Species	Monoculture plantation	Semi-evergreen forest	Scrub	Mixed plantation/ natural forest	Village-edge forest	Riverine forest	Hill forest
Puff-throated Babbler *Pellorneum ruficeps*							4.2
Pygmy Wren Babbler *Pnoepyga pusilla*		0.3					
Striped Tit Babbler *Macronous gularis*		4.4		1.1			10.8
Jungle Babbler *Turdoides striatus*	5.0		152.2				
Silver-eared Mesia *Leiothrix argentauris*		15.9					
White-bellied Yuhina *Yuhina zantholeuca*							12.
Pale-billed Flowerpecker *Dicaeum erythrorynchos*							2.5
Plain Flowerpecker *Dicaeum concolor*							2.5
Scarlet-backed Flowerpecker *Dicaeum cruentatum*		0.3		15.1			4.2
Black-throated Sunbird *Aethopyga saturata*							4.2
Crimson Sunbird *Aethopyga siparaja*		0.9		18.3			
Streaked Spiderhunter *Arachnothera magna*	1.0	8.7		4.3			
Olive-backed Pipit *Anthus hodgsoni*	0.7		19.6				
Baya Weaver *Ploceus philippinus*					18.7		
Scaly-breasted Munia *Lonchura punctulata*					4.0		
Little Bunting *Emberiza pusilla*					1.8		

APPENDIX 2

Bird species newly recorded for Buxa Tiger Reserve

Barred Buttonquail *Turnix suscitator*
Spot-billed Duck *Anas poecilorhyncha*
Pale-headed Woodpecker *Gecinulus grantia*
Stripe-breasted Woodpecker *Dendrocopos atratus*
Ruddy Kingfisher *Halcyon coromanda*
Common Coot *Fulica atra*
Eurasian Griffon *Gyps fulvus*
Eastern Marsh Harrier *Circus (aeruginosus) spilonotus*
Golden Eagle *Aquila chrysaetos*
Amur Falcon *Falco amurensis*
Little Egret *Egretta garzetta*
Malayan Night Heron *Gorsachius melanolophus*
Cinnamon Bittern *Ixobrychus cinnamomeus*
Asian Openbill *Anastomus oscitans*
Black-naped Oriole *Oriolus chinensis*
Chestnut-bellied Nuthatch *Sitta castanea*
Spotted Laughingthrush *Garrulax ocellatus*
Red-billed Leiothrix *Leiothrix lutea*
Olive-backed Pipit *Anthus hodgsoni*
Baya Weaver *Ploceus philippinus*
Scaly-breasted Munia *Lonchura punctulata*
Little Bunting *Emberiza pusilla*

Nesting ecology of Cattle Egrets and Little Egrets in Amroha, Uttar Pradesh, India

HILALUDDIN, AISHA SULTANA, AFIFULLAH KHAN, H. S. A. YAHYA and RAHUL KAUL

Heron species vary in their habitat preferences, diet and behaviour, but they have similar fundamental requirements for nesting (Hafner 2000). A good nesting site generally provides protection against predators, offers adequate stability and materials to support and construct the nest, and is located near adequate feeding areas (Thompson 1977, Beaver *et al.* 1980, Hafner and Britton 1983, Gibbs *et al.* 1987, Hafner *et al.* 1987, Hafner and Fasola 1992). Nest-site parameters also influence hatching success (Ludwig *et al.* 1994, Kazantzidis *et al.* 1997, Hilaluddin *et al.* 2003) and fledging success (Buckley and Buckley 1980).

Studies of nest-site selection by Cattle Egret *Bubulcus ibis* and Little Egret *Egretta garzetta* have been previously conducted in subtropical North America and in southern Europe (Telfair 1983, Arendt and Arendt 1988, Kazantzidis *et al.* 1997), but information on the nesting ecology of the two species from South and South-East Asia is lacking. We therefore surveyed egret colonies in Amroha, Uttar Pradesh, India, and examined nesting ecology of these two species.

METHODS

Study area

The study was carried out at Amroha, J. P. Nagar district, Uttar Pradesh, India, which is located 131 km north-east of Delhi at 28°26′–29°26′N 78°04–39′E and at an altitude of 213 m. Annual rainfall during 2001 totalled 1,210 mm. The area falls within a complex wetland system formed by the Ganges with its tributaries (Ban, Gagan, Yagad, Bagad, Kurla, Sotra and Krishna). The mean size of wetlands around colonies was 1.2 ha (range: 0.4–5 ha).

Data collection

We defined a nesting colony as a site with aggregations of >5 nests where nesting individuals were sufficiently close to be able to communicate vocally and visually to neighbouring individuals (Gochfeld 1980). Most nesting colonies in the study area were more than 1 km apart. An active nest was defined as one that contained either an egg or a nestling.

We collected data on 42 active nesting colonies in 158 nesting trees between 15 June and 30 August 2001. We counted the total number of active nests of each egret species in each nesting tree following the Tally Count Method (Copper *et al.* 1982). We measured the distance of each nesting tree from the nearest wetland, classifying these as: (1) open-water wetland (dominated by open water with occasional trees); (2) emergent wetland (dominated by persistent or non-persistent emergent vegetation); and (3) unconsolidated bottom marshland (largely unvegetated and underlain by gravel, mud or organic material). We defined man-made habitats around nesting trees as: (1) agriculture; (2) residential areas; (3) *panchayat* (local council) lands for common resource properties; (4) mango orchards; (5) religious sites (temples, mosques and graveyards); (6) government premises (institutions, offices and tube-wells); and (7) social forestry plantations along highways.

Nest trees were identified to the species level and were measured for the following structural features: bole height; girth at breast height (gbh); canopy diameter; and canopy height. The canopy shape of each tree was also recorded. Canopy spread (i.e. horizontal area covered by the canopy) was calculated following Muller-Dombois and Ellenberg (1974). Canopy volume (for calculating nest density) was calculated using standard algebraic formulas for cones, cylinders and half spheroids, depending upon the shape of the canopy, following Hilaluddin *et al.* (2005). We were unable to measure the structural variables of two nest trees owing to field conditions, so we discarded nests in these trees from most analyses.

We visually divided the canopy of each nesting tree vertically into three approximately equal parts (upper, middle and lower) and horizontally into two equal halves (inner and outer) from the centre point of the tree canopy. Thus, each tree was divided into six canopy sectors. The number of nests of each egret species was counted separately in each sector.

Data analysis

We compared the distance of colonies to different wetland types using an ANOVA. We used t-tests to compare the height of nests of each species, and to compare their distance from the ground and to the tree-top. We used a one-way ANOVA to analyse the distribution of nests in different canopy sectors.

We used separate ANOVAs to investigate whether habitat type or nearest wetland type affected the density of nests in nesting trees for both species separately and combined. We also tested which macro-habitat scale factors affected nest-density using a stepwise Discriminant Factor Analysis (DFA), with nest density as the dependent variable and distance to wetland, wetland area, wetland type, type of man-made structures in the vicinity, type of human disturbance (poaching, use of fire-crackers and/or drum-beating to deliberately scare away egrets, tree lopping, egg collection and nest destruction) as factors. To test which micro-habitat scale factors affected nest-density, we used a stepwise multiple regression with nest density as the dependent variable and girth at breast height, bole height, canopy spread, canopy height, canopy volume and tree height as factors.

All non-normal variables were transformed appropriately, following Sokal and Rohlf (1995), prior to analysis. Means ± 1 standard error are presented throughout.

RESULTS

Location of nesting colonies

We recorded 7,059 active nests (3,812 Cattle Egret nests, 3,247 Little Egret nests) in 42 colonies. Most colonies (64.3%) contained nests of both species, with 23.8% comprising only Little Egrets, and 11.9% comprising only Cattle Egrets. The nests of each species tended to be clustered together, although we did not quantify this. The mean number of nests per colony was 77±13 for Little Egrets, 91±21 for Cattle Egrets, and 168±33 for both species combined.

Most nesting colonies were located in residential areas (37.3%), followed by religious places (16.4%), government premises (15.2%), mango orchards (12.5%), *panchayat* lands (6.4%), plantations along highways (6.4%) and agricultural areas (5.8%). The majority (65%) of nesting trees were located <250 m from the nearest wetland, 34% were at a distance of 251–500 m and only 1% were >500 m. Nesting colonies were located significantly closer to open water wetlands (mean distance = 209±29 m) and emergent wetlands (232±57 m) than consolidated bottom marshlands (652±106 m; $F_{2,157}$=49.44, P<0.0001; Scheffe post-hoc tests).

Location of nests

The majority of nests (43.8%) of both species were located in trees of *Ficus* spp., followed by *Dalbergia sissoo* (12.5%), *Mangifera indica* (11.3%), *Azadirachta indica* (11.3%) and *Eucalyptus* spp. (5%). The remaining nests were located in trees of *Acacia nilotica*, *Albizia lebbek*, *Averrhoe carambola*, *Bombax ceiba*, *Delonix regia*, *Manlkara hexandraroxburgi*, *Melia azadirach*, *Mimusops elengi*, *Pithecellobium dulce*, *Syzygium cumini*, *Tamarindus indica* and *Ziziphus mauritiana*.

There was no difference between the mean height of nesting trees for Cattle Egrets (11.1±3.5 m, N=91) and Little Egrets (10±3.4 m, N=101; t_{190}=0.62, NS). Nests of both species were sited above the middle of the tree, having significantly greater mean distances from the ground than from the top of the tree (Cattle Egret: t_{91}=9.51, P<0.001; Little Egret: t_{101}=9.96, P<0.001). The number of nests of both species differed significantly between different canopy sectors (ANOVA: Cattle Egret: $F_{5,540}$=36.27, P<0.0001; Little Egret: $F_{5,600}$=22.34, P<0.0001), with significantly more nests in the inner-upper canopy sector for both species (Scheffe post-hoc tests).

Nest densities

On average, there were 0.016±0.004 Cattle Egret nests/m^3 of canopy volume and 0.024±0.001 Little Egret nests/m^3, with no significant difference between the two species (t_{316}=1.24, P=0.22).

The density of nests of each species separately and combined varied significantly between nesting trees in different man-made habitats (Table 1). Nest densities were highest in nesting trees located in religious sites (both species), agricultural areas (Cattle Egret) and plantations (Little Egret). The nest density of each species separately and combined did not vary significantly across various wetland types (Table 2). The distance to the nearest wetland had a significant effect on density of nests in nesting trees (Discriminant Function Analysis; Wilks' Lambda = 0.96, $F_{1,188}$=7.54, canonical discriminant function coefficient = 0.73, P<0.007). No other variables were significant predictors of nest density.

Table 1. Density of nests of Cattle and Little Egrets in nesting trees (nests/m^3 of canopy volume) in different man-made habitat types.

Habitat type (N = no. of trees)	Cattle Egret Mean±SE	Little Egret Mean±SE	Combined Mean±SE
Agriculture (N=6)	0.22±0.09	0.0±0.005	0.23±0.08
Government premises (N=24)	0.05±0.01	0.04±0.01	0.09±0.03
Housing N=69)	0.04±0.01	0.02±0.005	0.06±0.005
Mango orchards (N=17)	0.03±0.005	0.01±0.005	0.04±0.005
Religious places (N=26)	0.2±0.09	0.2±0.09	0.4±0.11
Plantations along highways (N=8)	0.04±0.01	0.28±0.13	0.32±0.16
Panchayat lands (N=8)	0.03±0.01	0.07±0.02	0.1±0.02
ANOVA	$F_{6,157}$=*1.92* *P=0.05*	$F_{6,157}$=*3.8* *P<0.008*	$F_{6,157}$=3.09 P<0.007

Table 2. Density of nests of Cattle and Little Egrets in nesting trees (nests/m^3 of canopy volume) located near different wetland types.

Wetland type (N = no. of trees)	Cattle Egret Mean±SE	Little Egret Mean±SE	Combined Mean±SE
Emergent (N=24)	0.09±0.02	0.02±0.005	0.11±0.02
Open water (N=96)	0.03±0.01	0.03±0.01	0.08±0.02
Unconsolidated bottom marshland (N=40)	0.07±0.02	0.04±0.02	0.11±0.02
ANOVA	$F_{2,157}$=*0.4* *P=0.67*	$F_{2,157}$=*0.15* *P=0.86*	$F_{2,157}$=0.5 P=0.9

At the micro-habitat scale, stepwise multiple linear regression models showed that canopy spread and canopy volume together explained 68% and 63% of the variation in nest density for Cattle Egret and Little Egret respectively. Canopy spread alone was found to be most important, explaining 48% of the variation in Cattle Egret nest densities (r_s=0.6, $F_{5,92}$=16.5, M.R.=0.4, P<0.001), and 41.0% of the variation in Little Egret nest densities (r_s=0.4, $F_{5,87}$=5.7, M.R.=0.6, P<0.001).

DISCUSSION

At the macro-habitat level, the proximity of wetland areas appeared to be the primary factor affecting the location of nesting colonies of Cattle Egrets and Little Egrets, with nearly all colonies located <500 m from a wetland, and two-thirds located <250 m. Presumably, invertebrate and small vertebrate fauna in and around these wetlands provide important food resources for the rearing of young, with colonies situated near wetlands providing efficient access to foraging resources (Gibbs and Kinkel 1997). Of all man-made habitat types, residential areas contained the largest proportion of colonies of Cattle and Little Egrets, despite the fact that people often disturb and harm these birds because of the smell of droppings and rotting food scraps that fall from nests.

The majority of nests were located in *Ficus* spp. trees. With their relatively large canopy spread and great height, these trees probably reduce nest visibility to potential predators (e.g. birds of prey, domestic cats) from both the top of the tree and the ground. Furthermore, the well-buttressed trunks and relatively strong branches and twigs of these trees may be better at supporting the weight of large numbers of nests and their contents.

Where different heron species nest together in colonies, the different species often stratify the placement of their nests vertically, with the largest species nesting highest and the smallest nesting lowest (Burger 1982). However, our data did not show any significant difference in nest height for Cattle and Little Egrets at Amroha, perhaps because the two species have approximately equal body sizes.

Our results differ from those of a study in Texas, where Cattle Egrets nest in tall herbs, shrubs or small trees, or even on the ground where no nest sites are available in higher vegetation in densely populated colonies (Telfair 1983, 1994). Furthermore, the average height of nesting trees in Amroha (10–11 m for the two species) was greater than in Texas (6–9 m: Telfair 1983) or in another study of Little Egrets in Macedonia (6.7 m: Kazantzidis *et al.* 1997). Differences in available nesting habitat influences nest-site choice in different locations (Arendt and Arendt 1988, Baxer 1994). Average colony size in Amroha (171 nests of both species combined) were smaller than in Texas (mean of 750 nests of Cattle Egret, Great Egret *Casmerodius albus*, Snowy Egret *Egretta thula*, Little Blue Heron *Egretta caerulea* and Black-crowned Night Heron *Nycticorax nycticorax* combined: Telfair *et al.* 2002), South Dakota (mean of 269 nests of Cattle Egret, Snowy Egret nests, Black-crowned Night Heron nests and Little Blue Heron combined: Naugle *et al.* 1996) and Greece (292–422 nests of Little Egret, 333–647 nests of Black-crowned Night Heron: Kazantzidis *et al.* 1997). We cannot compare our estimates of nest density with those in these studies, because we calculated nest density in three-dimensional space, whereas in other studies herons show a relatively uniform and approximately uni-layered nest placement within the vegetation, and nest density is calculated in two dimensions (e.g. Telfair 1983).

Breeding birds require safe nesting sites as well as sufficient quantity and quality of foraging habitat (Kallander 1974, Yom-Tov 1974, Bronssen and Jansson 1980, Drent and Daan 1980, Smith *et al.* 1980, Ewald and Rohwar 1982). Therefore, conservation efforts need to focus not only on protection of nesting colonies, but also large-scale preservation of adjacent foraging habitat. In Amroha, public awareness and education programmes are needed to protect nesting trees and minimise disturbance in order to ensure long-term persistence of waterbirds in general, and ardeids in particular.

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