International Journal of Zoology Studies
ISSN: 2455-7269; Impact Factor: RJIF 5.14
Received: 01-08-2019; Accepted: 03-09-2019
www.zoologyjournals.com
Volume 4; Issue 6; November 2019; Page No. 01-10

Conservation of the Spot-billed Pelican *Pelecanus philippensis* in southern India

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Abstract
The Spot-billed Pelican *Pelecanus philippensis* is one of the most threatened of the seven species of pelicans in the world. I carried out the surveys and studies on the species in southern India with the funding support of Ministry of Environment and Forests from May 2000 to 2003 and in 2004 the Important Bird Areas of the Bombay Natural History Society supported the survey. I estimated the population of pelican is of almost 2850-3700 birds in southern India, which is double that of the earlier estimates. Population estimates were largely based on total counts of birds in breeding grounds and counts of large congregations at rest and roost sites, and foraging birds. In southern India I found there were five/six active breeding population either regular/occasional. The population of pelican in southern India is now increasing. The future of nesting colonies of the Spot-billed Pelican that are located in protected areas appears safe when looked in isolation. However the breeding success is dependent on food supplies; their future will only be assured if their foraging grounds are in good health. However, their foraging grounds are under multitude of increasing pressures, if not addressed now, could result in decline of the species. A number of conservation measures have been forwarded in through this study for the conservation of Spot-billed Pelican in southern India.

Keywords: Conservation, southern India, Spot-billed Pelican, *Pelecanus philippensis*

Introduction
The Spot-billed Pelican was once common over much of the Indian subcontinent, numbering in hundreds of thousands or even 'millions' [Oates 1878, Baker 1929] [51, 5], but has now declined considerably and classified as *Vulnerable* with *Threatened* [BirdLife International 2001] [6]. Its decline in southern India, a major pelicanry that was lost in the middle of the last century is the Kolleru Pelicanry, which supported about 3000 breeding birds. For accounts of declines of the species in the Indian subcontinent, [Guttikar 1978, Neelakantan 1971a, b, 1980a, b, Sridhar 1992, Krishnan 1993, Mangalaraj Johnson *et al.* 1993, Riyazuddin 1994, Subramanya 1995, Talukdar 1994, 1995a, b, Crivelli & Anderson 1996] [20, 42, 43, 45, 46, 79, 26, 33, 67, 81, 84, 85, 86, 11].

Materials and Methods
Surveys were carried out in southern India in the states of Andhra Pradesh, Tamil Nadu and Karnataka from May 2000-April 2004. During the surveys the observation on status of the wetlands, breeding sites, number of breeding birds, and threats and disturbances were recorded. Additionally, the villagers were also interviewed at the existing pelicanries to know the attitude of the locals in supporting the pelicans and pelicanries. Based on our examination on all potential pelican sites I have formulated a number of conservation measures recommended that are vital threats specific to the pelicans.

Results and Discussion
I found from the study/surveys, that the pelicans in southern India are now holding their own population, increasing, and expanding their range (Kannan & Manakadan 2005) [23]. For example, from a single known pelicanry in Mandya district, Karnataka, the birds have now started nesting in small numbers in 2 or 3 other sites in the adjoining Mysore district. A number of new nesting sites have also been recorded in the other states, significant among these are the Uppalapadu Pelicanry in Andhra Pradesh with 114 nests recorded in December 2002; 244 (including adult and juveniles) in 2003 and 356 adult and 700 juveniles in 2004 (Manakadan & Kannan 2003, Kannan 2004) [30, 22]. Until recently (2001), 20 pelicans bred in the Bagagahan Heronry, inside the Bhitarkanika Wildlife Sanctuary, Kendrapara district, Orissa (Kannan & Manakadan 2005) [23]. Another positive factor is the high recruitment of young produced annually in many of the existing south Indian pelicanries.
However, the scenario is deceptive, the pelicans, pelicanries and their foraging grounds are under multitude of increasing pressures, which if not addressed, could result in the decline or extinction of the species. One major pelicanry where breeding has not been recorded in recent past is Kanjirankulam-Chitrangudi, which was operating as recently as in the 1980s and 1990s, with a breeding population of a few hundred birds (Abraham 1973, Mangalaraj Johnson *et al*. 1993, Perennou *et al*. 1994, BirdLife International 2001) [1, 33, 57, 6]. Besides problems at breeding colonies, most of the wetland habitats in India face severe and increasing threats from human and human related factors (Scott 1989, Lee Foote *et al*. 1996) [76, 28]. At the same time, pelicans in general are an adaptable species and have shown significant recoveries after implementation of remedial measures (Anderson & Gress 1983, Anon 1983, del Hoyo *et al*. 1992, BirdLife International 2001) [2, 4, 16, 6]. On the other hand, the Spot-billed Pelican also breeds readily in zoos with very basic facilities (Paulraj *et al*. 1990) [56] a plus point for undertaking ex-situ conservation initiatives for the species.
Discussed below are the threats faced by pelicans and their

habitats in southern India and significant measures that need to be taken up for their conservation. The threats pertaining to former and existing pelican sites in southern India based on our surveys and in the light of literature review have given in Table 1.

Table 1: Summary of threats to former and existing major pelican sites in Southern India

Pelican Sites	HT	PEC	F	LPS	LNT	TD	LCAY	E	CAW	P	HA
Pulicat Lake	Y	-	Y	-	-	N	-	?	-	Y	Y
Nelapattu	N	N	N	N	N	Y	Y	N	N	N	N
Telineelapuram	N	N	N	N	N	Y	Y	Y	N	N	N
Kakarapally Creek	Y	-	Y	-	-	-	-	-	-	?	Y
Kondakarla	Y	-	Y	-	-	-	-	Y	Y	?	Y
Kolleru Pelicanry	Y	Y	Y	Y	Y	?	?	?	Y	Y	Y
Kolleru Lake	Y	Y	Y	Y	Y	?	?	?	Y	Y	Y
Uppalapadu	?	?	Y	Y	Y	?	Y	?	?	Y	Y
Buchupalle	Y	-	Y	-	-	-	-	-	Y	?	?
Vedurupattu-Edhirpattu	?	?	N	N	Y	N	?	N	N	N	N
Koonthakulam	?	?	N	N	N	Y	Y	?	-	-	-
Moondradaippu	Y	Y	-	Y	Y	Y	Y	?	-	-	Y
Theroor	?	-	Y	-	-	-	-	-	-	Y	Y
Vembanur	?	-	Y	-	-	-	-	-	-	Y	Y
Suchindram	?	-	Y	-	-	-	-	-	-	Y	Y
Chitrangudi	?	?	Y	N	?	N	Y	-	-	-	Y
Kanjirankulam	?	?	Y	N	?	N	Y	-	-	-	Y
Ramnad Big Tank	Y	Y	Y	Y	Y	N	?	-	Y	Y	Y
Sakarakottai Tanks	?	?	?	?	Y	?	?	?	Y	?	Y
Watrup	?	?	?	?	?	?	?	?	Y	?	Y
Kulur Sandai Dam	Y	-	Y	Y	-	-	-	-	Y	Y	Y
Vembakottai Dam	Y	-	Y	-	-	-	-	-	-	Y	Y
Vettangudi Tank	Y	?	?	Y	?	Y	?	-	Y	?	Y
Kaliveli Tank-Yedayanthittu Estuary											
Madurai Tank	Y	-	Y	Y	-	-	-	-	Y	Y	Y
Great Vedaranyam Swamp	Y	-	Y	-	-	Y	-	-	-	Y	Y
Vaduvoor Bird Sanctuary	Y	Y	Y	-	?	?	Y	-	-	?	Y
Karaivetti-Vettakudi	?	?	?	?	?	?	?	?	?	?	?
Bhavanisagar Dam	?	?	?	?	?	?	?	?	?	?	?
Sundakamuthur Lake	Y	-	Y	Y	-	-	-	-	-	Y	Y
Edayur	?	?	?	?	?	?	?	?	?	?	?
Vedanthangal	N	N	?	N	?	Y	-	-	-	?	Y
Kokkare-Bellur	N	N	-	N	Y	N	N	Y	-	-	Y
Karanji Tank	N	N	N	N	N	N	N	N	N	Y	N
Kukkrahalli tank	?	?	Y	?	Y	-	-	-	Y	Y	Y
Lingabuddi Tank	?	-	Y	-	-	-	-	-	Y	Y	Y
Mandakally Kere	?	-	Y	-	-	-	-	-	Y	Y	Y
Dalawai Kere	?	-	Y	-	-	-	-	-	Y	Y	Y
Narasambudhi	?	-	Y	-	-	-	-	-	Y	Y	Y
Ynaehole	?	-	Y	-	-	-	-	-	Y	Y	Y
Hadinaru	?	-	Y	-	-	-	-	-	Y	Y	Y

HT-hunting, PEC – poaching of eggs or chicks, F – fisheries, LPS – Loss of peoples' support, LNT – loss of nesting trees, TD – disturbance by tourists, LCAY – lack of care for abandoned young, E – electrocution by power lines, CAW – clogging by aquatic weeds, P – pollution, HA – habitat alteration (silting, salt works, prawn farms, industrialisation, encroachment by agriculture and human habitation). Y = yes, N = no, ? = Uncertain (no records), - = not applicable

Conservation Issues and Conservation Measures

Hunting and poaching of eggs and chicks

Pelicans due to their large size are easy and preferred target for hunters of waterbirds (del Hoyo *et al*. 1992, BirdLife International 2001) [16, 6]. According to the locals of Sriharikota Island, hunting of waterbirds in Pulicat Lake was widespread in the past. Hunting is now rare in Pulicat Lake and carried out discretely due to the presence of forest department personnel.

During my study in Pulicat Lake, I obtained unconfirmed records of one case of poaching, where catfish baited hooks in flowing water caught pelicans during the monsoon. I were also informed of an incidence of shooting of pelicans in a prawn farm in 1995, with subsequent action being taken by the forest department. Other than these, I came across the remains of pelican on the shores of Pulicat Lake near a fish landing site (killed or natural death?). During the interrogation, one fisherman told us that some fishermen do manage to catch pelicans with cast-nets that congregate around fishing boats during cleaning operations.

Unlike Pulicat Lake, poaching has been identified as a major threat for waterbirds in the Great Vedaranyam Swamp; largely due to a community (Narikuravas) that traditionally traps waterbirds for living (Sugathan 1982, Manakadan 1992, Daniel *et al*. 1999) [82, 31, 14]. Poaching also appears to be a major problem in Kakarapally Creek

(foraging ground for pelicans of Telineelapuram) and it may be going on unreported or undetected in other foraging sites (for example see Sathasivam 1997) [74]. With regard to breeding colonies, one of the main factors for the loss of the Kolleru Pelicanry was killing and collection of eggs and nestling by some communities for food and even to cater to restaurants (Neelakantan 1949, 1971a, b, Gee 1960, Lamba 1963, Krishnan 1993) [44, 45, 46, 19, 26]. Hunting and poaching of eggs and chicks are also cited as reasons for birds abandoning the Kanjirankulam and Chitrangudi breeding sites.

Proposed Conservation Measures

1. Strict enforcement of existing state and central government laws that protect pelicans (or wildlife in general) and their habitats.
2. Intensive patrolling of sites known to have poaching pressures.
3. The state forests departments, in collaboration with other governmental and non-governmental organizations, should take up a rehabilitation programme for traditional hunting communities such as the *Kuruvikarans* of the Great Vedaranyam Swamp. Such a scheme was taken up in the Great Vedaranyam Swamp in the early 1990s (Daniel *et al*. 1999) [14], but it appears to have failed without follow-up action after the tenure of the project. The findings of the project revealed that the trappers were willing to take to other professions if given opportunities. The fear of the being caught by the forest department, overall decline in bird catches and disfavours among the new generation for the menial profession have made the trapping profession unattractive. Many of the trappers have already taken up more economical and less labour oriented jobs.

Pelican-fisheries conflict and depletion of fish stocks

Pelicans, due to their almost exclusive diet on fish and abundant requirement of the same due to their large size and gregarious habits, are known to come into conflict with fishermen (del Hoyo *et al.* 1992, Hatzilacou 1996, Shmueli *et al.* 2000, BirdLife International 2001) [16, 21, 77, 6]. Though the American and Palearctic pelicans are said to largely feed on non-commercial species (del Hoyo *et al.* 1992) [16], this does not hold true for countries like India where almost all fish species are eaten due to poverty and increasing human population. Even in the European region, fish species generally regarded as of non-commercial importance are eaten in some countries due to different food habits, e.g., the eating of eels in Greece (del Hoyo *et al.* 1992) [16]. A good example of pelican-fishermen conflict in the Indian region was from Pakistan. Pelican species were once numerous over the rivers and other wetlands of Pakistan, but by the 1960s they had been almost exterminated on the grounds where they ate too many fish. Plans for a factory on the River Indus to extract oil from their carcasses had to be abandoned when it became clear that there were no pelicans left to kill (Neelakantan 1980b) [43].

Over 30,000 fishermen spread over 50 settlements depend on Pulicat Lake for their livelihood and an average of about 1200 tones of fish is harvested each year. Since the lake dries up in the northern parts in summer, much of the fishing grounds of Pulicat Lake are not productive throughout the year (Ramesh 1994, Panini 1996) [61, 43]. However, none of the 460 fishermen interviewed in Pulicat Lake seriously considered the pelican (or other piscivorous birds) as a serious competitor for fish resources. In fact, a few said that they looked at foraging pelicans as indicators of fish to carry out fishing operations. In spite of knowing, that pelican were fish eaters, fishermen did not attempt to chase or kill pelicans in Pulicat Lake. However, the situation could change in the future with likely depletion of fish resources linked to food requirements and the growing human population.

It appears that the current pelican-fishermen conflict in southern India is largely restricted to aquaculture farms, e.g. prawn farms in Pulicat Lake (Nagulu 1983, Philip 1995) [40, 58]. During our enquiries at prawn farms in Pulicat Lake, owners cited piscivorous birds, including pelicans, as a problem. Measures adopted by farmers to deter birds include patrolling and use of scares. Many prawn farm workers interviewed were afraid to discuss about the problem, possibly since lethal methods were used. In Israel, the extensive aquaculture farms have become favourite feeding grounds of wintering and migrating Great White Pelicans due to the loss of natural feeding sites in the recent past (Shmueli *et al*. 2000) [77]. An apparent increase in night activity was also reported, hypothesized as an adjustment to conflict conditions (Shmueli *et al.* 2000) [77].

Besides the conflict with fisheries for food resources, fishing nets and other gears could inflict injury or death of pelicans. In Pulicat Lake, pelicans were observed to avoid sites that had a high density of fishing nets. At Kolleru, I recorded carcasses of a few waterbirds entangled in protective nets placed over fishponds. Records of pelicans getting killed by entanglement in fishing nets have also been reported in the Kokkare-Bellur area (*see* BirdLife International 2001) [6]. Injuries or deaths by being hooked, swallowing baited hooks and entanglement in nets have been reported in the Brown Pelican (Anon 1983) [4].

The depletion of fish resources due to over- and non-sustainable fisheries in India and its impact on the Spot-billed Pelican is a complex issue, which requires an in depth study. Such a study would require comparisons with past records of fish abundance at feeding sites, which is totally lacking or have not been quantified systematically as a rule in India. It is also plausible that historically, pelicans may have had a wider prey base than that at present due to fisheries and the diet has already been altered (Anon 1983) [4]. The pelican-fisheries conflict is likely to intensify in India in the coming years due to further declining fish stocks from over-exploitation and loss of wetlands due to the increase in human population and dependence on natural resources.

Proposed conservation measures

1. Ban on fishing practices and gears that are non-sustainable and destructive to fish populations, e.g., ban on small-mesh size fishing nets or traps.
2. In large wetlands such as Pulicat Lake and Great Vedaranyam Swamp, some areas could be declared as no-fishing zones during the breeding season (if practically and legally possible).
3. Strict enforcement of the wildlife protection laws to deter aquaculture owners from using lethal methods to tackle the problem of piscivorous birds.
4. Provisions for establishing of alternative attractive wetlands – to alleviate conflict with fishermen – (as

suggested by Shmueli *et al*. 2000 in Israel) [77] could be explored by the state forest departments. The wetlands could even be forest department owned fish farms to cater to the food requirement of pelicans. These could especially be established near pelicanries to improve breeding success.

Declining support for pelicanries by local communities

Many of the pelicanries of the Spot-billed Pelican in southern India owe their origin or continued existence to protection afforded by villagers due to sentimental or religious reasons. In some cases, the relationship has been mutually beneficial as the locals make use of the droppings (or the water enriched with droppings) as fertilizer for crop fields. Almost all the pelicanries in southern India are or were located in or near villages, and were not disturbed and afforded special protection in some cases (Table 2). The subsequent taking over or supplementary support given by the state forest departments to some of these sites gave an additional boost to the protection of the birds and their habitats. It appears that the cooperation between the local communities and forest department is vital for the survival of 'village pelicanries'. Three pelicanries that did not have the forest department's involvement but had locals' support earlier (i.e., Buchepalle, Kolleru, Moondradaippu) and two, which are under the control of the forest department but had lost locals' support (i.e., Chitrangudi, Kanjirankulam), have been lost.

Table 2: 'Village Pelicanries' of southern India

Pelicanry	Sources	Lost/Losing of local support	Pelicanry still in existence	Forest Department's role
*Kolleru	Neelakantan (1949), (1971a,b), (1980b) [43, 44, 45, 46], Gee (1960) [19], Krishnan (1993) [26]	Y	N	N
*Buchepalle	Campbell (1902) [10]	?	N?	N
Telineelapuram	Nagulu & Rao (1983) [40]	N	Y	Y
Uppalapadu	Rao & Kumar (2000a, b) [63, 564]	Y	Y	Y
*Nelapattu	Nagulu & Rao (1981) [41], Nagulu (1983) [38]	N	Y	Y
Vedurupattu-Edhirpattu	Ramakrishna (1990) [60]	N	Y	Y
*Koonthakulam	Rhenius (1907) [66], Webb-Peploe (1945) [90], Wilkinson (1961) [91], Mangalaraj Johnson (1971) [32], Suresh Kumar (1980) [83]	Y, N	Y	Y
Moondradaippu	Ganguli (1964) [18], Suresh Kumar (1980) [83]	Y	N	N
*Vedanthangal	Nagulu & Rao (1983) [40], Paulraj & Gunasekaran (1988) [55], Santharam & Menon (1991) [73]	N	Y	Y
Chitrangudi	Mangalaraj Johnson *et al*. (1993) [33]	Y	N	Y
*Kanjirankulam	Abraham (1973) [1]	Y	N	Y
*Kokkare-Bellur	Neginhal (1977), (1991) [47, 48], Saxena (1980), Nagulu & Rao (1983), Manu & Jolly (2000)	N, Y	Y	Y

* Droppings used as fertilizer. Y = Yes, N = No

Note: The role of the forest department may involve declaring the site as a protected area, posting of personnel, or cooperation with locals in protecting the birds and their habitat.Reasons for loss of community support for pelicanries include the noise, smell and waste matter generated by nesting colonies, fouling of water, advent of chemical fertilizers, need to lop or cut trees for timber, fuel, fodder or sale due to the growing human population, and loss of revenue in fruiting trees due to nesting activities (Webb-Peploe 1945, Neelakantan 1949, Suresh Kumar 1980, Rao & Kumar 2000a, b, Manu & Jolly 2000, Manakadan & Kannan 2003) [90, 83]. Loss of local support for pelicanries is not a recent phenomenon. Webb-Peploe (1945) [90] wrote that some villagers had earlier suggested destruction of nests and driving away of birds at Koonthakulam due to the noise and foul smell, but the headman did not accept this. Suresh Kumar (1980) [83] wrote that the Moondradaippu Pelicanry was in the heart of the small town and the area below was littered by bird droppings and commented of the bleak future of pelicanries like Moondradaippu. Until recently lost Kanjirankulam Pelicanry, the earlier extent of locals' support even involved the care of abandoned young (Abraham 1973) [1]. Support has even declined in Kokkare-Bellur, where forest department personnel were once taken to task for capturing chicks for a zoo (Saxena 1980) – a prime-nesting tree was cut down as recently as1985 (Sridhar 1992) [79].

All the above-cited cases show that locals' support for pelicanries is declining, primarily due to the problems of economic loss entailed by villages in having colonies in and around villages. There appears to be little possibility of 'village pelicanries' surviving into the future, unless there is a supplementary or substitution of the existing accord by State Forest Departments. In spite of the recent trend in advocacy of local communities' involvement in conservation initiatives, the risk factor involved in allowing villagers alone to protect pelicanries is high. This is due to the general poverty in villages, increasing human population, changing lifestyles and their related demands on natural resources, and the threatened status of the Spot-billed Pelican. Moreover, villages cannot afford to allot funds that forest departments could provide for conservation initiative to the species. These activities may involve care of abandoned young, paying of annual compensation for loss in revenue by allowing pelicans to nests on privately owned trees, acquire land to grow and maintain more nesting trees for expanding colonies, and creating/protecting/maintaining of wetlands near pelicanries.

Proposed conservation measures

1. There is a need to shift 'village pelicanries' to suitable sites outside villages due to the problems of having pelicanries in villages. Even though, the Spot-billed Pelican nests at the same sites or trees for generations, they are also able to shift quickly to new or better sites if the former sites face problems as evident from the presence of sub-colonies and instances of new pelicanries in southern India. The ability to shift from traditional sites has also been reported in the American White Pelican (Miller 1982) and there are many examples in southern India, e.g., the nesting site of pelicans in Nelapattu was formerly in the village and

not in the adjoining tank as at present (Nagulu 1983). Creating an islet or islets with suitable nesting trees species (e.g., *Acacia nilotica* and *Barringtonia acutangula*) in tanks and reservoirs – along with protection – appear to be an easy way to entice pelicans to shift colonies. Many pelicanries have got established under such conditions, e.g., Nelapattu, Uppalapadu, Vedanthangal, Karaivetti-Vettakudi and Karanji.

2. Creation of alternative foraging ground for pelicans near breeding sites by damming of streams or digging of tanks near pelicanries and stocking with fish so that the conflict between pelicans and the fishing community around 'village pelicanries' gets minimized.
3. Site-specific eco-development schemes for villages that support pelicanries so that the demands on the nature resources are lessened.
4. Financial compensation by the state forest departments for the incurred loss to villagers by permitting nesting of pelicans by not lopping, cutting trees or harvesting fruits, as is being implemented at Kokkare-Bellur.

Loss of nesting trees and scarcity of nesting material

Commenting on the now defunct pelicanry of 'millions' that Oates's discovered in the Sittang valley in Myanmar, B.E. Smythies wrote, "Since Oates's day much of the area has been cleared of its timber". Fourteen years later J.K. Stanford stated, "The southern end of this forest has all disappeared with cultivation and so have most of the pelicans." (Neelakantan 1980b). This shows that destruction of nesting trees was the primary reasons for the loss of the Sittang valley pelicanry. Loss of nesting trees due to tree cutting has also been cited as the cause for the abandonment of some pelicanries in southern India. Neelakantan (1949) reported that trees were cut in the Kolleru Pelicanry to prevent birds from occupying the remaining ones. Mangalaraj Johnson (1971) [32] wrote that pelicans stopped nesting in Koonthakulam after their traditional nesting trees (*Tamarindus indicus*) 'were felled 10 years back'. However, the birds did return subsequently and now nest on other tree species, showing that the pelican is not particularly fastidious about the nesting tree species (Table 3). Suresh Kumar (1980) [83] reported that the now abandoned pelicanry at Moondradaippu consisted of only two large tamarind trees 'smothered by Painted Storks and Grey Pelicans' amidst a small shopping centre. Ganguli (1964) [18], who visited the colony in 1964, mentioned that the colony consisted of 8 tamarind and 3 neem trees. During our visit to another abandoned Kanjirankulam Pelicanry, I found only the stumps of former nesting trees. Besides the loss of nesting trees, the decreasing availability of twigs for nest building may also be a constraint in many pelicanries due to their use as fuel wood (Krishnan 1978).

Other than tree cutting, destruction of nesting trees have been caused by cyclones: a devastating 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 (Santharam 1993, Narasimheulu 1995) [41]. Loss of nesting trees could also occur due to killing by the continued droppings of the nesting birds (e.g., *Prosopis chilensis* in Uppalapadu), and is reported in the only other tree-nesting pelican species, the Pink-backed Pelican in Africa (Burke & Brown 1970).

The question also arises whether pelicanries in general are over-saturated due to non-availability of nesting trees, and whether this be the reason for the apparently same numbers of pelicans (*ca*. 250 pairs) breeding in Nelapattu since the 1980s in spite of recruitment of about more than 50% fledglings annually. Or, could the numbers have remained constant over the years due to other limiting factors such as food resources? Only an experiment by increasing the number of trees or overall nesting area at Nelapattu or the establishment of an alternate nesting site could answer this.

Table 3: Nesting trees of the Spot-billed Pelican in southern India

Tree Species	Pelicanry	Reference
Azadirachta indica, *Tamarindus indicus*	Buchupalle	Campbell 1902 [10]
Prosopis chilensis	Uppalapadu	Rao & Kumar 2000a, b, Manakadan & Kannan 2003.
Azadirachta indica, *Tamarindus indicus*	Telineelapuram	Nagulu & Rao 1983, Manakadan & Kannan 2003.
Azadirachta indica Tamarindus indicus	Vedurupattu-Ethirapattu	Ramakrishna 1990 [60] Santharam 1998
Acacia nilotica, Tamarindus indicus, Ficus bengalensis, Ficus religiosa, Ficus balerica, Thespesia populnea,Delonix elata, Melia dubia	Kokkare-Bellure	Neginhal 1977, 1991 [47, 48], Saxena 1980, Nagulu & Rao 1983, Sridhar & Chakravarthy 1995, Subramanya & Manu 1996, Manakadan & Kannan 2003
Peltophorum roxburghii	Karanji	Neginhal 1997 [49], Manakadan & Kannan 2003
Prosopis chilensis	Kukkrahalli	K. Manu pers.comm, Manakadan & Kannan 2003
Enterolobium saman, Borassus flabellifer,Acacia nilotica, Cocos nucifera, Mangifera indica	Kolleru Pelicanry	Neelakantan 1949, Gee 1960, Krishnan 1978, 1993
Ficus bengalensis, Bassia latifolia	Ariyakulam	Nagulu & Rao 1983
Barringtonia acutangula, Acacia nilotica	Vedanthangal	Nagulu & Rao 1983, Paulraj 1984, Santharam 1985, Paulraj & Gunasekaran 1988 [55], Santharam & Menon 1991 [73], Venkataraman 1996, Venkataraman & Muthukrishnan 1993, Santharam & Chandrasekaran 1996
Tamarindus indicus, Ficus bengalensis	Moondraidapu	Ganguly 1964, Suresh Kumar 1980 [83], Nagulu & Rao 1983
Tamarindus indicus, Azadirachta indica, Ficus sp. Thespesia populnea, Delonix elata	Koonthakulam	Rhenius 1907 [66], Webb-Peploe 1945 [90], Wilkinson 1961 [91], Mangalaraj Johnson 1971 [32], Nagulu & Rao 1983, Manakadan & Kannan 2003
Ficus bengalensis Acacia nilotica, Ficus religiosa, Thespesia populnea	Kanjirankulam	Abraham 1973 [1]
Acacia nilotica	Karaivetti-Vettakudi	Relton 1998
Acacia nilotica, Prosopis chilensis	Ramnad Big Tank & Sakarakottai	Balachandran, *pers. com.*
Acacia nilotica, Prosopis chilensis	Chitrangudi	Manakadan & Kannan 2003
Prosopis chilensis	Watrap Big Tank	Balachandran, *pers. com.* 2003

Proposed conservation measures

1. Transplantation of 30, 50-year old *Barringtonia acutangula* trees was undertaken in 1988-1989 with 70% success, and pelicans nested on these during the following year. This transplantation took place after many trees were uprooted during the 1983 cyclone (Narasimheulu 1995) [41]. This could be tried in some pelicanries. However, instead of transplanting of slow-growing species like *Barringtonia*, which is an expensive exercise, another alternative would be to grow fast-growing favored nesting trees of the pelican such as *Acacia nilotica*.
2. An alternative to planting more trees could be the setting-up of alternative nesting sites. For example, in Pulicat Lake, the southern Kudiri Tank appears to hold good potential as an alternative-nesting site for pelicans. This tank is a preferred loafing site for pelicans. Deepening of the tank and planting of nesting trees besides protection are measures that need to be taken up. A strategy of releasing water up to the tanks current capacity, but not the extra water accumulated due to deepening, could solve possible conflict with irrigation requirements of farmers. At this tank there are currently no importance to fisheries, unlike the northern Kudiri Tank, the conflict with fishermen will not be a major issue. Its location on the route to the main tourist zone in Pulicat Lake is also a plus point for developing it into a pelicanry – however the tourist activity has to be strictly regulated to cause minimal disturbance.

Lack of care for abandoned young

Cases of chicks or nearly fledged young of pelicans falling from nests and ultimately getting killed by dogs and cats or dying of starvation have been reported in many pelicanries: Kolleru (Neelakantan 1949, Gee 1960) [40, 35]; Nelapattu (Nagulu 1983, Manakadan & Kannan 2003) [20]; Telineelapuram (Manakadan & Kannan 2003) [20], Kokkare-Bellur (Subramanya & Manu 1996, Manu & Jolly 2000, Manakadan & Kannan 2003) [20, 65, 38]. More than 100 nestlings are lost in this manner yearly in Kokkare-Bellur. Recently, attempts to take care of abandoned chicks till they fledge by naturalists based in Mysore and Bangalore with help from the forest department was successful and more than 40 chicks were saved in 1995. Besides human inputs, the financial costs involved feeding each young over 1000g of fish a day (Subramanya 1995, Sridhar & Chakravarthy 1995, Subramanya & Manu 1996, Manu & Jolly 2000) [26, 45, 26, 91].

Proposed conservation measures

1. Since there are significant cases of abandoned chicks yearly from many pelicanries, a programme to take care of abandoned chicks on the lines of the Kokkare-Bellur exercise should be implemented at all such sites by the state forest departments in collaboration or by giving employment to the locals.
2. Another alternative would be to send abandoned young to zoos for maintaining captive stocks of this threatened species. The Spot-billed Pelican breeds easily in zoos with provision of very basic facilities and breeding have been reported in the Guindy Deer Park and the zoological park in Chennai, Tamil Nadu (Paulraj *et al*. 1990, Manakadan & Kannan 2003) [54, 59]. In the Bannerghatta National Park, Karnataka, the present breeding stock was obtained from the abandoned young of Kokkare-Bellur (Subramanya & Manu 1996, Sridhar & Chakravarthy 1995) [45, 58]. Such abandoned young could serve for ex-situ conservation measures for building nucleus or supplement wild populations to build up declining population.

Electrocution by power lines

Large bodied birds such as cranes, herons and pelicans are highly susceptible to collision with power lines due to limited flying maneuverability (Thompson 1978, Mc Neil *et al*. 1985, Rusz *et al*. 1986, Brown *et al*. 1987, Crivelli *et al*. 1988, Morkill and Anderson 1991) [78, 64, 12, 34. 81, 48]. Electrocution along with shooting are cited as major factors for the decline of the Great White and Dalmatian pelicans in Europe and Asia (Crivelli *et al*. 1988, 1991) [31]. In Israel, pelican fatalities have been reported due to accidental electrocution in the aquaculture farms (Shmueli *et al*. 2000) [10]. In India, deaths of the Spot-billed Pelican or other heronry species have been reported from Kokkare-Bellur (Sridhar & Chakravarthy 1995) [30] and Telineelapuram (Manakadan and Kannan 2003) [87]. In Pulicat Lake, two lines of high and low tension power lines run from Sullurpet to Sriharikota Island and Venadu Island across Pulicat, and to some of the other inhabited islands in Pulicat Lake. I have come across two incidence of electrocution of the Spot-billed Pelican and Painted Stork from these lines. Sridhar & Chakravarthy (1995) [64] reported that the state electricity board had energized the electric supply lines that run along the main road bordering the nesting trees of pelicans in Kokkare-Bellur, which resulted in the electrocution of two Painted Storks *Mycteria leucocephala*. However, the mortality due to electrocution may be significant for species that are endangered or threatened or occurs in small local populations (Owen & Cadbury 1975, Anderson 1978, Lee 1978, Faanes 1987, Crivelli *et al*. 1988) [12, 20, 58, 69].

Proposed conservation measures

1. Shifting the routes of power lines from the flight path of pelicans in both breeding and foraging grounds.
2. Insulation of power lines around pelicanries or pelican habitats.

Disturbance from tourism

A number of tourists, and especially children from nearby schools and colleges, visit Nelapattu annually. The influx of tourists is extremely high (in thousands) during the annual Flamingo Festival, organised by the Tourism Department conducted since 2001 in collaboration with other governmental departments. A lot of noise and litter is generated during the influx of people during the festival. However, this has apparently not (yet) affected the pelicans of Nelapattu, probably since most of the southern Indian pelican populations have got used to people by nesting near villages. The barrier of water and the densely vegetated walkway in Nelapattu considerably reduces the disturbance by tourists, unlike in the case of pelicanries right in the middle of villages, e.g., Kokkare-Bellur and Telineelapuram.

Disturbance from tourism and the plea not to popularise Kokkare-Bellur as a tourist spot due to the disturbance factor has been voiced and is said to be one the contributory factors for dislodgment of nestlings from nests (Neginhal 1991, Sridhar & Chakravarthy 1995) [47]. Eggs and nestlings

also become prone to predators such as crows when the parents temporarily leave the nest unattended due to disturbance (Anon 1983, BirdLife International 2001) [4]. In Mihimukh area of Kaziranga National Park, Assam, about 150 nests were counted in 1981, but due to disturbances generated by heavy tourism, the birds deserted the site to nest at Koladuar area of the Park (Das 1991) [49]. Repeat disturbance over several seasons may cause pelicans to abandon breeding sites (Anon 1983) [4].

Proposed conservation measures

1. Tourists visiting pelicanries should be restricted and regulated to ensure minimal disturbances and reduce the other negative impacts (e.g., littering) of tourism.
2. Visits to Nelapattu should not be allowed during the annual Flamingo Festival, as the tourist influx is considerable. Another alternative would be to permit viewing only from one or two spots at a distance with binocular and telescopes and people should not be allowed to use the walkway during the Flamingo Festival.

Wetland loss

Pulicat Lake faces a number of threats such as siltation; pollution and industrialisation – see Manakadan and Kannan 2003 for details. The Ennore Creek, at the outskirts of Chennai and contiguous to Pulicat Lake, though physically intact, is practically devoid of bird life due to the heavy inflow of domestic and industrial wastes. In all probability, this area could have been an important foraging site for the pelicans of Pulicat Lake in olden days. Similarly, the Kaliveli-Yedayanthittu pelican habitat is threatened by planned industrialization with a caustic soda factory already in operation (Pieter 1987) [38]. The Great Vedaranyam Swamp has extensive areas under salt works (Sugathan 1982, Manakadan 1992) [82]. However, the reservoirs and low and medium salinity condensers of industrial salt works were found to be important feeding sites for pelicans – unlike edible salt works, which are almost entirely composed of crystallizers (Manakadan 1992) [19]. Pollution sources identified in Kolleru were inflow of effluents from sugar factories and rice mills, sewage, and residues of fertilizers and pesticides (Neelakantan 1980b) [84]. Another report (Rao 1982) [47] states that Kolleru Lake has lost 34,000 ha of natural wetlands to agriculture. A possibility of the large-scale deaths of pelicans reported by villagers in Kolleru around 1964 is attributed to pesticides (Guttikar 1978) [20]. In Sulekere (Kokkare-Bellur area), pelicans are reported to eat dead fish that have succumbed to pesticide poisoning (Manu & Jolly 2000) [52]. In Assam, the clogging of wetlands by aquatic weeds such as the exotic Water Hyacinth *Eichhornia crassipes* has resulted in loss of foraging habitat for the Spot-billed Pelican and was considered as one of the major threats for the species in the area (Talukdar 1995b, Bird Life International 2001) [21].

Sridhar & Chakravarthy (1995) [90] projected a gloomy prognosis of the future of the foraging sites of the Kokkare-Bellur Pelicanry. They found that the Tailur Lake, a crucial foraging ground of pelicans, now holds only a third of its original holding capacity due to silt deposits. There was a large-scale unregulated fishing activity in 60% of the lakes frequented by pelicans: with moderate fishing in the other wetlands. About 33% of the lakes received residual fertilizers and chemical from agricultural fields and 22% by sewage inflows. There were crop fields along the drying margins and excessive growth of vegetation and weeds in about 30% of the lakes. Hunting was reported in 20% of the lakes. These findings could be applicable in most of the irrigation tank based pelicans foraging sites in southern India.

Proposed conservation measures

1. All major foraging sites of pelicans should be declared as protected areas and handed over to the state forest departments.
2. Strict implementation of anti-pollution laws should be taken in and around the foraging grounds of pelicans.
3. Tackle problems facing foraging sites of pelicans such as clogging by aquatic weeds and silting.

Conclusion

An analysis of the threats faced by the Spot-billed Pelican in southern India reveals that most of them originate from the crisis of the human population growth. India has 16% of the world's population, yet the Indian subcontinent constitutes only 2.42% of the Earth's surface. Additionally, the largely rural makeup of India's population also places huge demands on natural resources such as wetlands leading to their exploitation, alteration, degradation or physical loss (Lee Foote *et al.* 1996) [28].

The future of nesting colonies of the Spot-billed Pelican that are located in protected areas appears safe when looked in isolation, but since breeding success is dependent on food supplies, their future will only be assured if their foraging grounds are in good health. As suggested by Nesbitt *et al*. (1978) [50] and Blus *et al*. (1977) 7[] in view of pelicans that are extremely sensitive to environmental pollutants and the potential for total extirpation in the wild, captive rearing may become an important tool. Pelicans produced in captivity can be used to restock former range, replacing birds for restoration purposes (Nesbitt *et al*. 1978) [50]. The future of foraging grounds, even those that constitute sanctuaries, are more at risk as besides the impact of fisheries, they face a number of disturbances and threats, especially at the borders. Breeding colonies and wetlands that are not under government protection will almost certainly disappear in the future with the declining community support (where existing) and increasing human demands on the natural resources.

Recommendations have been forwarded in through this study for the conservation of the pelican. Most, if not all, if implemented by the concerned authorities will help the pelican population to grow for some time. However, unless the crisis of the human population growth of India is addressed, the overall future of the Spot-billed Pelican and other wildlife and their habitats appears bleak.

Acknowledgements

I thank the Ministry of Environment and Forests, Government of India for funding. The 2003-2004 survey was funded by the IBA Programme of the Bombay Natural History Society (BNHS) and I thank Dr. A.R. Rahmani and Mr. J.C Daniel for support. Also I thank the officials and staff of the forest departments of Andhra Pradesh, Karnataka and Tamil Nadu for permission in carrying out the studies in their states.

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