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BREEDING BIOLOGY OF THE RED-NECKED NIGHTJAR *CAPRIMULGUS RUFICOLLIS* IN SOUTHERN SPAIN

Juan ARAGONÉS*

SUMMARY.—*Breeding biology of the Red-necked Nightjar* Caprimulgus ruficollis *in shouthern Spain.*
Aims: The main aim of this study is to describe several poorly known aspects of the breeding biology of the Red-necked Nightjar *Caprimulgus ruficollis*.
Location: Córdoba, Southern Spain (37° 55′ N, 4° 55′ E).
Methods: We studied breeding success, laying phenology and nest movement in a population of 26 breeding pairs of Red-necked Nightjar during 1994 and 1995. During 1996, 1997 and 1998 we collected additional data on nest site reuse on 25 nests. For each nest, we considered the following measures of reproductive success: hatching success (proportion of eggs that hatched), fledging success (proportion of hatchlings that resulted in fledged young) and breeding success (proportion of eggs that resulted in fledged young). Statistical analysis was performed using Chi–Square test, Kruskal-Wallis test and Spearman correlation.
Results and Conclusions: Breeding success did not differ between years but we found significant differences within the season. In both years, successful nests were those with earlier laying dates than in unsuccessful ones. Laying phenology patterns were very similar for 1994 and 1995 with median laying date corresponding to 19 May. Clutch size did not differ between years but there were significant differences between successful and unsuccessful nests. We failed to find any evidence of nest movement during the incubation period but during the fledgling period nest movement was very common and our results do not support previous claims on nest movement during the incubation period. Several nests sites from 1994 were reoccupied during the following years, one of them for at least five consecutive years. Reoccupied nest sites were very successful and all the eggs laid in these nests produced fledglings.

Key words: Caprimulgiformes, *Caprimulgus ruficollis*, nest movement, nest site reoccupation, Red-necked nightjar, reproduction.

RESUMEN.—*Biología reproductiva del Chotacabras Cuellirrojo* Caprimulgus ruficollis *en el Sur de España.*
Objetivo: El objetivo principal de este estudio es la descripción de varios aspectos poco conocidos sobre la biología reproductora del Chotacabras Cuellirrojo, *Caprimulgus ruficollis*.
Localidad: Córdoba, Sur de España (37° 55′ N, 4° 55′ E).
Métodos: Estudiamos el éxito reproductivo, la fenología de puesta y el movimiento de nido en una población de 26 parejas de Chotacabras Cuellirrojo durante la estación reproductora de 1994 y 1995. Entre 1996 y 1998 se recogieron datos adicionales sobre la reocupación de nido en otros 25 nidos. En cada nido, se consideraron las siguiente medidas del éxito reproductivo: éxito de eclosión (proporción de huevos que eclosionan), éxito de vuelo (proporción de pollos que se hacen volantones) y éxito reproductor (proporción de huevos que se convierten en volantones). El análisis estadístico se realizó por medio de Chi-cuadrados, test de Kruskal-Wallis y correlaciones de Spearman.
Resultados y Conclusiones: No se encontraron diferencias anuales en el éxito reproductivo aunque si se encontraron diferencias entre las nidadas tempranas y las tardías, siendo las primeras más exitosas. La fenología de puesta fue muy similar para los años 1994 y 1995 con una fecha mediana de puesta correspondiente al 19 de mayo. El tamaño de puesta no presentó diferencias significativas en relación con el año. No encontramos ninguna evidencia de movimiento de nidos durante la fase de huevos pero tras el nacimiento de los pollos el movimiento de nidos fue muy frecuente. Al contrario de lo que se ha sugerido en otros estudios, nuestros resultados no apoyan la existencia de movimiento de nido durante la incubación. Varios nidos de 1994 fueron reocupados durante los años siguientes, uno de ellos al menos durante cinco temporadas consecutivas. Los nidos reocupados tuvieron un alto éxito reproductivo y todos los huevos produjeron volantones.

Palabras clave: Caprimulgiformes, *Caprimulgus ruficollis*, Chotacabras Cuellirrojo, movimiento de nido, reproducción, reocupación de lugares de nidificación.

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* Departamento de Zoología, Universidad de Córdoba, Campus de Rabanales, Ctra. Madrid-Cádiz km 396, E-14071 Córdoba. España. e-mail: ba2biani@uco.es

Introduction

The Red-necked Nightjar *Caprimulgus ruficollis* is quite a common species in Southern Spain but one of the least known birds in its distribution area and there are few studies concerning this species (see reviews in Cramp, 1985; Cleere, 1998; 1999; Holyoak, 2001), most of them due to casual or sporadic observations. However, interest on this species is growing, as shown by several studies carried out recently (Gargallo, 1994; Forero *et al*., 1995; Aragonés, 1996, Cuadrado & Domínguez, 1996; Aragonés, 1997; Forero *et al*., 1997; Aragonés *et al*., 1998; 1999; 2000, Forero *et al*., 2001).

A controversial aspect of caprimulgid biology is nest movement during the incubation period as a defensive response against nest disturbance. Several authors cited this behaviour in different species (Cramp, 1985; Cleere, 1998; 1999; Holyoak, 2001) and there are old references of nightjars transporting eggs in the mouth or in the feet. These observations are not based in serious research and there is no evidence to support it (see review in Jackson, 1984).

During the fledging period, nest movement has been frequently observed (Orr, 1948; Gramza, 1967; Schlegel, 1969; Steyn, 1971; Berry, 1979; Berry & Bibby, 1981; Ingels *et al.,* 1984; Jackson, 1984; Langley, 1984; Jackson, 1985; Alayón, 1985; Roth, 1985; Fry *et al*., 1988; Marchant, 1988; Sick, 1993; Vilella, 1995, Aragonés, 2000, 2001).

In this paper we describe several aspects of the breeding biology of Red-necked Nigthjar such as breeding success, laying phenology and nest movement. Some of these aspects, such as nest site reoccupation and nest movement, were investigated here for the first time for this species.

Material and methods

The study area was located in Guadalcázar (Córdoba, Southern Spain) and was characterised by variable densities of trees (Holm oaks *Quercus ilex*), bushes (mainly *Q. coccifera*, *Pistacia lentiscus*, *Mirtus communis*, *Chamaerops humilis* and *Crataegus monogyna*) and crops (sunflower and wheat) with an intense degree of human management.

We searched the study area extensively for breeding pairs by monitoring singing males, as well as being guided by diurnal and nocturnal observations of individuals. During the 1994 and 1995 breeding seasons (from the end of May to the end of August), we recorded data on the breeding biology of Red-necked Nightjar. Additional data concerning nest site reuse were also recorded during 1996, 1997 and 1998 at several nests ($n = 10$, $n = 8$ and $n = 7$, respectively). All nest sites were plotted in a 1:50,000 UTM map in order to look for patterns of nest site reuse and all nest sites were marked on the field and photographs were taken for precise localisation in following seasons.

Nest search began in early April but the first clutches were not found until May. Nests were visited at two day intervals and eggs were marked using indelible marking pen. Chicks were colour banded at 2 to 4 days old but parents were not marked. At each nest we recorded the breeding stage (the incubation period, the fledgling period and the post-fledgling period), egg or chick numbers and exact localisation of the nest in order to detect nest movement.

The laying date for each nest was estimated from the hatching date, considering an incubation interval of 17 days (Cramp, 1985). For some of the nests ($n = 8$) we could determine the exact laying date from the asynchrony hatching interval between both eggs (Cramp, 1985; Cuadrado & Domínguez, 1996). The length of the incubation period was defined as the number of days between completion of the clutch and the first signs of hatching

We considered the following measures of reproductive success: hatching success (proportion of eggs that hatched), fledging success (proportion of hatchlings that resulted in fledged young) and breeding success (proportion of eggs that resulted in fledged young).

For the analysis of hatching date we followed the criteria used by Castaño (1997) and assigned the value 1, of an ordinal series, to 1st May. A nest was considered as unsuccessful when the eggs produced no fledglings. Measures of reproductive success are reported for those nests in which at least one nestling fledged.

RESULTS

During 1994 and 1995 we located 26 nests (n = 12 in 1994; n = 14 in 1995), of which 20 nests (76.92%) were successful (n = 10 in 1994; n = 10 in 1995), while six nests (23.08%, n = 2 in 1994; n = 4 in 1995) were unsuccessful. Differences in the number of successful nests between years were not significant ($X^2 = 1.00$, $P = 0.317$). Eggs were laid directly on the bare ground or on a leaf litter. In most cases the nest site was located under a tree (n = 17) or a bush (n = 6) with no direct sun light. In three cases, nests were located in the fallow, far away from any source of shadow, under direct sun light during the whole day. Two of these nests failed during the incubation period due to agricultural activities. Most of the chicks fledged at 18 to 20 days old but this date is very variable because some chicks could have been able to fly without being noticed by us.

Breeding parameters

Laying phenology patterns were very similar for both years. During 1994, the laying period was 23 days and 26 days in 1995 (May 14th to 10th June. Fig. 1). The median laying date was 19 May in both years. There were no significant differences in laying phenology between successful and unsuccessful nests. In both years, successful nests were those with earlier laying dates than unsuccessful ones. The mean laying date in unsuccessful nests was 30.50 (SD = 6.50, N = 6) and 18.80 in successful nests (SD = 3.47, n = 20). Differences were significant (Kruskall-Wallis test, $H = 11.16$, $P < 0.001$). On the other hand, there were no significant yearly differences in the mean laying date of successful nests (Kruskall-Wallis test, $H = 0.21$, $n = 20$, $P = 0.320$) between 1994 (mean = 19.30, SD = 1.03, n = 10) and 1995 (mean = 18.33, SD = 2.49, n = 10). In the nests where it was possible to follow the complete incubation period, we recorded an incubation period of 17 days (range = 16-19 days, n = 8). In 19 nests (73.1%) the females laid two eggs (n = 10 in 1994; n = 9 in 1995) while in seven nests (26.39%) clutch size was only one egg (n = 2 in 1994; n = 5 in 1995). There were no differences in clutch size between years (Table 1) but we found differences (Kruskall-Wallis test, $H = 9.72$, $P < 0.01$) between the clutch size of successful (mean = 1.85, SD = 0.37, n = 20) and unsuccessful nests (mean = 1.33, SD = 0.52, n = 6).

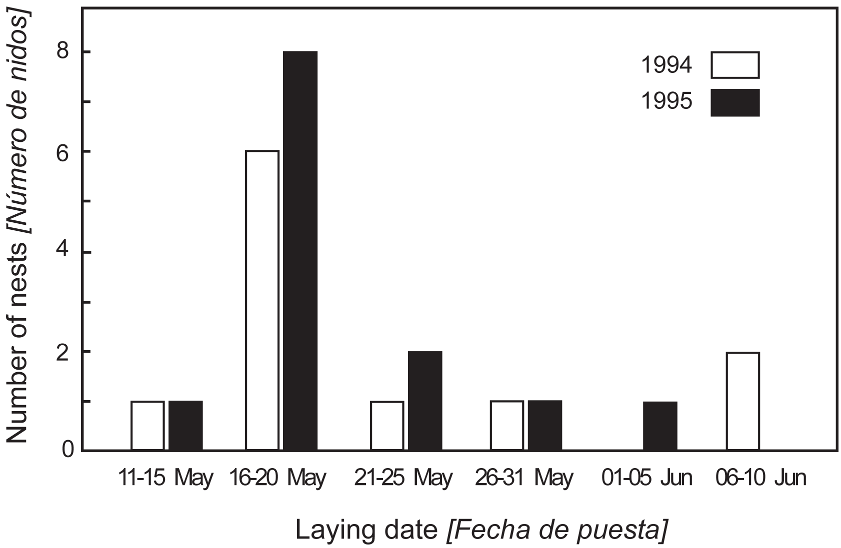

FIG. 1.—Laying phenology of Red-necked Nightjars in southern Spain.
[Fenología de puesta del Chotacabras Cuellirrojo en el sur de España.]

Hatching success was very high, with 34 chicks hatching (91.89%) from 37 eggs. Fledgling success was high too, with 86.11% of hatchlings (n = 31) producing fledglings. In the case of unsuccessful nests, losses took place during the incubation period (five eggs in four nests) and during the nestling period (three chicks in two nests). The causes of nest failure were due to agricultural activities (three nests) or to nest predation (three nests). During the incubation period we found evidence that losses were due to Eyed Lizard (*Lacerta lepida*), while during the fledgling period we found evidence of an undetermined species of snake trying to swallow a half grown chick and at another preyed nest tracks of a Fox (*Vulpes vulpes*).

Nest movement

During the incubation period, none of the 26 nests of 1994 and 1995 were moved but three of them disappeared from their initial site. We do not know if this was due to nest predation or due to nest movement. We were unable to find any evidence of a marked egg (n = 43, only two out of 45 eggs were not marked) being moved during this period, in spite of the fact that nests were disturbed due to data recording. Our observations concerning the breeding seasons of 1996, 1997 and 1998 (25 nests) were not as systematic as in the previous seasons but we could not find evidence of nest movement during the incubation period. On the other hand, all the nests were moved during the fledgling period but with individual variations in distance, which reached up to 18 m (Fig. 2). Nest movement increases with the age of the chicks, reaching the highest value when the chicks are ready to fly (r_s = 0.94, n = 6, P < 0.005). During the post-fledging period nest moment decreases but differences are not significant (r_s = –0.80, n = 4, P = 0.200).

Nest site reoccupation

We considered that a nest site of 1994 was reoccupied if a new nest was located in the exact same site or within 30 cm. We found one case of nest site reoccupation during five consecutive years. Another nest site was reoccupied during four consecutive years and two nest sites were used for three years. All reoccupied nest sites were very successful from 1994 to 1998, with all eggs laid producing fledglings. Between the years 1999 and 2002 we checked the nest site occupied for five years in order to look for new reoccupation. In 1999 we failed to find it but in 2000 we found a nest located at no more than 1.5 m from its 1998 location. We found no evidence of nest reoccupation in 2001, but in 2002 we found a nest in the same site in which there had been a nest during each season from 1994 to 1998.

Discussion

Our results suggest that clutch size is higher in successful nests and that there is a seasonal decline in reproductive success, with pairs breeding early in the season being more successful than pairs breeding late, a common pattern in

TABLE 1

Reproductive success of Red-necked Nightjars in southern Spain (H = Kruskall-Wallis test; *** = P < 0.001; ** = P < 0.01; * = P < 0.05, NS = P > 0.05).
*[Éxito reproductivo del Chotacabras Cuellirrojo en el sur de España (*H *= test de Kruskall-Wallis; *** = *P *< 0,001; ** = *P *< 0,01; * = *P *< 0,05;* NS = P *> 0,05).]*

	1994 mean (SD) n *[media (DT) n]*	1995 mean (SD) n *[media (DT) n]*	*H*	*P*
Clutch size *[Tamaño de puesta]*	1.90 (0.31) 10	1.80 (0.42) 10	0.37	*NS*
Hatching success (%) *[Éxito de eclosión (%)]*	94.73 (15.81) 10	88.89 (21.08) 10	0.50	*NS*
Fledging success (%) *[Éxito de vuelo (%)]*	83.33 (24.15) 10	100.00 (0.00) 10	3.03	*NS*
Breeding success (%) *[Éxito reproductor (%)]*	78.95 (25.81) 10	88.89 (21.08) 10	0.65	*NS*

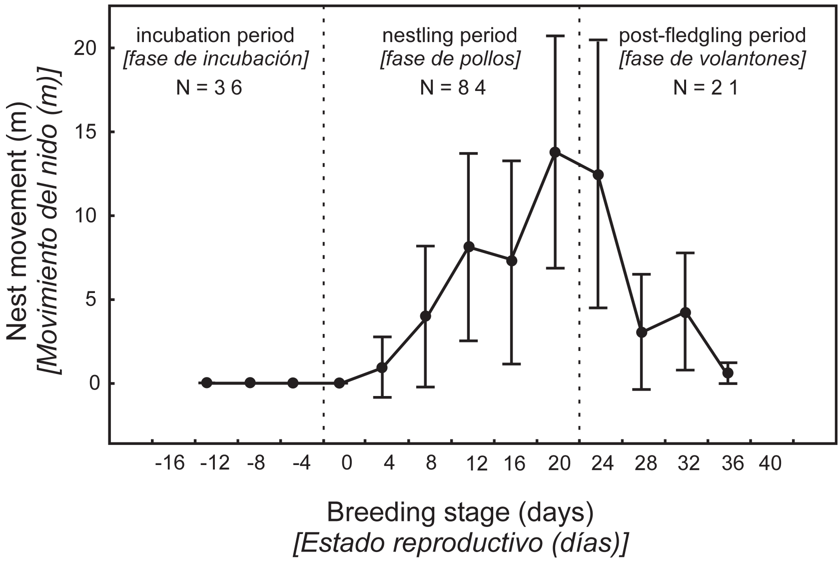

FIG. 2.—Nest movement (solid circles = mean, bars = SD, N = n.º nest re-visitations, day 0 = hatching date). *[Movimiento del nido (puntos negros = media, barras = DT, N = número de visitas a los nidos, día 0 = fecha de eclosión).]*

altricial species (Hasselquist & Bensch, 1991). The low breeding success of pairs breeding late in the season could be explained by the fact that those pairs are unable to access to the best quality territories (i.e. young birds) so their breeding success is highly influenced by the quality of the territory and by their lack of experience in breeding.

Nest movement during the incubation period has been described as a response against disturbance (Cramp, 1985; Cleere, 1998) and against thermal stress (Grant, 1982). We could not find any evidence of nest movement as a response against disturbance, in spite of nest disturbance during data recording. We do not have data to support the thermal stress as a factor explaining nest movement and, in fact, we found three nest sites located under severe thermal conditions where the parents did not move the eggs. Cuadrado & Domínguez (1996) cited egg movement in at least five cases based on personal observations by their own and others (T. Redondo). On the other hand, our results strongly disagree with this affirmation because eggs were not marked in their study (Cuadrado, *pers. obs.*) and therefore it is not possible to say whether or not the eggs were moved. Nest movement during the incubation period is not supported by other studies of caprimulgid breeding biology (Orr, 1948; Gramza, 1967; Schlegel, 1969; Steyn, 1971; Berry, 1979; Ingels & Ribot, 1983; Ingels *et al.*, 1984; Langley, 1984; Jackson, 1984; 1985; Roth, 1985; Marchant, 1988; Sick, 1993; Vilella, 1995), in spite of the fact that all of those studies implied a high degree of nest disturbance. Our results suggest that parents do not move eggs as a response to nest disturbance and we agree with Cleere (1999), who pointed out in his recent review, that egg movement is accidental or occasional and that «...reports of nightjars deliberately carrying their eggs away from danger appear to be erroneous» (see also Jackson, 1985). On the other hand, nest movement during the fledgling period seems to be very common. Our results agree with Cuadrado & Domínguez (1996) and others (Orr, 1948; Gramza, 1967; Schlegel, 1969; Steyn, 1971; Berry, 1979; Langley, 1984; Jackson, 1984; Alayón, 1985; Roth, 1985; Fry *et al.*, 1988; Marchant, 1988; Sick, 1993; Ingels *et al.*, 1984; Vilella, 1995). Nest movement during the fledgling period was more intense in our study (registered in 100% of 26 nests) than in that of

Cuadrado & Domínguez (registered in 13,5% of 37 nests) and we have experimental evidence that in our population nest movement is a chick response to nest revisitation (Aragonés, 1997), as has been suggest by Knight & Temple (1986a, 1986b, 1986c).

Adult birds were not marked so we do not know if the same pair used a nest site occupied during several seasons. We think that the most plausible possibility is that nest site reoccupation was carried out by the same pair which used that site the previous season. The possibility of a different pair selecting the exact nest site used the previous year by another pair seems to be very remote, especially considering that nightjars do not build nests and, therefore, there is not a single clue to guide a new pair to select an old nest site. The high breeding successes of pairs involved in nest site reoccupation support the possibility that these are pairs with long, lasting pair bonds and suggest that experienced birds are involved in nest reoccupation. We think that nest site reoccupation is not related to nest site availability, which seems to be high in Guadalcázar. All but three nest sites were located under a tree or a bush and tree and bush density was high enough to provide many available nest sites (5% of tree coverage, 20.27 trees/ha, and more than 50% of bush coverage). The ultimate reasons for nest site reoccupation seem to be better explained by pair bond lasting through several consecutive breeding seasons or, at least, by the strong territory fidelity that has been found in caprimulgids (Jackson, 1985; Sick, 1993).

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The main research topic of **Juan Aragonés** is nightjar behaviour and since 1986 he has studied a poorly known Mediterranean species, the Red-necked Nightjar. His main interest relies on the influence of nocturnality and crypsis on different aspects of its behaviour. As a result of this research several papers has been published concerning mortality due to road casualties, communication, sexual selection, antipredator strategies and breeding biology. Juan Aragonés holds a Ph.D in Biological Sciences from the University of Córdoba, a degree obtained in 1997 with a research on the behaviour of the Red-necked Nightjar. Actually, he is part of the research group RNM 321 «Biologia de la Reproduccion de Aves» at the Departamento de Biología Animal of the University of Córdoba.

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