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Nest Site Characteristics and Nest Densities of Ardieds (Night Heron: *Nycticorax nycticorax*, Grey Heron: *Ardea cinerea*, and Little Egret: *Egretta garzetta*) in the Nallıhan Bird Sanctuary (Sarıyar Reservoir, Ankara, Turkey)

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Abstract: In this study, the nesting site characteristics and nest densities of ardeids (grey heron: *Ardea cinerea*; night heron: *Nycticorax nycticorax*, and little egret: *Egretta garzetta*) were investigated in Nallıhan Bird Sanctuary. It was found that the site of breeding colony had 166 trees consisting of willows (92) and poplars (74); 105 of which (63 willow and 42 poplar) were found occupied by ardeid nests. In the sampled trees (n = 40), 395 nests (night heron: 254, grey heron: 103, and little egret: 38) were located; 244 of which were located in willows (night heron: 170, grey heron: 44; little egret: 30) and 151 (night heron: 84, grey heron: 59; little egret: 8) in poplars. Also the number of nests and nest density for the 105 occupied trees were calculated as 1037 and 0,027 nest/m^2, respectively. However, the difference between willows (4.07 ± 3.54 nest/tree) and poplars (2.52 ± 2.04 nest/tree) in terms of nest densities of ardeids were statistically insignificant.

Key Words: Nest densities, ardeid species, Nallıhan Bird Sanctuary

Nallıhan Kuş Cenneti'ndeki (Sarıyar Rezervuarı, Ankara) Balıkçılların (Gece Balıkçılı: *Nycticorax nycticorax*, Gri Balıkçıl: *Ardea cinerea* and Küçük Ak Balıkçıl: *Egretta garzetta*) Yuva Yeri Özellikleri ve Yuva Yoğunlukları

Özet: Bu çalışmada, Nallıhan Kuş Cenneti'nde balıkçılların (gri balıkçıl: *Ardea cinerea*; gece balıkçılı: *Nycticorax nycticorax* ve küçük akbalıkçıl: *Egretta garzetta*) yuvalanma yeri özellikleri ve yuva yoğunlukları araştırılmıştır. Üreme kolonisinin bulunduğu alanda, 92 tanesi söğüt ve 74 tanesi kavak ağacı olmak üzere, toplam 166 ağaç vardır. Bu ağaçlardan 105'inin, balıkçıllar tarafından yuvalama amacı ile işgal edildiği gözlenmiştir (63 söğüt and 42 kavak). Örneklenen ağaçlarda (n: 40), toplam olarak 395 yuva (gece balıkçılı: 254, gri balıkçıl: 103; küçük akbalıkçıl: 38) sayılmıştır ve bu yuvalardan 244'ü söğüt ağaçlarında (gece balıkçılı: 170; gri balıkçıl: 44; küçük akbalıkçıl: 30); 151'i ise kavak ağaçlarındadır (gece balıkçılı: 84; gri balıkçıl: 59; küçük akbalıkçıl: 8). Yuvalarla işgal edilmiş ağaçlardaki toplam yuva sayısı 1037 ve yuva yoğunluğu ise 0,027 yuva m^2 olarak hesaplanmıştır. Bununla birlikte balıkçıllara ait yuva yoğunlukları açısından söğüt (4.07 ± 3.54 yuva/ağaç) ve kavak ağaçları (2.52 ± 2.04 yuva/ağaç) arasındaki farklılık istatistiksel olarak önemsiz bulunmuştur.

Anahtar Sözcükler: Yuva yoğunluğu, balıkçıl türleri, Nallıhan Kuş Cenneti

Introduction

Differential resource selection is one of the principal factors permitting the coexistence of species (Schoener, 1974; Rosenzweig, 1981). Although different species of herons vary in their habitat preferences, diet, and behavior, they have certain common 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 there is access to feeding areas within foraging range (Thompson, 1977; Hafner and Brittin, 1983; Hafner and Fasola, 1992; Hafner, 2000). Further, the nest site should also promote hatching (Ludwig et al., 1994) and successful rearing of young individuals, which is important for the survival of the species (Buckley and Buckley, 1980).

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Studies pertaining to nest site selection by the cattle egret (*Bubulcus ibis*) and little egret (*Egretta garzetta*) (Arendt and Arendt, 1988; Kazantzidis et al., 1996; Hilaluddin et al., 2003) and its effect on breeding success (Kazantzidis et al., 1997) have been conducted but the factors governing breeding success vary between the regions. In studies of niche partitioning, nest location has received much less attention than food or habitat, perhaps because suitable nest sites are presumed to be readily available for most species. However, when a species has a specific nesting requirement, suitable nesting locations may be difficult to obtain (Wiens, 1989; Burger and Gochfeld, 1990), which may cause the overlap of nesting sites which consequently attracts the predators due to the increase in cumulative nest density (Martin, 1996).

For colonial herons, the existence of a vertical nest stratification of species within mixed colonies in relation to body size has been suggested, with the larger species nesting at higher levels (Burger, 1982; Burger and Gochfeld, 1990; Fasola and Alieri, 1992). Species nesting at higher levels of the trees are presumed to acquire these territories through dominance linked to body size (Burger, 1978) and/or early arrival to the colony (Burger and Gochfeld, 1990). Nesting site characteristics of many ardeid species have been studied several areas in the Mediterranean region (Moser, 1984; Fasola and Alieri, 1992; Kazandzitis et al., 1996 and 1997; Parejo et al., 1999). However, there is no scientific data available in Turkey's wetlands on the breeding bioecology of the ardeid species.

Sarıyar Reservoir in the central Anatolia (hereinafter called as reservoir), including Nallıhan Bird Paradise (NBS), is an internationally important bird area that has been declared as a national protected wetland for water birds, particularly for vagrant ardeid species (Perktaş and Ayaş, 2005). The number of bird species was determined in Turkey through research studies carried out during the last 50 years. Nine ardeid (herons) species were listed in Turkish avifauna: grey heron *Ardea cinerea,* night heron *Nycticorax nycticorax*, squaco heron *Ardeola ralloides*, egret *Egretta alba,* little egret *Egretta garzetta,* purple heron *Ardea purpurea,* cattle egret *Bubulcus ibis* bittern *Botaurus stellaris,* and little bittern *Ixobrycus minitus* (Kiziroğlu, 1989 and 1993). Previous studies showed that grey heron *Ardea cinerea,* night heron *Nycticorax nycticorax*, squaco heron *Ardeola ralloides*, little egret *Egretta garzetta,* and little bittern *Ixobrycus minitus* were recorded as regularly breeding species in the reservoir, including NBS. Also, egret *Egretta alba* was evaluated as wintering and purple heron *Ardea pupurea* were evaluated as vagrant (Perktaş and Ayaş, 2005).

The aims of the study are: (1) to examine the nesting site characteristics of ardeids, (2) to determine tree preferences of ardeids, (3) to determine arrival times to breeding area for each ardeids, and (4) to determine nest numbers and densities of grey heron (*Ardea cinerea)*, night heron (*Nycticorax nycticorax),* and little egret (*Egretta garzetta)* in mixed heronries in NBS, which is located in the central parts of Turkey.

Materials and Methods

Study area

Sarıyar Dam (reservoir, 31,700 ha, Figure 1) lies between Hamam Mountain on the south and Kapkiri Mountains on the north. The reservoir is one of the oldest (completed in 1956) large dams in Turkey, with a maximum depth of 79 m. and fed by Sakarya River, Kirmir and Aladağ Streams. The reservoir is used for the production of hydro-electric power. A small shallow seasonal wetland (dry by late summer) popularly known as the Nallıhan Bird Sanctuary (NBS, 425 ha) is formed where the Aladağ Stream flows into the lake. NBS holds significant breeding populations of grey herons, night herons, and little egrets which breed in the poplar and willow plantations on the southern shores; whereas black storks, Egyptian vulture, and lanner breed on the cliffs. NBS holds large number of roosting white storks on migration (maximum 15,000) and ruddy shelducks (maximum 10,000).

Also, NBS was declared as a Permanent Wildlife Reserve in 1994. Neighboring villagers cut down the privately owned poplar and willow trees, causing an important threat for the breeding bird species. To overcome this problem, a plan should be developed to guarantee a rotation scheme where different sections of the stands are cut during succeeding years (Kılıç and Eken, 2004). The study area (colony site, approx. 4 ha) is located in the NBS (40°06'N-31°36'E) within rural property of approximately 900 ha (40°06'873''N-31°36'565''E).

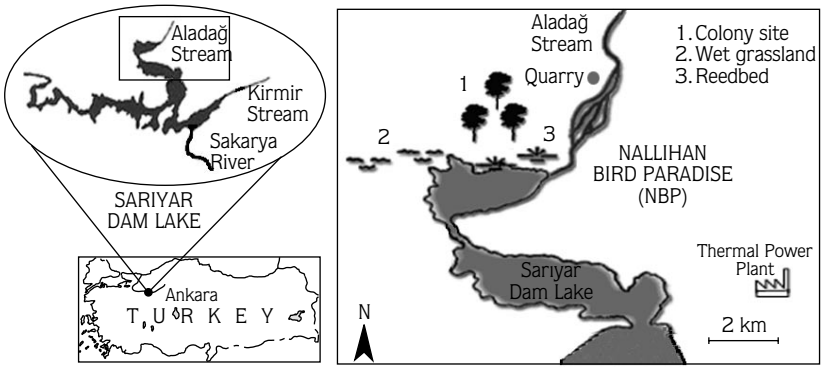

Figure 1. Location of Nallıhan Bird Sanctuary (NBS) and Sarıyar Reservoir, Ankara, Turkey (coordinates: 40°2'24"N-31°36'36"E).

The poplar and willow plantations in this area are arable and threatened by the effects of human disturbances (distances to the nearest village 235 m; main highway 1565 m.). At this site, a mixed species nesting colony is made by grey heron, night heron, and little egret. Nesting trees in the colony were within approximately 240 m radius and nesting pairs were close enough to interact socially among themselves.

Sampling and Measurements

Field studies were carried out from mid-March to mid-June 2006. Distances (from the colony site to the Aladağ Stream, Sarıyar Reservoir, settlement, main highway) and topographic measurements (area and circumference) of the colony site were calculated by the GIS database (Map Info Professional software) and topographic maps (scale: 1/10,000). Also, aerial photographs were used to estimate the surface areas, tree numbers, and particularly percentages of the canopy. Before the nesting season, the colony site, known to have been used in previous years, was divided to quadrates (10x10 m) using the maps and aerial photos for determining the nest numbers and measuring the tree characteristics.

From each of the quadrates, totally 40 nested trees (20 willows, 20 poplars; as 1 willow - 1 poplar for each quadrate) were selected for tree measurements and nesting activity observations. Nesting trees were identified at genus level and specifically measured for their morphometric characteristics. Twenty willows and 20 poplars were marked by small numbered labels placed at the lower part of each tree. Each sampled tree has been photographed using the length scale (2 m) with a DC-300 digital camera system for morphometric measurements and these photos were transferred to the computer. Morphometric calculations of the each tree were done using a TPS digital programmer. A total of 5 values were measured for the willows and poplars using TPS dig (Rohlf, 2003) software: (1) tree heights, (2) first limb heights, (3) trunk perimeter, (4) canopy depths, and (5) canopy diameters. The depth of the nest-tree canopy was measured as the distance between from the lowest limb to the top of the crown. In addition, canopy of each nesting tree was divided vertically into 3 equal parts (top, middle, and low) and horizontally into 2 equal parts (inner and outer), thus each tree providing a total of 6 canopy portions for nest counts (Hilaluddin et al., 2003). The number of nests of each species was counted separately within each part of the canopy for each nesting tree. The nests in selected parts of the colony were checked every week with binoculars and monocular from vantage points. All active nest numbers, nest heights, and arrival times of the species were recorded to the colonial water birds survey charts for each sampled tree and species. The nest numbers of each species were counted separately for each nesting tree.

Statistical Analysis

The distribution of the nests of each ardeid species in the willows and poplars were compared with the non-parametric Kruskal Wallis Test ($P < 0.05$). To analyze size variation between different tree species, Principal Component Analysis (PCA) was used.

Results

The morphometric measurements according to the 2 tree species were calculated with Principal Component Analysis (PCA) and tree scores are shown in Table 1. According to variance-covariance matrix, the first and second principal component axes explain 90.3% of total variation in size and shape in tree species (Table 1). To determine the correlation between tree size and nest counts, Spearman Rho Correlation coefficient is calculated, and the coefficient is only significant for grey herons ($r = -0.715$ $P < 0.001$). Moreover, chi squared test was also used to explain the relationship between nest count and nest height in trees. In grey heron population, there is a significant relationship between nest high and tree species ($\chi^2 = 10.755$, df = 2, $P = 0.005$).

With the size component of PCA, it was found that the relationship only with grey heron nest number (Spearman's Rho = -0.715, $P < 0.01$) was significant. This result showed that grey herons prefer the top parts of canopy and furthermore a tendency was observed for poplar trees. When a regression analysis was carried out to explain the relationship between grey heron nest density and tree size, it was found that the nest density of grey herons was changed related to tree size (grey heron nest densities = - 8,89, size = 6,21; $P < 0.01$). Regarding the tree size, 46.3% of the changes in grey heron nest density can be explained only by the above model. However, no relationships in other ardeids (night heron and little egret) were observed, suggesting that the nest distribution in the colonies is not random.

In the colony site, there are 166 trees consisting of willows and poplars. Among 105 (63.25%) of these trees, there were nests used by ardeid species in the recent years. It was observed that all of these trees with old nests were also used in 2006 breeding season by ardeid species. In the field studies, it was found that among 105 nest trees, 63 of them (60%) are willows, *Salix* spp., and 42 of them (40%) are poplars, *Populus* spp. (Table 2). Three ardeid species forming mixed colonies arrived to nest trees in 2006 breeding season at different times. Grey herons, which are the native species (Perktas and Ayas, 2005) of this reservoir, were recorded as the first arriving species to the colony site in mid-March, 2006. After that, night herons (early April) and little egrets (late April) arrived to the nesting site and occupied the used nests.

In all sampled trees (n = 40), in which nesting activity were observed, 395 active nests belonging to 3 ardeid species [night heron (254), grey heron (103), and little egret (38)] were determined (Table 2). In total, 244 of 395 active nests were located in willows [night heron (170), grey heron (44), little egret (30)] while 151 [night heron (84), grey heron (59), little egret (8)] were located in poplars. However, the difference between willows (4.07 ± 3.54 nest/tree) and poplars (2.52 ± 2.04 nest/tree) in terms of nest densities were statistically insignificant ($H = 3.58$, $P > 0.05$) (Figure 2). Nest number for the 105 occupied trees with nest and nest density were calculated as 1037 nest and 0,027 nest /m^2, respectively.

Table 1. Nest tree parameters measured and principal component analysis score for trees.

parameters	willow (*Salix* spp.) poplar (n = 20)			(*Populus* spp.) (n = 20)			PCA sores for trees***	
	mean	SD	range	mean	SD	range	PC1	PC2
height (m)	10.72	1.533	7.2 – 13.6	12.175	1.571	9.2 – 14.5	-0.462	-0.674
first limb height (m)	2.53	0.951	1.1 – 5.2	3.92	1.079	2.2 – 6.1	-0.726	-0.679
canopy depth (m)*	8.19	1.032	5.7 – 9.9	8.255	1.363	5.5 – 10.3	0.038	-.0.261
canopy diameter (m)*	8.315	1.455	4.5 – 11.5	4.25	1.367	2.8 – 6.4	0.895	-0.422
trunk circle (cm)	246.4	26.19	195 - 290	160.05	21.512	129 - 197	0.819	-0.445

* : Calculated as tree height - first limb height

** : Calculated as minimum nest height - maximum nest height

***: Applied to Principal Component analysis

Table 2. Habitat characteristics and nest numbers of the 3 Ardeid Species in the colony site.

PARAMETERS		Coordinates
Sarıyar Reservoir(ha) -	31,700	40°02'N-31° 37'E
Nallıhan Bird Paradise (ha)	425	40°06'N-31°36'E
Colony site (ha)	3753	40° 06'873''N-31°36'565''E
distance to river (m)	625	
distance to reservoir (m)	2200	
distance to nearest village (m)	1235	
distance to main road (m)	1565	
tree density (tree/ha)	44.14	
canopy closure (%)	68.2	
shrub cover (%)	21.6	

Numbers of Trees	Trees		
	Willow (*Salix* spp.)	Poplar (*Populus* spp.)	Total
Total Numbers of Tree	92	74	166
(%)	(55.4)	(44.6)	(100)
Trees Occupied with Nest	63	42	59
(%)	(60)	(40)	(100)
Nest Numbers and Density for Ardeid Species in Sampled Trees	Willow n = 20	Poplar n = 20	Total n = 40
Night Heron	170	84	254
Density**	8.5 ± 2.18*	4.2 ± 1.39*	6.35 ± 2.83*
Grey Heron	44	59	103
Density**	2.2 ± 1.23*	2.95 ± 1.57*	2.57 ± 1.45*
Little Egret	30	8	38
Density**	1.5 ± 1.14*	0.4 ± 0.75*	0.95 ± 1.11*
Total	244	151	395
Density**	4.07 ± 3.54	2.52 ± 2.04	3.29 ± 1.65

*: Average nest numbers of ardeid species in each tree species found statistically significant (Kruskal-Wallis, $P < 0.05$)

**: Nest densities for each species were calculated as total nest number/sampled tree number

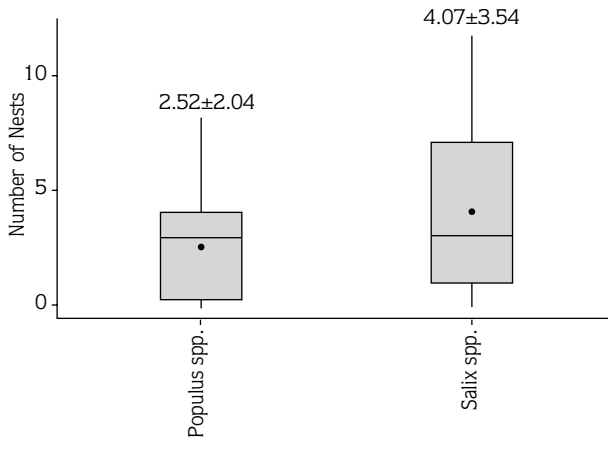

Figure 2. The distribution of the nest densities in regards of the 2 sampled tree species in the colony site. (Kruskal Wallis statistics H = 3.58, P > 0.05).

According to this result, the 3 ardeid species in the colony are nesting without considering the tree types. The nest densities were found as night herons > grey herons > little egrets (Table 2). When all sampled trees (Figure 3) and willows (Figure 4) and poplars (Figure 5) evaluated separately, the differences between nest densities of the 3 ardeid species were found to be statistically significant (Figure 2).

For grey herons, regarding nest density, the relationship between nest height and tree species is statistically significant ($X^2 = 10.755$, df = 2, P = 0.05); that is to say, grey herons prefer poplars, which are taller than willows. For night herons, regarding nest density, there is no relation between nest height and tree species ($X^2 = 1.704$, df = 2, P = 0.636). For this species, nests

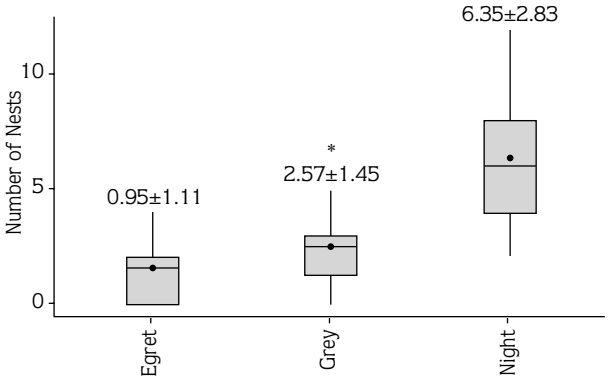

Figure 3. The distribution of nest densities in all sampled trees in the colony site regarding each ardeid species (Kruskal Wallis statistic, H = 77.59, P < 0.05 for all sampled trees, n = 40 trees).

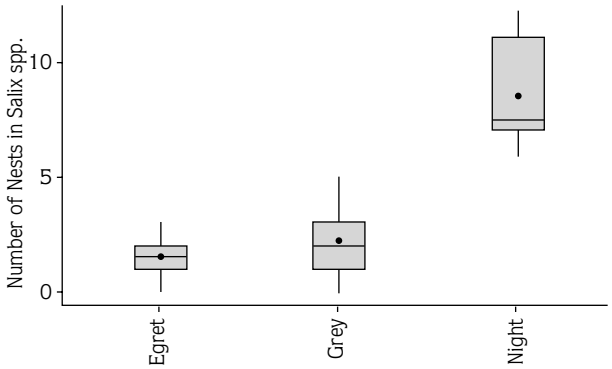

Figure 4. The distribution of nest densities in the sampled willows in the colony site regarding each ardeid species (Kruskal Wallis statistic, H = 41.48, P < 0.05, for *Salix* spp. n = 20 trees).

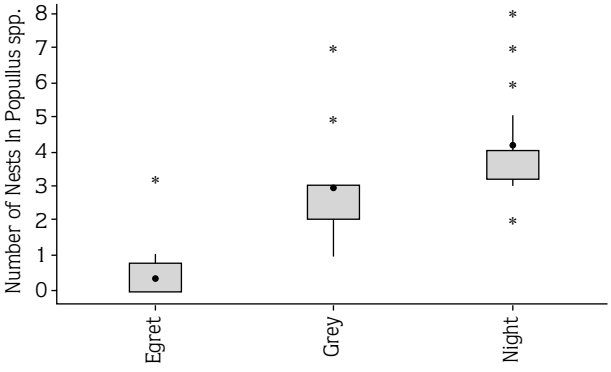

Figure 5. The distribution of nest densities in the sampled poplars in the colony site regarding each ardeid species (Kruskal Wallis statistic, H = 40.73, P < 0.05, *Populus* spp. N = 20 trees).

are randomly distributed regarding the tree type or nest height and, similarly, the same is valid for little egrets (X^2 = 4.212, df = 2, P = 0.239).

Discussion and Conclusion

Due to lack of enough and convenient data (for the other wetlands), it is not possible to compare the present findings with other wetlands in Turkey. Until today, it has been believed that only night herons (at least 120 pairs) breed in NBS (Kılıç and Eken, 2004). However, this study shows that, together with the night herons, grey herons and little egrets reproduce in mixed colonies in NBS.

In recent years, cutting of trees in order to make arable fields in Sarıyar reservoir, the increase of anthropogenic disturbances (excessive agricultural activities and the increase of vehicular traffic due to the use of the thermal power plant) and predator pressure (especially magpies and Egyptian vultures) could be the reasons of the herons living in this reservoir to move into a more appropriate breeding areas, e.g. NBS.

Consequently, it is inevitable that a competition will take place among the species in occupying the willow and poplar trees and occupying the higher parts. This study has revealed that there is a competition between ardeid species regarding tree species and the heights of the nesting sites in these trees. As a result of this competition, the nesting densities of ardeid species differ depending on the tree kind and height. Despite of all negative factors (e.g. nesting site insufficiency, predation, and anthropogenic originated disturbances), it can be said that nesting competition between the species can be tolerated by the abundance of food sources. Because, the colony area is very close to the reservoir and the river (distances to reservoir: 2200 m and to the river: 625 m); and lots of fish, mainly bleak (Ekmekçi et al., 2000), are available in this area. Studies have shown that, herons can live in a mixed colony due to breeding success even when there is insufficient nesting place available (Rosenzweig, 1981; Wiens, 1989; Martin, 1996).

The nest density of each ardeid species per tree in the colony area is quite large (Table 2). However, the nest density of the 3 species derived in this study can not be directly compared to other studies conducted in the other countries. Here, the nest density is based on the number of nests per tree canopy (Kazantzidis et al., 1997);

whereas, numbers per unit geographical area were used in previous studies. The approach used in this study provides a more realistic view of the available resources (mainly vegetation structure and food) and thus is a better indicator of nest abundance (Hilaluddin et al., 2003)

Salix species is one of the main factors for nest site selection of night herons and little egrets, whereas *Populus* species is important for grey herons. This can be explained with the arrival dates to site and body size of the ardeid species. Although vegetation structure is an important factor for the choice of a specific nesting site among ardeids (Baxer, 1994; Subramanya, 1996), the presence of large willow trees within the site (presumably more suitable and closer to feeding areas) is important in nest site selection by the 3 species in NBS (Hilaluddin et al., 2003).

Many ardeid species often vertically stratify the placement of their nests, with larger species nesting higher and smaller species nesting lower (Burger 1982; Burger and Gochfeld, 1990). In the study, nesting was initiated by the grey herons who had the advantage of choosing from all the potential nest sites and the opportunity to occupy the most suitable ones. Perhaps saturation at upper canopy levels by early-breeding grey herons forced late-nesting night herons and little egrets to nest on lower portions of canopies in the nesting trees.

Our analysis, supported by field observations, show that late nesting little egrets place their nests on the upper parts of the smaller trees in the colony. This confirms the findings of Naugle et al., (1996) who reported that vertical and horizontal orientation of nests within a multispecies heronry may be a function of timing of nest initiation, nest abundance in different areas of the heronry, and interspecific and intraspecific competition.

Body size has been discussed by other authors (Burger, 1978; Fasola and Alieri, 1992, Parejo et al., 1999; Hilaluddin et al., 2003) as the main reason of the success in the acquisition of preferred nest sites and it seems to act even when there are important similarities in the body sizes of the species (night heron and little egrets), which has been proposed as a factor causing the overlap in the nest height (Fasola and Alieri, 1992; Parejo et al., 1999).

Finally, it is very important to preserve the existing trees with better precautions, rehabilitate them, and plant new willow and poplar trees in this area for the diversity and continuity of wildlife.

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