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Cover: Pseudo-flying animals and wind-dependent seed & spore dispersers – made with digital painting in Krita. © Melito Prinson Pinto



Distribution of avifauna on twenty-one islands of the Gulf of Mannar Biosphere Reserve, India

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Abstract: Every research endeavour must start with closing the information gap about species distribution and biodiversity systematically. Even though enough avifaunal research has been done on the Gulf of Mannar, southeastern India, there have been limited studies about the avifauna from all 21 islands except two. Increasing species occurrence data on distribution from all the islands is highlighted for the future conservation plans for this Important Bird Area. We provide an updated and detailed checklist and distribution of bird groups for all islands individually from a sampling period of 2015–2022. A total of 96 bird species belonging to 34 families from 13 orders were recorded from all the islands; of which 58 species were waterbirds and other terrestrial ones. Of the 29 shorebird species recorded, one is Endangered and seven are Near Threatened by IUCN Red List. Some of the earlier recorded species, not seen in our survey, are not annotated as no record exists for the last decade.

Keywords: Central Asian Flyway, conservation, Gulls, shorebirds, terns, waterbirds.

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INTRODUCTION

Bird surveys are valuable for learning about basic and applied ecology as well as for selecting conservation priority areas (Daniels et al. 1991; Peterson et al. 2000). To our knowledge, only two of the 21 islands in the Gulf of Mannar (GoM) has professional bird checklists (Balachandran 1990). One of the crucial requirements for determining a country's real wealth is to monitor its biodiversity. Monitoring of biodiversity can be used to assess the overall health of the ecosystem and is a cost-effective technique to keep track of all the good and negative changes that occur in biotic groups. Coastal wetlands' stability, health, and variability are frequently revealed by the status and distribution of coastal birds. The structural and functional components of an ecosystem can alter in a way that makes birds vulnerable. The primary elements that frequently determine the diversity and density of bird populations are food, shelter, and human disturbance (Ramesh & Ramachandran 2005).

With 10 distinctly different biogeographical zones and many different habitat types, India is known among the top 12 mega biodiversity countries supporting 1,348 bird species (Praveen & Jayapal 2022), constituting about 12% of the world's avifauna. The Indian subcontinent harbours 1,419 species of birds. Out of the bird species found in India, 310 species rely on wetlands (Kumar et al. 2005; Praveen et al. 2020; Praveen & Jayapal 2022). India remains in the core central region of the Central Asian Flyway (CAF) and holds some important wintering populations of water bird species. Among the global flyways of migration, the CAF supports 257 species of waterbirds. Of these, 81 species are migratory birds of CAF conservation concern, including three Critically Endangered species, six Endangered species, and 13 Near Threatened species. Being part of one of the key biodiversity hotspots in the world, the Gulf of Mannar Biosphere Reserve (GoMBR) is one of the important habitats for the coastal birds migrating as far as the Arctic circle. About 187 species of aquatic and terrestrial birds have been identified in this Important Bird Area (IBA) (Balachandran 1990, 1995), which is famous for waders and seabirds (marine terns and gulls) where sometimes >50,000 water birds are found including pelagic ones (Balachandran 1990). Its proximity to Sri Lanka makes this IBA an important site along the CAF for both migratory water birds and passerines (Zafar & Rahmani 2003). The area is of particular significance as these islands also serve as resting places for birds migrating to and from the nearby Sri Lankan islands.

The Jaffna district of Sri Lanka which is the nearest to the GoMBR has 315 species of birds including the migratory shorebirds (Birdlife International 2022). As Sri Lanka is at the tip of peninsular India, many species migrate annually from the northern autumn-winter to the tropics along the Central Asian-Indian Flyway ending their southward journey on this island (Warakagoda & Sirivardana 2011). Most bird species in Sri Lanka are shared with the adjacent Indian mainland and the rest of Asia (Rasmussen 2005). Many migrant species occurring on the Indian mainland also occur in Sri Lanka (Rasmussen & Anderton 2005).

Bird distribution studies on the southeast coast of India were earlier done (Ali 1979; Ali & Ripley 1983). Biddulph (1938) studied the status of birds on Rameswaram Island. Balachandran (1990) studied the coastal birds of Mandapam and the neighbouring islands of peninsular India. Also, 15 species of migratory shorebirds and eight species of migratory terns were found to summer here, especially on Manoli Island and Hare Island (Balachandran 1990). The earlier studies were restricted only to two islands of the Mandapam region, Dhanushkodi and Pillaimadam lagoons, and have not included a checklist of the avifaunal species from all 21 islands. The present study lists the current diversity and distribution of coastal birds from all 21 islands of the GoMBR. This paper reports sight records of a few rare and threatened species, and updates the previous knowledge on the GoMBR with the first comprehensive list of the Island group's avifauna.

Study Area

The GoMBR, the first marine biosphere reserve of India, is located off the southern extremity of India. At distances ranging 0.2–8 km from the mainland, the GoMBR has a chain of 21 uninhabited islands, from Mandapam to Tuticorin covering 682.76 ha (Figure 1). Most of the islands are small, from a few hectares to less than 4 km², running roughly parallel to the coast. The GoMBR has a coastal length of about 141 km. At the end of the peninsular extension is Pamban Island, which is connected to the mainland by a railway bridge. The inshore region of Palk Bay is largely muddy, while the GoMBR, is rocky and interspersed with small areas of sand and mud (Balachandran 1995). The mixing of waters of Palk Bay and the Gulf of Mannar takes place through the Pamban Pass and Adam's Bridge between Dhanushkodi and the west coast of Sri Lanka (Jayaraman 1954). Like Chilika Lake in Odisha (an IBA) and Point Calimere in Tamil Nadu (an IBA), the GoMBR is extremely important for migrant and resident waders. On the Sri

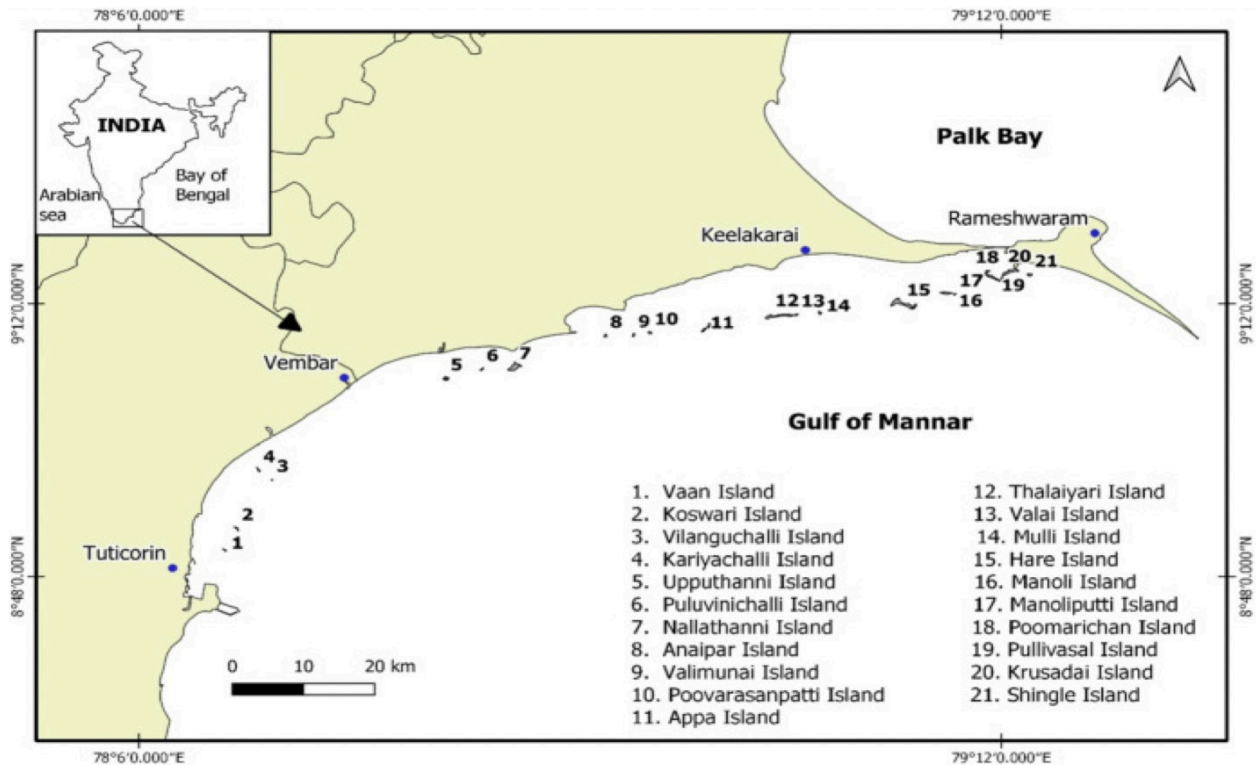


Figure 1. The Gulf of Mannar Biosphere Reserve, India depicting 21 islands where the present study was conducted.

Lanka side, about 10 km away, in the Jaffna district, there are four IBAs (Anatidal-Thondamannar, Araly South-Punale, Kaithady, and Kayts Island-Mandativu) (Anonymous 2003).

The size, form, height, and geomorphic characteristics of these islands vary considerably. The reduction of vegetation cover results from human habitat damage including illegal coral mining, dynamite fishing, and bottom trawling of which coral mining played a major role (Asir et al. 2020). These islands have sand dunes along their coastlines with salt-dominant plant species (e.g., *Sesuvium portulacastrum*, *Salicornia brachiata*). Some of the islands contain trees (e.g., *Acacia planifrons*, *Borassus flabellifer*, *Thespesia populnea*, *Prosopis chilensis*), while the marshy sections of some of the islands are occupied by mangroves (e.g., *Rhizophora mucronata*, *Avicennia marina*) and allied species (e.g., *Excoecaria agallocha*, *Salvadora persica*, *Pemphis acidula*) (GOMBRT 2012). Tropical weather prevails in the GoMBR due to the influence of both the South West and North East monsoons. Only a very small portion of the region's overall rainfall is caused by the South West monsoon. Between mid-October and mid-December, the north-east monsoon brings moderate to heavy rainfall along with occasional gales. The average annual rainfall ranges 762–1,270 mm. Atypically hot weather is

prevalent from January to May. December is the month with the lowest temperature, which is 25°C. In the GoMBR's coastal regions, the wind velocity is typically high (Kumaraguru et al. 2006). From June to December, the wind blows north-northeasterly before switching to a westerly direction. In November, the wind speed is lowest and maximum in August (Venkatraman & Gokula 2009).

The islands that are subdivided as small groups based on the nearest land names are listed from south-west to north-east in various groups given below with the extent of land coverage in hectares. These islands, which are grouped into the Mandapam group, Keelakkarai group, Vembar group, and Tuticorin group (Table 1), are mainly of coral origin. As the coral reefs harbour a variety of sea animals and weeds, this stretch of sea is biologically rich on the eastern coast of India.

MATERIALS AND METHODS

Bird counts were carried out at these islands during both low and high tide using binoculars during the peak migratory period and intermittent data was collected during the non-migratory period of two years from February 2017 to March 2019. The annual bird

Table 1. The island groups with area details and location.

Island groups	Island Name	Latitude & Longitude	Area (Hectares)
1. Tuticorin islands	1. Vaan	8.83639°N 78.21047°E	16.00
	2. Koswari	8.86879°N 78.22506°E	19.50
	3. Vilanguchalli	8.93815°N 78.26969°E	0.95
	4. Kariyachalli	8.95409°N 78.25235°E	16.46
2. Vembar islands	1. Uppu Thanni	9.08921°N 78.49148°E	22.94
	2. Puluvinu Challi	9.10320°N 78.53688°E	6.12
	3. Nalla Thanni	9.10667°N 78.57885°E	101.00
3. Kilakarai islands	1. Anaipar	9.15294°N 78.69481°E	11.00
	2. Valli Munai	9.15354°N 78.73052°E	6.72
	3. Poovarasam Patti (Kilinjan paar)	9.15413°N 78.76695°E	0.50
	4. Appa	9.16582°N 78.82596°E	28.63
	5. Talairi	9.18133°N 78.90673°E	75.15
	6. Valai	9.18421°N 78.93866°E	10.10
	7. Mulli	9.18641°N 78.96810°E	10.20
4. Mandapam islands	1. Hare (Musal)	9.19912°N 79.07530°E	124.00
	2. Manoli	9.21564°N 79.12834°E	25.90
	3. Manoli-putti	9.21581°N 79.12800°E	2.34
	4. Poomarichan	9.24538°N 79.17993°E	16.58
	5. Pullivasal	9.23699°N 79.19100°E	29.95
	6. Kurusadai	9.24690°N 79.20945°E	65.80
	7. Shingle	9.24174°N 79.23563°E	12.69

census for the years 2016, 2017, 2018, 2019, and 2022 conducted by the forest department, with bird watching volunteers and monitored by us, was also considered for the checklist. The frequency of visits depended on the availability of boats and the tidal movements.

Birds were counted using the direct count method from selected vantage points following Bibby et al. (2000). The observations recorded while moving from one scanning point to another were entered as incidental records. During low tide, the waders occur scattered all over the exposed intertidal area and shallow areas for feeding, facilitating easy identification. During high tide, they congregate in limited numbers and high tide roost is available for them to count if it is a smaller flock or estimate if the flock is denser (Howes & Bakewell 1989). Our main aim was to document the avifauna of all the islands and to provide information on species distribution. Terns and gulls feed in the sea and congregate at high tide roost, and they were documented during that time. Bird's congregation was photographed with 400 or 600 mm tele lens and were checked for their

identification and enumeration (Hayman et al. 2011; Grimmett et al. 2014). The status of waterbirds was categorised as Common (seen on most of the visits), Uncommon (seen less than five times), and Rare (seen once or twice). The migratory status of waterbirds was classified as, Resident (R), Resident but not breeding (R/NB), Local Migrant (LM), and Winter Visitor (WV). We have considered the old checklist prepared from GoMBR for apprising since the entire 21 island bird records were missing from the past except for some. Also, some of the earlier recorded species of migratory shorebirds of the 1980s and early 2000s are not recorded at present in this area. The available checklist prepared through the earlier study of only the two islands was upgraded with the distribution status for all 21 islands. This species checklist can be used as a baseline reference for future monitoring of individual islands and conservation planning schemes adopted on the islands separately.

RESULTS AND DISCUSSION

The study recorded 96 species of birds belonging to 34 families and 13 orders from the 21 uninhabited islands of GoMBR during 2016–2022 (Table 2). The order Charadriiformes with 44 species belonging to six families dominated followed by Passeriformes with 22 species belonging to 13 families.

Water birds (n = 58) from the islands belonging to the orders Charadriiformes (with six families), Pelecaniformes (with two families), Anseriformes, Gruiformes, and Suliformes (with one family each) were recorded (Table 3). Among families, the Family Scolopacidae dominated (with 19 species), followed by Laridae (with 15 species), Ardeidae (with nine species), Charadriidae (with six species), Burhinidae & Anatidae (with two species each), and Rallidae, Recurvirostridae, Dromadidae, & Threskiornithidae (each with one species) (Figure 2). The analysis of data on residential status revealed that out of 58 waterbird species, 15 were residents; whereas the 39 species were winter visitors (Table 3). Among the shorebirds, seven Near Threatened species (Bar-tailed Godwit *Limosa lapponica*, Black-tailed Godwit *Limosa limosa*, Red Knot *Calidris canutus*, Curlew Sandpiper *Calidris ferruginea*, Red-necked Stint *Calidris rufocollis*, Eurasian Curlew *Numenius arquata*, and Greater Thick-knee *Esacus recurvirostris*) and one Endangered species (Great Knot *Calidris tenuirostris*) were recorded.

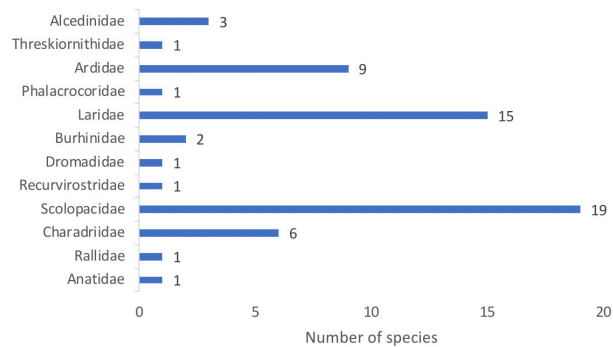


Figure 2. Family-wise species numbers of waterbirds in the islands of GoMBR, India.

Distribution Pattern of major coastal bird groups at different groups of islands

Mandapam group of islands is near the Pamban Bridge that connects the mainland with Rameswaram Island. Among all other groups of islands, the maximum number of species observed along with the highest number of some of the bird species were highest in these islands, especially on Manoli Island. The number of water bird species recorded on this island was the highest (inclusive of waders, ducks, terns, gulls, egrets, and herons). Even though the trend is similar to the early studies from these islands (Balachandran 1990; Daniel et al. 2007) overall count and the species diversity have significantly reduced (Balachandran 2006); the earlier record of 26 species (Balachandran 1990) had reduced to 19 species of shorebirds in our present study.

The inter-tidal zone around Manoli and Manoliputti islands is the only place where a good congregation of uncommon waders like Crab Plover *Dromas ardeola*, Bar-tailed Godwit *Limosa lapponica*, and Terek Sandpiper *Xenus cinereus* were observed. Crab plovers are only found in these groups of islands in the entire GoMBR (Byju 2020), hence the significance of the bird distribution studies of these islands. Our studies on other parts of the GoM including major congregation areas like Dhanushkodi lagoon and Pillaimadam where Crab plovers were earlier recorded were not recorded by us during the entire study period. The Northern Pintailed Ducks *Anas acuta* was seen on Manoli Island, this species was not reported in the earlier two studies (Balachandran 1990; Daniel et al. 2007) from these coral islands but were recorded from other areas of GoMBR. The absence of Eurasian Oystercatcher *Haematopus ostralegus* and Broad-billed Sandpiper *Calidris falcinellus* from the surveys done for several years shows the impact on habitat change and depletion of food in these islands, while the former being still reported from the southern

coast end of Tuticorin and the latter being sighted by us from the Dhanushkodi lagoon of the GoMBR, both though less than ten individuals. Sivaperuman & Jayson (2012) reported that there is a positive correlation between the population fluctuation and distribution patterns of shorebirds with respect to their prey abundance. The increased numbers of Curlew Sandpiper *Calidris ferruginea* in the Kole wetland of Kerala's west coast are due to the abundance of polychaetes and crustaceans (Sivaperuman & Jayson 2012).

Pullivaasal and Poomarichan islands among the Mandapam group of islands recorded hundreds of Lesser Crested Tern *Thalasseus bengalensis* and Greater Crested Tern *Thalasseus bergii*, Pallas Gull *Ichthyaeetus ichthyaeetus*, Lesser Black-backed Gull *Larus fuscus*, Caspian Tern *Sterna caspia*, and Brown-headed Gull *Chroicocephalus brunnicephalus*. Regular records of Osprey *Pandion haliaetus* and occasional records of Peregrine Falcon *Falco peregrinus* and White-bellied Sea-eagle *Haliaeetus leucogaster* are from these islands. The dominant shorebird species were the Lesser Sand Plover *Charadrius mongolus*. Among all the water bird species recorded from this group of islands Gulls as a group were the dominant one. The highest count of Greater Crested Tern, Lesser Crested Tern, and Caspian Tern was observed during February. During December, the Lesser Crested Tern and Greater Crested Tern were the dominant species.

Kilakarai, Tuticorin, and Vembar group of islands

The three groups of islands, Kilakarai, Tuticorin, and the Vembar, together constitute the remaining 14 islands. This group of islands recorded a smaller number of waders and less diversity of birds compared to the other seven islands of the Mandapam group were observed. The commonly recorded waders in all the islands include Lesser Sand Plover *Charadrius mongolus*, Kentish Plover *Charadrius alexandrinus*, and Ruddy Turnstone *Arenaria interpres*. Gulls and terns, and a few other waders as listed (Table 2). No single island in these three groups of islands supports more than 500 waterbirds and a family-wise abundance of waterbirds are given for all three island groups - Kilakarai, Vembar, and Tuticorin (Table 4). The first record of the Brown Noddy *Anous stolidus* from GoMBR was from Kariyashulli Island of the Tuticorin group. During January, Northern Pintail *Anas acuta* and Garganey *Anas querquedula* were higher in count exceeding 1,000 in numbers. As this is the first distribution checklist from these groups of islands, we cannot compare this with the population abundance or the loss of species diversity as from the Manoli and Hare

Table 2. Avifauna and their distribution on 21 islands of GoMBR, India.

Common name	Scientific name	Shingle	Kurusadai	Pulli vasal	Poomarichan	Manoliputti	Manoli	Musal	Mulli	Valai	Talairi	Appa	Poovarasapatti	Vali munai	Anaipar	Nallathanni	Puluvinchalli	Uppu thanni	Vilanguchalli	Karyachalli	Koswari	Vaan
Order: Anseriformes																						
Family: Anatidae																						
Garganey	<i>Spatula querquedula</i>						√													√		
Northern Pintail	<i>Anas acuta</i>					√	√															
Order: Gruiformes																						
Family: Rallidae																						
White-breasted Waterhen	<i>Amaurornis phoenicurus</i>						√															
Order: Charadriiformes																						
Family: Charadriidae																						
Blackbellied Plover	<i>Pluvialis squatarola</i>	√	√		√	√	√	√				√	√			√				√		√
Kentish Plover	<i>Charadrius alexandrinus</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Lesser Sand Plover	<i>Charadrius mongolus</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Greater Sand Plover	<i>Charadrius leschenaultii</i>					√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√
Pacific Golden Plover	<i>Pluvialis fulva</i>					√	√	√								√						
Red-wattled Lapwing	<i>Vanellus indicus</i>		√					√												√		
Family: Scolopacidae																						
Pin-tailed Snipe	<i>Gallinago stenura</i>							√														
Black-tailed Godwit	<i>Limosa limosa</i>					√	√															
Bar-tailed Godwit	<i>Limosa lapponica</i>					√	√	√														
Whimbrel	<i>Numenius phaeopus</i>	√				√	√	√														
Eurasian Curlew	<i>Numenius arquata</i>	√		√		√	√	√					√					√				√
Common Redshank	<i>Tringa totanus</i>		√	√		√	√	√														
Common Greenshank	<i>Tringa nebularia</i>	√		√	√	√	√	√														
Green Sandpiper	<i>Tringa ochropus</i>					√	√															
Wood Sandpiper	<i>Tringa glareola</i>						√															
Terek Sandpiper	<i>Xenus cinereus</i>					√	√	√														
Common Sandpiper	<i>Actitis hypoleucos</i>	√	√	√	√	√	√	√	√						√	√		√		√	√	√
Ruddy Turnstone	<i>Arenaria interpres</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Great Knot	<i>Calidris tenuirostris</i>		√			√	√	√	√						√							
Red Knot	<i>Calidris canutus</i>					√	√	√	√													
Sanderling	<i>Calidris alba</i>					√	√	√														
Little Stint	<i>Calidris minuta</i>	√	√			√	√	√														
Red-necked Stint	<i>Calidris ruficollis</i>					√	√	√														
Dunlin	<i>Calidris alpina</i>					√	√	√														
Curlew Sandpiper	<i>Calidris ferruginea</i>					√	√	√														
Family: Recurvirostridae																						
Black-winged Stilt	<i>Himantopus himantopus</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Family: Dromadidae																						
Crab Plover	<i>Dromas ardeola</i>					√	√	√														

Common name	Scientific name	Shingle	Kurusadai	Pulli vasal	Poomarichan	Manoliputti	Manoli	Musal	Mulli	Valai	Talairi	Appa	Poovarasampatti	Valli munai	Anaipar	Nallathanni	Puluvinchalli	Uppu thanni	Vilanguchalli	Karyachalli	Koswari	Vaan
Family: Burhinidae																						
Indian Thick-knee	<i>Esacus magnirostris</i>					√	√	√														
Greater Thick-knee	<i>Esacus recurvirostris</i>	√																				
Family: Laridae																						
Lesser Black-backed Gull	<i>Larus fuscus</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Pallas's Gull	<i>Ichthyaetus ichthyaetus</i>					√	√	√														
Brown-headed Gull	<i>Chroicocephalus brunnicephalus</i>	√	√	√	√	√	√	√							√							
Blackheaded Gull	<i>Chroicocephalus ridibundus</i>	√	√	√	√	√	√	√	√						√	√	√				√	√
Slender-billed Gull	<i>Chroicocephalus genei</i>		√			√	√															
Gullbilled Tern	<i>Gelochelidon nilotica</i>					√	√	√											√	√		
Caspian Tern	<i>Hydroprogne caspia</i>	√	√		√	√	√	√	√	√		√	√	√	√	√					√	√
Lesser Crested Tern	<i>Thalasseus bengalensis</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Greater Crested Tern	<i>Thalasseus bergii</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Common Tern	<i>Sterna hirundo</i>					√	√	√		√											√	
Sandwich Tern	<i>Thalasseus sandvicensis</i>					√	√	√														
Saunders's Tern	<i>Sternula saundersi</i>					√	√	√														
Little Tern	<i>Sternula albifrons</i>	√	√			√	√	√	√	√		√	√	√		√	√				√	√
Whiskered Tern	<i>Chlidonias hybrida</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Brown Noddy	<i>Anous stolidus</i>																				√	
Order: Suliformes																						
Family: Phalacrocoracidae																						
Little Cormorant	<i>Microcarbo niger</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Order: Pelecaniformes																						
Family: Ardeidae																						
Grey Heron	<i>Ardea cinerea</i>	√	√	√	√	√	√	√														√
Purple Heron	<i>Ardea purpurea</i>		√																		√	
Great Egret	<i>Ardea alba</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Little Egret	<i>Egretta garzetta</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Intermediate Egret	<i>Ardea intermedia</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Western Reef Heron	<i>Egretta gularis</i>		√			√	√	√														
Indian Pond Heron	<i>Ardeola grayii</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Straited Heron	<i>Butorides striata</i>	√	√	√		√	√	√				√										
Blackcrowned Night Heron	<i>Nycticorax nycticorax</i>		√																			
Family: Threskiornithidae																						
Eurasian Spoonbill	<i>Platalea leucorodia</i>		√																			
Order: Coraciiformes																						
Family: Alcedinidae																						
White-throated Kingfisher	<i>Halcyon smyrnensis</i>		√			√	√	√							√							

Common name	Scientific name	Shingle	Kurusadai	Pulli vasal	Poomarichan	Manoliputti	Manoli	Musal	Mulli	Valai	Talairi	Appa	Poovarasampatti	Valli munai	Anaipar	Nallathanni	Puluvinchalli	Uppu thanni	Vilanguchalli	Karyachalli	Koswari	Vaan
Pied Kingfisher	<i>Ceryle rudis</i>		√																			
Common Kingfisher	<i>Alcedo atthis</i>		√			√	√										√					
Family: Meropidae																						
Blue-tailed Bee-eater	<i>Merops philippinus</i>					√	√	√							√					√		
Family: Coraciidae																						
Indian Roller	<i>Coracias benghalensis</i>		√																			
Order: Falconiformes																						
Family: Falconidae																						
Common Kestrel	<i>Falco tinnunculus</i>					√	√							√			√					
Peregrine Falcon	<i>Falco peregrinus</i>						√															
Order: Accipitriformes																						
Family: Accipitridae																						
Black Kite	<i>Milvus migrans</i>	√	√			√	√		√													
Brahminy Kite	<i>Haliastur indus</i>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
White-bellied Sea Eagle	<i>Haliaeetus leucogaster</i>					√	√															
Family: Pandionidae																						
Osprey	<i>Pandion haliaetus</i>	√	√			√	√															
Order: Psittaciformes																						
Family: Psittaculidae																						
Rose-ringed Parakeet	<i>Psittacula krameri</i>		√																			
Order: Cuculiformes																						
Family: Cuculidae																						
Jacobin Cuckoo	<i>Clamator jacobinus</i>		√																			
Chestnut-winged Cuckoo	<i>Clamator coromandus</i>		√				√															
Order: Apodiformes																						
Family: Apodidae																						
Asian Palm Swift	<i>Cypsiurus balasiensis</i>	√	√				√								√							
Order: Bucerotiformes																						
Family: Upupidae																						
Eurasian Hoopoe	<i>Upupa epops</i>		√																			
Order: Passeriformes																						
Family: Dicruridae																						
Black Drongo	<i>Dicrurus macrocercus</i>		√																			
Family: Corvidae																						
House Crow	<i>Corvus splendens</i>	√	√																			
Large-billed Crow	<i>Corvus macrorhynchos</i>	√	√																			
Family: Hirundinidae																						
Barn Swallow	<i>Hirundo rustica</i>	√	√				√					√										
Red-rumped Swallow	<i>Cecropis daurica</i>		√																			
Family: Alaudidae																						
Jerdon's Bushlark	<i>Mirafra affinis</i>		√																			
Ashy-crowned Sparrowlark	<i>Eremopterix griseus</i>		√																			
Oriental Skylark	<i>Alauda gulgula</i>	√	√			√	√					√										
Family: Pycnonotidae																						

Common name	Scientific name	Shingle	Krusadai	Pulli vasal	Poomarichan	Manoliputti	Manoli	Musal	Mulli	Valai	Talairi	Appa	Poovarasapatti	Vali munai	Anaipar	Nallathanni	Puluvinchalli	Uppu thanni	Vilanguchalli	Karyachalli	Koswari	Vaan
Red-vented Bulbul	<i>Pycnonotus cafer</i>		√																			
Family: Cisticolidae																						
Plain Prinia	<i>Prinia inornata</i>		√																			
Zitting Cisticola	<i>Cisticola juncidis</i>		√																			
Common Tailorbird	<i>Orthotomus sutorius</i>		√																			
Family: Acrocephalidae																						
Blyth's Reed Warbler	<i>Acrocephalus dumetorum</i>		√				√															
Booted Warbler	<i>Iduna caligata</i>		√				√															
Family: Sturnidae																						
Rosy Starling	<i>Pastor roseus</i>		√																			
Family: Muscipidae																						
Indian Robin	<i>Copsychus fulicatus</i>		√																			
Family: Nectariniidae																						
Purple Sunbird	<i>Cinnyris asiaticus</i>					√	√	√							√							
Purple rumped Sunbird	<i>Leptocoma zeylonica</i>					√	√	√										√		√		
Family: Passeridae																						
House Sparrow	<i>Passer domesticus</i>		√																			
Yellow-throated Sparrow	<i>Gymnoris xanthocollis</i>		√														√					
Family: Estrildidae																						
Indian Silverbill	<i>Euodice malabarica</i>		√																			
Family: Motacillidae																						
White-browed Wagtail	<i>Motacilla maderaspatensis</i>		√		√																	

islands of the Mandapam group.

CONSERVATION IMPLICATIONS

A recent study done by Asir et al. (2020) using the mapping data and toposheets of the Survey of India from 1969–2018 for all the 21 islands of GoM BR reports that Vilanguchalli Island of the Tuticorin island group and Poovarasapatti Island of Kilakkarai island group are almost submerged. Among the 21 islands, the area cover of 15 islands has reduced by 144.15 ha and four have their area expanded during the last 49 years. Asir et al. (2020) reported that overall, the Tuticorin group of islands has experienced the highest percentage of land cover reduction (78.55%), followed by Keelakarai (43.49%), Vembar (36.21%), and Mandapam (21.84%) groups. This might be the reason for fewer birds found in these three island groups in the present study. The

four islands of the Mandapam group whose area has increased (16.44%) are Hare Island, Manoli Island, Krusadai Island, and Shingle Island (Asir et al. 2020). The abundance of the number of birds compared to other islands along with the diversity of species including the presence of Crab plovers and Pin-tailed ducks in these islands is a matter to be further investigated.

Shorebirds face threats from the degradation of intertidal habitats (Barter 2005; Moores et al. 2008) and the extension of mangroves (Augustinus 1995; Aarif et al. 2014). In the area between the Manoli and Manoliputti islands of the Mandapam group of islands, a vegetative structure had grown along with the extension of mangroves to the seaside degrading the intertidal zone for birds to forage and roost. It is explicit that these uninhabited islands possess a meager diversity and abundance of permanent resident birds. Even the scanty resident land birds are not distributed in all the islands as it appears to solely depend on the presence of humans,

Table 3. List of water birds recorded from the 21 islands of GoMBR, India.

	Common name	Scientific name	IUCN Red list status	Migration status
Order: Anseriformes Family: Anatidae				
1	Garganey	<i>Spatula querquedula</i>	LC	WV
2	Northern pintail	<i>Anas acuta</i>	LC	WV
Order: Gruiformes Family: Rallidae				
1	White-breasted waterhen	<i>Amaurornis phoenicurus</i>	LC	R
Order: Charadriiformes Family: Charadriidae				
1	Black-bellied plover	<i>Pluvialis squatarola</i>	LC	WV
2	Kentish Plover	<i>Charadrius alexandrinus</i>	LC	LM/R
3	Lesser Sand Plover	<i>Charadrius mongolus</i>	LC	WV
4	Greater Sand Plover	<i>Charadrius leschenaultii</i>	LC	WV
5	Pacific Golden Plover	<i>Pluvialis fulva</i>	LC	WV
6	Red-wattled Lapwing	<i>Vanellus indicus</i>	LC	R
Family: Scolopaciidae				
1	Pin-tailed Snipe	<i>Gallinago stenura</i>	LC	WV
2	Black-tailed Godwit	<i>Limosa limosa</i>	NT	WV
3	Bar-tailed Godwit	<i>Limosa lapponica</i>	NT	WV
4	Whimbrel	<i>Numenius phaeopus</i>	LC	WV
5	Eurasian Curlew	<i>Numenius arquata</i>	NT	WV
6	Common Redshank	<i>Tringa totanus</i>	LC	WV
7	Common Greenshank	<i>Tringa nebularia</i>	LC	WV
8	Green Sandpiper	<i>Tringa ochropus</i>	LC	WV
9	Wood Sandpiper	<i>Tringa glareola</i>	LC	WV
10	Terek Sandpiper	<i>Xenus cinereus</i>	LC	WV
11	Common Sandpiper	<i>Actitis hypoleucos</i>	LC	WV
12	Ruddy Turnstone	<i>Arenaria interpres</i>	LC	WV
13	Great Knot	<i>Calidris tenuirostris</i>	EN	WV
14	Red Knot	<i>Calidris canutus</i>	NT	WV
15	Sanderling	<i>Calidris alba</i>	LC	WV
16	Little Stint	<i>Calidris minuta</i>	LC	WV
17	Red-necked Stint	<i>Calidris ruficollis</i>	NT	WV
18	Dunlin	<i>Calidris alpina</i>	LC	WV
19	Curlew Sandpiper	<i>Calidris ferruginea</i>	NT	WV
Family: Recurvirostridae				
1	Black-winged Stilt	<i>Himantopus himantopus</i>	LC	R
Family: Dromadidae				
1	Crab Plover	<i>Dromas ardeola</i>	LC	WV

	Common name	Scientific name	IUCN Red list status	Migration status
Family: Burhinidae				
1	Indian Thick-knee	<i>Burhinus indicus</i>	LC	R
2	Greater Thick-knee	<i>Esacus recurvirostris</i>	NT	R
Family: Laridae				
1	Lesser Black-backed Gull	<i>Larus fuscus</i>	LC	WV
2	Pallas's Gull	<i>Ichthyaetus ichthyaetus</i>	LC	WV
3	Brown-headed Gull	<i>Chroicocephalus brunnicephalus</i>	LC	WV
4	Black-headed Gull	<i>Chroicocephalus ridibundus</i>	LC	WV
5	Slender bill Gull	<i>Chroicocephalus genei</i>	LC	WV
6	Gull-billed Tern	<i>Gelochelidon nilotica</i>	LC	WV
7	Caspian Tern	<i>Hydroprogne caspia</i>	LC	WV
8	Lesser Crested Tern	<i>Thalasseus bengalensis</i>	LC	R/LM
9	Greater Crested Tern	<i>Thalasseus bergii</i>	LC	WV
10	Common Tern	<i>Sterna hirundo</i>	LC	WV
11	Sandwich tern	<i>Thalasseus sandvicensis</i>	LC	WV
12	Saunders tern	<i>Sternula saundersi</i>	LC	WV
13	Little Tern	<i>Sternula albifrons</i>	LC	WV
14	Whiskered Tern	<i>Chlidonias hybrida</i>	LC	WV
15	Brown Noddy	<i>Anous stolidus</i>	LC	V
Order: Suliformes Family: Phalacrocoracidae				
1	Little Cormorant	<i>Microcarbo niger</i>	LC	R
Order: Pelecaniformes Family: Ardeidae				
1	Grey Heron	<i>Ardea cinerea</i>	LC	R
2	Purple Heron	<i>Ardea purpurea</i>	LC	R
3	Great Egret	<i>Ardea alba</i>	LC	R
4	Intermediate Egret	<i>Ardea intermedia</i>	LC	R
5	Little Egret	<i>Egretta garzetta</i>	LC	R
6	Western Reef Heron	<i>Egretta gularis</i>	LC	R/LM
7	Indian pond Heron	<i>Ardeola grayii</i>	LC	R
8	Striated Heron	<i>Butorides striata</i>	LC	R
9	Black-crowned Night Heron	<i>Nycticorax nycticorax</i>	LC	R
Family: Threskiornithidae				
1	Eurasian Spoonbill	<i>Platalea leucorodia</i>	LC	R/NB

LC—Least Concern | NT—Near Threatened | EN—Endangered | V—Vagrant | WV—Winter Visitor | LM—Local Migrant | R—Resident | R/NB—Resident/Non-Breeding.

Table 4. The Waterbird group population maximum estimated on the island subgroups of GoM-BR, India.

Families	Mandapam island group	Keezhakarai island group	Vembar island group	Tuticorin island group
Laridae	5000–10000	1000–2000	>1000	>500
Anatidae	2000–3000	<1000	-	-
Charadriidae, Scolopacidae, Recurvirostridae, Dromidae, Burhinidae	3000–5000	>1000	>1000	>500
Rallidae, Phalacrocoracidae, Ardeidae, Threskiornithidae	500–1000	200–300	100	300–500

as they are closely associated with the latter. One of the obstacles for the birds to colonize and thrive in this area could be the lack of habitat diversity in terms of flora, geography, and topography coupled with declining benthic diversity, which would provide a prey base. This is comparable to research on some significant atolls in the Lakshadweep Islands (Aju et al. 2021). Although there is a greater variety of birds in the Manoli group of islands than in past studies, their numbers are rapidly declining in GoMBR (Balachandran 2006).

Despite the Fisheries Department's efforts of educating and monitoring fishermen's community from preventing the indiscriminate destruction of marine life, it continues. We have observed that in some of the islands closer to the coast, the native vegetation has lost ground to the alien *Prosopis chilensis*, which has taken over. Although coral quarrying for industrial purposes has been outlawed, the coral reef has already been destroyed in several places. Corals, seagrass, and mangroves are among the three unique ecosystems present on the islands. Anthropogenic pressures like human settlements, though not permanent, are found on Poomarichan, Pullivasal, and Manoliputti islands in the Mandapam island group. They bring water from the shores for drinking and cook using the vegetation from the islands. Deployment of traditional fishing gear was infrequently recorded especially close to the mangrove fringes in many islands which offer an ideal foraging ground for large wading birds. Similar observations were reported in Kadalundi-Vallikunnu Community Reserve (KVCR), Kozhikode, and Malappuram districts, Kerala (Aarif et al. 2017). Proactive efforts to remove the discarded fishing gear or plastic debris from these islands, which are wintering as well as stopover grounds, could greatly reduce injuries to migratory birds. Aarif et al. (2021) found similar threats posed by leftover fishing gear injuring birds at KVCR. The long-distance migrant shorebirds are highly dependent on a series of key stop-over sites between wintering and more northerly breeding areas (Boere et al. 2006). Therefore, the

linkage between the coral islands of GoMBR and other major shorebird habitats both within the east and west coast of India and other nearby countries like Sri Lanka coming under the CAF must be understood by regular and systematic monitoring as it holds several important long-distance migrant species.

CONCLUSION

The islands of GoMBR are home to a high bird diversity supported by large expanses of natural ecosystems. As there are still unaltered habitats in the study area, preemptive conservation initiatives could help to protect them in the future. To create successful conservation strategies, comprehensive assessments of species ecology, and occurrences are essential. However, to date, no regular bird monitoring efforts exist for all 21 islands, and many of the islands lack comprehensive checklists. The importance of local landscapes for the conservation of avifauna can only be understood by knowing the structure of the bird community of that region (Kattan & Franco 2004). Our distribution checklist can be used as baseline data for future monitoring and to measure conservation success. Considering the limited data available on species distributions and occurrences, this will foster to refine the scientific focus and knowledge as the continuous expansion of monitoring birds helps in maintaining the important sites of the congregation for some species like Crab Plover in GoMBR are restricted to only one or two islands in a single island group.

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