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Spatial variations of shorebird community in the saltpans of East coast of Tamil Nadu, Southern India

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Abstract

We studied the spatial variations of bird species and invertebrates in the different saltpans of Kodikkarai regions of east coast of southern India. We selected five different saltpans and fortnightly quantification was made on birds and invertebrates. The birds were estimated by total count and the invertebrates were sampled at 20cm depth which used for foraging by shorebirds. In total 10345 of individual birds consisting of 46 species were using the saltpans as foraging grounds. In which, species of shorebirds used the saltpans more than the other bird species. Among the five saltpans, the Nedunthittu saltpan had highest density (21.08 / ha.), diversity (H'=2.1092) and bird species richness (38) than the other saltpans. The bird density showed significant difference among the saltpans ($P<0.05$). Also, there was a positive relationship between the density of bird species and density of benthic organisms ($P<0.05$). From this study, it is inferred that the conservation, restoration and development of saltpans at coastal wetlands, is a viable approach to the conservation of birds especially migratory shorebirds.

Keywords: birds, Coastal wetlands, habitats and interactions, prey, saltpans, shorebirds

INTRODUCTION

Salt pans are well-known for artificial hyper saline habitats that are of great significance for migratory water birds or shorebirds, due to the high productivity and certainty in time and space, as well as their shallow depth (Britton & Johnson 1987, Warnock et al. 2002). Shorebirds are long distance migrants which migrate thousands of kilometres between breeding and wintering areas and are heavily dependent on passage sites along the flyways where they can rest and refuel. In fact, natural and artificial coastal wetlands tend to be highly productive and are vital habitats for these birds and are very sensitive to habitat change (Hartke et al 2009). However, in recent decades, many coastal wetlands have been destroyed or transform, resulting in major impacts on shorebirds population. On the other hand artificial wetlands such as salt pans can provide important foraging habitats for shorebirds (Ramno et al. 2005). Salt production via the circulation of sea water through a system of ponds in salt pans is an ancient activity in the coastal areas.

In fact, shorebirds distribution are strongly influenced by food (Evans and Dugan 1984). Aquatic invertebrates in salt pans represent abundant prey for shorebirds, although there are relatively few invertebrate taxa owing to the extreme salinities. Among the benthic taxa, Chironomid larvae are particularly important for the survival of shorebirds. Numerous studies have been made and demonstrated a positive correlation between shorebirds and their prey densities (Goss-Custard 1970, Bryant 1979 and Pandiyan et al 2006). However, few analyses on the relationship between shorebirds abundance and prey densities conducted on finer spatial scales (eg., across sampling stations spaced 10-100m apart) obtained either weak (Wilson 1990) or inverse (Kelsey and Hassall 1989) numerical relationships.

Besides, in Tamil Nadu, seasonally the salt extraction is one of the major professions of the coastal areas and there are more than 12,000 hectares are under salt extraction. The salt pans represent 16% of the surface area of the coastal area, and are an important feeding and roosting area for shorebirds. During the migration periods and in winter seasons, several flocks of shorebirds can be regularly observed in salt pans (Pandiyan et al. 2013). In addition, the current study areas of salt pans are located adjacent to Point Calimere Bird Sanctuary which is one of the important Bird Sanctuary and the only RAMSAR site in Tamil Nadu. Although they attract good number of shorebirds, they do not get any protection. By this point of view we have decided to execute the present study with the following objectives i.e. to record and estimate the bird species and to assess the benthic prey items in the salt pans.

STUDY AREA

The study was carried out in the Kodikkarai salt pans of the east coast of Tamilnadu, southern India. The saltpans in the study area comprised 930 ha. and divided into five different saltpan areas (Camplast (250 Ha) ($10^0$19.678'N, $79^0$49.809'E), Kovilthalvu (190 Ha) ($10^0$20.793'N, $79^0$48.163'E), Nandupallam (170 Ha) ($10^0$20.394'N, $79^0$50.714'E), Nedunthittu (160 Ha)

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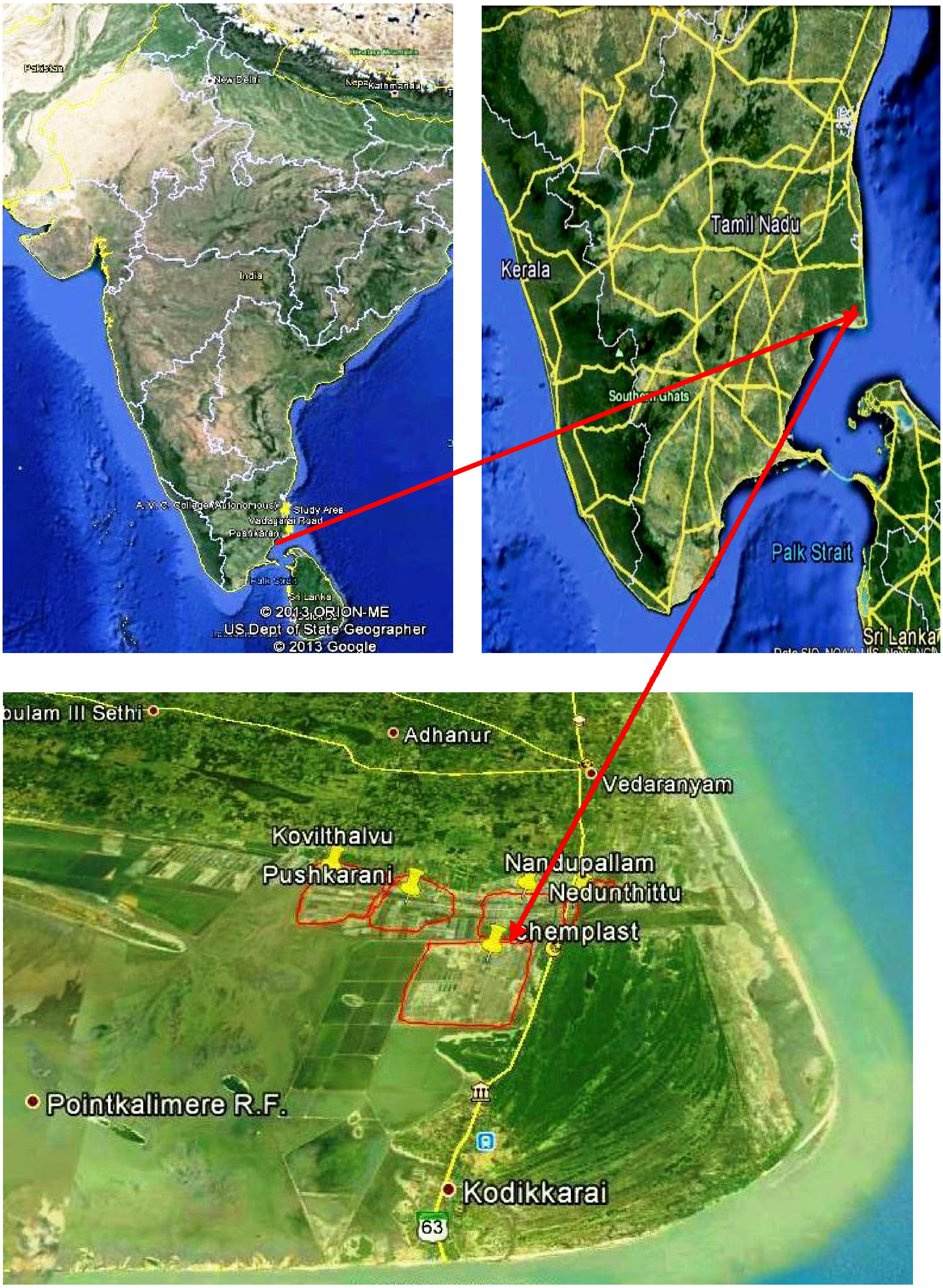
Fig.1 Map showing the saltpan areas of Kodikkarai, Tamilnadu, South India.



($10^0$20.520'N, $79^0$50.203'E) and Pushkarani (160 Ha) ($10^0$20.444'N, $79^0$48.989'E). These saltpans are located on the east coast of India near an important waterbird wintering area: Point Calimere Wildlife Sanctuary, which is the only RAMSAR site located in Tamilnadu (Fig. 1). The saltpans primarily comprise of reservoir ponds (which are mainly used to store sea water), Evaporation ponds (which are mainly used for increasing the salinity of the water) and crystallization ponds (these are true saltpans in which the sea water crystallizes into salt particles), which differ mainly in their salinity, vegetation and water levels. The salinity of the first (reservoir) pond type is very similar to that of the marine environment (35-38%), whereas in the last pond type (crystallization ponds) it reaches more than 250%. This region is subjected to the northeast monsoon, with most of the rainfall occurring during October–December. However, in the past decade, rainfall has declined remarkably and, in recent years, most rainfalls are over a period of 2–3 weeks. In fact, these study areas are important and are acting as stopover sites for the migratory birds during their migratory periods (Sampath and Krishnamoorthy 1989 and Pandiyan 2011).

METHODOLOGY

SHOREBIRD COUNT

Since all the saltpans appeared relatively homogenous, the study area was divide into five different areas, and its name was based on their nearby location. Birds were counted with 7 × 50 binocular and 20 x 60 spotting scope from vantage points on the saltpans. Birds were counted individually using the 'direct count' method which gave a total count of birds in each area (Yates and Goss-Custard, 1991 and Nagarajan and Thiyagesan 1996). On each day, we carried out two counts of 3.00h duration and as far as possible, counts were undertaken on clear and sunny days to minimise bias arising from variation in weather. All the study areas were entirely open and had very scanty vegetation so birds could be seen and counted without difficulty. During the census, we were always aware of any arrival or departure of flocks of birds in the areas to be counted to avoid missing or duplicating records. The birds were not particularly disturbed by our counts and in fact they tolerate our presence very reasonably.

BENTHIC FAUNA SAMPLING

In the selected salt pan areas the benthos were sampled twice in a month, selecting two points at random and laid 1x1 m^2 quadrates, in each quadrate six core samples were collected from a depth of 5 cm with a 20 cm^2 core sampler. Smaller samples were taken at the saltpans in order to reduce laboratory processing time and hence to increase the number of samples we could process. Previous studies on benthos had shown the benthic fauna to be extremely abundant and dominated by small animals, so only small cores were required to capture enough animals for analytical purposes. At most sites it would not have been possible to take considerably deeper cores, because the sediment in these saltpans is very hard due to saltpan activities so at least 10 cm deep at some sites were considered. However, benthic animals buried more than 5 cm below the surface are beyond the reach of the bill tips of the most common shorebird species (Red-necked Stint, bill length 16-22 mm; Curlew Sandpiper *Calidris ferruginea*, bill length 32-43 mm; and Sharp-tailed Sandpiper *Calidris acuminata*, bill length 22-27 mm; bill measurements from Higgins and Davies (1996). Moreover, observations on these species had shown that these species rarely probe deeply into the mud, usually taking prey from the top centimetre or so of the sediment (Loyn *et al.* 2002; Beasley 2004). The samples were filtered with 0.5, 0.3 and 0.1 mm sieves, and the organisms in them were counted and identified. Unidentified organisms were preserved in 95% alcohol, than they were brought to the laboratory for identification with standardised references.

DATA ANALYSIS

Shorebird density was calculated as number per hectare for each area. Species richness was calculated by the number of shorebird species recorded in the salt pans (Verner 1985), and species diversity was calculated by using the Shannon– Wiener Index (H': Shannon & Wiener 1949). Individual bird density was calculated as number per hectare for each saltpan area in each month. Shorebirds were observed at all levels, including evaporation ponds. The General Linear Molde (GLM) was applied to the density of benthic organisms between months and saltpan areas. The GLM was also applied for the bird species between the months and saltpan areas. All the statistics were run by using SPSS. Results of the analyses were interpreted using standard statistical procedures (Sokal and Rohlf 1981).

RESULTS

BIRD SPECIES DENSITY

In total 10345 of individual birds consisting of 46 species were using the salt pans as feeding and foraging grounds. The results of the present study showed that among the five salt pans, shorebirds had occurred maximum density than the other bird species recorded for the entire study periods from November 2012 to October 2013 (Table 1).

Out of 46 species of birds, the Little stint was observed high density when compared to the other bird species studied in the five different salt pans i.e. 171.3 ± 48.80, 212.0± 186.1, 72.0 ± 18.0, 85.6± 66.2 and 139.83± 62.38 / ha. Nedunthittu, Kovilthalvu, Camplast, Nandupallam and Pushkarani respectively (Table 1). Among the five salt pans, the Nedunthittu salt pan had retained highest

Table.1. Mean density of shorebirds (No. / Ha.) recorded at different Salt Pans of Kodikkarai regions, Tamilnadu, Southern India, from November 2012 to October 2013

S. No	Species name	Saltpan areas				
		Nedunthittu	**Kovilthalvu**	**Camplast**	**Nandupallam**	**Pushkarani**
1	Common kingfisher	0.27 ± 0.19	0	0	0	0
2	White breasted kingfisher	0.18 ± 0.01	0.17 ± 0.16	0	0.2 ± 0.04	0.3 ± 0.21
3	Pied kingfisher	1.0 ± 0.75	4.3 ± 0.71	0	0.8 ± 0.16	1.5 ± 0.80
4	Common redshank	8.4 ± 4.88	46.6 ± 4.58	23.0 ± 2.6	0.6 ± 0.10	33.0 ± 18.46
5	Broad bellied sandpiper	0	38.17 ± 38.16	0	0	0
6	Common greenshank	9.6 ± 5.08	8.0 ± 7.2	0	1.0 ± 0.2	7.1 ± 5.41
7	Common sandpiper	21.0 ± 11.7	32.8 ± 28.7	12.7 ± 8.73	10.4 ± 6.85	22.8 ± 11.77
8	Curlew sandpiper	2.82 ± 2.02	2.3 ± 1.96	0	0.8 ± 0.16	0
9	Dunlin	1.3 ± 0.1	0	0	0	2.8 ± 0.46
10	Eurasian curlew	0	0	0	1.2 ± 0.24	0
11	Green sandpiper	2.4 ± 1.64	14.3 ± 2.38	0	0.8 ± 0.16	4.3 ± 2.86
12	Marsh sandpiper	3.8 ± 1.21	27.3 ± 26.5	5.5 ± 5.17	1.4 ± 0.87	11.1 ± 5.7
13	Little stint	171.3 ± 48.80	212.0 ± 186.1	72.0 ± 18.0	85.6 ± 16.2	139.83 ± 62.38
14	Spotted redshank	1.5 ± 1.03	3.6 ± 3.47	0	0	1.3 ± 0.21
15	Temminks stint	9.0 ± 6.94	0	0	1.8 ± 0.36	14.5 ± 11.28
16	Tereck sandpiper	0.45 ± 0.04	0	0	0	0
17	Whimbrel	0.3 ± 0.03	0	0	0	0
18	Wood sandpiper	2.8 ± 1.81	5.6 ± 0.93	1.2 ± 0.3	0	3.3 ± 1.54
19	Common ringed plover	0.8 ± 0.55	0	0	0	0.3 ± 0.05
20	Kentish plover	0.82 ± 0.81	0	0	0	0
21	Lesser sand plover	2.3 ± 1.91	61.1 ± 10.1	0	2.0 ± 1.54	0
22	Little ringed plover	37.6 ± 16.68	48.8 ± 43.61	28.2 ± 15.54	30.8 ± 3.52	53.83 ± 26.99
23	Pacific golden plover	0.18 ± 0.01	0	0	0	0
24	Red wattled lapwing	0	0	0	0.2 ± 0.04	0
25	Black0winged stilt	2.8 ± 2.53	1.5 ± 0.80	0.5 ± 0.12	1.6 ± 0.98	1.3 ± 0.66
26	Brown headed gull	0	0	0	3.2 ± 0.64	0
27	Heuglins gull	5.9 ± 1.71	0	2.5 ± 0.62	0	18.1 ± 17.57
28	Yellow legged gull	0	0.3 ± 0.05	0	30.2 ± 12.2	0.3 ± 0.05
29	Caspian tern	2.4 ± 0.27	0	1.0 ± 0.25	3.2 ± 1.05	4.6 ± 1.89
30	Common tern	0.64 ± 0.03	3.67 ± 3.66	0	0	1.5 ± 1.02
31	Gull0billed tern	1.7 ± 1.30	0.83 ± 0.13	0	5.2 ± 1.04	0.83 ± 0.13
32	Little tern	1.4 ± 0.8	0.3 ± 0.05	0.20 ± 0.05	0.6 ± 0.12	1.83 ± 1.13
33	Whiskered tern	0.36 ± 0.27	3.0 ± 0.05	2.2 ± 1.65	6.0 ± 1.68	3.5 ± 2.12
34	Black kite	0.36 ± 0.14	0	0.20 ± 0.05	0.3 ± 0.06	0.28 ± 0.12
35	Brahminy kite	1.1 ± 0.01	1.7 ± 1.03	2.4 ± 1.60	3.3 ± 0.92	2.06 ± 0.58
36	White bellied sea eagle	0	0	0	0.17 ± 0.16	0.06 ± 0.04
37	Little cormorant	0.36 ± 0.20	0	0	0.50 ± 0.1	0.22 ± 0.11
38	Great egret	0.73 ± 0.50	0.25 ± 0.04	1.0 ± 0.25	1.17 ± 0.54	1.0 ± 0.43
39	Intermediate egret	0.64 ± 0.36	0.75 0.12	2.2 ± 1.35	1.17 ± 0.83	1.3 ± 0.48
40	Little egret	4.4 ± 1.21	2.7 ± 0.47	8.4 ± 2.65	5.5 ± 1.80	6.81 ± 1.51
41	Western egret	0.18 ± 0.01	0	0	0.17 ± 0.16	0.09 ± 0.06
42	Grey heron	0	0	0.40 ± 0.1	0	0.06 ± 0.01
43	Indian pond heron	0.45 ± 0.04	0.50 ± 0.08	1.2 ± 0.73	0.83 ± 0.54	0.84 ± 0.32
44	Yellow bittern	0.09 ± 0.009	0	0	0	0.03 ± 0.005
45	Greater flamingo	0	0	2.4 ± 0.4	6.0 ± 1.2	1.5 ± 1.1
46	Painted stork	4.7 ± 3.30	1.0 ± 0.16	4.8 ± 1.74	1.5 ± 0.95	3.1 ± 1.2

(0) indicates the absence of species

density (21.08/ha.), diversity 2.1092 (H') and bird species richness (38) than the other salt pans studied. The bird density showed significant differences among the saltpan areas ($P<0.05$).

BENTHIC FAUNAL DENSITY

There were six different species of benthic organisms recorded from the five different salt pans. In which, the Chironomid larvae and Artemia were noted predominant benthic organisms than the other benthic organisms. Highest density of benthic organisms recorded in the Nedunthittu (258.4 ± 63.5 No. / M^2) and lowest density was recorded in Camplast salt pan areas (11.5 ± 5.8 No. / M^2) (Figs.2&3). The benthic density varied significantly among the saltpan areas ($P<0.05$).

RELATIONSHIP BETWEEN BIRD AND BENTHIC ORGANISM DENSITY

The results of the present study showed that there was a positive relationship between the density of bird and benthic organism ($P<0.05$). In the case of density of birds, was observed in the highest value of (21.1/ha.) in Nedunthittu salt pan area lowest of (2.5/ha.) in Camplast salt pan area. Similarly density of benthic organisms was also highest in Nedunthittu Salt Pan Area (319 No / M^2) and lowest in Camplast salt pan area (44.7 / No. / M^2) (Fig.4).

DISCUSSION

The present study indicated that the salt pan areas could even support a larger population of shorebirds. This is the first study with regard to spatial variation of shorebirds and benthic community in active salt works or salt pans of east coast of Tamilnadu, Southern India and never done before. The overall findings of patterns of results indicated that the shorebirds and chironomid larvae were observed highest density than the other species recorded spatially in the five different salt pans during the entire study periods from November 2012 to October 2013. Already several studies indicated that the salt pans are alternate habitat and providing sufficient prey and food for avian community to full fill their day to day survival.

The salt pans are attracting birds especially shorebirds, because hypersaline systems such as salt pans have relatively simple food webs (Britton and Johnson 1987), in which the chironomid larvae is the dominant benthic organisms. Most of the invertebrates, we recorded in our study are important prey for shorebirds including chironomid larvae (Kalejta 1993, Sánchez et al. 2005). The chironomid larva is the major prey item of shorebirds (Pandiyan *et al*., 2006). Chironomid larvae are also important prey for a variety of waterbirds (Krapu and Reinecke 1992). Chironomid larvae are extremely abundant or dominant in the benthos in a variety of aquatic ecosystems, (Armitage et al. 1995 and Sa´nchez et al. 2005a, b). Shorebirds are sporadic predators likely to have major effects on invertebrate prey because they have high foraging intake and energy demands, and they are present in large concentrations at stopover and wintering sites (Wilson 1991). In addition to that many authors have shown that shorebirds have high intake rates and have suggested that they are likely to consume a significant amount of benthic chironomid larvae (Rehfisch 1994, Masero and Pe´rez-Hurtado 2001). Several studies mentioned that the saltpans are most significant alternate habitats for

Fig. 2. Density of chironomid larvae (No./m^2) in different saltpans of Kodikkarai area, Nagai District, Tamilnadu, Southern India, from November 2012 to October 2013.

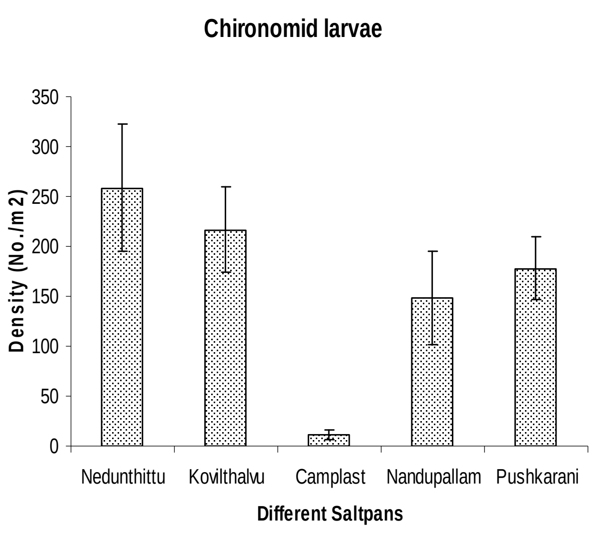


Fig. 3. Density of *Artemia salina* (No./m^2) in different saltpans of Kodikkarai area, Nagai District, Tamilnadu, Southern India, from November 2012 to October 2013.

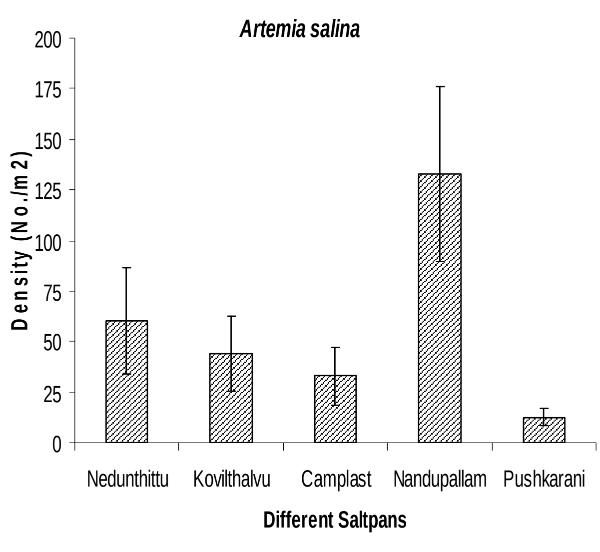
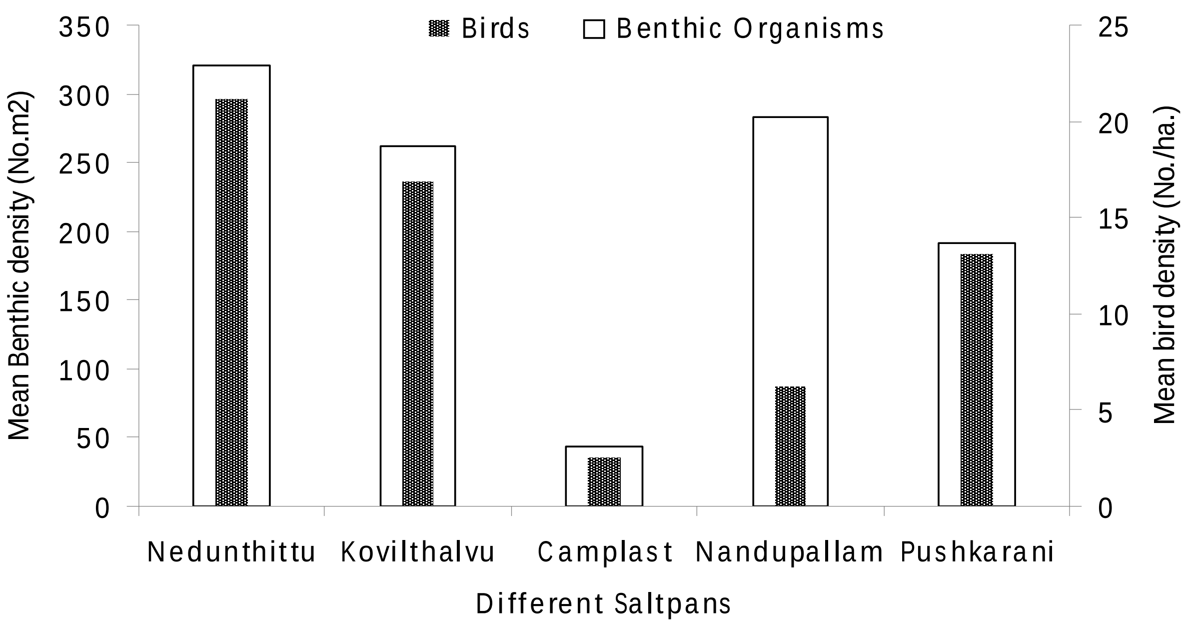


Fig. 4. Comparison of density of chironomid larvae (in Y1 axis as No./m^2) and bird density (in Y2 axis as No./ha.) in different saltpans of Kodikkarai area, Nagai District, Tamilnadu, Southern India, from November 2012 to October 2013.



shorebirds. For example, saltpans are often classified as functional wetlands with a high biological richness, supporting important numbers of shorebirds around the world (Britton and Johnson 1987 and Sadoul et al. 1998). Many shorebird species feed on intertidal mudflats and adjacent saltpans (e.g., Velasquez et al. 1991 and Masero et al. 2000).

There was an evidence that birds were being distributed themselves spatially between saltpans in relation to differences in the volume of prey present in the different saltpans. There was a strong relationship between the mean number of feeding shorebirds in a given saltpan and the density of benthic organism. The results showed that the saltpans generate a higher availability of chironomid prey and which provide a preferred habitat for waders/shorebirds. The extent to which a high production of chironomid larvae is translated into a good foraging habitat for shorebirds depends largely on appropriate management of water levels (Velasquez, 1992; Rehfisch, 1994). Smaller shorebird species are those that are most limited in the depth range where they can feed, and also they most dependent on alternative, artificial habitats such as saltpans since their low body mass and high metabolic rate requires them to feed practically all day round (Goss-Custard 1977 and Fasola & Ruiz, 1996). Some species such as Whimbrels are less limited by water depth, as they also feed on Artemia in deeper parts of our study site (by swimming and taking brine shrimps close to the surface).

Hence, saltpans are man-made supratidal habitats that may provide suitable habitats for shorebirds to feed and forage (Britton & Johnson 1987 and Velasquez & Hockey 1992). Although they are generally located in estuarine areas, saltpans are not influenced by tidal rhythms and the water levels change slowly (Velasquez 1992), making them regular and predictable habitats over the time (Masero et al. 2000). These features mean that salt pans are particularly important for shorebirds. Shorebirds strongly depend on estuarine intertidal flats during migration and wintering periods and are particularly vulnerable to such impacts, whose importance will depend on the availability of alternative feeding habitats. We conclude that saltpans can be used as alternative habitat by larger species during winter and southward migration. We also reinforce the need to manage the saltpans as key habitats for shorebirds.

CONSERVATION VALUE OF SALT PANS AND MANAGEMENT IMPLICATIONS

The most important conclusion of this study is that the conservation, restoration, or enhancement of salt pans at coastal wetlands, is a viable approach to the conservation of shorebirds. Most efforts for the conservation of the saltpans have been focussed on the inclusion of these habitats under some form of legal protection. However, this effort is not enough, because all the salt pans are private properties and therefore the salt production has been abandoned. The saltpans lost their value for shorebirds in the absence of adequate water management. Therefore, at least in nearby sanctuary reserves (the present study area near by one of the Ramsar Site in India, Wildlife and Bird Sanctuary), the site-managers of coastal wetlands should establish agreements with the owners to manage water levels to balance the interest of salt producers and shorebirds, which will be a support to shorebirds (Rufino and Neves 1992). On the other hand, it must be noted that large evaporation surfaces of modern saltpans usually are emptied during winter or rainy season. Consequently, these surfaces are unsuitable for most shorebirds during a large proportion of winter. We recommend that flooding conditions are maintained in the evaporation saltpans throughout the winter seasons, because during that particular season most of the birds are visited. It increases the available surface for the shorebirds, and decreases potential density-dependent effects on the feeding distribution of some shorebird species (Masero and Pe´rez-Hurtado 2001). Hence we have to take appropriate steps to conserve these wetlands for the betterment and conservation of bird species, which are facing under threat due to scarcity of prey and habitats. In addition to that collaboration between researchers, salt farmers and planning authorities in soundly manage salt-pans for betterment of shorebirds and their survival.

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