Nesting period and breeding success of the Little Egret *Egretta garzetta* in Pattani province, Thailand

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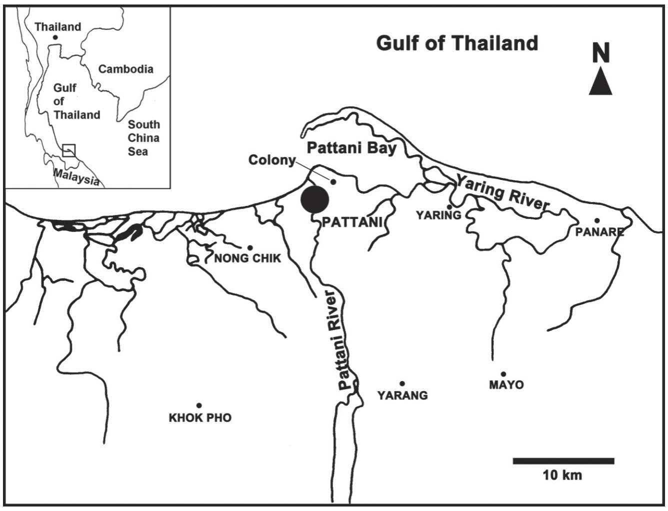
Nesting of Little Egret *Egretta garzetta* was studied between October 2008 and September 2009 in a colony near Pattani, southern Thailand, where the species is a recent colonist. Nesting was bimodal over a 12-month observation period. The first nesting period started in December in the middle of the rainy season (November–December). The second period started in March during the dry season (February–April). In the second period, nesting began in an area not occupied during the first period but gradually expanded into areas used in the first period. Egg and chick losses were high; the mean number of chicks that reached two weeks of age was 1.0 ± 1.2 (*n* = 467 nests), based on nests that had contained at least one egg. Considerable heterogeneity of clutch size and nest success was apparent between different locations within the colony. The main predator appeared to be the Malayan Water Monitor *Varanus salvator*.

INTRODUCTION

The breeding range of the Little Egret *Egretta garzetta* extends from western Europe (northern limit about 53°N) and North Africa across Asia south of the Himalayas to east Asia including Korea and Japan (northern limits about 40°N), with some isolated areas in southern Africa, the Philippines and north and east Australia (Hancock *et al*. 1978, Wong *et al*. 2000). Thus, the breeding range covers temperate, subtropical and tropical climate zones. The Little Egret is a colonial nesting species, constructing nests in trees, low shrubs and reedbeds. Several nesting studies have been conducted throughout the species's breeding range, e.g. in France (Hafner *et al*. 2008), Greece (Kazantzidis *et al*. 1997), Israel (Ashkenazi & Yom-Tov 1997), India (Hilaluddin *et al*. 2003), China (Ruan *et al*. 2003, Wei *et al*. 2003, Wong 2003), and South Korea (Kim *et al*. 2006).

Nesting success of the Little Egret in central Thailand was studied in the Wat Tan-en Non-Hunting Area (Keithmaleesatti *et al*. 2007) while the seasonality of breeding had previously been studied in the Thale Noi Non-Hunting Area, southern Thailand (Kaewdee 1999). Prior to this last-cited study, Little Egret was known only as as a winter visitor in the southern provinces of Thailand. However, in the second half of the 1990s it expanded its breeding range 160 km to the south of Thale Noi and started nesting near Pattani (Figure 1). Here, information on the breeding of the Little Egret in this relatively new colony in southern Thailand is presented. The objectives were to obtain descriptive metrics for breeding success; understand nesting synchrony; and finally document if breeding success parameters varied spatially within the focal colony.

Figure 1. Location of the study area near Pattani, Thailand.



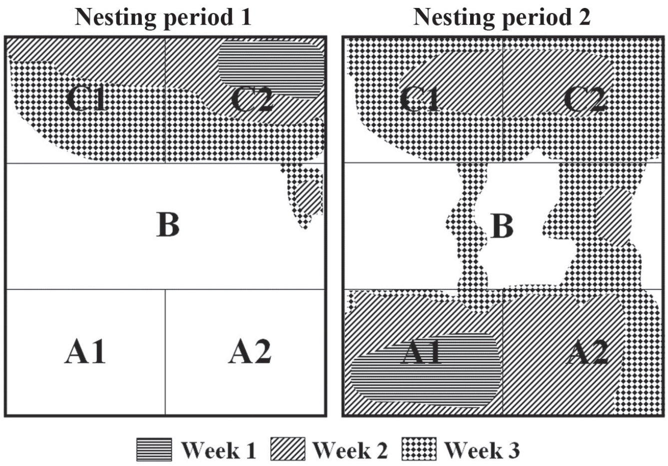
MATERIALS AND METHODS

Study area

The study was conducted at the Pattani waterbird colony, which is located next to the local Central Prison (6.867°N 101.250°E) near Pattani Bay, Gulf of Thailand (Figure 1). Pattani is a mixed colony which includes Little Egrets, Cattle Egrets *Bubulcus ibis* and Little Cormorants *Phalacrocorax niger*. About 4,000 Little Egret nests are located in this colony. Within the fence enclosing the prison is a small, brackish wetland measuring about 180 × 240 m (approx. 4.3 ha) with a maximum water depth of 0.8 m in the rainy season. The wetland contains short stature White Mangroves *Avicennia marina*, some Red Mangroves *Rhizophora mucronata* and open spaces. The area is surrounded on three sides by a wall with barbed wire on top and on the fourth by the high wall around the prison buildings.

The whole area is flat and largely covered by Holocene sand and clay deposits mainly of marine origin. The area has a tropical monsoon climate with the south-west monsoon from mid-May to mid-October and the north-east monsoon from mid-October to mid-February. The driest months are February to April, followed by moderate rain in May to September, while most precipitation occurs from October to December.

Figure 2. Spatial and temporal expansion by nesting Little Egrets of the Pattani colony during the two nesting periods in the 2008–2009 nesting season.



The nesting area was not homogeneous, with variation in both the density of the woodland and the tree species present. Prior to the nesting season, it was measured and divided into three sub-areas A, B and C of 1.44 ha (180 × 80 m). The outer two sub-areas were further subdivided into two parts of 0.72 ha each (90 × 80 m; see Figure 2). The middle part was not subdivided because it had large open spaces without trees. A total of five sections were therefore recognised, A1, A2, B, C1 and C2. This stratification was necessary to assess if breeding success parameters varied between strata.

Data collection

The colony was studied from October 2008 to September 2009. A fixed survey route that criss-crossed all sub-areas was delineated. A sample of nests were surveyed in each of the sub-areas in each nesting period. Sample sizes were determined prior to the study based on rough estimates of nest density. The sample sizes were as follows: Nesting period 1: 50, 100 and 100 nests for B, C1 and C2, respectively (there were no nests in the other sections during the first round of nesting); Nesting period 2: 100, 50, 30, 50 and 50 nests for A1, A2, B, C1 and C2, respectively. New nests without eggs were marked in each section until the predetermined sample size was reached. The colony was surveyed once every three days in the morning during the nesting season. Occupied nests along the route were marked with a numbered plastic tag placed below the nest to allow determination of nest outcomes. Surveys were temporarily stopped during brief, light rain showers. However, during heavy continuous rain, surveys were rescheduled for the next day. Surveys to check all marked nests took about four hours to complete. Nest content was checked using a mirror attached to a 2 m pole. The number of eggs and nestlings were recorded for each marked nest. Nestlings were aged each survey and placed in three age classes: hatchlings (1–4 days), young nestlings (5–9 days) and old nestlings (10–14 days) respectively. This classification by age is arbitrary. Surveys of nests containing nestlings older than 14 days were discontinued because these nestlings could move out of nests preventing individual identification. A nest was deemed to be successful if it contained at least one egg.

The total number of Little Egret nests in the colony was estimated towards the end of each of the two nesting periods by delimiting the proportion of each sub-area where nesting had occurred. For this purpose two possible states, 'nesting' or 'not-nesting', were assumed. The mean density of nests within areas identified as 'nesting' was estimated for each sub-area randomly using two 10 × 10 m survey plots within such areas (80 × 90 m) since the focus was not on individual trees. The total number of nests for each species was calculated by multiplying the mean density within each sub-area by the corresponding area that contained suitable nesting trees and subsequently summed over all sub-areas. Estimates are therefore very crude.

Data analysis

Homogeneity of variance was tested using Levene's test (SAS 2009). Generally, it was found that variances of measurements of nesting success (number of eggs and hatchlings) for each period and sub-area were homogeneous. Wilk-Shapiro tests were used to test for normality and it was found that measurements of success often deviated from normality. Therefore, non-parametric one-way analyses of variance (ANOVA) were also used (Kruskal-Wallis test) to test for differences among areas and among areas by nesting period for nest success (Tables 1 and 2). The results of these non-parametric tests were the same as the (parametric) analyses of variance results presented in this paper. This is not surprising, given the fact that the (parametric) analysis of variance is robust with respect to the assumption of the underlying populations' normality (Zar 1984). A considerable body of literature (see Zar 1984) has concluded that the validity of the ANOVA is affected only slightly by even considerable deviations from normality, especially with increasing sample sizes. Thus, given the fact that variances of populations are (generally) homogeneous, that parametric analysis of variance are robust (especially to even considerable deviations from normality), supported by the fact that results of non-parametric analyses of variances provided similar results, it is believed that both the one-way and two-way ANOVA results presented in this paper are accurate.

RESULTS

Little Egrets started using the study area as a night roost early in October 2008 and abandoned it in late July 2009. The first nests were built by 1 December 2008 in the middle of the rainy season. The first eggs were found on 5 December 2008 and the first chicks were seen on 30 December 2008. During this period, more pairs initiated nest building, laid eggs and hatched chicks. The last eggs were reported on 28 January 2009. Thus, the laying period extended over about 54 days, which includes replacement clutches after early egg loss.

About 3.5 months after the start of the first nesting period (Nesting period 1), a second nesting period (Nesting period 2) began around 12 March 2009 in the dry season. New nests were constructed in sub-areas not used during the first period, but soon thereafter also expanded into sub-areas that had been used in the previous nesting period (Figure 2). During both nesting periods colony growth occurred mainly during the first three weeks. The first eggs of Nesting period 2 were found on 15 March 2009 and the last eggs were laid around 12 May 2009, resulting in a laying period of 58 days, similar to Nesting period 1.

Clutch sizes ranged from 1 to 6 eggs, with an average clutch size of 2.8 ± 0.9 eggs. Clutch size was significantly different across nesting periods (two-way ANOVAs; $Ps<0.0001$) but not by sub-area, while chick rearing (all three stages) was significantly influenced by sub-area but not nesting period (Table 1).

For Nesting period 1, clutch size did not differ among sub-areas (Table 2). Although number of young hatched, and 7 and 14 day old nestlings did not differ between sub-areas C1 and C2, nest success in these sub-areas was significantly higher than in sub-area B (Table 2). Nesting period 2 showed somewhat different results for nest success among sub-areas (Table 2; Figure 3). Generally, the highest nest success was found for sub-areas C1 and C2, followed by A1, A2, and B (Table 2, Figure 3). Specifically, for all nesting stages, sub-areas A2 and B showed significantly lower nest success than sub-areas C1 and C2.

Clutch sizes were significantly lower in Nesting period 2 compared to Nesting period 1 for all sub-areas (B: $F_{1,59} = 22.27$, $P<0.0001$; C1 $F_{1,134} = 22.27$ $P<0.0001$; C2 $F_{1,133} = 22.27$, $P<0.0001$). No differences were found in nest success between Nesting periods 1 and 2 for either number of young hatched, or the number of 7- and 14-day-old young, respectively, for sub-areas B, C1 and C2 ($Ps>0.10$). The low nest success in sub-area B appears not to be the result of an initial small clutch size, but could be due

Table 1. Two way ANOVAs to determine effects of nesting period and sub-area on nesting stages of the Little Egret in the Pattani colony.

Nesting stage	Nesting period $F_{1,7}$	P	Sub-area $F_{4,7}$	P
Clutch size	128.48	<0.0001	3.24	0.01
Hatching	1.69	0.19	11.17	<0.0001
Nestlings 7-days	0.15	0.70	10.29	<0.001
Nestlings 14-days	0.14	0.71	8.44	<0.0001

Table 2. Mean (± SD) clutch size, young hatched and nestlings 7 and 14 days old, based on successful nests, during the two successive nesting periods of the Little Egret in the Pattani colony during the 2008–2009 nesting season.

Nesting period	Sub-area	$N_{Successful}$	Clutch size (x ± SD)	Young hatched (x ± SD)	Nestlings (7 days) (x ± SD)	Nestlings (14 days) (x ± SD)
1	B	33	3.3 ± 0.9a[2)]	0.8 ± 1.4b	0.6 ± 1.3b	0.5 ± 1.0b
	C1	87	3.3 ± 0.8a	1.7 ± 1.6a	1.5 ± 1.6a	1.1 ± 1.3a
	C2	84	3.3 ± 0.8a	2.0 ± 1.6a	1.6 ± 1.6a	1.2 ± 1.3a
	All	204	3.3 ± 0.8	1.7 ± 1.6	1.4 ± 1.6	1.0 ± 1.3
2	A1	92	2.5 ± 0.8a,b	1.5 ± 1.1a,b	1.3 ± 1.1a,b	0.9 ± 1.0a,b
	A2	46	2.2 ± 0.7b	1.0 ± 1.2b,c	1.0 ± 1.1b,c	0.7 ± 1.0b,c
	B	27	2.3 ± 0.7a,b	0.7 ± 1.1c	0.4 ± 1.0c	0.3 ± 0.7c
	C1	48	2.7 ± 0.7a	2.0 ± 1.2a	1.9 ± 1.2a	1.5 ± 1.2a
	C2	50	2.7 ± 0.7a	1.2 ± 0.2a	1.8 ± 1.2a	1.3 ± 1.2a,b
	All	263	2.5 ± 0.7	1.5 ± 1.3	1.3 ± 1.2	1.0 ± 1.1

1) Successful nests contained at least 1 egg.
2) Clutch sizes, young hatched and nestlings 7 and 14 days old with the same letter do not differ significantly within a nesting period among areas surveyed (Bonferroni multiple range test, $P = 0.05$).

to higher nest predation (Figure 3). In both periods, sub-areas C1 and C2 showed substantially higher success rates for young to 14 days averaging 45% survival for Nesting period 1 and 62% for Nesting period 2 (Figure 3). Sub-areas A1 and A2 showed survival rates intermediate between sub-areas B and C1, and C2 (Figure 3).

Little Egrets built nests more frequently in White Mangroves than in Red Mangroves in both nesting periods. Little Egrets nests had long thick twigs in the base and long thin twigs in the upper layer and were built at the lowest levels in the trees. Cattle Egrets constructed their nests of tiny twigs and in the middle layer of the foliage. Little Cormorants used thick short twigs in the base layer and twigs with leaves on top and placed their nests highest in the trees.

Various predators noted in the colony were suspected of predating eggs and nestlings, including Fishing Cat *Felis viverrina*, Brahminy Kite *Haliastur indus*, Large-billed Crow *Corvus macrorhynchos*, Malayan Water Monitor *Varanus salvator* and Siamese Cobra *Naja kaouthia*. Actual predation was not observed, but fresh nail scrapes on the bark of trees where nests were destroyed strongly suggesting that a large Malayan Water Monitor had climbed the tree and predated the nests. The effect of destruction of nests and the differences between sub-areas in different stages of the breeding process is summarised in Figure 3.

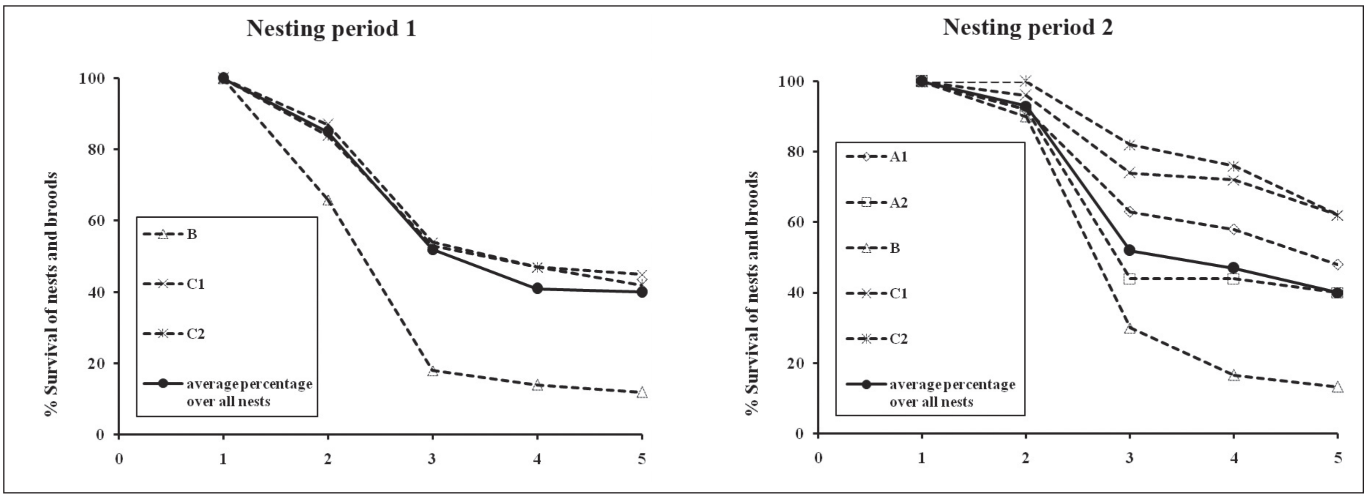
Predation of nests in the sub-areas showed similar patterns between Nesting periods 1 and 2 (Figure 3). The highest predation rates were found in sub-area B: only 12.0% and 13.3% survival rates of the selected nests that produced 14-day-old young for Nesting periods 1 and 2, respectively.

DISCUSSION

In temperate climatic regions, the reproductive season of Little Egrets starts in spring when increased temperature and day length induce nesting. The species has typically one brood per year, but re-nesting may occur after clutch loss (Bauer & Glutz von Blotzheim 1966). In tropical areas daylight and temperature do not fluctuate much over the year and the nesting period is related largely to the rainy season that varies both temporally and regionally (del Hoyo *et al*. 1992). The nesting seasons summarised in del Hoyo *et al*. (1992) also indicate a unimodal and not bimodal nesting pattern. No studies were found that describe the bimodal pattern observed in Thailand. Nesting periods 1 and 2 were similar in length (54 and 58 days, respectively). The interval between occupation of the colony and the start of egg-laying in both nesting periods was about 100 days. Hancock *et al*. (1978) and del Hoyo *et al*. (1992) estimated the interval between egg-laying and independence of the nestlings to be least 68 days (incubation about 23 days, hatching to independence/fledging of young about 45 days). In Nesting period 2, nesting started in the sub-areas not occupied in Nesting period 1 and gradually expanded to all sub-areas. Egrets avoided nesting in sub-areas B, C1 and C2 where some fledglings of relatively late broods of Nesting period 1 were present (pers. obs.).

Ali and Ripley (1987) summarised information from 'Egret Farms' in Sind (India), in which captive egrets were maintained to harvest valuable egret plumes. Captive, well-fed Little Egrets produced up to four or even five clutches between March and September when one-week old chicks were removed for hand rearing. This suggests that Little Egrets are neither genetically nor physiologically predisposed to one brood per year. Thus, food availability seems to be the driver for the start and continuation of nesting. There is little reason to presume that the Pattani colony was used by two different populations of Little Egrets. The fact that there were many more nests in Nesting period 2 than in Nesting period 1 may suggest that older and therefore more experienced birds nested in Nesting period 1. More experienced Little Egrets are likely to initiate the nesting cycle early and be able to nest twice, while less experienced birds start later and nest only

Figure 3. Little Egret nest success in the two nesting periods at the Pattani colony during the 2008–2009 nesting season. Points on *x*-axis, 1: nests surveyed; 2: nests with at least one egg; 3: nests with hatchlings; 4: nests with 7-day-old chicks; 5: nests with 14-day old chicks.



once per year (Nesting period 2). The slightly larger eggs and clutch sizes during the first breeding period might support these assumptions, which could be verified by longer-term studies using colour-banded birds. It is unclear why there is not a gradual transition between these two nesting populations, resulting in a single long breeding season. However, there seems a benefit of synchronous nesting that is triggered by an environmental cue that signals the start of a nesting season. Several authors have suggested a relationship between the onset of the rainy season or water conditions in tropical areas (Hancock *et al*. 1978, Ali & Ripley 1987, del Hoyo *et al*. 1992). In this area, precipitation patterns in November and December cause local flooding that may improve feeding conditions and induce birds to start nesting. The heavy rain showers did not seem to affect nesting in Nesting period 1. The adults protected their eggs well during incubation and the rainy season had ended by the time the young hatched. Weather conditions were dry during Nesting period 2 and it was not clear what prompted egrets to begin a second round of nesting.

Clutch sizes observed (average 2.8 ± 0.9 eggs) were similar to clutch sizes reported from other tropical areas summarised by Hancock *et al*. (1978). Nest, egg and chick losses were high at Pattani, resulting in a low number of nestlings surviving beyond 14 days. Most predatory attacks resulted in complete loss of a clutch or chicks and often partial destruction of the nest structure. The result was that a relatively low number of pairs reared chicks to 14 days (1.0 ± 1.2 young). Hilaluddin *et al*. (2003) reported a slightly higher success of 1.74 nestlings up to 15 days from India. The highest successes were reported from China, 3.86 young by Ruan *et al*. (2003) and 3.96 young by Zhang *et al*. (2000), but the authors did not report whether nest loss was incorporated in these numbers.

Partitioning the colony in sub-areas and carefully designing a survey route through the entire colony proved to be useful to determine spatial and temporal differences in nesting and nest success in the colony, even when initial clutch sizes did not differ by sub-area. This was an unexpected outcome, but suggests that studies of colonies should take into account that differences in nest initiation and establishment of pairs in a colony can have a strong spatio-temporal component which should be addressed in study design. Spatial heterogeneity within nesting sites of *E. garzetta* has not been reported, but has been seen in Cattle Egret *Bubulcus ibis* (Petry & Fonseca 2005). The cause of the differences in nesting success in different parts of the colony may be due to varying predation rates, but this requires confirmation using improved nest observation methods. In both nesting periods the losses in section B were highest while C1 and C2 had the best results. The difference may be due to the less dense vegetation in B where there was also a large area of water allowing easier access by the Malayan Water Monitor and raptors.

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