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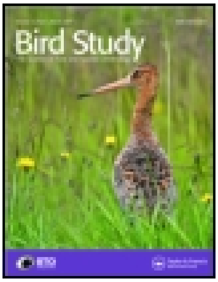

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Nest-site selection and breeding success in the Lesser Kestrel *Falco naumanni*

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Nest site occupancy by Lesser Kestrels was studied in three colonies located in churches in southern Spain. Occupied nest-holes were located significantly higher than unused potential nest-holes. Precise nest dimensions, on the other hand, seemed to be of secondary importance. As breeding success was positively correlated with the height on the nest, we suggest that Lesser Kestrels selceted the highest positions to avoid predation and disturbance (by carnivores or humans). Additionally, 78% of all breeding attempts were in previously ooccupied nest-holes and were more successful than attetmts in holes used only once during the 3-year study. The fact that re-occupied, and hence preferred, nest registered earlier laying dates, suggests that a hierarchy might by established at the time of selcecting the nest site, This hierarchy would be determined by the different times of arrival of each individual at the ecolony after the winter.

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The Lesser Kestrel *Falco naumanni* is a small migratory falcon that breeds in holes, often in colonies of up to 100 pairs.[1] In Europe, colonies are usually in old buildings, such as churches and castles.[1-3] The species has suffered a sharp decline in Europe since the 1960s.[1] In Spain, which has the largest population in the Western Palearctic,[3] the Lesser Kestrel is now an endangered species,[4,5] even though some decades ago it was considered the most abundant bird of prey in that country.[6,7] Pesticides have been considered responsible for this decline in Spain and elsewhere.[1,8] Recently, it has been suggested that Lesser Kestrels could also be suffering from a shortage of suitable nest sites,[5,9] because some traditional colonies in Southern Spain have been deserted after rebuilding operations.[10]

Our aims were (a) to describe the nest-holes and to examine how they are distributed in the colonies, and (b) to identify the factors involved in nest-site selection by the Lesser Kestrel. Collias & Collias[11] stated that the nest quality may affect breeding success. So, we hypothesized that preferred holes should be occupied sooner and by individuals having the greatest success. If the quality of the nest-holes does not decrease after use (e.g. due to parasites[11,12]) a reoccupation of the preferred nest-holes would also be expected.

STUDY AREA AND METHODS

The study was conducted in three neighbouring colonies of Lesser Kestrel in the intensively farmed Guadalquivir river valley, Sevilla province (Southern Spain) The colonies were on brick and stone churches, in the villages of Arahal, Carmona and Morón de la Frontera. Almost all the nest-holes were prism-shaped, and they were regularly distributed in both internal and external walls of the buildings. Formerly, these holes supported wooden scaffolds during restoration work.

In 1988 we made an exhaustive inventory of all the holes capable of housing kestrels. We considered as potential nests those holes having an external opening larger than 25 cm^2, and more than 10 cm deep. We measured the height, width, and depth of every hole, as well as their height from the floor (not the ground level but the nearest floor from which a walking predator could reach the hole). Many holes, and also some nests, were located indoors, and the kestrels reached them through open windows. The orientation of the opening was recorded in the case of the external nest-holes. Some holes went right through the walls and had two openings. Additionally, we measured the distance from each hole to its nearest neighbour in one of the colonies (Arahal). We also estimated the distance from every Lesser Kestrel's nest-hole to the nearest neighbour each season to examine the distribution of nests in this colony.

During the 1988 to 1990 breeding seasons we located all nests in Arahal and Morón de la Frontera, and visited them to determine the number of young fledged per laying pair (including total failures). In the colony at Carmona we estimated breeding success in 1988. Samples sizes vary between analyses because we were unable to measure every parameter for every nest-hole (particularly laying-date and breeding success).

RESULTS

On average, nest holes were 17 cm wide, 14 cm high and 80 cm deep, being located 3.29 m from the floor (Table 1). Sites occupied by Lesser Kestrels were significantly higher than unoccupied holes, but similar in any other respect (Table 1). The orientations of the nest openings apparently followed that of the available holes (Table 2). The kestrels did not show preferences either for holes opening outdoors or indoors, or for holes with one or two openings (Table 3). With regard to the distribution of nest-holes in Arahal, the average nearest neighbour distance between them (mean = 104 cm, sd = 33, n = 29) did not differ from the

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Table 1. Means (±sd) for selected parameters of the Lesser Kestrels' nest-holes and other holes

Parameters	*Nest-holes (n = 89)*	*Other holes (n = 157)*		
Width (cm)	17.2±5.0	17.4±8.9	t = 0.17 df = 244	P = 0.86 ns
Height (cm)	14.4±4.0	14.0±3.5	t = −0.84 df = 244	P = 0.40 ns
Depth (cm)	80.4±35	80.2±40	t = −0.04 df = 244	P = 0.97 ns
Height from floor (m)	3.29±2.2	2.39±2.1	t = −3.06 df = 244	P = 0.002**

Table 2. Number of available holes, as well as Lesser Kestrels' nest-holes, grouped in quadrants (Note: the Lesser Kestrels did not seem to prefer any particular orientation (x^2_3 = 0.646, P = 0.885)

	1–90°	*91–180°*	*181–270°*	*171–360°*
Available holes	15	25	28	21
Nest-holes	5	9	14	9

Table 3. Frequency of nest-holes and unused holes being outdoors/indoors and having 1 opening/2 openings

	Nest-holes	*Other holes*	
Outdoors	39	64	χ^2_1 = 0.11 P = 0.73 ns
Indoors	50	93	
1 Opening	21	48	χ^2_1 = 1.04 P = 0.3 ns
2 Openings	68	109	

Table 4. Summary of data concerning nest occupancy by Lesser Kestrels in the colonies at Arahal and Morón de la Frontera

	Arahal	*Morón*	*Total*
Suitable holes	105	132	237
Lesser Kestrels' nest-holes	40 (38%)	64 (48%)	104 (43%)
Breeding pairs (1988–1990)	65	112	177
Broods in re-occupied holes	52 (78%)	88 (78%)	140 (79%)

average distance between neighbouring holes in the building (mean = 96 cm, sd = 42, $n = 61$) ($t = -0.0979$, $P = 0.164$, df = 88). Therefore, it seems that Lesser Kestrels did not try to space themselves as much as possible.

The availability of potential nest-sites seemed to be high and 57% ($n = 237$) of the holes in the colonies were never occupied by kestrels during the period of study (Table 4). Most breeding attempts at Arahal and Morón de la Frontera (79%, $n = 177$) took place in nest-holes used during more than one season. The pairs using re-occupied nests were more successful on average (mean = 1.88 fledglings, sd = 1.3, $n = 133$) than those breeding in holes where we registered a single occupancy during the study (mean = 1.22 fledglings, sd = 1.22, $n = 36$) (Mann–Whitney *U*-test = 3165, $P = 0.018$, $n = 173$). In addition, we detected a positive correlation between the height of the nests from the floor and breeding success ($r_s = 0.243$, $P < 0.001$, $n = 173$) (Fig. 1). High nests registered earlier laying dates in 1988 ($r_s = -0.457$, $P < 0.05$, $n = 47$), but this correlation was not evident in 1989 ($r_s = 0.020$, $P > 0.05$, $n = 52$) and 1990 ($r_s = 0.12$, $P > 0.05$, $n = 49$). Laying dates started earlier in re-occupied nests (mean = 23.17 days, sd = 7.88, $n = 123$, day 1 corresponds to the starting of the first clutch) than in the others (mean = 26.19 days, sd = 7.47, $n = 26$) ($t = -1.79$, $P = 0.037$, df = 147). Correspondingly, re-occupied nest-holes were in higher positions (mean = 344 cm, sd = 214, $n = 63$) than the others (mean = 293 cm, sd = 213, $n = 30$), although the difference was not significant ($t = 1.06$, $P = 0.14$).

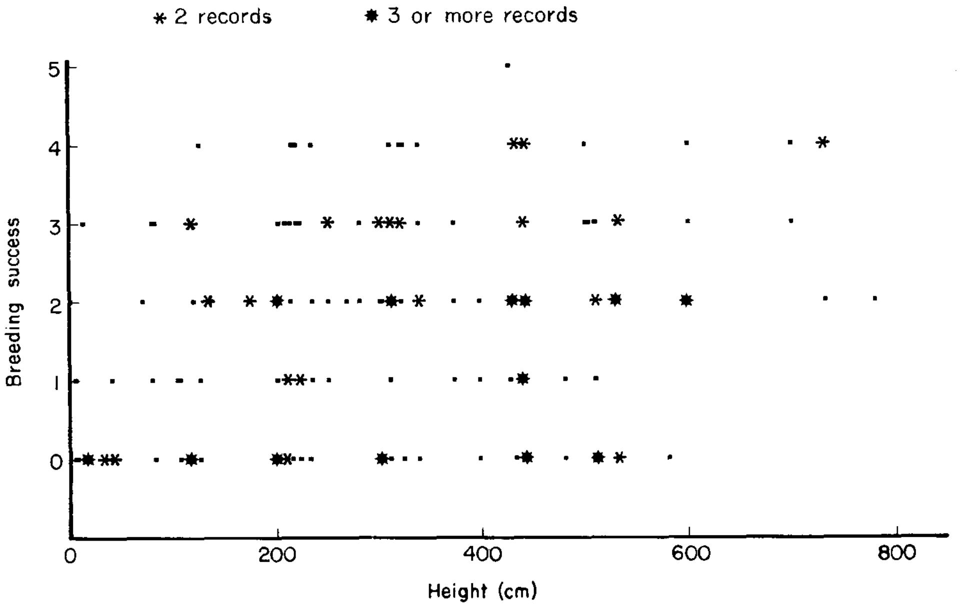

Figure 1. Breeding success (number of fledglings) against height of the nest-holes.

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DISCUSSION

Lesser Kestrels selected the highest holes to breed in and, as expected, the number of fledged young was correlated with the nest's height from the floor. It is not strange that we did not find differences between the width, height and depth of the nest-holes and the other holes, as the prism-shaped holes were all of similar dimension. We cannot discount, however, that the above mentioned variables may be important in locations where Lesser Kestrels have a wider range of potential nest-sites to choose from (e.g. in natural outcrops[1,5]). On the other hand, it seemed that the quality of the nest-holes did not decrease from year to year in our study area, as most of them were re-occupied, and those that were re-occupied had a higher breeding success. The reason why the kestrels preferred to breed in the highest holes can be explained as a mechanism to avoid predation.[13,14] The colonies were located on public buildings visited by people, so nests were sometimes disturbed or even robbed.[5,9] Additionally, some carnivores have been reported preying upon adult and nestling Lesser Kestrels (Domestic Cat *Felis catus* and Black Rat *Rattus rattus*;[2] Marten *Martes foina*[8]). Cats and rats were observed at the colonies that we studied and could have been responsible for some losses, although we were unable to confirm any specific cases. The higher breeding success for pairs using the holes in the highest positions—with lower disturbance and/or predation—would explain why Lesser Kestrels preferred these holes. The fact that they did not select any particular orientation, nor discriminate between holes with one or two openings suggests that the probability of failure by predation or disturbance was the same irrespective of those features.

It has been suggested that hole-nesting birds are limited by the number of available nest-sites at the time of breeding.[15,16] In fact, the density of some kestrel species has been notably increased after the installation of nest-boxes (Common Kestrel *Falco tinnunculus*,[17,18] American Kestrel *Falco sparverius*[19]). The Lesser Kestrels that we studied seemed to have a surplus of potential nest-sites. Nevertheless, the fact that they preferred to breed in the highest locations, and were more successful there, indicate that they could be actually suffering from a shortage of optimal nest-sites.

Several observations led us to think that a hierarchy might be established at the time of selecting the nest-holes: (a) re-occupied, and hence preferred, nests registered earlier laying dates, (b) higher nests tend to register earlier laying dates and (c) adult males breed significantly earlier than yearling males and clutch size declines as the breeding season progresses.[20] The more dominant individuals would take the higher locations, and the subordinates, lower ones. This being the case, the difference between 'low' and 'high' nests, in terms of breeding success, might be increased by the different abilities of the birds involved. The factor establishing the suggested hierarchy would be the time of arrival at the colonies after the winter. Adult birds would have more opportunities to choose nest-holes as they return during February and March, whereas yearlings, which are able to reproduce, [2,8] arrive from March to May.[21] The same phenomenon has been recorded in the Common Kestrel with regard to territory occupancy.[22]

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