

Research Article

SPATIAL AND TEMPORAL VARIATIONS OF THE DENSITY OF SPOT-BILLED PELICAN *PELECANUS PHILIPPENSIS* IN PULICAT LAKE, EAST COAST OF SOUTHERN INDIA

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ABSTRACT

This study examined status and the population density of Spot-billed pelican from October 2010 to September 2012 in Pulicat Lake. Statistical analyses enabled distinctions to be made between pelican density with month, season, habitat, environmental factors and prey abundance. The analysis revealed spatial and temporal differences in pelican density in Pulicat Lake. Pelican populations were recorded in five different habitats. The freshwater habitat (2.18 km²) supported the highest density followed by mudflat (0.50 birds km²), river mouth (0.29 birds/km²), open water (0.028 birds/km²) and tidal flats (0.027 birds/km²). Population showed monthly, yearly and seasonal variations in numbers and densities in all habitats. Environmental factors and prey abundance greatly affects population density of pelicans and were considered to be influencing factor in Pulicat Lake. Within-site distribution of pelicans depends mainly on the movements of fish, which in turn is affected by meteorological parameters. On the other hand the occurrence of pelicans on this lake also much depended on ecological conditions in other nearby wetlands. It appears that pelicans present in freshwater habitats have favorable ecological conditions. The Pulicat Lake provides a mosaic of varying habitat conditions, essential for the population of Spot-billed Pelicans. However, the status of the Spot-billed Pelican in the Pulicat Lake appears to be a breeding resident.

Keywords: Status, Population, Pulicat Lake, Spot-billed Pelican, Habitat, Season, Southern India.

INTRODUCTION

The Spot-billed Pelican or Grey pelican *Pelecanus philippensis* was once widespread in Asia, but now limited to Sri Lanka, India and Cambodia with a recent suspected record from Sumatra (Silvius, 1986; Verheugt *et al.*, 1993). Its range extends between 1, 29,000 and 1, 81,000 km² (BirdLife International, 2000; 2001, Elliott, 1992; Ali and Ripley, 1987). Sri Lanka, Cambodia and Sumatra host 8,500 individuals of the species (Thomas, 1964; Scott, 1992; Archibald, 1992; Carr, 1993; Mundkur and Taylor, 1993; Silvius, 1986; Verheugt *et al.*, 1993; BirdLife International 2000; 2001). The population in India is estimated to be 6000–7000 birds and the global population is estimated to be 13,000–18,000 (BirdLife International 2001; Anon, 2006). In India, it is presently distributed in southern and north-eastern India (BirdLife International, 2000). Due to its progressive decline, (BirdLife International, 2000; 2001) the species was listed as globally threatened under the vulnerable category until 2005. However, thereafter the numbers

began to increase and it is now placed in the near-threatened category (Kannan and Pandiyan, 2013). The Species Survival Commission (SSC) and the Pelican Specialist Group have strongly urged for studying the species in depth in India (Crivelli and Schreiber 1984; Collar *et al.*, 1994; Crivelli and Anderson, 1996; BirdLife International, 2003; Crosby and Chan, 2006). In 2000-2003 estimated the population to be between 2850 and 3700 individuals in south India (Kannan and Manakadan, 2005). Waterbird communities have been examined in many studies for annual variations in abundance and species composition. The composition indicates the biogeography of the region (DuBowoy, 1988; Colwell, 1993; Weller, 1999; Colwell and Taft, 2000; Guadagnin *et al.*, 2005; Munguia *et al.*, 2005; Romano *et al.*, 2005; Junk *et al.*, 2006; Iriondo *et al.*, 2007; Vilella and Baldassarre, 2010; Khan, 2010; Cappelle *et al.*, 2010; Russell *et al.*, 2014), macro benthos (Kowenberg, 1993; Mercier and Mc Neil, 1994; Chapman, 2002; Mooraki *et al.*, 2009; Mulani *et al.*, 2009).

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One of the strongholds of the species in southern India is the Pulicat Lake. In this paper we provided information about the population and habitat use of the Spot-billed Pelican *Pelecanus philippensis* in Pulicat Lake. Spot-billed Pelicans are mobile (Elliott, 1992) and this is considered in the estimate of numbers. Estimation of population size can provide a strong foundation for the conservation of bird species and promote better knowledge on the

species (Bibby *et al.*, 2000) and to determine change in population size from time to time for better management operations. Little is known about population density of spot-billed pelicans in Pulicat Lake despite its large size and as a significant strong-

hold of this species. Lack of information on spot-billed pelican populations in the Pulicat Lake seriously hampers informed conservation decisions. Our objective was to conduct population studies to estimate the density of spot-billed pelican across Pulicat Lake and to suggest conservation measures.

METHODS

Pulicat Lake is located in the east coast of India ($13^{\circ} 40' 00''$ N; $80^{\circ} 11' 00$ E) and is shared between the states of Andhra Pradesh and Tamil Nadu (Figure 1).

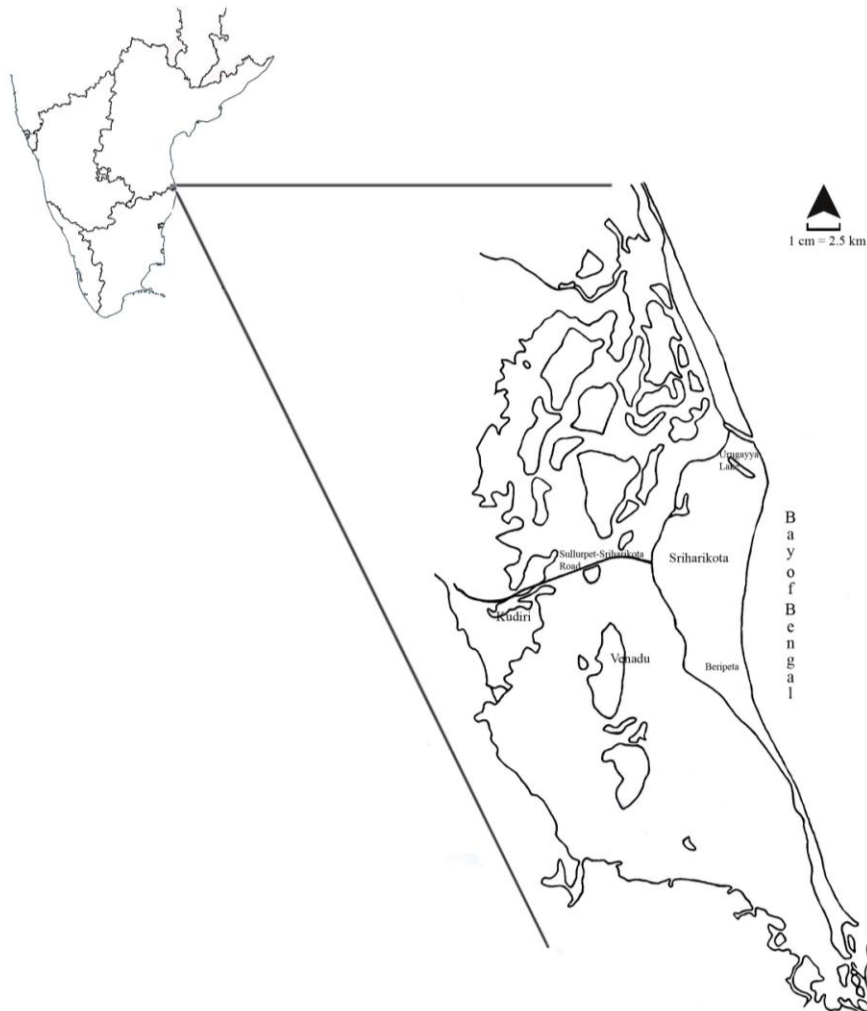


Figure 1. Map showing the study area the Pulicat Lake.

It covers a total area of 720 km^2 of which 461 km^2 forms water spread area. The annual rainfall ranges from 1000 mm to 1500 mm. The majority of rains are received during the north-east monsoon from October and December. Average annual temperature is 28°C ;

with a mean maximum of 36°C and mean minimum of 29°C . The lake possesses high bird species diversity and large concentrations of birds. A total of 251 bird species was recorded from Pulicat Lake, of these, 110 bird species were waterbirds (Kannan *et*

al., 2008) including some globally threatened species such as Oriental Darter, Painted Stork, Black-headed Ibis, Lesser Flamingo, Black Tern, Black-bellied Tern, Black-tailed Godwit, Eurasian Curlew, Greater Spotted Eagle, White-Rumped Vulture and Long-billed Vulture (Islam and Rahmani, 2005).

Pulicat is a brackish water lake consists of five predominant habitat types such as mudflats (267.9 km²), tidal flats (82.2 km²), river mouth (6.5 km²), open water (99.6 km²), and freshwater (4.9 km²). The mudflats in Pulicat Lake are either submerged or exposed depending on the rainfall and strong tidal influence with a maximum depth of 40 cm. Tidal flats are covered and exposed by tides and is located close to sea mouths of Pulicat Lake with a maximum depth of 50 cm, Open water is a pelagic type habitat away from the influence of shore with a maximum depth of about 5 m, the River mouth in Pulicat Lake is actually the delta where the river water flows into the lake, freshwater habitats are like ponds and tanks adjoining the Pulicat Lake with maximum depth of 5 m.

While many methods of assessing avian population are available (Ralph and Scott, 1981; Ralph *et al.*, 1995, Bibby *et al.*, 1998; 2000; Bennun and Howell, 2002; Gilbert *et al.*, 1998; Steinkamp *et al.*, 2003; Greenwood, 1991; Sutherland, 1996), population studies on spot-billed pelicans were mostly dependent on congregation count (Neelakandan, 1971a; 1971b; Guttikar, 1978; Perennou and Mundkur, 1992; Johnson *et al.*, 1993; Mundkur and Taylor, 1993; Krishnan, 1993; Mundkur, 1994; Perennou *et al.*, 1994; Riyazuddin, 1994; Talukdar, 1994; Subramanya, 1995; Talukdar, 1995a; 1995b; Kannan and Manakadan, 2005). For large and gregarious birds such as pelicans, estimates of the population may be derived from congregations, especially at roost and nest sites (Bibby *et al.*, 1992; Sutherland, 1996). Counting colonial birds and larger and more visible species is relatively easy as they congregate and concentrate in conspicuous aggregations and stationary flocks can be counted directly (Gregory *et al.*, 2004; Verner 1985).

Therefore, we used total count for assessing pelican population in Pulicat Lake as there is exceptional visibility and the species larger which allowed easy counting. Monthly surveys were carried out by travelling to all the places throughout the lake (covering 720 km²) using two-wheeler, boats and walking along the margins of the lake. To reduce the variability and to increase the precision of counts the lake was stratified (compartmentalized) into three

zones viz., south, central and north assuming that all pelicans seen are tallied in the entire stretch of each zone during the survey. Surveys were carried out immediately after sunrise and normally from 0600 to 1000 hrs (Dawson, 1981) and were not carried out during rainy days. To avoid overestimate or underestimate on counts of pelicans we repeated the counts of the flock for a maximum of four times, of which the highest and the second highest count was taken as the final count of the flock thereby a complete count of all pelicans present at each habitat was obtained. To avoid disturbance while counting we maintained a distance of about 50 m from the pelican congregation areas. A total of 120 survey visits was made to all three zones with an average of 60 visits per habitat in a month. The sampling for the population survey was opportunistic, however, there were on average of 60 counts per month consistent for 2-years (2010-2011; 2011-2012) were used in the analysis. The total number of trips made in month did not vary among the habitat types, therefore the opportunities for Spot-billed Pelican population was approximately equal. Environmental parameters such as temperature, rainfall and humidity were collected from the nearest metrological station located in the Pulicat Lake, prey abundance was measured from the fishermen catches throughout Pulicat Lake.

Population estimates were calculated as in the previous survey to ensure comparability. Thus, the total number of pelicans recorded in each zone (south, central and north) was used to calculate mean bird density for Pulicat Lake following (Greenwood, 1991). SPSS (Statistical Package for Social Studies) version 16 was used for analyzing the data. One-way ANOVA was used to compare mean yearly, monthly, season and habitat wise population densities. Non parametric Mann-Whitney tests were performed for the density analysis between first and second year. Similarly the same test was applied among habitats and season. We analyzed the influence of temperature, rainfall, humidity (*i.e.* Climatic) variability on the population of Spot-billed Pelican in Pulicat Lake. The influence of climatic effects on the pelican population was assessed using records of the species in different habitats and seasons. Pearson correlation analysis was used to test the influence of temperature, rainfall and humidity on Spot-billed Pelican density between years, months, seasons and habitats. Statistical inferences were made using (Sokal and Rolf, 1981). Significance of all tests was assessed at α 0.01 and 0.05 level.

RESULTS

From the data collected over the two year period (October 2010 – September 2012) the status of the Spot-billed Pelican in the Pulicat Lake-Nelapattu area appears to be a 'breeding resident'. However, seasonal fluctuations in numbers indicate that the pelicans could be undertaking local or even irregular, long distance movements, or, there could even be seasonal influxes of pelicans from other populations into Pulicat Lake. The nearest breeding or major feeding ground for pelicans to Pulicat-Nelapattu is Vedanthangal (c. 150 km) in the south and Uppalapaddu-Kolleru (c. 300 km) in the north.

Overall, the density in 2010-2011 was 0.65 birds/km² and in 2011-2012 was 0.56 birds/km²; among habitats the density was highest in freshwater 2.18 birds/km² and the lowest was in open water 0.028 birds/km² and in tidal flat 0.027 birds/km². The density in the mudflat was 0.50 birds/km² and in the river mouth 0.29 birds/km² (Figure 2). Among seasons, the highest was recorded in post-monsoon 0.92 birds/km² and the lowest was in monsoon 0.26 birds/km². The density in summers was 0.78 birds/km² and pre-monsoon 0.44 birds/km² (Figure 3). Across habitat the density was highest in freshwater 2.18 birds/km² followed by mudflat 0.5 birds/km². The density of pelicans in other habitats was 0.29 birds/km² in river mouth and 0.02 birds/km² in tidal flat and open water respectively (Fig 4). Freshwater habitat supported relatively higher number of pelicans, in both the study period. However, in Pulicat Lake, the largest congregation of pelicans seen during the 2010 - 2012 season consisted of 1513 birds in January 2011 and in the following year 694 birds in January 2012. Pelicans bred at Nelapattu only and the largest congregation of pelicans seen in Pulicat Lake during 2010-2012 other than January was 107 in March (2011), 137 in April (2011), 323 in (May 2011), 245 in June (2011), 154 in July (2011), 117 in November (2011), 515 in December (2011), 262 in February (2012), 127 in June (2012) 91 and 97 in July and September (2012). Due to sufficient rainfall during 2010-2012, pelicans bred at Nelapattu. During 2010-2012, a maximum of 1854 adults and 3708 fledglings were recorded and in 2011-2012, a maximum of 793 adults and 1585 fledglings were recorded. Fishermen interviewed during the survey in the different areas of Pulicat Lake put the maximum number of pelicans seen in Pulicat Lake as c. 1500 birds.

One-way Analysis of variance (ANOVA) test showed that density of pelicans significantly varied between habitats ($F = 8.754$, $df = 4$, $p < 0.000$), temperature ($F = 862.691$, $df = 4$, $p < 0.000$; $F = 119.874$, $df = 1$, $p < 0.000$), rainfall ($F = 700.824$, $df = 1$, $p < 0.000$; $F = 76.254$, $df = 11$, $p = 0.000$) and humidity ($F = 304.945$, $df = 11$, $p = 0.000$; $F = 136.597$, $df = 3$, $p = 0.000$) varied among months and season. The Mann-Whitney U test showed between year did not have any significance, whereas the density of pelicans between years, whereas the density of pelicans between mudflat and tidal flat ($Z = -4.599$, $p = 0.000$), followed by mudflat and open water ($Z = -4.984$, $p = 0.000$), mudflat and river mouth ($Z = -4.093$, $p = 0.000$) varied significantly at 0.05 level (Table 1). Among seasons the density did not found significant at 0.05 levels (Table 1). The value against Pearson Correlation coefficient between population, habitat and other climatic factors was positive and therefore it is concluded that spot-billed pelican population at Pulicat Lake dependent on habitat and other climatic factors (Table 2).

The climate in Pulicat Lake remains consistent throughout the year with minor variations between years. The mean monthly temperature, rainfall and humidity ranged from ($34.5 \pm 0.008^\circ \text{C}$), the rainfall ($58.3 \pm 0.00 \text{ mm}$), the humidity ($77.4 \pm 0.0 \%$) with increased pattern in the month of May, July and November. Mann-Whitney U tests shows that both the occurrence and population density did not vary significantly. As for the weather regime, only temperature was positively correlated with the population ($r = 0.664$, $p = 0.000$, $n = 120$) and with season ($r = 0.212$, $p = 0.020$, $n = 120$), rainfall and humidity show significant negative correlation with the population, ($r = -0.555$, $p = 0.000$, $n = 120$), ($r = -0.788$, $p = 0.000$, $n = 120$), whereas the rainfall and humidity showed positive correlation ($r = 0.553$, $p = 0.001$, $n = 120$) suggesting that the population in general was independent of the parameters studied (Table 2). Further, the multiple regression analysis revealed that among the independent variables tested, temperature explained 25.7% in mudflat habitat, rainfall explained 36.2 % in river mouth habitat, rainfall and humidity explained 28.4 % in freshwater habitat, influencing pelican density in Pulicat Lake and showed linear relationship, suggesting that pelican density in Pulicat Lake varying due to temperature, rainfall and humidity. Further, the pelican population density is particularly influenced by the prey abundance the fish species *Liza subviridis* and *Nematalosa nasus* explained by 3.6% (Table 3).

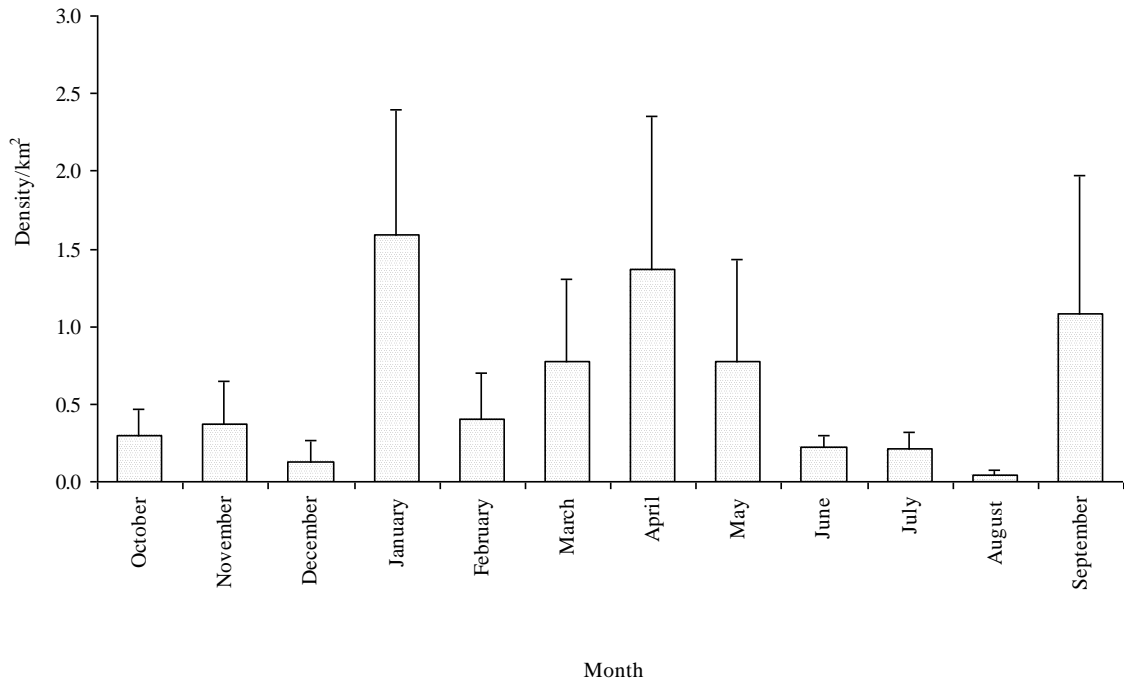


Figure 2. Density of Spot-billed Pelican in Pulicat Lake across months in 2010-2012.

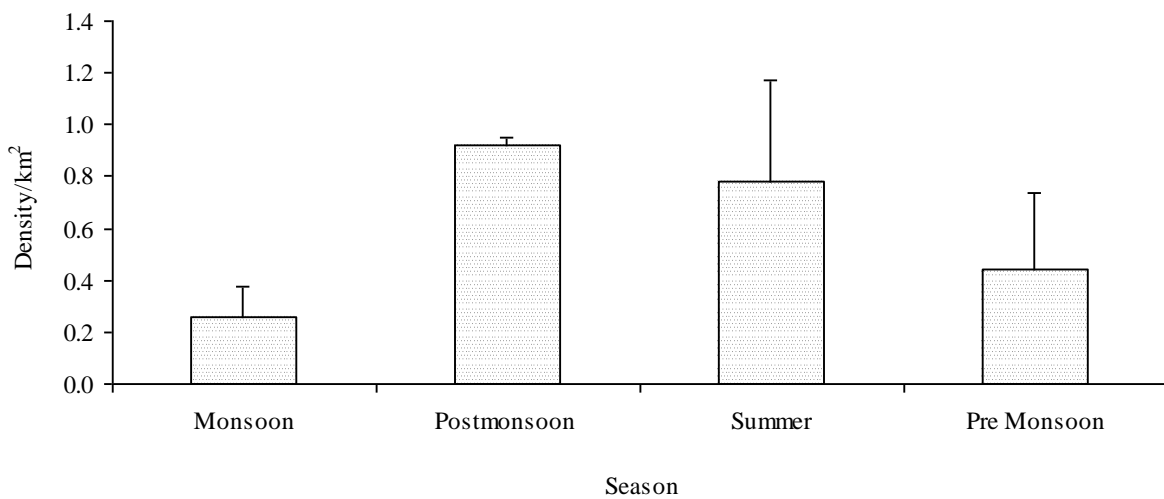


Figure 3. Density of Spot-billed Pelican in Pulicat Lake among seasons in 2010-2012.

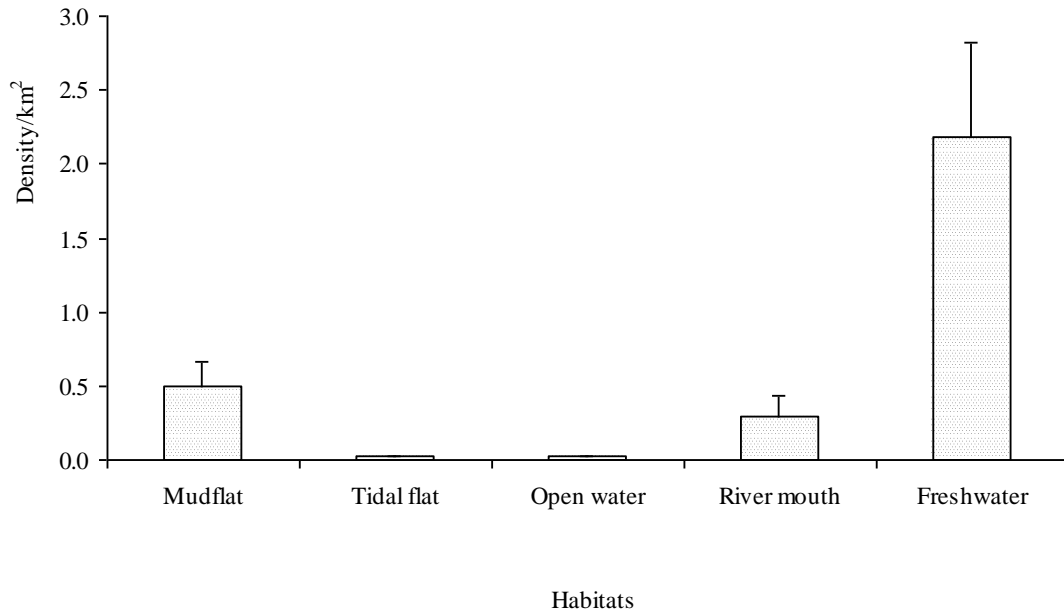


Figure 4. Density of spot-billed pelican in Pulicat Lake in various habitats.

Table 1. Density of Spot-billed Pelican in Pulicat Lake between years and habitat types.

Source	Mann-Whitney U	Wilcoxon W	Z	p
2010-2011 & 2011-2012	0.001	0.003	-0.434	0.664
Mudflat & Tidal flat	65.500	365.500	-4.599	0.000*
Mudflat & Open water	50.000	350.000	-4.984	0.000*
Mudflat & River mouth	98.000	398.000	-4.093	0.000*
Mudflat & Freshwater	252.500	552.500	-0.735	0.462
Tidal flat & Open water	210.000	510.000	-1.681	0.093
Tidal flat & River mouth	166.000	466.000	-2.775	0.006
Tidal flat & Freshwater	184.500	484.500	-2.175	0.030
Open water & River mouth	236.000	536.000	-1.335	0.182
Open water & Freshwater	153.000	453.000	-2.951	0.003
River mouth & Freshwater	154.000	454.000	-3.130	0.002

Table 2. Pearson Correlation analysis of density of pelicans and other parameters.

Source	Pearson Correlation	Density	Year	Month	Season	Habitat	Temperature	Rainfall
Year	r	-0.028						
	p	0.760						
	N	120						
Month	r	0.008	0.000					
	p	0.934	1.000					
	N	120	120					
Season	r	0.045	0.000	0.777**				
	p	0.628	1.000	0.000				
	N	120	120	120				
Habitat	r	0.307**	0.000	0.000	0.000			
	p	0.001	1.000	1.000	1.000			

	N	120	120	120	120		
Temperature	<i>r</i>	-0.016	-	0.664**	0.212*	0.000	
	<i>p</i>	0.861	0.033	0.000	0.020	1.000	
	N	120	120	120	120	120	
Rainfall	<i>r</i>	-0.121	-	0.555**	0.512**	0.000	-0.193*
	<i>p</i>	0.188	0.003	0.000	0.000	1.000	0.034
	N	120	120	120	120	120	120
Humidity	<i>r</i>	0.025	-	0.788**	0.461**	0.000	-0.849**
	<i>p</i>	0.788	0.022	0.000	0.000	1.000	0.000
	N	120	120	120	120	120	120

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

Table 3. Summary output of multiple regression equation model to explore the relationship between spot-billed pelican density in different habitats and spatio-temporal attributes and abundance of fish species.

Set	Group	Variables	Coefficient ± SD	<i>p</i>	Model <i>r</i> ²	Model <i>p</i>
1	Mudflat	Constant	12.533 ± 6.548	0.071	25.7	0.045
		Temperature	-0.3143 ± 0.1277	0.024		
2	River mouth	Constant	1.315 ± 1.278	0.315	36.2	0.003
		Rainfall	0.004560 ± 0.001315	0.002		
3	Freshwater	Constant	-64.14 ± 24.55	0.017	28.4	0.033
		Temperature	1.2140 ± 0.4789	0.020		
		Rainfall	-0.03204 ± 0.01195	0.015		
		Humidity	0.5128 ± 0.1870	0.013		
4	Prey	Constant	660.0 ± 376.7	0.083	3.6	0.182
		<i>Liza subviridus</i>	-0.7625 ± 0.3868	0.051		
		<i>Oreochromis mossambica</i>	1.4226 ± 0.4839	0.004		

DISCUSSION

Estimates of the population of pelicans in the Pulicat-Nelapattu area by earlier workers were mainly based on the counts at Nelapattu a breeding site near Pulicat Lake. Nagulu (1983) recorded 500-600 adults in 1980-1981 of which 150 pairs bred, and 400-500 pairs in 1981-1982 of which 300 pairs bred. Philip *et al.* (1998) counted 795 adults and 120 chicks in March 1997. Perennou and Santharam (1990a, b) recorded 382 birds (including some young) in 1989, followed by 570 birds (including several young) in the following month. Perennou (1990) reports of counts of c. 450 birds in 1988 and 1989; Santharam (1993) recorded less than 100 nesting pairs in 1989-1990,

and cautioned about the decline of the pelicanry, which now appears to be unfounded and Johnson *et al.* (1993) reports of counts of 382, 863, 253 and 560 for the years 1988-1991. Compiled data from forest department records (Sharma and Raghavaiah, 2002) show that the pelican have bred at Nelapattu from the years 1991-1992 till 1989-1990, with more than 1000 breeding birds during some years. Breeding did not occur during 1999-2000 and 2000-2001, attributed to the low rainfall.

All the above records suggest annual variations in the number of pelicans nesting at Nelapattu. These variations could be due to a number of factors, such as quantum of rainfall, availability of nesting trees and

food availability, major factors that are generally known to affect breeding activity. However, the numbers recorded could have also varied due to the fact that many of the estimates were based on one time visits, carried out at different times of the day and months of the breeding season – fewer birds in the mornings and early part of the breeding season. Therefore it is necessary to visit pelican colonies at least thrice a season to estimate the population as pelicans breed asynchronously (Crivelli *et al.*, 1998). The counts could further vary due to the areas covered and observer bias (Anon, 1983), e.g., fully fledged young without the parents are mistaken for adults by even seasoned birdwatchers in Nelapattu.

Few publications cite the numbers of pelicans seen in Pulicat Lake (and its adjoining areas), and pertain to the central zone of Pulicat Lake (Nagulu, 1983; Rao and Mohapatra, 1993; Philip, 1995). Low numbers of Spot-billed Pelican encountered after in March probably due to emigration. The first migrating birds arrived after November and the population increased. Afterwards, until the end of December population changes were mainly due to breeding birds. The increase of the population observed in January. April and June were due to appearance of young birds raised in the nearby breeding site (Nelapattu). Latter in April numbers decreased due to migration the population that remained after June probably over-summer in the Pulicat Lake.

Additionally, it would also have been ideal to continue the census for another two years, as pelican species tend to show high degrees of unexplained variance in densities over an area, largely due to their clumped population distribution (Din and Eltringham, 1974). Of these, since pelicans are only occasional visitors or breeders in Vedanthangal (Sanjeeva Raj, 1956; Shaw, 1959; Nagulu and Rao, 1983; Paulraj and Gunasekaran, 1988; Santharam, 1985; Santharam and Menon, 1991; Venkatraman, 1996), there is in fact no nearby known major pelican site towards the south or west of Pulicat Lake.

Spot-billed Pelican population was more strongly influenced with local climatic conditions. Local climate related to the demography of species that forage and disperse locally is reported in shags, gull and boobies (Frederiksen *et al.*, 2004; Velarde *et al.*, 2004). Climate is reported to have large impacts on biological systems and on individuals, populations, communities and ecosystems (Root *et al.*, 2003; Araujo and Rahbek, 2006). Evidence of the influence of climate on population and community dynamics is abundant (Lima *et al.*, 2001; Thomas *et al.*, 2004).

Pulicat Lake contains and supports a total of about 3000 species including flora and fauna, and about nearly 2, 00,000 birds (abundance), and about 5 species with 1% bio-geographic population, and 12 numbers of threatened birds, and 29 species of raptors (Kannan and Pandiyan, 2013; Kannan *et al.*, 2008). Therefore conservation of the species and ecosystem as well must be at various levels from local to global level. To attain international importance for a species and thus protection as a Ramsar Site under the Convention on Wetlands of International Importance or as a Special Protection Area (SPA) under the EC Directive 79/409 on the Conservation of Wild Birds (Birds Directive), a site must 'regularly' support a sufficient number of waterbirds to meet the 1% threshold qualifying levels. The Pulicat Lake regularly holds various waterbirds including shorebirds results ornithological value increases greatly when the whole surrounding wetland ecosystem system is taken into account. Therefore Pulicat Lake shall be recognized under 'Ramsar Convention' and should be monitored on regular basis due to rapid population changes in the Spot-billed Pelicans and in other shorebirds which are migrating from continent to continent. Sadly, due to increasing human population and hunger for land over the years, the need and care for this lake is drastically diminishing. Despite its ecological, economic, social and cultural importance, the Pulicat Lake is under serious pressure (Kannan and Pandiyan, 2014).

As pelicans are highly mobile, they can move in and out of the study area in large numbers if conditions are not conducive to feeding (Williams and Borello, 1997). These emigrations create real fluctuations in numbers. The number of breeding Spot-billed Pelicans at Nelapattu varies markedly and this can be related to lake conditions. When conditions are ideal for feeding, Pulicat attract more than 300-500 birds. However species fluctuations in numbers breeding are probably driven by the availability of food (Kingsford *et al.*, 1999) or nest sites (Clauss, 1972; Berry *et al.*, 1973). However, we suggest that protocols need to be established to standardize the counting and monitoring of Spot-billed Pelicans and the overall range of these species need to be established in Pulicat Lake complex. The population of Spot-billed Pelicans appears to be discrete as there are no other breeding sites within the Pulicat Lake range, then for the Spot-billed Pelicans an estimate of 1854 to 793 individuals might be acceptable. The variation in numbers indicates that there is a mass movement in and out of the study area. Banding studies may elucidate migration timing, routes, endpoints and mortality of Spot-billed

Pelicans. In addition to that satellite telemetry study could shed some insight into their true ranges and geographical boundaries for more accurate estimates of numbers.

Environmental factors can play an important role in influencing pelican population. Weather in particular has various biological and ecological impacts in population of spot-billed pelican (Sparks and Tryjanowski, 2005; Saether et al., 2006). Therefore this study tried to look into the possibility of understanding the weather influence on spot-billed pelican population in Pulicat Lake. The pelicans breeding at Nelapattu Bird Sanctuary have showed positive relationship between number of birds visiting the sanctuary (Sharma and Raghavaiah, 2002).

Results of the census and opportunistic visits indicate that during the monsoon period, the pelicans mostly concentrate in the central stretch of Pulicat Lake along the Sullurpet-Sriharikota road, especially between Kudri on the east and Sriharikota on the west. Pelicans forage and rest in an area of about 1-2 km on either side of the road during this period. This stretch is probably preferred due to a combination of factors such as overall relative shallowness and mosaic makeup of the habitat due to the uneven nature of the terrain. Additionally, the presence of a number of culverts on the road creates water flows and forms pools in which fish take shelter, especially when water levels recede. All these conditions create ideal fishing grounds for pelicans and many other piscivorous birds. The apparent total absence of poaching along this open stretch of road (poachers and transport of catch easily detected) could be another reason for the congregation of pelicans. Most of the fishermen interviewed during the survey all over Pulicat Lake also stated that pelicans largely congregate in this part of Pulicat Lake during the monsoon season.

As the mudflats and northern parts of Pulicat Lake commence to dry up by February, the birds move southwards to the area of Pulicat Lake between Beripeta of Sriharikota Island and Venadu Island (central zone). These areas lie around the border between the southern lagoon and the northern flats, and are relatively shallower than areas further south. More sightings are from the central zone, possibly due to the low levels of human disturbance on this portion of the lake. Pelicans also move to the freshwater irrigation tanks around March and stay there till the tank dries up completely by the end of April or later. Besides occasional bouts of feeding, the tank is largely used as a rest site, mostly on a small islet in the center of the tank. Other important site for

pelicans during summer are the water-bodies in Sriharikota Island, especially Urugayya and Katankayya lakes and the inlets or creeks cutting into the Sriharikota Island both from the Bay of Bengal and Pulicat Lake.

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