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BREEDING BIOLOGY OF THE NIGHT HERON *NYCTICORAX NYCTICORAX* IN THE SOUTH-WEST OF SPAIN

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Summary.—*Breeding biology of the Night Heron* Nycticorax nycticorax *in the south-west of Spain*. The breeding biology of the Night Heron was studied during two seasons in an inland mixed heronry of SW Spain, and the relations with nest location were tested. We compared reproductive parameters with those of other sites in the Western Palaearctic. The reproductive success was not different among years, but the median laying date was. The SW-Spain Night Herons were the least productive and the earliest to breed in the Palaearctic though the comparison is difficult owing to the different methods used by each author. Neither nest height nor the number of neighbour nests influenced breeding success, pointing to an absence of density-dependent effects on the reproduction of this species in SW-Spain.

Key words: inland colony, nest height and density, Night-Heron, *Nycticorax nycticorax*, reproductive success, Spain.

Resumen.—*Biología reproductora del Martinete Común* Nycticorax nycticorax *en el suroeste de España*. Durante dos temporadas se siguió la reproducción del Martinete Común en una colonia mixta interior del suroeste de España y se analizó su relación con la ubicación de los nidos. Los parámetros reproductores obtenidos fueron comparados también con los obtenidos por otros autores en el Paleártico Occidental. El éxito reproductor de la especie no difirió entre años aunque sí lo hizo la fecha mediana de puesta. Los Martinetes Comunes del suroeste de España fueron los menos productivos y de los más tempranos en reproducirse del Paleártico occidental, si bien la comparación es difícil debido a las distintas metodologías empleadas por los distintos autores. Ni la altura de nidificación ni la densidad de nidos en el entorno determinaron el éxito reproductor, apuntándose por tanto una ausencia de efectos densodependientes sobre la reproducción de esta especie en el área de estudio.

Palabras clave: altura y densidad de nidos, colonia de interior, España, éxito reproductor, Martinete Común, *Nycticorax nycticorax*.

Introduction

The Night Heron *Nycticorax nycticorax* is widespread across the Palaearctic region though its population has decreased during the last century (Cramp & Simmons, 1977). In the Iberian Peninsula it has a threatened status (Blanco & González, 1992) and its reproduction is concentrated in no more than thirty colonies in the North, Northeast and Southwest (Palacios, 1997). Currently, population estimates for the Mediterranean region (29000-37000 pairs) show an increasing trend (Perennou *et al*., 1996), while population estimates for Spain give values between 1480 and 2210 pairs that oscillate between years, which makes this species very vulnerable (Fernández-Cruz & Fernández, 1991).

Some information about the breeding biology of this species in the Palaearctic region has been published in recent years (Fasola & Hafner, 1997; Kazantzidis *et al*., 1997; Fasola, 1998), although part of the available information was restricted to a general framework about the breeding biology of herons (Schönwetter, 1967; Fasola & Barbieri, 1975; Hafner, 1977; Voisin, 1979). In Spain only Prósper & Hafner (1996) reported on the breeding phenology of the species in a coastal area, while there is no information for inland areas despite the high occurrence of inland Night Heron colonies in the Iberian Peninsula (Fernández-Cruz, 1975; Farinha & Leitâo, 1996; Parejo & Sánchez, 1999).

The aim of this study is to describe the breeding biology of Night Herons in an inland area

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in the South-west of Spain and to analyse the implications of nest location in the colony (nest height and density) on breeding parameters. Nest location influences reproductive success, especially in marsh-nesting species and when marshes are subject to changes (Burger, 1985), which is commonly observed in Mediterranean areas. In this respect, Night Herons in the South-west of Spain select the highest nest sites available in the vegetation structure of the colonies (Parejo *et al.*, 1999), and so we expect a higher breeding success in the higher nest locations. On the other hand, for many colonial birds density-dependent effects on reproduction have been detected (see revision in Wittenberger & Hunt, 1985; Bennetts *et al.*, 2000). Hypothesizing the existence of density-dependent effects on the reproduction of the Night Heron, we would expect an association between nest density and breeding success.

Study Area

The study was carried out in a mixed colony of Extremadura (SW of Spain), in Badajoz city (38°53′N-6°58′W). The colony was established in 1994 (Parejo *et al.*, 1997) and occupied a highly modified habitat (details in Parejo & Sánchez, 1999). The area has a mean temperature of 17°C and a mean annual rainfall of 600 mm. The colony was located on islands in the Guadiana river that are covered by *Tamarix* sp., *Phragmites* sp., *Populus* sp. and *Eucalyptus* sp. Cattle Egrets *Bubulcus ibis*, Little Egrets *Egretta garzetta* and Night Herons nested together on the islands.

Data Collection

Fieldwork was carried out during the 1996 and 1997 breeding seasons (March-August). Before the settlement of birds in the colony, we installed wooden stakes of known height to use them as references of distance. We made large-scale photographs of the colony sites at the time nests were being constructed, to facilitate subsequent individual identification and monitoring (see methods in Parejo *et al.*, 1999). This method allowed us to obtain the height of each nest. We visited the colony weekly and observed it from the places where we had taken the photographs. Nests were controlled an average of 6.7 times (±2.6 SD, n = 40). We only considered nests in which the brood could be followed from the hatchling stage to the age of 20-25 days. The date of laying for each nest was estimated by subtracting the mean incubation period of 21-22 days (Fasola & Hafner, 1997) from the observed hatching dates. We therefore monitored only successful nests, i. e. containing at least one chick. We recorded for each nest: a) the number of hatchlings (brood size per successful nest), b) the number of chicks aged 20-25 days (after this age chicks frequently leave the nest and brood size can no longer be monitored accurately, chicks fledging at about 45 days; Fasola & Hafner, 1997), and c) the mortality rate as percentage of the total number of chicks hatched per successful nest that did not fledge, assuming that a chick was dead when it was no longer recorded before it had reached the age of 20-25 days.

We divided the large-scale photographs from down to top in square areas of 2x2 m in which, when there were Night Heron nests, we recorded the total number of nests and the number of Night Heron nests in order to respectively estimate the total nest density and the Night Heron nest density per sample plot. To estimate density per m^3, as we only considered those nests situated in the foreground as seen from our sample points, we used 45 cm as the maximum width of each sample plot, which is the maximum diameter of a nest platform of this species (Fasola & Hafner, 1997).The volume plots would be represented by $2 \times 2 \times 0.45$ (1.8 m^3) rectangular prisms. The number of breeding birds was estimated by direct nest counts.

Data Analysis

For statistical tests the significance level was set at $P < 0.05$. The values are expressed as means ± SD and sample sizes are given in parentheses. Median values of two groups were compared by Mann-Whitney U-tests.

We used partial correlations to examine independently the effect of mean laying date, mean nest height and mean density of nests per m^3 on the mean reproductive rate of Night Herons by sample plot. When data did not differ significantly between the two study years, they were pooled. We used transformations of data if they did not meet parametric assumptions: laying date, nest height and density, brood size and number of chicks per successful nests were logarithmically transformed and mortality rate was arcsine transformed (Zar, 1996). When the dependent variables was the mean number of chicks per successful nest and sample plot, or the mean mortality rate per plot, we included the mean number of hatchlings per successful nest per plot as an independent variable.

We applied the sequential Bonferroni test to correct for the probability of a type-I error when we used two or more tests (that cannot be pooled) to test a common null hypothesis, and rejection of the null hypothesis was possible when only some of the tests were found to be individually significant (Rice, 1989).

Results

The number of pairs breeding were 43 and 62 in 1996 and 1997, respectively (Table 1). The onset of egg laying differed 43 days between the two years, and difference in median laying dates was statistically significant (U = 291.0, P = 0.01), with earlier reproduction in 1997 (Table 1).

Results presented are based on pooled data. The mean brood size did not vary between the two study years (U = 216.5, $P > 0.05$) and was 2.28 ± 0.68 (n = 40). The mean number of chicks up to 20-25 days was not different between years (U = 94.0, $P > 0.05$) and was 1.83 ± 0.84 (n = 40). Mean mortality rate was not different between years (U = 129.0, $P > 0.05$) and was 18.75 ± 31.17 (%) (n = 40) (Table 1).

Mean values per sample plot are given. The mean nest height (Table 1) of Night Herons was not different between years (U = 965.0, n_1 = 43, n_2 = 55, $P > 0.05$) and was 5.3 ± 1.5 m (n = 98), and neither was the nest density of Night Herons (U = 48.0, n_1 = 8, n_2 = 16, P = 0.33), nor mean nest density of all species where there were Night Heron nests (U = 49.0, n_1 = 8, n_2 = 16, P = 0.36; Table 1). The mean nest density of Night Herons per m^3 was 1.25 ± 0.81 (n = 24), while mean density of nests per m^3 of all species where there were Night Herons nests was 3.91 ± 2.81 (n = 24).

Table 1

Breeding variables of the Night Heron in the study area. Number of Little and Cattle Egret pairs are also included.
[Datos de reproducción del Martinete Común en la colonia estudiada. Se muestra también el número de parejas de Garceta Común y Garcilla Bueyera.]

Variables *[Variables]*	Years *[Años]* 1996	1997
Little Egret pairs *[Parejas de Garcetas Comunes]*	60	95
Cattle Egret pairs *[Parejas de Garcillas Bueyeras]*	750	1.000
Night Heron pairs *[Parejas de Martinete Común]*	43	62
Nest height *[Altura de nidificación]* $\bar{x}$ ± SD (n)	5.0 ± 1.5 (43)	5.5 ± 1.5 (55)
Nest density of all species/m^3 *[Densidad total de nidos/m^3]* $\bar{x}$ ± SD (n)	5.1 ± 3.8 (8)	3.3 ± 2.0 (16)
Density of Night Heron nests/m^3 *[Densidad de nidos de Martinete/m^3]* $\bar{x}$ ± SD (n)	1.1 ± 0.4 (8)	1.3 ± 0.9 (16)
Brood size/nest *[Tamaño de pollada/nido]* $\bar{x}$ ± SD (n)	2.6 ± 0.6 (9)	2.2 ± 0.6 (31)
Chicks up to 20-25 days/nest *[Número de pollos de hasta 20-25 días/nido]* $\bar{x}$ ± SD (n)	2.2 ± 0.7 (9)	1.7 ± 0.9 (31)
Mortality rate/nest *[Tasa de mortalidad/nido]* (%) $\bar{x}$ ± SD (n)	11.1 ± 16.7 (9)	21.0 ± 34.1 (31)
Onset of egg laying *[Inicio de las puestas]*	29 April	11 March
Median laying date (1 January = 1) *[Mediana de la fecha de puesta (1 de enero = 1)]* (n)	147.9 (10)	118.4 (38)

There were no significant relationships between the number of hatchlings per nest, number of chicks per nest or the mortality rate and laying date, nest height, density of Night Heron nests/plot or total density of nests/plot (Table 2).

Discussion

According to the onset of egg laying observed in the present study, Night Herons in Southwest Spain are some of the earliest breeding within the Western Palaearctic (Hafner, 1980; Prósper & Hafner, 1996; Kazantzidis *et al*., 1997), although Mackrill (1987) found several nests containing eggs in January in the Guadalquivir Delta, a more southern locality. Earlier reproduction in southern areas has been shown for other bird species, and has been interpreted as being due to the earlier onset of spring and production of food that occurs at these latitudes (Järvinen, 1989; Kazantzidis *et al*., 1997). In our study area, the earlier reproduction occurred in 1997, when winter temperatures were higher and winter rainfall lower (18.7°C and 1.5 mm in 1997 versus 14.8°C and 2.8 mm in 1996). However, only data for two seasons are available in this study and a longer time series would be needed to check this effect. The earlier reproduction in 1997 did not correspond to increased reproductive rates, as would be expected on the basis of the existence of longer available periods to make renesting attempts or replacement clutches. However, the study of only successful pairs did not allow us to fully estimate the advantages of breeding earlier.

Although the obtained breeding outputs overestimate the breeding performance of Night Herons with respect to some of the other analysed studies (we did not go into colonies to mark nests or eggs and consequently did not negatively affect survivorship of young; Maddock & Baxter, 1991; Baxter, 1994), we found the lowest values of the species' reproductive parameters in comparison with other localities in the Western Palaearctic (Table 3). It should be noted that the reproductive success in SW-Spain was obtained only from suc-

Table 2

Results of the partial correlations between the reproductive rates of Night-Herons and the independent factors analysed. The values of r (partial correlation coefficient) and P (level of significance) are given for each independent variable.
[Resultados de las correlaciones parciales entre las tasas reproductivas del Martinete Común y las variables independientes analizadas. Para cada variable independiente se muestra el valor de r *(coeficiente de correlación parcial) y* p *(nivel de significación).]*

	Mean no. of hatchlings/nest [*Número medio de pollos nacidos/nido*]		Mean no. of chicks up to 20-25 days/nest [*Número medio de pollos que sobreviven hasta los 20-25 días/nido*]		Mean mortality rate/nest [*Tasa media de mortalidad/nido*]	
	r	*P*	*r*	*P*	*r*	*P*
Mean nest height/sample plot *[Altura media de nidificación/parcela de muestreo]*	0.02	0.92	–0.29	0.26	0.33	0.19
Mean laying date/sample plot *[Fecha media de puesta/parcela de muestreo]*	0.22	0.38	0.07	0.78	–0.06	0.81
Density of Night Herons/m^3 *[Densidad de Martinetes Comunes/m^3]*	0.04	0.87	0.27	0.29	–0.33	0.20
Total density/m^3 *[Densidad total/m^3]*	0.08	0.75	–0.39	0.12	0.45	0.07
Mean no. of hatchlings/nest *[Número medio de pollos nacidos/nido]*	—	—	0.53	>0.0167	0.01	0.95

TABLE 3

Mean fledging success of Night Herons through the western Palaearctic.
[Éxito medio de vuelo del Martinete Común a través del Paleártico Occidental.]

Location *[Lugar]*	Latitude *[Latitud]*	Source *[Fuente]*	Fledging success *[Exito de vuelo]* $\bar{x} \pm$ SD (*n*)	No. Fledged per: *[Núm. de volantones por:]*	Fledged at: (days) *[Volados a: (días)]*	Nest/egg marking *[Marcaje de nidos o huevos]*
France	43°	Fasola & Hafner, 1997	2.2±0.49 (244) to 2.5±0.51 (160)	Nest	25	No
Greece	40°	Kazantzidis *et al.*, 1997	2.48 ± 0.95 (146)	Nest	25	Yes
Italy		Fasola & Hafner, 1997	2.0 (114)	Nest	20-25	—
Spain, Badajoz	38°	This study	1.83 ± 0.84 (40)	Successful nest	20-25	No
Spain, Córdoba	36°	Pulido *et al.*, 1993	2.1 (36)	Nest	—	—
Spain, Murcia	36°	Caballero, 1996	2.14 (6)	Nest	> 30	No

cessful nests and nesting failure accounts for a large source of variation (Butler *et al.*, 1995), which furthermore overestimates the breeding outputs.

For most bird species a seasonal decline in breeding parameters has been shown (Dalhaug *et al.*, 1996; Rodgers & Schwikert, 1997). However, laying date did not influence Night Heron breeding success in SW Spain, which is in accordance with the pattern found in this area for Little and Cattle Egrets (Parejo *et al.*, 2000; 2001), as well as for the Little Egrets and Night Herons in Italy (Fasola, 1998).

We found no evidence that the studied range of nest heights had any effect on mean reproductive success, in accordance with that showed for other egrets in the study area (Parejo *et al.*, 2000; 2001) and for Cattle Egrets in an Algerian heronry (Si Bachir *et al.*, 2000). However, other authors have shown the advantages of nesting high (Burger, 1982; Fasola & Alieri, 1992) and South-western Spanish Night Herons show a preference for high nest sites (Parejo *et al.*, 1999). But our results could be due to a bias in our sample because we concentrated on successful nests only. Future research should include estimates of successful versus unsuccessful pairs.

Similarly, the number of Night Heron nests or the total number of nests around each nest did not affect any of the breeding parameters. This suggests non-existence of density-dependent effects on reproductive performance in this species. Several studies have shown the common absence of these effects on Ciconiiform birds (Butler, 1994; Parejo *et al.*, 2000; 2001), although density-dependent reproductive success was detected in other studies of egrets (Bennetts *et al.*, 2000). However, the lack of effects of crowded environments around Night Heron nests shown with our data can only be considered as tentative, because only a colony during two years was studied and because the effect of population size on breeding performance of this species remains unclear. It could be also that the studied range of nest densities was not sufficiently wide for detecting density dependence. Consequently, the recording of population sizes and experimental approaches manipulating natural densities would be needed to support this point (Both, 1998).

To conclude, the effects of density-dependence on Ardeid reproduction remain unclear, given the differences found between populations. Density-dependence may be important in regulating Ardeid populations when density-independent factors such as food availability (Arcese & Smith, 1988), winter climate (Hafner e*t al.*, 1994) or nest site availability (Bennets *et al.*, 2000) would impose stronger constraints on reproduction.

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