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Nesting Ecology of the Spot-Billed Pelican Pelecanus Philippensis in Southern India

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Abstract: The nesting ecology of the threatened Spot-billed Pelican *Pelecanus philippensis* was studied in the southern India, during March 2002 to January 2004. We made a study of four colonies in the southern India during the 2002-2003 to 2003-2004 nesting season. Intensive studies were carried out in four colonies two colonies in Andhra Pradesh, one in Karnataka and one in Tamil Nadu with 746 nests in 60 trees. The colonies were distributed in the north, east and west direction and approximately 500 km from each other in southern India. All the colonies were close proximity and vicinity of the human settlements and close to roads. Almost 33.3 % of the breeding sites of pelicans the trees were belongs to the private growing near to their house or at the backyard, rest of them are in protected areas. The nearest water source to the colony ranged from 1 km to 20 km; while the nearest foraging ground was from 10 km to 100 km. The distance from a nest tree to the next nearest nest tree was 5 m and 1.5 m. Over all in southern India, almost 99.9% of nests were built on the top canopy of the tree.

Key words: Nesting · Spot-billed pelican · Southern India

INTRODUCTION

Pelicans are colonial birds. Of the seven species of pelicans in the world, the spot-billed pelican (*Pelecanus philippensis*) and the Pink-backed pelican (*Pelecanus rufescens*) are the tree nesting species, all the other five species are ground nesters [1] among, the seven species, two are found breeding in India. They are the spot-billed pelican and the Great White Pelican (*Pelecanus onocrotalus*) [2]. The first is the globally threatened pelican in the world [3, 4]. Historically, the spot-billed pelican was common across much of South Asia and has been reported from China, Pakistan, India, Nepal, Bangladesh, Sri Lanka, Myanmar, Vietnam, Laos, Thailand, Malaysia, Hong Kong and Taiwan. It has undergone a widespread decline in the recent past [3, 4]. In 1997, the population was estimated at 11,500 birds in the wild. The only known breeding populations are now confined to India, Sri Lanka and Cambodia and probable breeding in small numbers on Sumatra, but no longer they breeds in Myanmar [1, 3, 4].

In India, the strongholds of the species are in Northeast India (Assam) and southern India (Andhra Pradesh, Karnataka and Tamil Nadu). The breeding of the spot-billed pelican in the Indian Subcontinent was unknown for a very long time. The first record was by Jerdon [5], in the 'Carnatic' in southern India.

Mean while Oates [6] reported a huge colony in Burma (Myanmar). Legge [7] reported a colony in Sri Lanka. After which most of the studies have been based on short-term studies entirely on its breeding biology referring to accounts of pelicanries, nests, eggs and young [8-16]. No detailed study on requirements of its nesting ecology of spot-billed pelican exists.

We surveyed nesting colonies and studied the nesting ecology of spot-billed pelican during the nesting season in southern India. In addition, we undertook an intensive study at the nesting colonies of Nelapattu and Telineelapuram in Andhra Pradesh, Kokkare-Bellur in Karnataka and Koonthankulam in Tamil Nadu. We studied the vegetation structure and other habitat parameters associated with the colonies. We examined whether the nest trees differed from other parameters with respect to their structure and what features of the nesting trees and surrounding environment were important in determining the number of pelicans in the colony.

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Study Area: The study was confined to the states Andhra Pradesh (12°40' N to 76°45' E), Karnataka (11°30' N to 74°10' E) and Tamil Nadu (8°04' N to 76°14' E) in southern India. The intensive study was carried out at Nelapattu (13°51 N to 79°57' E), Telineelapuram (19°07' N to 84° 40' E) in Andhra Pradesh; Kokkare-Bellur (12°13' N to 77°05' E) in Karnataka; and Koonthankulam (8°28' N to 77° 43' E) in Tamil Nadu located in southern India.

Nelapattu is a bird sanctuary encompasses an area of 458.92 ha of which 82.56 ha constitute the tank area. Remaining forms the reserve forest surrounding the tank. It is an old pelicanry. Initially the birds were reported to be nesting in the Nelapattu village. The pelicans were intentionally distributed by the locals to make them shift the colony due to the problem of the bird droppings, which now continues in the tank inside the sanctuary limit. [13, 15- 17].

Telineelapuram Pelicanry is a village Pelicanry located in the Telineelapuram village of the Srikakulam district of Andhra Pradesh. This pelicanry is of recent origin. The pelicans nest in the vicinity of the villagers. According to the locals and forest department, it has been there for last 20 years.

Kokkare-Bellur pelicanry is believed to be the pelicanry that T.C. Jerdon discovered in the 'carnatic' in the 19th century [5]. This pelicanry again rediscovered in the 1970's [11]. Pelicans used to nest in the villages of Kokkare-Bellur and Bannali villages, but the birds shifted totally to Kokkare-Bellur over the years [19]. Prior to its discovery in the 1960's it is said to have more than 2000 birds breed in the villages [20, 21].

Koonthankulam Pelicanry is one of the oldest Pelicanry discovered during 19th century [22]. The pelicans built their nest in the village trees in the human vicinity. Now the pelicans have moved to the nearby tank located in the village [23, 24, 25].

MATERIALS AND METHODS

The methods of measuring the tree dimensions and nearest nest-tree distances were same as in the overall study. Visits were made once or twice to all the pelicanries except for the Nelapattu (intensive study site). Two breeding seasons was used in the analysis. In addition, we recorded the nest placement in the upper, middle or lower canopy. The survey of nesting colonies was conducted from March 2002 to January 2004 [26, 27]. The colony surveys were mainly based on the earlier reports and literature surveys. In addition to the surveys, information about new locations of Spot-billed Pelicans was also gathered to know the species colony extension. There were no breeding reports other than these existing colonies except Karnataka.

At each colony, we identified the nest trees and counted the number of nests in each tree. We measured tree dimensions, including height of the tree from the ground, diameter at breast height (DBH) and canopy area. Height of the tree and height of the nest were estimated visually by comparing known tree height. Canopy spread was determined by measuring the spread from the base of the tree trunk in four directions at right angles to each other. The mean canopy spread was taken as the average of the four radii. We measured trees containing pelican nests and the dominant vegetation around each nesting tree. The distances of other habitat parameters such as nearest house, nearest forest, nearest road, nearest water source and nearest foraging ground from the nest tree were also estimated.

T- Tests were used to test the significance of differences between nest trees, height, DBH and canopy area. Data were pooled to find the difference in tree dimensions of nesting trees. The mean height of nests in each tree was divided by the tree height to obtain the nest position by using non-parametric Kruskal-Wallis test [28] to know the relative nest height differed between the colonies. A t-test was used to compare the structure of trees with more ($\geq$ 5 nests) or fewer nests (< 5 nests). Pearson's correlation [29] was used to detect association between the number of nests and tree structure and between the number of nests and habitat parameters in the intensive study sites. All the analyses were performed using SPSS (SPSS 10.0).

RESULTS

We surveyed nine colonies in three states of Andhra Pradesh, Karnataka and Tamil Nadu. Intensive studies were carried out in four colonies two colonies in Andhra Pradesh, one in Karnataka and one in Tamil Nadu with 746 nests in 60 trees (Table 1 and Table 5). The colonies were distributed in the north, east and west direction and approximately 500 km from each other in southern India. Except for Nelapattu colony, Kokkare-Bellur and Telineelapuram colonies were in villages. Arrival of Spot-billed Pelican in southern India was timed and the breeding season indicated invariably, they were timed to arrive in October/November and to sojourn until April/May. Pelican starts constructing nests only after courtship or even after a couple of mating. Vegetation serving for nest material was dry, hard and thorny twigs

from the scrub and projections from the nesting trees. The nests were lined with water reeds such as *Psendoraphis aspera* and *Ipomea carnea*. The nesting activity was continued up to end of February or even up to March. In Nelapattu, the pelicans share the nesting habitat with a wide variety of avifauna. At Nelapattu, the birds nest on the Barringtonia acutangula and *Acacia nilotica* tress studded in the tank bed. At Telineelapuram, the bird shares the nesting habitat, in perfect harmony with the Painted Storks on the *Tamarindus indica* trees. At Koonthakulam, the pelican nest in *Acacia nilotica* and shares the habitat with Oriental White Ibis.

Pelicans breeding at villages in southern India are not having thick tree cover; however, they use traditional sites and traditional nesting trees. All the colonies were close proximity and vicinity of the human settlements and close to roads (Table 2). Almost 33.3 % of the breeding sites of pelicans the trees were belongs to the private growing near to their house or at the backyard rest were protected. Nine of the five colonies were in water tanks and the rest were in the villages (Table 5). The nearest water source to the colony ranged from 1 km to 20 km; while the nearest foraging ground was from 10 km to 100 km [19] (Table 2). In Telineelapuram and Kokkare-Bellur (40%), the distance from a nest tree to the next nearest nest tree was 10 m. Except for Nelapattu, there is no dominant vegetation around the nesting tree. At Nelapattu, the nest trees were surrounded by *Ipomea carnea*. In Nelapattu and Koonthankulam the distance from the nest tree to the next nearest nest tree was similar. The distance from a nest tree to the next nearest nest tree was 5 m and 1.5 m.

Sixty nest trees were examined. Height ($t = 0.400$, $P < 0.001$), DBH ($t = 5.42$, $P < 0.001$) and canopy area ($t = 2.58$, $P < 0.001$). The nest trees were not significantly greater than those of non-nesting tree. The non-nesting trees were used as resting and roosting tree by the adult birds. After the chicks are grown to fledgling stage due to their bigger size and non-availability of space to accommodate parent bird and young, the adult birds use the nearest non-nesting tree for resting and roosting.

We found nests of Spot-billed Pelican in seven species of trees, among which the *Barringtonia acutangula* (33%) and *Acacia nilotica* (38%) were most frequently used (Table 3). The height of the nests between different colonies was a maximum of 7.4 m and a minimum of 5.6 m in Telineelapuram and Kokkare-Bellur, whereas at Nelapattu and Koonthankulam it was 4.9 m and 3.6 m (Table 1). The relative height of the nests between different colonies was not significant (Kruskal-Wallis $X^2 = 4.68$, n.s.).

During the study period, (2002-2004) the Spot-billed Pelicans used the same trees of seven species year after year. Highest no of nests (226) was recorded in Koonthankulam (2002-2003), followed by 215 nests at Nelapattu (2002-2003) and 200 nest in 2003-2004. Maximum of 200 nests and 105 nests were recorded at Kokkare-Bellur and Telineelapuram. Number of nests was positively correlated with DBH, followed by tree height and canopy area (Table 4), nearest house was not significantly correlated. Over all in southern India, almost 99.9% of nests were built on the top canopy of the tree.

Pelicans in southern India observed to have association with six different bird species belongs to two different families such as ciconiiformes and pelecaniformes (Table 5). Among the ciconiiformes, the Oriental White Ibis *Threskiornis melanocephalus*, the

Table 1: Number of nests and nest tree dimensions of Spot-billed Pelican

State	Colony	No. of Trees	No. of Nests	Height of tree m±SD)	Height of nest (m±SD)	DBH (m)	Canopy area (m^2±SD
Andhra Pradesh	Nelapattu	26	215	3.8 ± 0.6	3.6 ± 0.5	0.95	$8.3^2 \pm 1.2$
	Telineelapuram	5	105	5.6 ± 2.1	5.6 ± 2.1	1.67	$2.6^2 \pm 3.8$
Karnataka	Kokkare-Bellur	6	200	7.4 ± 0.6	7.4 ± 0.6	3.2	$16.3^2 \pm 9.3$
Tamil Nadu	Koonthakulam	23	226	4.9 ± 0.7	4.9 ± 0.7	0.4	$5.2^2 \pm 0.8$

Table 2: Characteristic of Spot-billed Pelican colonies in the southern India

State	Colony	Nearest house (m±SD)	Nearest road (m±SD)	Nearest forest (m±SD)	Nearest water (km)	Nearest foraging Area (Km)
Andhra Pradesh	Nelapattu	615.4 ± 54.3	144.2 ± 40.8	5.0 ± 0.0	1	20 km
	Telineelapuram	10 ± 3.5	18.0 ± 8.4	1000.0 ± 0.0	10	10 km
Karnataka	Kokkare-Bellur	26.6 ± 12.5	15.8 ± 4.9	1000.0 ± 0.0	20	50-100 km radius
Tamil Nadu	Koonthakulam	734.7 ± 146.5	300 ± 0.0	500 ± 0.0	2	35 km

Table 3: Dimensions of nest tree species used by Spot-billed Pelican

Tree Species	No. of trees Nelapattu	Telineelapuram	Kokkare-Bellur	Koonthakulam	Height (m ± SD)	DBH (m ± SD)	Canopyarea (m ± SD)
Barringtonia acutangula	20	-	-	-	3.5 ± 0.5	1.1 ± 15.1	8.1 ± 1.3
Azadiracta indicia	2	-	-	-	4.3 ± 0.3	0.4 ± 7.07	9.5 ± 0.7
Ficus bengalensis	-	-	1	-	7.0 ± 0.0	5.3 ± 35.3	28 ± 0.0
Ficus religiousa	-	-	4	-	8.0 ± 0.0	1.9 ± 92.9	9.3 ± 2.5
Prosopis chilensis	-	2	-	-	3.2 ± 0.3	0.3 ± 0.0	8.5 ± 0.7
Acacia nilotica	4	-	-	23	4.9 ± 0.7	0.4 ± 2.1	5.7 ± 1.4
Tamarindus indicia	-	3	1	-	7.0 ± 0.4	2.6 ± 28.7	15 ± 1.1

Table 4: Linear correlation between number of nests (dependent variable) and other variables (tree dimensions and nearest house) among the breeding colonies.

	Tree height	DBH	Canopy area	Nearest house
R	0.285	0.530	0.223	-0.398
P	<0.001	<0.001	<0.001	n.s

Table 5: Nesting sites and nesting associations of Spot-billed Pelican in southern India.

S. No	Nesting Sites	Nesting Associations	State
1.	Telineelapuram	Painted Stork	Andhra Pradesh
2.	Uppalapadu	Open-billed Stork, Oriental White Ibis	Andhra Pradesh
3.	Nelapattu	Open-billed Stork, Oriental White Ibis, Little Cormorant, Indian Shag, Night Heron	Andhra Pradesh
4.	Kokkare-Bellur	Painted Storks	Karnataka
5.	Karanji	-	Karnataka
6.	Koonthakulam	Oriental White Ibis	Tamil Nadu
7.	Karaivetti-Vettakudi	Painted Stork, Oriental White Ibis	Tamil Nadu
8.	Vedanthangal	Open-billed Stork, Oriental White Ibis and Painted Stork	Tamil Nadu
9.	Chitrangudi	Painted Stork, Oriental White Ibis	Tamil Nadu

Painted Storks *Mycteria leucocephala* and the Open-billed Storks *Anastomus oscitans* are the major associated birds found breeding with pelicans. Of the nine nesting sites, 50% of these birds were found breeding at the pelicanries in southern India. The Little Cormorant *Phalacrocorax niger*, Indian Shag *Phalacrocorax fuscicollis* and Black-crowned Night Herons *Nycticorax nycticorax* were found only at Nelapattu and Uppalapadu. Relationships between species co-nesting in a pelican colony are truly of social relationships.

DISCUSSION

Pelicans breed in tropical and temperate regions [1]. The breeding period starts in the month of October/November and lasts up to May/June [6, 8, 10, 30] depending on the monsoon. However, it was observed that in Ceylon (Sri Lanka) the breeding season starts in December to March [9]. Ramana Rao [31] recorded five pelicans breeding at Nelapattu in March and first hatchling appeared in first week of April. The presence of suitable nesting sites is often important in determining both the presence and abundance of birds [32].

A total of nine colonies were found in southern India either regular or occasional. Of these four colonies were in villages five were in water tanks. Throughout the southern India and at the intensive study site, we found that the spot-billed Pelican nest in compact colonies. The nearest tree distance shows the compact nature of Spot-billed Pelican colonies. Pomeroy [33] compactness is possible only where sufficient suitable trees are close together. In contrast to the argument of Beaver *et al*. [34] that availability of suitable vegetation influences nest dispersion more than social factors [35, 36] suggest that in herons, egrets and ibises social interactions are the main force determining intra-colony nest dispersion, particularly in homogenous habitats. In Spot-billed Pelican colonies, it appears that both the availability of suitable trees and social interactions determine the compactness. In southern India nesting, colonies of pelicans were situated close to human settlements and roads suggesting tolerance of humans. Other species found in association with human settlements includes the Marabou Stork (*Leptoptilos crumeniferus*) in Africa [33], the Open bill Stork *Anastomus oscitans* in India [37, 38] the Painted Stork *Mycteria leucocephala* and the Greater Adjutant Stork *Leptoptilos dubius* in India [39, 40, 41] and reported human disturbance causing mortality of Open billed Storks.

The two-year study at south India was not adequate to reveal the impact of human activity on the nesting ecology of the Spot-billed Pelican. The number of nests at the four colonies in southern India was stable in the two nesting seasons but destruction of nesting trees was the

primary reason for the loss of the Sittang valley Pelicanry and Kolleru Pelicanry [42,8]. Pelicans stopped nesting in Koonthankulam and Moondradaippu after their traditional nesting trees (*Tamarindus indicus*) was felled [43, 25, 44]. Other than tree cutting, destruction of nesting trees have been caused by cyclones: a devasting cyclone uprooted many nesting trees in Nelapattu in 1984 and of the 120 trees in the tank prior to the cyclone, less than 40 survived [45, 16]. Loss of nesting trees could also occur due to killing by the continued droppings of the nesting birds and is reported in the only other tree nesting species, the Pink-backed Pelican in Africa [46]. The arrival of pelicans breeding in south India starts from the onset of the northeast monsoon (September-October). However, Sharma and Raghavaiah [47] found that there is no exact relationship between number of birds and quantum of rainfall. Though most of the nest trees were found in close proximity to human habitation, they were in thick vegetation. Agricultural lands and trees near houses characterize the nesting colonies.

We found foraging areas were up to 100 km from the nesting colonies of Spot-billed Pelican. Presumably, the close distance to the foraging ground enables the pelicans to increase foraging trips for the nestling. Most of the nests were built on top of the canopy, which facilitates easy movement to and from the nest. Though the tree height varied among colonies, most of the nests were located on the top canopy of relatively large trees. In mixed species heronries, the mean height of the nest of each species correlated positively with mean vegetation height [48,36]. Some birds may position their nest to receive more solar radiation, which may affect nest temperature and thus the amount of incubation required [49, 50]. This could be particularly true for the Spot-billed Pelican as it breeds during the monsoon period.

Spot-billed Pelican build large platform nests [30, 13] and require sparse foliage cover at the nest site to facilitate arrival and departure. Because of these requirements, most of the nests were built on flat horizontal of slightly inclined branches top parallel to the ground. Nests were not found in the fork. The minimum distance between two nests was approximately 0.5 meter. The nest trees were found to be larger and significantly different in structure. In addition, the number of nests in a tree was correlated with tree size (height, DBH and canopy area). These results indicate that the Spot-billed Pelican select taller and big trees for nesting. However, pelicans nest in *Prosopis chilensis* at Telineelapuram and *Azadiracta indica* at Nelapattu could be due to the non-availability of nest space and bigger trees. In mixed heronries of Cormorants, Egrets, Herons, Open-bill Storks, Night Herons and Spoonbills, there was a general preference for the taller trees [51, 52] and the larger bird species nest highest in the trees [35].

Like other waterbirds, pelicans are generally found on or near water. However, in the breeding season, due to their 'strict requirements' for nesting and feeding, they may find themselves to move/fly long distances. Due to its large size and their strong gregarious tendencies, pelicans need an abundant supply of fish, a requirement that servely restricts the potential range of most species. Pelicans can fly up to 24 hrs non-stop and can cover about 500 km in a day [1]. The Spot-billed Pelican obviously need suitable wooded trees and nest high up in tall trees, in mixed colonies with other waterbirds. Comparing to other pelican species spot-billed pelican and the pink-backed pelican are less gregarious in their feeding behaviour, which helps them feeding in reservoirs, rivers, tanks and seasonal ponds. Foraging takes up only a rather small proportion of the day. The rest of the day is spent in loafing, preening and bathing, which are frequently seen in the company of cormorants, storks, white ibises and other waterbirds. Pelicans eat almost exclusively fish, so their breeding colonies are typically found not far from an ample supply of food. Hence, their colonies are large and require abundant source of fish, if the fish run out, a colony is usually abandoned [1]. The best-known example from southern India is the Kolleru Pelicanry in Andhra Pradesh [8, 53] that the Great White Pelican in Africa needs about 1,200g per day, which is roughly 10% of its body weight. Brown and Urban [54] calculated that the pelican population on Lake Nakuru in Kenya, averaging 10,000 birds, eats 12,000 kg of fish per day. Adult coming to feed nestling at the Danube Delta was found to be carrying 3950 g of fish and the Pink-backed Pelican needs only about 776 g per day [54].

Nesting of Spot-billed Pelican indicated that at least 90 % of the foraging habitat is shallow forms as a potential foraging habitat. We found that the pelicans were found using various water bodies including the Pulicat Lake and shows a wide range of foraging ground from the breeding colony. Storks breeding in Southern Florida have been documented foraging at sites 130 km from their colony [55]. Adult American White Pelican (*Pelecanus erythrorhychos*) nesting at Pathfinder Reservoir, Wyoming may travel up to 75 km to gather food [56].

Like other large waterbirds, the Spot-billed Pelican prefer to nest in compact colonies in large and medium sized widely branched trees with thin foliage cover, near food and water sources and human settlements.

Inter-species association of nesting birds have been reported widely, colonies of gulls and terns, diving ducks [57, 58], skimmers [59] and grebes of several species [48, 60]. Pelicans, storks, ibises, cormorants and herons nests at different times of the year results patterns of environmental seasonality, laying patterns, incubation period and growth rates of young. These are influenced by adaptations to available resources in chosen habitats and fast depletion of resources [61]. Association among co-nesting species could be to reduce aerial nest predation. Defense of nests and young often is enhanced among dispersed or colonial birds by virtue of alarm calls and mobbing behaviour of birds associated in the same habitat type [62]. Co-existing species breed with pelican did not show aggression could be due to the hierarchy in occupying top canopy of the tree. The probable reason could be due to the availability of nesting material, structural support, habitat suitability, nesting success induce the pelicans returning to the same site year after year.

On the other hand, it is important that there is possibility of 'displacing' the Spot-billed Pelicans to other sites or forming/extending new pelicanries due to dense population of other colonial nesting waterbirds, over population of the same species and non-availability of suitable nesting trees. Narayanan *et al*. [63] reported that the Great Cormorants *Phalacrocorax carbo* displacing other colonial waterbirds in Kumarkom heronry, Kerala. For example, Great Cormorants are reported from Vembanad Lake and adjacent areas [64], but their status varies from 'uncommon' to 'fairly common', according to the season. [65,66] reported that the Little Cormorant *Phalacrocorax niger* and Darter *Anhinga rufa melanogaster* populations in the Periyar Tiger Reserve declined due to the '*invasion*' of and competition from Great Cormorants. Nesting requirements of the similar colonial nesting species may require adequate nesting trees and nesting requirements. The selection of a nesting tree, height of the nest and social factors influence nesting [67]. For successful long-term conservation of nesting Spot-billed Pelican, it is crucial that the existing colonies are protected with people participation and raising of fast growing adequate nesting trees.

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