birds

MDPI

Article

Movements of Juvenile Hen Harriers (*Circus cyaneus*) Tracked by Satellite Telemetry in Spain

Sara Morollón [1,*], Simon Lee [2,3] and Vicente Urios [1]

[1] Grupo de Investigación Zoología de Vertebrados, Universidad de Alicante, Apdo. 99, 03080 Alicante, Spain; vicenteurios@yahoo.es
[2] Centre for Ecology and Conservation, University of Exeter, Penryn, Cornwall TR10 9FE, UK; sl768@exeter.ac.uk
[3] Natural England, Exeter EX1 1QA, UK
* Correspondence: sara.morollon@ua.es

Simple Summary: This study examined the juvenile dispersal behaviour of seven Hen Harriers tracked with GPS/GSM transmitters. We analyse movement patterns, differences between sexes, and changes between the first and second years of dispersal. The results highlight that dispersal in the first year is more extensive and variable, whereas in the second year, the movements become more efficient, reflecting a progressive adaptation to the environment.

Abstract: The Hen Harrier (*Circus cyaneus*) is a medium-sized raptor with a broad distribution across the Palearctic. In Spain, Hen Harrier behaviour is diverse due to being at the southern limit of its distribution, and the margins of distributions tend to show greater variability in the strategies and behaviours of animals. This study focused on juvenile dispersal, using GPS/GSM data from seven individuals to define movement patterns, compare variables between sexes, and analyse differences between the first and second years of dispersal. To analyse the movements during each annual period, six variables were considered, namely the mean distance from nest location, maximum distance from nest location, mean daily distance travelled, total distance travelled, 95% weekly kernel, and 95% total kernel. In their first year after leaving the nest, the Hen Harriers began dispersal movements on 21 August ± 34.41 days, with highly variable distances and durations among individuals. They travelled an average total of 6774.66 ± 5360.46 km over the two first years, with some significant differences between sexes and periods in terms of movement patterns, particularly in the daily and total distances travelled. Overall, the maximum distance from nest location and the total distance travelled were greater in the first year of dispersal than in the second year, indicating, as expected, an improved understanding of their environment and more efficient movements. The juvenile dispersal behaviour of the Hen Harrier is highly variable and represents the most vulnerable season for survival as the birds navigate new and unexplored territories.

Keywords: distance; ethology; hen harrier; kernel; GPS/GSM; raptor; Spain; transmitters

check for updates

Citation: Morollón, S.; Lee, S.; Urios, V. Movements of Juvenile Hen Harriers (*Circus cyaneus*) Tracked by Satellite Telemetry in Spain. *Birds* **2024**, *5*, 832–844. https://doi.org/10.3390/birds5040055

Academic Editor: Guillermo Blanco

Received: 30 October 2024
Revised: 27 November 2024
Accepted: 4 December 2024
Published: 10 December 2024

Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

The Hen Harrier (*Circus cyaneus*) is a medium-sized raptor with a wide distribution throughout the Palearctic [1]. The breeding habitat preferences of the Hen Harrier differ according to the area under study. While in Northern Europe, the Hen Harrier typically breeds in semi-natural upland areas, even in forest plantation gaps [2,3]. In Mediterranean areas, it breeds in pseudo-steppe landscapes, predominantly those with cereal crops [4]. Concerning post-reproductive strategies, in northern areas, Hen Harriers are fully migratory and typically undertake long-distance migrations [1,5]. In contrast, Central and Southern European areas have partial or short-distance migrants, with individuals moving from Northern Europe to Southern Europe, such as the Iberian Peninsula [6,7]. Spain represents

the southernmost area of the distribution and is an area where the behaviour of this species differs from the rest [4,6], as the margins of distributions tend to show greater variability in the strategies and behaviours of the animals [8,9]. The population exhibits a range of strategies, from being sedentary to carrying out long-distance migrations (more than 400 km [10]) across the Strait of Gibraltar to Morocco [11].

The species ecology is well-documented, particularly in Northern European areas (Ireland and the United Kingdom). Extensive studies have been conducted on its reproduction [3,12–16], population dynamics [17–19], feeding habits [20,21], and conservation [22–24]. In recent years, we have published some information about the spatial movement of Hen Harrier focused on migration in Mediterranean areas [11].

To ensure the long-term conservation of a species, it is essential to have a comprehensive understanding of its various life stages and the areas it occupies. In raptors, the juvenile dispersal stage and migration are of significant importance for the species' survival, as it is the stage with the highest mortality [25–27]. This mortality is largely due to the lack of knowledge and inexperience of the young in the face of different challenges, such as finding resources or escaping from dangers. Studying the juvenile dispersal of the Hen Harrier in Spain, the southern limit of its distribution, is an interesting objective, given that this is an area where this species displays a diverse range of behaviours.

In this study, we have used satellite data from seven Hen Harrier juvenile individuals to analyse the dispersal pattern behaviours of this species. The goals of this work were (1) to define the dispersal movements of juvenile Hen Harriers using the travelled distances and distribution areas in the first two years; (2) to compare and describe these variables between sexes; and (3) to compare and describe the movements in the first and the second year of juvenile dispersion.

2. Materials and Methods

2.1. Tagging and Tracking

The movements of seven Hen Harrier juvenile individuals (four males and three females) were monitored with GPS/GSM transmitters from 2019 to 2023. The individuals were captured mainly from Central and Northern Spain in different provinces, namely Alava (2), Segovia (2), Toledo (1), and Valladolid (2). These seven individuals provided us with data for 12 annual periods, with six individuals (two females and four males) in the first annual period and six individuals (three females and three males) in the second annual period (Table 1). We analysed the initial two years of dispersal, as this is the age when Hen Harriers typically first breed [6]. While instances of successful breeding at one year have been noted (about 30% of breeding birds [6]), the predominant breeding age within the Spanish population is at two years old (SEO/BirdLife, own data). Additionally, observing the movements of individuals throughout the year, including departure from the natal nest, dispersal movements, and return to the natal nest, facilitated comparisons across annual periods.

The two-year study period started from the point of tagging. Although in one case (ID: 5690B91E), an individual was tagged as a sub-adult, we only used data in the second annual period.

The juvenile Hen Harriers were taken from nests monitored as part of a conservation programme. During the marking process, individuals were ringed and morphometric measurements, such as wingspan, weight and tarsus length, were taken. Sexing was based on the clear sexual colour dimorphism of the species [5]. Individuals were fitted with satellite tracking transmitters (9 g Milsar GSM Tag-U9 and 10 g–12 g Ornitela OrniTrack-10/E10 3G GPS/GSM) that were back-mounted using thoracic Teflon harnesses. The devices were set to collect locations every 15–30 min, depending on battery voltage, season, and time of day. Data packages were transmitted via the digital cellular network. Then, the data were filtered within a 30 min period to standardise the sample.

Table 1. Metadata from the seven juvenile Hen Harriers. The variables Dnest, DD, and WK95 are shown with ± standard deviation. Dmax, TD and TK95 are unique values. Start: initial day of annual period. Finish: last day of annual period. Xnest: longitude of the nest location; Ynest: latitude of the nest location. Locs: number of tracking locations to calculate Dnest and Dmax. Dnest: mean distance to the nest. Dmax: maximum distance to the nest. Days: number of tracking days to calculate DD and TD. DD: daily distance travelled. TD: total distance travelled. Week: number of tracking weeks to calculate WK95. WK95: 95% weekly kernel. TK95: 95% total kernel. First: first year. Second: second year.

ID	Period	Sex	Province	Year	Start	Finish	Xnest	Ynest	Locs	Dnest	Dmax	Days	DD	TD	Week	WK95	TK95
200428	First	Male	Toledo	2020/21	15 July 2020	15 July 2021	359,477.9	4,553,009.8	17,594	4.28 ± 13.97	147.17	361	22.92 ± 24.19	8227.04	52	380.86 ± 1957.41	194.80
200436b	First	Female	Segovia	2021/22	16 July 2021	16 July 2022	363,900.3	4,564,704.0	18,482	27.69 ± 17.49	133.86	360	53.06 ± 66.92	18,993.72	52	504.43 ± 2064.86	922.06
	Second			2022/23	17 July 2022	11 January 2023	363,900.3	4,564,704.0	5469	16.27 ± 10.93	82.37	135	18.8 ± 33.28	2538.44	20	163.5 ± 341.94	376.40
200444	First	Male	Valladolid	2020/21	3 June 2020	3 June 2021	331,084.2	4,562,454.8	12,439	30.56 ± 45.18	188.36	351	10.64 ± 13.21	3724.82	52	762.53 ± 2842.92	3178.33
	Second			2021/22	4 June 2021	16 July 2021	331,084.2	4,562,454.8	2918	5.04 ± 1.52	8.06	43	47.2 ± 60.46	2029.44	7	18.56 ± 8.88	25.63
200446	First	Male	Segovia	2020/21	15 July 2020	15 July 2021	359,469.8	4,553,006.9	14,575	43.35 ± 25.01	136.11	359	38.2 ± 44.17	13,636.84	52	841.96 ± 1422.37	3301.94
	Second			2021/22	16 July 2021	16 July 2022	359,469.8	4,553,006.9	765	64.46 ± 6.07	80.02	26	21.29 ± 22.8	553.61	5	189.9 ± 143.34	437.22
200450	First	Female	Valladolid	2020/21	3 June 2020	3 June 2021	331,068.6	4,562,464.1	16,478	22.47 ± 40.04	356.73	351	28.82 ± 25.52	10,057.40	50	4903.66 ± 16,644.98	5335.75
	Second			2021/22	4 June 2021	4 June 2022	331,068.6	4,562,464.1	10,826	30.63 ± 33.09	145.61	265	20.59 ± 22.29	5414.28	44	1313.17 ± 3023.53	2559.36
5690B91E	Second	Female	Alava	2019/20	28 July 2019	28 July 2020	549,696.4	4,744,734.7	9328	29.11 ± 34.97	132.76	340	9.13 ± 14.1	3104.45	51	971.4 ± 2744.3	2070.38
5C90B91E	First	Male	Alava	2019/20	19 July 2019	19 July 2020	547,523.4	4,741,920.9	11,950	83.35 ± 40.59	130.87	364	14.63 ± 21.64	5310.04	54	647.25 ± 1651.49	1821.60
	Second			2020/21	20 July 2020	20 July 2021	547,523.4	4,741,920.9	12,832	54.08 ± 45.94	110.80	280	27.52 ± 21.32	7705.82	44	444.83 ± 1632.76	1989.07

2.2. Spatial Parameters

Based on previous studies on juvenile dispersal movements [28–31], six variables were considered to analyse the movements of each annual period, namely the mean Euclidean distance from nest location (Dnest); the maximum distance from nest location (Dmax), that is, the Euclidean distance of the farthest location from nest; the mean daily distance travelled (DD); the total distance travelled in each annual period (TD); the 95% weekly kernel (WK95); and the 95% total kernel in each annual period (TK95). The nest location was calculated with the first GPS fixes of each juvenile individual, giving the starting location to derive Dmax and Dnest. In the case of the second-year individual (ID: 5690B91E), we considered the tagging location as the "nest".

We also calculate the dates of the initial dispersal movements in the first year when the individual leaves the nest surroundings with dispersive behaviour. In this case, we excluded the second-year individual (ID: 5690B91E).

To calculate the variables, we used the following R packages with version 4.1.2: *adehabitatHR* [32] to obtain the 95% weekly kernels; *amt* [33] for the daily and total distances; and the base R package *stats* [34] to compute the distances from the nest locations.

2.3. Statistical Analysis

We computed five different linear mixed models (LMM) to check the differences between juveniles in each annual period and among the sexes. In all models, Sex (male or female) and Period (first or second annual period) were modelled as fixed effects, while ID was a random effect. The response variables were Dmax, Dnest, DD, TD, WK95 and TK95. We square-rooted Dmax and log-transformed WK95 to improve model fit, checking for normality with the Shapiro–Wilk test.

Statistical analyses were performed with R software version 4.2.1 [34], and the level of significance was set at $p < 0.05$. We have used the following R packages: LMMs were computed using the package *lme4* [35]. QGIS software version 3.22.6 [36] was used to visualise the dispersal movements, as well as for the creation of the maps.

We know that the sample size is small. However, the behaviour and movements of juvenile Hen Harriers have never before been described and compared so precisely.

2.4. Ethics Statement

Trapping and marking activities were conducted under permissions issued by regional authorities (Departamento de Industria, Transición Energética y Sostenibilidad, Gobierno Vasco; Consejería de Administración Autonómica, Medio Ambiente y Cambio Climático, Principado de Asturias; Consejería de Fomento, Ordenación del Territorio y Medio Ambiente, Gobierno de Cantabria; Consejería De Agricultura, Ganadería Y Medio Ambiente, Gobierno de La Rioja; Departamento de Desarrollo Rural y Medio Ambiente, Gobierno de Navarra (0001-0261-2020-000027); Departamento de Acción Climática, Alimentación y Agenda Rural, Generalitat de Cataluña; Consejería de Medio Ambiente Licencias de Caza y Pesca, Comunidad de Madrid; Consejeria de Fomento y Medio Ambiente, Junta de Castilla y León (AUES/CYL/28/2021); and Consejería de Agricultura, Ganadería y Desarrollo Rural, Gobierno de Castilla-La Mancha). All efforts were made to minimise the handling time to reduce the stress on the Hen Harriers. Following established guidelines, the weight of the backpacks was less than 3% of the body weight of each individual [37]. The handling time until the release of captured individuals was less than one hour to avoid stressing the animals. The capture of individuals was carried out by expert licenced ringers from the Spanish Ornithological Society (SEO/BirdLife), complying with the ethical standards for the capture and tagging of Hen Harriers.

3. Results

In the first year after leaving the nest, the Hen Harriers on average started dispersal movements on 21 August ± 34.41 days (range: 9 July–27 September), although the distances and duration of these movements were highly variable among individuals (Figures 1–5, Table 1).

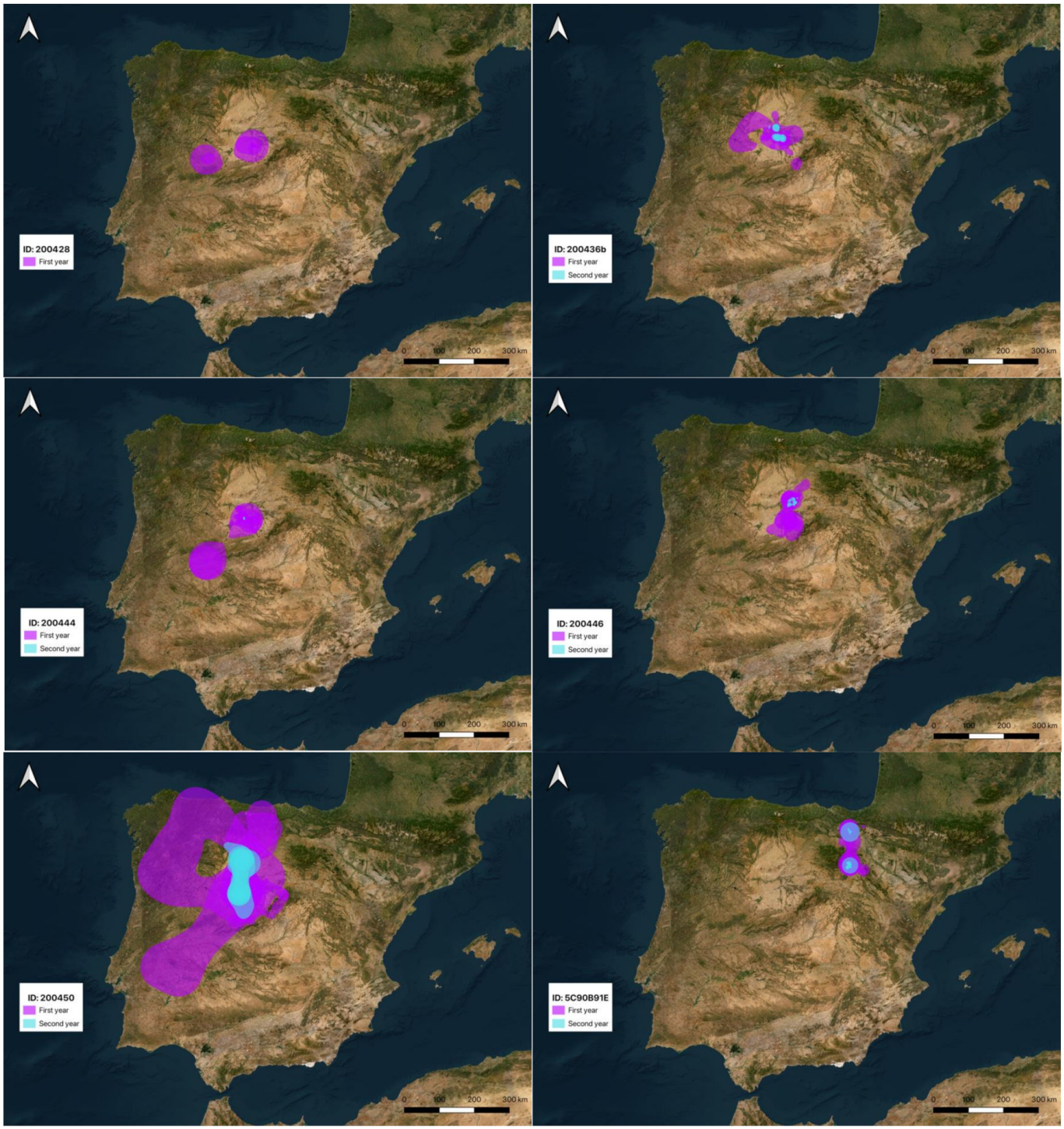


Figure 1. *Cont.*



Figure 1. The 95% weekly kernel of the 7 juvenile Hen Harriers during the first (purple) and second year (light blue).

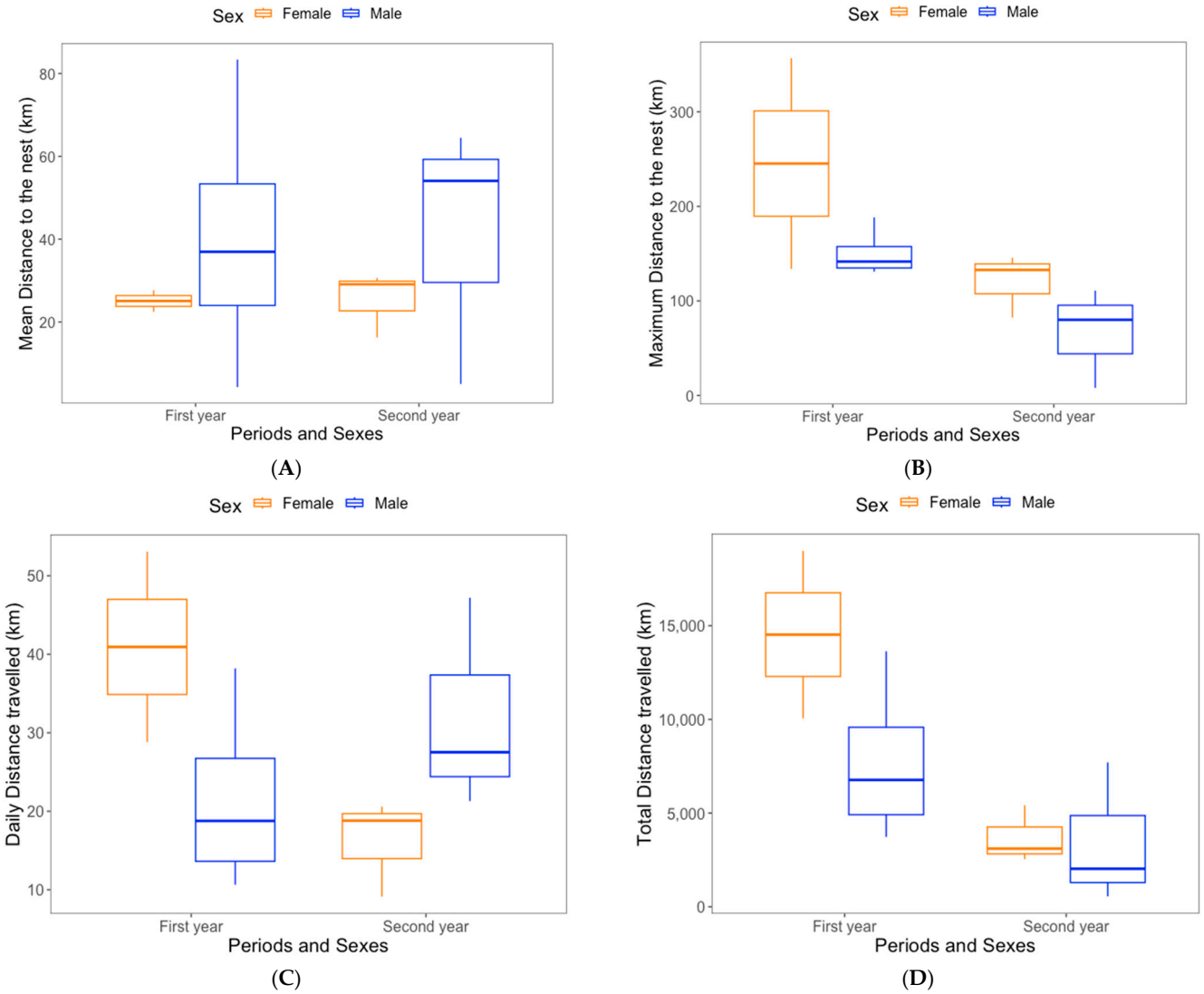


Figure 2. *Cont.*

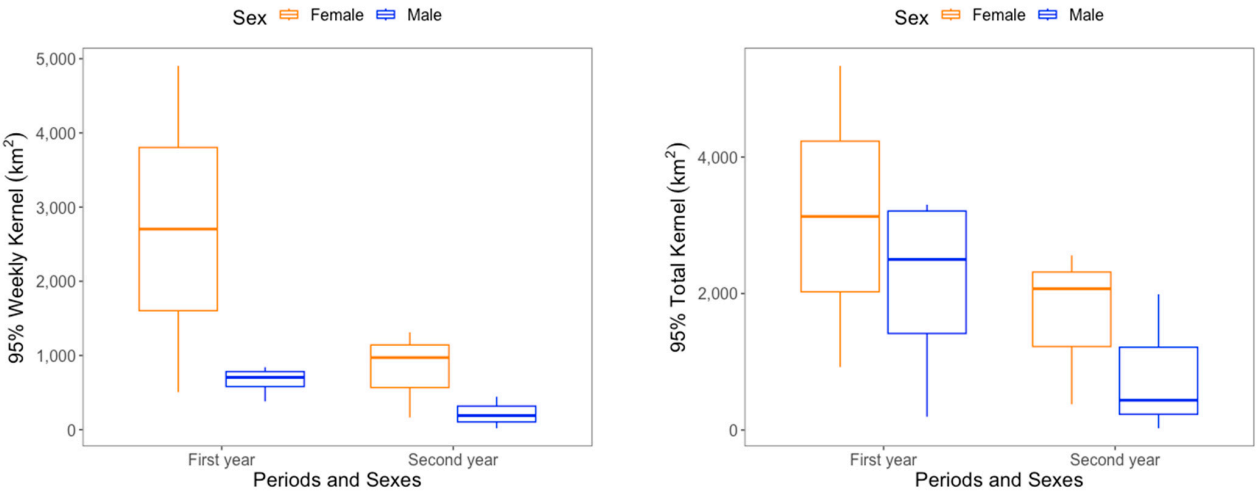


Figure 2. Boxplot between annual periods and sexes of (**A**) mean distance to the nest, (**B**) maximum distance to the nest, (**C**) daily distance travelled, (**D**) total distance travelled, (**E**) 95% weekly kernel, and (**F**) 95% total kernel (shorted from top left to bottom right).

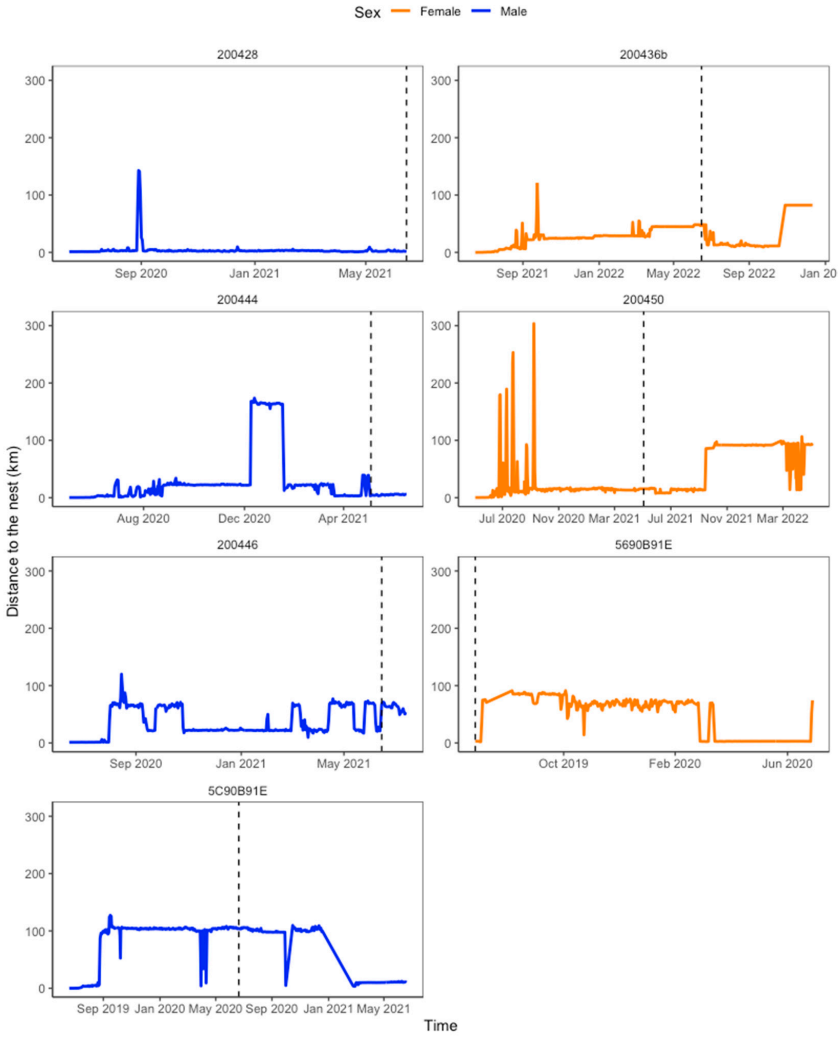


Figure 3. Mean distance to the nest of the seven juvenile Hen Harriers in their two first years of dispersal. Blue lines show male movements and orange lines show female movements. The vertical dashed line shows the starting point of the second annual period.

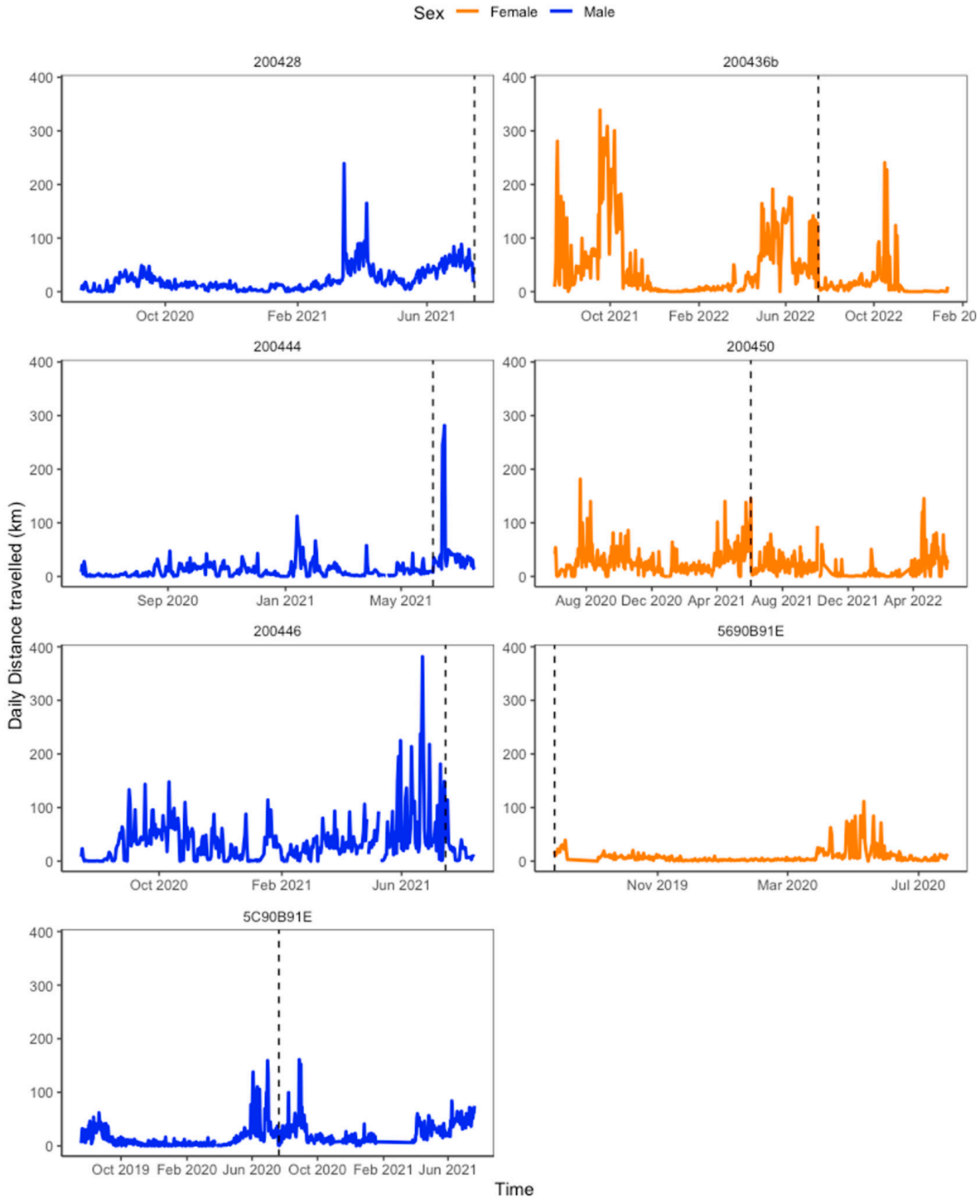


Figure 4. Daily distance travelled by the seven juvenile Hen Harriers in their two first years of dispersal. Blue lines show male movements and orange lines show female movements. The vertical dashed line shows the starting point of the second annual period.

Juvenile Hen Harriers moved, on average, a total of 6774.66 ± 5360.46 km (range: 553.61–18,993.72 km) during their first two years. From the nest location (Dnest), they moved an average per day of 34.27 ± 23.57 km (range: 4.28–83.35 km). The maximum distance (Dmax) from the nest was 137.73 ± 82.41 km (range: 8.06–356.73 km). The mean daily distance covered was 26.07 ± 13.83 km (range: 9.13–53.06 km). Taking these movements into account, the 95% weekly kernel was 928.5 ± 1305.18 km^2

(range: 18.56–4903.66 km^2), and finally, the 95% total kernel was 1851.05 ± 1586.63 km^2 (range: 25.63–5335.75 km^2) (Figure 1, Tables 1 and 2).

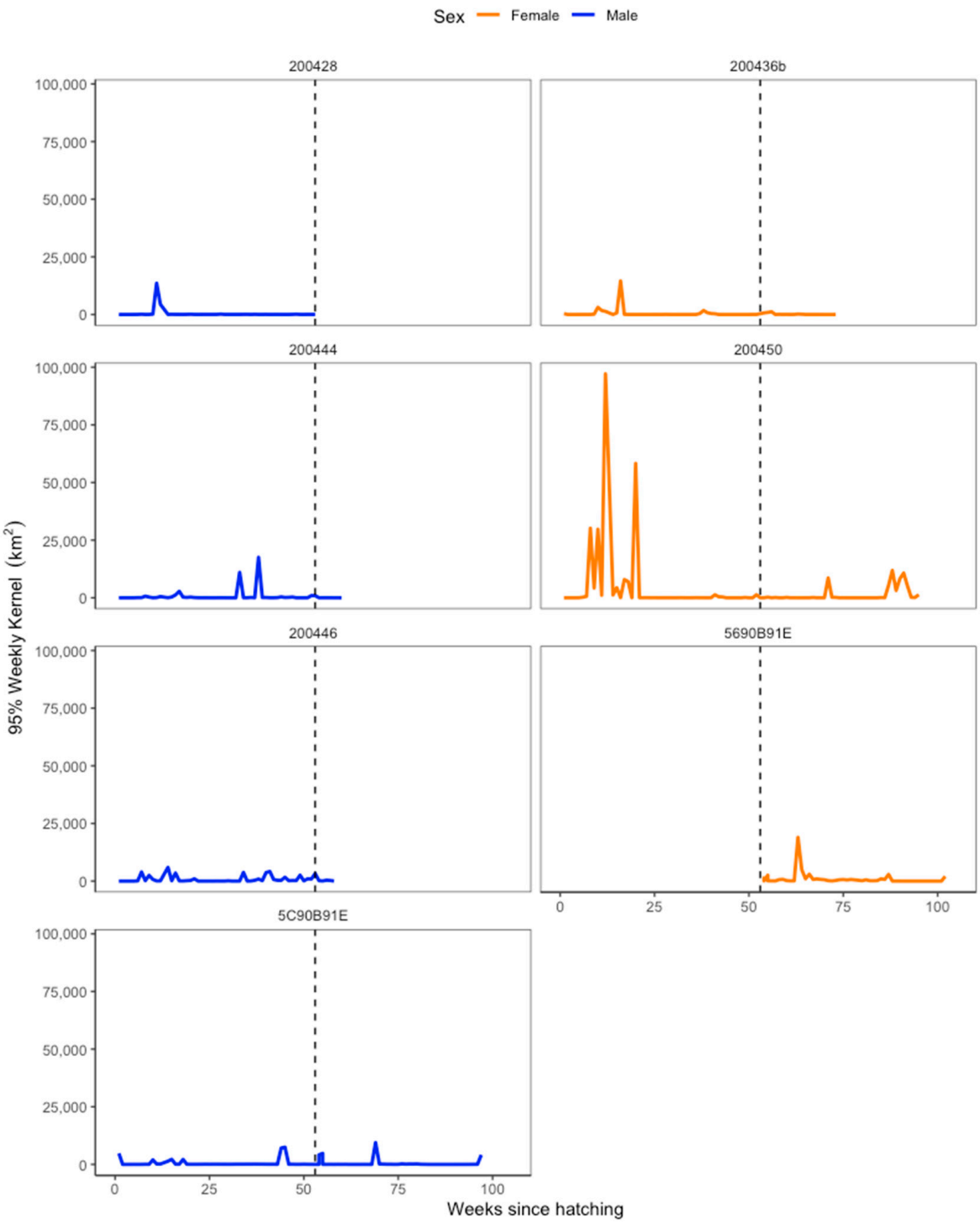


Figure 5. The 95% weekly kernel of the seven juvenile Hen Harriers in their two first years of dispersal. Blue lines show male movements and orange lines show female movements. The vertical dashed line shows the starting point of the second annual period.

Table 2. Mean results of the 7 juvenile Hen Harriers by sex, period, both sex and period at the same time, and overall mean. The results are shown as mean ± standard deviation (minimum–maximum). Dnest: mean distance to the nest. Dmax: maximum distance to the nest. DD: daily distance travelled. TD: total distance travelled. WK95: 95% weekly kernel. TK95: 95% total kernel. First: first year. Second: second year.

Period	Sex	n	Dnest	Dmax	DD	TD	WK95	TK95
-	F	5	25.23 ± 5.88 (16.27–30.63)	170.27 ± 107.04 (82.37–356.73)	26.08 ± 16.62 (9.13–53.06)	8021.66 ± 6811.27 (2538.44–18,993.72)	1571.23 ± 1913.85 (163.5–4903.66)	2252.79 ± 1931.55 (376.4–5335.75)
-	M	7	40.73 ± 29.64 (4.28–83.35)	114.48 ± 57.43 (8.06–188.36)	26.06 ± 12.89 (10.64–47.2)	5883.94 ± 4419.23 (553.61–13,636.84)	469.41 ± 301.71 (18.56–841.96)	1564.09 ± 1377.46 (25.63–3301.94)
First	-	6	35.28 ± 26.76 (4.28–83.35)	182.18 ± 88.12 (130.87–356.73)	28.04 ± 15.74 (10.64–53.06)	9991.64 ± 5632.65 (3724.82–18,993.72)	1340.12 ± 1753.81 (380.86–4903.66)	2459.08 ± 1865.41 (194.8–5335.75)
Second	-	6	33.26 ± 22.43 (5.04–64.46)	93.27 ± 49.32 (8.06–145.61)	24.09 ± 12.79 (9.13–47.2)	3557.67 ± 2579.08 (553.61–7705.82)	516.89 ± 514.97 (18.56–1313.17)	1243.01 ± 1082.24 (25.63–2559.36)
First	F	2	25.08 ± 3.69 (22.47–27.69)	245.3 ± 157.59 (133.86–356.73)	40.94 ± 17.14 (28.82–53.06)	14,525.56 ± 6318.94 (10,057.4–18,993.72)	2704.05 ± 3110.73 (504.43–4903.66)	3128.9 ± 3120.95 (922.06–5335.75)
	M	4	40.39 ± 32.94 (4.28–83.35)	150.63 ± 26.06 (130.87–188.36)	21.6 ± 12.19 (10.64–38.2)	7724.68 ± 4360.25 (3724.82–13,636.84)	658.15 ± 201.4 (380.86–841.96)	2124.17 ± 1450.56 (194.8–3301.94)
Second	F	3	25.34 ± 7.89 (16.27–30.63)	120.25 ± 33.42 (82.37–145.61)	16.17 ± 6.16 (9.13–20.59)	3685.72 ± 1523.49 (2538.44–5414.28)	816.02 ± 590.38 (163.5–1313.17)	1668.72 ± 1145.57 (376.4–2559.36)
	M	3	41.19 ± 31.74 (5.04–64.46)	66.29 ± 52.73 (8.06–110.8)	32 ± 13.52 (21.29–47.2)	3429.62 ± 3776.1 (553.61–7705.82)	217.76 ± 214.5 (18.56–444.83)	817.31 ± 1035.43 (25.63–1989.07)
Total		12	34.27 ± 23.57 (4.28–83.35)	137.73 ± 82.41 (8.06–356.73)	26.07 ± 13.83 (9.13–53.06)	6774.66 ± 5360.46 (553.61–18,993.72)	928.5 ± 1305.18 (18.56–4903.66)	1851.05 ± 1586.63 (25.63–5335.75)

A comparison of the descriptive variables between the Periods reveals a general trend in which the values of the first annual period are consistently higher than those of the second (Figures 1–5, Tables 1 and 2). However, there are significant differences only in the total distance travelled (TD: t = −2.94, p = 0.019; Table 3). In particular, the total distance travelled was higher during the first annual period, at 9991.64 ± 5632.65 km (range: 3724.82–18,993.72 km), than during the second annual period, when the distance travelled was 3557.67 ± 2579.08 km (range: 553.61–7705.82 km) (Figure 2D, Table 2).

Table 3. Linear mixed models of the six response variables. Significative results ($p < 0.05$) are highlighted in bold. Dnest: mean distance to the nest. Dmax: maximum distance to the nest. DD: daily distance travelled. TD: total distance travelled. WK95: 95% weekly kernel. TK95: 95% total kernel.

Variable	Factor	Estimate	S.E.	t-Value	df	*p*-Value
Dnest	Intercept	26.13	17.60	1.48	7.81	0.177
	Period Second year	−0.79	16.86	−0.05	3.28	0.965
	Sex Male	14.26	21.96	0.65	7.43	0.536
	Period Second year: Sex Male	−5.09	21.85	−0.23	3.22	0.830
Dmax	Intercept	15.24	2.06	7.39	8.00	<0.001
	Period Second year	−4.35	2.64	−1.65	5.24	0.158
	Sex Male	−2.99	2.53	−1.19	8.00	0.270
	Period Second year: Sex Male	−0.46	3.44	−0.13	5.14	0.899
DD	Intercept	40.94	8.59	4.76	8.00	0.001
	Period Second year	−24.76	11.09	−2.23	8.00	0.056
	Sex Male	−19.34	10.52	−1.84	8.00	0.103
	Period Second year: Sex Male	35.17	14.46	2.43	8.00	0.041
TD	Intercept	14,525.56	2851.80	5.09	8.00	0.001
	Period Second year	−10,839.84	3681.66	−2.94	8.00	0.019
	Sex Male	−6800.88	3492.73	−1.95	8.00	0.087
	Period Second year: Sex Male	6544.78	4800.29	1.36	8.00	0.210
WK95	Intercept	7.45	0.80	9.36	7.98	<0.001
	Period Second year	−1.07	0.87	−1.23	4.46	0.279
	Sex Male	−1.01	0.98	−1.02	7.88	0.337
	Period Second year: Sex Male	−0.69	1.12	−0.61	4.38	0.571
TK95	Intercept	3210.71	1108.77	2.90	7.96	0.020
	Period Second year	−1542.00	1179.04	−1.31	3.72	0.266
	Sex Male	−1086.55	1371.15	−0.79	7.78	0.452
	Period Second year: Sex Male	−26.84	1530.45	−0.02	3.65	0.987

The six response variables examined between Sexes show a general trend where females have longer movements with larger areas of occupancy (Figures 2–5, Table 2). However, no significant differences were found for any of the variables (all $p > 0.05$; Table 3), probably due to the small sample size.

When we compare both Periods and Sexes, we observe the same general trend in the six descriptive variables (Figure 2) but with higher values in the first annual period and in females. In this model, significant differences were found for daily distance travelled (DD). The daily distance travelled by females in the first annual period was 40.94 ± 17.14 km (range: 28.82–53.06 km), which is almost double that of males (21.6 ± 12.19 km (range: 10.64–38.2 km)). Conversely, these values were higher in males in the second year at 32.00 ± 13.52 km (range: 21.29–47.2 km) than in females with 16.17 ± 6.16 km (range: 9.13–20.59 km) (DD: t = 2.43, $p = 0.041$; Figure 2C, Tables 2 and 3).

4. Discussion

Juvenile Hen Harriers, as is the case with many other raptors in their first year of dispersal, move much further from their nests and travel greater distances than in their second year [30,31,38–40]. This suggests that Hen Harriers frequently revisit territories during their second year but in a more efficient manner. It is likely that, in their second year, as expected, juveniles demonstrated an enhanced understanding of their environment [26,30,41]. Consequently, they reduced the costs of energy during travel by flying directly to the previously identified optimal sites.

The start of the dispersal period generally ranged from late August to mid-September, noting that one female (ID: 200450) began dispersal in early July. During the dispersal phase, we did not observe a marked pattern in the tagged individuals, characterised by birds returning to the breeding areas on different dates and settling for varying periods and differing distances from their natal area. Some individuals only move a maximum of 80 km (ID: 200446) away from the nest site, while others go as far as 350 km (ID: 200450). The physical condition of the animal and the availability of resources in the area are key factors influencing dispersal [28,39]. Studies have shown that animals in better physical conditions are more likely to settle in areas with more resources, while those in poorer conditions continue their dispersal in search of more favourable areas [28,30,39]. The phenomenon of juveniles congregating in specific areas during dispersal has been extensively researched in other species, including Bonelli's Eagle *Aquila fasciata* [28] and the Red Kite *Milvus milvus* [30].

In conclusion, the juvenile dispersal phase of the Hen Harrier, as in so many other raptors, is a period of highly variable behaviour [42] and, perhaps, even more so in the region under study. Considering that 60% of mortality occurs in their first year [6], juvenile dispersal is the key period for the conservation and protection of this species.

Concerning sex differences in juvenile dispersal, the only significant observation is that, in the first year, females cover a greater daily distance, while this sex difference is reversed in the second year. As to the remaining parameters, the trend indicates that females tend to travel greater distances. This may be due to their larger wingspan, which in inexperienced birds, can facilitate dispersal. This has been observed in different raptors [1,5,6]. Another perspective may be the ecological differences between sexes, where females are involved in habitat and nest site selection, and probably, they are more active than males in the movements.

We do not consider our results to be statistically robust due to the very small sample size and the high variability in dispersal behaviour. However, we do consider the descriptive results to be of interest, and they add to the currently limited data on the spatial ecology of the Hen Harrier in Spain.

Author Contributions: S.M. and V.U. conceived the ideas and designed the methodology, S.L. managed the data, and S.M. analysed the data. S.M. and V.U. wrote the manuscript. S.M., S.L. and V.U. and contributed critically to the drafts. S.L. and V.U. gave final approval for publication. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Fundación Iberdrola España (MIGRA program of SEO/BirdLife) and Natural England.

Institutional Review Board Statement: Trapping and marking activities were conducted under permissions issued by re-gional authorities (Departamento de Industria, Transición Energética y Sostenibilidad, Gobierno Vasco; Consejería de Administración Autonómica, Medio Ambiente y Cambio Climático, Principado de Asturias; Consejería de Fomento, Ordenación del Territorio y Medio Ambiente, Gobierno de Cantabria; Consejería De Agricultura, Ganadería Y Medio Ambiente, Gobierno de La Rioja; Departamento de Desarrollo Rural y Medio Ambiente, Gobierno de Navarra (0001-0261-2020-000027); Departamento de Acción Climática, Ali-mentación y Agenda Rural, Generalitat de Cataluña; Consejería de Medio Ambiente Li-cencias de Caza y Pesca, Comunidad de Madrid; Consejeria de Fomento y Medio Ambi-ente, Junta de Castilla y León (AUES/CYL/28/2021); and Consejería de Agricultura, Ga-nadería y Desarrollo Rural, Gobierno de Castilla-La Mancha). The capture of individuals was carried out by ex-pert licenced ringers from the Spanish Ornithological Society (SEO/BirdLife), complying with the ethical standards for the capture and tagging of Hen Harriers.

Informed Consent Statement: Not applicable.

Data Availability Statement: All data used in this study are publicly available upon request to data managers in the online data repository Movebank (www.movebank.org, accessed on 30 March 2023). The projects are: "Hen Harrier in Spain–Migra Program in Spain" (project ID: 1169461367, https://www.movebank.org/cms/webapp?gwt_fragment=page=studies,path=study1169461367) and "Hen Harriers in Spain" (project ID: 1135251191, https://www.movebank.org/cms/webapp?gwt_fragment=page=studies,path=study1135251191).

Acknowledgments: The results provided in this publication were obtained thanks to the work of SEO/BirdLife in the Migra program and its funding by the Fundación Iberdrola España and Natural England. Numerous individuals, ornithological groups, ringing groups, research centres, forestry agents and technicians from the autonomous communities were involved. Without their collaboration, it would not have been possible to carry out part of the work. Many people from SEO/BirdLife also took part in the work, especially Javier de la Puente, Ana Bermejo, and Carmen Fernández., and of course, the administration staff who helped with the less pleasant tasks of the project related to invoices and justifications. From Natural England, we would especially like to thank, for their great collaboration in the capture of individuals, Javier de la Puente, Arturo Rodríguez and Juan Martínez.

Conflicts of Interest: The authors declare that no conflicts of interest exist.

References

1. Cramp, S.; Simmons, K.E.L. *The Birds of the Western Palearctic*; Oxford University Press: Oxford, UK, 1980; Volume II.
2. Amar, A.; Redpath, S.M. Habitat Use by Hen Harriers *Circus cyaneus* on Orkney: Implications of Land-use Change for This Declining Population. *IBIS Int. J. Avian Sci.* **2005**, *147*, 37–47. [CrossRef]
3. Amar, A.; Arroyo, B.; Meek, E.; Redpath, S.; Riley, H. Influence of Habitat on Breeding Performance of Hen Harriers *Circus cyaneus* in Orkney. *IBIS Int. J. Avian Sci.* **2008**, *150*, 400–404. [CrossRef]
4. Arroyo, B. Aguilucho Pálido *Circus cyaneus*. In *III Atlas de las Aves en Época de Reproducción en España*; Molina, B., Nebreda, A., Muñoz, A.R., Seoane, J., Real, R., Bustamante, J., del Moral, J.C., Eds.; SEO/BirdLife: Madrid, Spain, 2022.
5. Ferguson-Lees, J.; Christie, D.A. *Raptors of the World*, 1st ed.; Editorial Houghton Mifflin Harcourt: Boston, MA, USA, 2001.
6. Del Hoyo, J.; Elliot, A.; Sargatal, J.; Christie, D.A. *Handbook of the Birds of the World*, 1st ed.; Editorial Lynx Edicions: Barcelona, Spain, 1994.
7. Agostini, N. Hen Harrier Circus Cyaneus. In *Migration Strategies of 278 Birds of Prey in Western Palearctic*; Panuccio, M., Mellone, U., Agostini, N., Eds.; CRC Press: Boca Raton, FL, USA, 2021; pp. 142–145.
8. Brown, J.H. On the Relationship between Abundance and Distribution of Species. *Am. Nat.* **1984**, *124*, 255–279. [CrossRef]
9. Brown, J.H.; Lomolino, M.V. *Biogeography*; Sinauer Associates, Inc. Publishers: Sunderland, UK, 1998.
10. Kerlinger, P. *Flight Strategies of Migrating Hawks*; Chicago University Press: Chicago, IL, USA, 1989.
11. Morollón, S.; García-Macía, J.; Onrubia, A.; Lee, S.; Urios, V. Migration Patterns of Breeding Hen Harriers *Circus cyaneus* in Spain. *Bird Study* **2024**, *71*, 40–47. [CrossRef]
12. Picozzi, N. Sex Ratio, Survival and Territorial Behaviour of Polygynous Hen Harriers *Circus c. cyaneus* in Orkney. *IBIS Int. J. Avian Sci.* **1984**, *126*, 356–365. [CrossRef]
13. Picozzi, N. Breeding Biology of Polygynous Hen Harriers *Circus c. cyaneus* in Orkney. *Ornis Scand.* **1984**, *15*, 1–10. [CrossRef]
14. Irwin, S.; Wilson, M.W.; Kelly, T.C.; O'Mahony, B.; Oliver, G.; Troake, P.; O'Halloran, J. The Breeding Biology of Hen Harriers Circus Cyaneus in Ireland over a Five Year Period. *Ir. Birds* **2011**, *9*, 165–172.

15. Baines, D.; Richardson, M. Hen Harriers on a Scottish Grouse Moor: Multiple Factors Predict Breeding Density and Productivity. *J. Appl. Ecol.* **2013**, *50*, 1397–1405. [CrossRef]
16. Fernández-Bellon, D.; Wilson, M.W.; Irwin, S.; Kelly, T.C.; O'Mahony, B.; O'Halloran, J. Activity Patterns of Breeding Hen Harriers *Circus Cyaneus* Assessed Using Nest Cameras. *Bird Study* **2017**, *64*, 557–561. [CrossRef]
17. Meek, E.R.; Rebecca, G.W.; Ribbands, B.; Fairclough, K. Orkney Hen Harriers: A Major Population Decline in the Absence of Persecution. *Scott. Birds* **1998**, *19*, 290–299.
18. Amar, A.; Redpath, S.M. Determining the Cause of the Hen Harrier Decline on the Orkney Islands: An Experimental Test of Two Hypotheses. *Anim. Conserv.* **2002**, *5*, 21–28. [CrossRef]
19. Wotton, S.R.; Bladwell, S.; Mattingley, W.; Morris, N.G.; Raw, D.; Ruddock, M.; Stevenson, A.; Eaton, M.A. Status of the Hen Harrier *Circus cyaneus* in the UK and Isle of Man in 2016. *Bird Study* **2018**, *65*, 145–160. [CrossRef]
20. Balfour, E.; Macdonald, M.A. Food and Feeding Behaviour of the Hen Harrier in Orkney. *Scott. Birds* **1970**, *6*, 57–66.
21. Redpath, S.M.; Arroyo, B.E.; Etheridge, B.; Leckie, F.; Bouwman, K.; Thirgood, S.J. Temperature and Hen Harrier Productivity: From Local Mechanisms to Geographical Patterns. *Ecography* **2002**, *25*, 533–540. [CrossRef]
22. Watson, M.; Thirgood, S. Could Translocation Aid Hen Harrier Conservation in the UK? *Anim. Conserv.* **2001**, *4*, 37–43. [CrossRef]
23. Arroyo, B.; Amar, A.; Leckie, F.; Buchanan, G.M.; Wilson, J.D.; Redpath, S. Hunting Habitat Selection by Hen Harriers on Moorland: Implications for Conservation Management. *Biol. Conserv.* **2009**, *142*, 586–596. [CrossRef]
24. Thompson, P.S.; Amar, A.; Hoccom, D.G.; Knott, J.; Wilson, J.D. Resolving the Conflict between Driven-grouse Shooting and Conservation of Hen Harriers. *J. Appl. Ecol.* **2009**, *46*, 950–954. [CrossRef]
25. Stoychev, S.; Demerdzhiev, D.; Spasov, S.; Dobrev, D.; Meyburg, B.-U. Survival Rate and Mortality of Juvenile and Immature Eastern Imperial Eagles (*Aquila heliaca*) from Bulgaria Studied by Satellite Telemetry. *Slovak Raptor J.* **2014**, *8*, 53–60. [CrossRef]
26. Oppel, S.; Dobrev, V.; Arkumarev, V.; Saravia, V.; Bounas, A.; Kret, E.; Velevski, M.; Stoychev, S.; Nikolov, S.C. High Juvenile Mortality during Migration in a Declining Population of a Long-distance Migratory Raptor. *IBIS Int. J. Avian Sci.* **2015**, *157*, 545–557. [CrossRef]
27. Newton, I.; McGrady, M.J.; Oli, M.K. A Review of Survival Estimates for Raptors and Owls. *IBIS Int. J. Avian Sci.* **2016**, *158*, 227–248. [CrossRef]
28. Cadahía, L.; Urios, V.; Negro, J.J. Bonelli's Eagle *Hieraaetus fasciatus* Juvenile Dispersal: Hourly and Daily Movements Tracked by GPS. *Bird Study* **2007**, *54*, 271–274. [CrossRef]
29. Urios, V.; Muñiz-López, R.; Vidal-Mateo, J. Juvenile Dispersal of Harpy Eagles (*Harpia harpyja*) in Ecuador. *J. Raptor Res.* **2017**, *51*, 439–445. [CrossRef]
30. García-Macía, J.; López-Poveda, G.; De La Puente, J.; Bermejo-Bermejo, A.; Galán, M.; Álvarez, E.; Morollón, S.; Urios, V. The Variability of Juvenile Dispersal in an Opportunistic Raptor. *Curr. Zool.* **2022**, *69*, 244–254. [CrossRef] [PubMed]
31. García-Macía, J.; Álvarez, E.; Galán, M.; Iglesias-Lebrija, J.J.; Gálvez, M.; Plana, G.; Vallverdú, N.; Urios, V. Age, Season and Sex Influence Juvenile Dispersal in the Iberian Cinereous Vultures (*Aegypius monachus*). *J. Ornithol.* **2024**, *165*, 325–335. [CrossRef]
32. Calenge, C. The Package "Adehabitat" for the R Software: A Tool for the Analysis of Space and Habitat Use by Animals. *Ecol. Model.* **2006**, *197*, 516–519. [CrossRef]
33. Signer, J.; Fieberg, J.; Avgar, T. Animal Movement Tools (Amt): R Package for Managing Tracking Data and Conducting Habitat Selection Analyses. *Ecol. Evol.* **2019**, *9*, 880–890. [CrossRef]
34. R Core Team. *R: A Language and Environment for Statistical Computing*; R Foundation for Statistical Computing: Vienna, Austria, 2022.
35. Bates, D.; Mächler, M.; Bolker, B.; Walker, S. Fitting Linear Mixed-Effects Models Using Lme4. *J. Stat. Softw.* **2015**, *67*, 1–48. [CrossRef]
36. QGIS Development Team. QGIS Geographic Information System; QGIS: 2022. Available online: https://www.qgis.org (accessed on 26 November 2024).
37. Kenward, R.E. *A Manual for Wildlife Radio Tagging*, 2nd ed.; Academic Press: Cambridge, MA, USA, 2001.
38. Newton, I.; Marquiss, M. Fidelity to Breeding Area and Mate in Sparrowhawks Accipiter Nisus. *J. Anim. Ecol.* **1982**, *51*, 327. [CrossRef]
39. Ferrer, M.; Morandini, V. Better Nutritional Condition Changes the Distribution of Juvenile Dispersal Distances: An Experiment with Spanish Imperial Eagles. *J. Avian Biol.* **2017**, *48*, 1342–1347. [CrossRef]
40. Balbontín, J.; Ferrer, M. Movements of Juvenile Bonelli's Eagles *Aquila fasciata* during Dispersal. *Bird Study* **2009**, *56*, 86–95. [CrossRef]
41. Sergio, F.; Tavecchia, G.; Blas, J.; López, L.; Tanferna, A.; Hiraldo, F. Variation in Age-Structured Vital Rates of a Long-Lived Raptor: Implications for Population Growth. *Basic Appl. Ecol.* **2011**, *12*, 107–115. [CrossRef]
42. Newton, I. *Bird Migration*; William Collins: London, UK, 2010.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.