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Journal of Threatened Taxa

Building evidence for conservation globally

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

COMMUNICATION

VADUVUR AND SITHERI LAKES, TAMIL NADU, INDIA: CONSERVATION AND MANAGEMENT PERSPECTIVE

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26 May 2021 | Vol. 13 | No. 6 | Pages: 18497–18507

DOI: 10.11609/jott.5547.13.6.18497-18507



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INTRODUCTION

Wetlands are declining globally. Between 1993 and 2007, the global acreage of wetlands decreased by 6% (Prigent et al. 2012). Hence, it is reasonable to assume that most existing wetlands are impacted to some degree by human land-use that in turn caused population declines in many wetland-dependent taxa. Wetlands have many successional stages and hydroperiods, represented in close proximity, thus, managing wetlands effectively requires an understanding of basic ecosystem processes besides using appropriate management techniques that depend on target species, coastal versus interior wetlands, available infrastructure, resources, and management objectives.

The National Wetland Atlas, prepared by the Ahmedabad (Gujarat) Space Application Centre (SAC), Indian Space Research Organization (ISRO), has classified Tamil Nadu as a wetland-rich state as they occupy 6.92% of the geographic area. One-hundred-and-twenty-five species of birds including both migratory and resident that depend on wetlands fully or partly and 28 other species found in the vicinity of wetlands are known from Tamil Nadu. Although Tamil Nadu State has several wetlands, studies are limited to very few: Point Calimere (Sugathan 1982), Kaliveli (Pieter 1987), Singanallur Lake (Reginald et al. 2007), Pallikaranai (Raj et al. 2010), Karaivetti (Gokula 2010), Vaduvor (Gokula & Raj 2011), and Sitheri (Gokula & Raj 2015). The majority of research work on wetland management in Tamil Nadu relates to the limnological and ornithological aspects. Nevertheless, the land-use changes and socio-economic activities leading to changes in limnological and biodiversity aspects of these wetlands have not been explored substantially. Moreover, the national water sector agenda pays little attention to wetland management resulting in over exploitation of wetland's resources. Hence, an attempt was made to identify the threats to the Vaduvur and Sitheri lakes and their associated fauna.

STUDY AREA

The Vaduvur Lake, situated between 10.698–10.706 °N & 79.309–79.322 °E, spread over c. 128ha and Sitheri Lake, situated between 10.712–10.728 °N & 79.323–79.342 °E, spread over c. 87ha, are located at a distance of 20km from Mannargudi, a town, situated between 10.636–10.677 °N & 79.432–79.450 °E in Tiruvavur District in Tamil Nadu. The Vaduvor Lake was declared a bird

sanctuary by the forest department in July 1999. The bunds help in holding the water up to an average depth of c. 2.5m. Vegetation of the lake consists of *Prosopis chilensis*, *Azadirachta indica*, *Tamarindus indica*, and *Acacia nilotica* including planting of *A. nilotica* by the forest department under the Sanctuary Management Program. The Sitheri Lake is currently being maintained by the public works department, Tamil Nadu, however, the forest department of Tamil Nadu has a plan to bring this wetland and its components under the protected areas network. The Vennaru River is the main source of water in addition to the monsoon (largely from the north-east) for both the lakes.

METHODS

Birds were counted using direct count method from selected vantage points following Bibby et al. (1992) and Sutherland (1997). Counts were made four times in a month during which birds were observed from 06.00–10.00 hr and 16.00–18.00 hr, being their most active periods of the day from September 2010 to February 2012. No count was done during extreme weather conditions. The water quality of the lakes was assessed using the standard methods described by APHA (1996). Identification of zooplankton was done by following Alfred et al. (1973) and Adoni et al. (1985). Zooplankton samples were collected from the two lakes by towing a plankton net, made up of bolten silk with a mesh size of 100µm, from surface water to 1m depth. One-hundred litre of water from the lakes was filtered through the zooplankton net and collected planktons were preserved in 5% formalin. Planktons were identified up to species level. Planktons were enumerated using SedgwickRafter chamber and species richness and diversity were calculated. Fish collected by the local people were inspected and identified up to the species level, based on which, a list of fish species for each lake was prepared. Jayaram (1999) was followed to identify the fish fauna. Several visits were made around the lakes and villages nearby for collecting information on threats to avifauna and two lakes. Formal and informal interviews were conducted with local people to prepare a list of threats to these two lakes and dependant avifauna. During the fieldwork, anthropogenic activities, viz., hunting, illegal fishing, and woodcutting (if any) were monitored and quantified (if possible) following Joshua & Johnsingh (1994). Only fishing and illegal hunting of birds were identified as threats to the wetlands. People who are directly or indirectly involved in the above said two

threats were approached for additional quantitative (if possible) and qualitative information. Fish markets were periodically visited for collecting information on illegal bird trade. Informal interviews were conducted with those traders for further details. Wherever permission was granted, quantification were made on the number of individuals and species of birds involved in the trade. The methodology was based on the principles and procedures of the Australian/New Zealand Standard for Risk Management ISO 31000:2009 (Standards Australia 2009; AZ/NZS 4360:1999) and HB 203: 2000 Environmental Risk Management – Principles and Process (Standards Australia 2009).

RESULTS AND DISCUSSION

In total, 118 species of birds belonging to 87 genera, 48 families, & 18 orders in Vaduvur Lake and 87 species of birds belonging to 71 genera, 48 families, & 16 orders in Sitheri Lake were recorded and the details are given elsewhere (Gokula & Raj 2011, 2015). The numerical differences may be attributed to the combination of any of the factors, viz., size and location of wetlands, proximity to other wetlands, water level, foraging opportunity, food availability, availability of nest-sites, inter and intra specific competition, human pressure, site fidelity of bird species, and site history. Besides regular common migrants, both the lakes harbour Near Threatened bird species, viz.: Darter *Anhinga melanogaster*, Painted Stork *Mycteria leucocephala*, and Oriental White Ibis *Threskiornis melanocephalus*. Among the bird species recorded, the most numerous were Garganey *Anas querquedula* and Northern Shoveller *Anas clypeata*, however, individuals of a majority of the species were poor in numbers. Little Grebe *Tachybaptus ruficollis*, Little Cormorant *Phalacrocorax niger*, Little Egret *Egretta garzetta*, Cattle Egret *Bubulcus ibis*, Indian Pond Heron *Ardeola grayii*, and Pheasant-tailed Jacana *Hydrophasianus chirurgus* nest in Sitheri; while, Little Grebe, Asian Openbill *Aenastomus oscitans*, Cattle Egret, Black-crowned Night Heron *Nycticorax nycticorax*, Grey Heron *Ardea cinerea*, Little Egret, Little Cormorant *Microcarbo niger*, Pheasant-tailed Jacana nest in Vaduvur Lake. In both the wetlands, birds breed largely during and after the north-east monsoon as reported by Subramanya (2005) for majority of the heronries of Tamil Nadu.

A total of 28 zooplankton species were recorded in both the lakes comprising 14 species of rotifers, six species of cladocerans, five species of copepods, two

species of ostracods, and one species of protozoa (Table 1). A greater number of species of zooplanktons was recorded during November to June followed by May to July (Table 2). The diversity of planktons was more during the monsoon rather than in the summer in both the lakes, which is in contrast to other such studies carried out in Tamil Nadu. Manikam et al. (2014, 2017) reported high diversity of planktons in summer and attributed it to favourable temperature and availability of food in the form of bacteria, phytoplankton, and suspended detritus during the season. Hence, a detailed long-term study is needed to confirm it further.

The Sitheri Lake is a very good fishery resource. A total of 15 species of fishes were identified from the sellers who catch fishes from the Sitheri Lake and the Vennaru River, a prime source for the two lakes (Table 3). Thiyagesan & Nagarajan (1995) reported the negative impacts of the over exploitation of aquaculture and fisheries resources in inland and coastal wetlands of the eastern coast of India on their bird life.

With respect to water quality the changes in water chemistry has been considered to exert influence in the distribution of many aquatic plant species (Catling et al. 1986; Shay & Shay 1986; Chee & Vitt 1989; Engelhardt & Ritchie 2001; Lentz-Cipollini & Dunson 2006). As waterbirds and wetland dependant birds depend directly or indirectly on aquatic fauna and flora which in turn depend on water chemistry, birds' distribution is expected to change with changes in water chemistry. As anticipated the physico-chemical parameters of water varied according to the seasonal fluctuations (Table 4). The limnological variables showed two distinct clusters: July to December with high rainfall and January to April with less/no rainfall (Figure 1). The rainfall (both from north-west and south-east monsoons between June to December) and lack of rainfall (between January to May) showed greater influences in the values of water quality parameters in both the lakes.

Three major villages are situated around these two lakes: Vaduvur Vadpathi (2,289 individuals belonging to 575 families of which 1,154 are males while 1,135 are females), Vaduvur Melpathi (3,010 individuals belonging to 817 families of which 1,478 are males while 1,532 are females), and Vaduvur Thenpathi (3,412 individuals belonging to 896 families of which 1,673 are males while 1,739 are females). The socio-economic status of the people of these villages revealed that both the lakes play a vital role in the livelihood of many people. Agriculture is the main occupation of the people of these villages and they greatly depend on the lake for irrigation and other domestic purposes. Paddy is the main crop cultivated

Table 1. Species of planktons recorded in Vaduvur and Sitheri lakes during the study period.

	Vaduvur Lake	Sitheri Lake
Group	Species	Species
Protozoa	<i>Vorticella</i> sp.	<i>Vorticella</i> sp.
Rotifera	<i>Brachionus calyciflorus</i>	<i>Brachionus calyciflorus</i>
Rotifera	<i>B. quadridentatus</i>	<i>B. quadridentatus</i>
Rotifera	<i>B. forticula</i>	<i>B. forticula</i>
Rotifera	<i>Euchlanis</i> sp.	
Rotifera	<i>Horella brehmi</i>	<i>Horella brehmi</i>
Rotifera	<i>Lepadella</i> sp.	
Rotifera	<i>Mytilina</i> sp.	<i>Mytilina</i> sp.
Rotifera	<i>Notholca</i> sp.	<i>Notholca</i> sp.
Rotifera	<i>Trichotria</i> sp.	<i>Trichotria</i> sp.
Rotifera	<i>Trichocera rattus</i>	<i>Trichocera rattus</i>
Rotifera	<i>Testudinella patina</i>	<i>Testudinella patina</i>
Rotifera	<i>Asplanchna brightwelli</i>	
Rotifera	<i>Lecane lunaris</i>	<i>Lecane lunaris</i>
Rotifera	<i>L. bulla</i>	<i>L. bulla</i>
Cladocera	<i>Alonella</i> sp.	<i>Alonella</i> sp.
Cladocera	<i>Bosmina longirostris</i>	<i>Bosmina longirostris</i>
Cladocera	<i>Daphnia carinata</i>	<i>Daphnia carinata</i>
Cladocera	<i>Diaphanosoma</i> sp.	
Cladocera	<i>Diaphanosoma</i> sp.	<i>Diaphanosoma</i> sp.
Cladocera	<i>Moina daphnia</i>	<i>Moina daphnia</i>
Copepoda	<i>Calonoid copepod</i>	<i>Calonoid copepod</i>
Copepoda	<i>Heleodiptomus viduus</i>	<i>Heleodiptomus viduus</i>
Copepoda	<i>Mesocyclops hyalinus</i>	<i>Mesocyclops hyalinus</i>
Copepoda	<i>Thermocyclops</i> sp.	<i>Thermocyclops</i> sp.
Copepoda	<i>T. crassus</i>	<i>T. crassus</i>
Ostracoda	<i>Cypris</i> sp.	<i>Cypris</i> sp.
Ostracoda	<i>Stenocypris malcolmsoni</i>	<i>Stenocypris malcolmsoni</i>

around these two wetlands and it is grown three times in a year. The first crop is known as ‘Kuruvai’ (the short-term crop) with a duration of three and a half to four months from June–July to October–November. The second crop called the ‘Thaladi’ has a duration of five to six months from October–November to February–March. The third is the ‘Samba’ (the long term) crop and has a duration of almost six months from August to January. During the cultivation periods, in particular, between the months of October and January, the agriculture fields are water-logged with aquatic invertebrates. Thus, the agriculture fields surrounding these two wetlands and in nearby villages not only act as a unique foraging ground but also provide various foraging opportunities

Table 2. Species richness and diversity of planktons recorded during various months of the study area.

	Vaduvur	Sitheri	Vaduvur	Sitheri
months	Taxa_S	Taxa_S	Shannon_H	Shannon_H
Sep-10	19	16	2.795	2.642
Oct-10	23	19	2.963	2.784
Nov-10	28	24	3.132	3.009
Dec-10	28	24	3.127	3.007
Jan-11	21	17	2.841	2.636
Feb-11	17	16	2.614	2.566
Mar-11	13	12	2.336	2.272
Apr-11	8	8	1.895	1.895
May-11	9	9	2.062	2.062
Jun-11	8	8	1.934	1.934
Jul-11	8	8	1.992	1.992
Aug-11	11	11	2.322	2.322
Sep-11	18	16	2.768	2.655
Oct-11	23	19	2.9	2.729
Nov-11	28	24	3.09	2.961
Dec-11	27	24	3.018	2.934
Jan-12	20	17	2.73	2.596
Feb-12	17	15	2.566	2.487

to the waterbirds and wetland dependant birds during their stay at in these two lakes. The water-logging of agricultural fields often attracts waterbirds, especially when they are close to other wetlands (Nagarajan & Thiyagesan 1996; Kahlert et al. 2007). Moreover, paddy fields support the highest bird diversity when they are water logged with abundant aquatic insects, worms, snails, and tadpoles (Deep 2008). Moreover, when they are flooded in winter they often provide a good feeding habitat for large numbers of birds (Chan et al. 2007). Croplands that are flooded to a shallow depth act as temporary foraging grounds for waders. Some species appear to need very large rice-fields while others prefer smaller ones and edge habitats (Burton et al. 2002). Hence, lakes with sufficient water and surrounded by agriculture fields with agricultural activities are more crucial to sustain the population of waterbirds and wetland dependent birds that traditionally inhabit any wetland. Due to unusual drought and fall in rainfall due to climate change, lack of interest in agricultural practices, and conversion of agricultural land into human habitation, agricultural activities in agriculture fields have drastically been declining not only around these lakes but also in the entire district. Recently, the Federation of Tamil Nadu Agricultural Associations reported that

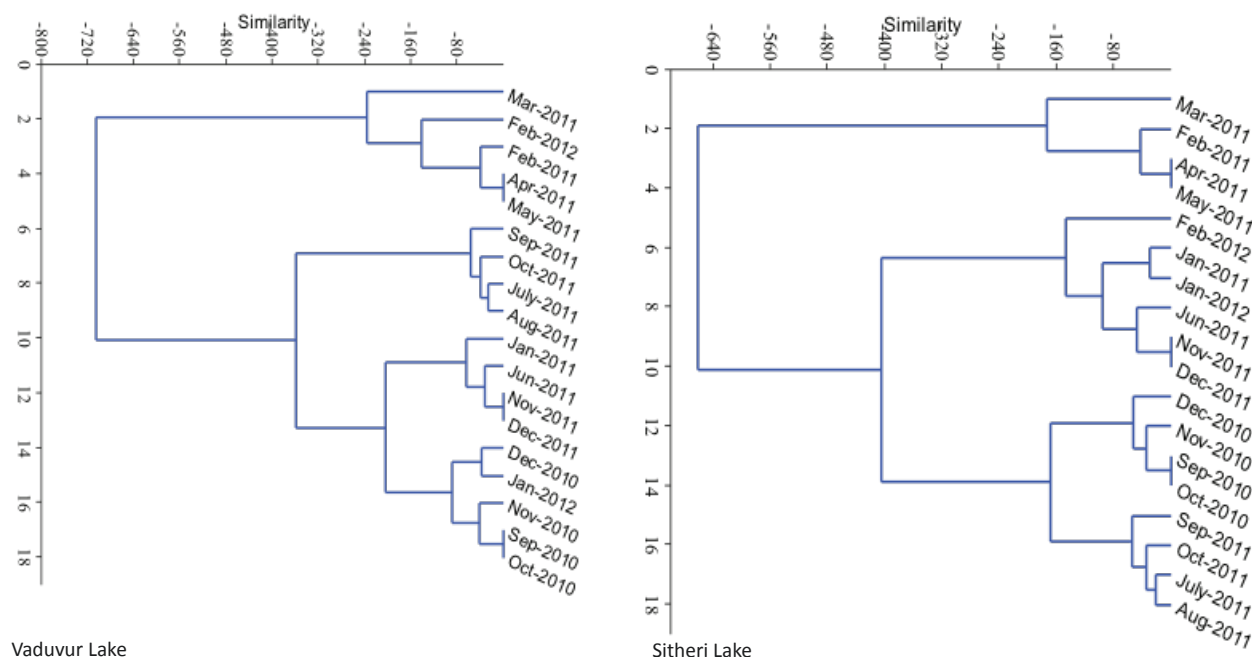


Figure 1. Dendrogram showing seasonal clusters for water quality parameters recorded in Vaduvur and Sitheri lakes.

from 2001 to 2011, nearly 8,67,582 farmers have stopped agriculture due to various reasons, including huge losses. Interestingly, there was an increase in the number of agricultural labourers during the period, as the farmers sell their land for real estate and prefer to work on daily wages. They attributed the reason for the plight of the farmers to wrong import policies of the government, unremunerative prices for farmers' produce, industrialization and urbanization, coupled with the failure to divert the rain and other waters going to sea to the farmers' fields, by linking rivers.

As majority of the lakes in Tamil Nadu go dry in summer, it is presumed that waterbirds move from places lacking adequate water to places with adequate water ignoring site fidelity. Although, both these lakes go 90% dry in the month of May, they still attract a significant number of waterbirds from other parts. The Spot-billed Pelican *Pelecanus philippensis* being a late arrival (largely during late November) particularly in the southern districts of Tamil Nadu performs its breeding activity until the month of April (February to April being crucial months to raise the young ones) while all other species complete their breeding activities largely by January. As majority of the lakes go dry from the month of February onwards in Tamil Nadu, the movement of pelicans from their traditional sites to new lakes with sufficient water is common (Gokula 2011). The Vaduvur Lake is one such wetland that supports pelicans during the above said crucial months. Hence, in order

to support Spot-billed Pelican, a near threatened bird, proper steps have to be taken to sustain the water level during April and May.

Various kinds of threats such as excessive fishing, poaching of birds, cattle grazing, fuel-wood collection, siltation, weed invasion, and pollution were identified particularly for the lakes during the study period. Earlier Wolstencroft et al. (1989) reported that these were the major threats in Asia in various wetlands. Thiyagesan & Nagarajan (1995) listed similar threats to the coastal wetlands of Tamil Nadu, southern India. Divakaran (2000) also noticed a majority of these threats in different islands of the Gulf of Mannar, southern India, causing great havoc for bird life there. The forest department of Tamil Nadu has protected the Vaduvur Lake under the bird sanctuary category thus the lake is comparatively free from above said illegal activities such as fishing and poaching of birds. All such activities have been prevailing in the Sitheri Lake.

Waterbird harvest is widespread, long-standing, and an important activity for local communities around the world. In many countries, the harvest takes place as a primary food source, but sport or recreational hunting is also popular; however, waterbird harvest has not been a popular activity in India since time immemorial and it may either be due to the availability of food resources in plenty or due to the culture. Sport or recreational hunting of waterbirds, however, was a part of the recreational activities of kings/maharajas

Table 3. List fish species recorded in the Sitheri Lake, Tamil Nadu, India.

	Fish	Vernacular name	National status, Global status (in parenthesis)
	Cyprinidae		
1	<i>Barilius bendelisis</i>	Vannathikendai	LRnt/N (LC)
2	<i>Puntius sophore</i>	Kullakendai, Mochakendai	LRnt/N (LC)
3	<i>Ileobrama latipinna</i>	Karupan sel, Selukendai	LRnt/N (LC)
4	<i>Cirrhinus reba</i>	reba	VU (LC)
5	<i>Puntius conchionius</i>	Vallikendia	VU (LC)
6	<i>Rasbora daniconius</i>	Bhavanikendia	NE (LC)
	Cobitidae		
7	<i>Lepidocephalus thermalis</i>	Ayirai	NE (LC)
	Bagridae		
8	<i>Mystus cavasius</i>	Naikeluthi	LRnt/N (LC)
9	<i>Mystus vittatus</i>	Vazhppu	VU (LC)
10	<i>Mystus bleekeri</i>	Keluthi	VU (LC)
	Cichlidae		
11	<i>Etroplus suratensis</i>	Sella kasu, Puradi, Salladai meen	NE (LC)
12	<i>Etroplus maculatus</i>	Sethakendai, Bommi	NE (LC)
	Gobiidae		
13	<i>Awaous gutum</i>	Ulluvai, Kalulluvai	VU (LC)
	Clariidae		
14	<i>Clarias batrachus</i>	Thalmeen, Thal Kendia	VU (LC)
	Mastacembelidae		
15	<i>Mastacembelus armatus</i>	Aarra	VU (LC)

EN—Endangered | VU—Vulnerable | LRnt—Lower Risk near threatened | NE—Not Evaluated | LC—Least concern (IUCN status).
Status nationally as per CAMP assessment (Molur & Walker 1998).

and it continued until the British colonial period. Later, the Indian Wildlife (Protection) Act 1972 prevented this activity to be practiced anywhere in India. Still a nomadic community called 'Narikurava' in Tamil Nadu hunts birds for food as well as commercial purposes. In the interview, some admitted they supply birds dead or alive, specific or common to customers depending on their needs. Some suggested they should be given controlled hunting permits enabling them to make a sustainable living while protecting wildlife. Due to their small population size and the insignificant demand for wild birds among the public comparing others (fish, mutton, domestic chicken) in the market, however, it is generally assumed that hunting is well below the sustainable utilization, a level commonly regarded as a

cornerstone in the conservation of nature.

In the present study, frequent visits were made to fish markets of Vaduvur and Mannargudi (a town situated 12km away from the study area) to assess the wild bird trade from 2009 to 2015 (Table 5 & Image 1). In total 68 visits were made of which wild bird trade was found on 26 occasions. On all the occasions, (except three), no same person was found trading in wild birds. Two (belonging to Narikurava) persons involved in wild bird trade were sighted on three occasions. When approached for informal interviews we found many illegal wild bird traders made good their escape, while a very few stayed and engaged in conversation. People belonging to Narikurava though afraid to be photographed with birds, revealed facts like where and how they caught the birds. In total, 974 birds belonging to 21 species, 11 families and eight orders were recorded in the wild bird trade. It even included the Spot-billed Pelican, a Near Threatened bird. Among the orders, Ciconiiformes dominated with seven species of birds followed by Gruiformes with five species of birds. Among the bird species, White-breasted Waterhen (89), Little Egret (87), Common Coot (76), and Water Cock (73) were sold in more numbers. Although wild bird trade was found in all the months of the year, it was more frequent during November to January. All the species of birds were largely bought for the purpose of meat. On one occasion, a crow was found sold to a customer and the enquiry with the trader revealed that it was for the purpose of black magic. He also revealed that they do supply crow on request occasionally for the above said purpose. The traders also revealed that all the birds were caught from the paddy fields surrounding the wetlands during early morning and late evening hours using indigenous traps (such as clap trap, mesh nets, and nooses). Although the forest officials frequently intercept, and arrest those involved in the hunting of wild birds in and around Vaduvur area, patrolling larger areas surrounding these two wetlands is not possible and feasible with the existing work force in the forest department. Often, arrested people are booked under the provisions of the Indian Wildlife (Protection) Act 1972. In the early 1970s and 1980s, over 150 families of different communities from Nagapattinam, Thanjavur, and Thiruvavur districts were involved in trapping migratory shorebirds and ducks that used to frequent the coastal wetlands, in several lakhs, during the migratory season (October to April). Now, many bird trappers have shifted to fishing as they were looked down upon for carrying on this illegal profession. Cattle egrets and pond herons are often bought by roadside restaurants and wine shops to serve and sell as



Table 4. Descriptive statistics of water quality parameters recorded during various months of the study area.

Water Quality Parameters	Descriptive Statistics: Vaduvur Lake					Descriptive Statistics: Sitheri Lake						
	Min	Max	Mean	SE	V	SD	Min	Max	Mean	SE	V	SD
Turbidity (NTU)	8.00	32.00	18.56	1.72	53.08	7.29	8.00	30.00	17.39	1.61	46.60	6.83
Total Dissolved Solids	270.00	595.00	394.89	20.80	7785.75	88.24	265.00	560.00	385.67	20.37	7472.12	86.44
Electrical Conductivity MicS/cm	415.00	912.00	605.56	31.88	18292.73	135.25	415.00	897.00	595.67	29.25	15404.40	124.11
pH	6.74	8.00	7.38	0.06	0.08	0.28	6.40	7.90	7.33	0.08	0.10	0.32
Alkalinity pH as CaCO3 (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alkalinity Total as CaCO3(mg/l)	105.00	222.00	146.17	6.87	848.97	29.14	108.00	223.00	143.89	6.89	855.28	29.25
Total Hardness as CaCO3(mg/l)	81.00	238.00	126.06	8.94	1437.59	37.92	78.00	237.00	123.22	8.71	1366.89	36.97
Calcium as Ca(mg/l)	24.00	61.00	33.33	2.11	79.88	8.94	24.00	56.00	31.44	1.81	58.97	7.68
Magnesium as Mg (mg/l)	4.00	20.00	10.56	0.93	15.44	3.93	5.00	19.00	10.00	0.82	12.00	3.46
Iron Total as Fe (mg/l)	0.00	2.50	0.72	0.16	0.44	0.66	0.00	2.20	0.67	0.14	0.36	0.60
Manganese as Mn (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Free Ammonia as NH3 (mg/l)	0.00	1.13	0.48	0.08	0.11	0.33	0.00	1.10	0.43	0.07	0.08	0.28
Nitrite as NO2 (mg/l)	0.00	0.45	0.14	0.04	0.03	0.16	0.00	0.45	0.13	0.04	0.02	0.15
Nitrate as NO3 (mg/l)	0.00	5.00	0.67	0.38	2.59	1.61	0.00	4.00	0.56	0.30	1.67	1.29
Chloride as Cl (mg/l)	48.00	127.00	91.06	5.71	585.94	24.21	43.00	120.00	88.83	5.17	480.50	21.92
Fluoride as F (mg/l)	0.00	0.40	0.19	0.02	0.01	0.08	0.00	0.40	0.14	0.02	0.01	0.08
Sulphate as SO4 (mg/l)	2.00	36.00	23.44	2.67	128.26	11.33	6.00	34.00	23.00	2.30	94.94	9.74
Phosphate as PO4 (mg/l)	0.08	1.64	0.60	0.11	0.20	0.45	0.07	1.54	0.59	0.10	0.19	0.43
Tidy's as O	0.40	1.84	0.94	0.11	0.20	0.45	0.40	1.70	0.93	0.10	0.19	0.43

Table 5. Various species of birds recorded in the illegal trade.

	Common name	Aviculture/pet use	Meat	Sport	Used in trade as/for			Availability rating	Frequency of occurrence	Number of visits	Total number birds found
					Medicinal use	Black magic	Available months				
1	Little Grebe <i>Tachybaptus ruficollis</i>	*	*				Nov–Feb	Frequent	18	26	67
2	Spot-billed Pelican <i>Pelecanus philippensis</i>		*				Nov–Jan	Rare	1	26	1
3	Little Cormorant <i>Phalacrocorax niger</i>	*	*				Nov–Jan	Less Frequent	4	26	12
4	Little Egret <i>Egretta garzetta</i>		*				Nov–Jan	Frequent	22	26	87
5	Grey Heron <i>Ardea cinerea</i>		*				Nov–Jan	Less frequent	4	26	5
6	Large Egret <i>Casmerodius albus</i>		*				Nov–Jan	Less frequent	5	26	8
7	Cattle Egret <i>Bubulcus ibis</i>		*				All the months	Very frequent	26	26	67
8	Indian Pond-Heron <i>Ardeola grayii</i>		*				All the months	Very frequent	26	26	56
9	Black-crowned Night Heron <i>Nycticorax nycticorax</i>		*				All the months	Very frequent	26	26	69
10	Asian Openbill-Stork <i>Anastomus oscitans</i>		*				Nov–Jan	Rare	2	26	2
11	White-breasted Waterhen <i>Amaurornis phoenicurus</i>		*				Nov–Jan	Frequent	16	26	89
12	Water Cock <i>Gallicrex cinerea</i>		*				Nov–Jan	Frequent	14	26	73
13	Purple Moorhen <i>Porphyrio porphyrio</i>		*				Nov–Jan	Frequent	15	26	67
14	Common Moorhen <i>Gallinula chloropus</i>		*				Nov–Jan	Frequent	16	26	68
15	Common Coot <i>Fulica atra</i>		*				Nov–Jan	Frequent	18	26	76
16	Pheasant-tailed Jacana <i>Hydrophasianus chirurgus</i>		*				Nov–Jan	Frequent	14	26	56
17	Gull-billed Tern <i>Gelochelidon nilotica</i>		*				Nov–Jan	Frequent	14	26	45
18	Common Tern <i>Sterna hirundo</i>		*				Nov–Jan	Frequent	14	26	46
19	Little Brown Dove <i>Streptopelia senegalensis</i>	*	*	*	*		All the months	Frequent	19	26	45
20	Asian Koel <i>Eudynamis scolopacea</i>		*				All the months	Frequent	15	26	34
21	House Crow <i>Corvus splendens</i>					*		Based on order	1	26	1
	Total										974

chicken. Regardless of months, Cattle Egrets and Pond Herons are trapped every day for this purpose. Hence, proper awareness programmes to other communities and alternate sources of livelihood for Narikurava are essential to wean them away from their traditional but destructive profession. All these birds involved in the illegal trade play a very significant role in the agro-ecosystem as they feed on various insect species and thereby control the pest population.

Anand (1999) reported desiltation was not only useful in terms of improvement of irrigation and fisheries potential, but also to the increase of wildlife diversity and use. During the rainy season the eroded soil from their catchments, gets dumped into these lakes, which in turn reduces the water holding capacity of the lake.

Siltation, a serious problem, results in low water depth thereby facilitating the invasion of weed patches. Vallenweider (1968) reported that water bodies with less water depths would be more affected by eutrophication problems. The *Ipomoea aquatic* (weed) invasion was very extensive in these lakes. Anand (1999) observed that the *Ipomoea* invasion changed the water quality and reduced the primary production and nutrient cycle. As a result the weeds should be cleared either manually or by application of weedicide. Such a step will increase the irrigation potential of the lake and improve the condition for the wildlife, especially waterbirds.

The lake area is used by surrounding villagers for grazing their domestic livestock especially during summer. This intensive cattle grazing could result in



Image 1. Various species of waterbirds found in the local market. © V. Gokula

breaking the nutrient cycle of the lake. Further, the trampling cattle might harden the soil surface and reduce the aeration of the lake. Earlier Meganathan (2002) also expressed similar apprehensions for the freshwater lakes of Tamil Nadu. The local people must be educated in this aspect. The surrounding village people are using the lake for washing their livestock. The livestock are allowed to freely drink and bathe in this lake. This cattle washing pollutes the water and acts as a deterrent for waterbirds. Hence, cattle washing should be prohibited in the lake.

Another threat is wood collection for fuel by the local villagers from the lakes and its immediate surroundings. *Acacia*, *Zizypus*, and *Prosopis* were the plants cut for fuel wood. They are the roosting and nesting places for birds like openbill storks and night herons. Dickson et al. (1995) stated that protection of vegetation along the sides of the wetlands is important to retain water quality and accommodate wildlife including breeding birds. Hence, this vegetation, especially at the northern region of the Vaduvor Lake and the entire Sitheri Lake

must be given full attention and protection to prevent human disturbances to nesting activities through wood removal. In 2015, *Prosopis chilensis*—then roosting and nesting sites for several species of birds, were completely removed by the people, which in turn affected the avifauna

Although many of the heronries in Tamil Nadu, despite the stench emanating from the nesting activities of the birds, are zealously protected by villagers (e.g., Kanjirankulam, Udayamarthandapuram, Vettangudi, Vedanthangal, and Koonthakulam), villagers in and around the Vaduvor Lake lack such interest towards protection of birds. Usage of crackers and musical instruments by villagers are very common during festival times in Vaduvor Lake area. A prominent Kothandaramar Temple and a community temple are situated around the Vaduvor Lake. Although, festivals of Kothandaramar Temple largely come between June and August, disturbance to birds by the devotees are considerably less as birds are less during these months. Frequent family functions held at the community temple

situated at the edge of the lake, however, cause a major threat to the breeding birds particularly during the migration and breeding seasons. It has been suggested that the greatest and most depressing problem in conservation is not habitat loss or overexploitation but the human indifference to such problems (Balmford 1999). Overcoming such indifference is likely to depend on providing both the opportunities to appreciate areas and species, and education to highlight the ecological, aesthetic, cultural, spiritual, recreational, and economic importance. Education is one of the major techniques available to conservationists through which change in behaviour or compliance with new legislation can be achieved. Moreover, maintaining protected areas is easier if there is public support, which often leads to political and financial support and greater adherence to rules and regulations (Shepard & McNeely 1998). Hence, a proper public awareness program has to be initiated about the conservation of birds and lakes among the public.

As the lake is situated on one side of the Trichy-Mannargudi main road, vehicular sound is a great threat to the breeding birds. High decibel noise often disturbs the breeding activities of the birds, and frail chicks. Hence, usage of horns by vehicles should be banned from start to end of the lake at least during the peak breeding season of birds.

Pesticides, manures, and fertilizers are being increasingly used to ensure greater production of food in the nearby paddy fields around the lake. Some of these chemicals find their way into soils, water and other parts of the environment as a result of direct application or by indirect means. Hence, it is also necessary to monitor the water for possible pesticide contaminants since the lake is also the main source of water supply for agricultural consumption. In addition to awareness, volunteers should be trained to monitor the breeding population of birds and other threats to birds and wetlands.

CONCLUSION

In general, wetland management for waterbirds of these two lakes should focus on providing suitable nesting habitats and available food resources for dependant avifauna. Management of invertebrates, amphibians, and fishes in these two lakes is one technique that can be used to provide foraging opportunities for waterbirds. Most species often rely much on nearby aquaculture fields thus a straightforward 'farm crisis' may badly affect the avifauna of these two lakes. Hence,

agricultural activities around the two lakes should be encouraged. The water level and water quality of the lake should be properly maintained to cater to the needs of both irrigation and wildlife. Periodic desilting should be initiated with proper care and planning to provide a variety of depth levels. Cattle grazing and cattle washing in the lake should be totally prohibited. The weed *Ipomoea* should be removed totally. Poaching of waterbirds should be stopped by effective steps, such as better vigil and weaning of nomadic life from wildlife hunting by educating them and providing alternative livelihood. An awareness campaign must be conducted so that the local public realizes the significance of the lake in terms of their wildlife values and need to utilize them judiciously and sustainably for mutual benefit. There is an excellent potential for developing these lakes as very good tourist attractions since these lakes are situated near other famous tourist areas such as Point Calimere Wildlife Sanctuary, Karaivetti Lake, and other cultural heritage sites (such as Tharangambadi, Thanjavur, and Velankanni). Ecotourism would increase the income of the local people. Hence, an integrated approach and increased co-operation would result in the rational use of this freshwater resource leading to improved standards of living around this lake.

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ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

May 2021 | Vol. 13 | No. 6 | Pages: 18411–18678

Date of Publication: 26 May 2021 (Online & Print)

DOI: 10.11609/jott.2021.13.6.18411-18678

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