

Shorebirds (Charadriidae) of Pulicat Lake, India with Special Reference to Conservation

Vaithianathan Kannan and Jeganathan Pandiyan

Department of Zoology and Wildlife Biology, A.V.C. College (Autonomous),
Mannampandal 609 305, Mayiladuthurai, Tamil Nadu, India

Abstract: This study was carried out in the entire Pulicat Lake of Andhra Pradesh and Tamil Nadu covering wet and dry seasons, from April 2005 to July 2007 to account ecological information on waterbirds. Shorebirds species composition, relative abundance and distribution were studied in mudflats, tidal flats and freshwater habitats. A total of 28 shorebirds were recorded, of which two species are near-threatened Black-tailed Godwit and Eurasian Curlew. The species composition of shorebirds during the wet and dry seasons did not show significant differences. The freshwater and tidal flats had the highest species diversity and evenness when compared with the mudflats. Among the 28 species of shorebirds six species over summered in the Pulicat Lake. The overall results of the present study showed that there were no significant difference among the seasons and habitats ($P>0.05$) in terms of shorebird population. Threats identified for the shorebirds are trapping, lime shell mining and pesticide contamination.

Key words: Pulicat Lake % East Coast % Population % Species Composition % Species Diversity % Conservation % India

INTRODUCTION

The majority of populations of waders of known population trend are in decline all around the world – a matter of international conservation concern [1]. For long-distant migrants, the ecological quality of major staging areas appears to be of key importance [2]. India is the core country of the Central Asian Flyway; this flyway supports 257 species of waterbirds. Of these, 81 species are migratory birds of Central Asian Flyway conservation concern, including three critically endangered species, six endangered species, 13 near threatened species [3]. The East Coast of India a bio-geographic unit recognised for three important flyways namely Central Asian-South Asian Flyway, East Asian-Australasian Flyway, Western (or Central) Pacific Flyway and has been estimated to be wintering ground for millions of waders [4] and are important and overlapping migration routes for different species of waterbirds [5]. The main wintering grounds for waders (shorebirds) in the Central Asian/South Asian Flyway are located in India, especially along the east coast [6]. In the Central Asian Flyway the Pulicat Lake falls in the Eastern Flyway. The decline has been reflected

in wader numbers at other important habitats on the east coast [6] but the reasons for these declines are diverse and poorly understood. Information on the population structure of shorebirds of Eastern Asia and Pacific region is available [7-11]. In India, population structure is known for Point Calimere [12-17], Pitchavaram [18], Chilika [19]. No published information available on the shorebird population structure for Pulicat Lake. Information on the populations, information sharing, research and conservation activities for migratory species of conservation concern compared to other flyway systems or geographical regions [5]. To unify the flyway conservation programme a number of key preliminary steps are needed right from identifying and filling gaps in knowledge of how waders use the flyways; identifying when and where human activities have an adverse impact; quantifying such impacts and filling gaps in knowledge; and identifying the current level and efficacy of conservation action along flyways [20]. However, the importance of Pulicat Lake for waterbirds is widely recognised [21]. No systematic studies were undertaken in Pulicat Lake except the studies in the Sriharikota Island and ringing studies during the 1980s and 1990s [22, 23]

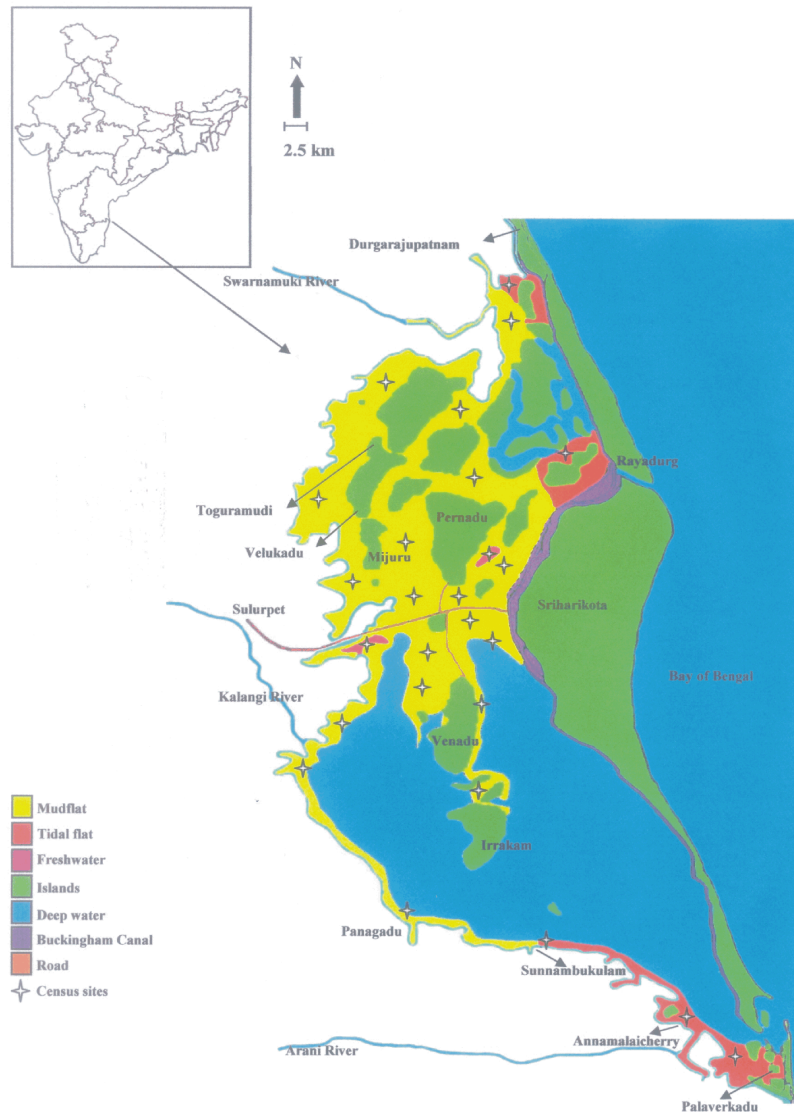


Fig. 1:

and the information on the bird population was only from the easy accessible areas therefore, to fill up the lacuna a study on the waterbirds of Pulicat Lake was carried out from 2005 to 2007 [24]. This study will give insight into the population, species composition, diversity, seasonality, abundance and threats to shorebirds of Pulicat Lake in the light of recent information and to place the Pulicat Lake shorebird populations in a wider international context for effective monitoring and protection.

Study Area: Pulicat Lake is situated on the south coast of Andhra Pradesh (13°25'-13°55'N, 80°03'-80°19'E), on the eastern seaboard of India (Fig. 1). It covers an area of about 720 sq. km and is the second largest brackish-water

lagoon in India after Chilika Lake in Orissa sprawling across Andhra Pradesh and Tamil Nadu. Both the portions of the lake are declared as a bird sanctuary. The lake has a number of small and big islands which are declared as Reserved Forests, the large ones are Sriharikota, Irrakkam, Venadu and Pernadu. The entire area is a vast, brackish to saline lagoon with extensive mudflats. The Buckingham Canal traverses in a north to south direction along the eastern edge of the lake. This site is subjected to northeast and south-west monsoon, with most rainfall occurs between October and December. The mean annual rainfall ranged from 10 mm to 467 mm during the study period. The temperature ranged from 28.2°C to 40.3°C. The humidity ranged from 60.7% to

91.8%. The lake receives water from three major rivers the Swarnamukhi, Kalangi and Arani during the monsoon. The Pulicat Lake has three openings (Durgarajupatnam, Rayadurg and Pazhaverkadu) from the sea which plays a vital role on the flora and fauna of Pulicat Lake. Like the other major wader areas in the eastern coast this site is also identified as potential Important Bird Area (IBA) [25,26] and the lake is one of identified costal flyway used by a number of pelagic and coastal migrants linking Point Calimere in Tamil Nadu with Chilika (Orissa) and Pulicat Lake (Andhra Pradesh and Tamil Nadu) on the India's east coast [27]. However, the Pulicat lake has declared as threatened lake of the year 2010 [28].

MATERIAL AND METHODS

A study on waterbirds was carried out in Pulicat Lake from April 2005 to July 2007. The shorebirds considered here included are lapwings, plovers, godwits, curlews and sandpipers as these were considered as true waders. Censuses were carried out throughout the Pulicat Lake [29,30]. Censuses (0600 hrs to 1000 hrs) were carried out in the morning throughout the study period. Additionally wader congregatory sites also used for counts in all three years to obtain an index of overall population of each species. Dates of first sighting and last sighting of wintering shorebirds were also maintained for two years (2005-2006; 2006-2007). Two year data was used for this assessment. The shorebird density in 3-years was measured in three habitat types such as mudflats, tidal flats and freshwater. Density was calculated for birds/ha. Species richness was measured by the number of species recorded on the habitat during the monthly census [31]. Species diversity was calculated using the Shannon-Wiener index (H') [32, 33]. Species evenness (H'/H'_{max}) was also calculated. Analysis of Variance Test was used to analyze the effect of two variables viz. season and habitat. Differences were considered statistically significant at 5 and 1% levels. Over-summering of shorebirds for Pulicat Lake was distinguished based on the season, species that are recorded from October to March are considered wintering; species that are recorded to be found in Pulicat Lake after March from April to September are considered over-summered.

RESULTS

A total of 28 species of shorebirds belongs to seven families was recorded in Pulicat Lake during the wet and dry seasons (Table 1). Of the total registered, 24 species

Table 1: List of shorebirds recorded in Pulicat Lake during the study this is only list so there is no need to add column for the difference

S. No.	Common Name	Species Name
1.	Greater Painted-Snipe	<i>Rostratula benghalensis</i>
2.	Pacific Golden-Plover	<i>Pluvialis fulva</i>
3.	Grey Plover	<i>Pluvialis squatarola</i>
4.	Little Ringed Plover	<i>Charadrius dubius</i>
5.	Kentish Plover	<i>Charadrius alexandrinus</i>
6.	Lesser Sand Plover	<i>Charadrius mongolus</i>
7.	Red-wattled Lapwing	<i>Vanellus indicus</i>
8.	Yellow-wattled Lapwing	<i>Vanellus malabaricus</i>
9.	Common Snipe	<i>Gallinago gallinago</i>
10.	Black-tailed Godwit	<i>Limosa limosa</i>
11.	Whimbrel	<i>Numenius phaeopus</i>
12.	Eurasian Curlew	<i>Numenius arquata</i>
13.	Spotted Redshank	<i>Tringa erythropus</i>
14.	Common Redshank	<i>Tringa totanus</i>
15.	Marsh Sandpiper	<i>Tringa stagnatilis</i>
16.	Common Greenshank	<i>Tringa nebularia</i>
17.	Wood Sandpiper	<i>Tringa glareola</i>
18.	Common sandpiper	<i>Actitis hypoleucos</i>
19.	Ruddy Turnstone	<i>Arenaria interpres</i>
20.	Little Stint	<i>Calidris minuta</i>
21.	Temminck's Stint	<i>Calidris temminckii</i>
22.	Curlew Sandpiper	<i>Calidris ferruginea</i>
23.	Ruff	<i>Philomachus pugnax</i>
24.	Black-winged Stilt	<i>Himantopus himantopus</i>
25.	Pied Avocet	<i>Recurvirostra avosetta</i>
26.	Red-necked Phalarope	<i>Phalaropus lobatus</i>
27.	Eurasian Thick-Knee	<i>Burhinus oedienemus</i>
28.	Oriental Pratincole	<i>Glareola maldiivarum</i>

were migrants and four species were residents. 24 species was registered for 2005 and 2006 where as 21 species was recorded for 2007. The *Calidris ferruginea* was not recorded in 2005 and *Arenaria interpres* and *Glareola maldiivarum* were not recorded in 2006. The *Numenius phaeopus*, *Arenaria interpres*, *Calidris ferruginea* and *Phalaropus lobatus* were not recorded in 2007. A checklist of shorebirds for Pulicat Lake is given in Appendix 1 (2005-2007). Arrival of shorebirds in Pulicat Lake is observed to be in August and the additions of species thereafter in the subsequent months (September, October, December, January, April, May and July). First arriving species are the *Charadrius mongolus*, *Limosa limosa*, *Numenius phaeopus*, *Tringa totanus*, *Tringa nebularia*, *Tringa glareola*, *Actitis hypoleucos*, *Calidris minuta*, *Philomachus pugnax* and *Himantopus himantopus* in August, followed by the *Pluvialis squatarola* and *Phalaropus lobatus* in September and in the course of northeast monsoon (October) the other species such as *Gallinago gallinago*, *Tringa stagnatilis*

Table 2: Arrival and departure of shorebirds in Pulicat Lake based on three year observation (April 2005 to July 2007)

Species	Arrival	Departure	Remarks
Pacific Golden Plover	2 nd week of December	2 nd week of June	
Grey Plover	3 rd week of September	Discontinuously recorded during the study period	Small numbers over summered
Little Ringed Plover	More records in August	Continuously recorded	The population increases from December
Kentish Plover	More records in August	Continuously recorded	The population increases from August
Lesser Sand Plover	1 st week of August	Discontinuously recorded during the study period	
Common Snipe	1 st week of October	2 nd week of April	
Black-tailed Godwit	1 st week of August	Erratic movements	
Whimbrel	1 st week of August	Discontinuously recorded during the study period	
Eurasian Curlew	2 nd week of December	Continuously recorded	Small numbers over summered
Spotted Redshank	1 st week of April	1 st week of May	
Common Redshank	2 nd week of August	1 st week of May	Small numbers over summered
Marsh Sandpiper	1 st week of October	1 st week of May	
Common Greenshank	1 st week of August	1 st week of May	Small numbers over summered
Wood Sandpiper	1 st week of August	1 st week of April	
Common Sandpiper	1 st week of August	2 nd week of June	
Ruddy Turnstone	2 nd week of May	Recorded once during the study period	
Little Stint	1 st week of August	1 st week of May	
Temminck's Stint	1 st week of October	2 nd week of April	
Curlew Sandpiper	1 st week of December	After which no record of this species	
Ruff	1 st week of August	1 st week of May	
Black-winged Stilt	1 st week of August	Erratic movements	
Pied Avocet	1 st week of January	Last week of May and some leaves by 1 st week of May	
Red-necked Phalarope	2 nd week of September	Recorded twice in the 2 nd week of September	
Oriental Pratincole	1 st week of July	1 st week of August	

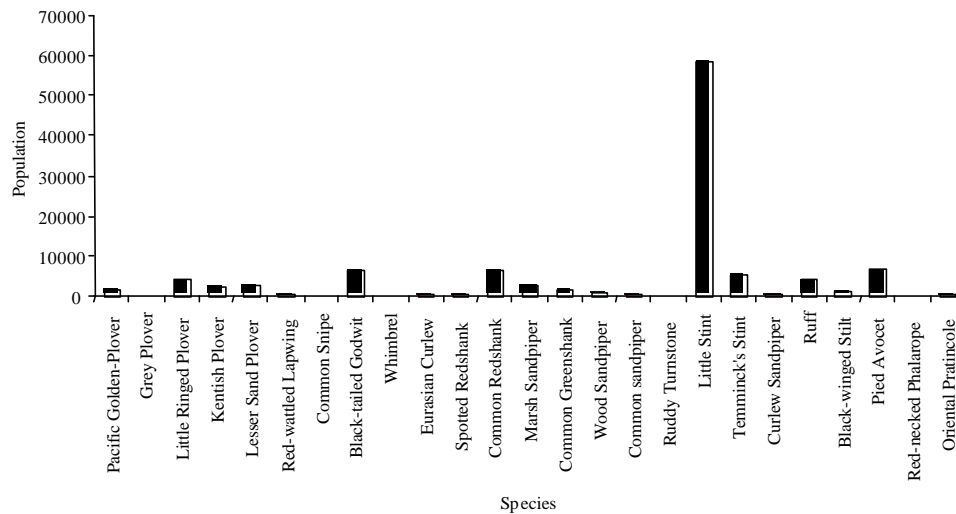


Fig. 2: Over all shorebird population in Pulicat Lake from April 2005 to July 2007

and *Calidris temminckii* arrives and in September the *Pluvialis fulva*, *Numenius arquata* and *Calidris ferruginea* arrives. The *Recurvirostra avosetta* arrives in January, the *Tringa erythropus* arrives in April, the *Arenaria interpres* arrives in May and the *Glareola maldivarum* arrives in July. The departure of the shorebirds of Pulicat Lake starts from April and continues till June (Table 2).

Population and Distribution: Altogether a total of 1, 03, 282 shorebirds was recorded for 3-years. Of the total population the numerically abundant shorebirds are *Calidris minuta*, *Recurvirostra avosetta*, *Limosa limosa*, *Tringa totanus*, *Calidris temminckii*, *Charadrius dubius*, *Philomachus pugnax*, *Tringa stagnatilis*, *Charadrius mongolus*, *Charadrius alexandrinus*, *Tringa nebularia* and *Himantopus himantopus* (Fig. 2). The peak shorebird

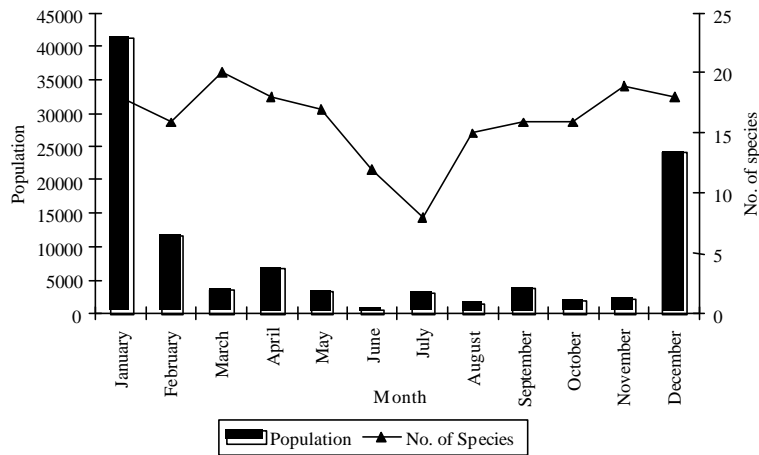


Fig. 3: Monthly shorebird population and species richness in Pulicat Lake

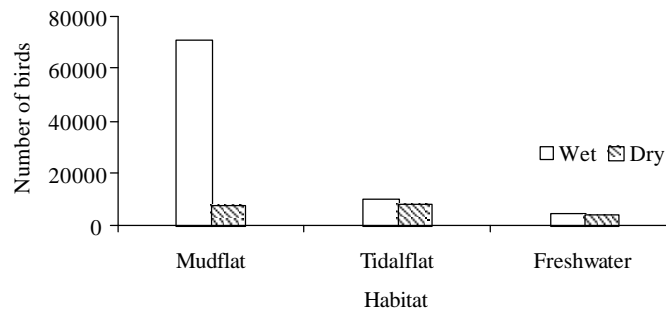


Fig. 4: Seasonal shorebird population in different habitat types from April 2005 to July 2007

population for Pulicat Lake is observed to be in January, December and February but the highest number of species was recorded in March and the lowest number of species was in July (Fig. 3). The distribution of the shorebirds in the Pulicat Lake is not uniform and has aggregated distribution except for the species such as *Actitis hypoleucos*, *Tringa glareola* and *Arenaria interpres* which were randomly distributed in mudflats, tidal flats and freshwater during the dry season and the *Numenius phaeopus* was the only species randomly distributed in all habitats during the wet season. Wet season constitutes maximum number of shorebirds in the mudflats and tidal flats, more or less equal number of birds was recorded for freshwater habitat during wet (3761) and dry (3621) season (Fig. 4).

Density, Diversity, Species Composition and Abundance:

The overall density of the shorebirds in Pulicat Lake was 1.43 birds/ha for the entire lake during the study period. During the wet and dry seasons, 21 and 23 species of shorebirds were recorded, respectively. 20 bird species were common to both seasons, but one and three species were exclusive to the wet and dry seasons, respectively.

The highest species diversity (D) was observed during the wet season in mudflat, 0.983, followed by tidal flat, 0.138. The species diversity during the dry season in mudflat, tidal flat and freshwater was 0.098, 0.110 and 0.050, respectively. The highest species evenness was recorded for freshwater habitat for both seasons followed by tidal flat 0.72 during wet season and 0.63 during dry season; mudflat had highest species diversity and modest evenness respectively (Table 3). No significant difference was observed in the species composition in seasons ($F_{1, 10} = 0.263, p > 0.05$) and among habitats ($F_{5, 36} = 0.978, p > 0.05$) results no interaction with season and habitat. The mean numbers of species also not differ significantly between three habitats. (Mudflat, mean no. of species = 0.91, n = 22; Tidal flat, mean no. of species = 0.75, n = 18; Freshwater, mean no. of species = 0.87, n = 21). The relative abundance of shorebirds during the wet season showed that 7, 7 and 8 species were frequent; 5, 1 and 3 were common; 3, 3 and 3 were uncommon at mudflats, tidal flat and in the freshwater habitat, respectively. During the dry season, 5, 3 and 8 species were frequent; 2, 1 and 3 species were common; 4, 4 and 5 were uncommon at mudflats, tidal flat and in

Table 3: Shorebird species diversity during wet and dry seasons from April 2005-July 2007

Habitat	Season	Month	No of Species	D	H'	H'/H' max
Mudflat	Wet	October-March	22	0.983	0.538	0.401
	Dry	April-September	16	0.098	0.448	0.372
Tidal flats	Wet	October-March	14	0.138	0.825	0.72
	Dry	April-September	15	0.110	0.74	0.629
Freshwater	Wet	October-March	17	0.052	0.947	0.77
	Dry	April-September	19	0.050	1.021	0.798

D= Diversity Index; H'= Shannon-Wiener Index

Table 4: Number of shorebirds in different relative abundance categories

Habitat	Season	Month	Frequent	Common	Uncommon	Rare
Mudflat	Wet	October-March	7	5	3	7
	Dry	April-September	5	2	4	5
Tidal flats	Wet	October-March	7	1	3	3
	Dry	April-September	3	1	4	4
Freshwater	Wet	October-March	8	3	3	3
	Dry	April-September	8	3	5	3

the freshwater habitat, respectively. Rare species abundance were 7, 3 and 3 wet season; 5, 4 and 3 dry season for mudflat, tidal flat and freshwater for both seasons (Table 4). The highest number of species was recorded in the mudflat (22) during the wet season and in the freshwater (19) during the dry season. However, the species like *Numenius arquata*, *Arenaria interpres* and *Glareola maldivarum* was only registered for dry season (April-September) and the *Calidris ferruginea* only in the wet season (October-March).

Over-Summering of Certain Shorebirds in the East Coast with Reference to Pulicat Lake: Over summering of shorebirds is not an unusual phenomenon however, the information on the details of the over summering shorebirds in Pulicat Lake could provide clue to mystery of its migration within the country or between the sites in the Central Asian (Eastern) Flyway. To differentiate and to avoid ambiguity of over summering shorebirds for Pulicat it was classified based on the season from October to March considered are wintering; species that continued to be found after March from April to September are considered over-summered. Species over-summered registered for Pulicat Lake are *Pluvialis fulva*, *Limosa limosa*, *Tringa stagnatilis*, *Actitis hypoleucos*, *Calidris minuta* and *Philomachus pugnax* (Table 2). Species such as *Pluvialis squatarola*, *Charadrius mongolus*, *Numenius phaeopus*, *Tringa erythropus*, *Tringa glareola*, *Calidris ferruginea*, *Himantopus himantopus* and *Recurvirostra avosetta* were recorded

both in the winter and summer but appears to have local movement between the wintering ranges along the east coast or using the Pulicat Lake as stop over site. Species that are found throughout the year were *Charadrius dubius*, *Charadrius alexandrinus*, *Numenius arquata*, *Tringa totanus* and *Tringa nebularia*. The three species *Xenus cinereus* (April), *Arenaria interpres* (May), *Phalaropus lobatus* (September) and *Glareola maldivarum* (June to August) were recorded only in the summer. Apart from the resident species, species that are known for migratory nature and breeds in temperate countries recorded throughout the year are *Charadrius dubius*, *Charadrius alexandrinus*, *Numenius arquata*, *Tringa totanus* and *Tringa nebularia*. Of the 25 shorebirds recorded in Pulicat Lake, seven species observed to develop breeding plumage partially or completely. The species observed are *Pluvialis fulva*, *Charadrius mongolus*, *Limosa limosa*, *Tringa erythropus*, *Actitis hypoleucos*, *Philomachus pugnax* and *Glareola maldivarum*. A shorebird chart for Pulicat Lake is designed based on the three year study (Table 5).

Threats to Shorebirds of Pulicat Lake: The significant threats identified for the shorebirds are shorebird trapping, lime shell mining and pesticide contamination. Shorebird trapping is one of the major threats for the shorebirds at Pulicat. Shorebirds are trapped using nets and snares for food. Species susceptible for trapping are *Calidris minuta*, *Calidris temminckii*,

Table 5: Chronology of visitation of shorebirds to Pulicat Lake

Species Name	Post-monsoon (wet season)			Summer (dry season)			Post-summer (dry season)			Monsoon (wet season)			Remarks
	January	February	March	April	May	June	July	August	September	October	November	December	
Pacific Golden Plover	P	P	P	P	P	P	A	A	P	A	P	P	Full breeding plumage in flocks
Grey Plover	P	A	P	A	A	A	A	A	P	P	P	A	-
Little Ringed Plover	P	P	P	P	P	P	P	P	P	P	P	P	Breeds in Pulicat Lake
Kentish Plover	P	P	P	P	P	P	P	P	P	P	P	P	Breeds in Pulicat Lake
Lesser Sandplover	A	A	A	A	P	P	P	P	P	P	A	A	Full breeding plumage in 1 or 2 birds
Red-wattled Lapwing	P	P	P	P	P	P	P	P	P	P	P	P	-
Yellow-wattled Lapwing	A	A	A	A	P	P	P	A	A	A	A	A	Restricted to Irrakam Island
Common Snipe	P	P	P	P	A	A	A	A	A	P	P	P	-
Black-tailed Godwit	P	P	P	P	P	P	A	P	P	P	P	P	Partial breeding plumage in some flocks
Whimbrel	A	A	P	A	A	P	A	P	A	A	P	A	-
Eurasian Curlew	P	P	P	P	P	P	P	P	P	P	P	P	-
Spotted Redshank	A	A	P	P	P	A	A	A	A	A	A	A	Partial breeding plumage in few birds
Common Redshank	P	P	P	P	P	P	P	P	P	P	P	P	-
Marsh Sandpiper	P	P	P	P	P	P	A	A	P	P	P	P	-
Common Greenshank	P	P	P	P	P	P	P	P	P	P	P	P	-
Green Sandpiper	A	A	A	A	A	P	A	A	A	P	A	A	Recorded outside of Pulicat Lake
Wood Sandpiper	P	P	P	P	A	A	A	P	P	P	P	P	-
Terek Sandpiper	A	A	A	P	A	A	A	A	A	A	A	A	-
Common Sandpiper	P	P	P	P	P	A	A	P	P	P	P	P	Full breeding plumage in 1 or 2 birds
Ruddy Turnstone	A	A	A	A	P	A	A	A	A	A	A	A	-
Little Stint	P	P	P	P	P	A	A	P	P	P	P	P	-
Temminck's Stint	P	P	P	P	A	A	A	A	A	P	P	P	-
Curlew Sandpiper	A	A	A	A	A	A	A	A	A	A	A	P	-
Ruff	P	P	P	P	P	A	A	P	P	P	P	P	Full and partial breeding plumage in 1 or 2 female birds
Black-winged Stilt	P	P	P	P	P	A	A	P	P	P	P	P	-
Pied Avocet	P	A	P	P	P	A	A	A	A	A	P	P	-
Red-necked Phalarope	A	A	A	A	A	A	A	A	P	A	A	A	-
Oriental Pratincole	A	A	A	A	A	P	P	P	A	A	A	A	Full breeding plumage in flocks

- = no changes observed, P = present, A = absent

Calidris ferruginea, *Philomachus pugnax*, *Himantopus himantopus*, *Recurvirostra avosetta*, *Pluvialis fulva*, *Pluvialis squatarola*, *Charadrius dubius*, *Charadrius alexandrinus* and *Charadrius mongolus*. This activity is largely confined to southern part and to a limited extent in the northern part of the lake. Vulnerable areas identified in the southern part of Pulicat Lake are Panagadu, Sunnambukulam, Annamalicherry and Irrakam and in the northern part (Toguramudi, Mijuru and Valukadu) Fig. 1. Snares and nooses were recovered from a group of trappers and the caught birds (species caught in their nooses are Lesser Sand Plover and Little Stint) were released during this study. The second major threat for the shorebirds identified in the Pulicat Lake is lime shell mining. The Pulicat Lake bed has rich source of sub-fossilised lime shell [67]. Due to its abundant source the people from the southern side frequents the lake for mining, they use a long sharp iron rod to find the lime

shell deposits depth, if they find the deposits at low depth the miners start digging the soil manually for more than 5 m like a well and place the soil like mounds everywhere along the mining areas this activity in turn affects the shorebird habitats unsuitable for feeding. The crop fields along the borders of the Pulicat Lake are at the start of paddy cultivation and the farmers use weedicides to prevent the growth of unwanted grass and high use of inorganic fertilizer to increase the growth of the crop, this will have possible effects on the birds wintering in Pulicat Lake naturally coincides with the cultivation and due to flooding in the lake many birds are seen using this crop fields species in particular are *Galinago galinago*, *Limosa limosa*, *Tringa erythropus*, *Tringa glareola* and *Actitis hypoleucos* largely depend on these crop fields for feeding during their wintering however, no dead birds seen in the crop fields but possible weedicide contamination in the shorebirds needs to be studied.

DISCUSSION

The record of 28 shorebirds in Pulicat Lake during the study shows that the diversity is very high. Most of these were observed for three years from April 2005 to July 2007. Two near-threatened species (*Limosa limosa* and *Numenius arquata*) was registered for Pulicat Lake during the wet and dry seasons. The arrival of shorebirds starts from August and continues till October thereafter from December to January. Palearctic migrants arrives in April, May and July indicates that the Pulicat Lake act as a facilitating site for shorebirds in the Eastern Flyway. Based on the three year study an attempt was also made to maintain the arrival and departure timings of 24 shorebirds wintering in Pulicat Lake. Among the 24 species, the *Pluvialis fulva*, *Charadrius dubius*, *Charadrius alexandrinus*, *Limosa limosa*, *Numenius arquata*, *Tringa totanus*, *Tringa nebularia* have lengthy wintering behaviour for Pulicat Lake. The information obtained will provide some useful information to understand more about their populations, migration movements and distributions in the Eastern Flyway. Shorebird population increases during December and January and drastically decreases in June and July might be due to the effect of scanty rainfall or less feeding ground for the birds due to flooding.

The species diversity index and evenness of habitats during the entire study period revealed that the freshwater habitat had the highest species diversity and evenness. The reason is due to the closeness and overlapping nature of the freshwater habitat with brackish water of Pulicat Lake. It is also due to availability of variety of food resources for birds that might contribute to the highest bird species diversity and evenness compared to other two habitats and also due to fewer disturbances. The mudflat and tidal flat have high human disturbance in the form of fishing during the shorebird wintering season and after large area of the mudflat dries up due to shallow nature of the lake naturally drives the birds towards tidal flats and freshwater habitats. However, the mudflat and tidal flat are prone to high human disturbance for fishing, cultivation and lime shell collection result birds gets affected for feeding and hiding. Differences in feeding habits and habitats could also increase diversity, evenness and species richness [34]. The smallest size of the freshwater habitat might have contributed to the high evenness and diversity of species both during wet and dry seasons. The shorebird species composition during the wet and dry seasons was not significantly different. The extended time of inundation of the area during the

wet and dry seasons could contribute to the insignificant effect of seasons on bird species composition in the studied habitats. This might account for the high numbers and species composition recorded in other areas in the eastern coast.

The relative abundance of shorebirds during seasons might be related to the availability of food, habitat condition of the species. The Pulicat Lake has year-round warm weather, moderated by ocean winds and considerable moisture. The mean temperature ranges from 28.2°C to 40.3°C. The rainfall pattern influenced by the monsoon winds of Bay of Bengal and has four seasons. The first season is from October to December, the monsoon months. During this season, the cyclones bring overcast skies and rains to northeast in all parts of the southern India. The second season occurs in January to March months. Third and fourth season occurs from April to June (summer) and from July to September (post summer), in between the two seasons the southwest rainfall occurs (June to September) and irregular along the coast. The distinct seasonality of rainfall and seasonal variation in the abundance of food resources result in seasonal changes in the species abundance of birds [35, 36]. Due to the geographical and environmental reasons a particular bird species may appear, increase or decrease in number and disappear as the habitat changes. As the area is prone to cyclones during such instance species drown might also occur in Pulicat Lake. However there will be changes in the occurrence of the species during heavy rainfall and cyclone years or during the drought years. The distribution of shorebirds is determined by drying of lake and disturbance in their habitats. But were largely depends on the hydrological conditions of the lake. Bird population parameters such as species richness, density and diversity of birds are frequently used as indicators of habitat quality [37, 38, 18]. Long-term monitoring is an important component of effective conservation oriented research and management. Additional information on important shorebird areas in the region is still needed. Such data will enhance our ability to focus monitoring efforts on appropriate areas and define appropriate protocols for species of interest.

Shorebird Varying Populations in Relevance to Pulicat Lake: The main wintering grounds for waders (shorebirds) in the Central Asian/South Asian Flyway are located in India, especially along the east coast (Point Calimere, Gulf of Mannar and Pulicat) hundreds of thousands of birds migrate a decline of over 70% of wader

Table 6: Published information on the population of shorebirds with Pulicat Lake and other key wintering sites in the eastern coast in various years

Species Name	Gulf of Mannar 1985-86; 2001	Pitchavaram 1986-1987	Pulicat Lake 1988-1989	Pulicat Lake 1998-1999	Point Calimere 2000-2003	Chilika Lake 2001-2003	Pulicat Lake 2005-2007
Pacific Golden Plover	-	-	-	-	-	1,886	1477
Grey Plover	180	-	-	-	-	516	28
Little Ringed Plover	-	-	-	-	-	569	3961
Kentish Plover	850	-	-	-	-	1,577	2215
Lesser Sandplover	14,000; >4,000	2,825	>25,000	>15,000	<40,000	15,330	2426
Common Snipe	-	-	-	-	-	-	55
Black-tailed Godwit	-	380	>20,000	>18,000	>15,000	57,963	6122
Whimbrel	186	18	-	-	-	1,301	6
Eurasian Curlew	443; 67	-	-	-	-	2,052	369
Spotted Redshank	Rare	-	-	-	-	80	181
Common Redshank	730	315	-	-	-	2,082	5959
Marsh Sandpiper	Few hundreds	2,960	-	-	-	8,168	2650
Common Greenshank	Several hundreds;180	65	-	-	-	82	1351
Wood Sandpiper	Small numbers	-	-	-	-	3,427	568
Common Sandpiper	124 (1987-88)	28	-	-	-	4,582	231
Ruddy Turnstone	Maximum numbers	22	-	-	-	130	3
Little Stint	In thousands; >2,000	3,340	>60000	>35,000	<20,000	9,140	58424
Temminck's Stint	Rare	15	-	-	-	510	5173
Curlew Sandpiper	Over 10,000; >5,000	2,200	>35,000	>20,000	<25,000	9,928	225
Ruff	-	360	>40,000	>30,000	<10,000	1,536	3825
Black-winged Stilt	Several hundreds	2,760	>5,000	>3,000	>1000	2,957	1002
Pied Avocet	7	35	>1,000	>400	<100	218	6544
Red-necked Phalarope	-	-	-	-	-	-	2
Oriental Pratincole	-	-	-	-	-	-	230
Source	[63, 6]	[17]	[6]	[6]	[6]	[64]	This study

population and decline is observed in Pulicat Lake and Gulf of Mannar [6]. It is necessary to determine why several of Pulicat Lake's internationally important populations of wader are declining and in particular why species such as *Pluvialis fulva*, *Charadrius dubius*, *Charadrius alexandrinus*, *Charadrius mongolus*, *Limosa limosa*, *Tringa totanus*, *Tringa stagnatilis*, *Calidris minuta*, *Calidris temminckii*, *Philomachus pugnax* and *Recurvirostra avosetta* are found predominantly in the Pulicat Lake. It should be considered a priority to apply 1% thresholds of Pulicat Lake population to qualify as Ramsar Site on the basis of the wader numbers (Table 6). The decline of waders was due to early effects of climate change and the declines in flyway population size [39]. The increase in salinity is found to be reason for the decline of coastal birds in the Eastern Coast [40].

Pacific Golden-Plover *Pluvialis fulva* which is a strong migratory species [41] and breeds between June and July [42] is found with full breeding plumage in Pulicat Lake till June. The Pacific Golden-Plover *Pluvialis fulva* is listed as a 'least concern' species; however, its

population trend appears to be declining [43]. The Black-tailed Godwit *Limosa limosa* decline was observed in Europe during 1970-1990, over 35% and similar decline was observed in Australia from 1977-1981 to 1998-2001. Now the population observed to be increasing along the Central Asian-Flyway [3], which was found to be in many thousands [6]. The Curlew Sandpiper *Calidris ferruginea* and the Little Stint *Calidris minuta* was described as abundant winter visitor to Pulicat [6] but the former was recorded only in May during the study period. The Black-winged Stilt *Himantopus himantopus* is now recognized to be a resident breeding in suitable localities which was recorded in thousands at Pulicat [23]. The highest decline was observed in the two commonest sandpipers, Curlew Sandpiper *Calidris ferruginea* and Little Stint *C. minuta* which occurred in many thousands [6]. He further observed decline in the populations of Pied Avocets *Recurvirostra avosetta* and Black-winged Stilts *Himantopus himantopus* wintered at Point Calimere in the 1980s, which occurred in several thousand have now become scarce.

Over-Summering of Shorebirds with Reference to Pulicat Lake: Shorebird migrations between breeding and wintering grounds are well known [42] depending on location and other factors northward migrations occur in March-June and southward movements take place in July-October [44, 45, 46]. The over-summering phenomenon has been reported in 15 families of birds with high occurrence in the shorebird families Charadriidae and Scolopacidae [44]. Over-summering birds are found mainly in species which feed in wetlands or intertidal habitats [47] and is not unusual to find in their winter ranges where they breed in southern latitudes [48-53]. Such individuals represents for over-summering shorebirds [49]. Although it is not an unusual phenomenon in shorebirds it would give some insights in their migration strategies and its ecology in the wintering sites. Non breeding wintering migrants belong to 17 species were observed to have over summered in Pulicat Lake. Over summered migrants recorded from the Visakhapatnam coastal swamp are for *Tringa totanus* [54]. Similarly information exists for Gulf of Mannar was recorded for *Pluvialis squatarola*, *Charadrius mongolus* (with partial breeding plumage), *Numenius arquata*, *Tringa nebularia*, *Tringa totanus*, *Tringa terek* and *Himantopus himantopus* [55]. However, the Little Stint *Calidris minuta* and Temminck's Stint *Calidris temminckii* appears to be rare in summer at Gulf of Mannar which is seen during April in Pulicat Lake. However, the Kentish Plover and Little Ringed Plover observed to breed in Pulicat Lake [24] information exists on more breeding records for Kentish Plover from the Point Calimere [56, 57]. Over wintering of some species recorded for Pulicat Lake needs to be investigated further in the context of global warming and climate change.

The Pacific Golden-Plover spends 8 months in Pulicat Lake and is not found in July-October, the Grey Plover is not sighted in February and from May to August and was found using Pulicat Lake for 6 months, Lesser Sand Plover was found using Pulicat Lake for 6 months from May-October, this was not sighted from November to April. The Black-tailed Godwit is not found in June to July but was recorded from August to May. The Whimbrel was sighted in March, June, August and November which shows an irruptive pattern of migration between the sites, the Spotted Redshank was found only during April and May. The Marsh Sandpiper was not recorded in July, August and November, but was found using the lake for 9 months. The Wood Sandpiper was not found from May to July, but was found using the site for 9 months. The Common Sandpiper was not found in June and July, but was recorded using the site for 10 months. The Ruddy

Turnstone and Red-necked Phalarope was recorded in May and September. The Little Stint was not found in June and July but was recorded using the site for 10 months. The Temminck's Stint was recorded from October to February, but was not seen from March to September. The Curlew Sandpiper was recorded only in May which was a common species till 1980 [6]. The Ruff was not recorded in June and July but was found using Pulicat Lake from August to May. The Black-winged Stilt was not recorded in March and from June-July. The Pied Avocet was not recorded in February and from July to October, but was found using 7 months. Species such as Eurasian Curlew, Little Ringed Plover, Kentish Plover, Common Redshank and Common Greenshank was found throughout the year.

Conclusion and Further Studies

Why Pulicat Lake needs international importance?

Many of the shorebirds migrate from temperate countries to tropical countries to take advantage of favourable conditions. India is one among the important country which is recorded to be 70 species of shorebirds. And the east coast is one of the bio-geographic regions for wintering shorebirds and the significant among them is Pulicat Lake. To attain international importance for a species and thus protection as a Ramsar Site under the Convention on Wetlands of International Importance [58] 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 system is taken into account. Therefore Pulicat Lake shall be recognized under Ramsar Convention [59] and should be monitored on regular basis due to rapid population changes in the shorebirds which are migrating from continent to continent. The Central Asian/South Asian Flyway lies entirely within the Northern Hemisphere and is the shortest flyway in the world and most poorly known flyway and for a high proportion of its wader populations, nothing is known of population size or trends [5] and the protection of Pulicat Lake and its shorebirds are matter of national and international concern (Table 7). The results of this study indicate seasonality in the diversity and abundance of shorebirds in Pulicat Lake. The Pulicat Lake is observed to have continuous drastic siltation which makes the shallow areas in to sand-flats which is a serious threat to the ecosystem and the birds as well.

Table 7: Shorebird importance for Pulicat Lake in relation to Global and Asian populations for high conservation importance

Species Name	Estimated Asian population	Estimated Global Population	1% threshold level	No. observed in Pulicat Lake	% for Pulicat Lake	Red List Status	Global trend
Pacific Golden Plover	116,000+(50,000-100,000)	1, 90, 000-2, 50, 000	750	1477	1. 96	LC	9
Grey Plover	155,000	3,60,000	300	28	0.09	LC	9
Little Ringed Plover	25,000-100,000+?	2, 80, 000-5, 30, 000	NA	3961	-	LC	:
Kentish Plover	130,000-210,000	3, 00, 000 -4, 60, 000	1000	2215	2.22	LC	9
Lesser Sandplover	130,000-150,000+?	3, 10, 000-3, 90, 000	1,000	2426	2.43	LC	9
Red-wattled Lapwing	NA	NA	NA	255	-	LC	Unset
Common Snipe	200,000->2,000,000	6,300,000-8,100,000	NA	55	-	LC	Unset
Black-tailed Godwit	260,000	6, 30, 000-805,000	1,000	6122	6.1	NT	9
Whimbrel	80,000-155,000	1,000,000-2,300,000	1000	6	0.006	LC	9
Eurasian Curlew	45,000-135,000	7, 70, 000-1,065,000	1000	369	0.37	NT	R9
Spotted Redshank	35,000-125,000	1,10,000-3,50,000	250	181	0.7	LC	:
Common Redshank	145,000-1,300,000	9, 60, 000-2,600,000	1,000	5959	5.95	LC	NBD
Marsh Sandpiper	115,000-1,090,000	2, 60, 000-1,200,000	1,900	2650	1.4	LC	9
Common Greenshank	65,000-155,000	4, 40, 000-1,500,000	1,000	1351	0.056	LC	:
Wood Sandpiper	200,000-1,100,000	3, 100,000-3,500,000	10,000	568	-	LC	:
Terek Sandpiper	60,000-150,000	1, 60, 000-1, 200, 000	1,000	-	-	LC	:
Common Sandpiper	55,000-1,030,000	2, 600, 000-3, 200, 000	NA	231	-	LC	9
Ruddy Turnstone	35,000-200,000	4, 60, 000-800,000	1,000	3	0.003	LC	9
Little Stint	200,000	1, 400, 000- 1, 500, 000	2,000	58424	29.2	LC	9
Temminck's Stint	35,000-200,000	1, 70, 000-1, 300, 000	1,000	5173	5. 2	LC	NBD
Curlew Sandpiper	280,000	1, 800, 000-1, 900, 000	1,000	225	0.23	LC	8
Ruff	100,000	2,000,000-2,600,000	1000	3825	3.8	LC	*
Black-winged Stilt	125,000-1,100,000+?	4, 50,000-7, 80, 000	10,000	1002	0.1	LC	8
Pied Avocet	35,000-200,000	2, 10, 000-4, 60, 000	1000	6544	6.54	LC	NBD
Red-necked Phalarope	Unknown	3, 600, 000-4, 500, 000	NA	2	-	LC	9
Oriental Pratincole	100,000-1,075,000	2,900,000-3,000,000	NA	230	-	LC	Unset
Eurasian Thick-Knee	Unknown	1,30,000-310,000	NA	Good numbers	?	LC	Unset
Source	[65]	[43]	[66]			[43]	[43]

9-decreasing, R9- rapidly decreasing, 8-increasing, : - Stable, NBD-not believed to be decreasing, *-Asia population not decreasing, LC-least concern, NT-near threatened, NA-not available, ?-uncertain

Studies on the wintering shorebird feeding ecology are needed to be addressed to restore the habitats for the conservation of shorebirds as well for other waterbirds. More details on this aspect need to be studied to assess the ecology of wintering shorebirds and their role in Pulicat Lake ecosystem. Studies on the impact of pesticides in the wintering shorebirds of Pulicat Lake need to be examined with particular reference to Black-tailed Godwit (near-threatened species), Spotted Redshank, Wood Sandpiper and Common Sandpiper for their conservation. Information on migration dynamics, phenology, migration routes, migration strategy and moult patterns of the waders wintering in Pulicat Lake is required on continuous basis. Studies on the aspects of stop over ecology of transitory populations and sudden increase in the shorebird population could be due to stop over of the transitory populations or species.

In nutshell, shorebird information is largely from known sites such as Gulf of Mannar, Point Calimere, Pitchavaram, Pulicat Lake, Bittarkanika, Chilika Lake in the eastern coast. Many sites in the east coast of India needs attention which are unprotected that holds significant population of shorebirds. The sites needs attention for shorebird monitoring are Coringa Creek, the Krishna Mangroves, the Godavari Mangroves, Kandikuppa, Nachgunta, Salagondi, Yanum, Antarvedi, Ellichitladibba, Repalle and Bandamuslanka in Andhra Pradesh [60, 61], for Tamil Nadu the Edayar, Ennore, Cooum, Adayar, Uppanar, Vellar, Kollidam, Cauvery, Agniyar, Kallar, Chatram, Adhirampattinam and Muthupet [62]. If these sites are also monitored on regular basis the patchy information on the shorebird population size in the Eastern Flyway will gives us some understanding. Also it will provide the decision makers across the Central Asian

Flyway with crucial information on the wintering shorebirds conservation and protection with special reference to Eastern Flyway.

ACKNOWLEDGEMENTS

We thank the Ministry of Environment and Forests, Government of India for funding the study and the Forest Departments for giving permission to work in the Pulicat Lake. We thank the Bombay Natural History Society and the PG Department of Zoology and Wildlife Biology, A.V.C. College (Autonomous) for their cooperation.

REFERENCES

1. International Wader Study Group. 2003. Waders are declining worldwide, Conclusions from the 2003 International Wader Study Group Conference, Cádiz, Spain.
2. Stroud, D.A., 2006. Declining waterbirds: problems, processes and sites. Workshop Introduction. In: Boere, G.C., C.A. Galbraith and D.A. Stroud, (eds.). Waterbirds around the world. The Stationery Office, Edinburgh, UK. pp: 641-642.
3. Davidson, N., 2003. Status of wader populations on the Central/South Asian flyway. Wader Study Group Bulletin., 101/102: 7-8.
4. Straw, P.J., K.B Gosbell and C.D.T. Minton, 2006. Shorebird research in the East Asian-Australasian Flyway: looking to the future. In: Boere, G.C., C.A. Galbraith and D.A. Stroud, (eds). Waterbirds around the world. The Stationery Office, Edinburgh, UK. pp: 328-331.
5. Mundkur, T., 2006. Flyway conservation in the Central Asian Flyway. Workshop Introduction. In: Boere G.C., Galbraith C.A., Stroud D.A. (eds). Waterbirds around the world. The Stationery Office, Edinburgh, UK. pp: 263.
6. Balachandran, S., 2006. The decline in wader populations along the east coast of India with special reference to Point Calimere, south-east India. In: Boere, G.C., C.A. Galbraith and D.A. Stroud, (eds.). Waterbirds around the world. The Stationery Office, Edinburgh, UK. pp: 296-301.
7. Parish, D. and D.R. Wells, 1984. Interwader Annual Report 1983 (eds). Interwader Publication, pp: 1.
8. Parish, D. and D.R. Wells, 1985. Interwader Annual Report 1984 (eds). Interwader Publication, pp: 2.
9. Howes, J.R., A.F.A Hawkins and D. Parish, 1986. Preliminary survey of wetlands and shorebirds along the east coast of Peninsular Malaysia. Interwader Publication, pp: 14.
10. Parish, D., R.C. Prentice and C.E. Taylor, 1986. Interwader Annual Report for 1985. Interwader Publication, pp: 16.
11. Parish, D., R.C. Prentice and C.E. Taylor, 1987. Interwader Annual Report for 1986. Interwader Publication, pp: 19.
12. Ali, S., XXXX. Ecological reconnaissance of Vedaranyam Swamp. Report to the Industries Department, Tamil Nadu Government, Bombay Natural History Society, Mumbai.
13. Ali, S., 1986. Studies on the movement and population of India avifauna. Annual Report 1985-1986. Bombay Natural History Society, Bombay.
14. Ali, S. and S.A. Hussian, 1981. Studies on the movement and population structure of Indian avifauna. Annual Report 1, Bombay Natural History Society, Bombay.
15. Ali, S. and S.A. Hussian, 1982. Studies on the movement and population structure of Indian avifauna. Annual Report 2. Bombay Natural History Society, Bombay.
16. Ali, S. and R. Sugathan, 1985. Studies on the movement and population structure of India avifauna. Annual Report (August 1984-July 1985). Bombay Natural History Society, Bombay.
17. Sampath, K. and K. Krishnamurthy, 1989. Shorebirds of the salt ponds at the Great Vedaranyam Salt Swamps, Tamil Nadu, India. Stilt, 15: 20-23.
18. Sampath, K. and K. Krishnamurthy, 1990. Shorebirds (Charadriiformes) of the Pichavaram mangroves, Tamil Nadu, India. Wader Study Group Bulletin, 58: 24-27.
19. Hussian, S.A., K.K. Mohapatra and S. Ali, 1984. Avifauna profile of Chilika Lake. A case for conservation. Technical Report No. 4, Bombay Natural History Society.
20. Davidson, N.C., P. I., Rothwell and M.W. Pienkowski, 1995. Towards a flyway conservation strategy for waders. Wader Study Group Bulletin, 77: 70-81.
21. Hussain, S.A., 1987. The conservation of waders and wetlands in India. Wader Study Group Bulletin. 49, Suppl./IWRB Special Publ., 7: 128-131.
22. Samant, J.S. and P. Rao, 1996. An ecological investigation of the avian community of Sriharikota Island. Final Report. Bombay Natural History Society, Bombay, pp: 45.

23. Balachandran, S., 1998. Bird Migration Studies in India (1980-1992). Final Report. Phase I and II. Bombay Natural History Society, Mumbai, pp: 142.
24. Kannan, V., R. Manakadan, P. Rao, K.K. Mohapatra, S. Sivakumar and V. Santharam, 2008. The waterbirds of Pulicat Lake andhra Pradesh-Tamil Nadu, India, including those of the adjoining wetlands and heronries. Journal of Bombay Natural History Society, 105(2): 162-180.
25. Islam, M.Z. and A.R. Rahmani, 2004. Important Bird Areas in India: Priority Sites for Conservation. Indian Bird Conservation Network, Bombay Natural History Society and BirdLife International., pp: 157-158.
26. Islam, M.Z., 2006. Conservation of waterbirds and wintering areas through Important Bird Areas in India. In: Boere, G.C., C.A. Galbraith and D.A. Stroud, (eds). Waterbirds around the world. The Stationery Office, Edinburgh, UK, pp: 687.
27. Grimmett, R., C. Inskipp and T. Inskipp, 2001. Pocket Guide to the Birds of the Indian Subcontinent. Oxford University Press, pp: 10-12.
28. Kannan, V. and J. Pandiyan, 2010. Pulicat – threatened lake of the year 2010. Current Science, 99: 1496-1497.
29. Bibby, C.J., N.D. Burgess and D.A. Hill, 1992. Bird Census Techniques. Published for RSPB and BTO by Academic Press, San Diego.
30. Sutherland, W.J., 1996. Ecological Census Techniques. A Handbook. Cambridge University Press, Cambridge.
31. Verner, J., 1985. Assessment of counting techniques. In: Johnston, R.F. (eds.). Current Ornithology, New York: Plenum Press, pp: 247-302.
32. Shannon, C.E. and W. Wiener, 1949. The Mathematical Theory of Communication. Urbana, III: Illinois University Press.
33. Simpson, E.H., 1949. Measurement of diversity. *Nature* 163: 688.
34. Smith, R.L., 1992. Elements of Ecology. 3rd edn. Harper Collins Publishers Ltd, London.
35. Gaston, K.J., T.M. Blackburn, J.D. Greenwood, R.D. Greroryx, M.Q. Rachel and J.H. Lawton, 2000. Abundance-occupancy relationships. Journal of Applied Ecology, 37: 39-59.
36. Karr, J.R. and R.R. Roth, 1971. Vegetation structure and avian diversity in several new world areas. American Naturalist, 105: 423-435.
37. Nilsson, S.G. and I.N. Nilsson, 1978. Breeding bird community densities and species richness in lakes. Oikos, 31: 219-221.
38. Weller, M.M., 1978. Management of freshwater marshes for wildlife. In: Good, R.E., D.F. Whingham and R.L. Simpson, (eds). Freshwater Wetlands: Ecological process and management potential. New York: Academic Press.
39. Rehfisch. M.M., G.E. Austin, M.J.S. Armitage, P.W. Atkinson, S. J.Holloway, A.J. Musgrove and M.S. Pollitt, 2003. Numbers of wintering waterbirds in Great Britain and the Isle of Man (1994/1995-1998/1999): II Coastal waders (Charadrii). Biological Conservation, 112: 329-341.
40. Sandilyan, S., K. Thiyagesan, R. Nagarajan and V. Jayshree, 2010. Salinity rise in Indian mangroves – a looming danger for coastal biodiversity. Current Science, 98(6): 754-756.
41. Del Hoyo, J., A. Elliott and J. Sargatal, (eds)., 1996. Handbook of birds of the world, 3. Barcelona: Lynx Edicions.
42. Hayman, P., J. Marchant and T. Prater, 1986. Shorebirds. An identification guide to the waders of the world. London and Sydney: Croom Helm.
43. BirdLife International, 2010. Species factsheet: *Pluvialis fulva*. Downloaded from <http://www.birdlife.org> on 24/8/2010.
44. McNeil, R., 1970. Hivemage et estivage d'oiseaux aquatiques nord-americains dans le nord-est du Venezuela (mue, accumulation de graisse, capacite de vol et routes de migration). Oiseau et R.F.O, 40: 185-302.
45. McNeil, R. and J. Burton, 1973. Dispersal of some southbound migrating North American shorebirds away from the Magdalen Islands, gulf of St. Lawrence and Sable Island, Nova Scotia. Caribbean Journal of Science, 13: 257-278.
46. Hicklin, P.W., 1987. The migration of shorebirds in the Bay of Fundy. Wilson Bulletin, 99: 540-570.
47. McNeil, R., M.T. Diaz and A. Villeneuve, 1994. The mystery of shorebird over-summering: A new hypothesis. Ardea, 82: 143-152.
48. Liversidge, R., F. Broekhuysen and A.R. Thesen, 1958. The birds of Langebaan Lagoon. Ostrich, 29: 95-106.
49. Loftin, H., 1962. A study of boreal shorebirds summering on Apalachee Bay, Florida. Bird Banding, 33: 21-42.
50. Morel, G. and F. Roux, 1966. Les migrateurs palearctiques au Senegal. Terre Vie, pp: 19-72.
51. Johnson, O.W. and M.L. Morton, 1976. Fat content and flight range in shorebirds summering on Enewetak Atoll. Condor, 78: 144-145.

52. Johnson, O.W., 1979. Biology of shorebirds summering on Enewetak Atoll. Stud. Avian Biology. 2: 193-205.
53. Summers, R.W., L.G. Underhill, D.J. Pearson and D.A. Scott, 1987a. Wader migration systems in southern and eastern Africa and western Asia. Wader Study Group Bulletin. 49, Supplement/ IWRB Special Publication, 7: 15-34.
54. Daniel, J.C. and S.S. Somane, 1975. Bird migration studies in India the migrant waders of the family Charadriidae. Journal of Marine Biological Association of India, 17(1): 199-205.
55. Balachandran, S., 1990. Interesting bird records from Mandapam and its neighbouring islands. Tamil Nadu. Journal of Bombay Natural History Society, 87: 456-457.
56. Sugathan, R., 1982. Some interesting aspects of the avifauna of the Point Calimere Sanctuary, Thanjavur district, Tamil Nadu. Journal of Bombay Natural History Society, 79(3): 567-575.
57. Natarajan, V., 1992. Wintering waterbirds at Point Calimere, Tamil Nadu. Journal of Bombay Natural History Society, 89(2): 316-320.
58. Ramsar, 1988. Proceedings of the Third Meeting of the Conference of the Contracting Parties. Regina, Saskatchewan, Canada, 27 May-5 June 1987. Ramsar Convention Bureau, Gland, Switzerland.
59. Ramsar Convention Bureau, 1990. Proceedings of the fourth meeting of the Conference of the Contracting Parties (Montreux, Switzerland). Ramsar Convention Bureau, Switzerland.
60. Taher, S.A. and G.M. Taher, 1996. Wetlands of Andhra Pradesh, India-Status and Pressures. Mayura 13: 28-43.
61. Banerjee, L.K., 2002. Mangrove diversity sustainable uses and conservation of Godavari-Krishna Delta in the Eastern Ghats regions of Andhra Pradesh. In: Proceedings of the National Seminar on Conservation of Eastern Ghats. March 24-26, 2002, Tirupati andhra Pradesh, pp: 34-54.
62. Ramakrishna, S. and K. Venkataraman, 2001. Marine. In: Alferd, J.R.B., Das, A.K. and Sanyal, A.K. (eds). Ecosystems of India. ENVIS-Zool. Surv. India, Kolkata, pp: 291-315.
63. Balachandran, S., 1995. Shorebirds of the Gulf of Mannar Marine National Park, Tamil Nadu. Journal of Bombay Natural History Society, 92(3): 303-313.
64. Nayak, A.K., 2006. Status of migratory shorebirds at Bhitarkanika and Chilika wetlands on the east coast of India. In: Boere G.C., Galbraith C.A., Stroud D.A. (eds) Waterbirds around the world. The Stationery Office, Edinburgh, UK, pp: 305-307.
65. Wetlands International, 2002b. Waterbird Population Estimates – Third Edition. Wetlands International Global Series No.12, Wageningen. www.wetlands.org/IWC/WPEnote.htm.
66. Wetlands International, 2002. *Waterbird Population Estimates*: Third Edition. Wetlands International Global Series No. 12. Wageningen, The Netherlands.

Appendix 1: Checklist of the shorebirds of Pulicat Lake

S. No.	Common Name	Species Name
1.	Greater Painted-Snipe	<i>Rostratula benghalensis</i>
2.	Pacific Golden Plover	<i>Pluvialis fulva</i>
3.	Grey Plover	<i>Pluvialis squatarola</i>
4.	Common Ringed Plover	<i>Charadrius hiaticula</i>
5.	Little Ringed Plover	<i>Charadrius dubius</i>
6.	Kentish Plover	<i>Charadrius alexandrinus</i>
7.	Lesser Sand Plover	<i>Charadrius mongolus</i>
8.	Greater Sand Plover	<i>Charadrius leschenaultii</i>
9.	Black-fronted Plover	<i>Charadrius melanops</i>
10.	Red-wattled Lapwing	<i>Vanellus indicus</i>
11.	Yellow-wattled Lapwing	<i>Vanellus malabaricus</i>
12.	Pintail Snipe	<i>Gallinago stenura</i>
13.	Common Snipe	<i>Gallinago gallinago</i>
14.	Jack Snipe	<i>Lymnocyptes minimus</i>
15.	Black-tailed Godwit	<i>Limosa limosa</i>
16.	Whimbrel	<i>Numenius phaeopus</i>
17.	Eurasian Curlew	<i>Numenius arquata</i>
18.	Spotted Redshank	<i>Tringa erythropus</i>
19.	Common Redshank	<i>Tringa totanus</i>
20.	Marsh Sandpiper	<i>Tringa stagnatilis</i>
21.	Common Greenshank	<i>Tringa nebularia</i>
22.	Green sandpiper	<i>Tringa ochropus</i>
23.	Wood Sandpiper	<i>Tringa glareola</i>
24.	Terek Sandpiper	<i>Xenus cinereus</i>
25.	Common sandpiper	<i>Actitis hypoleucos</i>
26.	Ruddy Turnstone	<i>Arenaria interpres</i>
27.	Great Knot	<i>Calidris tenuirostris</i>
28.	Red Knot	<i>Calidris canutus</i>
29.	Little Stint	<i>Calidris minuta</i>
30.	Long-toed Stint	<i>Calidris submunuta</i>
31.	Temminck's Stint	<i>Calidris temminckii</i>
32.	Curlew Sandpiper	<i>Calidris ferruginea</i>
33.	Dunlin	<i>Calidris alpina</i>
34.	Ruff	<i>Philomachus pugnax</i>
35.	Black-winged Stilt	<i>Himantopus himantopus</i>
36.	Pied Avocet	<i>Recurvirostra avosetta</i>
37.	Red-necked Phalarope	<i>Phalaropus lobatus</i>
38.	Eurasian Thick-Knee	<i>Burhinus oedienemus</i>
39.	Small Pratincole	<i>Glareola lactea</i>
40.	Oriental Pratincole	<i>Glareola maldivarum</i>

Source: [24]