon harness, tied with a cotton thread (Garcelon 1985; Thaxter et al. 2014; García et al. 2021). During the tagging process, the individuals were weighed and ringed, and a blood sample was taken for sex determination by DNA (Ellegren 1996). The average body weight of the nestlings was 886.6 ± 70.9 g (mean ± *SD*; range = 720–1045 g). The transmitter's weight was between 2% and 3% of the bird's body weight, which is within the recommended range (< 5%; Kenward 2001). Birds were returned to the nest within < 30 min after capture.

We used the following transmitter models: 21–22 g SAKER GPS-GSM (Ecotone telemetry; n = 19), 25 g OrniTrack-E25 GPS-GSM and 30 g OrniTrack-30 GPS-GSM (Ornitela; n = 13 and n = 8, respectively), PTT-100 30g solar-powered Argos/GPS (Microwave Telemetry Inc.; n = 2), and 27 g Anitra GPS-GSM (Anitra; n = 1). Different positioning frequencies were programmed in the transmitter models. Ecotone tags obtained locations every 1–2 h. The Ornitela and Anitra models collected locations every 5–10 min. Microwave tags collected positions every 1–3 h. The transmitters started to record locations at sunrise and stop their activity at nightfall, frequently from 7:00 to 19:00, but they were adjusted depending on the hours of daylight in the different seasons.

Sampling

Complete data for the first dispersal year were available for 44 individuals (20 females, 15 males, and 9 individuals with undetermined sex), and for the second dispersal year were available for 21 individuals (13 females, 7 males, and 1 individual with undetermined sex).

We considered the first 2 years of dispersal for two reasons. On the one hand, it is the most common age to breed in this species. The red kite starts breeding at 2–4 years up to 7 years (Newton et al. 1989, Mougeot et al. 2011), although exceptional cases of successful breeding at 1 year have been reported (Evans et al. 1998). However, the most frequent age in the Spanish population for breeding is 2 years old (SEO/BirdLife own database). On the other hand, the dynamics of the individuals throughout the year (departure from natal nest—dispersal movements—return to natal nest; more details in the Results section) allowed the comparison between natural years. We only considered complete "years" of dispersal, that is, continuous data recorded from the departure from the nest until they return in the next year. These "years" of dispersal, based on own data (see Results section), could last from 7 to 14 months, due to variability in the departure and arrival dates. Therefore, the dispersal years lasted from summer to summer, from departure from the nest until the return to it. Individuals dead before the first arrival to the nest, or with serious transmitter failures, were discarded.

Spatial parameters and statistical analysis

We calculated the mean and maximum distance to nest, the daily traveled distances, and the hourly traveled distance. The maximum distance was calculated as the difference between the nest and the farthest point reached by the individual during the year, following a straight-line distance. The daily distance was calculated by selecting the last location of each day, the closest as possible to midnight to assure a stable point during the resting of the individual (Limiñana et al. 2012). The hourly traveled distance was obtained by dividing the distance between two locations, previously filtered at 1-h frequency, to homogenize the data provided by the different transmitters (García-Macía et al. 2021). We did not include locations close to the nest; therefore, parameters were calculated after departure from the nest, both in the first and second years of dispersal. To study the differences in dispersal movements within the same individual, Mann–Whitney–Wilcoxon tests (MWW; data followed by a non-normal distribution) were

performed (Vidal-Mateo 2019). We compared the first and the second years of dispersal for each individual separately, using the mean distances to the nest, the daily traveled distances, and the hourly traveled distances. We summarized the results by providing percentages of individuals that decreased, increased, or kept these values constant. We also performed a repeatability test, that is, the intraclass correlation coefficient of the variable "year", using the LMM method with the *rptR* package (Stoffel et al. 2017). Repeatability is the proportion of the variation between measurements that is due to consistent differences between the measures (Harper 1994).

We analyzed the differences in dispersal movements in relation to sex. We used the mean distances to the nest, the daily traveled distances, and the hourly traveled distances as response variables in three different linear mixed models (LMM). "Sex" was included as a fixed factor in all models. In addition, "individual" identity and "period" were included as random effects. Data from the Balearic Islands individual was excluded from LMM analyses, due to the geographic limitations of islands for dispersal, where they are expected to travel lower distances than in the Iberian Peninsula (Panuccio 2011).

The establishment of the first breeding area was considered when individuals ended their dispersal movements, settling during the breeding season of the second year and remained in the same area for, at least, the whole summer. No ground truthing of the breeding events took place; therefore, we presumed they were settled to breed. Not all individuals ended their dispersal movements after the second year; therefore, those were not considered in these analyses. We also did not consider individuals that died or had transmitter failures during the summer of the second year. Therefore, only individuals with complete data for the 2 years were considered, that is, those that reached at least the month of July of their second year, as breeding comprises March to July (Vidal-Mateo 2019).

Temporary settlement areas (TSAs) of the individuals were determined and analyzed. Earlier studies used different criteria to define TSAs (Balbotin and Ferrer 2009; Nemček et al. 2016; Vidal-Mateo 2019). However, based on our data, we considered TSA as a zone where one or more juveniles settled for a period longer than 30 days and traveled < 10 km per day. TSA for different periods and/or individuals whose mean locations were separated by < 15 km were considered as the same TSA. We estimated the home range area for each TSA with the 95%, 75%, and 50% kernel density estimation (KDE) (Worton 1989), excluding a few individuals with gaps and transmitter failures during the settlement period.

All statistical analyses were performed using R software version 4.0.3 (R Core Team 2020), and the significance level was established at $P < 0.05$. The QGIS software version 3.12 was used to visualize the positioning and routes followed by the individuals, the TSA locations, as well as for the creation of maps. Values were expressed as mean ± standard deviation (*SD*).

Results

Differences between the first and second years of dispersal

Red kites in our study moved across the entire Iberian Peninsula, in all directions, without a clear pattern due to their wandering movements and geographic variability of their nests (Supplementary Figure IA). They abandoned the nest after their first summer as chicks. Then, they performed wandering movements, usually combined with establishments in TSAs. Finally, they returned to the parental breeding area the next summer. If individuals lived for more than a year, they repeated these dynamics during the second one, until they established in their first breeding area in their third summer. Four individuals continued their dispersal during the third year, but they died after a few months; therefore, we considered this information was incomplete, and we excluded them from the analyses. Not a single individual left the Iberian Peninsula during its dispersal period.

The dispersal for all juveniles started between 26 May and 26 July, with an average date of 7 July, showing a high variability. The duration of the dispersal periods (departure from the natal nest and later return to it) was 314 ± 63 days (mean ± *SD*), from a minimum of 210 days (7 months) up to 403 days (13 months). There was high individual variability during the dispersal period regarding mean distance to nest, traveled distances, and maximum distance reached. The first year of dispersal (n = 43) had higher and more variable values of these parameters than the second one (n = 21; Figure 1), but there was an overlap between the values of one and another year.

However, we found differences in pairwise comparisons between the first and second dispersal years of each individual, showing a decreasing trend of the mentioned variables (Table 1, Figure 2). Eighty percent of individuals reached a shorter maximum distance during the second year, 70% decreased their mean distance to nest, 65% decreased their hourly traveled distances, and 50% decreased their daily traveled distances. The remaining individuals either kept constant or increased these variables (Supplementary Figure IIA). The repeatability values (intra-class correlation coefficients for the variable "individual") varied between the different variables: mean distance to nest (r = 0.744 ± 0.110), maximum distance to nest (r = 0.570 ± 0.19), hourly traveled distance (r = 0.596 ± 0.142), and daily traveled distance (r = 0.176 ± 0.165).

On the other hand, there were no significant differences between males and females (n = 57) for any variable (Supplementary Figure IIB): mean distance to the nest (df = 45.42; P = 0.199), maximum distance to the nest (df = 42.77; P = 0.120), daily traveled distance (df = 34.44; P = 0.464) and hourly traveled distance (df = 47.60; P = 0.394).

First breeding area

Coinciding with the breeding season of their second year, 9 individuals (n =13 with complete data until that date) settled with breeding expectations at 29.1 ± 29.8 km from their natal nests (range = 5–91 km; Table 2). Four individuals settled at < 10 km from their natal nest, 3 individuals at 25–30 km, and 2 individuals at >60 km. The 4 remaining individuals continued their dispersal across the territory and did not settle.

Temporary settlement areas (TSA)

We identified 76 TSAs (Supplementary Table IIIA, Figure 3). Forty-one individuals (95 %) established at least 1 TSA during their dispersal (according to our definition criteria). Individuals settled in 1.85 ± 1.04 different TSAs (range = 1–6) considering their complete dispersal period (until end of data, death, or end of dispersal). The duration of settlement in each TSA was 75 ± 40 days (up to 182 days;

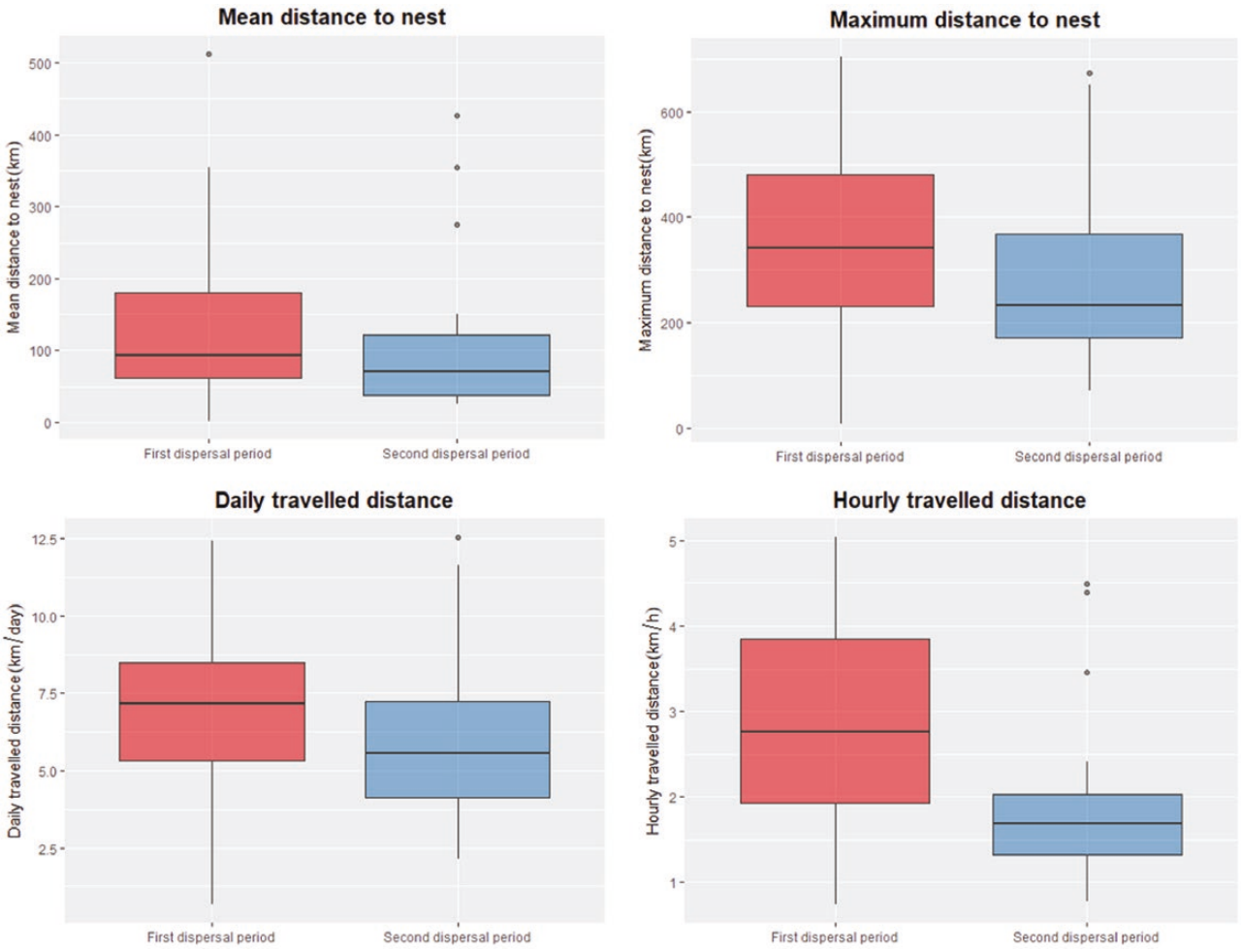

Figure 1. Comparison between first and second dispersal periods according to the mean distance to nest (km), maximum distance to nest (km), daily traveled distance (km/day) and hourly traveled distance (km/h).

Supplementary Table A1; Figure 6). The TSAs were located at 182 ± 168 km from the nest, with high variability between individuals. The closest TSA was at 13 km from the nest, and the farthest was at 653 km (Supplementary Figure IA). Nevertheless, the highest proportion of TSAs was located at < 100 km from the nest (Figure 5). The TSA surface presented high variability (Figure 6, Supplementary Table IIIB): 95% KDE estimated 781.0 ± 1895.0 km^2 (range = 7.4–14244.6), 75% KDE estimated 241.9 ± 462.8 km^2 (range = 1.1–3189.9), and 50% KDE estimated 93.7 ± 180.8 km^2 (range = 0.1–1214.9).

Many juveniles coincided spatially during their settlement. We found 10 common TSAs (Figure 4), where between 2 and 4 individuals settled. Fifty-four percent of the individuals in our study settled in one of these common areas at least once during their dispersal. They were distributed in the provinces of Madrid, Toledo, Badajoz, and Córdoba. There were five TSAs located on the outskirts of the city of Madrid, close to urban areas, with landscapes of plains with tree patches and clearings. Two of these points were found near landfills and dumps. In Toledo, the two areas were surrounded by wide areas of fields and dispersed tree crops. In Badajoz, one TSA was 2 km from an urban area with dispersed trees and frequent crops, while the second TSA was more isolated, in a landscape with frequent forest patches and a few tree crops. The TSA of Córdoba was in a landscape with clearings and groves, close to a residue treatment plant.

Discussion

Here, we studied the dispersal period of juvenile Spanish red kites with a large sample size. We found differences in their behavior between the first and second years of dispersal, and identified their TSAs, which could be one of the keys to the conservation of this raptor.

Despite the high individual variability, expected due to the wandering and exploratory nature of these movements (Carter 2007; Newton 2010), variables describing the dispersal movements of juveniles showed a decreasing trend during the second dispersal year, which was characterized by shorter journeys and smaller distances to the nest than the first year. On the other hand, the repeatability values showed that birds with long dispersal distances and hourly traveled distances in the first year also showed similar trends relative to other individuals in the second year. Therefore, this could indicate that red kites often explore similar territories during their second year, but they do it in a more efficient manner. In the first year, the red kites performed far and long-lasting journeys, reaching higher distances from the nest to scout the potential areas of interest, including TSAs.

Table 1. Distance from the nest, daily distance, hourly traveled distance, and maximum distance of the 2 years of the dispersal of all individuals. Mann-Whitney-Wilcoxon test *p*-values are also shown

Name Id	Distance from the nest		Daily traveled distance		Hourly traveled distance		Maximum distance to the nest
	Mean (km)	M-W *P* value	Mean (km/day)	M-W *P* value	Mean (km/h)	M-W *P* value	Value (km)
Millau	354.85	<0.0001	7.33	<0.0001	2.69	<0.0001	641.15
	121.93		12.54		4.40		551.85
Espinosa	58.46	<0.0001	4.90	0.4286	1.87	<0.0001	241.40
	71.23		4.12		0.78		97.67
Caballero	68.07	<0.0001	7.46	0.8166	2.31	<0.0001	228.08
	57.77		7.22		1.93		171.43
Baleares01	9.99	<0.0001	1.11	0.0125	1.32	<0.0001	35.37
	12.82		1.62		2.43		42.49
Azpeitia	512.10	<0.0001	10.20	0.149	2.50	<0.0001	703.57
	426.90		10.20		2.03		673.25
Azcoitia	112.91	<0.0001	8.10	<0.0001	2.05	0.0001	384.80
	29.95		2.76		1.29		208.17
Quintana	42.31	<0.0001	3.30	0.556	1.62	<0.0001	163.12
	275.44		11.65		1.83		530.54
Oncala	322.09	0.0054	9.15	0.697	1.95	0.0150	681.38
	354.62		9.96		1.69		651.11
Menasalbas	89.65	<0.0001	7.63	<0.0001	1.92	<0.0001	266.41
	77.66		3.22		1.07		161.35
Zarzalejo	69.89	<0.0001	6.70	<0.0001	3.50	0.0038	283.80
	37.86		10.31		4.49		243.05
Sala	62.07	<0.0001	8.11	0.0037	3.69	0.0077	375.77
	31.53		3.44		3.46		82.92
Victoria	71.57	<0.0001	9.70	0.0183	2.16	<0.0001	306.53
	45.71		5.28		1.91		71.50
Cerceda	114.73	<0.0001	8.46	<0.0001	2.92	<0.0001	336.97
	54.11		3.81		1.71		265.22
Abantos	42.31	<0.0001	7.51	0.1624	2.39	<0.0001	346.31
	72.66		4.17		1.33		232.51
Jarosa	179.66	<0.0001	10.70	0.0071	2.70	<0.0001	524.06
	149.59		4.30		1.21		254.14
Branch	119.47	<0.0001	6.55	0.0008	1.82	0.6636	508.72
	41.90		5.54		1.67		196.11
Tronco	73.21	<0.0001	8.69	0.0296	2.66	<0.0001	244.26
	24.90		5.45		2.15		218.55
Yelmo	274.35	<0.0001	12.43	<0.0001	1.93	0.0663	434.81
	133.32		5.86		1.55		377.51
Angus	32.05	0.7208	4.35	0.0192	1.67	<0.0001	137.20
	31.08		5.95		2.40		212.23
Gerónimo	142.98	<0.0001	10.41	0.9018	2.02	0.06353	352.11
	87.84		5.92		1.64		367.67
Collado	72.81	0.1663	8.61	0.0011	1.69	<0.0001	268.87
	98.32		5.98		1.60		269.54

During the second year, juveniles had a better knowledge of the territory, including the areas with the best conditions for settlement. Thus, individuals reduced the energetic cost of their trips and flew directly to the best areas discovered in the previous year. Other studies on juvenile dispersal of raptors showed the same trend. In the case of the Spanish imperial eagle *Aquila adalberti*, the exploratory flights decreased after the 4th month of dispersal, due to acquired knowledge of the dispersal area (Ferrer 1993). Furthermore, the immature raptors, including the red kite, take more time and travel longer distances during migration than adults (Mellone et al. 2013; Sergio et al. 2014; García-Macía et al. 2021), also indicating that raptors improve their movements as they reach adulthood.

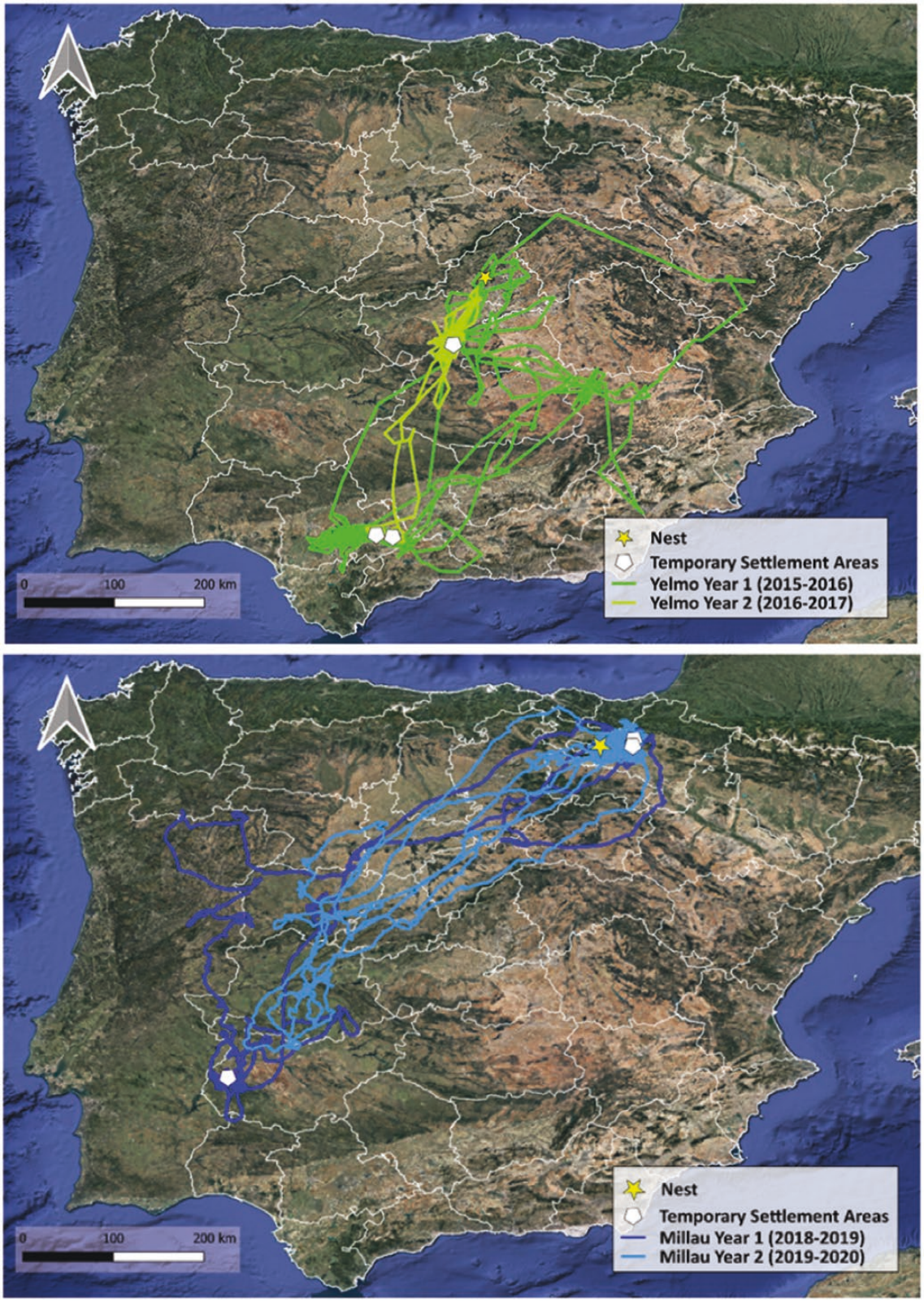

Figure 2. Example of two individuals' tracks (Yelmo and Millau) which reduced their dispersal movements between the first and second years of dispersal. TSAs areas are represented by a white pentagon, while natal nest is represented by a yellow star.

Juvenile dispersal of the Spanish red kites was not influenced by sex, which is supported by earlier studies on this species and other raptors (Newton et al. 1989, Walls and Kenward 1995; Real and Mañosa 2001; Balbontín and Ferrer 2009). However, Literák et al. (2022) demonstrated that female red kites from Central European populations traveled higher distances than males, including both migratory and dispersal movements, which was already pointed out by some

Table 2. Location of the breeding areas for the individuals that settled to breed at the end of the second year. The relative distance to their natal nest is presented, with the duration of the settlement periods

Name Id	Province of natal nest	Period of settlement in the new breeding area	NO Days	Distance from natal nest (km)
Azcoitia	Guipúzcoa	16/01/2019–26/07/2019	190	6
Menasalbas	Toledo	06/03/2019–03/07/2019	119	60
Cerceda	Madrid	04/03/2020–08/07/2020	125	2
Abantos	Madrid	17/02/2019–31/07/2019	164	31
Jarosa	Madrid	21/02/2019–10/07/2019	139	26
Branch	Madrid	19/01/2018–31/07/2018	193	33
Yelmo	Madrid	05/03/2017–24/07/2017	141	91
Gerónimo	Madrid	30/01/2017–31/07/2017	182	5
Collado	Madrid	09/03/2014–24/07/2014	137	8

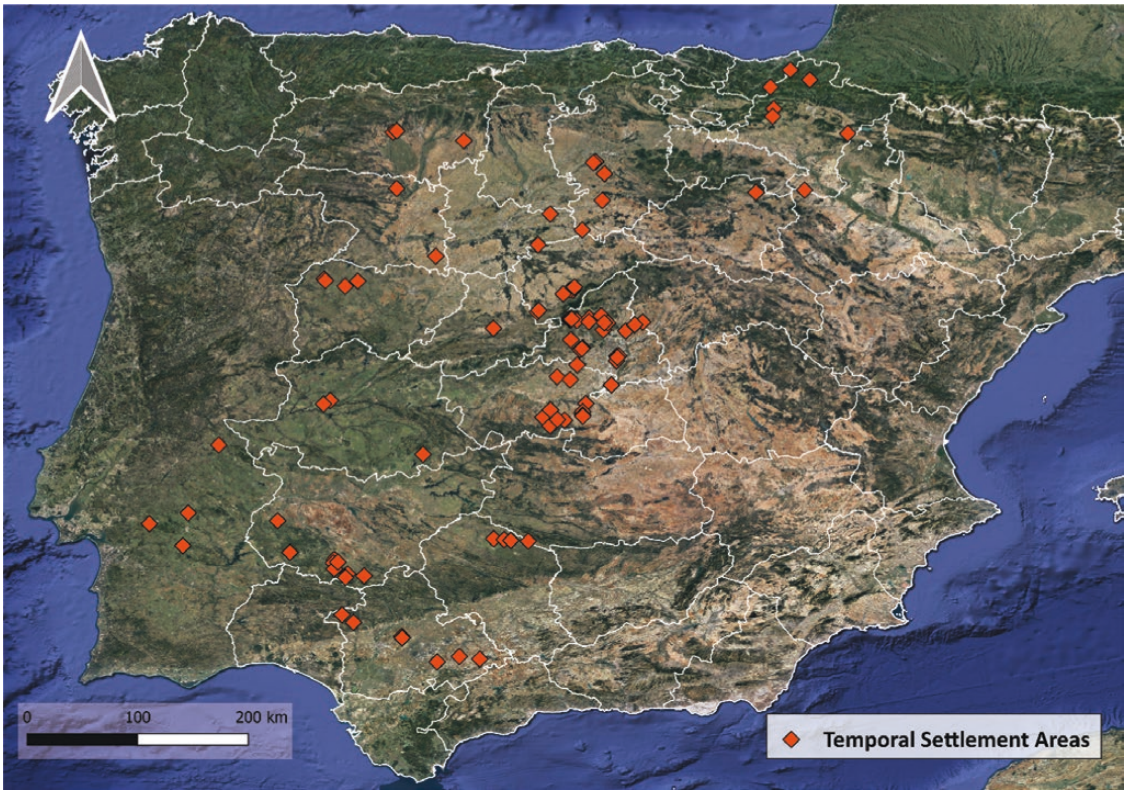

Figure 3. Locations of all the TSAs where tagged red kites settled during their juvenile dispersal.

studies on other raptors (Forsman et al. 2002; Whitfield et al. 2009; Millsap et al. 2014). These differences in movement lengths may not be appreciable in the Spanish breeding population due to the geographical limits of the Iberian Peninsula. These individuals do not migrate long distances, as Central European red kites do, and do not leave the Iberian Peninsula during their dispersal, so both males and females can only reach small distances.

We identified a philopatric tendency in the juvenile red kites. Most of the juveniles settled with breeding expectations after their second year of dispersal near their natal nests. This philopatric behavior has been found in the red kite and other raptors (Bustamante 1993; Ferrer 1993; Newton et al. 1994; Negro et al. 1997; Literák et al. 2022), and could have negative consequences in terms of population recovery and expansion of their distribution area. Short dispersal when establishing the first nest hinders the colonization of new or abandoned breeding areas, impeding the expansion of the species (Heuck et al. 2013). However, our results may not be conclusive about this issue, because we did not confirm breeding by field monitoring and did not have breeding performance data. Therefore, some further studies about the philopatric behavior in the Spanish red kites should be made, including specific data on the first breeding of juveniles.

The establishment of TSAs is fundamental to understand the juvenile dispersal of red kites, as well as the main threats they face, and the possible conservation measures. Our results showed that juvenile red kites stopped during their dispersive phase in TSAs, where they spent at least 1 month. These TSAs have already been described in previous literature, in which the time and space criteria differ depending on the authors (Ferrer 1993; Prommer and Bagyura 2007; Nemček et al. 2016;

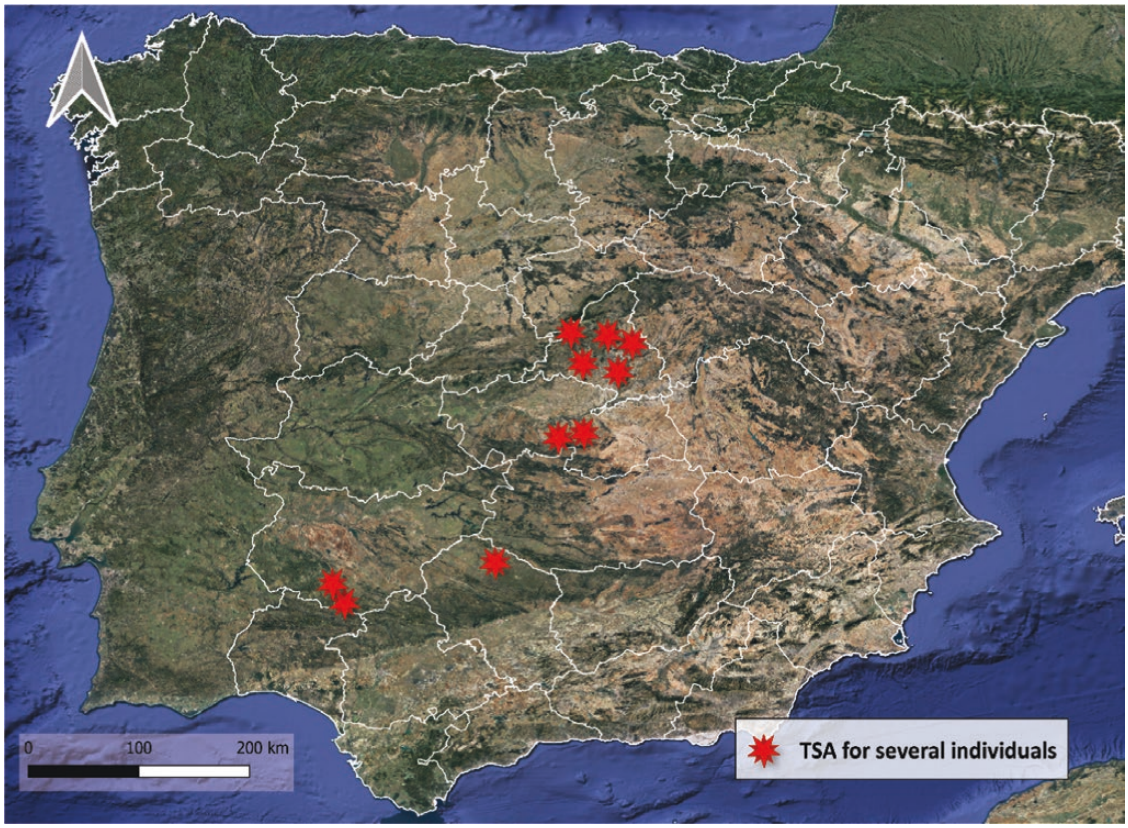

Figure 4. Distribution of the TSAs shared by more than one individual.

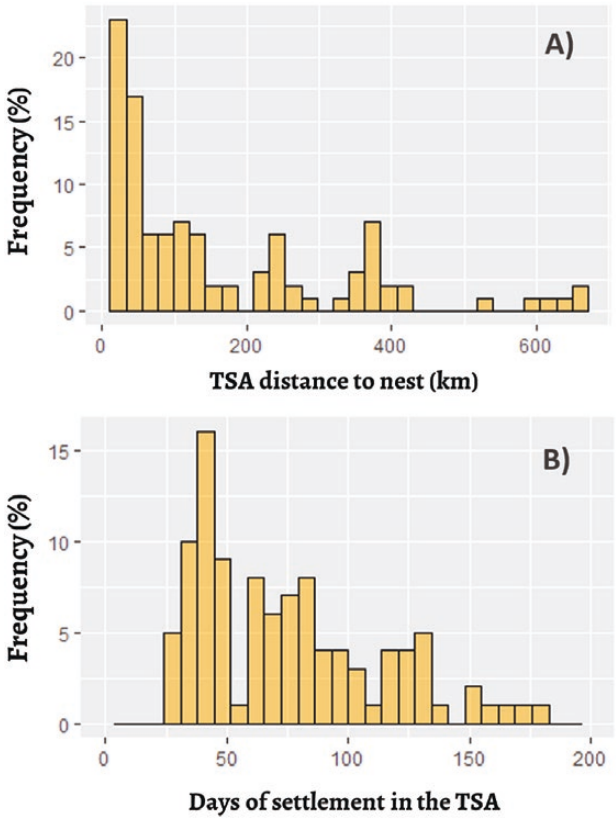

Figure 5 Histograms of the mean distances from the nest (A), and duration settlement (B) of TSAs identified for the juvenile red kites.

Vidal-Mateo 2019). Not all the TSAs of the Iberian Peninsula can be established based on our individuals, but a large sample size in our study allows us to draw some relevant conclusions. The common factor of the shared TSA described in this study is a landscape formed by open spaces with pastures and disperse tree patches, which offer the best conditions for prey detectability and roosting places (Ontiveros et al. 2005). Also, all the TSAs were located in the surroundings of urban nuclei, at distances lower than 5 km, which has been lately reported because of low food availability in their traditional settlement areas in countryside agricultural areas (McIntyre et al. 2009; Nicolai et al. 2017).

Landfills and similar facilities were also located near TSAs. Three of the 10 TSAs shared by several individuals were placed near landfills and residue treatment plants (<10 km). These landfills offer a regular food supply, which facilitates the settlement of juvenile individuals. Thus, the concentration of carrion and organic residues is attractive to both red kites and other animals such as rodents. Similarly occurs with a fourth TSA, which instead of a landfill, is located near a cattle facility, which also acts as a food source and a juveniles' area of interest for settlement. Poisoning by pollutants in the red kite has been widely studied, is considered one of the biggest threats to the conservation of this species (Viñuela et al. 2021). Many studies demonstrated intoxication after feeding on middens (Viñuela 1999; Monclús et al. 2018). However, there are not many reports of poisoning near landfills, except for one individual found in Spain (Herrero-Villar et al. 2021). However, our results suggest that landfills may be a risk factor for the conservation of this species, so further specific studies are necessary to examine this issue.

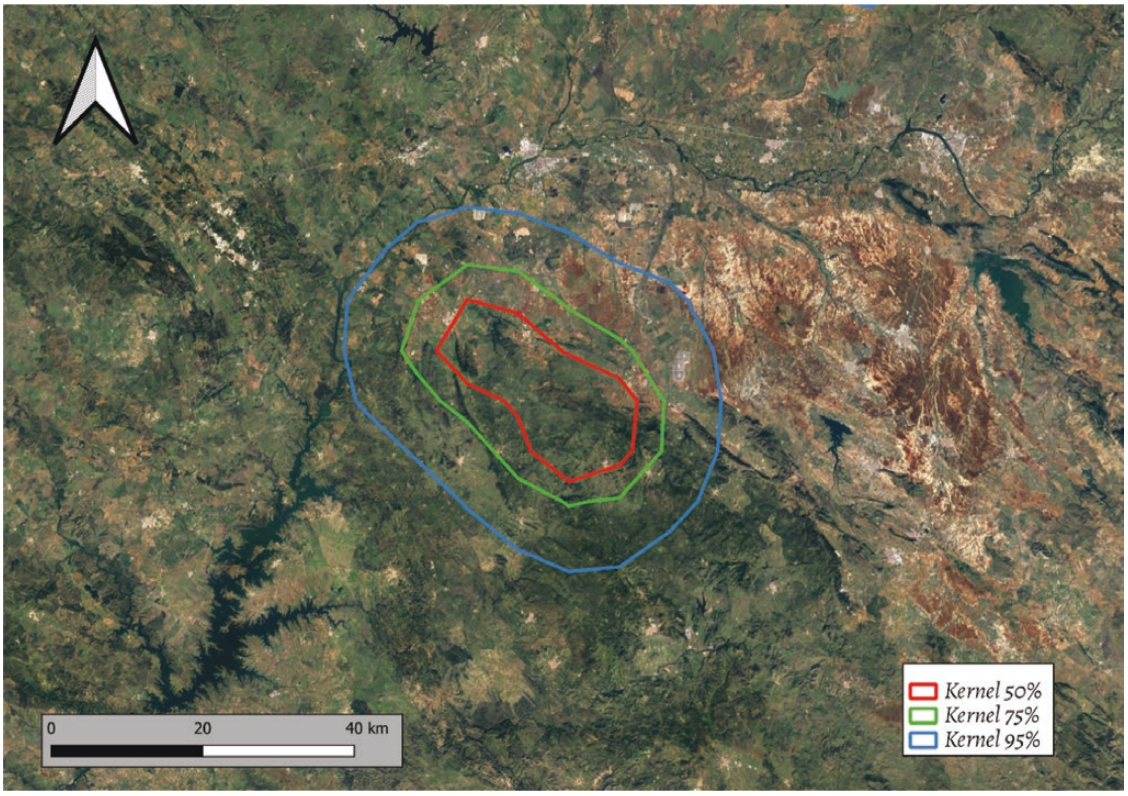

Figure 6. Kernel Density Estimators (95%, 75% and 50%) for a TSA of Millau in the province of Badajoz during its first year of dispersal. This area is representative because forest, agricultural, urban, river, and montane patches are found inside the home range of this red kite.

Acknowledgements

Information about tagged red kites has been obtained within the 'Migra' program developed by SEO/BirdLife, with the collaboration of Fundación Iberdrola España, the Conservation of Red Kite in Central Spain program developed by GREFA with the collaboration of MITERD, and the "Centinelas para el Veneno" project developed by GREFA and WWF Spain within the LIFE SWIPE project. We are grateful to all volunteers that helped during all the fieldwork. Specially, we want to thank for their help to: Alberto Díez, Ángela García, Arturo Rodríguez, Consuelo Temiño, Enrique Gómez, Ernesto Madejón, Francisco Jiménez, Javier Higuera, Joaquín Sanz-Zuasti, José Francisco Pedreño, José Manuel Meneses, Juan Pablo Castaño, María Ángeles Osorio, Mariano Rodríguez, Marta Olalde, Miguel Rico, Mikel Olano, Nicolás González, and Roberto Carbonell, Toni Muñoz, Juan Martínez, Juan José Iglesias, Juan Pablo Díaz, Laura Suárez, Irene López, and Virginia Moraleda. The tagging of the birds was developed thanks to the collaboration and/or funding of: Fundación Iberdrola España, Fundación Patrimonio Natural de Castilla y León, EDP Renováveis, LIFE Eurokite, Hontza, Diputación Foral de Araba, Grup Balear d'Ornitologia, Conselleria de Medi Ambient I Territori del Govern de les Illes Balears, Endesa, TB Raab, and Artesa, MITERD, and LIFE SWIPE. We are thankful to Junta de Castilla y León, Comunidad de Madrid, Diputación Foral de Araba, Diputación Foral de Gipuzkoa, Govern de les Illes Balears, and Junta de Castilla-La Mancha for giving all the necessary permissions. Special thanks to Víctor García Matarranz, from MITERD, for the support in tagging birds for GREFA, and all the Rangers who collaborated in the tagging. This paper is part of Jorge García-Macía's PhD thesis.

Supplementary Material

Supplementary material can be found at https://academic.oup.com/cz.

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