



Article

Avifaunal Diversity and Abundance in the Proposed Sarasalai Mangrove Reserve, Jaffna, Sri Lanka

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Simple Summary: The Sarasalai mangrove reserve has not been properly studied for its avifaunal diversity. Sarasalai is located in the northern avifaunal region in the Jaffna peninsula of Sri Lanka. The objective of this study is to assess the avifaunal diversity in the proposed Sarasalai mangrove reserve. A total of 107 avian species of 45 families were recorded during this study. The bird sightings differed among the studied sites. Greater Flamingos showed the highest abundance. A few threatened species such as the critically endangered Indian Spot-billed Duck and nine nationally threatened species were recorded in high abundance in the Sarasalai mangrove.

Abstract: Mangrove ecosystems are excellent habitats for migrating and resident birds. The proposed Sarasalai mangrove reserve is located in one of the richest waterbird zones in Sri Lanka. This site has never been properly studied as a single site for its avifaunal diversity. Hence, the present study aims to find avifaunal diversity in the Sarasalai mangrove. Data collection was performed from April to December 2021. Eight permanent sampling stations were demarcated along the existing roads and were visited twice a month to collect bird abundance data. A total of 107 bird species belonging to 45 families including 58 waterbird species were recorded in the present study. Bird abundance did not significantly differ among the eight studied sites. Studied sites with the availability of water and good tree cover had the highest Shannon Diversity Index. The mangrove vegetation, with tall grasses, and the high water level were significant factors for bird abundance in some sites. Monthly bird abundance showed a notable increase during the migratory months. Among the recorded bird species, Greater Flamingos showed the highest abundance. Moreover, some rare waterbirds including Indian Spot-billed Duck and Glossy Ibis were commonly recorded. Several putative threats have been recorded during this study, namely unplanned land encroachments, bird hunting, and clearing of mangroves. Although this site has a high value in providing a healthy habitat for many wetland birds, it is yet to be declared a protected area. The lack of a clear boundary and a governing body to protect this area exacerbates its protection issues. Hence, it is proposed that immediate legal actions must be taken to declare this important migratory bird area a mangrove forest reserve.

Keywords: biodiversity; central Asian fly-way; ecosystem; microhabitats; northern avifaunal region; waterbird



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1. Introduction

Mangroves protect approximately 3.5 million people from climate change impacts such as flooding, sea level rise, storms, and erosion [1]. Mangroves are excellent plant communities that are tolerant to extreme intertidal environmental conditions [2]. They provide favorable ecosystems to a large number of marine biodiversity, while offering employment opportunities and food for local communities, and protect cultural identity [3]. They also provide ecosystem services, especially for local and regional coastal communities in the tropic and sub-tropic [4]. Ecosystem services include supporting breeding and

providing a nursery ground for many fish species, timber and fuel wood, protection from storms and floods, and erosion control, as well as providing recreational, educational, and spiritual values [4–6]. They are among the most threatened ecosystems in the world [7]. Unfortunately, their loss has contributed to 0.6% of global greenhouse gas emissions [8]. In Sri Lanka, only a small extent of land is classed as mangroves, which is approximately 0.1–0.2% [2]. The majority of these mangrove habitats are found in the northern province [2].

Wetlands are the permanent or temporary accumulations of water with associated floral and faunal communities [9]. Together with mangrove habitats, wetlands are considered ideal biodiversity hotspots that support various faunal species, especially waterbirds [10]. According to the Ramsar convention, waterbirds can be defined as species of birds that are ecologically dependent on wetland [11]. Waterbirds permanently reside or temporally utilize wetlands as they provide diverse microhabitats for feeding, nesting, resting, and roosting [12]. Waterbirds are significant indicators of the ecological health and productivity of wetland ecosystems [13]. A total of 524 avian species have been recorded in Sri Lanka, which includes 34 endemic species, 68 endemic subspecies, and 24 globally threatened species [14–16]. Of the total 524 species recorded, there are 238 breeding residents, 144 regular migrants and 72 vagrants [17]. A total of 116 species of waterbirds have been recorded in the northern avifaunal region [18].

The Indian subcontinent provides the primary wintering ground for most of the winter migrants that arrive in Sri Lanka through the Central Asian Flyway (CAF) [19,20]. Further, the wetlands in Sri Lanka are the final destination for thousands of migrant birds flying southward along the CAF as there is no land mass beyond the south of Sri Lanka [21]. The Jaffna peninsula is among the five main entry and exit points that migratory birds use to enter Sri Lanka [22]. Hence, the Jaffna district becomes a significant area for avian studies and conservation. However, wetlands and mangrove ecosystems have become the most threatened habitats due to anthropogenic activities [23]. The proposed Sarasalai mangrove reserve is located on the CAF, hence it is important for migrant waterbirds. Its mangroves provide substantial ecosystem services for the surrounding local communities as well. Since Sarasalai Mangrove is a prominent migratory bird stopover, protecting its mangroves and associated ecosystems will eventually protect biodiversity and birds in the Jaffna peninsula.

Although few bird-related studies have been undertaken in the northern region of Sri Lanka, avifaunal diversity has not been comprehensively studied in most areas in this region due to the armed conflicts that prevailed for three decades. Moreover, studies on birds in mangrove forests in Sri Lanka are also limited. We had three main study aims: firstly, to study diversity and abundance of avian species; secondly, to investigate seasonal variation in bird diversity; and lastly, to list out potential site-specific threats. We hypothesized that seasonality might influence bird diversity among the eight studied sites. We predicted that habitat heterogeneity may influence bird diversity within the Sarasalai mangrove.

2. Materials and Methods

2.1. Study Area

Jaffna district covers an area of 1,025 km² [24], and the study area is located in the Jaffna district in the northern province, approximately 18 km away from the Jaffna town center (9°43′00.4″ N 80°10′30.7″ E; Figure 1). The study area is located in the northern avifaunal region, in the arid climatic zone of Sri Lanka [25]. According to Forest Department information, this proposed mangrove reserve covers a total area of approximately 1598 ha. This is a small mangrove sanctuary consisting of five species of true mangroves and 14 mangrove-associated tree species [26]. The average temperature varies from 28.3 to 32.2 °C during the dry season and 25 to 27.7 °C during the wet season [24] and the annual rainfall is approximately 204.8 mm [27]. The Chavakachcheri-Puloli (B75) road has been constructed across the Sarasalai mangrove reserve. Limited nature-based recreational activities occur in the Sarasalai mangrove. However, an increasing number of local as well

as foreign birders visit this mangrove during the migrating season, especially to watch larger flocks of Greater Flamingos (*Phoenicopterus roseus*) as the main attraction. Fishing activities are frequent in the area since many locals depend on the mangrove fish for their protein requirements. Most of the surrounding area consists of paddy fields. Although there is a well-developed road that crosses the Sarasalai, road traffic is not so busy as it is a rural area.

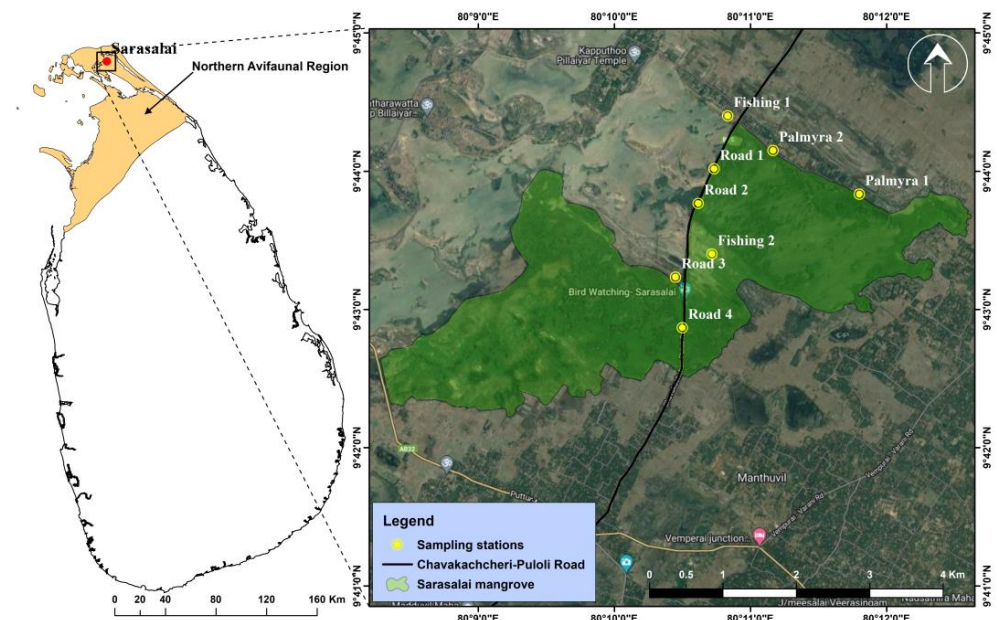


Figure 1. Sarasalai proposed mangrove showing the eight sampling stations.

2.2. Sampling

Data collection and field visits of the current study were conducted for eight months from April to December 2021. Data were collected using point transects with limited distance based on the method reported by Sutherland [28]. Eight permanent sampling stations were marked along the existing roads due to limited accessibility inside the mangrove and logistic reasons (Figure 2) [29]. Only sampling points Fishing 1 and Fishing 2 were located further in the interior part of the site, approximately 200 m from the roads. Hence, sampling stations were not evenly represented to cover the entire mangrove. Sampling sites are briefly described below in Table 1.

Table 1. Description of the sampling stations.

Site	Description	Vegetation	Water Level	Human Disturbance
Palmyra 1	Located on a narrow footpath to the main road	Dense mangrove/paddy field/palmyra	Very low in dry season	Medium
Palmyra 2	Located on the same footpath close to the main road	Low mangrove/palmyra/home garden	Low in dry season and high in wet season	High
Fishing 1	Located outside of the main road	Low mangrove/open grasses/palmyra/home garden	Low in dry season and high in wet season	High
Fishing 2	Located outside of the road network	Low mangrove/open areas	Zero during dry season	High
Road 1	Located on the main road	Low mangrove/scattered trees/open areas with tall grasses	Medium	High
Road 2	Located on the main road	Dense mangrove/grasses/pond	High	High
Road 3	Located a little away from the main road	Low mangrove/open grasses	Zero during dry season	High
Road 4	Located on the main road	Dense mangrove	Medium	Low



Figure 2. The waterlogged habitat in the Sarasalai proposed mangrove forest.

We ensured a minimum of 500 m between sampling sites to avoid double recordings. A circular plot with a width of 200 m was employed to count the birds and their abundance [28,30]. The sampling points were visited on two randomly selected days a month and observations were conducted during the daytime hours, from 0600 h to 1800 h. The observation time for each point was 15 minutes. A pair of binoculars with an optic power of 10×42 (FOV330FT) was used to observe the birds. The birds were identified using popular field guides of Birds of Sri Lanka by Harrison, and Deepal Warakagoda [31,32]. Photographs were taken using a digital camera for later identification (Canon 7D fitted with a 500 mm telephoto lens).

2.3. Analyses

The alpha diversity was calculated for each study site including the Shannon Diversity Index (H), Shannon Evenness, Margalef's Richness Index and the Berger-Parker Dominance Index to compare the diversity of birds at eight different points [33]. Biodiversity indices were calculated using an online biodiversity calculator by Al Young Studios [34]. The Kruskal–Wallis test was calculated by using IBM SPSS 26.0 to find out the variations in the abundance (number of records) of birds at each point. The percentage of occurrence was summarized for families of birds recorded [17]. The Sørensen qualitative index, followed by the Kruskal–Wallis test and pairwise comparison, was conducted using IBM SPSS 26.0. The Mann–Whitney test was performed for sightings of birds between migrant and non-migrant seasons.

3. Results

Bird diversity did not significantly differ between the study sites ($H = 11.5$, $df = 7$, $p > 0.05$; Kruskal–Wallis test). The total number of records differed among the studied sites (Table 2). The present study recorded a total of 12,851 sightings of 107 species belonging to 45 families (Table A1 Appendix A). Of these species, 36 were migrants and 15 migrant species were recorded in all the sites. Among recorded migrants, 32 were recorded in Fishing 2 and Road 1. The lowest number of migrants (22) was recorded in Palmyra 1. The sites are not significantly different from each other as per the Sørensen qualitative

index (Sørensen qualitative index with pairwise post hoc comparison; $p = 0.464$; Kruskal-Wallis test) (Table S1). The monthly variation in bird abundance in the Sarasalai mangrove showed an increasing trend in abundance towards the migratory months (Figure S1). Road 1 shows a rapid increase in abundance in the month of October. However, it also shows a notable decline in November. Moreover, Fishing 1 and Road 2 show a rapid increase in the month of November (Figure S1). Among the recorded families, Scolopacidae was the highest-recorded family in all sites while Haematopodidae was the least (Figure S4). The critically endangered Indian Spot-billed Duck (*Anas poecilorhyncha*) abundance varied from 13 (0.2031 (Mean) \pm 0.0809 (SE)) to 99 (1.238 (Mean) \pm 0.357 (SE)) towards the migratory period. They were absent from April to May. The rare Glossy Ibis (*Plegadis falcinellus*) abundance varied from 79 (1.234 (Mean) \pm 0.449 (SE)) to 189 (2.362 (Mean) \pm 0.661 (SE)) towards the migratory period and was absent during the month of April. Bird records significantly differed between migrant (103 (Mean) \pm 111.1 (SD)) and non-migrant (57.7 (Mean) \pm 32.18 (SD)) seasons (Mann-Whitney test; $U = 879$, $p = 0.001$).

Table 2. Diversity indices in the different sampling stations in the proposed Sarasalai mangrove reserve.

Location	Palmyra 1	Palmyra 2	Fishing 1	Road 1	Road 2	Fishing 2	Road 3	Road 4
Abundance (no. of records)	1512	1460	1620	3103	1770	1120	1047	1219
Richness	87	88	86	91	88	83	89	89
Shannon Diversity Index (H')	3.47	3.83	3.72	3.59	3.59	3.83	4.06	4.06
Simpson Index	0.0949	0.0325	0.0387	0.0534	0.0575	0.0304	0.0231	0.0229
Berger-Parker Dominance Index	0.2877	0.0767	0.1130	0.1650	0.1864	0.0634	0.0573	0.0673
Margalef Richness Index	11.7467	11.9410	11.5017	11.1939	11.633	11.6791	12.6552	12.3843
Reciprocal Simpson Index	10.4595	30.1329	25.4440	18.6045	17.2234	31.9218	41.6572	42.1609

3.1. Waterbird Diversity

A total of 58 waterbird species of 17 families were recorded during this study. The most abundant waterbirds recorded include Greater Flamingo (*Phoenicopterus roseus*) (6.55%), Purple Swampphen (*Porphyrio porphyrio*) (4.23%), Bridled Tern (*Onychoprion anaethetus*) (4.12%), Spot-billed Pelican (*Pelecanus philippensis*) (3.74%), Black-tailed Godwit (*Limosa limosa*) (3.57%), Painted Stork (*Mycteria leucocephala*) (3.10%), Sooty Tern (*Onychoprion fuscatus*) (2.55%), Little Tern (*Sternula albifrons*) (2.37%), Little Cormorant (*Microcarbo niger*) (2.33%), Roseate Tern (*Sterna dougallii*) (2.16%), Glossy Ibis (*Plegadis falcinellus*) (2.09%), and Asian Openbill (2%) (*Anastomus oscitans*) (Figure 3). The Greater Flamingo was the highest abundant waterbird species followed by Purple Swampphen (Figure S2). It is significant to report Glossy Ibis in the high abundance category, since this bird species was considered as locally extinct species a few years back in Sri Lanka [35].

3.2. Threatened and Northern Restricted Species Recorded during This Study

Indian Spot-billed Duck (*Anas poecilorhyncha*) was recorded in sampling sites Fishing 1, Road 1, Road 2, and Fishing 2. It is a critically endangered bird species in Sri Lanka. Indian Spot-billed Duck was most abundant in Road 1. The Glossy Ibis (*Plegadis falcinellus*), which was a rare migrant to Sri Lanka, was also recorded (Figure S3). It has been recorded that there is Glossy Ibis breeding activity in the south of Sri Lanka [36]. They were recorded at all the sites except for Palmyra 1. Of 107 species recorded, there were 9 nationally threatened bird species [37]. Northern restricted birds, such as Grey Francolin (*Francolinus pondicerianus*), Indian Spot-billed Duck (*Anas poecilorhyncha*), Eurasian Wigeon (*Mareca penelope*), Black Kite (*Milvus migrans*), Pied Avocet (*Recurvirostra avosetta*), Lesser Golden-backed Woodpecker (*Dinopium benghalense*), Eurasian Collared Dove (*Streptopelia decaocto*), and Black Drongo (*Dicrurus macrocercus*) were recorded during this study (Figure A1 Appendix B).

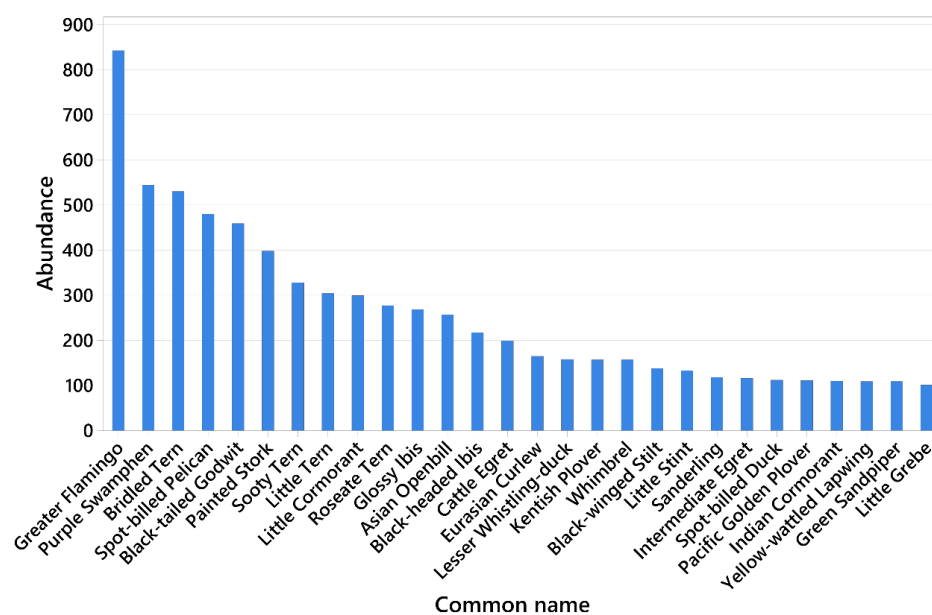


Figure 3. Abundance (number of records) of the most common waterbird species in the Sarasalai mangrove.

4. Discussion

Bird diversity did not significantly differ among the studied sites. The highest species richness was recorded in Road 1 that might be due to the availability of water year-round with suitable microhabitats for birds. The species richness is higher in Sarasalai mangrove than Sathurukondan mangrove in Batticaloa [38]. Moreover, tall grasses with some salt marsh in Road 1 provided the best habitats and cover for waterbirds. The lowest richness was recorded in Fishing 2, attributed to year-round low water availability and low mangrove density.

The proposed Sarasalai mangrove reserve is located in the Jaffna district, which is among the richest waterbird regions in Sri Lanka. High species richness has been recorded in the Sarasalai mangrove compared with some mangroves in India such as the Muthupet mangroves of Tamil Nadu [39]. The Indian subcontinent maybe rich in waterbirds because it lies at an endpoint of the Central Asian flyway (CAF) [40]. The CAF extends from northern Russia and Central Siberia through the Himalayas to the Indian subcontinent [41,42]. Some waders fly as far as 9,000 km from the arctic breeding grounds and to south India and Sri Lanka as their wintering ground, which is the southernmost end of the flyway [41,42]. Most of the winter visitors to Sri Lanka reach the southern tip of India along the eastern coastline and cross the Indian Ocean through the Palk Strait and finally enter Sri Lanka [22]. The island chain in the Gulf of Mannar supports a wintering ground for thousands of waders [42]. Habitat heterogeneity in the northern province including marshland, sand dunes, tidal flats, coastal lagoons and mangroves provides healthy stopover habitats for most of these winter visitors [43]. Hence, protecting these stopovers, including the Sarasalai mangrove reserve, will eventually protect habitats for most of the migrant birds flying from the northern hemisphere through the CAF during the winter season [21].

The abundance of birds on their wintering and stopover sites is influenced by local habitat characteristics such as cover patterns, moisture and biomass associated with invertebrate prey, and vegetative structure [44]. It is apparent that these ecological conditions and the availability of proper microhabitats are significant for their survival. According to Aarif et al. [45], relative humidity, air temperature, water temperature, salinity and invertebrate prey abundance can also affect the departure date of waders. During the migration as well as in the wintering ground, migrant birds need to feed; and for that, they stop at a number of sites along their migrant route, thus these sites must be productive and undisturbed [42]. Even birds such as Brown Headed Gull fly over the Himalayan Moun-

tain Range from the Tibetan plateau and travel as far as 3200 km to Mannar island [46]. Therefore, the conditions of these stopovers are critical for their survival during their stay.

Among the studied sites, Fishing 1, Road 1, and Road 2 show a drastic increase in abundance from October to December. This might be due to the availability of habitats for migrant waterbirds such as salt marshes and wetland habitats with suitable microhabitats. On the other hand, other study sites have not demonstrated such a drastic increase in abundance due to less availability of suitable microhabitats. Hence, it is obvious that these sensitive ecological conditions are playing a critical factor in the continuation of migrant birds in the proposed Sarasalai mangrove. However, the winter migrant population in the traditional wetlands in the last three decades is dwindling [42,47]. Among the major threats attributed to the sustainability of these wetlands is human disturbances [42].

Importantly, the Sarasalai mangrove shows considerable waterbird diversity. Among the recorded waterbirds, Greater Flamingo was the highest abundant species followed by the Purple-swamp Hen. However, Kandasamy et al. [17] recorded higher richness (65) from eight different locations studied in the Jaffna and Killinochchi districts than Sarasalai. Further, Wijesundara et al. [18] recorded 116 waterbirds in Jaffna, Killinochchi, Mullaitivu and Mannar in the northern province. Rare species such as Glossy Ibis and Indian Spot-billed Duck came under the common category. Spot-billed Duck was recorded in four of eight study sites, while Glossy Ibis was recorded in all study sites. Hence, the Sarasalai mangrove reserve can be considered among the best places to observe these rare species in Sri Lanka. Moreover, some northern restricted bird species were also recorded in this area. Therefore, the Sarasalai mangrove is ideal to promote community-based avitourism activities. According to Balachandra [42], knowledge of the status of bird populations on this stopover provides significant information on the wider environment such as climate change impact, habitat loss, development impact, unsustainable agricultural practices, and human disturbance. This study indicates that the above threats are in the primary stage and this would be the right time to implement the protective measures.

4.1. Livelihood Activities of People Depend

The local community has been conducting fishing activities in this area for many generations, especially in this mangrove forest. Their catch often contains brackish water fishes, some freshwater species and prawns. Many families depend entirely on this mangrove reserve for their livelihood. Despite their dependence on the mangroves of Sarasale, destruction activities such as extraction of mangroves for firewood, construction, and fishing nest-making continue.

4.2. Threats to the Proposed Sarasalai Mangrove

The major threat to this mangrove reserve is the Chavakchcheri-Puloli main road. This road has been constructed through the mangrove habitat, fragmenting the mangrove habitat into two parts. This fragmentation has negatively affected this mangrove reserve. Bird hits on vehicles are common due to this road and many birds collide due to speeding vehicles. Moreover, the dumping of garbage is common around the area and threatens the entire habitat. Extractive activity is also present, sometimes extensive, removing mangroves for various purposes (Figure 4). Encroachment is also common around this mangrove reserve, especially for farming activities. As Bart et al. [48] stated, the main driver for declining waders in most of the counties was habitat degradation and the same factor is applicable for this mangrove reserve. Bird hunting is a common practice, especially during the migratory season that creates a major threat to the avifauna in the Sarasalai mangrove. The lack of awareness among people of the importance of this mangrove ecosystem and its ecological values is among the main factors driving destruction. Finally, a proper governing body to protect this mangrove has not been assigned although the Forest Department has placed an information board. Hence, unchecked destruction activities continue on a daily basis.



Figure 4. Threats to the Sarasalai mangrove reserve. (A) Dumping of garbage; (B) cleared mangrove *Lumnitzera racemosa*; (C) dumping of garbage close to the main road; (D) dead bird due to unverified reason.

4.3. Recommendations

There is no clear boundary demarcation for the Sarasalai mangrove reserve although the Forest Department has mentioned the extent of the reserve in their information board. People continue illegal activities such as bird hunting and cutting mangroves even within sensitive areas. Therefore, clear boundary demarcation is of uttermost important to protect this ecosystem. The mangrove habitat is already fragmented due to the construction of the main road. Hence, speeding vehicles frequently collide with flying birds. We recommend introducing speed bumps to slow down vehicle speeds when traveling through the mangrove. Further, road controls and attractive sign boards should be placed by the road to inform people of the ecological value of Sarasale. Awareness programs to convey the importance of this ecosystem and its protection to people should be carried out. This mangrove forest is yet to be declared a mangrove forest, remaining a proposed mangrove. Hence, it must be declared as an important mangrove habitat with an important migratory bird area to strengthen its legal protection. Since the sampling stations in this study are limited to areas close to the roads and only conducted over an eight-month period, further studies are required to investigate the population dynamics, activity patterns, feeding behavior, breeding, etc., of the birds. Further, there are many understudied mangrove sites in the Jaffna peninsula, hence these studies can be extended to the mangrove habitats in the entire Jaffna district.

5. Conclusions

The present study indicates the significance of the Sarasalai mangrove as a place for bird diversity, especially for waterbirds. The Sarasalai mangrove has never been studied for bird-related studies. The present study recorded 107 avian species of 45 families. These include one critically endangered species and eight northern restricted bird species from the Sarasalai mangrove reserve. The presence of Greater Flamingos at the highest abundance during the migratory season indicates the importance of the conservation of this mangrove. It has been shown that the Sarasalai mangrove reserve is an important site for both resident

and migrant bird species; therefore, further studies are recommended. For instance, such studies should include investigating feeding areas, determining turnover, determining microbenthic biomass in feeding sites, identification of prey items and determining the availability of benthic and other prey. The Sarasalai mangrove faces several threats including encroachment, illegal bird hunting, and mangrove extraction. Therefore, necessary steps should be taken to protect this important bird habitat in the future.

Supplementary Materials: The following are available online at <https://www.mdpi.com/article/10.3390/birds4010009/s1>, Table S1: Pairwise comparison of Sorensen Coefficient index; Figure S1: Monthly variation of bird abundance in different sampling points in Sarasalai proposed mangrove, Figure S4: Composition of birds in eight locations in Sarasalai proposed mangrove, Figure S2: A flock of Greater Flamingos in Sarasalai mangrove, Figure S3: Two rare and nationally threatened birds from Sarasalai mangrove (A; Glossy Ibis, B; Indian Spot-billed Duck).

Author Contributions: Conceptualization, N.A. and S.M.; methodology, S.M.; software, S.M.; validation, S.M. and N.A.; formal analysis, S.M.; investigation, N.A.; resources, N.A. and C.C.; data curation, N.A.; writing—original draft preparation, S.M.; writing—review and editing, S.M.; visualization, N.A.; supervision, S.M.; project administration, N.A. and C.C.; All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Status of avifauna in the Sarasalai mangrove reserve.

	Scientific Name	Common Name	Family	M/R	NCS
1	<i>Francolinus pondicerianus</i>	Grey Francolin	Phasianidae	R	EN
2	<i>Dendrocygna javanica</i>	Lesser Whistling Duck	Anatidae	R	LC
3	<i>Tadorna ferruginea</i>	Ruddy Shelduck	Anatidae	M	LC
4	<i>Anas poecilorhyncha</i>	Spot-Billed Duck	Anatidae	R	CR
5	<i>Mareca penelope</i>	Eurasian Wigeon	Anatidae	M	LC
6	<i>Spatula clypeata</i>	Northern Shoveler	Anatidae	M	LC
7	<i>Anas acuta</i>	Northern Pintail	Anatidae	M	LC
8	<i>Spatula querquedula</i>	Garganey	Anatidae	M	LC
9	<i>Phoenicopiterus roseus</i>	Greater Flamingo	Phoenicopteridae	M	LC
10	<i>Mycteria leucocephala</i>	Painted Stork	Ciconiidae	R	LC
11	<i>Anastomus oscitans</i>	Asian Openbill	Ciconiidae	R	LC
12	<i>Threskiornis melanocephalus</i>	Black-Headed Ibis	Threskiornithidae	R	LC
13	<i>Plegadis falcinellus</i>	Glossy Ibis	Threskiornithidae	M	DD
14	<i>Nycticorax nycticorax</i>	Black-crowned Night Heron	Ardeidae	R	LC
15	<i>Butorides striata</i>	Striated Heron	Ardeidae	R	LC
16	<i>Ardeola grayii</i>	Indian Pond Heron	Ardeidae	R	LC
17	<i>Ardea cinerea</i>	Grey Heron	Ardeidae	R	LC
18	<i>Ardea purpurea</i>	Purple Heron	Ardeidae	R	LC
19	<i>Bubulcus ibis</i>	Cattle Egret	Ardeidae	R	LC
20	<i>Ardea alba</i>	Great Egret	Ardeidae	R	LC

Table A1. Cont.

	Scientific Name	Common Name	Family	M/R	NCS
21	<i>Ardea intermedia</i>	Intermediate Egret	Ardeidae	R	LC
22	<i>Egretta garzetta</i>	Little Egret	Ardeidae	R	LC
23	<i>Pelecanus philippensis</i>	Spot-Billed Pelican	Pelecanidae	R	LC
24	<i>Tachybaptus ruficollis</i>	Little Grebe	Podicipedidae	R	LC
25	<i>Microcarbo niger</i>	Little Cormorant	Phalacrocoracidae	R	LC
26	<i>Phalacrocorax fuscicollis</i>	Indian Cormorant	Phalacrocoracidae	R	LC
27	<i>Anhinga melanogaster</i>	Oriental Darter	Anhingidae	R	LC
28	<i>Milvus migrans</i>	Black Kite	Accipitridae	R	LC
29	<i>Haliastur indus</i>	Brahminy Kite	Accipitridae	R	LC
30	<i>Accipiter badius</i>	Shikra	Accipitridae	R	LC
31	<i>Amaurornis phoenicurus</i>	White-breasted Waterhen	Rallidae	R	LC
32	<i>Porphyrio porphyrio</i>	Purple Swampphen	Rallidae	R	LC
33	<i>Burhinus oedicnemus</i>	Eurasian Thick-knee	Burhinidae	R	LC
34	<i>Haematopus ostralegus</i>	Eurasian Oystercatcher	Haematopodidae	M	LC
35	<i>Himantopus himantopus</i>	Black-Winged Stilt	Recurvirostridae	R	LC
36	<i>Recurvirostra avosetta</i>	Pied Avocet	Recurvirostridae	M	LC
37	<i>Vanellus malabaricus</i>	Yellow-Wattled Lapwing	Charadriidae	R	LC
38	<i>Vanellus indicus</i>	Red-wattled Lapwing	Charadriidae	R	LC
39	<i>Pluvialis fulva</i>	Pacific Golden Plover	Charadriidae	M	LC
40	<i>Charadrius asiaticus</i>	Caspian Plover	Charadriidae	M	LC
41	<i>Charadrius alexandrinus</i>	Kentish Plover	Charadriidae	R	EN
42	<i>Lymnocyptes minimus</i>	Jack Snipe	Scolopacidae	M	LC
43	<i>Limosa limosa</i>	Black-tailed Godwit	Scolopacidae	M	LC
44	<i>Numenius phaeopus</i>	Whimbrel	Scolopacidae	M	LC
45	<i>Numenius arquata</i>	Eurasian Curlew	Scolopacidae	M	LC
46	<i>Tringa totanus</i>	Common Redshank	Scolopacidae	M	LC
47	<i>Tringa stagnatilis</i>	Marsh Sandpiper	Scolopacidae	M	LC
48	<i>Tringa nebularia</i>	Common Greenshank	Scolopacidae	M	LC
49	<i>Tringa ochropus</i>	Green Sandpiper	Scolopacidae	M	LC
50	<i>Tringa glareola</i>	Wood Sandpiper	Scolopacidae	M	LC
51	<i>Actitis hypoleucos</i>	Common Sandpiper	Scolopacidae	M	LC
52	<i>Arenaria interpres</i>	Ruddy Turnstone	Scolopacidae	M	LC
53	<i>Calidris tenuirostris</i>	Great Knot	Scolopacidae	M	LC
54	<i>Calidris alba</i>	Sanderling	Scolopacidae	M	LC
55	<i>Calidris minuta</i>	Little Stint	Scolopacidae	M	LC
56	<i>Calidris temminckii</i>	Temminck's Stint	Scolopacidae	M	LC
57	<i>Calidris ferruginea</i>	Curlew Sandpiper	Scolopacidae	M	LC
58	<i>Sterna dougallii</i>	Roseate Tern	Laridae	R	CR
59	<i>Sternula albifrons</i>	Little Tern	Laridae	R	VU
60	<i>Onychoprion anaethetus</i>	Bridled Tern	Laridae	M, R	CR
61	<i>Onychoprion fuscatus</i>	Sooty Tern	Laridae	M, R	CR
62	<i>Columba livia</i>	Common Pigeon	Columbidae	R	LC
63	<i>Streptopelia decaocto</i>	Eurasian Collard Dove	Columbidae	R	NT
64	<i>Spilopelia chinensis</i>	Spotted Dove	Columbidae	R	LC
65	<i>Psittacula krameri</i>	Rose-Ringed Parakeet	Psittaculidae	R	LC
66	<i>Clamator jacobinus</i>	Jacobin Cuckoo	Cuculidae	R	LC
67	<i>Eudynamis scolopaceus</i>	Asian Koel	Cuculidae	R	LC
68	<i>Centropus sinensis</i>	Greater Coucal	Cuculidae	R	LC

Table A1. Cont.

	Scientific Name	Common Name	Family	M/R	NCS
69	<i>Aerodramus unicolor</i>	Indian Swiftlet	Apodidae	R	LC
70	<i>Coracias benghalensis</i>	Indian Roller	Coraciidae	R	LC
71	<i>Merops orientalis</i>	Green Bee-Eater	Meropidae	R	LC
72	<i>Merops philippinus</i>	Blue-tailed Bee-eater	Meropidae	M	CR
73	<i>Pelargopsis capensis</i>	Stork-Billed Kingfisher	Alcedinidae	R	LC
74	<i>Halcyon smyrnensis</i>	White-throated Kingfisher	Alcedinidae	R	LC
75	<i>Alcedo atthis</i>	Common Kingfisher	Alcedinidae	R	LC
76	<i>Ceryle rudis</i>	Pied Kingfisher	Alcedinidae	R	LC
77	<i>Megalaima zeylanica</i>	Brown-headed Barbet	Megalaimidae	R	LC
78	<i>Dinopium benghalense</i>	Lesser Golden-Backed Woodpecker	Picidae	R	LC
79	<i>Pitta brachyura</i>	Indian Pitta	Pittidae	M	LC
80	<i>Oriolus xanthornus</i>	Black Hooded Oriole	Oriolidae	R	LC
81	<i>Corvus splendens</i>	House Crow	Corvidae	R	LC
82	<i>Corvus macrorhynchos</i>	Large-billed Crow	Corvidae	R	LC
83	<i>Hirundo rustica</i>	Barn Swallow	Hirundinidae	M	LC
84	<i>Artamus fuscus</i>	Ashy Woodswallow	Artamidae	R	LC
85	<i>Dicrurus macrocercus</i>	Black Drongo	Dicruridae	R	LC
86	<i>Dicrurus leucophaeus</i>	Ashy Drongo	Dicruridae	M	LC
87	<i>Anthus richardi</i>	Richard's Pipit	Motacillidae	M	LC
88	<i>Anthus rufulus</i>	Paddyfield Pipit	Motacillidae	R	LC
89	<i>Anthus godlewskii</i>	Blyth's Pipit	Motacillidae	M	LC
90	<i>Alauda gulgula</i>	Oriental Skylark	Alaudidae	R	LC
91	<i>Eremopterix griseus</i>	Ashy-crowned Sparrow Lark	Alaudidae	R	LC
92	<i>Pycnonotus cafer</i>	Red-vented Bulbul	Pycnonotidae	R	LC
93	<i>Pycnonotus luteolus</i>	White-browed Bulbul	Pycnonotidae	R	LC
94	<i>Prinia hodgsonii</i>	Grey-breasted Prinia	Cisticolidae	R	LC
95	<i>Prinia inornata</i>	Plain Prinia	Cisticolidae	R	LC
96	<i>Orthotomus sutorius</i>	Common Tailorbird	Cisticolidae	R	LC
97	<i>Phylloscopus trochiloides</i>	Greenish Warbler	Parulidae	M	LC
98	<i>Turdoides affinis</i>	Yellow-billed Babbler	Leiothrichidae	R	LC
99	<i>Acridotheres tristis</i>	Common Myna	Sturnidae	R	LC
100	<i>Copsychus saularis</i>	Oriental Magpie-robin	Muscicapidae	R	LC
101	<i>Saxicoloides fulicatus</i>	Indian Robin	Muscicapidae	R	LC
102	<i>Dicaeum erythrorhynchos</i>	Pale-billed Flowerpecker	Dicaeidae	R	LC
103	<i>Cinnyris asiaticus</i>	Purple Sunbird	Nectariniidae	R	LC
104	<i>Cinnyris lotenius</i>	Loten's Sunbird	Nectariniidae	R	LC
105	<i>Ploceus philippinus</i>	Baya Weaver	Ploceidae	R	LC
106	<i>Passer domesticus</i>	House Sparrow	Passeridae	R	LC
107	<i>Euodice malabarica</i>	Indian Silverbill	Passeridae	R	LC

NCS—national conservation status, CR—critically endangered, NT—near threatened, LC—least concern, VU—vulnerable, DD—data deficient, R—resident, M—migrant, and M, R—major migrant population with minor resident population [19,37].

Appendix B

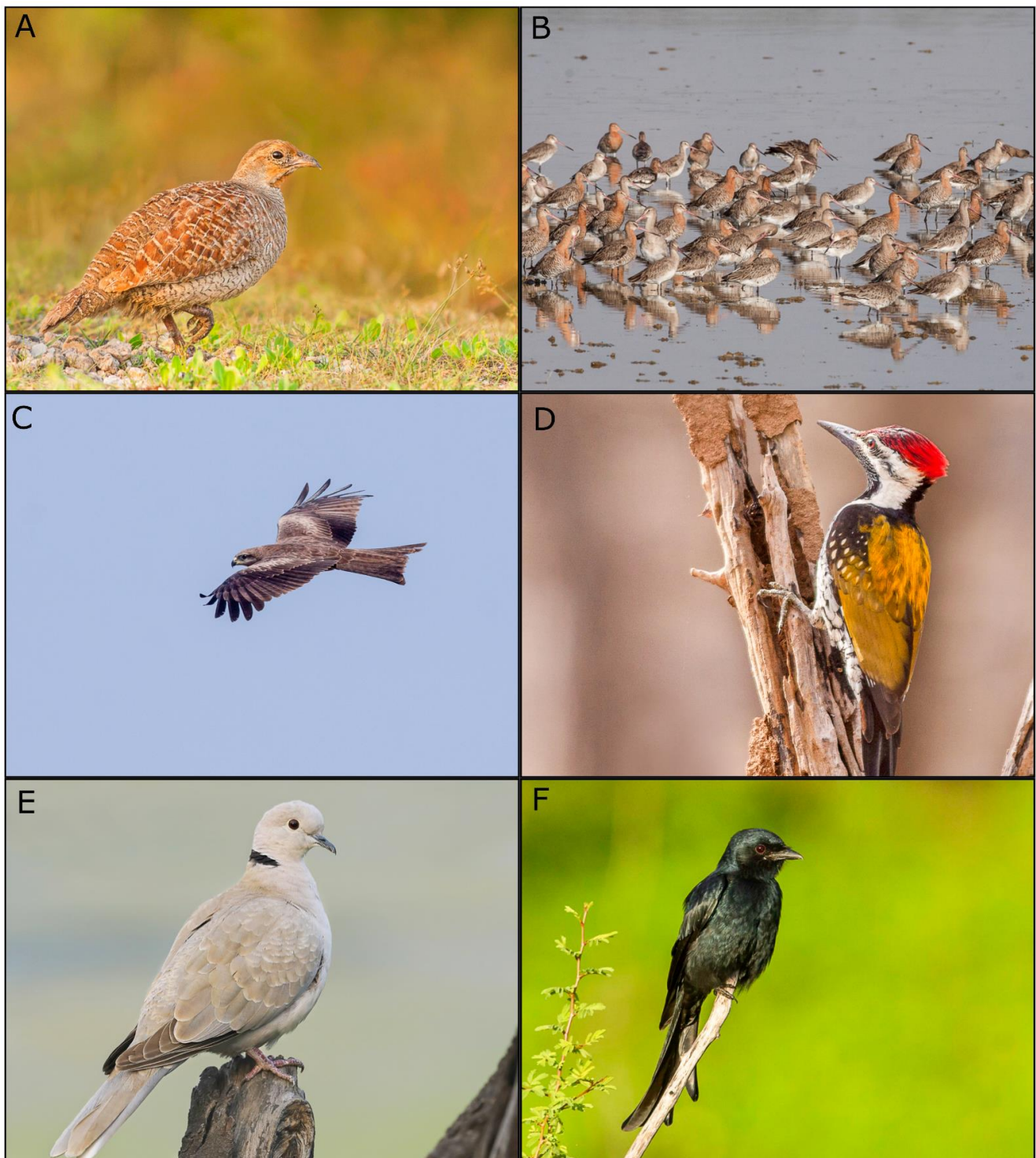


Figure A1. Some northern restricted bird species recorded in the Sarasalai mangrove. (A) Gray Francoline, (B) a flock of Black-tailed Godwit, (C) Black Kite, (D) Lesser Golden-backed Woodpecker, (E) Eurasian Collared Dove, and (F) Black Drongo.

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