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**Cover: Life and death in one night - wolf hunting the hare. Mixed media—gouache, acrylics, pen & colour pencils. © Dupati Poojitha.**

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ARTICLE

# Avifaunal diversity and conservation significance of coastal ecosystems on Rameswaram Island, Tamil Nadu, India

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**Abstract:** Biodiversity-rich areas tied to heritage, religious tourism, and ecotourism, often face changes to their landscapes due to infrastructure development. Such activities may threaten the species survival and disrupt the delicate ecosystems in these regions. Hence it becomes imperative to build up baseline species data from such areas for biodiversity conservation and management interventions. Towards achieving this objective, avifaunal inventories were documented from Kothandaramar Lagoon, Dhanushkodi Lagoon, and the Arichalmunai beach in Rameswaram Island, Ramanathapuram District, Tamil Nadu, which is an important site for winter migrants. A total of 147 avian species belonging to 17 orders and 45 families from August 2021 to July 2023 were recorded. Order-wise, Charadriiformes (52 species) dominated the area, followed by Passeriformes (27 species) and Pelecaniformes (21 species). According to the IUCN Red List of Threatened Species, 11 'Near Threatened', three 'Vulnerable', two 'Endangered' (Great Knot *Calidris tenuirostris* and Siberian Sandplover *Anarhynchus mongolus*), and one unassessed species (Hanuman Plover *Charadrius seebohmi*) were recorded. The relative abundance based on the frequency of observations indicated that 61% (90 species) were common, 22% (32 species) were uncommon, and 17% (25 species) were rare. Winter visitors constituted 42% (62 species) and one was a passage migrant (Rosy Starling *Pastor roseus*). Coastal lagoons of this region comprise diverse habitats that play a vital role for birds, which provide places for nesting, roosting, and foraging. This baseline data emphasizes the importance of Dhanushkodi Lagoon along with adjacent areas as an important wintering site on the southeastern coast of India for migratory shorebirds as well as highlights the importance of adjoining small forested patches thus required to be declared as a protected area.

**Keywords:** Bird migration, Central Asian Flyway, Gulf of Mannar, Hanuman Plover breeding, over-summering, shorebirds, waterbirds, winter visitors.

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**Competing interests:** The authors declare no competing interests.

**Author details:** Byju, H., has worked on the shorebirds and waterbirds in the Gulf of Mannar region for a decade and at present a member of the biodiversity panel of five bird sanctuaries including two Ramsar sites and the Gulf of Mannar Biosphere Reserve. Maitreyi, H., is a research scholar working on seabirds in the region. Raveendran, N., is a naturalist with a decade of experience in birds and awareness education and serves as a biodiversity member in the bird sanctuaries and Gulf of Mannar Biosphere Reserve. Ravichandran, S., is a professor with three decades of experience in marine ecology and oceanography.

**Author contributions:** BH—conceptualization, writing, editing and supervision, MH—writing, editing, data management and maps, RN—data curation; SR—editing and overall supervision.

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## INTRODUCTION

India is home to numerous biodiversity hotspots including those designated as Ramsar sites (Sandilyan 2017). Wetlands including coastal lagoons, characterized by shallow water bodies separated by natural barriers like sandbars or coral reefs support diverse avifauna, both migratory and resident (Chandana et al. 2012; Silva et al. 2013). Coastal lagoons are critical habitats for migratory shorebirds such as mudflats, beaches, or mangroves (Alfaro & Clara 2007). Migratory shorebirds are a global indicator species for habitat changes (Piersma & Lindstrom 2004). As India experiences a massive economic boom, many unprotected areas are under severe strain on landscape changes and biodiversity loss, and many of these areas lack biodiversity documentation to understand the actual loss. Documentation of avifaunal diversity and distribution in India (Ali & Ripley 1987) has played a pivotal role in assessing long-term landscape changes (Rika & Santosa 2007). Bird surveys represent a valuable tool in gathering pertinent information and aid in identifying priority conservation sites (Peterson et al. 2000) as the structural composition of bird communities within an area provides invaluable insights into landscape changes over time (Kattan & Franco 2004). This comprehensive understanding has facilitated ecological assessments and conservation planning efforts (Kati & Sekercioglu 2006), leading to the development of management strategies and interventions (Paul & Cooper 2005).

The Ramanathapuram District in Tamil Nadu harbours five bird sanctuaries, including two Ramsar sites and the Gulf of Mannar (GoM) Biosphere Reserve, an Important Bird and Biodiversity Area (IBA). Recent records of an Arctic Skua *Stercorarius parasiticus* (Byju & Raveendran 2022a) and an uncommon sighting of a Light-mantled Albatross *Phoebetria palpebrate* (Byju & Raveendran 2022b) underscore the importance of bird monitoring efforts in the island. It also highlights the necessity of conducting field surveys to establish bird population data in new or adjoining areas of well-established bird congregation sites (Llanos et al. 2011). Extensive research and conservation interventions will help manage threats like pollution, habitat loss, hunting, disturbance, or impact of climate change. Several reports emphasized that habitat destruction is one of the vital reasons for the decline of waterbirds (Brooks et al. 2002; Sandilyan et al. 2010). Coastal wetlands of tropical countries including India, face impounding anthropogenic pressures, leading to the rapid loss of these ecosystems. Most of such pressures are related to the conversion of the coastal wetlands for agriculture, aquaculture, tourism, transport, construction, and disposal of industrial wastes and untreated sewage (Prasad et al. 2002; Bassi et al. 2014). Avifaunal updates from the district include documentation from the 21 islands within the GoM (Byju et al. 2023a) and identification of a new wintering sites within the Karangadu Mangroves (Byju et al. 2023b) and Valinokkam Lagoon (Byju et al. 2023c). Through intensive monitoring, three breeding sites of the new taxon, i.e., Hanuman Plover *Charadrius seebohmi* from the Kentish Plover subspecies *Charadrius alexandrinus seebohmi* have been discovered in the district (Byju et al. 2023d), which encompasses the current study area.

The mentioned findings from the region underscore the importance of gathering baseline data from previously unexplored regions to designate areas of conservation significance. Consequently, the present study on the Kothandaramar Lagoon, Dhanushkodi Lagoon, and Arichalmunai Beach in Rameswaram Island was devised to compile an avifaunal checklist since this is an important bird congregation place for long distant migrant shorebirds on the GoM region in the Central Asian Flyway (CAF) (Rashiba et al. 2022) and the findings will contribute to declare it as a protected area. Additionally, our additional objectives of the study include the impact of tourism on the coastal areas by vehicles and plastic waste disposal by the visitors (religious, heritage, and ecotourism initiatives).

## MATERIALS AND METHODS

### Study Area

The study area extended from the Rameswaram Reserve Forest up to Arichalmunai Beach encompassing the 15 km long Dhanushkodi Lagoon (Image 1). It consists of the Kothandaramar Lagoon, Dhanushkodi Lagoon, and Arichalmunai Beach, which hereafter is referred to as Dhanushkodi Lagoon (9.15–9.27 N & 79.32–79.44 E). This area includes zones that are muddy and flooded with rain water during winter months like Kothandaramar Lagoon which is surrounded by the Bay of Bengal and GoM, having saline water which leads to plenty of phytoplankton including diatoms, dinoflagellates, and blue green algae. It provides a foraging ground for flamingos. The Arichalmunai part is exclusively marine earlier with sandy beaches but some muddy substratum of late becoming sandier; the central part near Mukundarayar Chatram and Dhanushkodi is a mixture of sandy clay and thus intermediate between the other two zones.

**Field Surveys**

In Dhanushkodi Lagoon, field surveys were conducted monthly from August 2021 to July 2023. The surveys focused on observing bird activity during the peak hours, at 0600–1000 h and 1600–1800 h. The methodology employed a combination of block count and direct visual count methods (Howes & Bakewell 1989; Bibby et al. 2000). Eleven vantage points (Image 1) were identified along the entire stretch of the lagoon considering the consistent water availability and congregation patterns, with distances ranging 600–1,500 m starting from the forested patch. Observations were conducted using Nikon binoculars (10 x 50) and photographs were taken with a Canon camera with 100–400 mm lens and later identified with the help of field guides (Grimmett et al. 2011; Hayman et al. 2011). Since this is a 15-km long stretch with different tidal variations, survey were conducted during low tides when the maximum bird activity was there, mainly for waterbirds. A 5-min setting period was observed at each vantage point to allow the waterbirds to settle down to the human presence. Land birds were recorded as and when it was observed at each vantage point for 15 min. The observations recorded while moving from one vantage point to another were entered as incidental records. The residential status of the birds was grouped as resident (R), resident/ non-breeding (R/NB), passage migrant (PM), and winter visitor (WV) depending on their timing and duration of occurrence (Grimmett et al. 2011). The common name, scientific name, and IUCN Red List status are followed (IUCN 2024). The relative abundance of species was based on the frequency of observation as common (C): frequently observed in the study area (encountered on most visits 6–8/10 visits); uncommon (UC): spotted on multiple occasions but not as frequently as in the case of common (encountered less than 3–5/10 visits); rare (R): less frequently encountered in the entire study period (encountered 1–2/10 visits) (Mackinnon & Philips 1993).

To understand the impact on the number of tourists visiting the Arichalmunai region of the island, the number of tourist vehicles and the local vehicles plying on the road were counted, with the help of the forest department from the forest check post exclusively for plastic usage deterrence in the area. An average of 300 tourist vehicles plies were found along with 200 local vehicles to Kothandaramar Temple (religious tourism) and beyond to Arichalmunai (beach drive) every weekday (Image 12). This increased up to 700

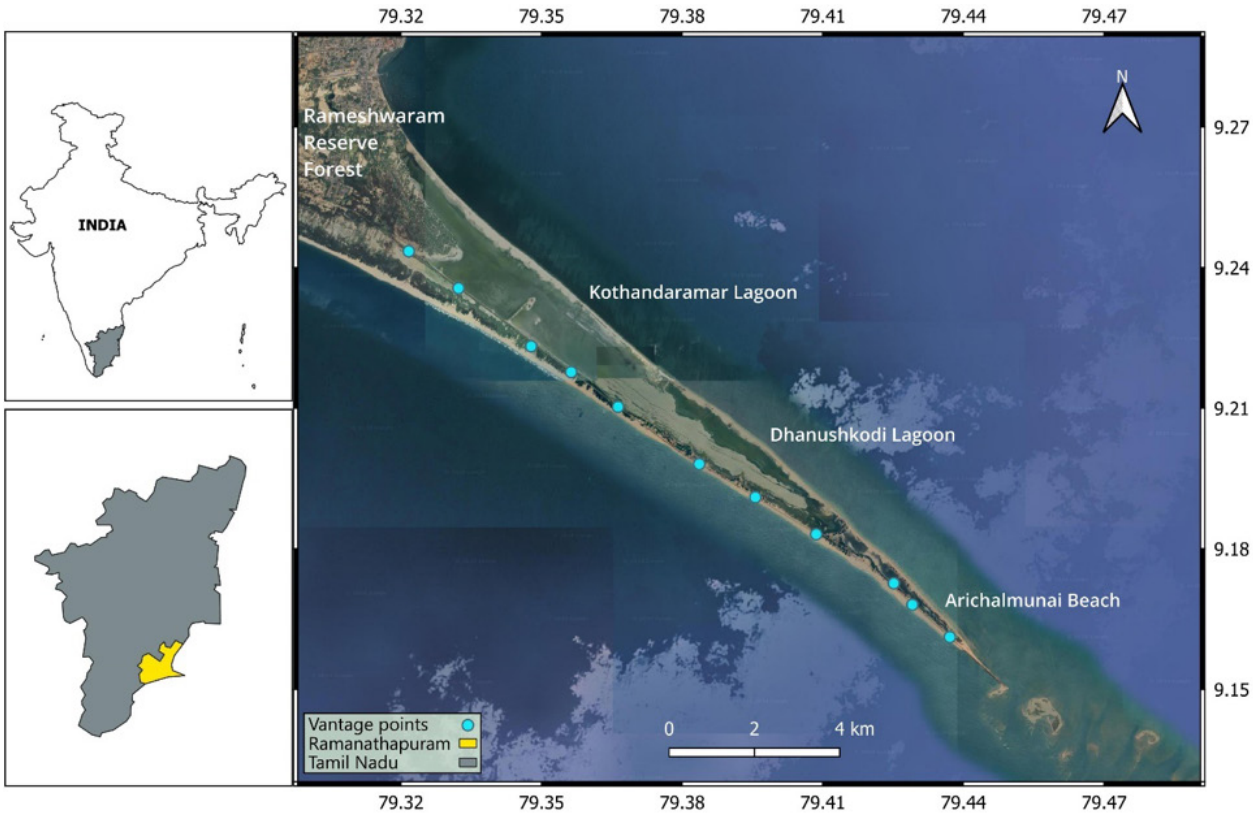


**Image 1. Study area showing the vantage points in Dhanushkodi Lagoon.**

during weekends with 300 local vehicles (total 1,000). Assuming a vehicle can accommodate an average of four people (a tourist van can hold up to 15), the number of tourists could be 2,000–4,000 individuals per day/week and up to 800,000/year. The area is restricted for tourists after 1800h and a few fishermen community stay there overnight, for fishing purposes.

## RESULTS AND DISCUSSION

A total of 147 avian species across 17 orders and 45 families from the study area (Table 1) (Images 2–8) were recorded. Order Charadriiformes was the most dominant (52 species), represented by families of Scolopacidae (25 species), Laridae (17 species), and Charadriidae (10 species). The other major representation of orders was Passeriformes (27 species), Pelecaniformes (21 species), and Accipitriformes (10 species) (Figure 1). The residential status of the birds revealed that winter visitors (WV) constituted 42% (62 species) and one (i.e., Rosy Starling *Pastor roseus*) was passage migrant (PM). Three species of local migrants (LM) recorded, were Western Reef Egret *Egretta gularis*, White-bellied Sea Eagle *Icthyophaga leucogaster,* and Oriental Honey Buzzard *Pernis ptilorhynchus*. Among the avifauna recorded, 54 species constituted 36.7% of residents (R), and 26 species (17.6%) were residents but non-breeding (R/NB). The relative abundance based on the frequency of observation indicated that 90 species (61.2%) were common, 32 species (21.7%) were uncommon, and 25 species (17%) were rare.

The arrival of migrants usually begins in the first week of August and departure of migrants extend till the last week of April to the first week of May. Family Stercorariidae with two exclusive seabirds, Arctic Skua *Sterocorarius parasiticus* and Pomarine Skua *Sterocorarius pomarinus*; rare seabirds like Flesh-footed Shearwater *Ardenna carneipes*; and rare shorebirds like Red-necked Phalarope *Phalaropus lobatus* were recorded during the migratory period. Among the Laridae family, Bridled Tern *Onychoprion anaethetus*, Sooty Tern *Onychocommonprion fuscatus,* and White-winged Tern *Chilidonias leucopterus* are the highlighted (rare) species from the study area. Eleven 'Near Threatened' (NT) species were documented during the study period, all of which are waterbirds or shorebirds: Bar-tailed Godwit *Limosa lapponica,* Black-tailed Godwit *Limosa limosa*, Ruddy Turnstone *Arenaria interpres*, Dunlin *Calidris alpina*, Eurasian Curlew *Numenius arquata,* Great Stone-curlew *Esacus recurvirostris*, Red-necked Stint *Calidris ruficollis,* Red Knot *Calidris canutus,* Spot-billed

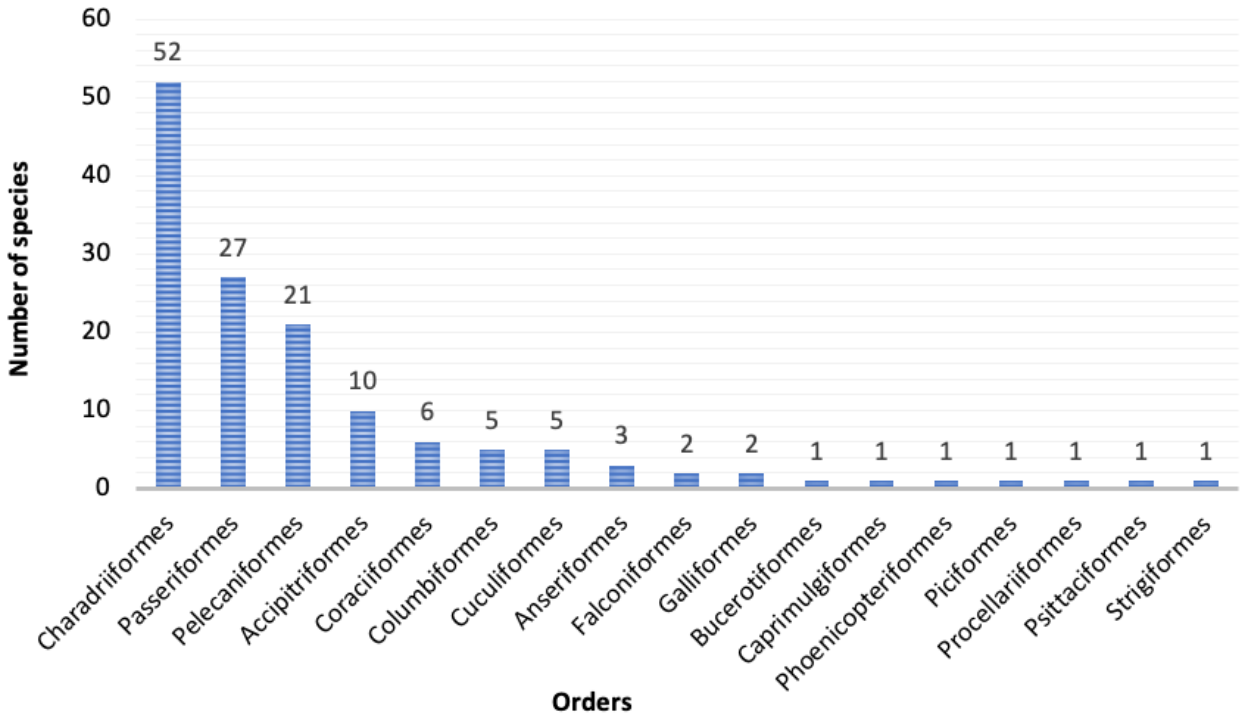


**Figure 1. Order-wise representation of bird species at Dhanushkodi Lagoon.**

**Table 1. Avifaunal checklist of Dhanushkodi Lagoon of Ramanathapuram, Tamil Nadu, India**

| | Order/Family/Common name | Scientific name | Global IUCN Red List status | Resident status | Relative abundance |
|---|---|---|---|---|---|
| | **Anseriformes: Anatidae** | | | | |
| 1 | Knob-billed Duck | *Sarkidiornis melanotos* | LC | R/NB | Ra |
| 2 | Indian Spot-billed Duck | *Anas poecilorhyncha* | LC | R/NB | Ra |
| 3 | Northern Pintail | *Anas acuta* | LC | WV | Ra |
| | **Phoenicopteriformes: Phoenicopteridae** | | | | |
| 4 | Greater Flamingo | *Phoenicopterus roseus* | LC | R/NB | C |
| | **Columbiformes: Columbidae** | | | | |
| 5 | Rock Pigeon | *Columba livia* | LC | R | C |
| 6 | Spotted Dove | *Spilopelia chinensis* | LC | R | C |
| 7 | Eurasian collared Dove | *Streptopelia decaocto* | LC | R | C |
| 8 | Laughing Dove | *Spilopelia senegalensis* | LC | R | C |
| 9 | Red Collared Dove | *Streptopella tranquebarica* | LC | R | UC |
| | **Caprimulgiformes: Apodidae** | | | | |
| 10 | Asian Palm Swift | *Cypsiurus balasiensis* | LC | R | C |
| | **Cuculiformes: Cuculidae** | | | | |
| 11 | Asian Koel | *Eudynamys scolopaceus* | LC | R | C |
| 12 | Grey-bellied Cuckoo | *Cacomantis passerinus* | LC | R | Ra |
| 13 | Greater Coucal | *Centropus sinensis* | LC | R | C |
| 14 | Blue-faced Malkoha | *Phaenicophaeus viridirostris* | LC | R | C |
| 15 | Pied Crested Cuckoo | *Clamator jacobinus* | LC | R/NB | C |
| | **Galliformes: Phasianidae** | | | | |
| 16 | Grey Francolin | *Ortygornis pondicerianus* | LC | R | C |
| 17 | Indian Peafowl | *Pavo cristatus* | LC | R | C |
| | **Pelecaniformes: Ciconiidae** | | | | |
| 18 | Asian Openbill | *Anastomus oscitans* | LC | R/NB | C |
| 19 | Painted Stork | *Mycteria leucocephala* | LC | R/NB | C |
| | **Pelecanidae** | | | | |
| 20 | Spot-billed Pelican | *Pelecanus philippensis* | NT | R/NB | C |
| | **Ardeidae** | | | | |
| 21 | Black-crowned Night Heron | *Nycticorax nycticorax* | LC | R/NB | C |
| 22 | Eastern Cattle Egret | *Bubulcus coromandus* | LC | R/NB | C |
| 23 | Purple Heron | *Ardea purpurea* | LC | R/NB | UC |
| 24 | Grey Heron | *Ardea cinerea* | LC | R/NB | C |
| 25 | Indian Pond Heron | *Ardeola grayii* | LC | R/NB | C |
| 26 | Intermediate Egret | *Ardea intermedia* | LC | R/NB | C |
| 27 | Great Egret | *Ardea alba* | LC | R/NB | C |
| 28 | Little Egret | *Egretta garzetta* | LC | R/NB | C |
| 29 | Striated Heron | *Butorides striata* | LC | R/NB | C |
| 30 | Western Reef Egret | *Egretta gularis* | LC | LM | UC |
| | **Threskiornithidae** | | | | |
| 31 | Black-headed Ibis | *Threskiornis melanocephalus* | LC | R/NB | UC |
| 32 | Red-naped Ibis | *Pseudibis papillosa* | LC | R/NB | UC |
| 33 | Eurasian Spoonbill | *Platalea leucorodia* | LC | R/NB | C |
| 34 | Glossy Ibis | *Plegadis falcinellus* | LC | R/NB | C |

| | Order/Family/Common name | Scientific name | Global IUCN Red List status | Resident status | Relative abundance |
|---|---|---|---|---|---|
| | **Phalacrocoracidae** | | | | |
| 35 | Great Cormorant | *Phalacrocorax carbo* | LC | R/NB | UC |
| 36 | Indian Cormorant | *Phalacrocorax fuscicollis* | LC | R/NB | C |
| 37 | Little Cormorant | *Microcarbo niger* | LC | R/NB | C |
| | **Anhingidae** | | | | |
| 38 | Oriental Darter | *Anhinga melanogaster* | LC | R/NB | UC |
| | **Charadriiformes: Recurvirostridae** | | | | |
| 39 | Black-winged Stilt | *Himantopus himantopus* | LC | R | C |
| | **Burhinidae** | | | | |
| 40 | Indian Stone-curlew | *Burhinus indicus* | LC | R | C |
| 41 | Great Stone-curlew | *Esacus recurvirostris* | NT | R | C |
| 42 | Beach Stone-curlew | *Esacus magnirostris* | NT | R | Ra |
| | **Charadriidae** | | | | |
| 43 | Black-bellied Plover | *Pluvialis squatarola* | VU | WV | C |
| 44 | Pacific Golden Plover | *Pluvialis fulva* | LC | WV | UC |
| 45 | Siberian Sandplover | *Anarhynchus mongolus* | EN | WV | C |
| 46 | Greater Sandplover | *Anarhynchus leschenaultii* | LC | WV | C |
| 47 | Kentish Plover | *Anarhyncus alexandrinus* | LC | WV | C |
| 48 | Common Ringed Plover | *Charadrius hiaticula* | LC | WV | UC |
| 49 | Hanuman Plover | *Charadrius seebohmi* | NA | R | C |
| 50 | Little-ringed Plover | *Charadrius dubius* | LC | WV | C |
| 51 | Red-wattled Lapwing | *Vanellus indicus* | LC | R | C |
| 52 | Yellow-wattled Lapwing | *Vanellus malabaricus* | LC | R | UC |
| | **Scolopacidae** | | | | |
| 53 | Black-tailed Godwit | *Limosa limosa* | NT | WV | UC |
| 54 | Bar-tailed Godwit | *Limosa lapponica* | NT | WV | UC |
| 55 | Whimbrel | *Numenius phaeopus* | LC | WV | C |
| 56 | Red-necked Phalarope | *Phalaropus lobatus* | LC | WV | Ra |
| 57 | Eurasian Curlew | *Numenius arquata* | NT | WV | C |
| 58 | Temminck's Stint | *Calidris temminckii* | LC | WV | UC |
| 59 | Little Stint | *Calidris minuta* | LC | WV | C |
| 60 | Ruff | *Calidris pugnax* | LC | WV | UC |
| 61 | Curlew Sandpiper | *Calidris ferruginea* | VU | WV | C |
| 62 | Dunlin | *Calidris alpina* | NT | WV | Ra |
| 63 | Red-necked Stint | *Calidris ruficollis* | NT | WV | Ra |
| 64 | Common Sandpiper | *Actitis hypoleucos* | LC | WV | UC |
| 65 | Ruddy Turnstone | *Arenaria interpres* | NT | WV | C |
| 66 | Green Sandpiper | *Tringa ochropus* | LC | WV | C |
| 67 | Marsh Sandpiper | *Tringa stagnatilis* | LC | WV | UC |
| 68 | Wood Sandpiper | *Tringa glareola* | LC | WV | UC |
| 69 | Common Greenshank | *Tringa nebularia* | LC | WV | C |
| 70 | Common Redshank | *Tringa totanus* | LC | WV | C |
| 71 | Terek Sandpiper | *Xenus cinereus* | LC | WV | C |
| 72 | Broad-billed Sandpiper | *Calidris falcinellus* | VU | WV | C |
| 73 | Sanderling | *Calidris alba* | LC | WV | C |

| | Order/Family/Common name | Scientific name | Global IUCN Red List status | Resident status | Relative abundance |
|---|---|---|---|---|---|
| 74 | Great Knot | *Calidris tenuirostris* | EN | WV | UC |
| 75 | Red Knot | *Calidris canutus* | NT | WV | UC |
| 76 | Common Snipe | *Gallinago gallinago* | LC | WV | UC |
| 77 | Pin-tailed Snipe | *Gallinago stenura* | LC | WV | Ra |
| | **Rostratulidae** | | | | |
| 78 | Greater Painted Snipe | *Rostratula benghalensis* | LC | R/NB | Ra |
| | **Laridae** | | | | |
| 79 | Slender-billed Gull | *Chroicocephalus genei* | LC | WV | C |
| 80 | Black-headed Gull | *Chroicocephalus ridibundus* | LC | WV | C |
| 81 | Brown-headed Gull | *Chroicocephalus brunnicephalus* | LC | WV | C |
| 82 | Pallas's Gull | *Ichthyaetus ichthyaetus* | LC | WV | C |
| 83 | Lesser Black-backed Gull | *Larus fuscus* | LC | WV | C |
| 84 | Steppe Gull | *Larus fuscus barabensis* | LC | WV | Ra |
| 85 | Common Tern | *Sterna hirundo* | LC | WV | UC |
| 86 | Little Tern | *Sternula albifrons* | LC | WV | UC |
| 87 | Caspian Tern | *Hydroprogne caspia* | LC | WV | C |
| 88 | Great Crested Tern | *Thalasseus bergii* | LC | R/B | C |
| 89 | Lesser Crested Tern | *Thalasseus bengalensis* | LC | WV | C |
| 90 | Sandwich Tern | *Thalasseus sandvicensis* | LC | WV | Ra |
| 91 | Gull-billed Tern | *Gelochelidon nilotica* | LC | WV | C |
| 92 | Whiskered Tern | *Chlidonias hybrida* | LC | WV | UC |
| 93 | White-winged Tern | *Chilidonias leucopterus* | LC | WV | Ra |
| 94 | Bridled Tern | *Onychoprion anaethetus* | LC | WV | Ra |
| 95 | Sooty Tern | *Onychoprion fuscatus* | LC | WV | Ra |
| | **Stercorariidae** | | | | |
| 96 | Arctic Skua | *Stercorarius parasiticus* | LC | WV | Ra |
| 97 | Pomarine Skua | *Stercorarius pomarinus* | LC | WV | Ra |
| | **Procellariiformes: Procellariidae** | | | | |
| 98 | Flesh-footed Shearwater | *Ardenna carneipes* | NT | WV | Ra |
| | **Accipitriformes: Pandionidae** | | | | |
| 99 | Osprey | *Pandion haliaetus* | LC | WV | Ra |
| | **Accipitridae** | | | | |
| 100 | Booted Eagle | *Hieraaetus pennatus* | LC | WV | UC |
| 101 | Black Kite | *Milvus migrans* | LC | R | C |
| 102 | Black-winged Kite | *Elanus caeruleus* | LC | R | C |
| 103 | Brahminy Kite | *Haliastur indus* | LC | R | C |
| 104 | Shikra | *Accipiter badius* | LC | R | C |
| 105 | Eurasian Marsh Harrier | *Circus aeruginosus* | LC | WV | Ra |
| 106 | Monatgu's Harrier | *Circus pygargus* | LC | WV | Ra |
| 107 | Oriental Honey-buzzard | *Pernis ptilorhynchus* | LC | LM | UC |
| 108 | White-bellied Sea Eagle | *Icthyophaga leucogaster* | LC | LM | C |
| | **Strigiformes: Strigidae** | | | | |
| 109 | Spotted Owlet | *Athene brama* | LC | R | C |
| | **Bucerotiformes: Upupidae** | | | | |
| 110 | Common Hoopoe | *Upupa epops* | LC | R | C |

| | Order/Family/Common name | Scientific name | Global IUCN Red List status | Resident status | Relative abundance |
|---|---|---|---|---|---|
| | **Piciformes: Picidae** | | | | |
| 111 | Black-rumped Flameback | *Dinopium benghalense* | LC | R | C |
| | **Coraciiformes: Meropidae** | | | | |
| 112 | Blue-tailed Bee-eater | *Merops philippinus* | LC | R | C |
| 113 | Green Bee-eater | *Merops orientalis* | LC | R | C |
| | **Coraciidae** | | | | |
| 114 | Indian Roller | *Coracias benghalensis* | LC | R | C |
| | **Alcedinidae** | | | | |
| 116 | Pied Kingfisher | *Ceryle rudis* | LC | R | C |
| 117 | Common Kingfisher | *Alcedo atthis* | LC | R | C |
| 118 | White-throated Kingfisher | *Halcyon smymensis* | LC | R | C |
| | **Falconiformes: Falconidae** | | | | |
| 118 | Peregrine Falcon | *Falco peregrinus* | LC | WV | Ra |
| 119 | Eurasian Kestrel | *Falco tinnunculus* | LC | R | C |
| | **Psittaciformes: Psittacidae** | | | | |
| 120 | Rose-ringed Parakeet | *Psittacula krameri* | LC | R | C |
| | **Passeriformes: Dicruridae** | | | | |
| 121 | Black Drongo | *Dicrurus macrocercus* | LC | R | C |
| | **Laniidae** | | | | |
| 122 | Brown Shrike | *Lanius cristatus* | LC | WV | UC |
| | **Corvidae** | | | | |
| 123 | House Crow | *Corvus splendens* | LC | R | C |
| 124 | Rufous Treepie | *Dendrocitta vagabunda* | LC | R | UC |
| 125 | Large-billed Crow | *Corvus macrorhynchos* | LC | R | C |
| | **Nectariniidae** | | | | |
| 26 | Purple-rumped Sunbird | *Leptocoma zeylonica* | LC | R | C |
| 127 | Purple Sunbird | *Cinnyris asiaticus* | LC | R | C |
| | **Estrildidae** | | | | |
| 128 | Indian Silverbill | *Euodice malabarica* | LC | R | UC |
| | **Passeridae** | | | | |
| 129 | House Sparrow | *Passer domesticus* | LC | R | C |
| | **Motacillidae** | | | | |
| 130 | Paddy Field Pipit | *Anthus rufulus* | LC | R | C |
| 31 | White-browed Wagtail | *Motacilla maderaspatensis* | LC | R | C |
| 132 | Western Yellow Wagtail | *Motacilla flava* | LC | WV | Ra |
| | **Alaudidae** | | | | |
| 133 | Jerdons Bushlark | *Mirafra affinis* | LC | R | C |
| 134 | Oriental Skylark | *Alauda gulgula* | LC | R | C |
| 135 | Skyes's Short-toed Lark | *Calandrella dukhunensis* | LC | WV | UC |
| | **Cisticolidae** | | | | |
| 136 | Common Tailorbird | *Orthotomus sutorius* | LC | R | C |
| 137 | Plain Prinia | *Prinia inornata* | LC | R | C |
| 138 | Ashy Prinia | *Prinia socialis* | LC | R | C |
| | **Leiotrichidae** | | | | |
| 139 | Yellow-billed Babbler | *Argya affinis* | LC | R | C |

| | Order/Family/Common name | Scientific name | Global IUCN Red List status | Resident status | Relative abundance |
|---|---|---|---|---|---|
| | **Acrocephalidae** | | | | |
| 140 | Blyth's Reed Warbler | *Acrocephalus dumetorum* | LC | WV | UC |
| 141 | Booted Warbler | *Iduna caligata* | LC | R/NB | Ra |
| | **Hirundinidae** | | | | |
| 142 | Barn Swallow | *Hirundo rustica* | LC | WV | Ra |
| | **Pycnonotidae** | | | | |
| 143 | Red-vented Bulbul | *Pycnonotus cafer* | LC | R | C |
| | **Sturnidae** | | | | |
| 144 | Brahminy Starling | *Sturnus pagodarum* | LC | R | UC |
| 145 | Common Myna | *Acridotheres tristis* | LC | R | C |
| 146 | Rosy Starling | *Pastor roseus* | LC | PM | UC |
| | **Muscicapidae** | | | | |
| 147 | Indian Robin | *Copsychus fulicatus* | LC | R | C |

IUCN Red list status: LC—Least Concern | NT—Near Threatened | VU—Vulnerable | EN—Endangered | NA—Not assessed | Resident status: WV—Winter Visitor | LM—Local Migrant | R—Resident | R/NB—Resident/Non-Breeding | Relative abundance: C—Common | UC—Uncommon | Ra—Rare.

Pelican *Pelecanus philippensis,* Flesh-footed Shearwater *Ardenna carneipes,* and Beach Stone- Curlew *Esacus* magnirostri; three 'Vulnerable' species Curlew Sandpiper *Calidris ferruginea,* Broad-billed Sandpiper *Calidris falcinellus*, and Black-bellied Plover *Pluvialis squatarola*; two 'Endangered' (EN) Great Knot *Calidris tenuirostris* and Siberian Sandplover *Anarhynchus mongolus*; one unassessed Hanuman Plover; and the rest of 130 species were in the 'Least Concern' (LC) category according to the IUCN Red List of Threatened Species.

It is evident from the study that 62 species of winter migrants visited or occupied the area during the migratory period. This is one of the best waterbird congregation sites during the migratory season in the Gulf of Mannar region (Rashiba et al. 2022). Similar studies on the eastern coast of India were recorded in Valinokkam Lagoon (Byju et al. 2023c) with 154 species of birds, of which 35 were shorebirds and 58 species were winter visitors, and, Karangadu mangroves (Byju et al. 2023b) with 107 species of birds, of which 18 were shorebirds and 15 species were winter visitors. Findings from Pulicat Lagoon by Alam et al. (2023), the second-largest brackish water lagoon on the east coast of India, also complement these findings with the record of 52 species of winter visitors. The maximum counts as one-time peak counts of a few species of shorebirds, gulls, and terns were recorded during the study period (Table 2), along with the global population size and population trend of each species for a better understanding.

From the observations, the following are the shorebird species that were dominant in the region: Siberian Sandplover *Anarhynchus mongolus*, Curlew Sandpiper *Calidris ferruginea*, Greater Sandplover *Anarhyncus leschenaultii,* and Kentish Plover *Anarhynchus alexandrinus*. This is in line with previous studies carried out on the eastern coast of India at Point Calimere (Balachandran 2006), Chilika (Balachandran et al. 2020), and Valinokkam (Byju et al. 2023c). A study by Balachandran (1998) showed that Greater Sandplover is found in abundance only in GoM on the eastern coast compared to the western coast of India. Byju et al (2023e) observed Siberian Sandplover, Curlew Sandpiper, and Little Stint as the most abundant shorebirds on the Manoli Island of GoM.

Family Laridae was represented by six species of gulls and 11 species of terns. The gull species recorded are Slender-billed Gull *Chroicocephalus genei*, Black-headed Gull *Chroicocephalus ridibundus*, Brown-headed Gull *Chroicocephalus brunnicephalus*, Pallas's Gull *Ichthyaetus ichthyaetus*, Steppe Gull *Larus barabensis*, and Lesser Black-backed Gull *Larus fuscus*. Of these, the most dominant ones were Brown-headed and Black-headed gulls. The tern species include, Little Tern *Sternula albifrons*, Gull-billed Tern *Gelochelidon nilotca*, Caspian Tern *Hydroprogne caspia*, Whiskered Tern *Chlidonias hybrida*, Common Tern *Sterna hirundo*, Greater Crested Tern *Thalasseus bergii*, Lesser Crested Tern *Thalasseus bengalensis*, Sandwich Tern *Thalasseus sandvicensis,* White-winged Tern *Chilidonias leucopterus*, Bridled Tern *Onychoprion anaethetus*, and Sooty Tern *Onychocommonprion fuscatus*. Lesser Crested Tern and Greater Crested Tern, the breeding residents of

**Table 2. One-time peak count of a few important waterbirds with global population trends.**

| Species | One-time peak count | Month and Year of observation | Global population trend (BirdLife International 2024) | Global population size (number of mature individuals) (BirdLife International 2024) |
|---|---|---|---|---|
| *Numenius phaeopus* | 34 | February 2023 | Decreasing | Unknown |
| *Limosa lapponica* | 6 | August 2022 | Decreasing | Unknown |
| *Limosa limosa* | 9 | August 2022 | Decreasing | Unknown |
| *Pluvialis squatarola* | 206 | April 2023 | Decreasing | 490,000–630,000 |
| *Charadrius hiaticula* | 2 | October 2023 | Decreasing | Unknown |
| *Pluvialis fulva* | 7 | April 2022 | Decreasing | Unknown |
| *Anarhynchus leschenaultii* | 2,998 | April 2023 | Decreasing | 100,000–225,000 |
| *Charadrius dubius* | 50 | March 2022 | Stable | Unknown |
| *Anarhynchus mongolus* | 4,006 | March 2022 | Decreasing | 18,000–50,000 |
| *Charadrius seebohmi* | 25 | October 2023 | Not assessed | Unknown |
| *Anarhyncus alexandrinus* | 1,402 | March 2022 | Decreasing | 100,000–499,999 |
| *Esacus magnirostris* | 8 | June 2022 | Decreasing | 4,000 |
| *Numenius arquata* | 47 | February 2022 | Decreasing | Unknown |
| *Esacus recurvirostris* | 3 | January 2023 | Decreasing | Unknown |
| *Actitis hypoleucos* | 21 | August 2022 | Decreasing | Unknown |
| *Tringa stagnatilis* | 304 | February 2022 | Decreasing | Unknown |
| *Tringa ochropus* | 151 | October 2023 | Increasing | Unknown |
| *Xenus cinereus* | 95 | August 2022 | Decreasing | Unknown |
| *Calidris ferruginea* | 3,498 | September 2023 | Decreasing | Unknown |
| *Tringa glareola* | 27 | February 2023 | Stable | Unknown |
| *Calidris falcinellus* | 40 | February 2023 | Decreasing | Unknown |
| *Tringa nebularia* | 86 | August 2022 | Stable | Unknown |
| *Tringa totanus* | 352 | September 2022 | Unknown | Unknown |
| *Calidris alpina* | 10 | February 2022 | Decreasing | Unknown |
| *Calidris ruficollis* | 2 | September 2023 | Decreasing | Unknown |
| *Calidris temminckii* | 50 | February 2022 | Unknown | 110,000– 850,000 |
| *Calidris minuta* | 710 | February 2022 | Increasing | 1,000,000– 1,100,000 |
| *Calidris tenuirostris* | 102 | March 2022 | Decreasing | Unknown |
| *Arenaria interpres* | 520 | April 2023 | Decreasing | 300,000–500,000 |
| *Calidris alba* | 80 | February 2022 | Unknown | Unknown |
| *Calidris pugnax* | 2 | March 2023 | Decreasing | Unknown |
| *Phalaropus lobatus* | 2 | January 2023 | Decreasing | Unknown |
| *Himantopus himantopus* | 45 | December 2021 | Increasing | Unknown |
| *Sterna hirundo* | 202 | March 2021 | Unknown | Unknown |
| *Gelochelidon nilotica* | 80 | February 2021 | Decreasing | Unknown |
| *Hydroprogne caspia* | 301 | November 2020 | Increasing | Unknown |
| *Thalasseus bergii* | 2007 | March 2021 | Stable | Unknown |
| *Thalasseus bengalensis* | 2996 | March 2021 | Stable | Unknown |
| *Sternula albifrons* | 509 | March 2021 | Decreasing | Unknown |
| *Chlidonias hybrida* | 4 | July 2022 | Stable | Unknown |
| *Ichthyaetus ichthyaetus* | 15 | March 2021 | Increasing | Unknown |
| *Chroicocephalus brunnicephalus* | 814 | March 2022 | Stable | Unknown |
| *Chroicocephalus ridibundus* | 308 | January 2021 | Unknown | Unknown |
| *Chroicocephalus genei* | 260 | December 2022 | Unknown | 180,000–230,000 |
| *Larus barabensis* | 55 | February 2021 | Data not available | Data not available |
| *Larus fuscus* | 170 | November 2022 | Increasing | Unknown |
| *Phoenicopterus roseus* | 1409 | February 2021 | Increasing | Unknown |

this area, were the most prevalent tern species during the study period, followed by Little Tern and Common Tern. Among other large waterbirds, Greater Flamingo *Phoenicopterus roseus* was seen mostly restricted to the Kothandaramar Lagoon compared to other study areas but rarely in the Dhanushkodi region only few in numbers. Although 50% of the species for which one-time peak count was mentioned are 'Least Concern' on the IUCN Red List, global population analysis shows a decreasing trend (BirdLife International 2024). Notably, the global population size of 76% of these listed species is unknown (Table 2).

Most land birds are recorded from the lagoon peripheries or the Rameswaram Reserve Forest areas. Some ground-nesting land birds such as Oriental Skylark *Alauda gulgula* used the grassy patches in Dhanushkodi areas as breeding ground emphasizing the need for avifaunal diversity assessments in lagoon regions, besides waterbirds. The new breeding records of Hanuman Plover from the study areas in Dhanushkodi emphasize the need to conserve these unprotected habitats as a significant part of the CAF (Byju et al. 2023d).

For long-distance migratory shorebirds, stop-over sites are essential along with breeding and wintering locations (Boere et al. 2006). Waterbirds, particularly shorebirds, mudflats, and shallow lagoons provide pivotal habitat (Sandilyan et al. 2010) which is evident in the study where shorebirds constituted 35.3% (52 species) of the total avifauna. Therefore, it is important to perform extensive investigations to identify all crucial stopover sites, seasons, and ecosystems along the Indian east coast (Rao et al. 2022) that are not hitherto done. The present study area along with Valinokkam Lagoon (Byju et al. 2023c), Karangadu Mangrove ecosystem (Byju et al. 2023b) will fill up the gap in bird studies on the east coast in the Ramanathapuram region.

**Potential Threats and Conservation Suggestions**

The newly proposed railway line work (Image 9) for Dhanushkodi from Rameswaram and concretization in the region by building roads that have been extended up to Arichalmunai from Dhanushkodi will impact the habitat in the future as new soil will be brought to the area for construction activities impacting the feeding activity of the shorebirds. Seepage of hard soil from these structures may result in the hardening of the substrate in the long run. This may lead to the disappearance of the natural habitat for invertebrates, like molluscs, nereis worms, and crustaceans like crabs, the food for these migratory birds (Byju et al. 2023a). Many studies have proven that shorebird diversity, abundance, and dispersion are influenced by food availability, substrate type, water quality, and other factors (Skagen & Knopf 1993; Manikannan et al. 2012).

Other threats include invasive plant species like *Neltuma juliflora* which is profusely taking over the mudflats and lagoon edges in Dhanushkodi region (Image 10). According to Murugan et al. (2020), invasive species modify ecosystems by impacting the dynamics of soil organic carbon and nutrients. Disturbance may also be a major issue during the breeding season, as the presence of humans may scare away adults and allow predators to take eggs and young ones (Martínez-Abraín et al. 2010; Tobajas et al. 2022). It was also observed that domestic dogs are becoming a source of disturbance to migratory birds (Mundkur & Langendoen 2019) and breeding birds (Byju et al. 2023d), and disturbance can have severe consequences for migratory shorebirds that forage and roost in the coastal mudflats (Das et al. 2022).

Tourism is a major industry based on coastal wetlands of India (Jayappa & Deepika 2018) including Rameswaram Island due to the importance of religious belief and beach drives. Tourists may unintentionally disturb shorebirds by walking too close to their nesting sites, driving vehicles on beaches, or engaging in activities such as kite flying or dog walking, all of which can disrupt the birds' normal activities and lead to negative consequences (Mundkar et al. 2023). One of the major impacts is the religious (heritage) tourism in Rameswaram, Kothandaramar temple area, and the Dhanushkodi region. The amount of waste like used clothes which is a religious custom to throw the used ones after taking a holy dip on the beaches and plastics (mostly from packed foods and water bottles) is having a long-term impact on the habitat utilization of the shorebirds in the area (Images 11 & 12). Microplastics were found in the corals of GoM and tourism was found to be the source of these (Krishnakumar et al. 2021). Several species are vulnerable to the effects of plastic pollution including the consumption of microplastics even by juveniles (Athira et al. 2024).

The impact of the tourist vehicles and visitors includes the leftovers of food, plastics, and used clothes. This has increased the dog population which is again a major threat to shorebirds and the nesting of Olive Ridley Turtle *Lepidochelys olivacea* (Image 13). Restricting the number of vehicles to 200–250 per day or restricting private vehicles after a certain point in Rameswaram and introducing public transport facilities through local vehicles involving local communities in the fragile area could be some of the steps towards a management solution to the threats. This would also help in boosting


Image 2. Arctic Skua.


Image 3. Beach Stone-curlew.


Image 4. Hanuman Plover.


Image 5. Lesser Noddy.


Image 6. Bridled Tern.


Image 7. Sooty Tern.


Image 8. Red-necked Phalarope.


Image 9. Red Pillar stone laid for proposed railway line acquisition on the beach.


Image 10. *Neltuma juliflora* overgrowing to the edge of mudflats.


Image 11. Remnants on religious practices as garbage on the edge of the foraging area.


Image 12. Overcrowding of tourist carrying vehicles and vendors in Arichalmunai.


Image 13. Feral dog feeding on dead Olive Ridley Turtle in Dhanushkodi.

the local economy. The plastic check post started by the forest department with the assistance of the local community towards the entry to these regions had collected around one tonne of plastic bottles, five tonnes of plastic covers, and small throw-away items in one year during our study period. The estimations are that uncollected plastic items are around four tonnes in the area during the same period. The interactions with the local administration exposed the lack of garbage collection staff and improper disposal methods. Hence the resolution of this issue needs the collaborative efforts of all local stakeholders.

Coastal wetlands are in a critical state and essential to maintain them for shorebird migration routes worldwide. Although GoM is a protected area and an IBA, the adjacent sites often suffer from management issues like the invading exotic species (Gan et al. 2009). In a nutshell, both the designation of new reserves and the improved management of existing reserves are essential in this case.

## CONCLUSION

In conclusion, prioritizing the creation of new protected areas is crucial to preserving locations of global significance for waterbirds including migratory shorebirds and breeding studies of unassessed Hanuman Plovers on the selected sites in Arichalmunai and Dhanushkodi of the Rameswaram Island. Unchecked tourism remains a major threat to the Dhanushkodi region, which can have adverse impact on shorebirds, including habitat loss, disturbance, and pollution. These impacts can lead to reduced reproductive success, decreased survival rates, and overall population decline. Some steps can be taken to mitigate these impacts, such as implementing strict regulations on coastal development, establishing protected areas for shorebirds, educating tourists about the importance of minimizing their impact on wildlife, and investing in sustainable tourism practices as suggested. By adopting some of the suggestions, it can be ensured that shorebirds will continue to thrive in coastal environments, while also benefiting tourism.

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