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Nest site selection and breeding success in an expanding species, the Cattle Egret *Bubulcus ibis*

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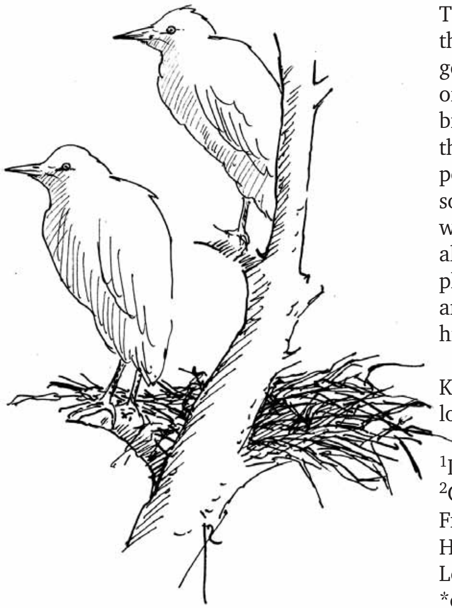

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Native to the Indo-African area, the Cattle Egret *Bubulcus ibis* is now a cosmopolitan species, still in great range expansion. The factors affecting breeding success of the species remain however poorly known, and here we investigate the breeding biology of the Cattle Egret in a new breeding population in the Soummam Valley (Petite Kabylie, Algeria). The installation chronology and nest site selection are described, and their effect on breeding success investigated. The nesting season lasted generally from the end of March to the end of July. Clutch size, number of hatched chicks and breeding success were low compared to other breeding areas in the Mediterranean. The first Cattle Egrets arriving at the colony in March selected the highest trees and the highest nest supports close to the trunk. With new arrivals during the course of the season, a gradual decrease was observed in the height of the nests which were progressively built away from the trunk. This selective behaviour allowed the first installed pairs to have a better breeding success. This phenomenon is discussed here within the framework of territoriality and the breeding advantages of being high ranking in the 'territorial hierarchy' for the individual.

Key words: Cattle Egret, *Bubulcus ibis*, expanding species, breeding biology, nest site, territorial behaviour, Algeria, North Africa

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INTRODUCTION

The Cattle Egret Bubulcus ibis is a species of Indo-African origin which has become globally-distributed in recent times. Its progress was accentuated considerably during the last half-century not only by extension in range but also by local increases in number (Bredin 1983, Hafner 1994, Kushlan & Hafner 2000). Hancock & Kushlan (1989) reported that the northern boundary of the species' distribution is around 45°N in North America and Eurasia, and that the southernmost latitude is between 35 and 40°S. This southern limit recently extended south to the Falkland Islands and Tierra de Fuego as far as 55°S (Morales in Kushlan & Hafner 2000). In the Mediterranean region, in particular the Western half, the distribution and size of the breeding populations has made great strides since the 1980s (Kushlan & Hafner 2000). In Algeria until the 18th century, the species only bred in the lakes of Fetzara and Halloula (the extreme North-East) and perhaps elsewhere in the Tell (Heim de Balsac & Mayaud 1962, Etchecopar & Hue 1964). More recently, the species has become a numerous breeder in several areas, in particular in Tizi Ouzou, Bouira, Jijel, Béjaia, in Constantinois and on the High Plateaux, M´sila (Moali & Isenmann 1993, Moali 1999, Isenmann & Moali 2000, Boukhemza 2000, Si Bachir *et al.* 2000, Si Bachir 2005). In these areas the species is partly migratory with regional movements during the non-breeding period (Isenmann & Moali 2000, Si Bachir 2005).

Despite its range expansion, the breeding biology of this invasive species remains poorly known. The choice of nest site by the Cattle Egret has not been examined in detail (Ranglack *et al.* 1991, Parejo & Sanchez-Guzman 1999), although colony selection by several other species of tree-nesting herons has been studied (Valverde 1955–56, Thompson 1977, Hafner 1982, Erwin *et al.* 1987, Gibbs *et al.* 1987, Fasola & Alieri 1992, Hafner & Fasola 1992, Dami *et al.* 2006).

The Cattle Egret nested for the first time at our study site in the Soummam valley (Kabylie, Algeria) in 1993. The regular occupation of this colony since this date gave us the opportunity to study some aspects of the breeding biology of the species. The first aim of the present study is to describe the installation chronology and breeding biology of the species. Then, we investigated factors involved in nest site selection. Finally, we studied the effect of the installation period and nest site position on the breeding parameters.

METHODS

Study site

The colony was located 2 km east of the village of El Kseur (36°41'N, 04°51'E) and 20 km west of Béjaia town, in the lower Soummam valley, at 55 m above sea level. The area comprises part of the sub-wet Mediterranean bioclimatic stage with hot winters (Stewart 1969). The colony was established 300 m north of the Soummam River on 8 to 16 m tall Ash *Fraxinus angustifolia* trees. The trunks of trees supporting nests were 2 to 4 m high with a diameter ranging from 0.25 to 0.8 m. The ash trees were alongside national road N26 forming a well sheltered wood in association with Plane *Platanus orientalis*, Eucalyptus *Eucalyptus rostrata*, and Mastic *Pistacia lentisticus*. Heavy road traffic restricted pedestrian passage. The understory of the wood was little diversified and largely open. The colony was also girdled by two wind breaks of Cypress *Cupressus macrocarpa* in the South and Eucalyptus *Eucalyptus sempervirens* in the North. Adjacent to the site were cereal fields, market-gardening, orchards and a railway.

In 1997, the single monospecific colony under study was in high Ash trees, and counted ten pairs at the first installation. It has been occupied regularly since and comprised more than eight hundred pairs in 1999 (Si Bachir *et al.* 2000) confirming the dynamic nature of the species in Algeria (Ledant *et al.* 1981, Isenmann & Moali 2000) and in North Africa (Rencurel 1972, Franchimont 1986, Kushlan & Hafner 2000).

Data collection

Researchers generally desist from exploring a colony at the start of its establishment for fear of disturbance because disastrous effects by human intrusion have been documented (Dusi & Dusi 1968, Tremblay & Ellison 1979, Utschick 1983, Drapeau *et al.* 1984, Parnell *et al.* 1988, Frederick & Collopy 1989). However, the reaction of *Ardeidae* to human disturbance is correlated to the habitat structure (Vos *et al.* 1985, Rodgers & Smith 1995). The colony studied was characterized by trees from 8 to 16 m in height. Nests were placed at a height of 4 to 15 m. These conditions offered security to the herons and permitted study with some precautionary measures during intrusion into the site (Si Bachir *et al.* 2000).

Nest installation chronology and nest contents were followed in 1997, 1998 and 1999 during weekly visits. Observations were carried out from the first nest building to the end of the breeding season. For a total of 1981 nests monitored during the 3 breeding seasons (511 in 1997, 665 in 1998 and 805 in 1999), we noted for every new nest the vertical position (the height of the colonized tree and the height of the nest) using marks placed beforehand on the trunk of trees (0.5 m precision). The horizontal position of nests was defined according to Hafner (1977): (1) against the trunk, (2) on solid branches with vertical structure, (3) on secondary branches in the periphery of the tree or (4) in the extreme periphery.

The status and contents of a total of 210 marked nests selected randomly in the colony (64 in 1997, 82 in 1998 and 64 in 1999) were recorded: nest site position (horizontal and vertical), egg number and/or chick number. Visits to the colony took place in the morning, between 06:00 and 09:00 h by a maximum of two people to limit disturbance. Nest contents were recorded using a pole equipped with a mirror at the top.

The breeding biology data (clutch size, hatched chicks per nest, fledged chicks per nest) and losses of eggs and young chicks (up to 20 days) were expressed by means and proportions in order to compare them with other studies. Because chicks after 20–25 days old leave the nest and wander in the colony, the term fledged chicks designate chicks' age up to 20–25 days old. The breeding success was expressed as the ratio of the total number of fledglings (20–25 days old) to the total number of eggs incubated (Hafner 1977, Franchimont 1985).

Data analysis

We used GLM (generalized linear models) (Mc Cullagh & Nelder 1989) to test for the effects of installation period, tree height, nest height, and nest horizontal position on reproductive parameters. Because tree height and nest height were highly correlated ($r = 0.803$, $n = 1981$, $P < 0.001$) we chose not to include tree height as an explanatory variable. Despite some interannual differences in reproductive parameters (see Results) we decided not to include year as an explanatory variable because our primary interest was to investigate overall effects of nest site selection on reproductive parameters across years, and to increase sample sizes so as to avoid over parameterization of the models. For clutch size, number of hatched chicks and number of fledged chicks we used a normal distribution and a log link. For breeding success we used a Poisson distribution and a log link. The goodness of fit of each model was assessed using the ratio χ^2/df (dispersion parameter $\hat{c}$), and we corrected for over dispersion when necessary. We used a backward selection procedure starting from the more complex model with single effects and their interactions, and removing at each step the least significant effect until no effect could be removed. When main effects were not retained, interaction terms including the main effect were not retained. The height in meters of the nest and the parameters of the breeding biology are regarded as continuous variables. The horizontal position was allocated a scale from 1 to 4 from the nearest position to the trunk until the periphery of the tree (see above). The period of installation was noted in ten-day periods counted from 1 March: 25 for the last decade of March, 35 for the first decade of April, etc. In 1998, the breeding season was prolonged to September but because these nests were exceptionally late the records were excluded from statistical analyses.

RESULTS

Installation chronology

In the Soummam valley, the first nests under construction were observed on 28 March 1997, 22 March 1998 and 26 March 1999. The peak of installation occurred between 11 April and 10 May. Nest building ended generally at the end of June. In 1998, the colony was completely deserted towards the end of July, but 48 pairs started breeding again in September (Fig. 1). In 1999, the nest installation ended at the beginning of May when we noted a new colony installed on *Eucalyptus* in the centre of the El-Kseur (approximately 2 km to the west of the studied colony). The number of pairs increased from 511 in 1997, 665 in 1998 to 805 in 1999.

The clutch size increased from one year to the next, with an overall mean of 2.92 over the 3 study years (Table 1). The mean number of hatched

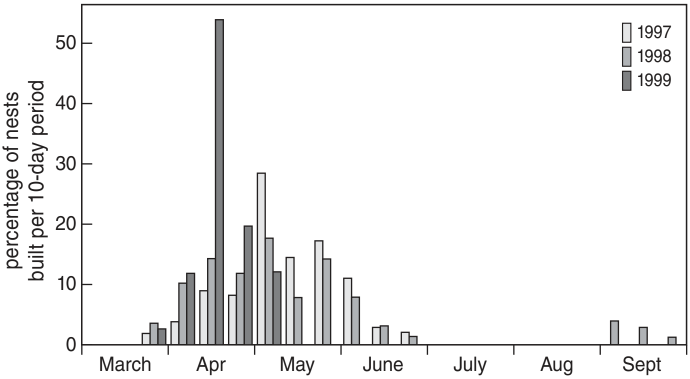

Figure 1. Chronology of nest installation during the breeding seasons 1997, 1998 and 1999.

Table 1. Annual breeding parameters of an Algerian colony of Cattle Egrets during 1997–99. (A) Distribution (%) of clutch sizes, (B) percentage of losses, (C) mean number of hatched and fledged chicks per nest, and breeding success by year.

A Clutch size

Year	1	2	3	4	5	7	Mean
1997 (n = 64)	9.4	21.9	65.6	3.1	-	-	2.77 ± 0.06
1998 (n = 82)	1.2	22.0	57.3	18.3	1.2	-	2.96 ± 0.07
1999 (n = 64)	3.1	23.4	37.5	29.7	4.7	1.6	3.16 ± 0.10
3 years (n = 210)	4.3	22.4	53.8	17.1	1.9	0.5	2.92 ± 0.08

B Losses

Year	Eggs	Young chicks (<20 days)	Total
1997 (n = 64)	43.4	14.7	58.1
1998 (n = 82)	7.0	11.9	18.9
1999 (n = 64)	27.7	25.3	53.0
3 years (n = 210)	23.8	16.7	40.5

C Reproductive parameters

Year	Hatched chicks/nest	Fledged chicks/nest (>20 days)	Breeding success
1997 (n = 64)	1.68 ± 0.87	1.53 ± 0.12	0.47 ± 0.11
1998 (n = 82)	2.76 ± 0.75	2.43 ± 0.13	0.82 ± 0.09
1999 (n = 64)	2.28 ± 1.28	1.70 ± 0.12	0.55 ± 0.18
3 years (n = 210)	2.22 ± 0.12	1.85 ± 0.14	0.63 ± 0.16

chicks was 2.22, the number of fledgings per nest was 1.85 and the breeding success was 0.63. The nests contained one to five eggs, with 53.8% of the nests containing three eggs. One nest contained an exceptional number of seven eggs, although the eggs may have been laid by two females. Losses were generally more important at the egg stage than during chick rearing. The highest breeding success was in 1998 (0.82; Table 1).

Losses were primarily due to eggs and chicks falling from the nest because of strong winds. Particularly notable was the Sirocco, a southern wind in summer, accompanied by temperatures higher than 30°C which often occurred between May and July in 1997 and 1999. This was the most likely origin of the important losses recorded in these two years (Table 1). We also recorded a large variety of predators, both aerial (Common Raven *Corvus corax*) and terrestrial (Red Fox *Vulpes vulpes*, Wildcat *Felis sylvestris*, Weasel *Mustela nivalis*, Common Genet *Genetta genetta*, Montpellier Snake *Malpolon monspessulanus* and Ocellated Lizard *Lacerta lepida*), each with the potential to depredate on eggs and young chicks. Some of these predators could enter the nests (e.g. Montpellier Snake) and others could scavenge under the nests for chicks that fell out of the nests.

Nest site selection and breeding parameters

The first pairs initiated their nests high in the trees and close to the trunk, whereas later nests were initiated lower and further away from the trunk (Table 2, Fig. 2A–C).

Table 2. Parameter estimates of the effect of installation period on horizontal nest site position in an Algerian population of Cattle Egrets (n = 1981). Goodness of fit: $\hat{c}$ = 11.863.

Parameter	Estimate	SE	Wald	*P*
Intercept	4.745	0.040	13836.3	<0.001
Nest height	–0.060	0.004	258.38	<0.001
Position 1	–0.124	0.031	15.54	<0.001
Position 2	0.025	0.017	2.25	0.134
Position 3	0.025	0.018	1.95	0.162

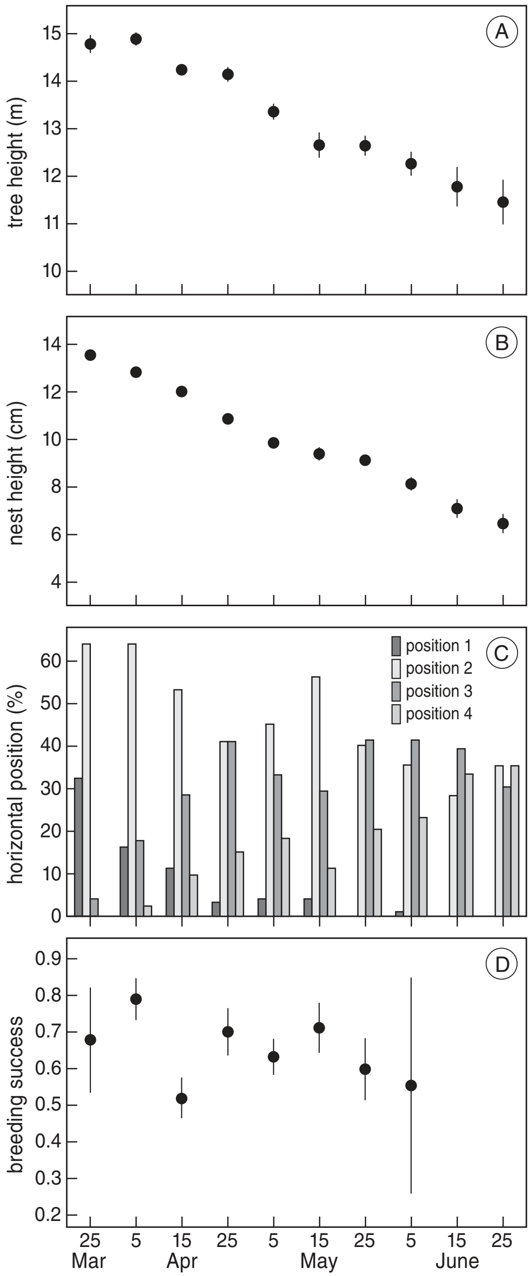

Figure 2. Nest site selection in an Algerian population of Cattle Egrets. (A) height of the tree, (B) height of the nest, (C) horizontal position, and (D) breeding success according to date of the built nests. Bars indicate standard errors.

Clutches laid early in the breeding season were larger than late clutches (Table 3). Hatching success was affected by nest position, with nests situated further away from the trunk hatching less chicks (Table 3). Nests situated close to the trunk fledged a higher number of chicks (Table 3). The interaction between nest position and installation period affected the number of chicks fledged, which decreased as the installation period increased for nests situated close to the trunk, but not for nests situated further away from the trunk (Table 3). None of the parameters affected the breeding success (Table 3).

This demonstrated that the first pairs showed a preference for the more protected positions (on the highest trees, with the highest position and nearest to the trunk) and fledged the highest number of chicks.

DISCUSSION

In the present study, we investigated breeding date and nest site selection and their effect on breeding parameters in a breeding population of Cattle Egret that recently settled in North Africa. Our results showed a strong asynchrony of laying dates. Early breeders selected highest, apparently most favourable, places, and fledged a higher number of chicks.

Comparison with other populations

As shown for other bird species at the intraspecific level (Lack 1968, Farner & King 1971), the breeding season of the Cattle Egret becomes longer closer to the equator compared to higher latitudes. The nesting of Cattle Egrets in the Soummam valley extends for more than four months, from the

Table 2. Estimates of effects of installation period and horizontal nest site position on reproductive parameters of Cattle Egrets (n = 210). Goodness of fit tests: clutch size ($\hat{c}$ = 0.687), hatched chicks ($\hat{c}$ = 1.188), fledged chicks ($\hat{c}$ = 1.245), breeding success ($\hat{c}$ = 0.211).

	Estimate	SE	Wald	*P*
A Clutch size				
Intercept	1.340	0.069	374.10	<0.001
Installation period	–0.005	0.001	15.27	<0.001
B Hatched chicks				
Intercept	0.848	0.037	515.77	<0.001
Position 1	0.115	0.074	2.42	0.120
Position 2	–0.061	0.051	1.42	0.234
Position 3	–0.155	0.061	6.54	0.011
C Fledged chicks (>20 days)				
Intercept	0.928	0.182	25.90	<0.001
Installation period	–0.006	0.003	3.75	0.053
Position 1	0.999	0.318	9.90	0.002
Position 2	–0.294	0.245	1.45	0.229
Position 3	–0.381	0.298	1.64	0.201
Position 1 x installation period	–0.019	0.007	6.62	0.010
Position 2 x installation period	0.006	0.004	2.17	0.141
Position 3 x installation period	0.005	0.005	1.15	0.284
D Breeding success				
Intercept	–0.465	0.040	135.37	<0.001

end of March to the end of July with a higher installation frequency in April–May. Exceptionally, when weather conditions are favourable, a second breeding period can occur in September, as in 1998. In Extremadura (south-western Spain) the nesting period is similar (Parejo *et al.* 2001). However, in the Camargue (France) and in Albufera de Valencia in Spain, the nesting period is later and shorter. It begins in the second decade of April and lasts until the end of August with a peak of laying similar to that of the Soummam valley (Hafner 1982, Prosper & Hafner 1996).

Herons and egrets exhibit a decrease in clutch size with latitude (Jenni 1969, Custer & Osborn 1977, Pratt & Winkler 1985, Arendt & Arendt 1988, Ranglack *et al.* 1991), and our results fit within this general pattern. However, the average clutch size is relatively low (2.92 eggs per nest) compared to other populations. Darmallah (1989) noted an average of 3.34 eggs per nest in El Kala (Algeria), which is at the same latitude as El Kseur (36°N). Hafner (1980) and Prosper & Hafner (1996) recorded average clutch sizes of 4.6 (at 46°N) and 4.23 (at 39°N). Franchimont (1985) calculated an average clutch size of 3.27 for a colony in Asjène in Morocco (34°N). The small clutch size that we observed may be a founder effect, in which the first breeders were inexperienced young birds, because mean clutch size increased during the three year of study.

The average breeding success seems relatively low (0.63) which can be partly explained by the effects of the strong wind. The majority of the recorded losses (totalling 40.5%) was related to the action of the Sirocco which caused eggs and young chicks to be projected out of their nests. After periods of such strong winds, tens of chick corpses and hundreds of broken eggs were found below the nesting trees (Si Bachir 2005). At sites surrounded by water, nests are generally built at lower heights (Hafner 1977, Darmallah 1989, Prosper & Hafner 1996) leading to a breeding success that generally exceeds 65%. However, the breeding success of our study colony was similar to the mean breeding success of other populations where breeding success was measured. The average breeding success of 30 populations was 0.618 ± 0.214, as compiled by Ranglack *et al.* (1991), Petry & Fonseca (2005), Telfair & Bister (2004), Parejo *et al.* (2001) and Mora (1991) .

Breeding success varied considerably between years. In 1998, we recorded the highest breeding success, and the highest number of fledged chicks per nest, and moreover the species bred during a second period in September–October. The strong precipitation of 1998 (865.2 mm against 504.7 and 506.7 mm in 1997 and 1999, respectively) may have caused this high breeding success.

Effect of timing on nest selection

Our results show that Cattle Egrets preferably choose a nest site on the highest trees, at the highest point and nearest to the trunk. As the breeding season progresses, new birds are constrained to occupy the vacant sites, which are situated lower and further away from the trunks. Nest positions relative to the trunk strongly affected reproductive output. Early breeders are able to choose the most favourable nest positions, which causally links to their higher reproductive output. Similar benefits of nest site quality on reproductive output have been demonstrated for other Ciconiiform populations (Post 1990, Butler 1994). Therefore, positions close to the tree trunks in the heronry may confer benefits to the individuals breeding there independently of their intrinsic condition. However, we cannot exclude the possibility that the observed drop in reproductive success for birds that settle later is associated with a concomitant decline in quality of individuals. Studies using marked individuals would be needed to estimate the relative contribution of these two processes.

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SAMENVATTING

Koereigers *Bubulcus ibis* waren ooit alleen te vinden in Afrika en Zuidwest-Azië, maar in de afgelopen eeuw hebben ze in rap tempo grote delen van de wereld veroverd. Er is maar weinig bekend over hoe de vestiging in nieuwe gebieden gaat en wat het broedsucces van deze succesvolle kolonist bepaalt. In dit onderzoek wordt de kolonisatie van een gebied in Algerije beschreven, waar een kolonie zich in 1993 vestigde en vervolgens snel uitbreidde. Gedurende 1997–99 werd de kolonie intensief bestudeerd. Het broedseizoen duurde van eind maart tot eind juli, met in 1998 nog een tweede broedperiode in het najaar. Ieder jaar vestigden de eerste vogels zich in de toppen van de bomen en zo dicht mogelijk bij de stam. Latere paren zaten lager en verder weg van de stam. Reproductief succes was lager voor deze late vogels, vooral omdat veel van hun jongen bij sterke wind van de nesten vielen en dan op de grond door tal van predatoren werden opgegeten. Door de groei van de kolonie werden steeds meer vogels gedwongen op slechte plekken te broeden met een laag reproductiesucces, wat waarschijnlijk de reden was waarom in 1999 een nieuwe kolonie ontstond op twee kilometer afstand. (CB)

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