RESEARCH ARTICLE

Diversity and Conservation of Waterbirds in the Northern Avifaunal Region of Sri Lanka

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Abstract: The aim of the present study is to evaluate the waterbird diversity, distribution, and conservation status in the northern avifaunal region of Sri Lanka, which includes two of the four richest waterbird regions in Sri Lanka, namely Jaffna and Mannar. We compiled data from the annual waterbird censuses and monthly records of the Ceylon Bird Club from 2011 to 2017 and from a systematic survey carried out by us from October 2014 to March 2016.

We recorded a total of 116 species of waterbirds belonging to 23 families. Among them are species confined to the northern region including the rare breeding residents the Crab Plover (*Dromas ardeola*), Indian Courser (*Cursorius coromandelicus*), Spot-billed Duck (*Anas poecilorhyncha*), and Saunders's Tern (*Sternula saundersi*). The Greater Flamingo (*Phoenicopterus roseus*), which is now uncommon elsewhere in Sri Lanka, was recorded in high numbers. The Spot-billed Duck, which was a very rare migrant to Sri Lanka until recently, was found to have established breeding populations in the region. The Glossy Ibis (*Plegadis falcinellus*) and Comb Duck (*Sarkidiornis melanotos*), which are extirpated breeding residents in Sri Lanka, were recorded as part of the migrant population. The Common Coot (*Fulica atra*), which was previously considered a very rare breeding resident, was found to be abundant with over 1,000 individuals in some localities.

Keywords: Waterbirds, diversity, northern avifaunal region, conservation, wetlands.

INTRODUCTION

Bird diversity in the South Asian region

At present, of the 10,000 or more known species of birds in the world, some 1,800 species are found in the Oriental Region (Clements *et al.*, 2016). The South Asian biogeographical region, defined as Afghanistan, Pakistan, India including the Andamans and Nicobars, Nepal, Bhutan, Bangladesh, Sri Lanka, the Maldives and the Chagos archipelago, forms only a small part of the Oriental Region, but is home to some 1,300 species of birds (approximately 13% of the world's bird species) (Rasmussen and Anderton, 2012). Of these, some 143 bird species (11%) are endemic to the South Asian region. Hence, this region is critical for the preservation of avian biodiversity.

Several factors contribute to the avian species richness in the South Asian region. These include altitudinal variation (from sea level up to the Himalayas, the world's tallest mountain range), variability in climate and associated vegetation diversity, and its geographical location within the major Central Asian migrant flyway. The region is close to two other biogeographic provinces (Palearctic and Afrotropical or Ethiopian), which has resulted in species from these two regions extending their ranges into the South Asian region. Most species in the region are Oriental (Indo-Malayan) species, typified by minivets and ioras; some are Palearctic species, including accentors, and a small number originate in Africa and these include creepers.

Bird diversity in Sri Lanka

Sri Lanka is a tropical island (65,610 km²) located south of India (5°.55' - 9°.55'N, 79°.42' - 81°.52'E). At present 454 bird species belonging to 20 orders have been recorded from Sri Lanka. Of these, 238 are breeding residents¹, 144 are regular migrants², and 72 are vagrants³ (Warakagoda *et al.*, 2012). The majority of migrant species arrive in Sri Lanka from northern latitudes. A large number of migrant species are waterbirds (Warakagoda and Sirivardana, 2006).

Waterbirds of Sri Lanka

The Ramsar Convention defines 'waterbirds' as birds 'ecologically dependent upon wetlands'. Waterbirds are important indicators of the ecological condition and productivity of wetland ecosystems (Wei *et al.*, 2009), and are one of the key attributes of the biodiversity of many wetlands. Counts of waterbirds form one of several elements that are used to identify important wetlands. It has been stated that the number of waterbirds using a given wetland is a good indicator of that site's biological importance, *e.g.* the number of faunal and floral species it can support (Scott, 1980).

Approximately 164 species of waterbirds belonging to 23 families have been identified in Sri Lanka. These birds

- 1 Species which breed within the territory of the country.
- 2 Species which are present in the country for some months but do not breed within the territorial limits of the country.
- 3 Species recorded irregularly in Sri Lanka.

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are found in a wide variety of wetlands from sea level to an elevation of 2,200 m. Large concentrations are found in the coastal and inland wetlands of Sri Lanka's dry zone. Table 1 gives a list of the families of waterbirds found in Sri Lanka.

The four richest waterbird regions in Sri Lanka are Jaffna, Mannar, Puttalam-Chilaw and the Southern Coastal. In the area demarcated until recently as the South-East Coastal region the destruction of critical feeding and resting wetlands within it for a seaport has caused a drastic fall in the number of waterbirds. This has now been observed throughout several years in the waterbird censuses and at other times. It was thought that therefore it is more apt to enlarge its range and name the new area the Southern Coastal region. (Warakagoda and Sirivardana, 2006, Wei *et al.*, 2009, Price *et al.*, 2014) (Figure 1 and Figure 2).

Aim of the study

Over the past century researchers have documented significant changes to the actual and known status of several species of waterbirds. The aim of the present study was to evaluate the waterbird diversity and distribution in the northern avifaunal region of Sri Lanka, with the intention of recording areas of high waterbird abundance and high priority conservation areas, especially wetlands. The northern avifaunal region as defined here comprises the area north of a straight line from north of the Wilpattu National Park on the west coast to Nilaveli on the east coast. As a southern boundary cannot be precisely defined meaningfully, with reference to inland water bodies, we consider the use of such a line to be justified. This region includes two of the richest waterbird regions in Sri Lanka, *viz.* Jaffna and Mannar.

MATERIALS AND METHODS

We compiled data from 2011 to 2017 obtained from the

annual waterbird censuses conducted by the Ceylon Bird Club (Ceylon Bird Club 2011-2017) and the monthly records of the Club (*Ibid.*), and from a systematic survey carried out from October 2014 to March 2016 by some of us (CW, DC, TH, NP, PR, SW, GW) in parts of the region.

Several factors can significantly affect the data gathered in a waterbird census: the extent of coverage of each region and site, weather conditions, movements of birds among sites, the degree of visibility and the current conditions of the sites, especially including variable water levels.

The annual censuses by the Ceylon Bird Club are coordinated with those in other countries by Wetlands International, and carried out generally following standard guidelines set out by the latter (*e.g.* Wetlands International 2010), by spot counts in the first two weeks of February during the northern winter migrant season.

The observations by members of the Club published in its monthly journal may be described as random sampling. The club exercises care to maintain a high standard of authenticity in its data, especially in regard to the identification of bird taxa (*e.g.* Warakagoda and Sirivardana, 2009).

The systematic survey (2014-2016) was done twice a month. Point counts with unlimited distance were used for assessing the diversity and abundance of birds. Observations were made using standard birding binoculars (Nikon 8×40 Action Extreme and Nikon Monarch 10×42) and a spotting scope (Vixen 25×50). The major sites in Jaffna region included Mandaitivu, Allaipiddy, Mankumban, Melingimunai (Kayts), Kaladaipiddy (Pungudutivu), Delft Island wildlife conservation area, Araly, Ponnalai Bridge area, Kaithady, Thanankilappu, Kopay, Puthur, Sarasalai, Anthanathidal, Kapputhu, Thondaimanaru, Vallai, Mulli, Nagar Kovil, Mamunai, and Chundikkulam National Park. The major sites in Mullaitivu and adjacent areas included Chalei, Nanthikadal, Nayar, and Kokilai Sanctuary whereas Giant's Tank, Vankalai Sanctuary,

Table 1: Families of waterbirds found in Sri Lanka and the number of species recorded from each family in the northern avifaunal region.

Family	No. of Species	Family	No. of Species
Podicipedidae (grebes)	1	Phalacrocoracidae (cormorants)	3
Anhingidae (darters)	1	Pelecanidae (pelicans)	1
Ardeidae (herons, egrets)	12	Ciconiidae (storks)	4
Threskiornithidae (ibises, spoonbills)	3	Phoenicopteridae (flamingos)	2
Anatidae (ducks)	10	Rallidae (rails, crakes, coots)	6
Jacaniidae (jacanas)	1	Rostratulidae (painted-snipes),	1
Haematopodidae (oystercatchers)	1	Recurvirostridae (stilts, avocets)	2
Dromadidae (Crab Plover)	1	Burhinidae (stone-curlews, stone-plovers)	2
Glareolidae (coursers, pratincoles)	3	Charadriidae (plovers, lapwings)	9
Scolopacidae (stints, sandpipers, etc.)	23	Laridae (gulls)	5
Sternidae (terns)	15	Accipitridae (raptors)	6
Alcedinidae (kingfishers)	4		

Figure 1: Regions of high waterbird density in Sri Lanka. After Warakagoda and Sirivardana (2006). Map prepared by Chaminda S. Wijesundara.

Figure 2: Sites with high density of waterbirds in Sri Lanka 1987-2007. The area covered by the present study, the Northern Avifaunal Region, is highlighted in red. (Source: Wei *et al.*, 2009).

Erukulampiddy, Thalaimannar, and Vidaththativu were the major sites surveyed in Mannar region (see Figure 3).

Censuses during the systematic survey were conducted between sunrise and sunset of each census day, with peak counting hours between 0630 h and 1000 h and 1530 h and 1800 h. These represent the times when the birds are most active. Each count lasted about 20 minutes. Point transects were established as delineated by Sutherland (2006), Buckland *et al.* (2001), Marsden (1999), Bibby *et al.* (2000), and Raman (2003). Each area had a minimum of five point counting stations, each separated from the next by at least 250 m, to minimize double-counting. During the study period, each site was visited multiple times to allow for temporal variation of bird diversity.

To minimize time-of-day bias, each point count station was given an equal chance of visitation during different times of the day, on different counting days. For example, if station 1 was surveyed from 0630-0730 h on a given day, it was surveyed from 1700-1800 h on another day. By dividing the day into different census sessions (*e.g.* 0630-0730 h, 0730-0830 h, etc.), it was possible to spend approximately equal amount of sampling time in each session to represent different times of the day during the study period.

RESULTS

We recorded a total of 116 species of waterbirds belonging to 23 families in the study region (see Appendix 1). Of these, 54 species were migrants, 6 species were mainly migrants with resident populations, another 6 were mainly

residents with migrant populations, 1 species was mainly a migrant with doubtful resident status, 2 species were mainly residents with doubtful migrant status, and 47 were residents.

The total numbers of individuals in the annual census during this period (2011 – 2017) varied from 69,000 to 227,000. By far the majority of waterbirds were migrants. The most numerous by group were ducks and shorebirds. More than 100,000 waterbirds were seen at a site on four occasions: three times in Mannar, estimated at 200,000 to 500,000, and once 130,000 in Jaffna.

Figure 4 shows the most abundant waterbird species recorded during the systematic survey, whose total counts were over 1,000 and Figure 5 shows the monthly variations in the abundance of these species. The Eurasian Wigeon (*Anas penelope*) and Brown-headed Gull (*Chroicocephalus brunnicephalus*), both of which are migrants, showed higher abundances toward the latter part (early 2016). The reason may be higher numbers of migrating individuals making landfall in Sri Lanka that year compared to previous years. Whether the same pattern will follow in the following migrant season should be further investigated. Little Cormorant (*Phalacrocorax niger*), a resident species, showed an increased abundance in the early part of the systematic survey and another (lower) peak in abundance during the middle part of the survey. Thereafter it was recorded in lower numbers. The reason may have been that most of the population has moved to other parts of its range in Sri Lanka, due to changes in water level patterns.

All eight species of waterbirds in Sri Lanka whose breeding is known to be confined to the northern region were

Figure 3: Systematic survey 2014-2016. Major sampling areas in the Northern Province. Map prepared by Chaminda S. Wijesundara.

Figure 4: Systematic survey 2014-2016. Abundance of the most common waterbird species in the present study area (including Mandaitivu, Allaipiddy, Mankumban, Melingimunai [Kayts], Kaladaipiddy [Pungudutivu], Delft Island wildlife conservation area, Araly, Ponnalai Bridge area, Kaithady, Thnankilappu, Kopay, Puthur, Sarasalai, Anthanathidal, Kapputhu, Thondaimanaru, Vallai, Mulli, Nagar Kovil, Mamunai, and Chundikkulam National Park), Mullaitivu (including Chalei, Nanthikadal, Nayar, and Kokilai lagoons), and Mannar (including Giant's Tank Sanctuary, Vankalai Sanctuary, Erakkulampiddy, Thalaimannar, and Vidaththaltivu).

Figure 5: Systematic survey 2014-2016. Monthly variations in the abundance of the most common waterbird species in the present study area.

recorded during the present study (Table 2). The breeding of three of them, the Sooty Tern (*Onychoprion fuscatus*), Brown Noddy (*Anous stolidus*) and Lesser Noddy (*Anous tenuirostris*), was discovered for the first time, in each case on the islet chain Adam's Bridge, Mannar.

The Spot-billed Duck (*Anas poecilorhyncha*), a very rare migrant to Sri Lanka until recently, was observed to have established a breeding population in Jaffna, also a new locality. Others of the eight species include the Indian Courser (*Cursorius coromandelicus*) and Crab Plover (*Dromas ardeola*), of whom only very small populations are known in Sri Lanka, the former species only in this region. Of these species again, the Spot-billed Duck, Indian Courser, and Saunders's Tern (*Sterna saundersi*) are considered Critically Endangered in Sri Lanka (Weerakoon and Gunawardena, 2012).

The Common Coot (*Fulica atra*), earlier recorded as a very rare breeding resident in Sri Lanka, was found to be common, with nearly or over 1,000 birds at some sites. The Black-necked Stork (*Ephippiorhynchus asiaticus*), one of the rarest resident bird species, and Critically Endangered in Sri Lanka (Weerakoon and Gunawardena, 2012), was recorded in the region after several decades.

The Greater Flamingo (*Phoenicopterus roseus*), uncommon elsewhere in Sri Lanka, was recorded in high numbers in the region, for example a flock of approximately 6,000 in the Jaffna Lagoon. During the systematic survey it was observed throughout the year 2015 and in the early part of 2016. It showed the second highest abundance of any migrant bird species in the Jaffna Peninsula during the systematic survey (Wijesundara et al., 2016). The Lesser Flamingo (*Phoenicopterus minor*) was recorded in Sri Lanka for the first time.

The Glossy Ibis (*Plegadis falcinellus*) and Comb Duck (*Sarkidiornis melanotos*), extirpated breeding residents, were recorded as migrants, in their largest numbers to date.

Table 2: Waterbird species which breed in Sri Lanka only in the Jaffna-Mannar area that were recorded during the present study period (2011-2017). See text for important sites. (U=Uncommon; R=Rare; see Appendix 1 for explanation.)

Species	Status
Spot-billed Duck (<i>Anas poecilorhyncha</i>)	U
Crab Plover (<i>Dromas ardeola</i>)	R
Indian Courser (<i>Cursorius coromandelicus</i>)	R
Saunders's Tern (<i>Sternula saundersi</i>)	R
Bridled Tern (<i>Onychoprion anaethetus</i>)	U
Sooty Tern (<i>Onychoprion fuscatus</i>)	U
Brown Noddy (<i>Anous stolidus</i>)	U
Lesser Noddy (<i>Anous tenuirostris</i>)	U

Avifaunal diversity of selected locations was compared using formal diversity indices such as Shannon Index (Table 3). The island of Mandaitivu, Thondaimanaru, and Vallai had higher Shannon index values in terms of waterbird diversity. Furthermore, these also had higher

Table 3: Systematic survey 2014-2016. Shannon Diversity Index and Shannon Evenness Index for waterbird fauna in selected localities in the northern avifaunal region (sorted by Shannon Index, highest to lowest).

Locality	Shannon Index	Shannon Evenness
Mandaitivu	2.482	0.716
Thondaimanaru	2.184	0.601
Vallai	2.025	0.481
Mankumban	1.252	0.433
Allaipiddy	0.971	0.324

evenness values.

DISCUSSION

Importance of the region for waterbirds

The study region includes two of the four richest waterbird regions in Sri Lanka: Jaffna (the Peninsula, Chundikkulam National Park to its south, and the islands to its west) and Mannar (from Iluppaikadavai in the north to Adam's Bridge to Silavaturai in the south and extending inland to Giant's Tank Sanctuary).

As stated above, during the period of the study 116 species of waterbirds in 23 families were recorded in the region. In 2010 at least a million shorebirds were seen at the Vidatthalthivu lagoon in the Mannar region, and it has been suggested as possibly the most important shorebird site in the Central Asian Flyway (Sirivardana and Hettige 2010, Warakagoda *et al.*, 2012).

During the period of the study 100,000 or more birds were recorded at a site on four occasions. At the Vankalai Sanctuary, Mannar in 2011 more than 200,000 ducks were seen, in 2014 an estimated 200,000-250,000 ducks, and in 2016 an estimated 500,000 shorebirds (Ceylon Bird Club 2011-2017). On the shores of Jaffna Lagoon and the east coast of Kayts Island 100,000 gulls and terns were recorded in 2014. At gatherings of this scale, in general, the larger the number of birds the greater the species diversity, and the higher the chance of observers missing species present within it in smaller numbers, including rarities.

The reason why this region is so rich in waterbirds may be because it lies at an end point of the major Central Asian flyway (Figure 6). Each year 100,000s of waterbirds migrating away from the Northern winter along this flyway end their journey in Sri Lanka, and most make landfall in Jaffna or Mannar. Furthermore, most of these birds stay on in these areas.

Shorebirds, ducks, gulls, and terns in very large numbers feed and rest in, and fly among, the many wetlands

within the Jaffna and Mannar regions, and intermittently fly between these two regions, throughout each migratory season. Waterbirds prefer sites less altered by humans, an exception being salterns, and with low human disturbance. The coastal systems preferred include lagoons, marshes, estuaries, mangroves, sea shore, islets in the sea, sand and mud flats, and salterns. Most birds in these habitats belong to the families Anatidae, Charadriidae, Scolopacidae, Laridae and Sternidae. Locally numerous at these sites are species in Ardeidae, Ciconiidae, Threskiornithidae and Phoenicopteridae. Most of the coastal waterbird species, including all the forms (ducks, waders, gulls, etc.) found in large numbers, are migrants.

Inland systems most preferred by waterbirds include paddy fields, marshes, reservoirs and their associated wetlands. In these habitats, large populations of species in families Phalacrocoracidae and Ardeidae can be seen. Locally common are species in Anatidae, Rallidae and Ciconiidae. These are mostly residents.

In the present study area numerous lagoons, very extensive sand and mud flats bordering these, and low gradients of the littoral region in several localities, form prime feeding sites for waterbirds, especially ducks and shorebirds. The low gradients of the littoral region (for example at the Mannar causeway) also enables flamingos to stand in the sea more than 1 km away from the shore. Numerous sites of all the other wetland types described above occur in the region.

The total extent of mangroves in the present study areas is over 3,400 ha or about 29% of the total extent of mangroves in Sri Lanka (MOE 2012, Rajkumar and Wijesundara, 2016). The largest extents of the mangroves in Sri Lanka are recorded from the north, northwest, and eastern coasts (Pinto, 1986, Wetlands International 2010, Prasanna and Ranawana, 2014). These areas support large numbers of prey species of waterbirds (e.g. fish, mollusks, other invertebrates, and plankton). The phytoplankton contributes to a major portion of the primary production in

Central Asian Flyway

Figure 6 Central Asian Flyway. After Wetlands International (2012). Map prepared by Saumya Wanniarachchi.

these lagoons. This provides the basis for the food chain. High densities of prey species support large populations of waterbird species. The study region also has some of the most seriously threatened wetlands in Asia (Scott, 1989).

The great majority of these wetlands are either not or marginally utilized by humans, and most of the adjacent human populations are sparse, with little disturbance from them. Ironically, the armed conflict in the country, which in fact was concentrated in this region, protected birds at wetlands within it. Civilian firearms were banned by both parties, upon which the hunting of waterbirds ceased; but with peace this has resumed. During the conflict it had been observed that the sound of artillery made waterbirds leave certain wetlands in this region but that they returned soon when the spell of disturbance was over.

Diversity of waterbirds in the region

The species of waterbirds resident in Sri Lanka which breed only in the region are listed in Table 2. Of these, Sooty Tern, Brown Noddy, Lesser Noddy, and Saunders's Tern, are known to breed only on Adam's Bridge.

The Spot-billed Duck was a very rare migrant to Sri Lanka until recently (Henry, 1998). In 2003 it was established as a breeding resident in Mannar (Warakagoda and Sirivardana, 2006), and in 2011 in Jaffna (Ceylon Bird Club 2011-2017). The species has now established breeding populations in both the Mannar and Jaffna regions (Ibid.) Adults with young were observed also during the systematic survey, in Jaffna.

The Indian Courser is a very rare breeding resident species in Sri Lanka, and it is confined to the present region. It was recorded in Jaffna after more than a decade, on Delft Island, during the systematic survey (2014 - 2016).

The Crab Plover is a rare and local breeding resident in Sri Lanka seen at the Adam's Bridge islets, northwestern coastal areas, and very seldom elsewhere. It was observed in these localities in this study with no other records in Sri Lanka during this period. The species breeds in the present region (Jaffna-Mannar), as young have been recorded, and observed to be fed, on Mannar Island (Gunawardena, 2007). All indications are that the breeding site is Adam's Bridge, but a nest is yet to be found there. This monotypic species has been recorded as nesting only around the Arabian Peninsula globally to date (BirdLife International 2017).

Of other species, the Common Coot had been earlier recorded as a very rare breeding resident in Sri Lanka (Henry, 1971). It has now been recorded with over 1,000 individuals in some sites such as the Giant's Tank in Mannar, during the present and other recent studies (Wijeyamohan et al., 2002). This species appears to have spread gradually eastwards to Vavuniya, where it has been observed in one of the large tanks in the city, and northwards to Jaffna, where it occurs in considerable numbers. It was also observed in large numbers during the systematic survey in some areas in Jaffna such as Vallai.

The Black-necked Stork has probably the smallest population size of any resident bird species in Sri Lanka. It was recorded in the eastern coastal strip, in the Nilaveli area, during the present study. This is the only record of it outside the south-east of Sri Lanka for several decades.

Greater Flamingos were seen in the 1,000s during the migrant seasons in this study. They were observed year-round in the Jaffna region during the systematic survey (2014 – 2016). This indicates that they stay on in Sri Lanka beyond the migrant season in some years, as previous workers (e.g. Legge, 1880, Henry, 1971) have suggested. It appears that more or less regularly for decades now about 10,000 flamingos have been gathering in the Chundikkulam Lagoon around May. For some decades the species has been known to remain in Sri Lanka outside the migrant season. This was mostly in the South East, represented by a few 100 to >1,000 birds. Their nearest known breeding site is the Rann of Kutch at the India-Pakistan border. It was noted that in such years (when they stayed in Sri Lanka) the conditions at the Rann were unfavorable for breeding. The causal connection between this fact and not migrating is not known. One of the earliest records of this species staying on in Sri Lanka beyond the migrant season is from Legge (1880). He gives a record of a large flock of flamingos seen in Jaffna during June. Wait (1925) also records seeing a large flock in June in Kokkilai Lagoon. In Henry (1998) it is reported that a considerable number of flamingos loiter through the south-western monsoon (May-September), and the building of nest mounds has occasionally been observed. To date there is no definite indication of the species breeding in Sri Lanka. During the systematic survey, greater flamingos have been observed in large numbers (*i.e.* >1,000) in June and July in the Jaffna Peninsula.

The Lesser Flamingo was recorded in Sri Lanka for the first time, with two individuals observed in a flock of about 200 Greater Flamingo, in 2013, in Jaffna. The next nearest record of its occurrence is Andhra Pradesh, India.

Two species which were once breeding residents and became extinct as breeding residents a century ago later reappeared as migrants in Sri Lanka, *viz.* the Glossy Ibis and the Comb Duck (Henry, 1998). At present, their largest numbers are recorded in the Jaffna and Mannar areas. The largest flocks of Glossy Ibis and Comb Duck in Sri Lanka were recorded in Jaffna during the present study period. Over 200 individuals of the Glossy Ibis have been recorded by the Ceylon Bird Club during the present study period, and 100+ individuals in the systematic survey (2014-2016) from Sarasalai, Jaffna.

Two migrant species, the Wigeon (*Anas penelope*) and Black-tailed Godwit (*Limosa limosa*) were very rarely recorded in Sri Lanka until a few decades ago (Legge, 1880, Wait, 1925, Henry, 1971). Since then, during most seasons they have been recorded in the 1,000s, the Wigeon only in the Jaffna and Mannar regions (Henry, 1998). For example, in February 2016 over 4,000 Wigeon were recorded from Mankumban, Jaffna during the systematic survey. Black-tailed Godwits were also recorded in large numbers in Jaffna, with flocks of several 1,000 individuals.

The diversity indices suggest that among the selected areas in Jaffna, the island of Mandaitivu, Thondaimanaru, and Vallai had higher waterbird diversity. Furthermore, these also had higher evenness values. This suggests that in these areas the bird species were more or less equally abundant or evenly distributed.

Conservation

Recently several areas that include major waterbird habitats have been either declared or proposed as protected areas within the present study area (see Figure 7). These include two newly declared national parks, i.e. Adams Bridge and Delft Island National Parks, and two sanctuaries upgraded to National Park status in 2015, i.e. Chundikulam National Park and Madu Road National Park (Government of Sri Lanka Gazette No 1920/3 2015). Furthermore, it is proposed to upgrade Kokilai Sanctuary as a National Park including the adjacent Nayar Lagoon area (Mallawatantri *et al.*, 2014). This area also includes highly significant waterbird habitats.

The entire Jaffna Lagoon and the area covering Karaveddi-Nagarkovil region in the Jaffna Peninsula have been either proposed or declared as sanctuaries/nature reserves. These include most of the significant waterbird habitats in the Jaffna Peninsula. For example, Sarasalai, Anthanathidal, Vallai, and Thondaimanaru areas in this proposed sanctuary include major waterbird habitats providing refuge for significant species such as the Greater Flamingo, Glossy Ibis, and Common Coot. Some of these areas (e.g. Nagar Kovil) also include significant extents of mangroves. Nagar Kovil has recently (in 2016) been declared as a nature reserve (Department of Wildlife Conservation Sri Lanka 2017).

The entire coastal and pelagic strip north from Iluppaikadavai south to Toddaveli (on Mannar Island) has been very recently (in 2016) declared as a Nature Reserve, the Vidaththaltivu Nature Reserve (Department of Wildlife Conservation Sri Lanka 2017). This area is used by very large numbers of migrant birds each year. For example, over a million migrant birds were recorded in Vidaththaltivu in 2010 (Sirivardana and Hettige, 2010, Warakagoda *et al.*, 2012). Mannar area also includes a Ramsar Wetland, the Vankalai Sanctuary (Ramsar Convention, 2013). All of these areas on the northwestern coastal area of Sri Lanka

are important for the survival of avian species which are specialties in the northern region, such as Crab Plover and Indian Courser. Furthermore, Nanthikadal Lagoon has been proposed as a sanctuary and re-establishment of Vavunikulum Sanctuary is also proposed (Mallawatantri *et al.* 2014). Both these areas are significant as habitats for both resident and migrant waterbirds. For example, the systematic survey recorded 100+ individuals of Eurasian Spoonbills (*Platalea leucorodia*) in one flock and several Glossy Ibis in Nanthikadal Lagoon in 2015.

The present study area (especially Jaffna, Mullaitivu, and Mannar) has large extents of prime waterbird habitats such as mangroves and salt pans. Road and hotel construction have negatively impacted on these habitats. Destruction of mangroves, especially during post-war years, is evident in many areas such as Mandaitivu. The ongoing salt water exclusion scheme in the Thondaimanaru lagoon results in the slow desalination of the lagoon. It will have far-reaching ecological consequences including threats to the mangrove ecosystems of the area and the associated bird life.

CONCLUSION

The present study area has a number of important sites for waterbird conservation. It includes two of the four richest waterbird regions in Sri Lanka, namely Jaffna region (including islands and the Chundikkulam National Park) and Mannar region (including Adam's Bridge National Park and Giant's Tank Sanctuary). The study recorded a total of 116 species of waterbirds in 23 families in the northern avifaunal region. These included eight species which breed only within the region, and three of them were recorded as breeding in Sri Lanka for the first time, all on Adam's Bridge. The present study area also supports a large number of Greater Flamingo (*Phoenicopterus roseus*), which is now uncommon elsewhere in Sri Lanka.

Figure 7: Proposed and recently declared wildlife conservation areas in the northern region of Sri Lanka. The systematic survey was based on sites 2, 3, 4, 6, 7, 9, 10, 11, and 16; the censuses of the Ceylon Bird Club were based also on the other sites shown in addition to these sites. After Department of Wildlife Conservation, Sri Lanka, 2011; Map prepared by Saumya Wanniarachchi.

Furthermore, it is one of very few global breeding areas of the Crab Plover (*Dromas ardeola*), which is a monotypic species.

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Appendix 1: Status of waterbirds found in the northern avifaunal region of Sri Lanka.

Information based on the data from Ceylon Bird Club (2011-2017) and the systematic survey (2014-2016).

Status:

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.

Distribution Zones:

C - Coastal, I – Inland

C, I denotes the main populations being coastal, with minor inland populations.

I, C denotes the main populations being inland, with minor coastal populations.

Abundance:

C - Common (found in fair numbers within its zone/s / main zone)

L - Locally common (occurs in fair numbers locally but is rare or not well distributed elsewhere)

U - Uncommon (found in small numbers throughout its zone /s or locally)

R - Rare (occurs only in very small numbers or only occasionally).

Family & Species	Resident/Migrant	Zone	Abundance
Family Podicipedidae			
Little Grebe <i>Tachybaptus ruficollis</i>	R	I, C	L
Family Phalacrocoracidae			
Little Cormorant <i>Phalacrocorax niger</i>	R	I, C	C
Indian Shag <i>Phalacrocorax fuscicollis</i>	R	I, C	C
Great Cormorant <i>Phalacrocorax carbo</i>	R	I	U
Family Anhingidae			
Indian Darter <i>Anhinga melanogaster</i>	R	C, I	U
Family Pelecanidae			
Spotted-billed Pelican <i>Pelecanus philippensis</i>	R	C, I	L
Family Ardeidae			
Yellow Bittern <i>Ixobrychus sinensis</i>	R,M	I, C	C
Black Bittern <i>Ixobrychus flavicollis</i>	R,M	I, C	U
Night Heron <i>Nycticorax nycticorax</i>	R	I, C	L
Little Green Heron <i>Butorides striatus</i>	R	I, C	L
Indian Pond Heron <i>Ardeola grayii</i>	R	C, I	C
Median Egret <i>Ardea intermedia</i>	R	C, I	C
Cattle Egret <i>Ardea ibis</i>	R,M?	I, C	C
Grey Heron <i>Ardea cinerea</i>	R	C, I	C
Purple Heron <i>Ardea purpurea</i>	R	I, C	C
Large Egret <i>Egretta alba</i>	R	C, I	C
Little Egret <i>Egretta garzetta</i>	R	C, I	C
Indian Reef Heron <i>Egretta gularis</i>	M	C	R
Family Ciconiidae			
Painted Stork <i>Mycteria leucocephala</i>	R	C, I	L

Family & Species	Resident/Migrant	Zone	Abundance
Openbill <i>Anastomus oscitans</i>	R	I, C	C
White-necked Stork <i>Ciconia episcopus</i>	R	I, C	U
Black-necked Stork <i>Ephippiorhynchus asiaticus</i>	R	C	R
Family Threskiornithidae			
Glossy Ibis <i>Plegadis falcinellus</i>	M	C, I	U
White Ibis <i>Threskiornis melanocephalus</i>	R	C, I	L
Spoonbill <i>Platalea leucorodia</i>	R	C, I	L
Family Phoenicopteridae			
Greater Flamingo <i>Phoenicopterus ruber</i>	M	C	L
Lesser Flamingo <i>Phoeniconaias minor</i>	M	C	R
Family Anatidae			
Lesser Whistling Teal <i>Dendrocygna javanica</i>	R	I, C	C
Ruddy Shelduck <i>Tadorna ferruginea</i>	M	C	R
Comb Duck <i>Sarkidiornis melanotos</i>	M,R?	I	U
Cotton Teal <i>Nettapus coromandelianus</i>	R	I	U
Wigeon <i>Anas penelope</i>	M	C	C
Common Teal <i>Anas crecca</i>	M	C	U
Spot-billed Duck <i>Anas poecilorhyncha</i>	R,M?	C, I	U
Pintail <i>Anas acuta</i>	M	C, I	C
Garganey <i>Anas querquedula</i>	M	C, I	C
Shoveller <i>Anas chlypeata</i>	M	C, I	L
Family Rallidae			
Ruddy Crake <i>Porzana fusca</i>	R	I, C	U
White-breasted Waterhen <i>Amaurornis phoenicurus</i>	R	I, C	C
Common Moorhen <i>Gallinula chloropus</i>	R	I, C	U
Purple Coot <i>Porphyrio porphyrio</i>	R	I, C	C
Watercock <i>Gallicrex cinerea</i>	R	I, C	U
Common Coot <i>Fulica atra</i>	R	I, C	L
Family Jacanidae			
Pheasant-tailed Jacana <i>Hydrophasianus chirurgus</i>	R	I, C	C
Family Rostratulidae			
Painted Snipe <i>Rostratula benghalensis</i>	R	I, C	U
Family Haematopodidae			
Oystercatcher <i>Haematopus ostralegus</i>	M	C	R
Family Recurvirostridae			
Black-winged Stilt <i>Himantopus himantopus</i>	R,M	C, I	C
Avocet <i>Recurvirostra avosetta</i>	M	C	R
Family Dromadidae			
Crab Plover <i>Dromas ardeola</i>	R	C	R
Family Burhinidae			
Stone-Curlew <i>Burhinus oedicephalus</i>	R	C, I	U
Great Stone-Plover <i>Esacus recurvirostris</i>	R	C, I	U
Family Glareolidae			
Indian Courser <i>Cursorius coromandelicus</i>	R	C	R
Collared Pratincole <i>Glareola pratincola</i>	M	C	R
Oriental Pratincole <i>Glareola maldivarum</i>	R	I, C	R
Family Charadriidae			
Little Ringed Plover <i>Charadrius dubius</i>	R,M	C, I	U
Ringed Plover <i>Charadrius hiaticula</i>	M	C, I	R
Kentish Plover <i>Charadrius alexandrinus</i>	R,M	C, I	L

Family & Species	Resident/Migrant	Zone	Abundance
Lesser Sand Plover <i>Charadrius mongolus</i>	M	C, I	C
Large Sand Plover <i>Charadrius leschenaultii</i>	M	C	U
Asiatic Golden Plover <i>Pluvialis fulva</i>	M	C, I	L
Grey Plover <i>Pluvialis squatarola</i>	M	C	U
Yellow-wattled Lapwing <i>Vanellus malabaricus</i>	R	C, I	U
Red-wattled Lapwing <i>Vanellus indicus</i>	R	I, C	U
Family Scolopacidae			
Great Knot <i>Calidris tenuirostris</i>	M	C	R
Red Knot <i>Calidris canutus</i>	M	C	R
Sanderling <i>Calidris alba</i>	M	C	U
Little Stint <i>Calidris minuta</i>	M	C, I	C
Temminck's Stint <i>Calidris temminckii</i>	M	C, I	R
Long-toed Stint <i>Calidris subminuta</i>	M	C	R
Curlew Sandpiper <i>Calidris ferruginea</i>	M	C, I	C
Broad-billed Sandpiper <i>Limicola falcinellus</i>	M	C	U
Ruff <i>Philomachus pugnax</i>	M	C	U
Pintail Snipe <i>Gallinago stenura</i>	M	I, C	C
Black-tailed Godwit <i>Limosa limosa</i>	M	C, I	C
Bar-tailed Godwit <i>Limosa lapponica</i>	M	C	R
Whimbrel <i>Numenius phaeopus</i>	M	C	U
Eurasian Curlew <i>Numenius arquata</i>	M	C	U
Common Redshank <i>Tringa totanus</i>	M	C, I	C
Marsh Sandpiper <i>Tringa stagnatilis</i>	M	C, I	C
Common Greenshank <i>Tringa nebularia</i>	M	C, I	U
Green Sandpiper <i>Tringa ochropus</i>	M	I, C	R
Wood Sandpiper <i>Tringa glareola</i>	M	C, I	U
Terek Sandpiper <i>Xenus cinereus</i>	M	C	U
Common Sandpiper <i>Actitis hypoleucos</i>	M	C, I	U
Turnstone <i>Arenaria interpres</i>	M	C	U
Red-necked Phalarope <i>Phalaropus lobatus</i>	M	C	R
Family Laridae			
Great Black-headed Gull <i>Larus ichthyaetus</i>	M	C	L
Common Black-headed Gull <i>Larus ridibundus</i>	M	C	R
Brown-headed Gull <i>Larus brunnicephalus</i>	M	C	L
Slender-billed Gull <i>Larus genei</i>	M	C	R
Lesser Black-backed Gull <i>Larus fuscus</i>	M	C	L
Family Sternidae			
Gull-billed Tern <i>Sterna nilotica</i>	M,R	C, I	L
Caspian Tern <i>Sterna caspia</i>	R,M	C, I	L
Large Crested Tern <i>Sterna bergii</i>	R	C	L
Lesser Crested Tern <i>Sterna bengalensis</i>	M	C	L
Sandwich Tern <i>Sterna sandvicensis</i>	M	C	R
Roseate Tern <i>Sterna dougallii</i>	R	C	U
Common Tern <i>Sterna hirundo</i>	M,R	C	L
Bridled Tern <i>Sterna anaethetus</i>	M,R	C	U
Little Tern <i>Sterna albifrons</i>	R	C, I	L
Saunders's Tern <i>Sterna saundersi</i>	R	C	R
Sooty Tern <i>Sterna fuscata</i>	M, R	C	U
Whiskered Tern <i>Chlidonias hybridus</i>	M	C, I	C
White-winged Black Tern <i>Chlidonias leucopterus</i>	M	C, I	L

Family & Species	Resident/Migrant	Zone	Abundance
Brown Noddy <i>Anous stolidus</i>	M, R	C	U
Lesser Noddy <i>Anous tenuirostris</i>	M, R	C	U
Family Accipitridae			
Brahminy Kite <i>Haliastur indus</i>	R	C, I	L
Osprey <i>Pandion haliaetus</i>	M	C, I	R
White-bellied Sea Eagle <i>Haliaeetus leucogaster</i>	R	C, I	U
Marsh Harrier <i>Circus aeruginosus</i>	M	I	U
Pallid Harrier <i>Circus macrourus</i>	M	I	U
Montagu's Harrier <i>Circus pygargus</i>	M	I	U
Family Alcedinidae			
White-breasted Kingfisher <i>Halcyon smyrnensis</i>	R	I, C	C
Common Kingfisher <i>Alcedo atthis</i>	R	I, C	U
Pied Kingfisher <i>Ceryle rudis</i>	R	C, I	U
Stork-billed Kingfisher <i>Pelargopsis capensis</i>	R	C, I	C

Appendix 2: Some of the avian specialties in the northern region that were found to breed only in the present study area.

Crab Plover (*Dromas ardeola*), Vankalai Sanctuary, Mannar. Photograph by Chaminda S. Wijesundara.

Indian Courser (*Cursorius coromandelicus*), Delft Island, Jaffna. Photograph by Chaminda S. Wijesundara.

Left: Spot-billed Duck (*Anas poecilorhyncha*), Allaipiddy, Jaffna. **Right:** Spot-billed Duck with chicks at Araly Junction, Jaffna. Photographs by Chaminda S. Wijesundara.