Low breeding success of the little egret (*Egretta garzetta*) near residential areas and in colonies exposed to gales: a comparison of colony in Sichuan, Southwest China, with literature

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**ABSTRACT**

The breeding biology of the little egret (*Egretta garzetta*) was studied in 20 nests within the mixed-species breeding colonies at Nanchong, Sichuan, Southwest China, in 2006. By measuring a set of physical characteristics of vegetation at the nests and at a set of 20 randomly chosen sites we showed that birds preferentially used taller trees in areas with fewer shrubs of higher species diversity. Nests at lower locations in trees had marginally lower hatching success due to their destruction by humans; this destruction contributed marginally significantly to lowering of the total nesting success in all studied nests. Although gale winds also had a negative effect on breeding success, the anthropogenic influences were a greater factor in reproductive failure. We found similar effects in our review of literature on breeding success of the little egret from various geographical areas. Our results may be of use by conservation organizations in their actions to protect colonies of the little egret.

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**Introduction**

In mixed-species heronries, the coexistence of hundreds of breeding birds results in dense nesting and partitioning of the available space (Jenni 1969; Maxwell and Kale 1977; Parsons 1995). Species display horizontal and vertical stratification during nest site choice according to vegetation type and structure (McCrimmon 1978; Beaver et al. 1980).

Nesting colonial waterbirds are potentially vulnerable to human intrusion (e.g. Carney and Sydeman 1999; Nisbet 2000). In certain habitats, nest site selection critically affects breeding success. For example, Samraoui et al. (2007) highlighted the anthropogenic influence on the reproductive success of cattle egrets (*Bubulcus ibis*) close to urban areas. In that study, approximately one-third of the nests were subjected to human disturbance prior to hatching.

Little egrets (*Egretta garzetta*) are widely distributed in Asia and southern Europe, and winter in Africa. This species often builds nests in multi-species heronries. The breeding biology of this species was reported in southwestern Spain and Greece (Tsahalidis 1990; Kazantzidis et al. 1997; Parejo et al. 2001), as well as in Asia (Ashkenazi and Yom-Tov 1997) and especially in central and southern China (Shi et al. 1991; Yang 2000; Zhang et al. 2000; Wang, Dong, et al. 2001; Wang et al. 2005). However, few studies have confirmed the effects of human visitation and disturbance on the breeding performance of little egrets.

During this study, little egrets began to arrive at Nanchong in flocks in early March. Roosting was common at this time and their numbers increased by late April. The first nest was started in mid-March. However, some breeding nests were low to the ground and exposed to frequent human disturbance, such as by local children who would approach the nests and take away their eggs. On the other hand, while nests located high above the ground lacked human disturbance, they were potentially vulnerable to the effects of gales. Because the interaction between humans and little egrets is likely to increase in Europe (e.g. Kazantzidis et al. 1997) and in South Asia (e.g. Kafle et al. 2008), it is particularly important to obtain information on the potential effects of human disturbance. We expected that both human disturbance and gales would be major factors associated with breeding failure.
Material and methods

Study site

The field study was conducted from March to October during the full breeding season in 2006, Gaoping County (30° 47′ N, 106° 08′ W, elevation 300 m), Nanchong city, Sichuan, southwest China. There is a mixed-species colony distributed throughout three adjacent low mounds, which are approximately 2.5 ha, 300 m long, and less than 100 m wide. This area has extensive paddy fields, a large reservoir (20 ha), a highway, and a residential area (0.2 ha), which is about 15 m from the nearest little egret nests.

The local climate is subtropical and influenced by monsoons, with annual rainfall averaging 1020.1 mm. The yearly average temperature is 17.6°C, the coldest month is January (6.5°C), and the hottest is August (32°C). Also, strong wind blows monthly from May to August in our study site. The geography and environment were summarized by Yu and Guo (2006). Vegetation is dominated by Chinese red pine (Pinus massoniana), a few Omei Mountain Bamboo (Neosinocalamus affinis), and black locust (Robinia pseudoacacia L.).

The nests of three species of waterbirds in the colony were counted by using a pair of 8 × 40 Panda binoculars in early April or late May, depending on when each species arrived to the site (e.g. Chinese pond herons, Ardeola bacchus arrived in late April). There were 450 nests of little egrets, 15 nests of Chinese pond herons and 45 nests of black-crowned night herons (Nycticorax nycticorax) in this colony. Nest height of the night herons was higher than those of little egrets or pond herons; night heron nests were typically located in the tops of Chinese red pine trees (>11 m). Little egrets nest in Chinese red pine between heights of 7 and 11 m along with smaller numbers of night herons. Pond herons selected willows or pines without other birds. Therefore, local children typically could not remove pond heron and night heron eggs by climbing the trees. In this case, we only investigated breeding biology of the little egret based on their number and nest height in this colony.

Field procedures

Prior to nest monitoring for this study, the colony site was checked regularly (once per week) to determine the arrival date of the little egrets. During the little egrets’ nest-building period (mid-March to mid-April), we visited this colony every three days to record when females began to incubate. When most nests were believed to have complete clutches, we randomly selected 20 quadrats including little egret’s nests and 20 control sites which were unused by little egrets. We measured habitat variables for both nest and random quadrats (10 × 10 m) (Table 1). To reduce disturbance during the breeding period, these habitat variables, including tree species, shrub species, diameter at breast height (DBH) of trees, and percentage of vegetation cover at 8 m, were collected after breeding following the breeding period. We identified and counted number of tree species and shrub species found in the quadrats. We measured perimeter at breast height of trees with a tape measure, then arrived at diameter by a simple formula (perimeter/π) to give us DBH. We recorded vegetation-covered areas using a circular plot (radius = 2 m) based on mean branch length at 8 m high of trees, and counted the proportion of the ground surface covered by vegetation under the tree.

To explore the assumption that two major factors had a negative effect on breeding success, nest heights in this study were classified in two distinct levels (e.g. higher and lower nests) within the colony. Nests located at heights between 6 and 8 m were considered low nests (n = 10), and nests at heights between 8 and 12 m were considered high nests (n = 10). Prior to hatching or during hatching, children frequently took eggs from nests, which was a primary cause of reproductive failure, especially for nests lower to the ground. In this colony, we did not observe cats or raptors; thus most

| Variables                      | Little Egret present, mean ± SE | Little Egret absent, mean ± SE | t-Value | Z-value | P         |
|--------------------------------|---------------------------------|-------------------------------|---------|---------|-----------|
| Distance to water body (m)     | 32.50 ± 6.96                   | 37.15 ± 3.17                 | -0.608  | .547    |           |
| Distance to forest edge (m)    | 17.17 ± 3.91                   | 18.70 ± 3.45                 | -0.294  | .770    |           |
| Number of arbor species       | 1.95 ± 0.14                    | 1.10 ± 0.07                  | -4.377  | <.001   |           |
| Arbor density (tree/100 m²)   | 14.00 ± 0.90                   | 17.70 ± 1.83                 | -1.184  | .078    |           |
| Arbor height (m)              | 11.05 ± 0.20                   | 6.87 ± 0.27                  | 12.226  | <.001   |           |
| Number of shrub species       | 2.05 ± 0.29                    | 1.20 ± 0.09                  | -2.062  | .007    |           |
| Shrub density (tree/100 m²)   | 6.00 ± 0.74                    | 14.50 ± 2.14                 | -3.111  | .001    |           |
| Shrub height (m)              | 1.89 ± 0.22                    | 2.76 ± 0.24                  | -2.665  | .011    |           |
| Vegetative cover (%)          | 30.50 ± 1.86                   | 45.00 ± 1.62                 | -5.882  | <.001   |           |
nests were likely destroyed by humans. Higher nests were observed to lack human disturbance, but they were potentially vulnerable to the effects of gales. To clarify which caused stronger negative impacts on reproductive success, we observed the nests using either a long fishing rod (13 m) with a digital camera (for higher nests), or a ladder (for lower nests). To reduce human disturbance, each nest was observed twice per week during laying, once per week in hatchling and twice per month during feeding period to determine clutch size, brood size, and to mark nestlings. Most of the time, we used a pair of Panda binoculars to observe the breeding behavior of little egrets.

At 10 d of age, we used different colored plastic rings and a numbered metal tag to mark the tarsus of each nestling to distinguish them within the same tree because there were about 6.25 ± 0.44 nests of little egrets and 0.70 ± 0.25 nests of other species in same breeding trees. The number of eggs, hatchlings, and chicks surviving per nest was recorded until the age of 25 days, when they became independent (Kazantzidis et al. 1997). To determine which nestling deaths were caused by gales, we carefully checked all nestlings that fell from their nest trees after the gales to immediately identify those with and without the numbered metal tags. Then, we estimated the nest to which each nestling belonged based on whether nestlings were marked with colored plastic rings or growth stage and which nests were missing nestlings. Hatching success (percent of eggs laid that hatched) and chick survival (percent of hatchlings that survived to age 25 days) were determined from these data. All breeding attempts were classified as successful or unsuccessful and this binary variable comprised ‘reproductive success’, when at least one chick survival until the age of 25 days.

**Statistical analyses**

A Kolmogorov–Smirnov test was used to assess normality of raw data. Where appropriate, data were transformed using arcsine square root (percentage data) or natural logarithms (distance variables) to improve normality. Non-parametric tests were used where assumptions of normality could not be met despite transformations. We performed Mann–Whitney U-test and Student’s t-test to compare the different features between 20 sites used by this species and 20 randomly selected quadrates where little egrets were not found. To ensure independence of predictor variables, we calculated Pearson’s correlation coefficients for all pairwise combinations of significant nest habitat variables. We considered $r \geq 0.70$ a suitable criterion for omitting a variable (Fielding and Haworth 1995). Because correlation coefficients were above this cut-off for tree height and DBH of nest trees, we excluded DBH of nest trees from the analysis. Nest habitat selection were analyzed with SPSS 19.0, SPSS Inc., 2004, Chicago, IL, USA.

In this study, we didn’t use Mayfield method (Jehle et al. 2004) to estimate nest success because we only visited the nest once or twice in feeding period for reducing human disturbance. In specific circumstances, the estimates using ‘classical’ method was equally applicable to our data, which were similar to the newer methods. Generalized linear models (GLM) with a Poisson error distribution were used to analyze the differences of clutch size, the number of hatched eggs (with clutch size as a covariate), and the number of nestlings at 25 days of age (with the number of hatched eggs as a covariate) between higher nests and lower nests. Further, the GLMs with a binomial error distribution were used to test the differences of hatching success (percent of eggs laid that hatched), chick survival (percent of hatchlings that survived to age 25 days), and reproductive success (successful or unsuccessful) between higher nests and lower nests. For hatching success, we used cbind function to create the response variable from the original raw number of eggs for a nest and number of hatched nestlings for a nest; and similarly, the response variable of chick survival was created from the number of hatched nestlings and number of survived nestlings. The analyses were implemented in R. All statistical tests were two-tailed, values are presented as mean ± standard deviation (SD).

**Analysis of data from literature**

We collected information from the literature on hatching success and nestlings’ survival in the little egret colonies world-wide and classified each study site with respect to the exposure to humans (exposed to humans: $n = 2$ colonies, less exposed to humans $n = 14$ colonies) and with respect to the exposure to gales/strong winds (exposed to gales: $n = 3$ colonies, not exposed to gales: $n = 11$ colonies). We used Mann–Whitney U-test to compare hatching success between colonies exposed to humans and those that are less exposed to humans. We also used the Mann–Whitney U-test to compare nestling survival between colonies exposed to gales and those that are less exposed to gales. The analyses were run with SPSS 19.0, SPSS Inc., 2004, Chicago, IL, USA.

**Results**

**Nest habitat selection**

Compared to random sites, little egrets’ preferred habitats included taller trees with larger diameters and
thinner vegetative cover (all $P < .001$, Table 1), higher number of tree species ($P < .001$), lower shrub density, lower shrub height, and more shrub species (all $P < .05$).

**Hatching and breeding success**

Mean clutch size was $4.75 \pm 0.23$ eggs (range: 3–7 eggs; $n = 20$, including 10 lower nests and 10 higher nests). Clutch size difference between lower and higher nests was not significant ($4.90$ vs. $4.60$ eggs; $Z = -0.31$, $P = .758$).

On average, $2.55 \pm 0.51$ young hatched/nest resulting in $53.92\%$ hatching success. The number of young hatched/nest from higher nests was larger than those from lower nests ($3.5$ vs. $1.6$ young hatched/nest; $Z = 2.36$, $P = .018$). The difference in hatching success between lower and upper nests was significant ($38.0\%$ vs. $69.8\%$; $Z = -3.49$, $P < .001$).

The number of nestlings surviving to 25 days of age was $2.00 \pm 0.45$ individuals/per nest ($78.11\%$ survival rate). The number of nestlings surviving to 25 days of age between lower and higher nests was not significantly different ($2.50$ vs. $1.50$ nestlings/nest; $Z = 1.12$, $P = .261$). The difference in nestlings’ survival rates between lower and higher nests was not significant ($70.3\%$ vs. $93.8\%$; $Z = 1.63$, $P = .103$).

The upper nests appeared to be more often successful based on the analysis of reproductive success ($70.0\%$ vs. $40\%$), but no significant difference was found ($Z = -1.33$, $P = .185$).

Prior to or during hatching, two higher and six lower nests were deserted due to humans taking away eggs, which suggests that these human disturbances had a marginally significant effect on lower nests (Barnard’s test: $P = .095$). The gales destroyed one higher nest (10%).

**Results of analysis of data from literature**

The hatching success ($53.92\%$) and survival rate ($78.11\%$) in our colony, in which humans stole eggs, was lower compared to values reported in the literature (Figure 1). Zhou and Song (1999) also found hatching success was lowered at Zipeng Mountain China because eggs were stolen by humans. The hatching success at those two sites was marginally significantly lower (Mann–Whitney $U$-test: $Z = -1.91$, $P = .057$) than in the remaining 14 colonies for which information on hatching success was found (Figure 1).

In addition to our colony, where nestlings’ survival appeared to have been negatively affected by natural factors such as gales, two other colonies were affected by gales (Huang et al. 1999; Zhou and Song 1999). We found that the nestlings’ survival in those three colonies with clear effect of gales was lower (Mann–Whitney $U$-test: $Z = -1.95$, $P = .052$) than in the remaining 11 colonies for which data on nestlings’ survival were available (Figure 1).

**Figure 1.** Comparison of hatching success and nestling survival between our population and other populations of the same species (triangle: this study; hatching success, filled circles: colonies under anthropogenic influence ($n = 1$ study site); unfilled circles: wild colonies ($n = 14$ study sites); nestling survival, filled circles: colonies exposed to gales influence ($n = 2$ study sites); unfilled circles: colonies without disturbance ($n = 11$ study sites)). Data come from the following studies. Colonies exposed to humans: Zhou and Song (1999); Colonies not exposed to humans: Jiang and Liu (1986); Shi et al. (1991); Zhang et al. (1994); Ashkenazi and Yom-Tov (1997); Kazantzidis et al. (1997); Huang et al. (1999); Zhang et al. (2000); Wang, Yi, et al. (2001); Wei et al. (2002); Hilaluddin et al. (2003); Wang et al. (2005); Han et al. (2008); Ashoori (2010); Colonies exposed to natural risks of gales and predation: Huang et al. (1999); Zhou and Song (1999); Colonies less exposed to natural risks of gales and predation: Shi et al. (1991); Zhang et al. (1994); Ashkenazi and Yom-Tov (1997) and so on.

**Discussion**

Our analyses demonstrated that humans have negative effects on breeding success of the little egrets through the removal of eggs from nests at lower locations, and that gales have negative effect on nestlings survival in nests at higher locations. We found human disturbances decreased the number of young hatchlings/nest from lower nests more than for higher nests. We also found that human disturbances result in nest desertion more for lower nests than higher nests. Therefore, by preferring to locate their nests in taller trees the little egrets avoid human disturbance. Preference for tall pines with...
larger diameters and lower vegetative cover in this colony, is similar to preferences recorded in other colonies in China (Shi et al. 1991; Zhang et al. 2000; Wang, Dong, et al. 2001; Wei et al. 2002; Li et al. 2006) and Korea (Kim and Koo 2009). We suggested that little egrets prefer higher trees with less shrubby undergrowth because it decreases disturbance from humans or other predators from the bottom of forest. In addition, the hatching success in our colony was lower compared to values reported in the literature, suggested that hatching success is importantly lowered by humans if egg stealing occurs in a colony.

In contrast to human disturbances, higher nests lead to increased exposure to gales. Gales may have crucial negative impact on breeding success; nesting survival in this colony, and in colonies with similarly strong gales, was lower due to the gales’s negative effect on nesting’s survival. Also, we found 21 nestlings may fall from 9 nests after gales in this colony. The nine destroyed nests were located at forest edge, suggested that trees reduction increased damaging effects of wind. However, compare to gales, human disturbances is more serious in this colony because hatching success in our colony, and in other colonies with similar human disturbance, was lower than other colonies without such a disturbance. Therefore, we suggested that local governments should adopt measures to protect colonies near human habitations by restricting access of humans to a colony during breeding season.

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Disclosure statement
No potential conflict of interest was reported by the authors.

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