J. Ornithol. 141, 345–350 (2000)
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ISSN 0021-8375

Nest-site selection and breeding success in the Roller (*Coracias garrulus*) in the Southwest of the Iberian peninsula

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Summary

Nest-site selection and breeding success was studied in a breeding population of Roller (*Coracias garrulus*) in the Southwest of Spain. 567 nest-boxes were installed on electric pylons in seven different habitats: fallow land, cereals, holm oaks, olive groves, pasture land, irrigated crops (rice and maize) and shrubs. The more favoured habitats were the irrigated crops, the olive groves and the holm-oaks, while only the cereals were clearly avoided. Fallow land, pastures and shrublands were preferred approximately according to their availability in the area. The mean laying date of Rollers was significantly different between habitats, however, the other reproductive variables did not vary with habitat type. The seasonal trend in reproductive value of the Roller varied relative to habitat type. So, in olive groves and irrigated crops no clear seasonal trends were detected in clutch size, while a clear seasonal decline in clutch size was detected in the rest of the habitat types. The intensity of selection of each habitat was only marginally related to the hatching success of the rollers in Extremadura. These results indicate that the decrease in natural nest-sites as a result of the intensification of agriculture is the principal cause of the decline in Roller populations in contrast to previous studies which argued that this was a consequence of the decrease in available food.

Key words: Habitat, nest-site selection, breeding rate

Zusammenfassung

Nistplatzwahl und Bruterfolg der Blauracke (*Coracias garrulus*) im Südwesten der Iberischen Halbinsel

In einem Gebiet in SW Spanien wurden Nistplatzwahl und Brutbiologie der Blauracke untersucht. Dazu wurden 567 Nistkästen in sieben verschiedenen Lebensräumen an Hochspannungsmasten angebracht, in Brachland, Getreide, Steineichen, Olivenhainen, Weideland, bewässerte Reis- und Maisfelder und in Buschland. Die bevorzugten Habitate waren die bewässerten Flächen, die Olivenhaine und die Steineichen; die Getreideflächen wurden auffällig gemieden. Brachland, Weideflächen und Buschland wurden etwa entsprechend ihres Flächenanteils im Gebiet genutzt. Der mittlere Legebeginn, nicht jedoch die anderen brutbiologischen Parameter, unterschied sich signifikant zwischen den Habiaten. Auch der saisonale Verlauf der Brutdaten variierte zwischen den Lebensräumen. Mit Ausnahme der Olivenhaine und der bewässerten Flächen nahm die Gelegegröße in allen anderen Habitaten mit Fortschritt der Brutzeit ab. Die Habitatwahl war nur wenig vom Bruterfolg bestimmt. Die Ergebnisse zeigen, dass der Verlust natürlicher Nistplätze in Folge der

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Intensivierung der landwirtschaftlichen Nutzung der haupsächliche Faktor für den Rückgang der Blauracke in der Estremadura ist und nicht, wie früher angenommen, der Rückgang an Nahrung.

Introduction

The Roller (*Coracias garrulus*) is widely distributed across the Palearctic region (Cramp & Simmons 1988). Their breeding populations are highly fragmented and generally in decline (see revision in Hagemeijer & Blair 1997). The main cause of this trend is considered to be the loss of suitable habitat as a consequence of the intensification of agriculture (Tucker & Heath 1994, Purroy 1997), although there are no studies in which this claim had been directly checked (Avilés 1999). Breeding data for Roller are scarce in Europe (Avilés et al. 1999), and almost nothing is known of their breeding biology under different habitat conditions because of their cliff-nesting habits (Cramp & Simmons 1988), and threatened status in Europe (Hagemeijer & Blair 1997).

Nest-boxes are used as nest sites by Rollers (Sosnowski & Chmielewski 1996, Avilés & Sánchez 1997) and they offer an opportunity for breeding studies in hole-nesting bird species in which natural nest-sites are very scarce (Jarvinen 1980, Clutton-Brock 1988). The aim of this study is to test the influence of habitat on the breeding performance of the Roller in the Serena region of Spain. On the basis of different qualities of habitats we expect highest breeding success in those habitats preferred by the species.

Study area and methods

The Serena region (39°03′ N, 5°14′ W) is in the mesomediterranean climate area (Rivas-Martínez 1981). During May and June the mean temperature is 17.7 °C and the mean rainfall is 11.6 mm (Avilés et al. 1998). On 1989 in the study area 567 nest-boxes were installed on electric pylons (see Sánchez & Sánchez 1991 for a detailed description) in seven different habitats: (1) fallow land (n = 26), (2) cereals (oats, wheat and barley; n = 159), (3) Holm oaks (*Quercus rotundifolia*; n = 63), (4) olive groves (n = 14), (5) pasture (n = 237), (6) irrigated crops (rice and maize; n = 18), and (7) shrubs (mainly *Retama sphaerocarpa*; n = 50; Fig. 1). Those habitats with possible natural holes (3 and 4) were visited during data collection to check possible breeding of Roller outside the nest-boxes. In no case Roller did breed outside the boxes, which meant that the breeding performance of the species in these two habitats was representative.

All the boxes were monitored weekly from the first stages of breeding. In those boxes occupied by rollers the frequency of visits was increased (every 3–4 days) during the nesting period to determine the breeding success more accurately. The laying date for each nest was determined by subtracting the incubation period of the species (Cramp & Simmons 1988) from the hatching date. Hatching date was determined by experienced observers, who took into account that the laying interval in the species is two days (Cramp & Simmons 1988). We calculated percent hatching success as the percentage of eggs within each clutch that hatched; counted the number of fledglings per successful nest, defining the latter as one in which at least one chick fledged and measuring the breeding success as the number of fledglings per pair that laid at least one egg.

We used the Jacobs index to compare the used and available habitats (Jacobs 1974). The index ranged from –1 to +1 these being respectively the extreme negative and positive preference. The Jacobs index has not a significance test but is very useful in studying the relationships between the intensity of selection and other variables (Atienza 1994). Taking into account that the home range of the Roller during the breeding season in the studied population

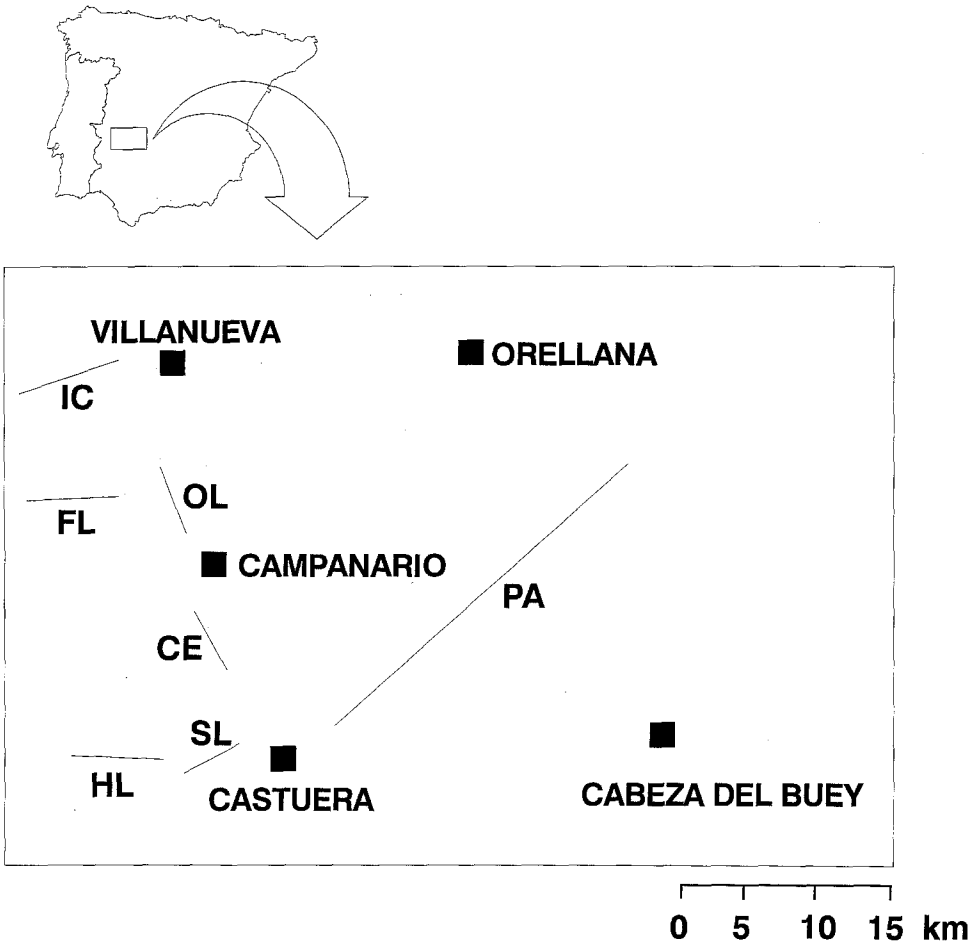

Fig. 1. Map of the study area showing the geographical situation and length of the studied electric power lines (lines) in each habitat type. The squares are the principal towns in the Serena region. The codes for habitat types are: fallow land (FL), cereals (CE), Holm oaks (HL), olive groves (OL), pasture (PA), irrigated crops (IC) and shrubs (SL).

Abb. 1. Karte des Untersuchungsgebietes mit den Hochspannungsleitungen (Linien). Quadrate: Städte. Abkürzungen für die Habitate: FL: Brachland, CE: Getreide, HL: Steineichenwälder, OL: Oliven, PA: Weideland, IR: bewässerte Flächen, SL: Gebüsch. Anzahl Nester in Klammern.

was 165.0 ± 171.2 m, and that the 66.7 % of the adult foraging flights in the same period were inside an area with a radius of 100 m (Avilés & Costillo 1998), each nest-box was assigned to the habitat in which it was situated. We did not consider in this study the last two boxes in each electric power line included in habitat type in order to avoid the possible effect of the proximity of two habitats type on nest site selection and breeding success of the Rollers. The availability was defined as the number of nest-boxes located in each habitat and the habitat used as the number of nest-boxes occupied by the species in each habitat type.

Analyses of the variance and of the covariance on transformed variables according to Zar (1996) were used to check habitat differences in reproductive values of rollers. Seasonal decline in breeding values and the relationships between the intensity of selection of each habitat and its respective breeding value were studied using two-tailed and one-tailed Spearman correlations.

Results

Habitat Selection

The habitat types in the study area most often selected by rollers were the irrigated crops, the olive groves tree lands and the holm-oaks, while only cereals were clearly avoided by nesting rollers (Fig. 2). Fallow lands, pastures and shrublands were selected approximately according to their availability in the area (Fig. 2).

Breeding values according to habitat type

The mean laying date of Rollers was significantly different between habitats (ANOVA; $F_{6,139} = 2{,}29$ $p = 0.038$, Table 1). However, clutch size, hatching success, fledglings per successful nest and the breeding success of the Roller did not vary with habitat type (ANOVA; $p > 0.05$ in the five cases; Table 1). Clutch size, hatching success, fledglings per successful nest and breeding success did not vary in relation to habitat type where the laying date was checked (ANCOVA; $p > 0.05$ in the four cases). The seasonal trend in clutch size varied with habitat type (ANCOVA; Interaction clutch size x habitat type; $F_{6,139} = 9.15$; $p < 0.0001$). Thus, in the

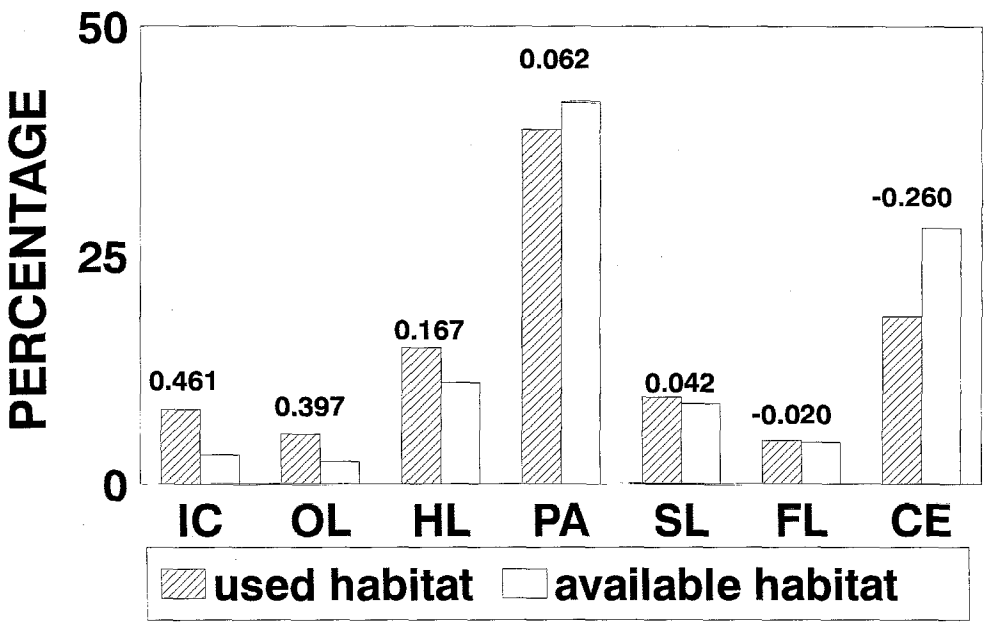

Fig. 2. Percentage distribution of used (dark bars) and available (white bars) nest-boxes in relation to habitat type. Jacob index is shown for each habitat on bars. The codes for habitat types are: fallow land (FL), cereal (CE), Holm oaks (HL), olive groves (OL), pasture (PA), irrigated crops (IC) and shrubs (SL). Habitats are ordered in relation to the magnitude of Jacob index.

Abb. 2. Häufigkeitsverteilung genutztet (dunkle Säulen) und verfügbarere (helle Säulen) Nistkästen in den verschiedenen Habitaten. Zahl über den Säulen: Jacob-Index. Abkürzungen für die Habitate: FL: Brachland, CE: Getreide, HL: Steineichenwälder, OL: Oliven, PA: Weideland, IR: bewässerte Flächen, SL: Gebüsch. Anzahl Nester in Klammern.

Table 1. Mean (± s. d.) reproductive values of the Roller according to habitat type in the Southwest of Spain. The codes for habitat types are: fallow land (FL), cereal (CE), Holm oaks (HL), olive groves (OL), pasture (PA), irrigated crops (IC) and shrubs (SL). Sample size in brackets.
Tab. 1. Mittlere (± s. d.) Fortpflanzungsdaten der Blauracke in verschiedenen Habitaten in SW Spanien. Abkürzungen für die Habitate: FL: Brachland, CE: Getreide, HL: Steineichenwälder, OL: Oliven, PA: Weideland, IR: bewässerte Flächen, SL: Gebüsch. Anzahl Nester in Klammern.

	FL	CE	HL	LO	PA	IC	SL
Laying date (days from 1 January)	140.6 ± 3.6 (7)	145.1 ± 5.8 (27)	140.3 ± 9.0 (21)	141.9 ± 2.1 (8)	144.4 ± 7.9 (57)	140.8 ± 11.7 (12)	138.2 ± 5.8 (14)
Clutch size	4.8 ± 1.1 (7)	4.3 ± 1.2 (27)	4.4 ± 0.8 (22)	4.4 ± 0.8 (8)	4.5 ± 1.2 (57)	4.2 ± 1.1 (12)	5.2 ± 0.8 (14)
Hatching Success	64.0 ± 32.5 (7)	73.8 ± 31.9 (26)	73.7 ± 23.7 (22)	78.9 ± 19.6 (8)	76.9 ± 31.5 (54)	84.8 ± 23.1 (10)	77.7 ± 25.3 (14)
Fledglings per successful nest	3.8 ± 0.9 (6)	3.4 ± 1,5 (24)	3.2 ± 1.0 (22)	3.5 ± 1.2 (8)	4.0 ± 1.3 (49)	3.9 ± 1.2 (10)	4.1 ± 1.5 (14)
Breeding success	3.3 ± 1.7 (7)	3.2 ± 1.8 (26)	3.2 ± 1.0 (22)	3.5 ± 1.2 (8)	3.6 ± 1.7 (54)	3.9 ± 1.2 (10)	4.1 ± 1.5 (14)

olive groves and in the irrigated crops no clear seasonal trends were detected in clutch size (two-tailed Spearman correlation; $r_s = -0.32$, $p = 0.43$, $n = 8$ and $r_s = 0.01$, $p = 0.97$, $n = 12$ respectively), while a clear seasonal decline in clutch size was detected in the fallow lands (two-tailed Spearman correlation; $r_s = -0.92$, $p = 0.002$, $n = 7$), in the cereals (two tailed Spearman correlation; $r_s = -0.57$, $p = 0.002$, $n = 27$), in the holm-oaks (two-tailed Spearman correlation; $r_s = -0.53$, $p = 0.012$, $n = 21$), in the pastures (two-tailed Spearman correlation; $r_s = -0.73$, $p = 0.000$, $n = 57$) and in the shrublands (two-tailed Spearman correlation; $r_s = -0.554$, $p = 0.039$, $n = 14$).

The intensity of selection of each habitat was only marginally related to the hatching success of the rollers in Extremadura (one-tailed Spearman correlation; $r_s = 0.678$, $p = 0.06$, $n = 7$). However, the rest of the breeding values were in no case related to the intensity of selection of each habitat type (one-tailed Spearman correlation; $p > 0.05$ in the three cases).

Discussion

The Rollers' choice of the habitat type for nesting affected their reproductive value. In the study area the irrigated area was the habitat most preferred by the Roller among the available ones. In this habitat the Rollers did not show a higher breeding success but the clutch size of each pair did not decline through the season. In the second most preferred habitat, olive groves, similarly clutch size did not decline through the season. In all other habitats, the Roller showed a seasonal decline in clutch size that has been related in pastures, cereals, fallow land and Holm oaks to a seasonal decline in the availability of potential prey for the species (Avilés et al. 1999). However, in that study the irrigated crops and the olive groves do not appear among available habitats. Previous studies have shown too the importance of the availability of food and natural perches in the selection of the breeding territories of the species (Avilés & Costillo 1998). In this light, the Roller would be expected to select olive groves and Holm oaks. In these habitats the growing of the herbaceous vegetation brings about a great abundance of arthropods in the soil (see Avilés & Costillo 1998) which are the main food of the chicks during their nesting period (Avilés & Parejo 1997), and adults can use the abundant natural perches that these two habitat types offer (Avilés & Costillo 1998). Conversely, in the ir-

rigated land, the removal of trees takes away natural perches, though the species use the electric pylons and cables as perches during the foraging time (pers. observ.), and, though there are no studies comparing the availability of potential prey in this and the other habitats in our study area, in other Mediterranean areas a great availability of potential prey for insectivorous waterbirds has been shown in the rice fields (González-Solís et al. 1996). Taking into account that during the study period most of the irrigated surface was devoted to rice fields in the study area (pers. observ.), the evidence points towards the high availability of food as the cause of the Roller preference for this habitat, going against the hypothesis that proposes the decline of food availability, caused by agriculture intensification, as the cause of the species decrease (Tucker & Heath 1994). Our results point to the lack of natural nest sites, as a consequence of the removal of trees, as the main factor influencing the decline in view of the maintenance of the reproductive value of the species through the season when nests were installed in Irrigated lands. But to prove this hypothesis adequately it would be necessary to study the food availability in the seven described habitats.

Acknowledgements

We would like to thank E. Costillo, C. Fuentes, M. Flores and F. J. Medina for their field assistance.

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Accepted: 22 October 1999