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# Space–Time Patterns of Nest Site and Nesting Area Selection by the Italian Population of European Rollers: A 3-Year Study of a Farmland Bird Species

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**Abstract:** The European Roller *Coracias garrulus* has suffered greatly from breeding habitat loss due to the renovation of old farmhouses and rural buildings and changing agricultural practices that took place extensively across Europe in the last decades. As a consequence, this species experienced a significant decline, and local extinctions of breeding populations were recorded in several European countries. We investigated nest sites and nesting area selection by the Italian Roller population during the breeding period (May–August) between 2016 and 2018. We collected 711 points from field surveys and used four types of point pattern analysis to detect space-time patterns of nest site and nesting area selection. We found that: (a) the spatial distribution of selected (i.e., occupied) nest sites was significantly nonrandom ($p < 0.01$) for all years and months; (b) only 2.6% of the selected nest sites was located within parks or reserves; (c) there were significant ($p < 0.01$) latitudinal, longitudinal, and altitudinal shifts of selected nest sites between May and August; (d) the geographical barycentres of selected nest sites shifted northward by about 80 km per month from May (southernmost barycentre) to August (northernmost barycentre); (e) four main nesting areas (7886 km$^2$ in total) occurred in central and southern Italy, whose utilization by the European Rollers differed between months but not between years; (f) the detected nesting areas corresponded mainly to non-irrigated arable lands (41.22% of their extent) and natural grasslands (12.80%). Our results are useful to support conservation strategies for the breeding sites of this farmland species, which is not a regular visitor to protected areas in Italy.

**Keywords:** *Coracias garrulus*; farmland; Italy; nesting hotspots; point pattern analysis; population monitoring; secondary cavity-nester; species conservation

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## 1. Introduction

The European Roller *Coracias garrulus* is a long-distance migrant, obligate secondary cavity-nesting, insectivorous, central-place forager of conservation concern [1]. It dwells in agricultural landscapes, and it breeds in abandoned woodpecker nests as well as in artificial places of breeding such as nestboxes, roof cavities, or wall cracks [2]. The clutch is 2 to 6 eggs, and only a single brood is laid each year [1]. This species has suffered greatly from habitat loss at breeding sites, caused by changes to agricultural practices in the last decades across

Europe [3], resulting in a decrease in prey availability due to the conversion of pastures into arable lands, heterogenous land into monoculture, and removal of hedges and trees in agricultural areas. The European Rollers face further important threats, such as illegal trapping and hunting, in their distribution range and migration routes [4]. In addition, due to their behavior of using electric wires as hunting perches, they are at electrocution risk [5]. Climate-driven shifts in species range have already been observed for the European Rollers, although the capability of this species to keep pace with fast climate changes is still in question [6]. Accordingly, Roller populations experienced a significant decline, and local extinctions of breeding populations were recorded in several countries [2,7].

Recently, direct management practices (such as nest-box provisioning) were implemented, which contributed to reversing this negative trend [8]. Nevertheless, this species has been decreasing in the last 30 years across its European breeding range [9]; therefore, it has been classified as SPEC 2 and thus deserves protection along the entire flyway [7]. Italy is one of the countries in Europe where its population trend is declining. The European Rollers arrive in Italy at the end of April, and in mid-May they occupy a nesting territory that is guarded by a male individual during both the courtship and breeding periods [10]. At the population level, the availability of nest sites and access to food resources are key drivers for the choice of the nesting territory [2,11]. Nest sites are often limited for this obligate secondary cavity-nesting species; in fact, the European Rollers are dependent upon the actions of primary excavators or the provision of man-made cavities [12]. Habitat composition around the nests of these central-place foragers can also affect pre-breeding conditions, laying dates, and fledging success [13].

Understanding the drivers of nest site and nesting area selection is thus a critical component of successful conservation interventions and requires identification of any significant spatio-temporal patterns of the breeding phase in order to make conservation management relevant at the population level [14–16]. However, no attention has so far been given to the European Roller nest site and nesting area selection at the national level in Italy, where, in fact, only local studies are available [17]. Accordingly, in this study, we carried out space–time investigations of nest site (i.e., the microhabitat of the nest itself, determined by the authors through accurate XY coordinates) and nesting area (i.e., areas with a higher number of nest sites than expected by chance; here named hotspots) selection by the Italian population of European Rollers between 2016 and 2018, aiming to answer the following questions: (1) Was the choice of nest sites governed by chance (and thus not influenced by environmental variables) or driven by precise spatial criteria? (2) Were the longitudinal, latitudinal, and altitudinal coordinates of selected nest sites the same in all months and years during the breeding season, or did significant shifts occur in specific time intervals? (3) Did the European Rollers maintain or change the barycentre of their nesting activity in the time intervals (months and years) considered? (4) Did the European Rollers choose specific nesting hotspots in the Italian peninsula? (5) Did the choice of nesting hotspots change over time? (6) What are the geographic, topographic, and land cover attributes of the nesting hotspots of this species?

Our results can improve the conservation strategies of these farmland birds in Italy.

## 2. Materials and Methods

### *2.1. Study Population*

In Italy, the Roller population has experienced a drastic reduction (> 30%) over the last 30 years, especially in the northern part of the country [7], although a moderate increase at a national scale has recently been recorded [17]. The Italian population is approximately estimated at 900–1000 breeding pairs, mostly concentrated in specific areas in central and southern Italy [17], with a few scattered isolated recolonizations of recent origin in northern Italy (Emilia-Romagna, Piedmont, and Friuli-Venezia Giulia regions; [10]).

*2.2. Data Collection and Pre-Processing*

Between 2016 and 2018, during May–August, we carried out intensive sampling sessions of the potentially suitable areas in Italy to identify the sites where the Roller population nested. We employed 33 field experts in 2016, 28 in 2017, and 31 in 2018. Sampling sessions were accomplished once every ten days on a regional basis. We surveyed both the nesting areas used by Rollers in previous years and also further potential areas that could fit the climatic and land cover requirements of Rollers during the breeding period. We used phototraps and safety distance monitoring by binoculars and telescopes in order to avoid any possible interference with the reproductive success of this population. Nest failure (i.e., nests selected at the beginning of the breeding season and then abandoned) did not change the terms of classification as "occupied" because we were interested in nest site selection and not breeding success. For each nest site selected (i.e., occupied) by Rollers, we recorded several variables, including geographical coordinates and elevation a.s.l., that were used in this study. We created a 1:25,000 Geographical Information System (GIS) in the WGS 84 reference coordinate system of the Italian peninsula, including: (a) regional boundaries, (b) provincial boundaries, (c) municipal boundaries, (d) nest site locations, (e) CORINE land cover, (f) boundaries of parks, reserves, special protection areas (SPA; Birds 2009/147/EC Directive), and special areas of conservation (SAC; Habitats 92/43/EEC Directive). We used these cartographic layers in the successive point pattern analyses to discover the space–time patterns of nest site and nesting area selection.

*2.3. Point Pattern Analyses*

Each nest site occupied by Rollers was a five-dimensional vector $<x, y, z, t_1, t_2>$, where $x$, $y$ and $z$ were longitudinal, latitudinal, and altitudinal coordinates, respectively, and $t_1$ and $t_2$ were year and month, respectively.

Firstly, we used first-order nearest-neighbor statistics [18] to test (separately for years and for months) whether the two-dimensional (i.e., $x$, $y$) spatial distribution of selected nest sites was random (null hypothesis) or not (spatially clustered or overdispersed; alternative hypothesis). In the former case, the choice of nest sites would be governed by chance and thus not influenced by environmental variables (e.g., land cover); in the latter case, such a choice would be driven by precise spatial criteria. This test calculates the $R$ value

$$R = \frac{d}{E(d_i)} = \frac{d}{0.5\sqrt{\frac{A}{n}}}$$

where $d$ is the observed mean distance between nearest neighbours, $E(d_i)$ is the expected value of the average nearest neighbor distance for a random sample of points, $A$ is the extension of the study area (Italy; 301,422.98 km$^2$), and $n$ is the number of points. Clustered, random, and overdispersed patterns of points yield $R < 1$, $R \sim 1$, and $R > 1$, respectively. We then measured the deviation of $d$ from theoretical expectation under complete spatial randomness (CSR) by calculating the $Z$ score

$$Z = \frac{d - E(d_i)}{\sigma} = \frac{d - 0.5\sqrt{\frac{A}{n}}}{\sqrt{0.0683\frac{A}{n^2}}}$$

where $\sigma$ is the expected standard deviation of the nearest neighbor distances under CSR. We used two-tailed tests with $p = 0.01$ to decide the significance of $Z$; thus, the rejection regions were $Z \leq -2.58$ (significant clustering) and $Z \geq 2.58$ (significant overdispersion).

Secondly, we used the two-sample Kolmogorov–Smirnov statistics [19] to test whether there were significant shifts in either the longitudinal, latitudinal, and altitudinal coordinates of selected nest sites between years and months (alternative hypothesis) or not (null hypothesis). We compared the statistical distributions ($D$) of the $x$, $y$, and $z$ coordinates of selected nest sites in the generic year/month $i$ with the statistical distribution of the $x$, $y$, and $z$ coordinates in the generic year/month $j$ (e.g., $D_{x\ 2016}$ vs. $D_{x\ 2018}$; $D_{y\ \mathrm{June}}$ vs. $D_{y\ \mathrm{July}}$), respectively. Tests were considered to be significant for (two-sided) $p < 0.01$.

Thirdly, we calculated the geographical barycentre of selected nest sites separately for each month and each year, as the mean of their $x$ and $y$ coordinates:

$$\vec{B} =< B_x = \frac{\sum_{i=1}^{n} x_i}{n}, B_y = \frac{\sum_{i=1}^{n} y_i}{n} >$$

Fourthly, we employed kernel density analysis [20] to identify the nesting hotspots (i.e., areas with high-density, statistically significant clustering of selected nests) of the European Rollers in Italy. We used the adaptive kernel method [21] with the Gaussian (bivariate normal) kernel function

$$f(x,y) = \frac{1}{nh_x h_y} \sum_{i=1}^{n} K\left(\frac{x_i - x}{h_x}, \frac{y_i - y}{h_y}\right)$$

where $<x, y>$ is a generic point of the study area, $<x_i, y_i>$ is a generic nest site, $h_x$ and $h_y$ are bandwidth (smoothing) coefficients, and the Gaussian symmetrical kernel $K$ takes any generic argument $u$ and delivers

$$K(u) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}u^2}$$

We utilised the reference bandwidth $h_{ref}$ [22] to choose the appropriate value for $h_x$ and $h_y$

$$h_x = h_y = h_{ref} = n^{-1/6} \sqrt{\frac{\sigma^2{}_x + \sigma^2{}_y}{2}}$$

where $\sigma^2{}_x$ and $\sigma^2{}_y$ are the variances in $x$ and $y$ coordinates of nest sites, respectively.

We used the resulting utilization distribution to delineate the nesting hotspots as the areas enclosed by continuous outer 90% isopleths. Within GIS, we then investigated the geographic, topographic, and land cover attributes of the detected hotspots.

## 3. Results

During field surveys, we found 711 nest sites, almost equally distributed between years, which amounts to about 25–30% of the European Roller population in Italy (Figures 1 and 2). Nest sites were scattered up to 900 and 700 km in latitude and longitude, respectively (Table S1). August was an exception; in fact, distances were shorter (approximately 700 km in latitude and 400 km in longitude). With regard to the network of protected areas in Italy, we found that the nest sites selected by Rollers were located as follows: (a) 175 out of 711 (i.e., 24.6%) inside SPA; (b) 44 out of 711 (6.2%) inside SAC; (c) 17 out of 711 (2.3%) inside national parks; (d) 1 out of 711 (0.14%) inside natural reserves (state, regional, or provincial).

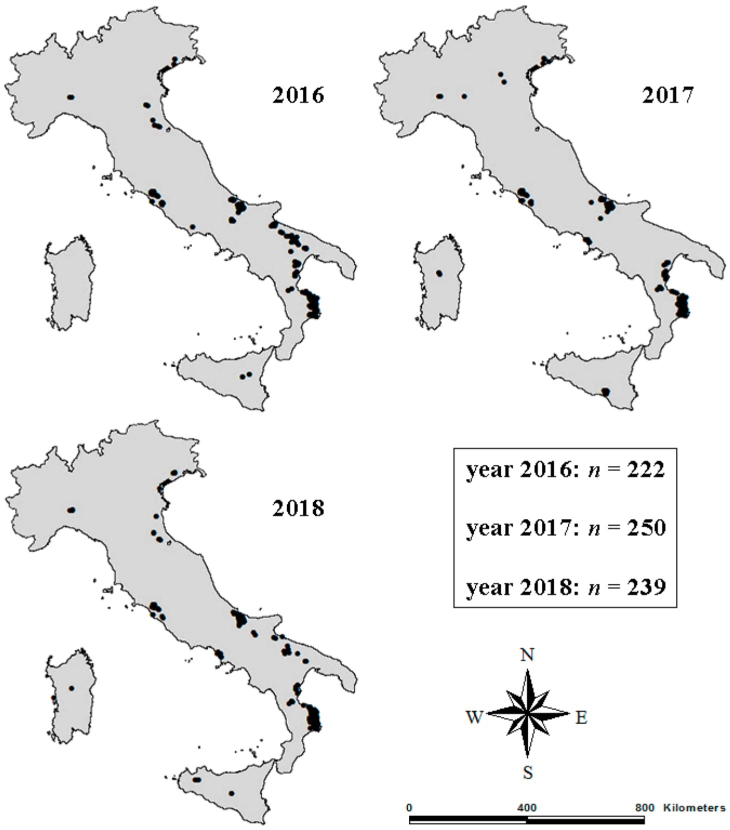


**Figure 1.** Nest sites (black points) selected by the European Rollers by year of sampling.


**Figure 2.** Nest sites (black points) selected by the European Rollers by month of sampling.

### 3.1. Choice of Nest Sites

The spatial distribution of selected nest sites in Italy was significantly nonrandom ($p < 0.01$) for all years and months considered (Table 1). Because $Z$ was always $\leq -2.58$, the selected nest sites were always significantly clustered (i.e., they formed hotspots).

**Table 1.** Results of the first-order nearest-neighbor analysis. The meanings of $R$ and $Z$ are detailed in the main text. Mean and expected distances are expressed in meters.

| Temporal Interval | Nest Sites | Mean Distance | Expected Distance | $R$ | $Z$ | $p$ | Interpretation |
|---|---|---|---|---|---|---|---|
| 2016 | 222 | 2542 | 17,929 | 0.1418 | −24.462 | <0.01 | statistically significant clustering |
| 2017 | 250 | 2071 | 20,342 | 0.1018 | −27.186 | <0.01 | statistically significant clustering |
| 2018 | 239 | 2385 | 21,498 | 0.1109 | −26.293 | <0.01 | statistically significant clustering |
| May | 167 | 1732 | 23,723 | 0.0730 | −22.917 | <0.01 | statistically significant clustering |
| June | 195 | 2664 | 21,912 | 0.1216 | −23.466 | <0.01 | statistically significant clustering |
| July | 244 | 3282 | 16,855 | 0.1948 | −24.064 | <0.01 | statistically significant clustering |
| August | 105 | 3639 | 13,522 | 0.2691 | −14.327 | <0.01 | statistically significant clustering |

### 3.2. Latitudinal, Longitudinal, and Altitudinal Shifts of Nest Sites

We found statistically significant shifts in the $x$, $y$, and $z$ coordinates of selected nest locations between all pairs of months (Table 2; Figure 3). More specifically, noticeable northward, westward, and upward shifts occurred from May to August (Figure 3; Figures S1 and S2). Between May and August, the median $z$ coordinates of selected nest sites were 80 m, 134 m, 161 m, and 230 m a.s.l., respectively.

**Table 2.** Results of the two-sample Kolmogorov–Smirnov test. $D_x$, $D_y$, and $D_z$ represent the statistical distributions of longitudes, latitudes, and altitudes of the nest sites occupied by the European Rollers, respectively.

| Statistical Distribution | Temporal Interval | 2016 | 2017 | 2018 | May | June | July | August |
|---|---|---|---|---|---|---|---|---|
| $D_x$ | 2016 | | $p < 0.01$ | $p = 0.02$ | | | | |
| $D_x$ | 2017 | $p < 0.01$ | | $p = 0.48$ | | | | |
| $D_x$ | 2018 | $p = 0.02$ | $p = 0.48$ | | | | | |
| $D_x$ | May | | | | | $p < 0.01$ | $p < 0.01$ | $p < 0.01$ |
| $D_x$ | June | | | | $p < 0.01$ | | $p < 0.01$ | $p < 0.01$ |
| $D_x$ | July | | | | $p < 0.01$ | $p < 0.01$ | | $p < 0.01$ |
| $D_x$ | August | | | | $p < 0.01$ | $p < 0.01$ | $p < 0.01$ | |
| $D_y$ | 2016 | | $p < 0.01$ | $p < 0.01$ | | | | |
| $D_y$ | 2017 | $p < 0.01$ | | $p = 0.26$ | | | | |
| $D_y$ | 2018 | $p < 0.01$ | $p = 0.26$ | | | | | |
| $D_y$ | May | | | | | $p < 0.01$ | $p < 0.01$ | $p < 0.01$ |
| $D_y$ | June | | | | $p < 0.01$ | | $p < 0.01$ | $p < 0.01$ |
| $D_y$ | July | | | | $p < 0.01$ | $p < 0.01$ | | $p < 0.01$ |
| $D_y$ | August | | | | $p < 0.01$ | $p < 0.01$ | $p < 0.01$ | |
| $D_z$ | 2016 | | $p < 0.01$ | $p = 0.13$ | | | | |
| $D_z$ | 2017 | $p < 0.01$ | | $p = 0.12$ | | | | |
| $D_z$ | 2018 | $p = 0.13$ | $p = 0.12$ | | | | | |
| $D_z$ | May | | | | | $p < 0.01$ | $p < 0.01$ | $p < 0.01$ |
| $D_z$ | June | | | | $p < 0.01$ | | $p < 0.01$ | $p < 0.01$ |
| $D_z$ | July | | | | $p < 0.01$ | $p < 0.01$ | | $p < 0.01$ |
| $D_z$ | August | | | | $p < 0.01$ | $p < 0.01$ | $p < 0.01$ | |

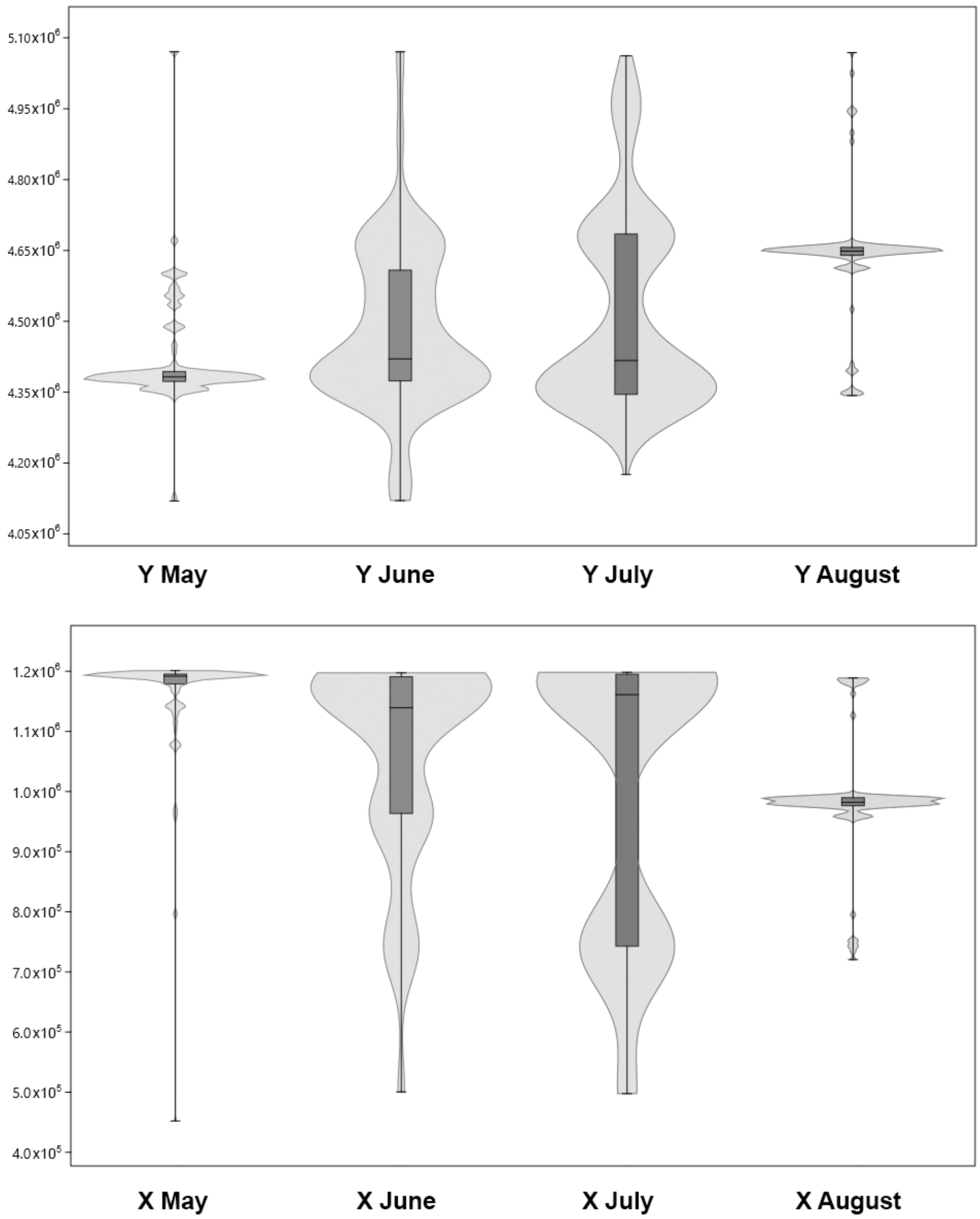


**Figure 3.** Distribution of the latitudinal (**top**) and longitudinal (**bottom**) coordinates (in meters; *Y*-axis) of the nest sites selected by the European Rollers during 2016–2018, separately for months (*X*-axis). The box plots inside the violin plots show median (horizontal line) and the 25–75 percent quartiles.

By contrast, we detected much more uniformity between years; in fact, most pairwise comparisons resulted in nonsignificance (Table 2; Figures S1 and S2).

### *3.3. Barycentres of the Nesting Activity*

We found minimal differences between years (Figure 4A); in fact, the average inter-distance between annual barycentres was only 28.8 km. In addition, we did not find any clear northward or southward trend.

By contrast, the monthly barycentres of selected nest sites (Figure 4B) shifted northward, on average, by about 80 km per month from May (southernmost barycentre) to August (northernmost barycentre), and the average inter-distance was 96.8 km.

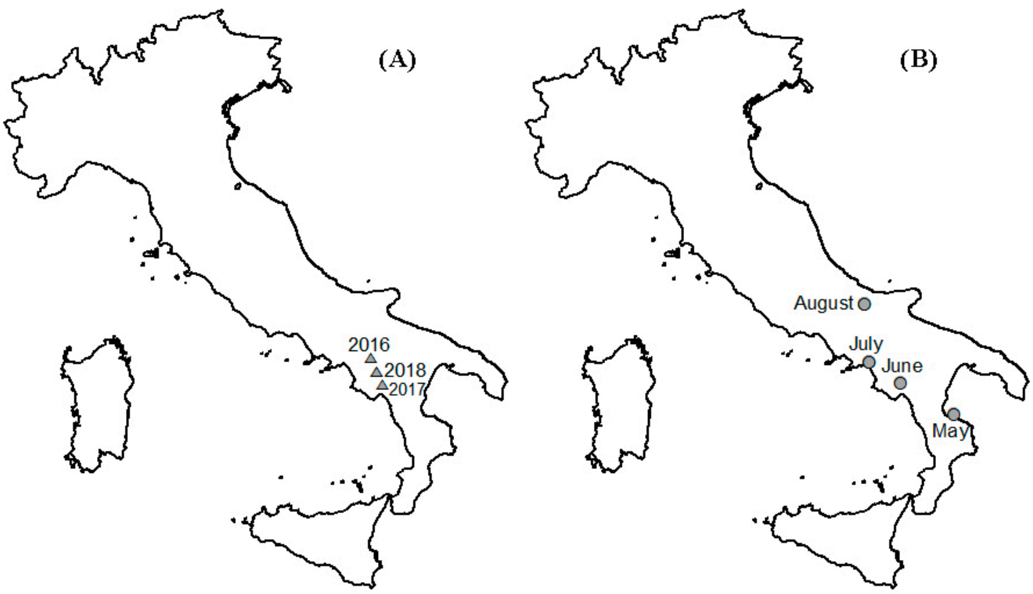


**Figure 4.** Geographical barycentres of the European Roller nesting activity, separately for years (**A**) and months (**B**).

### 3.4. Nesting Hotspots

We detected four nesting hotspots used by the European Rollers in Italy (Figure 5). They are located in central and southern Italy, nearby the coastline, in plain and hilly areas, with extents ranging from 104,000 to 251,000 hectares (Table 3). Of these four hotspots, two (H2 and H4) were used by the European Rollers every single month during the breeding season, while hotspot H1 was active only in June and July.

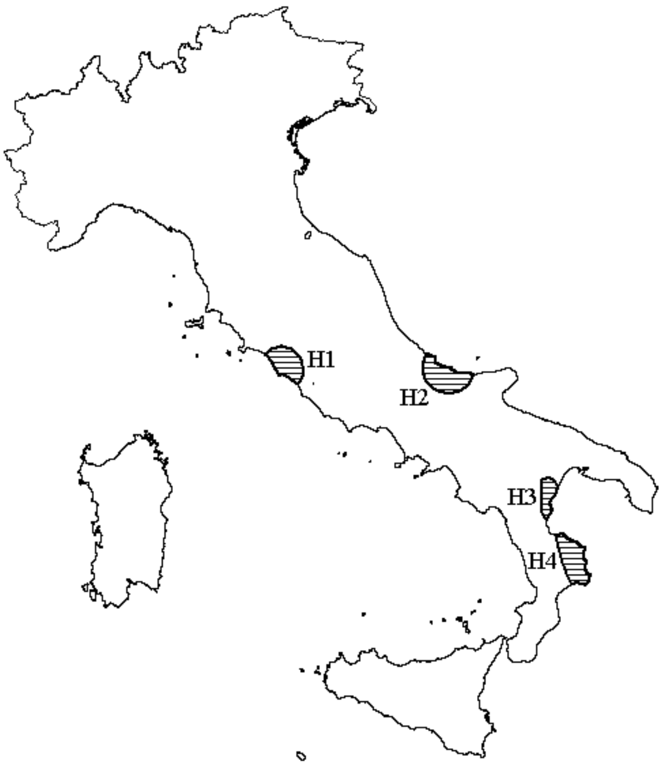


**Figure 5.** European Roller nesting hotspots detected in Italy. IDs are the same as those in Table 3.

**Table 3.** Details of the European Roller nesting hotspots detected in Italy. IDs are the same as those in Figure 5.

| ID | Regions | Provinces | Size (ha) | Mean Altitude a.s.l. (m) | Dominant Land Cover | Utilised in |
|---|---|---|---|---|---|---|
| H1 | Latium | Rome, Viterbo | 198,416 | 200 | non-irrigated arable land | June, July |
| H2 | Abruzzi, Molise | Campobasso, Chieti | 251,192 | 244 | non-irrigated arable land | May, June, July, August |
| H3 | Basilicata, Calabria | Cosenza, Matera | 104,089 | 205 | non-irrigated arable land | May, June, July |
| H4 | Calabria | Cosenza, Crotone | 234,918 | 268 | non-irrigated arable land | May, June, July, August |

The four nesting hotspots totaled 7886 km$^2$, of which 5579 km$^2$ (i.e., 70.7%) corresponded to agricultural areas (CORINE code 2) and 2004 km$^2$ (i.e., 25.4%) to forest and semi-natural areas (CORINE code 3). More specifically, the dominant land cover types were (Table S2): non-irrigated arable land (3251 km$^2$), natural grasslands (1009 km$^2$), complex cultivation patterns (685 km$^2$), and land principally occupied by agriculture with significant areas of natural vegetation (589 km$^2$).

## 4. Discussion

Understanding factors that affect nest site selection by threatened bird species is a prerequisite for the establishment of conservation programs of the breeding sites. For this reason, in this study we used point pattern analyses to thoroughly detect space–time patterns of nest site and nesting area selection by the Italian population of European Rollers between 2016 and 2018.

We found that the spatial distribution of selected nest locations was significantly nonrandom and clustered for all years and months investigated. This result was largely expected; in fact, the choice of nest locations by European Rollers is known to be influenced by precise spatial criteria and environmental factors [2,7]. However, it was also conceivable that, in July and August, late-breeding European Rollers could settle for less suitable nesting areas, thus causing random patterns in nest site selection. Instead, we found that choice of nest locations was significantly tied to spatial factors during the late breeding period as well.

We found only few differences in the spatial patterns of nest site selection between years. Our results confirm the breeding philopatry of European Rollers, whose breeding dispersal is low, with Rollers often nesting in the same cavity in subsequent years [1]. By contrast, we discovered significant shifts between months in both the longitudinal and latitudinal coordinates of selected nest locations, with northward and westward shifts from May to August. In May and June, early breeders chose the southernmost and easternmost nest sites along the Ionian and southern Adriatic coasts, while late breeders preferred, or were forced, to breed further north along the Adriatic coast or further northwest along the Tyrrhenian coast. Because the initiation of a replacement clutch after the failure of the first clutch is rare in the Roller [1], we can reasonably exclude that the explanation of the intra-annual geographical shift of nesting areas is a movement of failed breeders. The higher temperatures in the southern Italian areas might favour chick embryo development and subsequent egg hatching during the incubation phase [23]. In addition, high temperatures can maintain eggs in the right conditions during periods when parents are away from the nest, thereby ensuring the embryonic survival/growth [23]. This suggests that early breeders select the most favourable (and still uncolonised by conspecifics) areas for breeding, while late breeders must settle with the second-best options. In fact, because in this species early breeders tend to remain in the nesting areas even in the post-breeding period, particularly in the case of elevated fledging success [17], the southernmost nest sites are occupied by early breeders in the post-breeding period as well; thus, late breeders are forced to select the nesting areas at more northerly latitudes. In addition to the more suitable (i.e., warmer and dryer) climate conditions, it is also possible that distance to Africa is another criterion by which European Rollers decide priority areas for breeding, i.e., southern areas closer to Africa are considered better platforms for the successive migratory stage. This pattern of hierarchical nest site selection also held for altitude, suggesting that early breeders prefer lower (and, thus, warmer and dryer) areas for nesting. Instead, late breeders must settle with higher ones.

We detected four main nesting areas (i.e., hotspots) in central and southern Italy, whose utilization by the European Rollers differed between months but not between years. These hotspots have similar land cover compositions, with a prevalence of non-irrigated arable lands and natural grasslands. Interestingly, these hotspots are almost completely outside protected areas (parks and/or reserves); only the hotspot H1 is, in part (8.6% of its extent), within parks and/or reserves. This attests to the difficulty in preserving this species, which is not a regular visitor to protected areas in Italy. The Alta Murgia national park (68,565 hectares; Apulia region, Southern Italy; Figure S3) was the only important protected area in Italy to host a fair amount of selected nest sites, although the density of such nest locations was not sufficient to make this park a further nesting hotspot for this species. The reason is that the Alta Murgia national park is the only national park in Italy where agricultural, forest, and semi-natural areas (in particular, pseudo-steppes) co-occur, thus providing suitable habitat for many farmland bird species [24–26].

Because we sampled about 25–30% of the Italian population of European Rollers, we cannot exclude that further nesting hotspots are present in Italy.

*Implications for Conservation*

Our results can improve the conservation strategies of the breeding sites of this declining species in Italy, and indicate that the nesting hotspots detected in this study should go through urgent conservation and management activities.

First, illegal hunting (poaching) of European Rollers is common in Italy. Poachers do not kill these birds; instead, they capture both chicks and adults at the nest sites and sell them at the black market. The illegal trading of European Rollers in Italy can be limited by monitoring the detected nesting hotspots when they are most active (Table 3). The nest sites outside the four hotspots could be monitored against poaching, as well, by scheduling field work in accordance with the temporal dynamics detected in this study: in May and June, the highest priority should be assigned to the southernmost and easternmost nesting areas at lower elevations, while, in July and August, conservationists should shift their attention northward, westward, and upward to monitor the second-best options for nesting.

Second, the density of hole-nesting birds is closely correlated with the availability of natural cavities [27]; in fact, the removal of isolated trees and hedges has led to the decline of many cavity-nesting birds in agricultural areas [28]. The removal of old trees, which have the highest abundance of natural holes, should be thus prohibited in the four nesting hotspots detected in this study. Incentives to farmers from the European Agricultural Fund for Rural Development 2021–2027 could be used for this purpose.

Third, the installation of new nestboxes and the maintenance of old ones is a widely used conservation measure for enhancing habitat suitability for cavity-nesting birds wherever natural holes are scarce [29]. The provision of nestboxes promotes colonization of areas from which people have removed trees; however, it is necessary to assess the productivity of occupied nestboxes to obtain the best results in terms of conservation gain; otherwise, nestboxes could attract birds to unsuitable breeding places that could be ecological traps [30]. Our study suggests that the most suitable areas for European Rollers are a mix of non-irrigated arable land, natural grasslands, complex cultivation patterns, and land principally occupied by agriculture with significant areas of natural vegetation. In addition, the highest priority in nestbox provisioning should be assigned to the southernmost and easternmost nesting areas at lower elevations, as emerged in this study. Further criteria for the installation of new nestboxes deal with the absence of local-scale threats to this species [11]: (1) agricultural intensification; (2) intensification of forest management; (3) use of pesticides; (4) electrocution risk (due to the use of the electric wires as hunting perches); (5) proximity to heavy traffic roads. The installation of new nestboxes for European Rollers in areas with similar land cover compositions has a low risk of attracting birds to ecological traps.

In this view, the Alta Murgia national park seems an ideal place for intensive nestbox provisioning as it fits all the geographical (latitude, longitude, and altitude), landscape (land cover composition), and local-scale (absence of threats) criteria mentioned above. Although we detected sixteen breeding cavities occupied within this national park during 2016–2018, this was not enough to make it a nesting hotspot. However, the installation of new nestboxes could promote the intensification of nest site selection by European Rollers in this area and give rise to a new nesting hotspot for this species in Italy.

## 5. Conclusions

Farmland birds are considered key biodiversity indicators worldwide. These species have declined since the second half of the 20th century; therefore, effective analytical tools are necessary for the monitoring and conservation of bird diversity in farmlands.

In this study, we fed field data collected from 2016 to 2018 into point pattern analyses in order to investigate the space–time patterns of nest site and nesting area selection by the Italian population of European Rollers. Our methodological approach successfully extracted the complex behaviour of this species during the nesting stage. Our results indicate several ad hoc management practices to: a) better counteract illegal poaching; b) limit or prevent the removal of isolated trees and hedges within the main nesting areas detected in this study; c) supply new nestboxes only in those areas where the best results, in terms of conservation gain, can be achieved and ecological traps can be avoided. This knowledge can fill the knowledge gaps about this population in Italy and serve as information for conservationists and planners to design more effective monitoring and prioritizing of the nesting areas of this important farmland species in Italy.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/d16070359/s1, Figure S1: Distribution of the latitudinal and longitudinal coordinates of the nest sites selected by the European Rollers during 2016–2018, separately for years; Figure S2: Distribution of the altitudinal coordinates of the nest sites selected by the European Rollers during 2016–2018, separately for years and months; Figure S3: Alta Murgia National Park (Apulia region, Southern Italy); Table S1: Details of the nest sites selected by the European Rollers during 2016–2018; Table S2: Land cover types within the nesting hotspots of the Italian population of European Rollers.

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