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ORIGINAL ARTICLE

Breeding biology of the Spot-billed Pelican (*Pelecanus philippensis*) in Karaivetti Bird Sanctuary, Tamil Nadu, India

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Abstract The breeding biology of the Spot-billed Pelican (*Pelecanus philippensis*) was investigated from September 2007 to September 2010 in Karaivetti Lake, Tamil Nadu, India. The Spot-billed Pelican breeds between November and April at the Karaivetti Lake. It also breeds roughly during the same period at other breeding sites in Tamil Nadu, except for the Vedanthangal and Karikili bird sanctuaries, where pelicans arrives much earlier and their breeding activities start and end to some extent ahead of the other sites, i.e., from September to March. In essence, the breeding season starts after the onset of the northeast monsoon in Tamil Nadu. A few days after their arrival, pelicans perform courtship display, form pairs, start nest construction and lay eggs. Courtship display is not as attractive and impressive as in other waterbirds. The clutch size varies from two to three eggs and the incubation period from 25 to 36 days. The fledging period varies from a minimum of 90 to a maximum of 102 days. The nest success rate of the Spot-billed Pelican at Karaivetti was 90.28% during the study period.

Keywords Spot-billed Pelican, breeding biology, Karaivetti, Tamil Nadu, India

Introduction

The Spot-billed Pelican (*Pelecanus philippensis*), a near threatened bird, one of eight pelican species in the world, can be found only in South and Southeast Asia over an area between 129000 and 181000 km^2 with strongholds in India, Sri Lanka, southern Cambodia and coastal areas of Sumatra. In India, it is presently distributed in southern and north-eastern India with concentrations in Andhra Pradesh, Tamil Nadu, Karnataka and Assam states (BirdLife International, 2001, 2011). Although observations of a natural history of breeding of the Spot-billed Pelican have been reported from various sites in India (Campbell, 1902; Rhenius, 1907; Neelakandan, 1949; Gee, 1960; Ganguli, 1964; Johnson, 1971; Venkatraman, 1996; Taher, 2007), few specific attempts have been made to explore the breeding biology of this pelican in detail in India except by Nagulu (1983) and Rao (1986). In general, there has been no quantified account of breeding success, a key variable in demographic studies, of Spot-billed Pelican in India. Hence, an attempt was made to document the breeding biology of the Spot-billed Pelican from September 2007 to September 2010 in the Karaivetti Bird Sanctuary, Tamil Nadu, India.

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Study area

The study was carried out at the Karaivetti Lake, situated at 10°58′01″N and 79°11′07″E and covering an area of about 4.54 km^2 in the Ariyalur District (Fig. 1). It was declared a bird sanctuary by the Forest Department in 1997. Rainfall ranges between 800–2000 mm and the temperature varies from 14°C to 33°C. This freshwater lake is fed by the Pullambadi and Kattalai canals. It is the largest waterbody in the district and attracts a great number of birds every year.

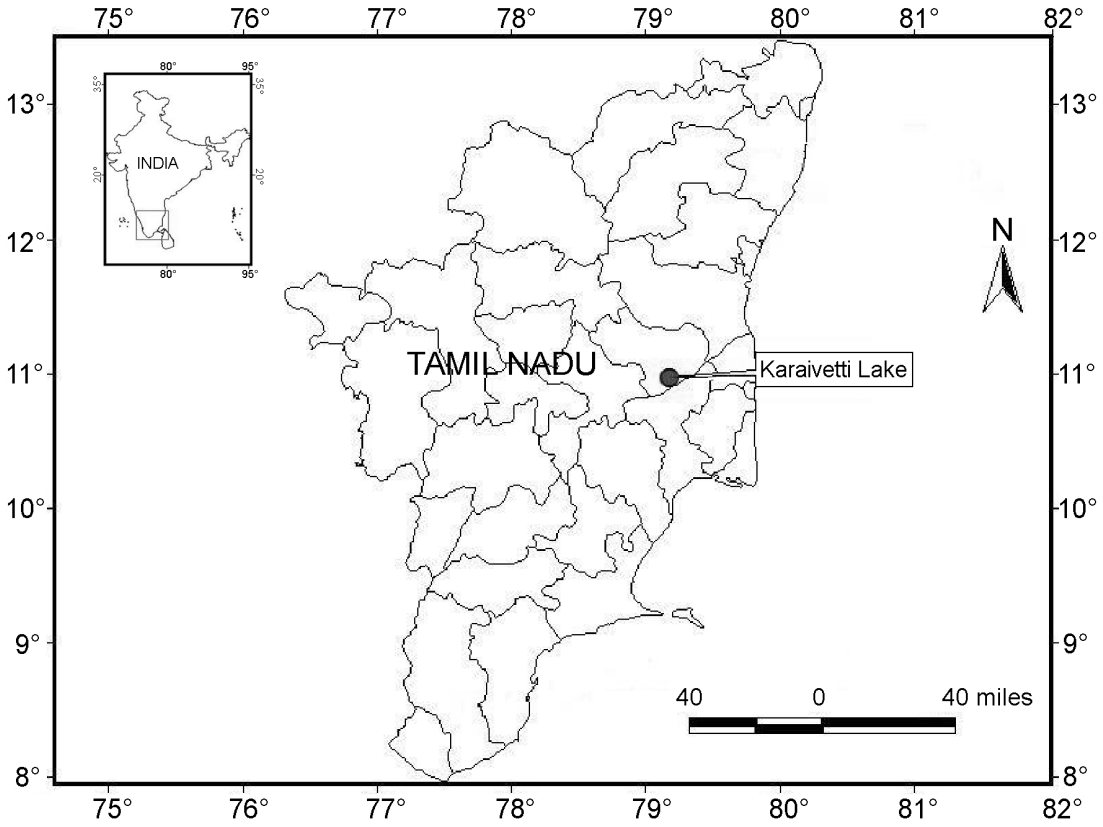

Fig. 1 Map showing location of study area

Vegetation, both natural and planted, in and at the edges of the lake, consists of *Acacia nilotica, Prosopis chilensis, Azadirachta indica* and *Tamarindus indica.* The *Acacia nilotica* plantation is the major nesting site for the pelicans. Recently, the lake has been designated as an Important Bird Area (IBA site code:IN-TN-13) in India by the Indian Bird Conservation Network (Islam and Rahmani, 2004) but despite this, no attempt has been made so far to study this wetland or its dependant avifaunal species.

Methods

Spot-billed Pelican nests were found in clusters on trees in the lake. I observed the behavior of the Spot-billed Pelican from a distance with binoculars and a spotting scope, permitting detailed observations without noticeably disturbing the pelicans. In total, 418 hours were spent studying the pelicans from September 2007 to September 2010. Completely visible nests along with their contents (eggs/chicks), built in the outermost trees in clusters found inside the lake, were chosen for a detailed study of the breeding biology of the Spot-billed Pelican during the study period. All eggs laid, eggs hatched and those failed to hatch, were recorded in order to calculate nesting success. In general, incubation can start as soon as the first egg is laid, in which case eggs will hatch asynchronously (one or two days apart); when the clutch is completed, eggs hatch synchronously, or at some point in between. In the case of the pelican, incubation starts as soon as the first egg is laid. For altricial species, the fledging period is typically the time spent in the nest, although birds may be dependent on their parents for a much longer period out of the nest (in some cases several weeks). In the present study, the fledging period of the Spot-billed Pelican was considered the time between the hatching of eggs and the independence of the chicks (leave the parents). In total, 68 nests were monitored for the present study: 14 nests in September 2007–June 2008, 20 nests in September 2008–June 09 and 34 nests in September 2009–June 2010. Besides, information on breeding was also collected from other breeding sites in Tamil Nadu.

Results and discussion

Breeding season

The greater part of the Spot-billed Pelican colony arrives at the Karaivetti Lake in late November while a very few arrive in late December. After a few days from their arrival, the pelican starts breeding activities when there is sufficient water in the lake. However, among the five breeding sites in Tamil Nadu, i.e., the bird sanctuaries of Vedanthangal, Karikili, Koonthagulam, Karaivetti and Melaselvanur & Kelaselvanur, breeding starts much earlier (late September) in the Vedanthangal and Karikili bird sanctuaries, where pelicans arrive much earlier than in the other three sites. In general then, the breeding season of the Spot-billed Pelican starts in September and ends in May for the entire state of Tamil Nadu. However, the season may at times extend up to June when the arrival of the pelicans is delayed (Table 1). Sharma and Raghavaiah (2002) reported that breeding of the Spot-billed Pelican is dependent on the monsoon and not on the amount of rainfall. It should be noted that the onset of the monsoon largely determines the arrival of pelicans in Tamil Nadu. The breeding season of the pelicans observed in the present study is similar to the observations by Kannan (2007), Talukdar (1994; 1995a; 1995b), Neelakandan (1949) and Lamba (1963) in other parts of India, Legge (1880) and Baker (1929) in Sri Lanka and Oates (1878) at Pegu in Myanmar (Burma).

The Spot-billed Pelican is a gregarious bird, roosting and nesting on trees in large numbers at the breeding sites. However, among the 149 species of birds that the Karaivetti Lake harbors, the Spot-billed Pelicans are the last arrivals and thus are forced to occupy the remaining trees for either nesting or roosting in the lake. Largely thin-canopied trees, present at the periphery of clusters of trees (*Acacia nilotica*) present in the lake, are often ignored by other bird species and therefore these trees are only occupied by pelicans. Every year, the Karaivetti Lake harbors both non-breeding (not mature enough to breed) and breeding Spot-billed Pelicans. Although pelicans arrive in large numbers, only a small part of pelicans actually breed (of the 114 individual birds, only 36 bred in 2007–2008, 100 of 265 in 2008–2009 and 112 of 295 in 2009–2010) since pelicans reach maturity only after three years.

Sexual dimorphism

The male pelican develops a bright yellow skin around its pinkish red eyes. The breeding adults are brilliantly white with darker grey primaries. Both sexes develop a grey and white mixed crest during the initial period of breeding, which gradually is shed as the breeding advances. The bill of both sexes becomes brilliant yellow and with noticeable dark brownish spots during the breeding season.

Courtship display and copulation

The Spot-billed Pelican, soon after its arrival, spends three to five days to settle and during these days, the birds find their nesting trees for breeding activities. The Spot-billed Pelican pairs after a few display events in many nesting trees in the lake. However, their display is not as attractive and impressive as that of other waterbirds. Pelicans perform their display activities only at the top of trees and not in the air or in water, in contrast to other pelican species. Brown and Urban (1969) reported group display in Great White Pelicans (*P. onocrotalus*), while Schaller (1964) reported strut walking in American White Pelicans (*P. erythrorhynchos*). However, no such displays were observed in the Spot-billed Pelican. In the Spot-billed Pelican, the bill and gular pouch are on prominent display. The male initially distends his reddish bright gular pouch and wobbles vigorously. After a few seconds, the male swings his head up and down and sideways (Fig. 2a, 2b). During this display, the pelican also throws his bill a few times over the back down to the tail (Fig. 2c). After a few seconds, the bird claps his bill loudly while swaying the head up and

Table 1 Various breeding activities of Spot-billed Pelican observed during various months of the study period (2007–2010) in Tamil Nadu (darkest area indicates peak breeding activity)

Breeding activities	Months											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Construction of nests												
Nest with Eggs												
Nest with chicks												
Overall breeding activities												

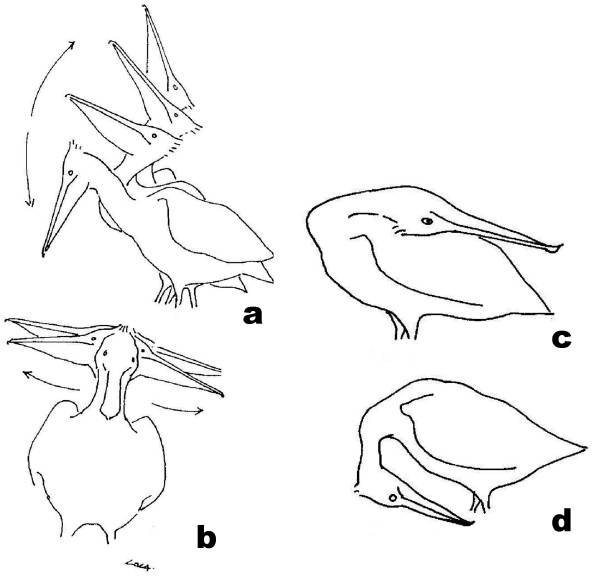

Fig. 2 Display behavior shown by Spot-billed Pelican. (**a**) head swaying up and down, (**b**) head sway-lateral, (**c**) head throwing, (**d**) bowing.

down. Schreiber (1977) reported a similar behavior by the Brown Pelican, (*P. occidentalis*). However, not all these displays are performed exclusively to attract the opposite sex. Head sways and bill claps are often performed when any intruder nears the pelican or even when in a disturbed state. Hence, head sways and bill claps are signals of threat to other males or predators besides acting as courtship signals to attract eventual partners. After head sways and bill claps, both sexes of the pelican bow to each other as an act of acknowledgement (Fig. 2d). After this event, a few males take flight and do some circling in the air above the nest for a few seconds. The partner at the nest performs the head sways, bill claps and bow activities when the male returns to the nest from his flight. Mating occurs at the nest just after the courtship displays. The male holds the neck of his partner between his mandibles, mounts her back and keeps his wings spread and outstretched while mating (Fig. 3). Once the mating is over, the male releases the neck of the female from his mandibles and dismounts.

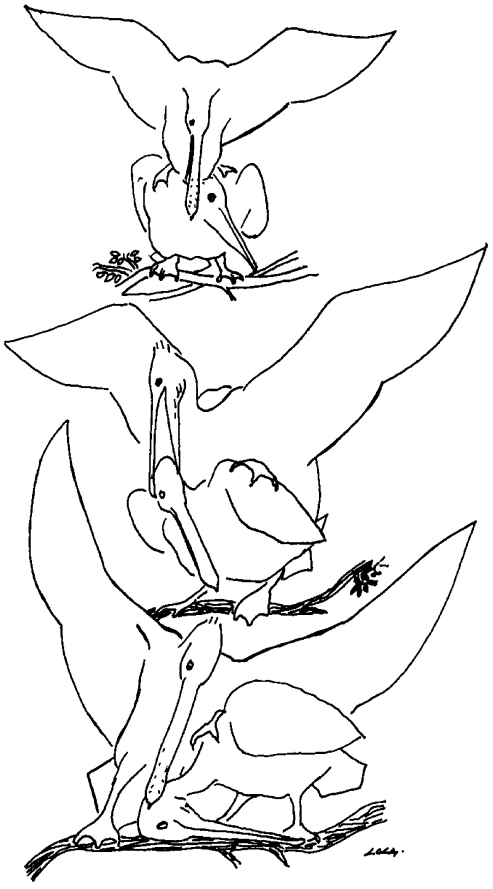

Fig. 3 Mating sequences of Spot-billed Pelican

Nest building

The Spot-billed Pelican start nest building largely after courtship. It is initiated by the collection of nest material, mainly small branches. Mating was also noticed during the collection of nest material and in some cases even after nest construction. Both sexes share nest building activities. However, the male largely collects the nest material and the female receives and aligns the material for nesting. Nest construction is undertaken by both members of the pair as reported elsewhere (Nagulu, 1983; Nagulu and Rao, 1990). Nest construction is largely done during the morning hours (07:00–10:00 hours, $n = 68$). Nest material is largely collected from the ground and occasionally from plants and older nests. Nest material consists primarily of small twigs and branches as reported by Oates (1878). Nests are placed very close to each other in such a way that an outstretched wing can touch the nest of a nearby pelican. The nests are constructed on the top and outer canopy and a minimum of 5 to a maximum of 7 nests are found in a single nest plant. No nest was found in the inner canopy of a tree since this prevents easy landing and takeoff of pelicans due to their size. Up to 6–12 nests have been recorded in a single tree in Assam (Talukdar, 1995a) and up to seven nests in a series at Kokkare Bellur (Subramanya and Manu,

1996). Nest construction largely ceases in early December; however a few nested in February 2008 due to their late arrival. Although nests look loosely arranged, they are strong enough to hold two adult birds. Fresh vegetation is often seen lining the nest.

Individual birds tend to nest in the same place in the canopy each year, although new locations within the canopy and new trees are sometimes chosen (Subramanya and Manu, 1996). Although nests are found in the same place every year, identification was not possible and it is therefore not known if the same individual birds are involved, but nest site fidelity may not be ruled out.

In India, the Spot-billed Pelican often nest beside the Painted Stork (*Mycteria leucocephala*) (Abraham, 1973) or the Lesser Adjutant (*Leptoptilos javanicus*) (Talukdar, 1995b). Oates (1878) mentioned that nests in trees in the Sittang colony in Myanmar were often created by adjutants (*Leptoptilus dubius*). In Cambodia, the colonies are again mixed with adjutants and other storks (Parr et al., 1996). In the Karaivetti Lake, the Painted Stork and Asian Openbill-stork (*Anastomus oscitans*) shared the nest trees with the Spot-billed Pelican

Egg laying

The Spot-billed Pelican lays its first egg 5–10 days after nest construction, with clutch sizes varying from two to three eggs (Table 2). In the Sittang colony, the clutch invariably contained three eggs (Oates, 1878), although there was presumably some undetected variation. Four-egg clutches have been recorded in Assam (Talukdar, 1995b). In Nelapattu, India, the mean clutch size was 2.4 (n = 13; Nagulu, 1983), with clutches of three eggs completed in about seven days. Clutch sizes of 2–4 have been reported elsewhere (Whistler, 1949; Ali and Ripley, 1978; Nagulu, 1983; Rao, 1986; del Hoyo et al., 1992). Eggs are laid at a minimum of two- to three- day intervals (mean = 2.04, SD = 0.4) at the Karaivetti Lake. The pelicans are not very aggressive against predators and thus they do leave the nest when any bird of prey approaches their nests.

Incubation

The Spot-billed Pelican starts incubation as soon as the

Table 2 Summary of reproductive success of Spot-billed Pelican at the Karaivetti Lake, Tamil Nadu, 2007–2010

Parameter	Breeding period			
	2007–2008	2008–2009	2009–2010	Overall
Clutch size				
Mean	2.42	2.95	2.64	2.69
Mode	3	3	3	3
Range	2–3	2–3	2–3	2–3
Incubation period				
Mean	30.82	30.5	30.9	30.8
Range	25–36	29–32	30–32	25–36
SD and SE	1.98, 0.36	1.02, 0.13	0.87, 0.09	1.18, 0.08
Fledging period				
Mean	95.06	94.05	92.91	93.71
Range	91–98	90–99	90–102	90–102
SD and SE	2.21, 0.57	2.85, 0.60	2.74, 0.47	2.77, 0.33
Survival rate				
% of successful nest [a]	100	100	100	100
% of eggs hatched	85.29	94.91	100	95.43
Nest success				
Rate (%) [b]	79.41	91.52	94.4	90.28
Fledging/total nests	1.9	2.7	2.5	2.3

[a] nests that hatched at least one young.

[b] total fledglings/total eggs.

first egg is laid (Nagulu, 1983). Both sexes share the incubation; however, incubation by females predominates. Both sexes contribute to "domestic duties" during nesting (Lamba, 1963). The incubation period varied from a minimum of 25 days to a maximum of 36 days (Table 2). During incubation, the adult bird puffs its wings to fully cover the entire nest and performs no activities. Nearly similar incubation periods (30–36 days) have been reported elsewhere (Nagulu, 1983; Rao, 1986; del Hoyo et al., 1992).

Fledging period

Hatching of the first egg starts after an average of 30 days. Newly hatched birds are altricial, i.e., born naked with red flesh (Fig. 4). The fledging period continues from a minimum of 90 days to a maximum of 102 days (Table 2). Fledging periods of around four months have been reported for the Spot-billed Pelican by Nagulu (1983), del Hoyo et al. (1992) and Talukdar (1995). The young birds start moving, perching and standing only after 30 days. During this act, chicks often fall from the nest, but no adults show any interest to rescue them from the water. Few are able to regain the nest and die in the water. During the study period, nine chicks lost their life due to such occurrences (2 in 2007–2008, 2 in 2008–2009 and 5 in 2009–2010). Adults largely try to flee when any intruder nears the nest rather than showing any aggression. Adults remain in the nest up to a maximum of 15 days after hatching; after that, they remain outside the nest to safeguard the young for about a further maximum of 19 days. After 30 days of hatching, adults are rarely seen in the nest. Adults visit the nest only during delivery of food to the young. When the young are 30–36 days old, they do not remain in the nest and dismantle it by pulling out the sticks from the nest. The young remain perching on the branches till they finally take off. At the end of the breeding season, it is very difficult to locate even the rudiments of nests on the tree and one finds on the ground, under the nesting tree, heaps of fallen white sticks.

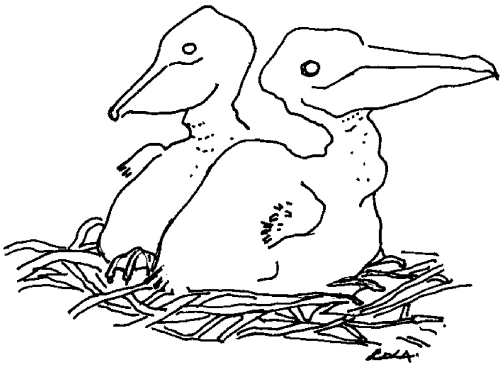

Fig. 4 Chicks of Spot-billed Pelican

Feeding the young

The Spot-billed Pelican feeds its young in three ways (Fig. 5). After a few days of hatching, the adults give a pre-digested liquid diet to their chicks. Adults drip this predigested liquid through the mandibles and right to the mouth of the young (Fig. 5a). After 7–10 days, the adult, by standing in front of the young, vigorously shakes its neck and regurgitates the food onto the nest (Fig. 5b). The

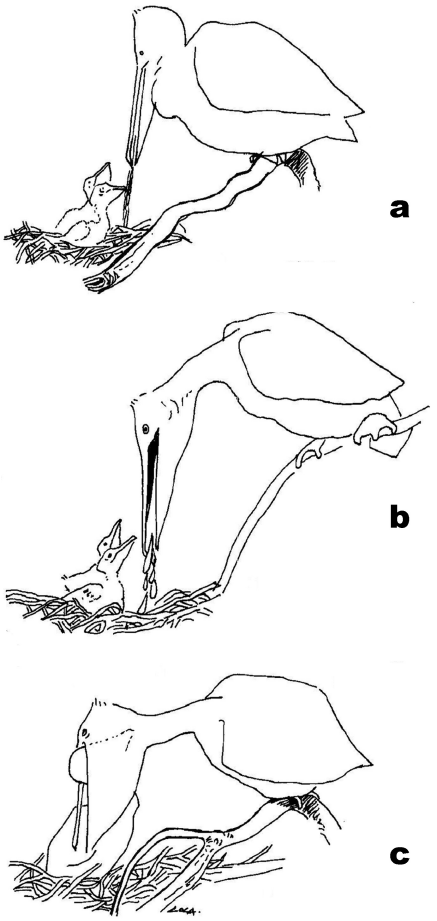

Fig. 5 Various ways of feeding the chicks by Spot-billed Pelican. (**a**) feeding pre-digested liquid diet, (**b**) regurgitating small fingerlings, (**c**) young picks up food from adult.

young pick up this food and eat it bit by bit by seriously tossing or jerking their mandibles. After 30 days, the young are very much capable to draw the food straight from the gullet of the parent by inserting their mandibles up to the neck into the adults' mouth (Fig. 5c). Up to 30 days, adults feed their young largely 3–7 times a day and gradually reduce the frequency.

Nest success rate

No studies have been reported on nest success of the Spot-billed Pelican. However, breeding success was reported to be constrained largely by floods, cyclones and felling of nesting trees (Nagulu, 1983; Santharam, 1993; Narasimhulu, 1995; Talukdar, 1995b). At Kokkare Bellur, India, an average of 1.6 nestlings fledged per nest in 1995. In the present study, a mean of 2.3 nestlings fledged per nest at the Karaivetti Lake (Table 2). Nagulu and Rao (1990) judged that the pelicans nesting at Nelapattu had a breeding success of 73.5%. Of the 68 nests studied, the Spot-billed Pelican had a nest success of 90.28% during September 2007 to September 2010 at the Karaivetti Lake (Table 2).

Conclusions

The Spot-billed Pelican breeds during November and April at the Karaivetti Lake. The availability of suitable nesting trees, nest material, colonies surrounded by water for safety reasons, good food supplies within the lake and at nearby lakes, fewer human disturbances and poaching activities could be the key reasons for the successful nesting activities of the Spot-billed Pelican in recent years at the Karaivetti Lake.

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印度泰米尔那德邦Karaivetti鸟类保护区斑嘴鹈鹕的繁殖生态

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摘要：于 2007 年 9 月至 2010 年 9 月在印度泰米尔那德邦 Karaivetti 湖研究了斑嘴鹈鹕（*Pelecanus philippensis*）的繁殖生物学。斑嘴鹈鹕于 11 月至次年 4 月在 Karaivetti 湖进行繁殖，此外，在该邦维旦汉加尔（Vedanthangal）和卡里吉利（Karikili）两个鸟类保护区以外的地区也有繁殖。斑嘴鹈鹕在维旦汉加尔和卡里吉利两个保护区繁殖的起止时间也比其他地方稍有提前 —— 为 9 月至次年 3 月。斑嘴鹈鹕在东北季风到来后开始繁殖。抵达该地数日后，即可陆续观察到其求偶炫耀、配对、筑巢及产卵等行为。斑嘴鹈鹕的求偶炫耀不如其他水鸟引人注目。窝卵数约 2–3 枚，孵化期为 25–36 天，育雏期则为 90 至 102 天。研究期内，Karaivetti 鸟类保护区斑嘴鹈鹕的繁殖成功率为 90.28%。

关键词：斑嘴鹈鹕，繁殖生物学，Karaivetti，泰米尔那德邦，印度