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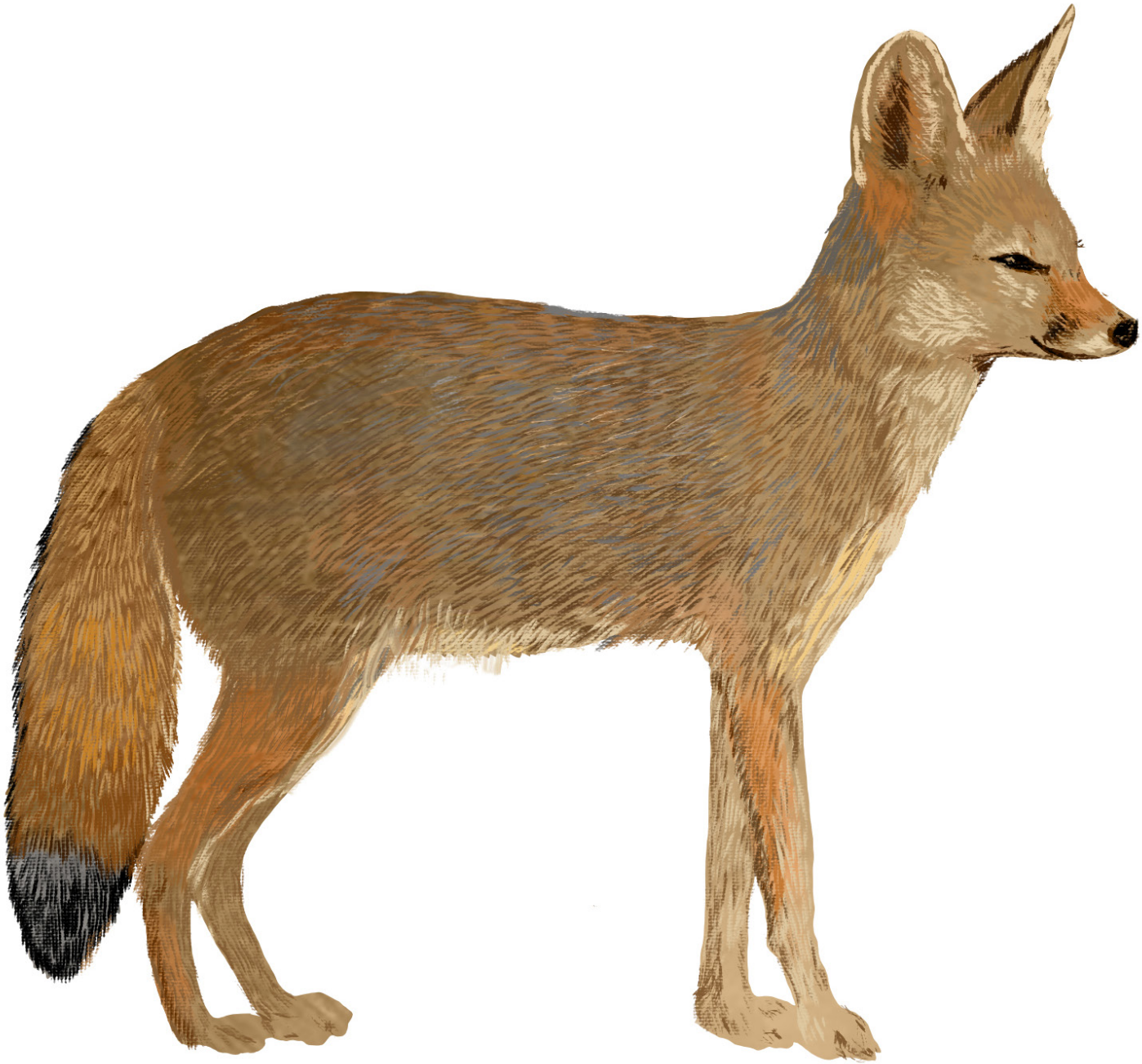

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**Cover: Bengal Fox *Vulpes bengalensis*—digital illustration. © Alagu Raj.**

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ARTICLE

# Avifaunal diversity assessment and conservation significance of Therthangal Bird Sanctuary, Ramanathapuram, Tamil Nadu: insights about breeding waterbirds

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**Abstract:** The study offers a comprehensive avifaunal diversity assessment within the Therthanagal Bird Sanctuary (TBS) in the Ramanathapuram district of Tamil Nadu, India, conducted from April 2021 to March 2023, covering two breeding seasons. A total of 96 bird species from 18 orders and 44 families were recorded. The family representations by species included: Ardeidae with 10 species, Accipitridae and Rallidae with six species each, Anatidae with five species, Alcedinidae, Cuculidae, Columbidae, Threskiornithidae and Cisticolidae with four species each. Four globally "Near Threatened" species (IUCN Red List) were reported: Oriental Darter *Anhinga melanogaster*, Black-headed Ibis *Threskiornis melanocephalus,* Asian Woolly-necked Stork *Ciconia episcopus,* and Spot-billed Pelican *Pelecanus philippensis*. The observed frequencies of species classes were: common (n=58, 60%), uncommon (n=28, 29%), and rare (n=10, 10%). The majority of species were residents (n=83, 86%), followed by winter visitors (n=12, 12%), and a single passage migrant, (Rosy Starling *Pastor roseus*). Of conservation significance was the finding that 23 of 40 waterbird species recorded in the sanctuary were breeding on-site. Maximum numbers of birds and nests were recorded in the second year, which was presumed to be due to improved rainfall and water availability. The findings underscored the importance of the sanctuary in providing bird habitat, and emphasised the need for its conservation, particularly in safeguarding breeding waterbird habitat. This study provided essential baseline data for any management plan that the forest department may develop for the sanctuary.

**Keywords:** Breeding birds, conservation policy, Gulf of Mannar Biosphere, heronry, land birds, bird migration, Near Threatened, protected areas, waterbirds, wetlands.

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

**Author details:** H. Byju works on the shorebirds and waterbirds in Gulf of Mannar region for a decade and is in the biodiversity panel of five birds' sanctuaries including two Ramsar sites and Gulf of Mannar Biosphere Reserve. H. Maitreyi is a research assistant working on seabirds in the region. N. Raveendran is a naturalist with a decade of experience in birds and awareness education. Reshmi Vijayan is a zoologist.

**Author contributions:** BH—conceptualization, design of work, writing and editing; MH—data compilation, mapping, writing, and editing; RN—data compilation, writing; RV—writing.

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## INTRODUCTION

Wetlands in tropical and sub-tropical Asia provide essential life support systems for many local communities (Ranga 2006; Friend 2007), serving as centres of ecosystem services, resources, and recreational values (Maltby & Acreman 2011). This stresses the importance of wetland conservation (Sharma et al. 2019). Worldwide, wetlands continue to be degraded (Zedler & Kercher 2005), with the global area shrinking by 6% between 1993 and 2007 (Prigent et al. 2012) and by 54–87% over the past three centuries (Davidson 2014). Degradation due to human land use has raised serious concerns about many taxa dependent on wetlands (Prigent et al. 2012), including waterbirds (Beyersbergen et al. 2004; Bakker 2005).

Wetland ecosystems face significant pressures stemming from extensive land alterations and infrastructure development (Pramod et al. 2011). The intensification of agricultural and industrial activities contribute to further stress (Bassi et al. 2014). These factors collectively lead to a reduction in the extent of wetlands, consequently diminishing their hydrological, economic, and ecological functions (Bassi et al. 2014). The link between wetland degradation and loss of bird biodiversity is established in earlier studies (Wang et al. 2021; IUCN 2023), with losses being more pronounced than in terrestrial ecosystems (Millennium Ecosystem Assessment 2005; Dudgeon et al. 2006;). Wetlands provide essential breeding, feeding, and roosting grounds for numerous bird species. Human activities that destroy or degrade these habitats (Brook & Aramde 2012) have a direct impact on the availability of suitable habitats for these birds, leading to population declines (Rajpar & Zakaria 2010). It is estimated that 55% of wetland bird species have declined worldwide, except for some large herbivorous waterbirds, which are increasing (BirdLife International 2017; Pöysä et al. 2019). Birds serve as valuable indicators of the ecological health of ecosystems (Peron et al. 2013), and play crucial functions as seed dispersers and pollinators, highlighting their essential roles in maintaining ecosystem balance (Bibi & Ali 2013).

Wetlands play a crucial role in supporting biodiversity, and in India, they have been instrumental in providing a lifeline for various bird species. In India, wetlands encompass approximately 4.1 million hectares of land, excluding areas used for irrigated agriculture, rivers, and streams. Among these, 1.5 million hectares are natural, while 2.6 million hectares are man-made. In recent years, there has been a growing interest in promoting the sustainable utilization and adaptive management of these ecosystems. However, challenges persist, including insufficient data and disparities in management approaches applied to these ecologically significant areas (Shan et al. 2021).

Colonial nesting waterbirds are important indicators of changes in the environment (Roshnath & Sashikumar 2019), as they breed in limited locations (Kushlan et al. 2002). These birds breed in single-species or mixed-species colonies, known as heronries, where they maintain healthy ecosystems by providing nutrients (Green & Elmberg 2014). Numerous heronries have disappeared in the last century across India (Subramanya 1996).

Studies on avian distribution in the Ramanathapuram district and the Gulf of Mannar Biosphere Reserve (GoM) in Tamil Nadu, India reported numerous additional birding hotspots (Byju et al. 2023 a, b, c), including the discovery of rare vagrant Light-Mantled Albatross *Phoebetria palpebrata* (Byju & Raveendran 2022), and additional breeding records of the newly described taxon Hanuman Plover *Charadrius seebohmi* (Byju et al. 2023 d). These findings underscored the importance of continuous monitoring in GoM, an Important Bird and Biodiversity Area (IBA) of the Central Asian Flyway (CAF).

This study on the avifaunal distribution of the Therthangal Bird Sanctuary (TBS) in the Ramanathapuram district was undertaken because the rainfed sanctuary faced problems of tree wilting due to anthropogenic pressures like water removal from the tank for agriculture and other related activities. An additional objective was to focus on the conservation importance of breeding waterbirds, including colonial nesters. This study aims to contribute to the management plan of the forest department for the well-being and conservation of this wetland and its breeding waterbird species.

## METHODS

### Study area

The Therthangal Bird Sanctuary (9.4566 N, 78.7719 E) with an estimated area of 29.295 hectares in Therthangal village (Image 1) was designated as a bird sanctuary in 2010 (Byju & Raveendran, 2024).

The dominant vegetation in this sanctuary is Babul trees, *Acacia nilotica,* which were planted by the Tamil Nadu state forest department as part of the social forestry scheme which started in 1960 (Wilson 1979). The sanctuary is mostly rainfed. It has, in general, one to three metres deep tank embankments. Between the

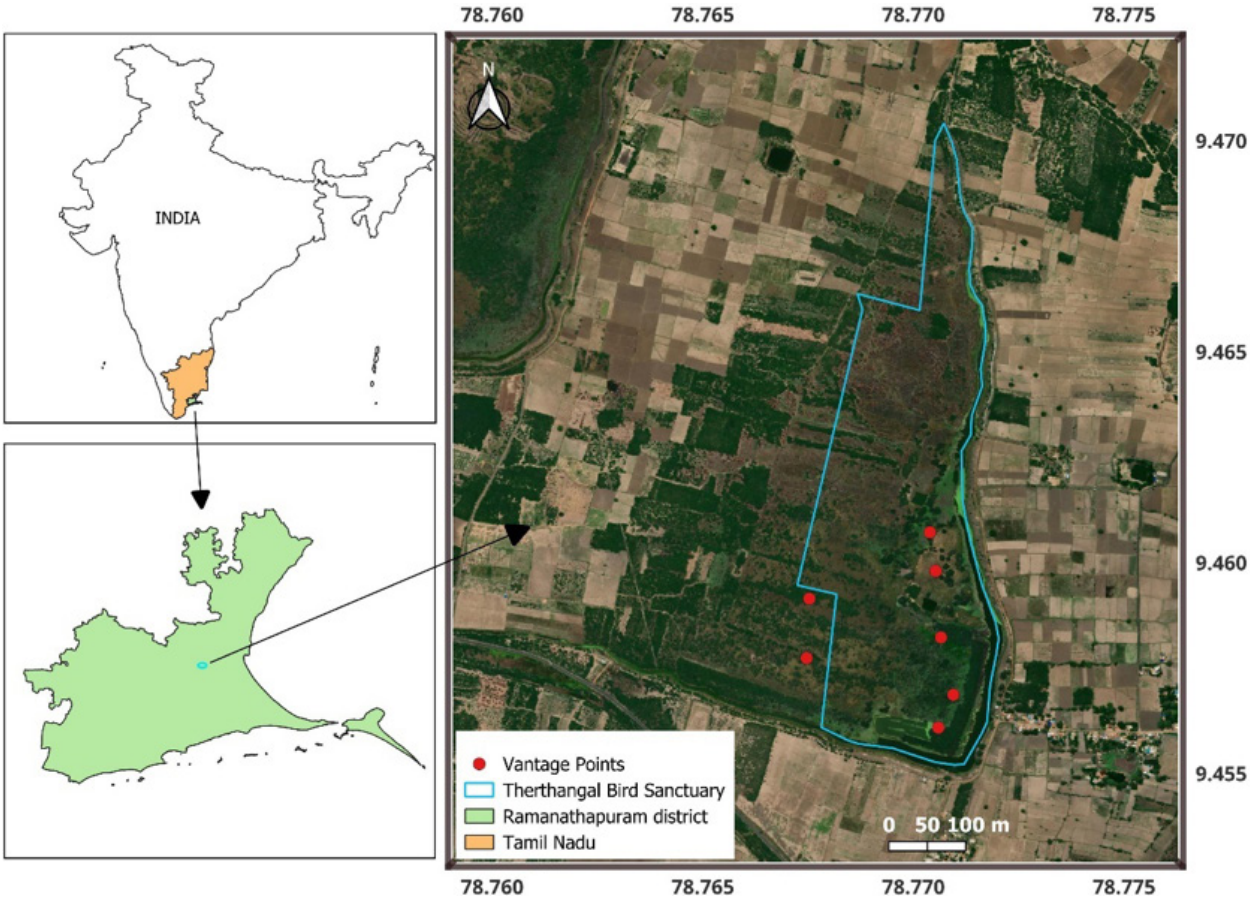


**Image 1. Location map of Therthangal Bird Sanctuary with scanning points.**

vegetation and the embankments, there is a wide water-holding region (~30m). The area receives an average rainfall of 503–1000 mm annually. The lowest and the highest temperature in Therthangal Bird Sanctuary ranges from 26–36 $^{0}$C. Agricultural lands surrounded the sanctuary and marked the northern boundary (Images 2 & 3). The main habitat types observed in the sanctuary are: 1. Open-water habitat (WL=Wetland), 2. Agricultural land (AL), 3. Trees (Tr) like *Babul,* Mesquite *Prosopis juliflora*, Palmyra *Borassus flabellifer,* and Tamarind *Tamarindus indica* trees on the bund bordering the wetland, 4. Grassland (GL) on the wetland area, and 5. Shrub habitat (OS=open scrub type). Three distinct seasons were northern Winter (December–February), northern Summer (March–June) and Monsoon (September–November).

**Monitoring methods**

This study was carried out between April 2021 and March 2023. Field visits were conducted once every two weeks to observe the status, breeding activity, number, and diversity of birds. The field surveys were conducted in the morning (07.00–10.00 hrs) and the evening (16.00 – 19.00 hrs), depending on the season when birds were most active. Data were collected following direct count and block count methods (Bibby et al. 2000; Howes & Bakewell 1989). Waterbirds were counted at seven scanning points separated by 100–200 meters (Image 1), depending on the landscape and visibility of the birds. We stopped at each point for five minutes before the actual count so that the birds could get acclimated to us. Observations recorded while moving from one scanning point to another were entered as incidental records. Birds were observed using Nikon binoculars (10x50) and identified with the help of a field guide (Grimmett et al. 2011). This communication follows the species nomenclature of Praveen & Jayapal (2023).

Species residential status was determined as Resident (R), Passage Migrant (PM), or Winter Visitor (WV) depending on the temporal patterns and duration of occurrence (Grimmett et al. 2011). Species were listed as per their global Red List status (IUCN 2023). We also documented any potential threats to the birds. The data collected in each survey were later analysed for the

relative abundance of families. Species were classified based on observation frequencies as: Common (C) - frequently observed in the study area (encountered on 6-8/10 visits); Uncommon (UC) - spotted on 3-5/10 visits; Rare (R) - encountered on 1-2/10 visits) (Mackinnon & Philips 1993). Relative diversity (RDi) was calculated with the following formula (Koli 2014):

$$RDi = \frac{Number\ of\ species\ in\ a\ family}{Total\ number\ of\ species} \times 100$$

We also documented the breeding activities of waterbirds within the sanctuary. Active nests were identified by fortnightly surveys and by monitoring the flights of adult birds commuting between nests and foraging areas. We visited the sanctuary twice a month during the breeding season to estimate the total number of nests, employing standard techniques such as ground counts or using binoculars and spotting scopes for nests, as the counts were less than 100 (Gibbs et al. 1988; Dodd & Murphy 1995). For sites with few nests or those that were completely inaccessible, we utilized perimeter counts (Dodd & Murphy 1995) based on visible nests and observed foraging flights from the colony edge, as other techniques were impractical.

## RESULTS AND DISCUSSION

### Avian community structure

A total of 96 species, representing 44 families across 18 orders, were documented in the study area; a comprehensive checklist is provided (Table 1). Of the 96 species, waterbirds were predominant with 40 species from 14 families (Figure 2). Notably, our observations highlighted the prevalence of families such as Ardeidae (10 species), followed by Accipitridae and Rallidae (6 species each), Anatidae (5 species), and Alcedinidae, Cuculidae, Columbidae, Threskiornithidae, and Cisticolidae (4 species each), representing the bird species of the region (Figure 2 & 3). The most speciose order was Passeriformes comprising 18 families and 29 species. Relative Diversity (RDi) analysis (Table 2) indicated that the most prevalent family in the Therthangal Bird Sanctuary was Ardeidae with a relative diversity of 10% (n=10 species). This was followed by the families Rallidae and Accipitridae with 6.2% (n=6 species each) and the Anatidae family with 5.2% (n=5 species). The families Cuculidae, Columbidae, Threskiornithidae, and Cisticolidae represented 4.1% (n=4 species each), while the families Coraciidae, Ciconiidae, Corvidae, Muscicapidae, and Phalacrocoracidae reported 3.1% (n=3 species each). The families that represented 2.0% (n=2 species each) were Phasianidae, Meropidae, Scolopacidae, Laniidae, Nectariniidae, and Motacillidae. The rest of the families had a single species each.

Within the sanctuary, the avian community was categorised based on the observed frequency, revealing that 58 species (60%) were Common (C); 28 species (29%) were Uncommon (UC), and the remaining ten (10%) were rare (R). Regarding residency status, the majority of species within TBS were Resident (R), accounting for 83 species (86%), while 12 species (13%) were Winter Visitors (WV) and the remaining one was a Passage Migrant (PM) Rosy Starling *Pastor roseus*. Common residents included the Peafowl *Pavo cristatus*, Indian Robin *Copsychus fulicatus*, Asian Koel *Eudynamys scolopaceus* and White-throated Kingfisher *Halcyon smyrnensis.* Our study documented seven diurnal and nocturnal raptors, including the Black-winged Kite *Elanus caeruleus*, Western Marsh Harrier *Circus aeruginosus*, Booted Eagle *Hieraaetus pennatus,* Shikra *Accipiter badius,* Oriental Honey Buzzard *Pernis ptilorhynchus,* Brahminy Kite *Haliastur indus* and Spotted Owlet *Athene brama*.

The distribution of waterbird species across families is graphically represented in Figure 1. Numerous wetland factors influenced waterbird abundance and diversity, including wetland area, water depth and quality, trophic level structure, and the availability of suitable roosting and breeding sites for birds (Wiens 1989; Mukherjee et al. 2002; Ma et al. 2010). Notably, migratory duck species such as Garganey *Spatula querquedula* and Northern Shoveler *Spatula clypeata* along with shorebirds like the Wood Sandpiper *Tringa glareola* and Common Sandpiper *Actitis hypoleucos* were recorded. The presence of these migratory bird species in reasonable numbers during both the migratory seasons of the study highlighted the importance of sanctuary in providing critical wintering grounds during their migration (see Figure 2 & 3).

During the observation period, the sanctuary recorded five major waterbird species: Asian Openbill *Anastomus oscitans* (n 1324), Spot-billed Pelican *Pelecanus philippensis* (n 785), Glossy Ibis *Plegadis falcinellus* (n 411), Black-headed Ibis *Threskiornis melanocephalus* (n 289) and Painted Stork *Mycteria leucocephala* (n 226). Additionally, the five major land bird species recorded included the passage migrant Rosy Starling (n 2200), Barn Swallow *Hirundo rustica* (n 200), Rose-ringed Parakeet *Psittacula krameri* (n 170), Baya Weaver *Ploceus philippinus* (n 120) and Common Myna *Acridotheres tristis* (n 82). TBS also supported four Near-Threatened waterbirds – Black-headed Ibis,

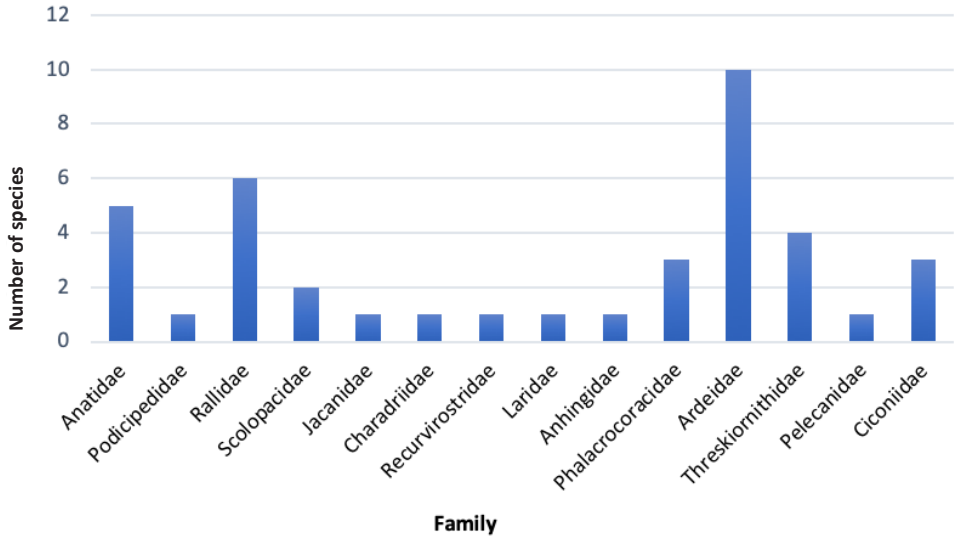


Figure 1. Family-wise species count of waterbirds from Therthangal Bird Sanctuary.

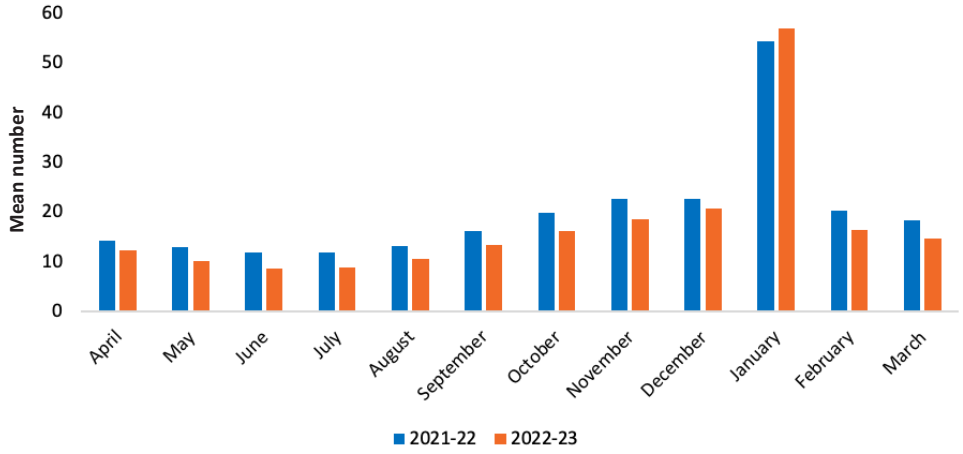


Figure 2. Mean monthly number of total land bird species in Therthangal Bird Sanctuary.

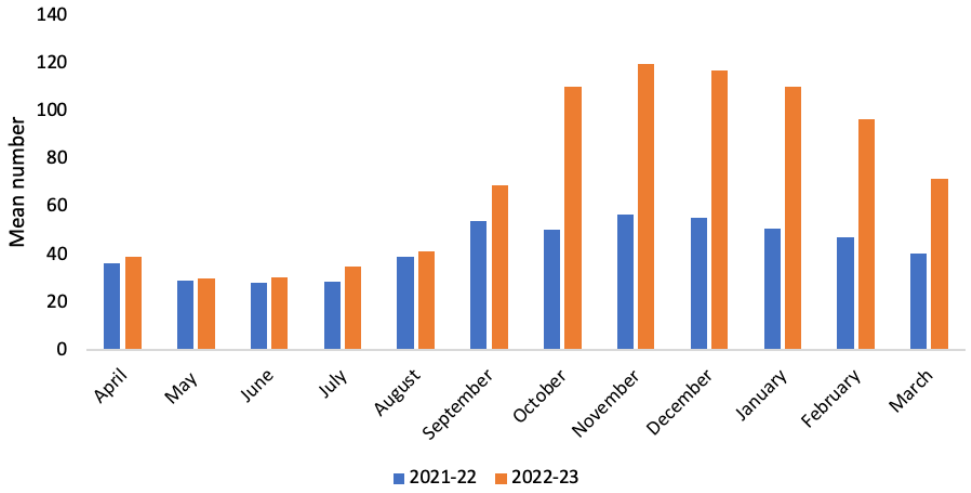


Figure 3. Mean monthly number of total waterbird species in Therthangal Bird Sanctuary.

**Table 1. Checklist of avifauna recorded from Therthangal Bird Sanctuary, Tamil Nadu.**

| Scientific name | Common name | Migratory status | IUCN Red List status | Frequency of observation | Habitat type |
|---|---|---|---|---|---|
| **Order: Galliformes** | | | | | |
| **Family: Phasianidae** | | | | | |
| *Pavo cristatus* | Indian Peafowl | R | LC | C | AL/OS |
| *Francolinus pondicerianus* | Grey Francolin | R | LC | C | GL/OS |
| **Order: Anseriformes** | | | | | |
| **Family: Anatidae** | | | | | |
| *Sarkidiornis melanotos* | Comb Duck | R | LC | C | WL |
| *Anas poecilorhyncha* | Indian Spot-billed Duck | R | LC | C | WL |
| *Spatula querquedula* | Garganey | WV | LC | UC | WL |
| *Spatula clypeata* | Northern Shoveler | WV | LC | R | WL |
| *Dendrocygna javanica* | Lesser Whistling-Duck | R | LC | UC | WL |
| **Order: Podicipediformes** | | | | | |
| **Family: Podicipedidae** | | | | | |
| *Tachybaptus ruficollis* | Little Grebe | R | LC | C | WL |
| **Order: Piciformes** | | | | | |
| **Family: Picidae** | | | | | |
| *Dinopium benghalense* | Black-rumped Flameback | R | LC | C | Tr |
| **Family: Megalaimidae** | | | | | |
| *Psilopogon haemacephalus* | Coppersmith Barbet | R | LC | UC | Tr |
| **Order: Bucerotiformes** | | | | | |
| **Family: Upupidae** | | | | | |
| *Upupa epops* | Common Hoopoe | R | LC | UC | AL/GL |
| **Order: Coraciiformes** | | | | | |
| **Family: Coraciidae** | | | | | |
| *Coracias benghalensis* | Indian Roller | R | LC | C | OS/AL |
| *Halcyon smyrnensis* | White-throated Kingfisher | R | LC | C | WL |
| *Alcedo atthis* | Common Kingfisher | R | LC | C | WL |
| **Family: Meropidae** | | | | | |
| *Merops orientalis* | Green Bee-eater | R | LC | C | OS/AL |
| *Merops philippinus* | Blue-tailed Bee- eater | WV | LC | C | OS/AL |
| **Order: Cuculiformes** | | | | | |
| **Family: Cuculidae** | | | | | |
| *Centropus sinensis* | Greater Coucal | R | LC | C | OS |
| *Eudynamys scolopaceus* | Asian Koel | R | LC | C | OS |
| *Clamator jacobinus* | Pied Cuckoo | R | LC | UC | OS |
| *Hierrococcyx varius* | Common Hawk Cuckoo | R | LC | UC | OS |
| **Order: Psittaciformes** | | | | | |
| **Family: Psittacidae** | | | | | |
| *Psittacula krameri* | Rose-ringed Parakeet | R | LC | C | Tr |
| **Order: Strigiformes** | | | | | |
| **Family: Strigidae** | | | | | |
| *Athene brama* | Spotted Owlet | R | LC | UC | OS/AL/Tr |

| Scientific name | Common name | Migratory status | IUCN Red List status | Frequency of observation | Habitat type |
|---|---|---|---|---|---|
| **Order: Columbiformes** | | | | | |
| **Family: Columbidae** | | | | | |
| *Columba livia* | Rock Pigeon | R | LC | C | AL/OS/GL |
| *Streptopelia decaocto* | Eurasian Collared-Dove | R | LC | C | AL/OS/GL |
| *Spilopelia senegalensis* | Laughing Dove | R | LC | C | AL/OS/GL |
| *Spilopelia chinensis* | Spotted Dove | R | LC | C | AL/OS/GL |
| **Order: Apodiformes** | | | | | |
| **Family: Apodidae** | | | | | |
| *Cypsiurus balasiensis* | Asian Palm- swift | R | LC | C | Tr |
| **Order: Gruiformes** | | | | | |
| **Family: Rallidae** | | | | | |
| *Gallinula chloropus* | Common Moorhen | R | LC | UC | WL |
| *Porphyrio* porphyrio | Grey-headed Swamphen | R | LC | UC | WL |
| *Amaurornis phoenicurus* | White-breasted Waterhen | R | LC | C | WL |
| *Fulica atra* | Eurasian Coot | R | LC | C | WL |
| *Zapornia pusilla* | Baillon's Crake | WV | LC | R | WL |
| *Gallicrex cinerea* | Watercock | R | LC | R | WL |
| **Order: Charadriiformes** | | | | | |
| **Family: Scolopacidae** | | | | | |
| *Tringa glareola* | Wood Sandpiper | WV | LC | UC | WL |
| *Actitis hypoleucos* | Common Sandpiper | WV | LC | UC | WL |
| **Family: Jacanidae** | | | | | |
| *Hydrophasianus chirurgus* | Pheasant-tailed Jacana | R | LC | UC | WL |
| **Family: Charadriidae** | | | | | |
| *Vanellus indicus* | Red-wattled Lapwing | R | LC | C | WL |
| **Family: Recurvirostridae** | | | | | |
| *Himantopus himantopus* | Black-winged Stilt | R | LC | C | WL |
| **Family: Laridae** | | | | | |
| *Chlidonias hybrida* | Whiskered Tern | WV | LC | R | WL |
| **Order: Accipitriformes** | | | | | |
| **Family: Accipitridae** | | | | | |
| *Circus aeruginosus* | Western Marsh Harrier | WV | LC | R | OS/GL |
| *Elanus caeruleus* | Black-winged Kite | R | LC | C | AL/OS |
| *Hieraaetus pennatus* | Booted Eagle | WV | LC | R | OS/Tr |
| *Accipiter badius* | Shikra | R | LC | UC | AL/GL/Tr/OS |
| *Pernis ptilorhynchus* | Oriental Honey Buzzard | R | LC | R | Tr |
| *Haliastur indus* | Brahminy Kite | R | LC | C | WL/GL |
| **Order: Suliformes** | | | | | |
| **Family: Anhingidae** | | | | | |
| *Anhinga melanogaster* | Oriental Darter | R | NT | UC | WL |
| **Family: Phalacrocoracidae** | | | | | |
| *Microcarbo niger* | Little Cormorant | R | LC | C | WL |
| *Phalacrocorax carbo* | Great Cormorant | R | LC | UC | WL |
| *Phalacrocorax fuscicollis* | Indian Cormorant | R | LC | C | WL |

| Scientific name | Common name | Migratory status | IUCN Red List status | Frequency of observation | Habitat type |
|---|---|---|---|---|---|
| **Order: Pelicaniformes** | | | | | |
| **Family: Ardeidae** | | | | | |
| *Ixobrychus sinensis* | Yellow Bittern | R | LC | UC | WL |
| *Ardea cinerea* | Grey Heron | R | LC | UC | WL |
| *Ardea purpurea* | Purple Heron | R | LC | UC | WL |
| *Egretta garzetta* | Little Egret | R | LC | C | WL |
| *Bubulcus ibis* | Cattle Egret | R | LC | C | WL |
| *Ardea alba* | Great Egret | R | LC | C | WL |
| *Ardea intermedia* | Intermediate Egret | R | LC | C | WL |
| *Ardeola grayii* | Indian Pond Heron | R | LC | C | WL |
| *Nycticorax nycticorax* | Black-crowned Night Heron | R | LC | C | WL |
| *Butorides striata* | Striated Heron | R | LC | UC | WL |
| **Family: Threskiornithidae** | | | | | |
| *Threskiornis melanocephalus* | Black-headed Ibis | R | NT | C | WL |
| *Plegadis falcinellus* | Glossy Ibis | R | LC | C | WL |
| *Pseudibis papillosa* | Red-naped Ibis | R | LC | C | WL |
| *Platalea leucorodia* | Eurasian Spoonbill | R | LC | C | WL |
| **Family: Pelecanidae** | | | | | |
| *Pelecanus philippensis* | Spot-billed Pelican | R | NT | C | WL |
| **Order: Ciconiiformes** | | | | | |
| **Family: Ciconiidae** | | | | | |
| *Anastomus oscitans* | Asian Openbill | R | LC | C | WL |
| *Mycteria leucocephala* | Painted Stork | R | LC | C | WL |
| *Ciconia episcopus* | Asian Woolly-necked Stork | R | NT | R | WL |
| **Order: Passeriformes** | | | | | |
| **Family: Artamidae** | | | | | |
| *Artamus fuscus* | Ashy Woodswallow | R | LC | C | OS/AL |
| **Family: Laniidae** | | | | | |
| *Lanius schach* | Long-tailed Shrike | R | LC | R | OS |
| *Lanius cristatus* | Brown Shrike | WV | LC | UC | OS |
| **Family: Dicruridae** | | | | | |
| *Dicrurus macrocercus* | Black Drongo | R | LC | C | GL/AL/OS |
| **Family: Corvidae** | | | | | |
| *Dendrocitta vagabunda* | Rufous Treepie | R | LC | UC | OS |
| *Corvus macrorhynchos* | Indian Jungle Crow | R | LC | C | OS/GL/WL |
| *Corvus splendens* | House Crow | R | LC | C | AL/OS/WL/GL |
| **Family: Sturnidae** | | | | | |
| *Acridotheres tristis* | Common Myna | R | LC | C | AL/OS/GL |
| *Pastor roseus* | Rosy Starling | PM | LC | UC | AL/OS/GL |
| **Family: Hirundinidae** | | | | | |
| *Hirundo rustica* | Barn Swallow | WV | LC | UC | AL/WL |
| **Family: Pycnonotidae** | | | | | |
| *Pycnonotus cafer* | Red-vented Bulbul | R | LC | C | OS/AL/GL |

| Scientific name | Common name | Migratory status | IUCN Red List status | Frequency of observation | Habitat type |
|---|---|---|---|---|---|
| **Family: Timaliidae** | | | | | |
| *Turdoides affinis* | Yellow-billed Babbler | R | LC | C | OS/AL |
| **Family: Cisticolidae** | | | | | |
| *Prinia socialis* | Ashy Prinia | R | LC | C | AL/OS/GL |
| *Prinia inornata* | Plain Prinia | R | LC | C | AL/OS/GL |
| *Orthotomus sutorius* | Common Tailorbird | R | LC | C | AL/OS/GL |
| *Cisticola juncidis* | Zitting Cisticola | R | LC | UC | AL/OS/GL |
| **Family: Acrocephalidae** | | | | | |
| *Acrocephalus dumetorum* | Blyth's Reed Warbler | WV | LC | R | OS |
| **Family: Alaudidae** | | | | | |
| *Galerida cristata* | Jerdon's Bushlark | R | LC | UC | AL/OS/GL |
| **Family: Muscicapidae** | | | | | |
| *Saxicola caprata* | Pied Bushchat | R | LC | C | OS |
| *Copsychus fulicatus* | Indian Robin | R | LC | C | AL/OS |
| *Copsychus saularis* | Oriental Magpie Robin | R | LC | C | AL/OS |
| **Family: Nectariniidae** | | | | | |
| *Cinnyris asiaticus* | Purple-rumped Sunbird | R | LC | C | OS/GL |
| *Cinnyris asiaticus* | Purple Sunbird | R | LC | C | OS/GL |
| **Family: Ploceidae** | | | | | |
| *Ploceus philippinus* | Baya Weaver | R | LC | UC | OS |
| **Family: Estrildidae** | | | | | |
| *Euodice malabarica* | Indian Silverbill | R | LC | UC | AL/GL/OS |
| **Family: Dicaeidae** | | | | | |
| *Dicaeum concolor* | Pale-billed Flowerpecker | R | LC | C | OS |
| **Family: Passeridae** | | | | | |
| *Passer domesticus* | House Sparrow | R | LC | C | AL/GL |
| **Family: Motacillidae** | | | | | |
| *Motacilla maderaspatensis* | White-browed Wagtail | R | LC | C | WL |
| *Anthus rufulus* | Paddy-field Pipit | R | LC | UC | GL/AL |

Migratory status: R—Resident | WV—Winter visitor | PM—Passage migrant | IUCN Status: CR—Critically Endangered | EN—Endangered | LC—Least Concern | NT—Near Threatened | VU—Vulnerable | WPA Frequency of observation: R—Rare | C—Common | UC—Uncommon | Habitat type: WL—Wetland | GL—Grass land | OS—Open scrub | AL—Agricultural land | Tr—Trees on the bund adjoining the wetland and agricultural lands.

Asian Woolly-necked Stork *Ciconia episcopus,* Oriental Darter *Anhinga melanogaster*, and Spot-billed Pelican - highlighting the sanctuary's critical role in conserving near-threatened species.

The habitat changes observed in the study area support different groups of waterbirds and terrestrial birds, each with distinct habitat preferences for activities like foraging, nesting, and roosting (Hattori & Mae 2001). Waterbirds, in particular, utilised various habitat changes in the region for different activities throughout the year (Kularatne et al. 2021). As many of the trees began to wilt and decay, the stronger trees were preferred by colonial nesters during the second breeding season.

**Breeding waterbird population and diversity**

Of the 40 species of waterbirds recorded, 23 were observed breeding in the sanctuary (Table 3). This heronry had partially submerged trees within the waterbody as the preferred habitat for nesting birds. The Spot-billed Pelicans and Painted Storks occupied the *Acacia nilotica* trees (Images 3 & 4). The predominant nesters were Asian Openbills closely followed by Spot-billed Pelicans. The maximum number of nests and birds were recorded in year 2. It could be inferred that an


Image 2. Aerial view of TBS with surrounding agriculture lands.


Image 3. Livestock grazing amongst invasive plants on the water and bank at TBS.

increase in rainfall in the second year compared to the previous year may have enabled the increase in nesting attempts (Frank et al. 2021). Oriental Darters, Eurasian Spoonbills, and Asian Openbills nested in the medium-sized trees like *Prosopis juliflora*, Black-headed Ibises nested in the canopy, and Cormorants, Egrets, and Pond Herons occupied the lower strata of the habitat of the trees. Most of the nesting materials were collected from the nearby agricultural fields.

**Conservation status of avian fauna**

Understanding the importance of a site requires an examination of its significance in relation to its species richness (Bruford 2002). The TBS supports four 'Near Threatened' species, such as the Black-headed Ibis, Oriental Darter, Asian Woolly-necked Stork, and Spot-bellied Pelican (IUCN 2023); the remaining 92 are 'Least Concern' (LC) species (Table 1). Previously, no proper

Table 2. Relative diversity (RDi) of various avifaunal families at Therthangal Bird Sanctuary.

| Family | Number of species observed | Relative diversity (%) |
|---|---|---|
| Phasianidae | 2 | 2.08 |
| Anatidae | 5 | 5.20 |
| Podicipedidae | 1 | 1.04 |
| Picidae | 1 | 1.04 |
| Megalaimidae | 1 | 1.04 |
| Upupidae | 1 | 1.04 |
| Coraciidae | 3 | 3.12 |
| Meropidae | 2 | 2.08 |
| Cuculidae | 4 | 4.16 |
| Psittacidae | 1 | 1.04 |
| Strigidae | 1 | 1.04 |
| Columbidae | 4 | 4.16 |
| Apodidae | 1 | 1.04 |
| Rallidae | 6 | 6.25 |
| Scolopacidae | 2 | 2.08 |
| Jacanidae | 1 | 1.04 |
| Charadriidae | 1 | 1.04 |
| Recurvirostridae | 1 | 1.04 |
| Laridae | 1 | 1.04 |
| Accipitridae | 6 | 6.25 |
| Anhingidae | 1 | 1.04 |
| Phalacrocoracidae | 3 | 3.12 |
| Ardeidae | 10 | 10.4 |
| Threskiornithidae | 4 | 4.16 |
| Pelecanidae | 1 | 1.04 |
| Ciconiidae | 3 | 3.12 |
| Artamidae | 1 | 1.04 |
| Laniidae | 2 | 2.08 |
| Dicruridae | 1 | 1.04 |
| Corvidae | 3 | 3.12 |
| Sturnidae | 2 | 2.08 |
| Hirundinidae | 1 | 1.04 |
| Pycnonotidae | 1 | 1.04 |
| Timaliidae | 1 | 1.04 |
| Cisticolidae | 4 | 4.16 |
| Acrocephalidae | 1 | 1.04 |
| Alaudidae | 1 | 1.04 |
| Muscicapidae | 3 | 3.12 |
| Nectariniidae | 2 | 2.08 |
| Ploceidae | 1 | 1.04 |
| Estrildidae | 1 | 1.04 |
| Dicaeidae | 1 | 1.04 |
| Passeridae | 1 | 1.04 |
| Motacillidae | 2 | 2.08 |

**Table 3. Breeding waterbirds of Therthangal Bird Sanctuary.**

| Common name | Scientific name | Maximum nest count during the study | | Maximum bird count during the study | |
|---|---|---|---|---|---|
| | | Year 1 | Year 2 | Year 1 | Year 2 |
| Spot-billed Pelican | *Pelecanus philippensis* | 54 | 182 | 335 | 785 |
| Little Cormorant | *Microcarbo niger* | 10 | 65 | 106 | 264 |
| Indian Cormorant | *Phalacrocorax fuscicollis* | 15 | 45 | 62 | 155 |
| Oriental Darter | *Anhinga melanogaster* | 9 | 30 | 40 | 90 |
| Great Egret | *Ardea alba* | 5 | 8 | 15 | 32 |
| Intermediate Egret | *Ardea intermedia* | 4 | 11 | 13 | 42 |
| Little Egret | *Egretta garzetta* | 3 | 8 | 20 | 63 |
| Cattle Egret | *Bubulcus ibis* | 6 | 18 | 50 | 126 |
| Grey Heron | *Ardea cinerea* | 5 | 15 | 18 | 40 |
| Purple Heron | *Ardea purpurea* | 2 | 5 | 9 | 15 |
| Indian Pond Heron | *Ardeola grayii* | 2 | 11 | 45 | 45 |
| Black-crowned Night Heron | *Nycticorax nycticorax* | 13 | 41 | 50 | 124 |
| Painted Stork | *Mycteria leucocephala* | 18 | 61 | 92 | 226 |
| Red-naped Ibis | *Pseudibis papillosa* | 2 | 2 | 5 | 8 |
| Asian Openbill Stork | *Anastomus oscitans* | 80 | 264 | 556 | 1324 |
| Glossy Ibis | *Plegadis falcinellus* | 4 | 12 | 167 | 411 |
| Black-headed Ibis | *Threskiornis melanocephalus* | 22 | 72 | 117 | 289 |
| Eurasian Spoonbill | *Platalea leucorodia* | 6 | 12 | 20 | 42 |
| Spot-billed Duck | *Anas poecilorhyncha* | 1 | 4 | 9 | 23 |
| Comb Duck | *Sarkidiornis sylvicola* | 1 | 2 | 8 | 20 |
| Black-winged Stilt | *Himantopus himantopus* | 2 | 4 | 20 | 46 |
| Red wattled Lapwing | *Vanellus indicus* | 1 | 2 | 16 | 42 |
| Lesser Whistling Duck | *Dendrocygna javanica* | 1 | 1 | 18 | 38 |


**Image 4. Nesting of Asian Open-billed Storks.**


**Image 5. Nesting of Spot-billed Pelican on top of trees.**

scientific studies had been conducted in this sanctuary, and 96 species, including 40 waterbirds, were recorded during the present study. The number of breeding waterbirds supported in the sanctuary is dependent on various factors mentioned earlier. This data provides fundamental information for future studies aimed at shaping management plans to enhance wetland conservation, supporting both resident and migratory bird populations.

## Potential management issues

Wetlands account for 24% of invasive species globally (Zedler & Kercher, 2004; Kaushik & Gupta 2014), including invasive trees like *Prosopis,* which support

breeding birds. The invasive *Prosopis* were being removed to prevent water loss, destruction of habitat and hindrance to native trees without a proper plan for their replacement which impacted birds like Asian Openbill and cormorants as they currently prefer to nest in these trees. The native *Acacia nilotica* was the main species on which the birds roosted in the sanctuary. Recently, some trees wilted and died due to changes in monsoon patterns. The removal of *Prosopis* coupled with drought driven wilting of *Acacia* trees reduced the number of potential nesting sites for the birds and also resulting in the abandonment of nests by waterbirds, affecting their nesting behaviour (Roshnath & Sinu 2017). Therefore, it is very important that the new trees planted are native and have greater adaptability to survive drought as well as excess water, to support the breeding population of waterbirds. The two-year nesting observations highlighted the difference in nesting preferences (Table 3) and the impact of irregular monsoons (Jabaraj & Gopi 2020) due to climate change affecting the habitats of waterbirds (Wormworth & Mallon 2006). *Ipomea carnea* was another invasive species that rapidly replaced the native vegetation at the site, with the potential to affect ground-nesting birds. Hence, we suggest long-term monitoring of nesting locations and breeding seasons (Urfi 2011; Pavon-Jordan et al. 2020).

During the study, we observed a few minor threats that affected the sanctuary. One such threat was the grazing of cattle during the drought seasons, which led to the destruction of trees. Cattle, in search of food, climbed the trees and ate the bark due to the scarcity of leaves, causing the trees to slowly die. Additionally, the adjacent agricultural lands were sprayed with pesticides during cultivation. The impact of these chemicals on breeding birds needs to be ascertained for future studies. Furthermore, the local caste dynamics played a significant role among villagers surrounding the sanctuary. Conflict arose over water usage rights and the lack of clear boundary markings between the sanctuary and the villagers' lands, leading to disputes with the forest department. Consequently, the officials and staff needed to be proactive to prevent any acts of retaliation against the birds and trees by the aggrieved parties.

## CONCLUSIONS

Therthangal Bird Sanctuary serves as a suitable habitat for a wide variety of bird species, both resident and migratory. This is a testament to the ecological richness and conservation value of the sanctuary. Conservation strategies for these ecological indicator species (Ogden et al. 2014) necessitates a comprehensive approach that addresses threats to wetland habitats and waterbird populations, as they have high site fidelity. Conserving a wetland like the TBS and its associated waterbird populations requires a collaborative effort involving diverse stakeholders to ensure sustained management interventions, education, and advocacy programmes. The local villagers are dependent on the water for household activities, agriculture, and grazing their cattle during drought periods. Conservation efforts should focus on habitat preservation, restoration, and sustainable management to ensure the long-term survival of these species. Habitat destruction, pollution, and anthropogenic activities in the surrounding areas pose serious challenges. Conservation strategies must address these threats to safeguard the sanctuary and its avifauna.

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