

Diversity and Abundance of Waterbird Communities in the Jaffna and Kilinochchi Districts: Where do we have to go from here?

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Abstract— Wetlands and waterbirds are inseparable elements. The preliminary study was conducted in eight sites, namely Mandaitivu, Mankumban, Kayts, Kavutharimunai, Pallai, Thadduvankoddy, Kapputhu and Nagarkovil in the Jaffna and Kilinochchi Districts of the northern region of Sri Lanka to determine the diversity and abundance of waterbirds. In each site, three counting blocks in length of 500 m with open width was selected for bird counting. Each block was separated at least by length of 500 m to avoid double counting. The counting of birds was done once a month from December, 2016 to May, 2017. Eighteen waterbird families were recorded. Phoenicopteridae, Anatidae and Scolopacidae were the dominant families. The presence of critically endangered species such as Spot-billed Duck (*Anas poecilorhyncha*) suggests the importance of conservation of these habitats. Two-way ANOVA indicated that waterbird families were significantly different among eight sites. The highest species richness was found in Kapputhu (57) and the lowest in Kavutharimunai (26). This study revealed that Mandaitivu, Mankumban, Kayts, Thadduvankoddy and Kapputhu are the excellent places to observe both migrant ducks and flamingos. Likewise Kavutharimunai is good for migrant shorebirds and seabirds by ferry while Nagarkovil and Kapputhu are suitable for viewing both feeding and roosting of waterbirds. On the whole this paper reveals that the northern region of Sri Lanka possess not only the potential of avitourism but also will become the hotspot of future bird researches, especially on waterbirds.

Keywords— Jaffna, Kilinochchi, waterbird communities, avitourism, hotspot

I. INTRODUCTION

Wetlands and waterbirds are inseparable elements (Grimmett and Inskipp, 2007). According to Ramsar convention, waterbirds have been defined as species of birds that are ecologically dependent upon wetlands (Wetlands International, 2010). Waterbirds inhabit or temporarily use wetlands because of the diversity of microhabitats for feeding, nesting, resting and roosting (Hattori and Mae, 2001). At present, 454 species of birds including 238 breeding resident and 144 regular migrants and 72 vagrants were recorded in Sri Lanka. 23 families of waterbirds (164 species) have been identified in Sri Lanka (Wijesundara *et al.*, 2017).

Wetlands in Sri Lanka are the final destination each year for tens of thousands of migrant birds flying southward along the Central-Asian ‘flyway’ (Warakagoda and Sirivardana, 2006). Migratory birds that use the Central Asian flyway, use five main entry and exit points to enter Sri Lanka, of which three are located in the Northern Province of Sri Lanka namely, the Jaffna Peninsula, the Adam’s Bridge/Mannar region and the Devil’s Point (Kotagama and Ratnavira, 2010).

Although bird-related studies have been undertaken in the northern region of Sri Lanka (Kandasamy *et al.*, 2016; Kandasamy *et al.*, 2017a; Kandasamy *et al.*, 2017b; Kandasamy *et al.*, 2017c; Kandasamy *et al.*, 2017d; Kandasamy *et al.*, 2018; Rajkumar and Wijesundara, 2014; Wijesundara *et al.*, 2015;

Wijesundara *et al.*, 2017; Rajkumar and Wijesundara, 2015a; Rajkumar and Wijesundara, 2015b; Wijesundara *et al.*, 2015; Rajkumar and Wijesundara, 2017; Wijesundara and Rajkumar, 2016; Wijesundara *et al.*, 2016; Wijesundara and Rajkumar, 2017; Wijesundara *et al.*, 2018) waterbird communities have not been studied in many areas in the northern region of Sri Lanka as the area was inaccessible for three decades due to the armed conflict. Hence the present study was conducted to document the diversity and abundance of waterbirds in these districts and to find out the possibilities of ecotourism in selected areas in this region.

II. MATERIALS AND METHODS

The present study was carried out in eight locations (Figure 1) namely, Mandaitivu in the Island South Divisional secretariat division (DSD (9° 37' 28" N, 79° 59' 52" E), Mankumban in the Island South DSD (9° 38' 31" N, 79° 56' 28" E), Kayts in the Island North DSD (9° 40' 17" N, 79° 55' 30" E), Kavutharimunai in the Pooneryn DSD (9° 34' 42" N, 80° 06' 24" E), Pallai wind farm in the Pachchilappalli DSD (9° 35' 59" N, 80° 18' 60" E), Thadduvankoddy in the Kandavalai DSD (9° 30' 0" N, 80° 25' 0" E), Kapputhu in the Vadamaradchi South West DSD (9° 44' 09" N, 80° 10' 48" E), and Nagarkovil in the Vadamaradchi East DSD (9° 36' 00" N, 80° 17' 00" E).

A line transect was established in each study site, the entire transect belt was divided into three blocks in length of 500 m with open width. Each block was separated at least by 500 m

to avoid double counting as most were open areas. All the waterbirds seen on either side of the transect up to 500 m were counted during dawn and noon or dusk on alternate months to capture temporal variations by walking along the transect line of each block. Waterbird counting was done by ferry in Kavutharimunai with the help of the Fisheries' Society, Maniththalai, Kavutharimunai. Waterbird species were identified using a standard field guide (Harrison, 2011). Counting blocks were visited once a month from December, 2016 to May, 2017. Then a list of status of waterbirds was prepared following Harrison, 2011 and Wijesundara *et al.*, 2017.



Figure 1: The eight study sites denoted with numbers. 1: Mandaitiv, 2: Mankumban, 3: Kayts, 4: Kavutharimunai, 5: Pallai, 6: Thadduvankoddy, 7: Kapputhu and 8: Nagarkovil.

III. DATA ANALYSIS

Diversity indices such as Shannon Diversity Index (H), Pielou Index (J), Margalef's Richness Index and Berger-Parker Dominance Index were used to compare the diversity and abundance of waterbirds in eight study sites (Magurran, 2004). The percentage of occurrence was compared for families of waterbirds recorded. Abundance of waterbird families were compared by creating the dendrogram with the help of Minitab 17 to find out similarities among the study sites. Two-way ANOVA was also calculated by using SPSS 14 to find out the variations in the diversity and abundance of birds with regards to the study sites.

IV. RESULTS AND DISCUSSION

Current study recorded a total of 65 waterbird species belonging to 18 families (Figure 2). Of these, 27 species were migrants, 1 was mainly migrant with resident population, another 5 were mainly residents with migrant population, 2 were mainly residents with doubtful migrant status, and rest of the 30 were residents. Among them, 12 waterbird species were recorded in all eight sites (Table 3). The highest species

richness was found in Kapputhu (57) and the lowest in Kavutharimunai (26). 116 species of waterbirds belonging to 23 families were recorded in the Jaffna, Kilinochchi, Mullaitivu and in Mannar in the northern region of Sri Lanka in a previous study (Wijesundara *et al.*, 2017).

A. Species richness, diversity and evenness

Among the eight locations, the highest measure of species richness was found in Kapputhu (57) (Table 1). However, the Shannon-Wiener diversity index was comparatively lower (2.92) in Kapputhu compared to Mandaitivu (3.22) due to the domination of two families Phoenicopteridae (percentage of occurrence 26.46%) and Anatidae (20.96%) in Kapputhu. Berger Parker dominance index was higher in Kapputhu (0.26) compared to Mandaitivu (0.16).

The highest Shannon diversity (3.22) and even distribution (0.84) and the lowest Berger Parker dominance (0.16) were found in the waterbird assemblages in Mandaitivu. This may be due to the presence of rich microhabitats such as mangroves, marshlands, open water pools, wet and dry mudflats that provide habitats for a range of waterbirds. As far as Mandaitivu, Mankumban and Kayts were concerned, migrant ducks (Family Anatidae), showed high abundance (38.46%, 37.03% and 38.09% respectively).

The lowest species richness and the lowest Shannon diversity and evenness were found in Kavutharimunai. The intertidal area and shallow waters of this location dominated by a large congregation of shorebirds belong to family Scolopacidae (54.79%) and seabirds of families, Sternidae (15.58%) and Laridae (11.12%) for feeding and resting which may have resulted the lowest species richness and diversity measures in Kavutharimunai.

Based on the abundance, Phoenicopteridae and Anatidae were the highly dominated waterbird families in Thadduvankoddy (Figure 02). Families Scolopacidae and Phalacrocoracidae were the dominant families in the seashore near the Pallai wind farm and Nagarkovil respectively. The deep water (>1 m) and dense mangrove vegetation of Nagarkovil provided suitable feeding and roosting for diving birds of Family Phalacrocoracidae. As such these observations showed the ecological value of these areas in the development of avitourism in the northern region of Sri Lanka.

A significant site effect (Table 2) indicated that waterbird families were different among the eight locations. Habitat heterogeneity, availability of water and food and disturbances

Table 1: Comparison of species richness, diversity, evenness, richness and dominance indices in eight study sites.

Variable	1	2	3	4	5	6	7	8
Species Richness	47	49	41	26	37	50	57	41
Shannon – Wiener (H)	3.22	2.89	2.71	1.92	2.57	2.46	2.92	2.57
Pielou Index (J)	0.84	0.74	0.73	0.58	0.71	0.62	0.72	0.68
Margalef's Species Richness index	6.50	5.56	5.13	3.42	5.48	5.64	6.30	5.36
Berger Parker Dominance Index	0.16	0.21	0.27	0.53	0.35	0.32	0.26	0.27

1: Mandaitiv, 2: Mankumban, 3: Kayts, 4: Kavutharimunai, 5: Pallai, 6: Thadduvankoddy, 7: Kapputhu and 8: Nagarkovil.

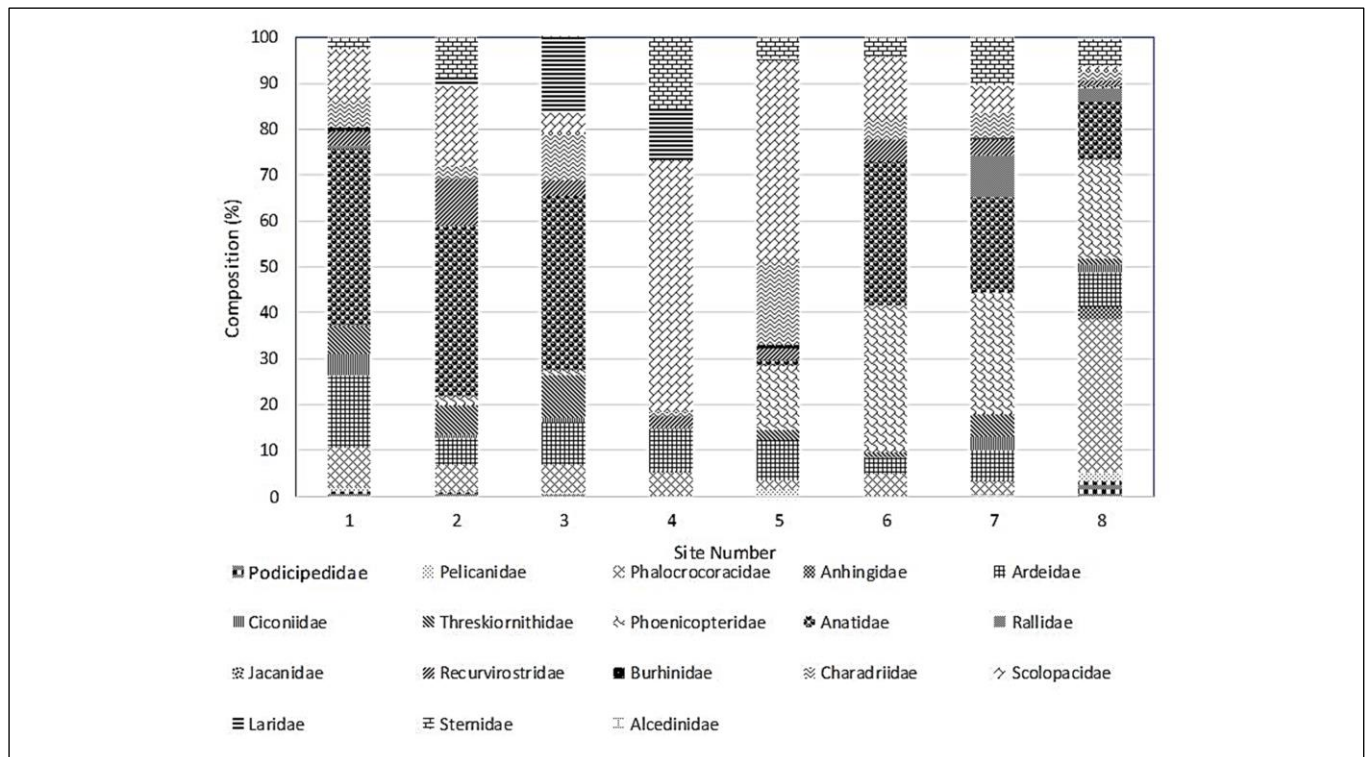


Figure 2: Composition of waterbird families (%) in eight locations; 1: Mandaitivu, 2: Mankumban, 3: Kayts, 4: Kavutharimunai, 5: Pallai, 6: Thadduvankoddy, 7: Kapputhu and 8: Nagarkovil.

may cause an effect in spatial variation in waterbird families in eight locations.

The dendrogram (Figure 3) showed three major clusters. The study sites namely Mandaitivu (1), Pallai (5), Kavutharimunai (4), Kayts (3), Nagarkovil (8) were closely related in terms of abundance of waterbirds compared to Mankumban (2), Thadduvankoddy (6) and Kapputhu (7). Kavutharimunai (Site 4) and Pallai (5) were clustered together because both were dominated by Scolopacidae. Mankumban (2), Thadduvankoddy (6) were clustered together. This may be due to the similarity in percentage in the most dominant waterbird family, Anatidae. Kapputhu (7) was separated from other sites. The highest species richness and high Shannon diversity Index next to Mandaitivu were recorded in Kapputhu. Therefore Kapputhu was found to be the most suitable area amongst all the sites to observe numerically abundant waterbird species with high species richness.

Table 2: The result of the two-way ANOVA (Tests of Between-Subject Effects) for the two variables (month and site) and their interaction. (Statistically significance levels in terms of abundance of waterbird species are given)

Source	Degrees of freedom	F	Significance (<0.05)
Corrected Model	47	1.66	0.02
Intercept	1	82.56	0
Month	5	1.11	0.36
Site	7	6.32	0
Interaction (Month × Site)	35	0.80	0.76

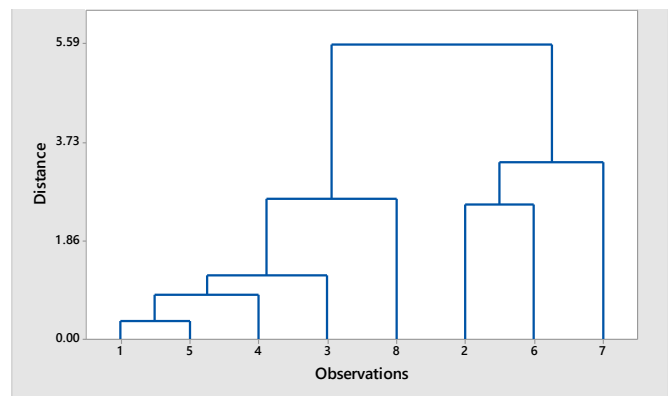


Figure 3: Dendrogram showing the relationship among the study sites based on the abundance of waterbirds (1: Mandaitivu, 2: Mankumban, 3: Kayts, 4: Kavutharimunai, 5: Pallai, 6: Thadduvankoddy, 7: Kapputhu and 8: Nagarkovil)

B. Threatened species in Sri Lanka

Spot-billed Duck (*Anas poecilorhyncha*) were recorded in Mandaitivu, Mankumban, Kayts, and Kapputhu (Figure 4). They were most abundant in Mankumban. They are considered as critically endangered species in Sri Lanka (Weerakoon, and Gunawardena, 2012). Food availability, water level and habitat structure of mangroves and saltmarsh ecosystem in the study area might provide suitable habitat for them, suggesting the importance of conservation of these habitats.



Figure 4: Spot-billed duck (*Anas poecilorhyncha*) in Kayts (Photograph by Gajavathany Kandasamy).

V. CONCLUSION

Mandaitivu, Mankumban, Kayts, Thadduvankoddy, Kapputhu and Nagarkovil were excellent habitats to observe waterbird families of Anatidae and Phoenicopteridae. Kavutharimunai is suitable to observe families Scolopacidae, Laridae and sternidae by ferry. These are potential areas for avitourism in the northern region of Sri Lanka. Moreover, Kapputhu and Nagarkovil are suitable to observe both feeding and roosting of waterbirds. The current study recognizes these sites as important habitats for protection of waterbirds and for the development of avitourism in the northern region.

VI. FUTURE DIRECTIONS AND RESEARCH PRIORITIES

Avitourism is an emerging sub-sector of the nature-based tourism industry (Steven *et al.*, 2015). Bird related studies were rare in the northern region of Sri Lanka nearly for three decades due to the armed conflict. In recent times most of the published researches focused on diversity and abundance of waterbirds in the northern region, Sri Lanka. Studies have identified considerable number of birding areas with a high avitourism potential in the northern region of Sri Lanka (Kandasamy *et al.*, 2016; Kandasamy *et al.*, 2017a; Kandasamy *et al.*, 2017b; Kandasamy *et al.*, 2017c; Kandasamy *et al.*, 2017d; Kandasamy *et al.*, 2018; Rajkumar and Wijesundara, 2014; Wijesundara *et al.*, 2015; Wijesundara *et al.*, 2017;

Rajkumar and Wijesundara, 2015a; Rajkumar and Wijesundara, 2015b; Wijesundara *et al.*, 2015; Rajkumar and Wijesundara, 2017; Wijesundara and Rajkumar, 2016; Wijesundara *et al.*, 2016; Wijesundara and Rajkumar, 2017; Wijesundara *et al.*, 2018).

In addition to identify the potential locations in the northern region of Sri Lanka, collaborations are needed between the natural and social science community to investigate the attitudes of currently visiting avitourists and the local public towards birds, bird habitats and bird conservation for the development of sustainable avitourism in the northern region of Sri Lanka. A more detailed research is needed to assess specific bird groups and locations in the northern region, Sri Lanka that can attract avitourists. This kind of research will direct to find opportunities for the development of avitourism and to find which sites may be vulnerable to the potential negative impacts of the industry.

The ecology of waterbirds is poorly known in the northern region of Sri Lanka. In the present study 18 waterbird families were recorded in the region. Each family has different foraging strategies for their survival. During migratory seasons, foraging is the most important activity for shorebirds, as it allows them to survive and ensures their safe arrival at the breeding ground (Norazlimi and Ramli, 2015). Moreover, different locations rich in different microhabitats support various waterbird families. A good knowledge of their habitat requirements is essential for the management and conservation of wetlands for the protection of waterbirds.

Foraging strategies play important roles in the habitat use of shorebirds at stopover sites and wintering grounds. Shorebirds with different foraging strategies select different habitats and use different food resources, and this may effectively avoid interspecific competition (Jing *et al.*, 2007). As such studies on abundance and availability of food in each habitat and habitat usage patterns of waterbirds are important in these areas. Therefore studies on feeding ecology and habitat use remain high priorities for the waterbird conservation of the northern region, Sri Lanka.

Table 3: Status of waterbird species in the eight study sites

	Family name	Common Name	Scientific Name	Resident / Migrant	NCS	GCS
1	Podicipedidae	Little Grebe	<i>Tachybaptus ruficollis</i>	R	LC	LC
2	Pelecanidae	Spot-billed Pelican	<i>Pelecanus philippensis</i>	R	LC	NT
3	Phalacrocoracidae	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	R	LC	LC
4	Phalacrocoracidae	Little Cormorant	<i>Phalacrocorax niger</i>	R	LC	LC
5	Anhingidae	Oriental Darter	<i>Anhinga melanogaster</i>	Uncommon R	LC	NT
6	Ardeidae	Grey Heron	<i>Ardea cinerea</i>	R	LC	LC
7	Ardeidae	Purple Heron	<i>Ardea purpurea</i>	R	LC	LC
8	Ardeidae	Great Egret	<i>Egretta alba</i>	R	LC	LC
9	Ardeidae	Intermediate Egret	<i>Ardea intermedia</i>	R	LC	LC
10	Ardeidae	Little Egret	<i>Egretta garzetta</i>	R	LC	LC
11	Ardeidae	Cattle Egret	<i>Ardea ibis</i>	R.M?	LC	LC
12	Ardeidae	Indian Pond Heron	<i>Ardeola grayii</i>	R	LC	LC
13	Ardeidae	Striated Heron	<i>Butorides striatus</i>	R	LC	LC

Table 3: (continued).

	Family name	Common Name	Scientific Name	Resident / Migrant	NCS	GCS
14	Ardeidae	Yellow Bittern	<i>Ixobrychus sinensis</i>	R,M	NT	LC
15	Ciconiidae	Painted Stork	<i>Mycteria leucocephala</i>	R	LC	NT
16	Ciconiidae	Asian Openbill	<i>Anastomus oscitans</i>	R	LC	LC
17	Threskiornithidae	Black-headed Ibis	<i>Threskiornis melanocephalus</i>	R	LC	NT
18	Threskiornithidae	Glossy Ibis	<i>Plegadis falcinellus</i>	M		LC
19	Threskiornithidae	Eurasian Spoonbill	<i>Platalea leucorodia</i>	R	LC	LC
20	Phoenicopteridae	Greater Flamingo	<i>Phoenicopus roseus</i>	M		LC
21	Anatidae	Lesser Whistling Teal	<i>Dendrocygna javanica</i>	R	LC	LC
22	Anatidae	Eurasian Wigeon	<i>Anas penelope</i>	M		LC
23	Anatidae	Northern Shoveller	<i>Anas clypeata</i>	M		LC
24	Anatidae	Northern Pintail	<i>Anas acuta</i>	M		LC
25	Anatidae	Garganey	<i>Anas querquedula</i>	M		LC
26	Anatidae	Common Teal	<i>Anas crecca</i>	M		LC
27	Anatidae	Spot-billed Duck	<i>Anas poecilorhyncha</i>	R,M?	CR	LC
28	Rallidae	White-breasted Waterhen	<i>Amaurornis phoenicurus</i>	R	LC	LC
29	Rallidae	Purple Swampphen	<i>Porphyrio porphyrio</i>	R	LC	LC
30	Rallidae	Common coot	<i>Fulica atra</i>	R	LC	LC
31	Rallidae	Common Moorhen	<i>Gallinula chloropus</i>	R	LC	LC
32	Jacaniidae	Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>	R	LC	LC
33	Recurvirostridae	Black-winged Stilt	<i>Himantopus himantopus</i>	R,M	LC	LC
34	Burhinidae	Great Thick-knee	<i>Esacus recurvirostris</i>	R	LC	LC
35	Charadriidae	Yellow-wattled Lapwing	<i>Vanellus malabaricus</i>	Uncommon R	LC	LC
36	Charadriidae	Red-wattled Lapwing	<i>Vanellus indicus</i>	R	LC	LC
37	Charadriidae	Asiatic Golden Plover	<i>Pluvialis fulva</i>	M		LC
38	Charadriidae	Common Ringed Plover	<i>Charadrius hiaticula</i>	M		LC
39	Charadriidae	Little Ringed Plover	<i>Charadrius dubius</i>	R,M	VU	LC
40	Charadriidae	Kentish Plover	<i>Charadrius alexandrinus</i>	R,M	VU	LC
41	Charadriidae	Monglian Plover	<i>Charadrius mongolus</i>	M		LC
42	Scolopacidae	Black-tailed Godwit	<i>Limosa limosa</i>	M		NT
43	Scolopacidae	Whimbrel	<i>Numenius phaeopus</i>	M		LC
44	Scolopacidae	Eurasian Curlew	<i>Numenius arquata</i>	M		NT
45	Scolopacidae	Common Redshank	<i>Tringa totanus</i>	M		LC
46	Scolopacidae	Common Greenshank	<i>Tringa nebularia</i>	M		LC
47	Scolopacidae	Green Sandpiper	<i>Tringa ochropus</i>	M		LC
48	Scolopacidae	Marsh Sandpiper	<i>Tringa stagnatilis</i>	M		LC
49	Scolopacidae	Wood Sandpiper	<i>Tringa glareola</i>	M		LC
50	Scolopacidae	Common Sandpiper	<i>Actitis hypoleucos</i>	M		LC
51	Scolopacidae	Pintail Snipe	<i>Gallinago stenura</i>	M		LC
52	Scolopacidae	Little Stint	<i>Calidris minuta</i>	M		LC
53	Scolopacidae	Curlew Sandpiper	<i>Calidris ferruginea</i>	M		NT
54	Laridae	Great Black-headed Gull	<i>Larus ichthyaetus</i>	M		LC
55	Laridae	Brown-headed Gull	<i>Larus brunnicapillus</i>	M		LC
56	Sternidae	Whiskered Tern	<i>Chlidonias hybridus</i>	M		LC
57	Sternidae	White-winged Tern	<i>Chlidonias leucopterus</i>	M		LC
58	Sternidae	Gull-billed Tern	<i>Sterna nilotica</i>	M,R	CR	LC
59	Sternidae	Caspian Tern	<i>Sterna caspia</i>	R,M	CR	LC
60	Sternidae	Little Tern	<i>Sterna albifrons</i>	R	VU	LC
61	Sternidae	Lesser-Crested Tern	<i>Sterna bengalensis</i>	M		LC
62	Sternidae	Great-crested Tern	<i>Sterna bergii</i>	R	NT	LC
63	Alcedinidae	Pied Kingfisher	<i>Ceryle rudis</i>	R	LC	LC
64	Alcedinidae	Common Kingfisher	<i>Alcedo atthis</i>	R	LC	LC
65	Alcedinidae	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	R	LC	LC

NCS- National Conservation Status, GCS – Global Conservation Status, CR-Critically Endangered, R - Resident, M – Migrant

M, R denotes the main populations being migrant, with minor resident populations.

R, M denotes the main populations being resident, with minor migrant populations

R, M? denotes species were mainly residents with doubtful migrant status

Status of waterbirds according to Wijesundara et al., (2017).

E- Endangered, LC - Least Concerned, VU- Vulnerable (Weerakoon and Gunawardena, 2012).

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