Foraging ecology and habitat use of wading birds and shorebirds in the mangrove ecosystem of the Andaman Islands

Final Technical Report

Submitted by:
Dr. C. SIVAPERUMAN, Scientist-D

Submitted to

Ministry of Environment, Forests and Climate Change
Government of India, New Delhi

Sanction Number (Date & Year) :
F.No.14/226/2013-RE, dated 25.11.2014

Government of India
Ministry of Environment, Forests and Climate Change
ZOOLOGICAL SURVEY OF INDIA
Andaman and Nicobar Regional Centre
Port Blair - 744 102, Andaman and Nicobar Islands

5 June 2018

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सत्यमेव जयते

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PROFORMA FOR FINAL TECHNICAL REPORT

PART - I

1. Title of the Project

Foraging ecology and habitat use of wading birds and shorebirds in the mangrove ecosystem of the Andaman Islands

2. Name of the PI & Address

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3. Number & Date of Sanction Letter

No.14/226/2013-RE, dated 25.11.2014

4. Duration of the Project

Three years

4.1. Date of Commencement: 8th December 2014

4.2. Date of Completion: 7th December 2017

4.3. Extension of period: Nil

5. Budget

5.1. Total amount sanctioned during the entire tenure under different subheads

Rs.21,42,000/-

5.2. Total amount spent during the entire tenure under different subheads

Sl. No.	Heads	Receipt	Expenditure
1.	Salaries	3,18,343	3,93,143
2.	Permanent Equipment	3,20,000	3,19,754
3.	Expendables / Consumables	1,22,490	1,93,933
4.	Travel	4,90,000	7,33,124
5.	Other project costs	0	0
6.	Contingencies	71,870	1,86,000
7.	Dissemination of Research work	0	1,52,130
8.	Institutional Charges	0	0
9.	Bank interest etc.	0	0
	Total	**13,22,703**	**19,78,084**

PART - II

ACKNOWLEDGEMENTS

The work was financially supported by the Ministry of Environment, Forest and Climate Change, Government of India.

I wish to express my deep gratitude to the Officials of MoEFCC, Government of India for their keen interest, encouragement and constant support to carry out this study in Andaman Islands.

I am thankful to Dr. Kailash Chandra, Director, Zoological Survey of India, Kolkata for encouragement and providing necessary facilities to undertake this research study.

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Dr. C. Sivaperuman

1. Preface

The Andaman and Nicobar Islands are known for their rich biodiversity resources. There are 572 islands, islets and rocky outcrops, which can be distinguished geographically into two groups, with land area extending up to 8,249 km^2 and a coastline of 1,962 km; the total area of Andaman Islands constitutes 6408 km^2 and the Nicobars 1841 km^2. The Andaman Islands are the extension of the submerged Arakan Yoma Mountain range of Myanmar and the Nicobars are the continuation of the Mentawai Islands to the south and southeast of Sumatra. There are two deep channels, the *Ten Degree Channel* which isolates Andaman Islands from Nicobar Islands and the *Sombrero Channel* which isolates Great Nicobar from Nicobars and the Nancowrie group. The topography of the Andaman and Nicobar Islands is hilly and undulating. The elevation in Andamans is from 0 to 732 m, Saddle Peak being the highest in North Andaman Island. In Nicobars the elevation rises from 0 to 568 m, Mt Thuillier being the highest peak on Great Nicobar Island. The average annual rainfall exceeds 3000mm, but the northern islands show greater seasonal climatic variation than the southern islands. The habitats represented in the islands include bays, mangroves, moist deciduous forests and evergreen forests. The fauna and flora of Andamans have close affinities to Indo-China and that of the Nicobars to the Indo-Malayan.

The Andaman and Nicobar archipelago encompasses a very high degree of endemism in all taxa, especially in plants, reptiles, fishes and birds, and is characterized by distribution of biodiversity in a contrasting interface of terrestrial and marine habitats. This archipelago is considered as a Paradise of Biological Diversity. Out of the 1340 species of birds recorded from Indian subcontinent, 26 per cent are found in Andaman and Nicobar Islands. A total of 349 species of birds were reported from A & N Islands, belonging to 56 families under 17 orders. Of the 142 endemic bird species of the Indian subcontinent, 30 are distributed in Andaman and Nicobar Islands. Though the A & N Islands form only 0.25 per cent of the landmass of India, they support 12 per cent of the endemic avifauna.

The project titled "Foraging ecology and habitat use of wading birds and shorebirds in the mangrove ecosystem of the Andaman Islands" is the first detailed studies on the Wading and Shore birds of Andaman Islands. The objective of this study was to describe the avian community at the Mangrove ecosystem of Andaman Islands, to investigate the relationship between the birds and their prey, to provide knowledge about the intertidal of the mangrove ecosystem as a foraging habitat for birds. This study has been carried out in the mangrove ecosystem of Andaman Islands. Surveys were conducted using previously established scientific sampling methods. Total of 442 surveys have been conducted in South Andaman, Middle Andaman and North Andaman Islands. Fifteen species of wading birds belongs to the order Ciconiiformes and Pelicaniformes; thirty four species of shorebirds, belongs to 4 families under the order Charadriiformes were sighted and nine species of gulls and terns belong to the family Laridae were recorded. Chinese Egret *Egretta eulophotes* has been reported for first time from Indian and South Asia during the study period.

This work carried out as a part of the major ecological studies funded by the Ministry of Environment, Forest and Climate Change, Government of India. The principal investigator, acknowledge the authorities of MoEFCC for financial support and the Director, ZSI for his valuable guidance and encouragement during the study period of project.

Dr. C. Sivaperuman
Scientist-D & Officer-in-Charge

2. Abstract of the Project

According to the Forest Survey of India, the total area under mangrove vegetation in India is 4,827 km^2. Out of this, 966 km^2 area of mangrove vegetation occurs in Andaman and Nicobar Islands. In Andaman district, the area under mangroves is 929 km^2; while in Nicobar district mangroves occupy only 37 km^2. Mangroves occurring in these islands are mostly fringing the creeks, backwater and muddy shores. Along the creeks, the width ranges from 0.5 to 1 km. This salt-tolerant community is found on rocky shores exposed to tidal action and sometimes is also found growing in tidal mudflat. Luxuriant mangroves are seen in South Andaman, Middle Andaman, Baratang Island, Mayabunder and North Andaman.

Mangrove ecosystem harbor much of the world's tropical biodiversity and 50 per cent of the world's mangrove forests have been lost as a result of clearing and alteration of coastlines. Mangrove vegetation provides a niche for the resident as well as migratory birds, which utilize the system in varying degree from feeding, roosting and breeding. The mangrove ecosystem serves the bird communities in different ways.

Many species of wading birds use them as roosting and nesting sites. Wintering migrant shorebirds use the mangrove habitat as roosting sites after feeding in the tidal mudflats. The mangrove ecosystems play a significant role in conservation of resident, migratory and endangered bird species.

The objective of this study was to describe the avian community at the Mangrove ecosystem of Andaman Islands, to investigate the relationship between the birds and their prey, to provide knowledge about the intertidal of the mangrove ecosystem as a foraging habitat for birds. This study has been carried out in the mangrove ecosystem of Andaman Islands. Surveys were conducted using previously established scientific sampling methods.

Total of 442 surveys have been conducted in South Andaman, Middle Andaman and North Andaman Islands. Fifteen species of wading birds belongs to the order Ciconiiformes and Pelicaniformes; thirty four species of shorebirds, belongs to 4 families under the order Charadriiformes were sighted and nine species of gulls and terns belong to the family Laridae were recorded. Chinese Egret *Egretta eulophotes* has been reported for first time from Indian and South Asia during the study period.

3. Highlight of the findings achieved in the project

- Total of 442 surveys have been conducted in South Andaman, Middle Andaman and North Andaman Islands.
- 15 species of wading birds belongs to the order Ciconiiformes and Pelicaniformes were recorded.
- 34 species of shorebirds, belongs to 4 families under the order Charadriiformes were sighted.
- 9 species of gulls and terns belong to the family Laridae.
- Chinese Egret *Egretta eulophotes* has been reported for first time from Indian and South Asia during the study period.
- Birds were estimated from six different habitat namely, mud flat, shallow water, rocky shore, mangrove creek, water edge and coral rubble. Among the habitat mud flat and shallow water showed highest in species richness and abundance.
- Of the forty nine recorded species, nineteen species were recorded from all locations namely, Little Egret, Pacific Reef-Egret, Large Egret, Median Egret, Eastern Cattle Egret, Chinese Pond-Heron, Andaman Little Green Heron, Yellow Bittern, Chestnut Bittern, Pacific Golden-Plover, Lesser Sand Plover, Greater Sand Plover, Pintail Snipe, Eurasian Whimbrel, Eurasian Curlew, Common Redshank, Wood Sandpiper, Common Sandpiper and Ruddy Turnstone.
- The arrival and departure of resident and migratory birds were assessed for the period of three years. The result shows that, most of the migratory birds are arriving during the month of August/September and stay up to March/April in Andaman Islands.
- Of the recorded species, Common Redshank showed highest in dominance in south Andaman followed by Curlew Sandpiper, Lesser Sand Plover, Large Egret, Long-toed Stint, Eastern Cattle Egret, Wood Sandpiper Eurasian Whimbrel, Pacific Golden Plover and Little Egret.
- Among the location South Andaman and North Andaman showed high similarity, followed by South and Middle Andaman.

- Time activity pattern and foraging behavior of Median Egret, Andaman Little Green Heron, Eurasian Curlew and Common Redshank were studied.

4. Detailed report of work done on the project

Mangroves are one of the most productive ecosystems of the world, providing shelter and feeding sites for many animal species (Mann, 1982). Mangroves harbor a greater variety of birdlife than other habitat like salt marshes, mudflats and beaches (MacArthur and MacArthur, 1961). Mangroves enable extensive breeding activity by a number of tree-nesting birds. Mangrove forests are one of the unique tropical habitats. They represent the dominant soft bottom plant community of the marine-terrestrial transition in tropical and subtropical regions (Pernetta, 1993) and the mudflat/mangrove ecosystems are recognized as of strong importance for shorebirds (Butler *et al.*, 1997).

Mangrove ecosystem are widely distributed and often support more migrants than nearby terrestrial habitats. One possible explanation is that flooded habitats such as mangroves are buffered from the effect of rainfall seasonality and the resulting marked fluctuations in arthropod availability (Sherry and Holmes, 1996). The availability of food in mangroves is, however, likely to vary geographically and with latitude through the differing salinity and inundation patterns at each locality (Duke, 1990). Therefore, migrant species that use mangroves extensively as a wintering habitat could move between mangrove forests to take advantage of these temporal variations in food resource. Quantitative information on bird species abundance in different habitats is necessary for solving many fascinating ecological issues. Through monitoring, it might be possible to identify long term population trends by determining the magnitude of annual population fluctuations. In addition, monitoring could detect a population's response to short term perturbations, whether they are natural or human caused.

Wetlands defined as areas of land that are either temporarily or permanently covered by water exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry. Wetlands are one of the most productive

ecosystems and play crucial role in hydrological cycle. Utility wise, wetlands directly and indirectly support millions of people in providing services such as storm and flood control, clean water supply, food, fiber and raw materials, scenic beauty, educational and recreational benefits. The Millennium Ecosystem Assessment estimates conservatively that wetlands cover seven percent of the earth's surface and deliver 45% of the world's natural productivity and ecosystem services. Around 50% of the earth's wetlands are estimated to already have disappeared worldwide over the last hundred years through conversion to industrial, agricultural and residential purposes. Even in current scenario, when the ecosystem services provided by wetlands are better understood - degradation and conversion of wetlands continues.

Ramsar convention entered into force in 1975. Under the text of the Convention (Article 1.1) wetlands are defined as: "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters". In addition, the Convention (Article 2.1) provides that wetlands: "may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands".

Birds are one of the better studied groups of vertebrates and they play an important role in the ecosystem *i.e.* Scientific, Birdwatching, Bird Photography, Ecotourism, Ecosystem services etc. The Andaman and Nicobar Islands constitute a globally important biodiversity hotspot, are well known for their rich biodiversity (Saldanha, 1989; Vijayan *et al.*, 2000; Jayaraj & Andrews, 2005). Because they are off the mainland and isolated, endemism is very high in all taxa, but especially in reptiles, plants, fish and corals. These islands are one of the Endemic Bird Areas recognized by the Birdlife International (Rao *et al.*, 1980; Stattersfield *et al.* 1998,; Das, 1999a, 1999b and Andrews, 2001).

4.1. Wetlands of Andaman

The mega undersea earthquake of 26 December 2004, and the consequent tsunami, has changed the landscape of Andaman and Nicobar Islands. About 40 km^2

of land, in many locations, has been directly or indirectly affected by this event, resulting in a drastic change in land use patterns (Roy *et al.,* 2009). The subsidence of the South Andaman Island by almost one meter had caused high tides that reached inland and flooded the low-lying flatlands, including agricultural lands and human habitations (Chatterjee, 2006). Prior to the tsunami, local inhabitants utilised the tsunami-inundated areas of South Andaman Islands for agriculture (Table 1). These inundated wetlands became opportunistic feeding grounds for migratory waders and resident waterbirds. The Andaman and Nicobar Islands, especially the south Andaman Island is one of the most human-influenced areas. The inundation of agricultural lands by the tsunami has led to them being abandoned by the people, as they have turned into wetlands (Malik *et al.* 2006). Wetlands have long attracted the attention of public and scientists because of the charm, copiousness, visibility and social behavior of the waterbirds, as well as for their recreational and economic importance. Recently, waterbirds have become of interest as indicators of wetland quality and as parameters of restoration success and regional biodiversity. Each year, a large number of water birds that breeds in areas of Europe and North and Central Asia in summer undertake migratory journey along major river valleys to spend the winter in more hospitable shelters in southerly latitudes. As the wetlands in northern areas become frozen due to the onset of winter and the food disappears under snow cover.

4.2. Detailed literature survey

4.2.1. International studies

Studies on wetland birds mainly focused on population, habitat selection, food and feeding and other related subjects. Some important studies carried out on the wetland birds in mangrove ecosystem are reviewed here. Kalejta and Hockey (1994) examined the foraging density in relation to prey and habitat of Curlew Sandpiper *Calidris ferruginea*, Grey Plover *Pluvialis squatarola* at Berg River Estuary, South Africa. Dann (1994) studied the Paleartic and Australian waders in the Coastal Victoria. Weller (1994) worked on the bird species richness and seasonality was sampled in diverse habitat of an estuarine wetland complex in a Texas Estuarine Wetland in USA. Evans and Harris (1994) studied the population of Avocet

Recurvirostra americana at Humboldt Bay, California and reported that wintering population of Avocets had increased and they used the inter tidal mudflats, a sewage oxidation pond, highest elevation mud flats and islands in a brackish lake for feeding and roosting. Lefebvre *et al.* (1994 a,b) examined the temporal dynamics of mangrove bird communities in Venezuela with special reference to migrant warblers. Noske (1995) studied the ecology of mangrove forest birds in Peninsular Malaysia. Lefebvre and Poulin (1996) investigated the seasonal abundance of migrant birds and food resources in Panamanian mangrove forests. Lefebvre and Poulin (1996) studied temporal variation in abundance of Nearctic-Neotropical migrants, particularly the Northern Waterthrush *Seiurus oveboracensis*, Prothonotary Warbler *Protonoturia citrea*, and American Redstart *Setophaga ruticillu* in two black mangrove sites of central Panama. Lefebvre and Poulin (1996), Lefebvre and Mcneil (1992) carried out studies on abundance, feeding behavior and body condition of Nearctic warblers in Venezuelan Mangorve. Sodhi *et al.* (1997) studied ecology of bird community in the Sungei Mandai Mangrove forest in Singapore. Miranda and Collzo (1997) investigated food habits of four species of wading birds in the tropical mangrove swamp. Gregory-Smith (1998) reported the birds of the mangroves, Nypa swamps and peat swamp forests of Sarawak.

Many studies have been carried out on shorebirds in relation to prey availability (Goss-Custard, 1977; Hicklin and Smith, 1984; Webter and Haig, 1997; Zwarts and Blomert, 1992). De Boer (2002) reported community structure of shore birds in the intertidal mudflat of Southern Mozambique. Wilson (2006) carried out survey of birds in mangrove, river mount and coastal habitats in Sarawak, Malaysia. Luiz *et al.* (2007) studied bird communities in the mangrove of Paranagua Bay, Brazil. Bird community dynamics and habitat associations in Karst, Mangrove and *Pterocarpus* forest fragments in an Urban Zone in Puerto Rico was carried out Acevedo and Aide (2008). Salgado-Ortiz (2009) provided baseline data on breeding seasonality of the Mangrove Warbler *Dendroica petechia bryanti* from southern Mexico. Aguinaldo *et al.* (2012) assessed bird species abundance and diversity in a critical habitat at Manila Bay, Philippines and was carried out during the months of January and February of 2004-2012.

4.2.2. National studies

Although considerable amount of research on wetland birds have been carried out in India (Sampath and Krishnamurthy, 1989; Sampath, 1989 and 1991; Acharya and Kar, 1996; Balachandran, 1990 and 1995; Nagarajan and Thiyagesan, 1995, 1996 and 1998; Ramachandran and Vijayan, 1995 and 1997; Bhupathy *et al.* 1998; Vijayan and Vijayan, 2002; Sivaperuman and Jayson, 2009, 2010, 2011 and 2012; Venkatraman, 2007; Maheswaran, 1998; Maheswaran and Rahmani, 2002, 2005 and 2007), only few studies are available on the bird communities in mangroves ecosystem in India. Samant (1985) reported avifauna of the mangroves around Ratnagiri, Maharashtra. Studies on the ecology of the birds of Bharathapuzha estuary in Kerala carried out by Kurup (1996). Oswin (1999) reported avifauna of Muthupet Mangrove forests. Sethuraman (2000) investigated the avifauna of the coastal Tamil Nadu, India. Structure, species composition and conservation of birds in Mangalavanam mangroves carried out by Jayson (2001). Verma *et al.* (2002) reported the preliminary report on the Biodiversity of Mahul Creek, Mumbai, India with special reference to Avifauna. Bird communities of Bhitarkanika Mangroves in Orissa were carried out (Pandav 1997; Nayak 2003a,b, 2005; Gopi *et al.*, 2005, 2006; Gopi and Pandav, 2007a,b). Narayanan and Vijayan (2007) assessed the status of colonial breeding waterbirds in Kumarakom Heronry in Kerala. Saravanan *et al.* (2008) studied floristic and macro faunal diversity of Pondicherry mangroves, South India.

Studies on food and feeding and habitat utilisation of different species of wetland birds in West Bengal were carried out by Mukherjee (1969, 1971, 1972, 1975, 1976 and 1977). Sampath and Krishnamurthy (1989) and Sampath (1989 and 1991) studied the ecology of shorebirds at Great Vedaranyam Swamp. Sampath (1989 and 1991) examined the food habits of shorebirds from the Great Vedaranyam Salt Swamp of Tamil Nadu. Feeding behaviour of Egrets and Herons at Point Calimere was reported by Sakthivel (1992). Kurup (1991) studied the ecology of wetland birds in the Malabar Coast and Lakshadweep. Uthaman and Namasivayam (1991) described the bird life of Kadalundi Estuary. Nagarajan and Thiyagesan (1995, 1996 and 1998) examined the patterns of habitat use by water birds in the Pichavaram Mangroves on the east coast of southern India.

4.2.3. Studies in Andaman and Nicobar Islands

The study on birds in the Andaman and Nicobar Islands has been initiated by Beavan (1867) listing the avifauna of Andaman Islands followed by Hume (1873, 1874 a,b, 1876). Recently, many researchers have been studied on various aspect of forest bird communities of Andaman and Nicobar Islands (Abdulali 1964, 1965, 1967a, 1967b, 1971, 1976, 1981a, 1981b; Mukherjee and Dasgupta, 1975; Dasgupta, 1976; Mukherjee, 1981; Saha and Dasgupta, 1980; Tikader, 1984; Whitaker, 1985; Davidar *et al.*, 1996; Sankaran, 1995a,b, 1998a,b, 2001; Sankaran and Sivakumar, 1999; Vijayan *et al.*, 2000; Dasgupta *et al.*, 2002; Pande *et al.*, 2003; Sivakumar, 2003; Yahya and Zarri, 2003; Pande *et al.* 2007; Sivaperuman and Raghunathan (2009, 2010 and 2012); Sivaperuman *et al.*, (2010c and 2012), Sivaperuman (2011a,b,c); Sivaperuman and Venkataraman (2012). Only little information is available on the wetland birds of Andaman and Nicobar Islands. Vijayan (1996 and 2006) investigated the ecology and conservation of Andaman Teal *Anas gibberifrons albogularis*.

4.3. Study area

Mangroves are among the world's most productive ecosystems. They are carbon-rich forests and their standing crop is greater than any other aquatic ecosystem on the earth. Mangroves are variously referred to as coastal woodlands, mangals, tidal forests and mangrove forests (Hutchings and Saenger, 1987) and constitute the characteristic vegetation of the intertidal environment of the sheltered tropical and subtropical coastlines. They support genetically diverse groups of both aquatic and terrestrial species. Mangroves are an important source of primary productivity and perform extremely important ecosystem functions. They harbour an array of diverse flora and fauna, microscopic and macroscopic, temporary and residential and also aquatic and semi-aquatic. A substantial part of the fauna is also derived from the neighboring terrestrial habitats. Compared to flora, mangrove fauna have been less studied.

Present distribution of mangroves worldwide is in two biogeographic centres, with the greatest species richness in the Indo-West Pacific Centre and a few species in the Caribbean and West Atlantic Centre (Duke, 1995). Global distribution of

mangroves indicates a pan-tropical dominance with major latitudinal limits relating to the main oceanic currents and the 20°C seawater isotherm in winter (Alongi, 2002).Mangroves in India cover a total area of 4,662.56 km^2 and occupy 0.14% of the land area. They represent 3% of the global mangroves and 8% of Asian mangroves. About 56% of the mangroves occur on the east coast along the Bay of Bengal, 28% on the west coast bordering the Arabian Sea and 13% in the Andaman and Nicobar islands.

The mangroves of Andaman are one of the world's most pristine and cover an area of 625 km^2 (FSI, 2005) which is about one fifth of the total mangrove cover in India (Fig. 1-4). Mangroves occurring in these islands typically fringe tidal creeks, backwaters and muddy shores. The mangroves found in Andaman mostly belong to the genera *Rhizophora*, *Bruguiera* and *Avicennia*. The numerous tidal creeks within the mangroves are sites of intense biogeochemical activity. The organic matter from terrestrial region is processed in the tidal creeks and estuarine mixing zones. Additionally suspended matter from the water column can be an important source of organic matter in the intertidal zone (Bouillon *et al.* 2003, 2007a). This is a crucial factor in the understanding of the functioning of these systems (Flindt *et al.* 2004, 2007). They have potential to alter the sources, quantity and composition of OC that is transported to the coastal zone. These waters are strongly heterotrophic and result in high CO^2 efflux into the atmosphere although the mangrove forests themselves act as a sink for atmospheric CO^2. Thus mangroves are unique trees with strong marine, terrestrial and atmospheric components.

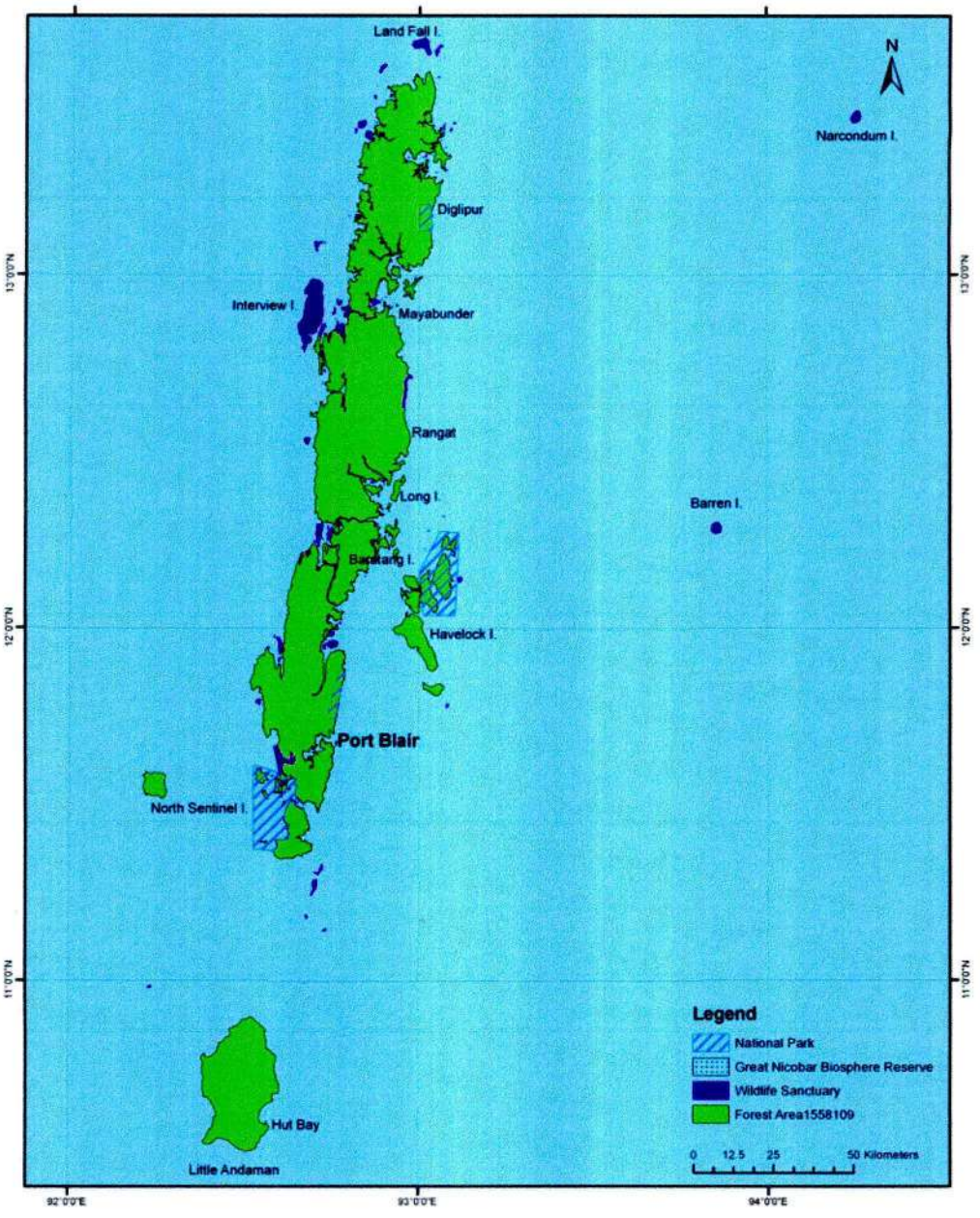

Fig. 1. Map of Andaman group of Islands

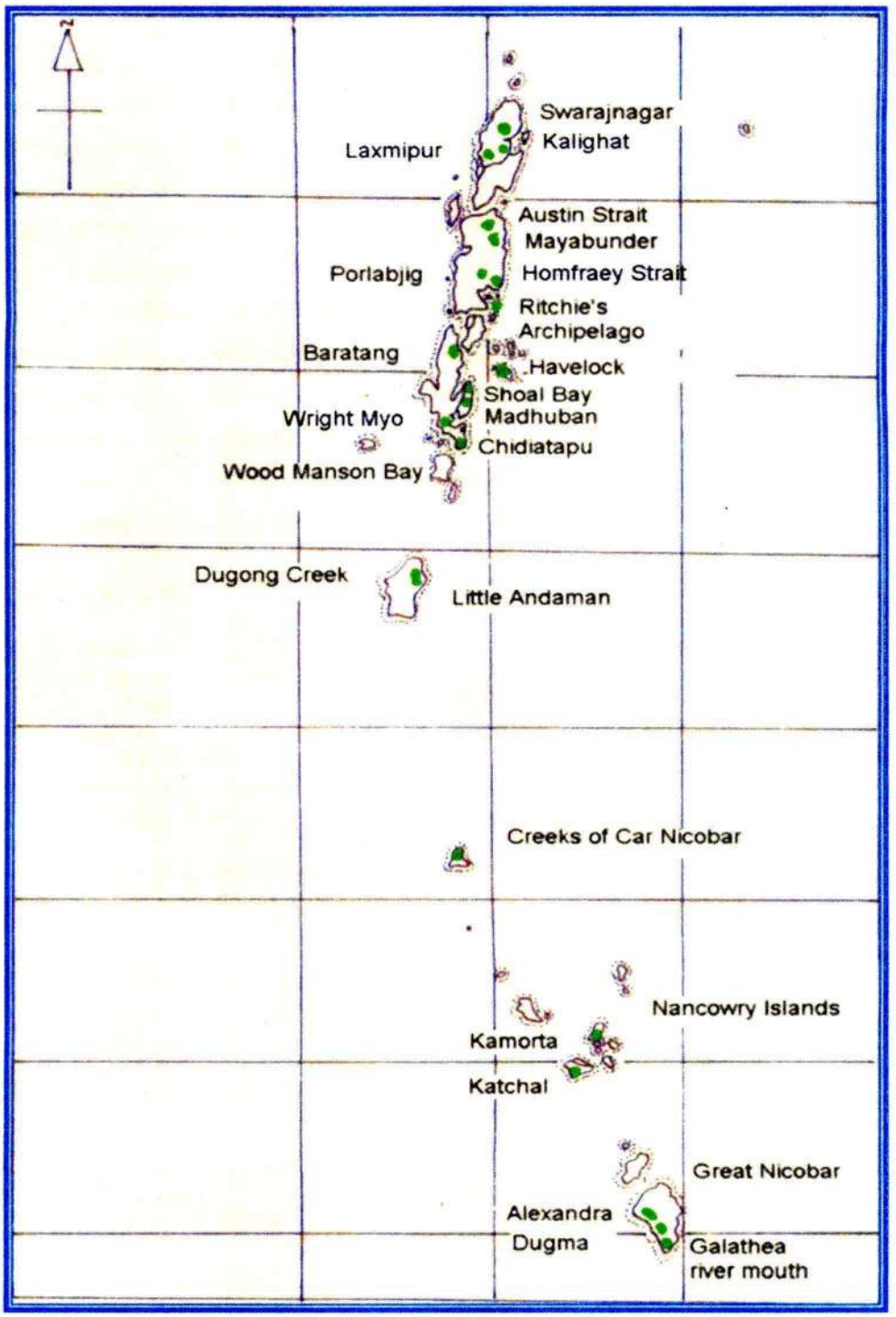

Fig. 2. Mangrove forest in Andaman and Nicobar Islands

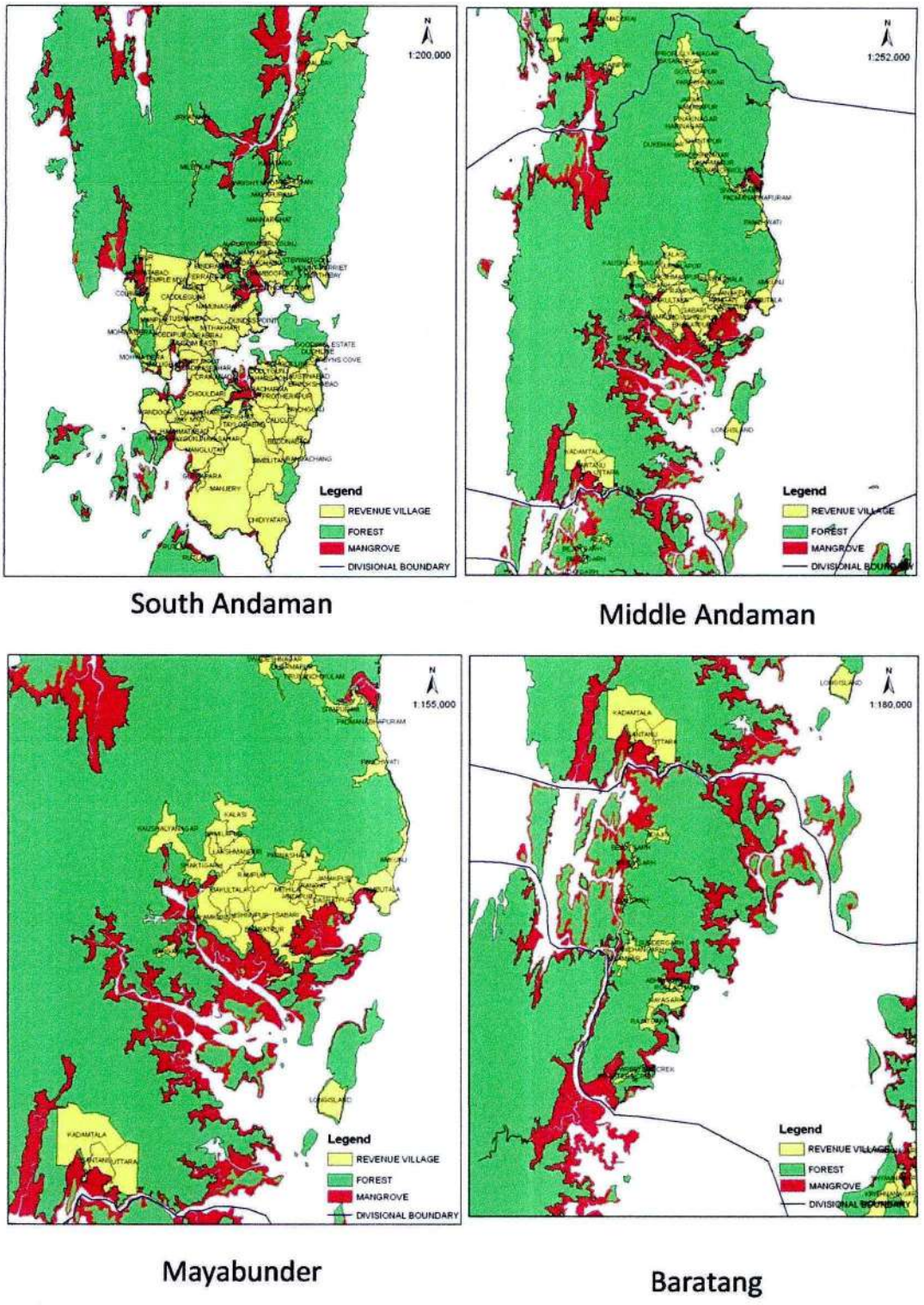

Fig. 3. Mangrove forests in different forest divisions in Andaman Islands

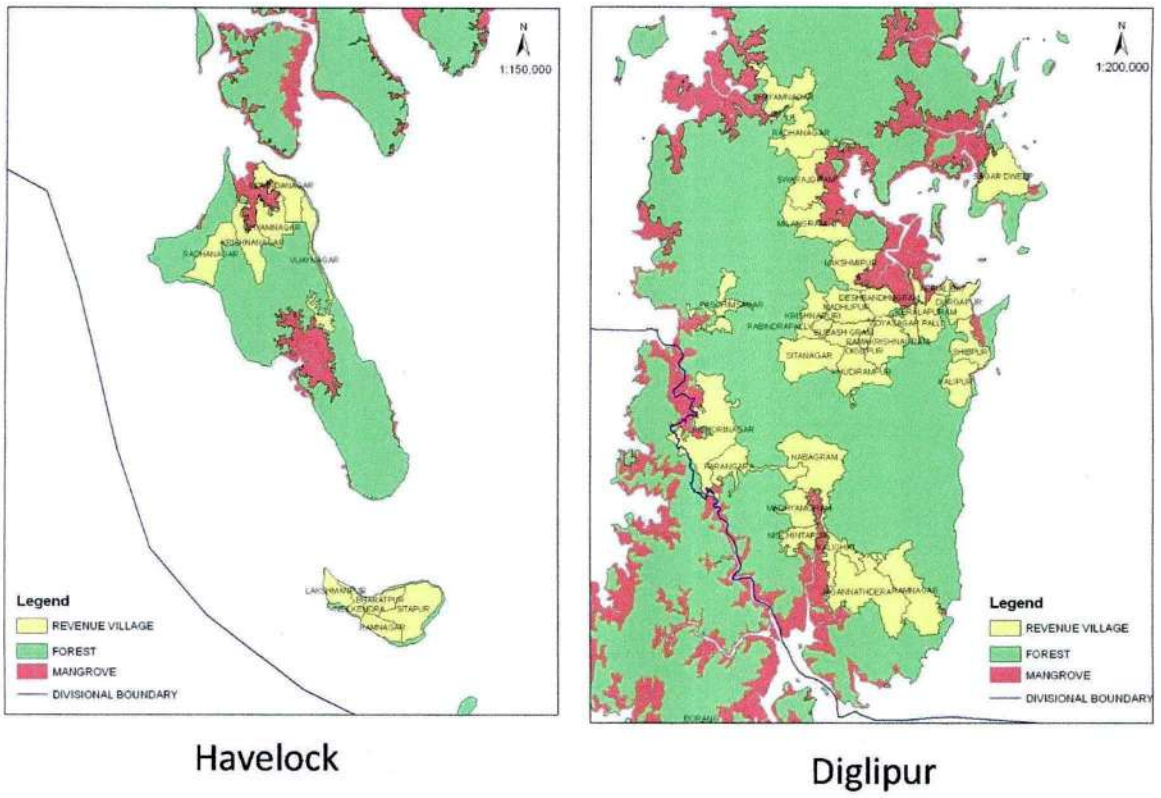

Fig. 4. Mangrove forests in different forest divisions in Andaman Islands

4.3.1. Study sites

Overall 442 surveys were conducted in 61 study sites. Of which, 21 located in in South Andaman and 312 surveys were conducted, fifteen sites in Middle Andaman and 30 surveys were carried out, twenty five locations and 100 surveys were conducted in North Andaman Islands (Table 1).

Table 1. Coordinates of the study locations

Sl. No.	Location	GPS Coordinates		No. of sites	Habitat description	No. of visits
			South Andaman			
1.	Garacharma	11°37.055' N	92°42.496' E	3	Tidal mudflat, Shallow Water & swamp	86
2.	Sippighat	11°36.749' N	92°41.583' E	2	Tidal mudflat & swamp	65

3.	Chouldhari	11°37.350' N	92°40.108' E	3	Tidal mudflat, water Edge & swamp	28
4.	Ograbraj	11°39.463' N	92°39.785' E	1	Tidal mudflat, Shallow Water	39
5.	Lohabarrake	11°36.076' N	92°38.978' E	2	Tidal mudflat, Shallow Water, Water Edge	14
6.	Wandoor	11°35.789' N	92°37.186' E	2	Tidal mudflat, Shallow Water, Water Edge	11
7.	Stewartgunj	11°43.617' N	92°42.826' E	1	Tidal mudflat, Shallow Water	10
8.	Shoal Bay	11°52.484' N	92°44.412' E	3	Tidal mudflat, Water Edge, Rockery	21
9.	Chidiyatapu	11°30.688' N	92°41.927' E	3	Tidal mudflat, Water Edge, Rockery	30
10.	Manjery	11°32.893' N	92°39.113' E	1	Water Edge, swamp	8
			Total sites	**21**	**Number of visits**	**312**
				Middle Andaman		
11.	Shyamkund	12°27.037' N	092°50.035' E	1	Tidal mudflat	2
12.	Yeratta	12°29.940' N	092°53.769' E	2	Tidal mudflat, Creek	5
13.	Long Island	12°21.888' N	092°55.434' E	2	Water Edge, Rockery	4
14.	Lalaji Bay	12°24.435' N	092°56.804' E	2	Tidal mudflat, Water Edge	3
15.	North Passage	12°17.282' N	092°56.003' E	2	Swamp , Shallow Water, Mudflat, Water Edge	4
16.	Guitar Island	12° 20.493'N	092°54.484'E	1	Water Edge	2
17.	Dhaninallah	12°36.947'N	092°57.045' E	3	Mangrove Creek, tidal mudflat, Water Edge	8
18.	Baratang	12°05.998'N	092°44.501' E	2	Mangrove Creek, Shallow Water	2
			Total sites	15	**Number of visits**	30
				North Andaman		
19.	Pokka Dera			2	tidal mudflat, Water Edge	3
20.	Austin Creek	12°52.593' N	92°50.330'' E	2	tidal mudflat, Shallow Water	2
21.	Panighat			2	tidal mudflat, Shallow Water	2
22.	Karmatang			2	tidal mudflat, Shallow Water	2
23.	Aerial Bay	13°16.368'N	93°01.914' E	2	tidal mudflat, Rockery	10
24.	Durgapur	13°16.569'N	093°01.866' E	3	Shallow Water, Mudflat, Rockery	13
25.	Shibpur	13°13.442'N	093°02.725' E	1	swamp	17
26.	Kalipur	13°06.077'N	092°59.469' E	2	tidal mudflat, Rockery, Shallow Water	10
27.	Lamiya Bay	13°13.945'N	093°03.155' E	1	Rockery	8
28.	Kalighat Creek	13°06.077'N	092°59.469' E	2	Mangrove Creek, Mudflat	6
29.	Bamboo Island	13°02.958'N	092°55.987' E	1	tidal mudflat	7
30.	Brush Islands	13°29.309'N	093°04.860' E	1	Water Edge	4
31.	Beema Dera			2	tidal mudflat, swamp	8
32.	Ram Nagar	13°04.563'N	093°01.519' E	1	tidal mudflat, swamp	6

33.	Smith Island	13°19.358'N	093°04.281' E	1	tidal mudflat, swamp	2
			Total sites	**25**	**Number of visits**	**100**

4.4. Annual average Rainfall and Temperature recorded in South Andaman

The average annual temperature and rainfall recorded in Port Blair airport is presented in Fig. 5. The temperature varied in different months and highest observed in the month of May, following by April. Similarly, the rainfall also varied, with highest from July and September and lowest in the month of February and March.

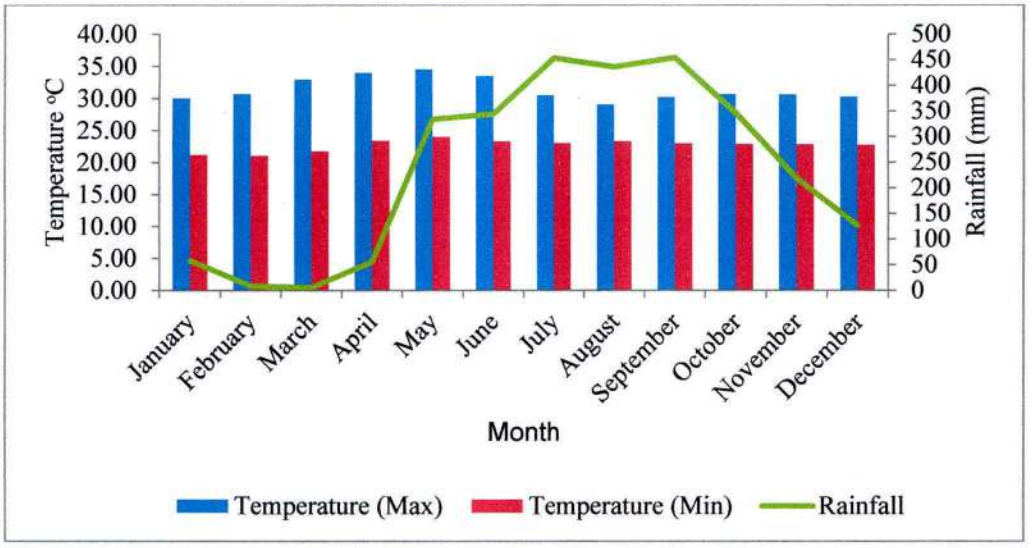

Fig. 5. Average annual Rainfall and Temperature recorded in Port Blair (2105-2017)

4.4. Summary of the objectives

1. To describe the avian community at the Mangrove ecosystem of Andaman Islands
2. To investigate the relationship between the birds and their prey
3. To provide knowledge about the intertidal of the mangrove ecosystem as a foraging habitat for the birds
4. To evaluate the consumption of the birds in the intertidal of the mangrove ecosystem and its meaning for the avian and the benthic community

4.5. Methodology

4.5.1. Environmental conditions and the benthic community

The study area were divided into different plots and data were collected four replicates in a month. The following samples were collected in each plot.

Sediment: Sediment sample were collected using corer of 2.5 cm diameter and 20cm length at different location of the plot. The sediment sample were investigated using methods developed by Hulbert (1984) and Buchanan and Kain (1984).

Salinity: At each plot, pore water were collected by digging a hole of 30cm depth and a sample of water which accumulate in it. The salinity of these samples were investigated with a conductometer.

Time of emergence: To assess the different inundated times, an observation over the complete tide cycle were conducted. Time period of time without water (time of emergence) were taken with a stop watch. A plot was termed as "without water" when the water level reach at <30 cm depth. It was assumed that at least the large birds could start using it from that water depth on.

Burrow openings: The benthic organisms are important for the habitat choice of birds, a measure of surface marks were employed. At each plot a square of 1 m^2 were selected randomly and marked temporary with a cord. Within its boundaries all burrow openings on the surface was counted without further distinction of responsible benthic organisms.

Benthic community: Three benthic samples were taken per plot with a corer of 15 cm diameter up to 20 cm depth at three different locations. Each sample were divided into three horizons of 0-5cm, 5-10cm, and 10-20cm depth. The samples were sieved through a 1mm sieve, the remains were sorted on a tray and the extract animals were stored in 70% ethanol. The specimens were classified to the lowered taxonomic level possible.

4.5.2. Avian community

Bird census: Regular bird surveys were conducted in the mangrove ecosystem of Andamans. Fixed point stations were established and distance sampling method were used to estimate the abundance of the wading birds and shorebirds (Howes and Bakewell, 1989; Burnham *et al.*, 1980). Along each fixed point station, bird species

were estimated with the following details namely, the number of individuals, pairs, or flocks of each species using spotting scope with a magnification of 20x. Birds were be counted as they were seen and were recorded and identified using a field guides (Ali and Ripley, 1983; Grimmett *et al.*, 1998). The survey were carried out early in the morning from 0530 to 0930 h. The detection of birds within each fixed point station were done for 10 min. The 10min count enabled the researchers to sufficiently record the individuals with minimal effort and disturbance (Lee and Marsden, 2008). During the each survey, all bird species and individuals seen from the point station were estimated.

***Foraging behaviour*:** The foraging behaviour of selected species of wading birds and shore birds were studied in the field and were investigated by focal observations at different locations. The bird species were observed for three minutes with the help of stop watches the following data were collected (Altman, 1974).

***Steps/min*;** were counted in slowly walking species. The species with fast movements, the time of walking were taken with a stopwatch. Videotapes were used for this species and used to count the steps in slow motion and were calculated an average step/min. With these approximations of the numbers of steps during the observation periods were calculated.

Pecks or probes/min; were counted

Prey taken/min; large prey were counted directly

Prey size; the size of larger prey were estimated in percentage bill length.

Prey type; was distinguished between worms, bivalves, gastropods and crabs.

Handling time; from the picking up of the prey item until it swallowed entirely, was estimated in seconds.

Microhabitats; were determined as mud flats, shallow water, water edge, bund etc.

Water depth; the water depth were indicated by max percentage of the leg under water. With leg sizes given by the literature water depth were estimated (Blake, 1977; del Hoyo *et al.*, 1996 and Poole and Gill, 2000).

Probing depth; the max percentage of bill length inserted into the sand were estimated. With bill sizes given by the literature insert depth was calculated (Blake, 1977; del Hoyo *et al.*, 1996 and Poole and Gill, 2000). In cases of birds foraging in

the water the probing depth were calculated by subtracting the insert depth in the water by the water depth.

Type of behaviour; the foraging behaviour were mostly determined as visual and/or tactile, depending whether birds detected their prey mainly by watching the sediment surface or by probing into the sediment with their beaks.

4.5.3. Distribution models

Species of birds were ranked in their order of abundance as represented by individuals seen in each species and this were plotted in the decreasing order for all species against the number of individuals (Pielou, 1975). It is another way of describing diversity in a community through species-abundance or distribution models (Fischer *et al.*, 1943). A species-abundance model utilises all the information gathered in a community and is the most complete mathematical description of the data (Magurran, 1988). Analyses was carried out to see which model fit the bird community at the study area.

4.5.4. Habitat utilization

Whenever a bird is observed, its exact location and activities was recorded. Each habitat were identified in the study area, depending on the vegetation type. In each habitat, "microhabitat" of birds were also recorded (Odum, 1971). Microhabitats were classified as tree trunk, foliage, branch, bushes, dead tree, ground, grass and open area.

4.6. Species richness and abundance

Species richness (number of species) and abundance (number of individuals) of birds in every month in the study area were calculated from the census data and field observations. The census method employed is described in detail in the first chapter (Page no. 23-24). Species richness indices like Margalef Index (R1) and Menhinick Index (R2) were calculated using the formula given by Magurran (1988). These indices provide easily understandable measures of diversity. Species richness as a yardstick of diversity was used in many earlier studies.

Margalef Index, $D_{mg} = (S-1) / 1n (N)$

[ln = $\log_e$]

Menhinick Index, $D_{mn} = S/(N)^{**} ½$

Where S = Number of species
N = Total number of individuals summed over all species

4.7. Species diversity indices

Diversity measures the variation in richness and abundance. Diversity Index combines the information on multiple species into a single number. These indices provide easily understandable measures of diversity. Shannon-Weiner (H'), Simpson's (λ), and Hill's diversity number N1 and N2 were calculated using the computer program SPDIVERS.BAS developed by Ludwig and Reynolds (1988).

Shannon-Weiner Index (H')

Shannon-Weiner Index of general diversity (H') is given as

$$H' = - \sum P_i \log P_i$$

where Pi the proportional abundance of the i^{th} species = (ni/N)

Simpson's Index (λ)

The following equation is used to calculate the Simpson's Index (λ)

$$\lambda = \sum (ni\ (ni-1)/(N\ (N-1))$$

where ni = the number of individuals in the i^{th} species
N = total number of individuals

Hill's diversity

Hill's diversity N1 is calculated from Shannon-Weiner Index

$$N1 = e^{H'}$$

In addition, Hill's diversity N2 is calculated from Simpson's Index

$$N2 = 1/lambda$$

Evenness measures

A number of indices have been used to quantify the evenness of diversity. Two evenness measures *viz.* Shannon Evenness and Sheldon Evenness were calculated using the computer program SPDIVERS.BAS developed by Ludwig and Reynolds (1988). The following formulae were used for calculating two Evenness measures based on Shannon-Weiner Index and Simpson's Index.

$$\text{Shannon Evenness (E1)} = \frac{H'}{\log (S)}$$

where H' = Shannon-Weiner Index
S = Number of species

$$\text{Sheldon Evenness (E2)} = \frac{e^{H'}}{S}$$

Similarity Indices

Similarity Indices between the intensive study areas were calculated using Jaccard Index, Sorenson Index (Magurran, 1988).

Dominance Index

The dominance of the each bird species in the Kole wetlands was calculated using the dominance index.

Dominance Index = n_i X 100/ N

where n_i = Number of individuals

N = Total number of all the species seen during the study period

Feeding guilds

Details of food habit of various species were collected from the literature (Ali and Ripley, 1983). Species richness and abundance of birds in different feeding guilds were also assessed. Bird species have been categorized into aquatic feeders, insectivores, granivores, nectar-frugivores, carnivores, frugivores and omnivores.

5. Results

5.1. Status and distribution of wading and shorebirds in Andaman

A total of 349 species/sub species (268 species & 81 sub species) of birds were recorded from Andaman and Nicobar Islands, belonging to 67 Families under 20 Orders (Sivaperuman *et al.*, 2018 in press). A total of 30 species are considered to be restricted (endemic) in distribution in the Islands of which, 21 species from Andaman Island group and 9 species from Nicobar Island group (Stattersfield *et al.* 1998). Of the recorded species, 59 species of wading and shorebirds were recorded from the mangrove ecosystem of Andaman Islands (Table 2). These belongs to 10 families under two orders. Of the recorded species 43 were winter migrants, 16 were residents with local migrants, 4 were residents, and 1 each seasonal migrant and passage migrant.

Of the 59 species, the following species were listed in the IUCN threatened category, Great Knot *Calidris tenuirostris,* Beach thick-Knee *Esacus magnirostris,* Rufous-necked Stint *Ereunetes ruficollis* (Pallas), Curlew Sandpiper *Erolia ferruginea,* Bar-tailed Godwit *Limosa apponica,* Western Black-tailed Godwit *Limosa limosa,* Eurasian Curlew *Numenius arquata,* and Chinese Egret *Egretta eulophotes* (Table 2).

Table 2. List of species of wading and shorebirds recorded during the study period

Sl. No.	Common Name*	Scientific Name*	Status			
			Residential	IUCN	Abundance	IWPA
		Wading Birds				
	Pelecaniformes					
	Ardeidae					
1.	Little Egret	*Egretta garzetta* (Linnaeus, 1766)	R/LM	LC	C	IV
2.	Pacific Reef-Egret	*Egretta sacra* (Gmelin, 1766)	R	LC	FC	IV
3.	Grey Heron	*Ardea cinerea* Linnaeus, 1758	R/WM	LC	FC	IV
4.	Purple Heron	*Ardea purpurea* Linnaeus, 1766	R/LM	LC	FC	IV
5.	Great Egret	*Egretta alba* (Linnaeus,1758)	R/LM	LC	A	IV
6.	Intermediate Egret	*Egretta intermedia* (Wagler,1829)	R/WM	LC	C	IV
7.	Eastern Cattle Egret	*Bubulcus coromandus* (Boddaert, 1783)	R/LM	LC	A	IV
8.	Chinese Egret	*Egretta eulophotes* (Swinhoe, 1860)	WM	VU	U	
9.	Indian Pond-Heron	*Ardeola grayii* (Sykes,1832)	R/WM	LC	U	IV

10.	Chinese Pond-Heron	*Ardeola bacchus* (Bonaparte, 1855)	WM	LC	FC	IV
11.	Andaman Striated Heron[ENS]	*Butorides striatus spodiogaster* Sharpe, 1894	R	NE	FC	IV
12.	Yellow Bittern	*Ixobrychus sinensis* (Gmelin,1789)	WM	LC	FC	IV
13.	Chestnut Bittern	*Ixobrychus cinnamomeus* (Gmelin,1789)	R	LC	U	IV
14.	Black Bittern	*Dupetor flavicollis* (Latham, 1790)	WM	LC	U	IV
	Threskiornithidae					
15.	Glossy Ibis	*Plegadis falcinellus* (Linnaeus, 1766)	PM	LC	VR	IV
		Shorebirds				
	Charadriiformes					
	Jacanidae					
16.	Pheasant-tailed Jacana	*Hydrophasianus chirurgus* (Scopoli,1786)	WM	LC	U	IV
	Charadriidae					
17.	Pacific Golden-Plover	*Pluvialis fulva* (Gmelin,1789)	WM	LC	C	IV
18.	Grey plover	*Pluvialis squatarola* (Linnaeus,1758)	WM	LC	U	IV
19.	Little Ringed Plover	*Charadrius dubius* Scopoli,1786	WM	LC	U	IV
20.	Kentish Plover	*Charadrius alexandrinus* Linnaeus, 1758	WM	LC	U	IV
21.	Lesser Sand Plover	*Charadrius mongolus* Pallas,1776	WM	LC	A	IV
22.	Greater Sand Plover	*Charadrius leschenaultii* Lesson,1826	WM	LC	FC	IV
23.	Grey-headed Lapwing	*Vanellus cinereus* (Blyth, 1842)	WM	LC	U	IV
	Scolopacidae					
24.	Pintail Snipe	*Gallinago stenura* (Bonaparte,1830)	WM	LC	C	IV
25.	Common Snipe	*Gallinago gallinago* (Linnaeus, 1758)	WM	LC	U	IV
26.	Western Black-tailed Godwit	*Limosa limosa* (Linnaeus,1758)	WM	NT	U	IV
27.	Bar-tailed Godwit	*Limosa lapponica* (Linnaeus, 1758)	WM	NT	U	IV
28.	Eurasian Whimbrel	*Numenius phaeopus* (Linnaeus,1758)	WM	LC	C	IV
29.	Eurasian Curlew	*Numenius arquata* (Linnaeus,1758)	WM	NT	FC	IV
30.	Common Redshank	*Tringa totanus* (Linnaeus,1758)	WM	LC	C	IV
31.	Marsh Sandpiper	*Tringa stagnatilis* (Bechstein, 1803)	WM	LC	U	IV
32.	Common Greenshank	*Tringa nebularia* (Gunner,1767)	WM	LC	U	IV
33.	Green Sandpiper	*Tringa ochropus* Linnaeus,1758	WM	LC	R	IV
34.	Wood Sandpiper	*Tringa glareola* Linnaeus,1758	WM	LC	C	IV
35.	Terek Sandpiper	*Xenus cinereus* (Guldenstadt,1775)	WM	LC	FC	IV
36.	Common Sandpiper	*Actitis hypoleucos* Linnaeus,1758	WM	LC	FC	IV
37.	Ruddy Turnstone	*Arenaria interpres* (Linnaeus,1758)	WM	LC	FC	IV
38.	Great Knot	*Calidris tenuirostris* (Horsfield, 1821)	WM	EN	U	IV
39.	Sanderling	*Ereunetes albus* (Pallas, 1764)	WM	LC	U	IV
40.	Little Stint	*Ereunetes minutes* (Leisler,1812)	WM	LC	R	IV
41.	Rufous-necked Stint	*Ereunetes ruficollis* (Pallas, 1776)	WM	NT	FC	IV
42.	Temminck's Stint	*Ereunetes temminckii* (Leisler, 1812)	WM	LC	R	IV
43.	Long-toed Stint	*Ereunetes subminutarr* (Middendorff, 1853)	WM	LC	C	IV
44.	Curlew Sandpiper	*Erolia ferruginea* (Pontoppidan,1813)	WM	NT	C	IV
45.	Broad-billed Sandpiper	*Limicola falcinellus* (Pontoppidan, 1763)	WM	LC	FC	IV
46.	Ruff	*Philomachus pugnax* (Linnaeus, 1758)	WM	LC	U	IV
	Recurvirostridae					
47.	Black-winged Stilt	*Himantopus himantopus* (Linnaeus, 1758)	WM	LC	U	IV
	Dromadidae					
48.	Crab-Plover	*Dromas ardeola* Paykull, 1805	R/WM	LC	R	
	Burhinidae					
49.	Beach thick-Knee	*Esacus magnirostris* (Vieillot,1818)	R	NT	U	
	Glareolidae					
50.	Oriental Pratincole	*Glareola maldivarum* J.R. Forster, 1795	WM	LC	FC	
		Sea Birds				
	Laridae					

51.	Common Black headed Gull	*Chroicocephalus ridibundus* Linnaeus, 1766	WM	LC	R	IV
52.	Common Gull-billed Tern	*Gelochelidon nilotica* (Gmelin, 1789)	WM	LC	R	IV
53.	Lesser Crested Tern	*Thalasseus bengalensis* Lesson, 1831	WM	LC	FC	IV
54.	Roseate Tern	*Sterna dougallii* Montagu, 1813	SM	LC	C	IV
55.	Black-naped Tern	*Sterna sumatrana* Raffles,1822	R/LM	LC	A	IV
56.	Little Tern	*Sternula albifrons* Pallas, 1764	WM	LC	FC	IV
57.	Bridled Tern	*Onychoprion anaethetus* Scopoli, 1786	R/LM	LC	R	IV
58.	Whiskered Tern	*Chlidonias hybria* (Pallas, 1811)	WM	LC	FC	IV
59.	Brown Noddy	*Anous stolidus* (Linnaeus, 1758)	WM	LC	FC	IV

IUCN: IUCN red list data for given species (IUCN 2015); LC: Least concern species; NT: Near threatened species; VU: Vulnerable; DD: Data deficient species; *: Species endemic to Andaman and Nicobar of Islands; **: Sub – Species endemic to Andaman and Nicobar Islands; Residential Status: R; Resident; R/LM: Resident with local movements; R/WM: Resident with winter influx; SM: Summer Migrant; M: Winter Migrant;V: Vagrant.

5.2. Comparative occurrence of wading and shore birds

A comparison of number of wading and shore birds recorded from the mangrove ecosystem of Andaman Islands, with those from, India, Asia and World is given in Table 3.

Table 3. Comparative occurrence of wading and shore birds

Order and Family	World[1]	Asia[1]	India[2]	A & N Islands[3]	Andaman Islands*
Ciconiiformes					
Ardeidae	82	33	20	18	14
Threskiornithidae	39	14	4	1	1
Charadriiformes					
Jacanidae	8	3	2	1	1
Charadriidae	75	32	19	9	7
Scolopacidae	102	72	42	29	23
Recurvirostridae	13	2	2	1	1
Dromadidae	1	1	1	1	1
Burhinidae	11	5	4	1	1
Glareolidae	18	9	6	2	2
Laridae	120	65	37	15	9

1 - Gill and Donsker (2012); 2 - Ali and Ripley (1983); 3 - Tikader, 1984; 3 - Sivaperuman *et al.* 2018 (In Press); 4 - Present study

5.3. Distribution of birds

Of the recorded bird species highest number of species from North Andaman (59 species), followed by South Andaman (46 species) and Middle Andaman (32 species) (Table 4.

Table 4. Distribution of birds in different part of Andaman Islands

Sl. No.	Common Name	North Andaman	Middle Andaman	South Andaman
1.	Little Egret	✓	✓	✓
2.	Pacific Reef-Egret	✓	✓	✓
3.	Grey Heron	✓	✓	✓
4.	Purple Heron	✓		✓
5.	Great Egret	✓	✓	✓
6.	Intermediate Egret	✓	✓	✓
7.	Eastern Cattle Egret	✓	✓	✓
8.	Chinese Egret			✓
9.	Indian Pond-Heron	✓	✓	✓
10.	Chinese Pond-Heron	✓	✓	✓
11.	Andaman Striated	✓	✓	✓
12.	Yellow Bittern	✓	✓	✓
13.	Chestnut Bittern	✓	✓	✓
14.	Black Bittern			✓
15.	Glossy Ibis			✓
16.	Pheasant-tailed Jacana	✓		✓
17.	Pacific Golden-Plover	✓	✓	✓
18.	Grey plover	✓		✓
19.	Little Ringed Plover	✓		✓
20.	Kentish Plover	✓	✓	✓
21.	Lesser Sand Plover	✓	✓	✓
22.	Greater Sand Plover	✓	✓	✓
23.	Grey-headed Lapwing			✓
24.	Pintail Snipe	✓	✓	✓
25.	Common Snipe			✓
26.	Western Black-tailed Godwit			✓
27.	Bar-tailed Godwit	✓	✓	✓
28.	Eurasian Whimbrel	✓	✓	✓
29.	Eurasian Curlew	✓	✓	✓
30.	Common Redshank	✓	✓	✓
31.	Marsh Sandpiper			✓
32.	Common Greenshank			✓
33.	Green Sandpiper			✓
34.	Wood Sandpiper	✓	✓	✓
35.	Terek Sandpiper	✓		✓
36.	Common Sandpiper	✓	✓	✓
37.	Ruddy Turnstone	✓	✓	✓
38.	Great Knot	✓		✓
39.	Sanderling	✓	✓	✓
40.	Little Stint	✓		✓
41.	Rufous-necked Stint	✓	✓	✓
42.	Temminck's Stint			✓

43.	Long-toed Stint	✓	✓	✓
44.	Curlew Sandpiper	✓	✓	✓
45.	Broad-billed Sandpiper	✓		✓
46.	Ruff			✓
47.	Black-winged Stilt			✓
48.	Crab-Plover	✓		✓
49.	Beach thick-Knee	✓	✓	✓
50.	Oriental Pratincole	✓	✓	✓
51.	Common Black headed Gull	✓		✓
52.	Common Gull-billed Tern	✓		✓
53.	Lesser Crested Tern	✓	✓	✓
54.	Roseate Tern	✓		✓
55.	Black-naped Tern	✓	✓	✓
56.	Little Tern	✓		✓
57.	Bridled Tern	✓		✓
58.	Whiskered Tern	✓	✓	✓
59.	Brown Noddy			✓

Distribution of bird species in different study sites in Andaman Islands is presented in Table 5-7. Among the nine location in south Andaman, the following species were recorded only from two to four locations namely, Grey Heron, Purple Heron, Chinese Egret, Black Bittern, Glossy Ibis, Grey plover, Common Snipe, Jack Snipe, Black-tailed Godwit, Bar-tailed Godwit, Spotted Redshank, Marsh Sandpiper, Common Greenshank, Green Sandpiper, Terek Sandpiper, Ruddy Turnstone, Great Knot, Little Stint, Temminck's Stint, Broad-billed Sandpiper, Black-winged Stilt, Crab-Plover and Beach Stone- Plover. Amont the eight locations in Middle Andaman, the following species were recorded from only three locations. Of the fifteen locations in North Andaman, the following species were recorded only from three to four locations, namely Median Egret, Eastern Cattle Egret, Indian Pond-Heron, Yellow Bittern, Chestnut Bittern, Kentish Plover, Wood Sandpiper, Little Stint, Long-toed Stint, Black-winged Stilt, and Oriental Pratincole.

Table 5. Species of birds recorded from wetlands of South Andaman

Sl. No.	Common Name	Garacharma	Sippighat	Chouldari	Ograbraj	Lohabarrak	Stewartgunj	Chidyatappu	Shoal Bay	Manjery
1.	Little Egret	✓	✓	✓	✓	✓	✓	✓	✓	✓
2.	Pacific Reef-Egret	✓	✓	✓	✓	✓	✓	✓	✓	✓
3.	Grey Heron			✓	✓		✓			
4.	Purple Heron			✓	✓		✓			
5.	Large Egret	✓	✓	✓	✓	✓	✓	✓	✓	✓
6.	Median Egret	✓	✓	✓	✓	✓	✓	✓	✓	✓
7.	Eastern Cattle Egret	✓	✓	✓	✓	✓	✓	✓	✓	✓
8.	Chinese Egret		✓		✓			✓		
9.	Indian Pond-Heron	✓	✓	✓	✓		✓	✓	✓	
10.	Chinese Pond-Heron	✓	✓	✓	✓	✓	✓	✓	✓	✓
11.	Andaman Little Green Heron	✓	✓	✓	✓	✓	✓	✓	✓	✓
12.	Yellow Bittern	✓	✓	✓	✓	✓	✓	✓	✓	✓
13.	Chestnut Bittern	✓	✓	✓	✓	✓	✓	✓	✓	✓
14.	Black Bittern		✓	✓	✓					
15.	Glossy Ibis	✓		✓						
16.	Pacific Golden-Plover	✓	✓	✓	✓	✓	✓	✓	✓	✓
17.	Grey plover	✓	✓	✓	✓					
18.	Little Ringed Plover	✓	✓	✓	✓	✓	✓	✓	✓	✓
19.	Kentish Plover	✓	✓		✓		✓		✓	
20.	Lesser Sand Plover	✓	✓	✓	✓	✓	✓	✓	✓	✓
21.	Greater Sand Plover	✓	✓	✓	✓	✓	✓	✓	✓	✓
22.	Grey-headed Lapwing	✓	✓	✓	✓		✓		✓	
23.	Pintail Snipe	✓	✓	✓	✓	✓	✓	✓	✓	✓
24.	Common Snipe	✓	✓	✓	✓					
25.	Jack Snipe				✓					
26.	Black-tailed Godwit	✓	✓	✓	✓					
27.	Bar-tailed Godwit	✓	✓		✓					
28.	Eurasian Whimbrel	✓	✓	✓	✓	✓	✓	✓	✓	✓
29.	Eurasian Curlew	✓	✓	✓	✓	✓	✓	✓		
30.	Spotted Redshank	✓	✓							
31.	Common Redshank	✓	✓	✓	✓	✓	✓	✓	✓	✓
32.	Marsh Sandpiper	✓	✓	✓	✓					
33.	Common Greenshank	✓	✓	✓	✓		✓			
34.	Green Sandpiper			✓	✓		✓			
35.	Wood Sandpiper	✓	✓	✓	✓	✓	✓	✓	✓	
36.	Terek Sandpiper	✓	✓	✓						
37.	Common Sandpiper	✓	✓	✓	✓	✓	✓	✓	✓	✓
38.	Ruddy Turnstone	✓	✓		✓					
39.	Great Knot	✓	✓							
40.	Little Stint	✓	✓		✓					
41.	Rufous-necked Stint	✓	✓	✓	✓	✓	✓	✓	✓	
42.	Temminck's Stint	✓	✓		✓					

43.	Long-toed Stint	✓	✓	✓	✓	✓	✓	✓	✓	
44.	Curlew Sandpiper	✓	✓	✓	✓	✓	✓	✓	✓	
45.	Broad-billed Sandpiper	✓	✓	✓	✓					
46.	Black-winged Stilt			✓	✓					
47.	Crab-Plover								✓	
48.	Beach Stone- Plover							✓	✓	
49.	Oriental Pratincole	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 6. Species of birds recorded from Mangrove of Middle Andaman

Sl. No.	Common Name	Baratang	Dhaninallah	Shyamkund	Yeratta	Long Island	Lalaji Bay	North Passage	Guitar Island
1.	Little Egret	✓				✓	✓	✓	
2.	Pacific Reef-Egret	✓	✓		✓	✓	✓	✓	✓
3.	Large Egret	✓	✓	✓	✓	✓	✓	✓	
4.	Median Egret	✓				✓		✓	
5.	Eastern Cattle Egret				✓	✓	✓		
6.	Chinese Pond-Heron	✓	✓		✓	✓	✓	✓	
7.	Andaman Little Green Heron	✓	✓	✓	✓	✓	✓	✓	✓
8.	Yellow Bittern	✓				✓			
9.	Chestnut Bittern					✓			
10.	Pacific Golden-Plover	✓	✓	✓	✓	✓	✓	✓	✓
11.	Lesser Sand Plover	✓	✓	✓	✓	✓	✓	✓	✓
12.	Greater Sand Plover	✓							
13.	Pintail Snipe	✓			✓	✓	✓	✓	
14.	Eurasian Whimbrel	✓	✓	✓	✓	✓	✓	✓	✓
15.	Eurasian Curlew							✓	✓
16.	Spotted Redshank								
17.	Common Redshank	✓	✓	✓	✓	✓	✓	✓	✓
18.	Wood Sandpiper	✓			✓	✓	✓	✓	
19.	Terek Sandpiper								
20.	Common Sandpiper	✓	✓	✓	✓	✓	✓	✓	✓
21.	Ruddy Turnstone					✓			
22.	Curlew Sandpiper							✓	
23.	Oriental Pratincole					✓			

Table 7. Species of birds recorded from Mangrove of North Andaman

Sl. No.	Common Name	Mayabunder									Diglipur					
		Pokka Dera	Austin Creek	Panighat	Karmatang	Aerial Bay	Durgapur	Brush Islands	Smith Island	Kalipur	Shibpur	Lamiya Bay	Kalighat Creek	Bamboo Island	Beema Dera	Ram Nagar
1.	Little Egret		✓		✓	✓	✓		✓	✓			✓	✓	✓	
2.	Pacific Reef-Egret	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3.	Grey Heron															✓
4.	Purple Heron															
5.	Large Egret	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
6.	Median Egret					✓	✓				✓		✓			
7.	Eastern Cattle Egret										✓					
8.	Chinese Egret															
9.	Indian Pond-Heron						✓				✓					
10.	Chinese Pond-Heron				✓	✓	✓		✓				✓	✓	✓	
11.	Andaman Little Green Heron	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
12.	Yellow Bittern	✓				✓	✓						✓			
13.	Chestnut Bittern									✓						
14.	Black Bittern															
15.	Glossy Ibis															
16.	Pacific Golden-Plover	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
17.	Grey plover						✓	✓	✓	✓				✓	✓	
18.	Little Ringed Plover															
19.	Kentish Plover						✓									
20.	Lesser Sand Plover	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
21.	Greater Sand Plover		✓			✓	✓	✓	✓		✓		✓			
22.	Grey-headed Lapwing															
23.	Pintail Snipe	✓			✓						✓	✓				✓
24.	Common Snipe															
25.	Jack Snipe															
26.	Black-tailed Godwit															
27.	Bar-tailed Godwit					✓	✓	✓	✓				✓	✓	✓	
28.	Eurasian Whimbrel	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
29.	Eurasian Curlew		✓			✓	✓	✓		✓			✓	✓	✓	
30.	Spotted Redshank															
31.	Common Redshank	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
32.	Marsh Sandpiper															
33.	Common Greenshank															
34.	Green Sandpiper															
35.	Wood Sandpiper				✓											
36.	Terek Sandpiper					✓	✓	✓					✓	✓	✓	
37.	Common Sandpiper	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

38.	Ruddy Turnstone	✓	✓	✓		✓		✓	✓	✓	✓	
39.	Great Knot	✓	✓	✓		✓		✓	✓			
40.	Little Stint			✓								
41.	Rufous-necked Stint	✓	✓	✓						✓	✓	
42.	Temminck's Stint											
43.	Long-toed Stint	✓	✓									
44.	Curlew Sandpiper	✓	✓	✓	✓					✓	✓	
45.	Broad-billed Sandpiper	✓	✓	✓						✓	✓	
46.	Black-winged Stilt						✓					
47.	Crab-Plover	✓	✓	✓	✓	✓		✓			✓	
48.	Beach Stone- Plover			✓		✓	✓	✓				✓
49.	Oriental Pratincole	✓	✓									

5.3. Arrival and departure of migratory bird species

5.3.1. Migratory Flyways

Water birds are an important component of most of wetland environment, as these occupy several trophic levels in the food web of wetland nutrient cycles. Water birds are broadly defined as '*birds ecologically dependent on wetlands*' and include recognized groups popularly known as wildfowl, waterfowl and shorebirds and waders. In addition to these groups, other species groups dependent on wetlands are passerines. Several wetlands in the coastal floodplains are important for the migratory waders and ducks. As the shorebirds use varied habitats like estuaries, riverbanks, paddy fields, etc. foraging and roosting sites are readily available. In the Asia-Pacific region, 243 species by virtue of their nature undertake annual migrations between the breeding areas and non-breeding grounds, along various flyways.

Migration remains one of the most compelling aspects of the avian world. Twice a year, billions of birds migrate vast distances across the globe. Typically, these journeys follow a predominantly north-south axis, linking breeding grounds in arctic and temperate regions with non-breeding sites in temperate and tropical areas. The routes followed by migratory birds on their journeys between their breeding and wintering places are known as flyways. Boere and Stroud (2006) defined the flyways as *"the biological systems of migration paths that directly link sites and ecosystems in different countries and continents"*. The International Wader Study Group (1998) recognized five major flyways for migratory shorebirds namely, Central Pacific

Flyway, American Flyway, African-West Eurasian Flyway, Central Asian Flyway and East Asian-Australasian Flyway. India is known to support 1232 species of bird species, out of these 257 species are water birds.

Wetlands in Andaman & Nicobar Islands come under East Asian-Australasian Flyway (Anonymous, 1996). During their annual migrations, water birds halt at sites for very short periods to rest and feed and these, 'stepping stones' are essential for their survival. The wetlands of south Andaman are one of the regions with international importance. Conservation of migrating water birds is the collective responsibility of all countries in the flyway. Many species of wetland birds also play a role in control of agricultural pests, while some species are themselves considered pests of paddy.

East Asian-Australasian Flyway (EAAF) extends from Arctic Russia and North America to the southern limits of Australia and New Zealand (Figs. 6-7). It encompasses large parts of East Asia, all of Southeast Asia and includes *eastern India and the Andaman and Nicobar Islands*. The migratory shore birds arrive in Andaman and Nicobar Islands during August/September and stay in the area up to March/April.

More than 50 million migratory waterbirds including 8 million waders are using the route annually. Many waders travel all the way from their high arctic breeding grounds to spend the northern winter in the temperate latitudes of the southern hemisphere. For the Bar-tailed Godwit *Limosa lapponica*, this can entail an 11,000 km non-stop flight from Alaska to New Zealand (BirdLife International). Some species, such as Red-necked Stint *Calidris ruficollis* and Spotted Greenshank *Tringa guttifer* (EN) also cross Bangladesh to spend the winter in eastern India.

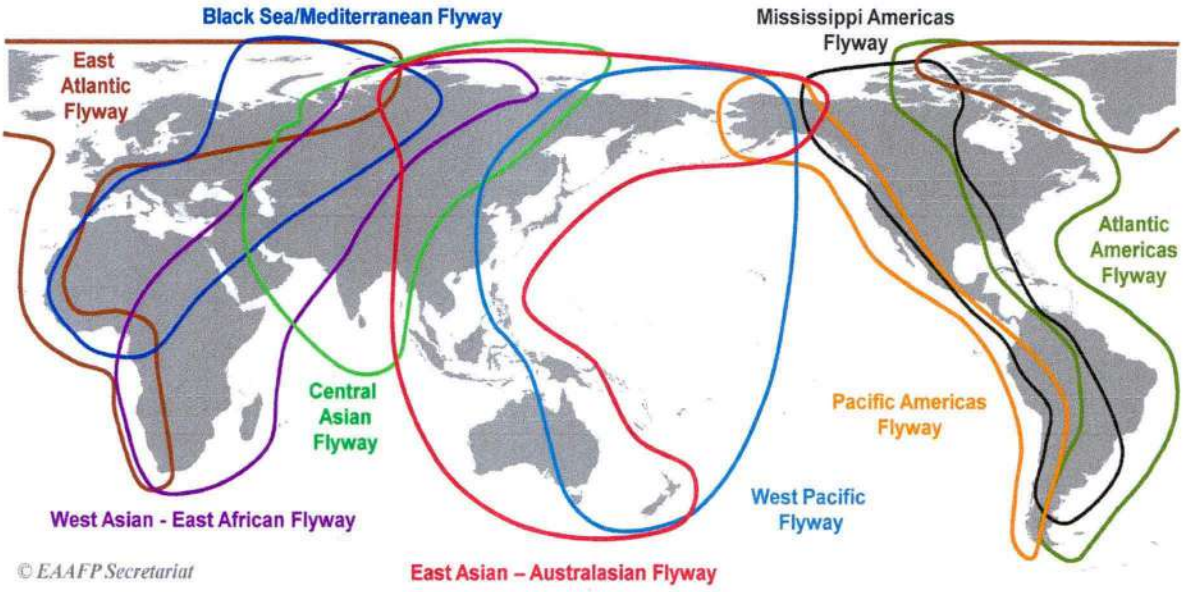

Fig. 6. Major global flyways for migratory birds

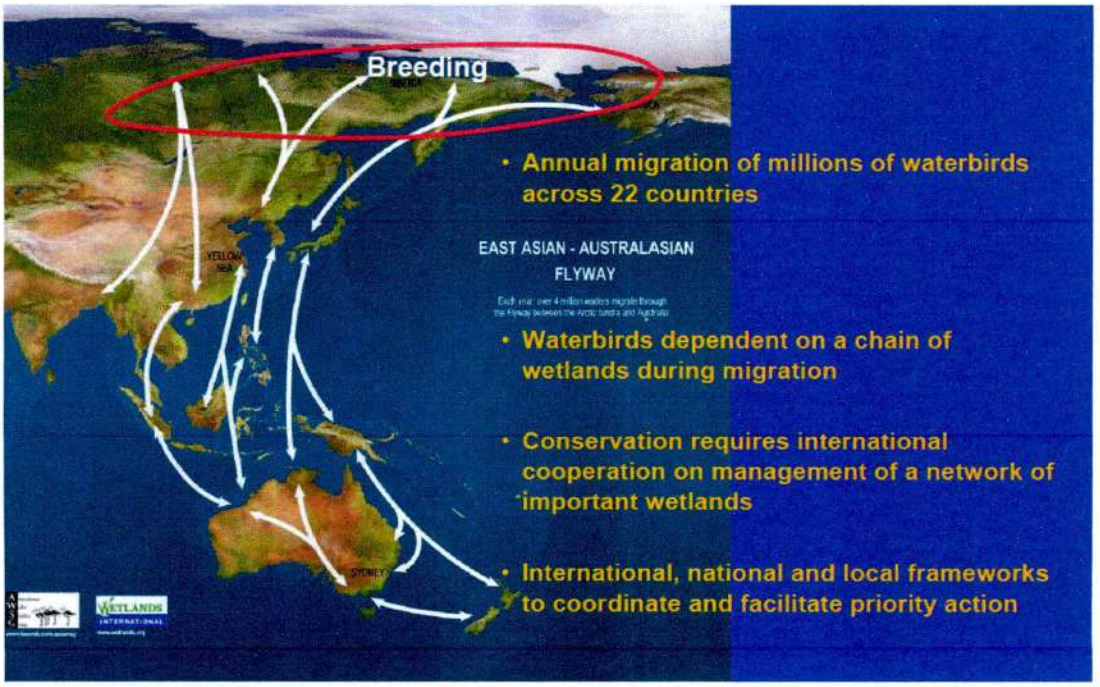

Fig. 7. East Asian - Australasian flyway

5.3.2. Arrival and departure of migratory birds

The arrival and departure of resident and migratory birds were assessed for the period of three years. The result shows that, most of the migratory birds are arriving during the month of August/September and stay up to March/April in Andaman Islands (Table 8).

Table 8. Arrival and Departure of migratory and resident migratory birds

Sl. No.	Common Name	2014-2015	2015-2016		2016-2017	
		Departure	Arrival	Departure	Arrival	Departure
1.	Little Egret	06-May	08-Jul	14-May	10-Sep	22-May
2.	Grey Heron	22-April	19- Sep	03-May	11-Oct	28-Apr
3.	Chinese Egret	17-March	22-Jan	12-Apr	11-Oct	May
4.	Great Egret	Jun	12-Sep	22-may	Jun	May
5.	Intermediate Egret	17-Mar	22-Jan	12-Apr	5-Nov	Apr
6.	Indian Pond-Heron	19-May	06-Oct	15-May	10-Sep	Apr
7.	Chinese Pond-Heron	15-Apr	7- Oct	29-Apr	01-Oct	Apr
8.	Black Bittern	12-Mar			13-Oct	May
9.	Yellow Bittern	06-June	07-October	25-May	Jul	May
10.	Glossy Ibis	12-Mar	17-Jan	24-Jan	11-Oct	Sep
11.	Pacific Golden-Plover	06-May	08-Jul	14-May	10-Sep	May
12.	Grey plover	25-April		5 Jun	10-Oct	Feb
13.	Little Ringed Plover	02-Apr	19- Sep	28-Mar	16-Oct	Mar
14.	Kentish Plover	27-Mar	19-Nov	20-Dec	15-Oct	Feb
15.	Lesser Sand Plover	11-May	11-Jul	28-May	10-Jul	May
16.	Greater Sand Plover	06-May	15-Jul	05-May	10-Jul	Apr
17.	Grey-headed Lapwing	14-Feb	09- Oct	09-Feb	12-Oct	Mar
18.	Pintail Snipe	22- Apr	19- Sep	24-Apr	11-Sep	Apr
19.	Common Snipe	12-Mar	27- Nov	05-Apr	Oct	Mar
20.	Black-tailed Godwit	02-Apr	12-Nov	28-Mar	NA	NA
21.	Bar-tailed Godwit	12-Mar	02-Oct	09-Mar	11-Sep	Mar
22.	Whimbrel	12-Jun	11-Apr	05-Jun	10-Jul	Jun
23.	Eurasian Curlew	29-Jun	18-Jul	28-Apr	10-Jul	May
24.	Common Redshank	27-May	07-Jul	12-Jun	10-Jul	May
25.	Marsh Sandpiper	13-May	18-Jul	02-May	11-Oct	Feb
26.	Common Greenshank	02- Apr	07- Oct	18-Apr	11-Oct	Mar
27.	Green Sandpiper	18-Dec	16-Dec	17-Jan	12-Oct	Feb
28.	Wood Sandpiper	22-Apr	12-Aug	8-Apr	06-Aug	May
29.	Terek Sandpiper	26- Nov	19- Sep	18-Mar	06-Aug	Apr
30.	Common Sandpiper	13-May	12-Aug	18-Apr	10-Jul	Apr
31.	Ruddy Turnstone	22-Mar	08-October	11-Mar	15-Aug	Mar
32.	Great Knot	27-Mar	15-Dec	NA	09-Nov	Mar
33.	Little Stint	04-Feb	19-Nov	NA	11-Oct	May
34.	Rufous-necked Stint	19-May	08-July	27-May	10-Sep	May
35.	Temminck's Stint	12-Dec			09-Nov	Jan
36.	Long-toed Stint	13-May	08-Jul	27-May	10-Jul	Apr
37.	Curlew Sandpiper	20-Apr	18- Aug	04-May	10-Jul	May
38.	Broad-billed Sandpiper	23-Jan	02-Dec	11-Mar	08-Oct	Mar
39.	Black-winged Stilt	22-Mar	15-Dec	04-Apr	12-Dec	Feb

40.	Crab-Plover		12-Jan		12-Oct	Mar
41.	Ruff				10-Sep	Apr
42.	Oriental Pratincole	22-Apr	12- Nov	17-Feb	05-Aug	Mar
43.	Common Black headed Gull	10-Mar				
44.	Common Gull-billed Tern		10-Oct	12-Dec	02-Sep	15-Apr
45.	Lesser Crested Tern	22-April	12- Nov	17-Feb	05-Aug	12-May
46.	Roseate Tern		8-June	NA	18-Jul	11-Oct
47.	Little Tern	15-Oct	15-Jun	12-Sep	02-Jul	04-Jan
48.	Bridled Tern				08-Dec	13-Jan
49.	Whiskered Tern	15-Oct	15-Jun	12-Mar	02-Jul	04-Apr
50.	Brown Noddy	22-Mar	15-Dec	04-April	12-Dec	11-May

5.4. Species richness of wading and shorebirds in different locations

Species richness of birds varied in different locations in the south Andaman. Highest number of species was recorded at Chouldhari (15 species of wading birds), Garacharma (36 species of shorebirds) Table 9. North Passage island had more number of species both wading and shorebirds (10 & 23 respectively). In North Andaman highest number of species recorded from Aerial Bay and Durgapur (22 species of shore birds).

Table 9. Species richness of species of wading and shore birds

Sl. No.	Location	Species richness	
		Wading birds	Shore birds
	South Andaman		
1.	Garacharma	13	36
2.	Sippighat	14	33
3.	Chouldhari	15	26
4.	Ograbraj	14	31
5.	Lohabarrake	12	16
6.	Wandoor	8	19
7.	Stewartgunj	10	18
8.	Shoal Bay	9	18
9.	Chidiyatapu	13	14
10.	Manjery	8	10
	Middle Andaman		
11.	Shyamkund	6	9
12.	Yeratta	8	12
13.	Long Island	7	18

14.	Lalaji Bay	6	8
15.	North Passage	10	23
16.	Guitar Island	4	11
17.	Dhaninallah	5	12
18.	Baratang	9	16
	North Andaman		
19.	Pokka Dera	8	17
20.	Austin Creek	7	14
21.	Panighat	8	13
22.	Karmatang	8	17
23.	Aerial Bay	8	22
24.	Durgapur	8	22
25.	Shibpur	5	10
26.	Kalipur	6	16
27.	Lamiya Bay	7	14
28.	Kalighat Creek	8	16
29.	Bamboo Island	8	20
30.	Brush Islands	8	20
31.	Beema Dera	8	17
32.	Ram Nagar	6	14
33.	Smith Island	3	20

5.5. Species abundance and dominance of wading and shorebirds

Common Redshank showed highest in dominance (17.4 %) in South Andaman, followed by Curlew Sandpiper (11.44 %), Lesser Sand Plover (10.32 %) and Common Snipe, Great Knot, Little Stint, Black Bittern, Glossy Ibis, Temminck's Stint, Crab-Plover and Jack Snipe were showed less than 1 % (Table 10).

Table 10. Species abundance and dominance of wading and shorebirds in South Andaman

Sl. No.	Common Name	Abundance	Dominance
1.	Common Redshank	694	17.34
2.	Curlew Sandpiper	458	11.44
3.	Lesser Sand Plover	413	10.32
4.	Large Egret	357	8.92
5.	Long-toed Stint	319	7.97
6.	Eastern Cattle Egret	269	6.72
7.	Wood Sandpiper	221	5.52
8.	Eurasian Whimbrel	212	5.30

9.	Pacific Golden-Plover	211	5.27
10.	Little Egret	179	4.47
11.	Pacific Reef-Egret	71	1.77
12.	Pintail Snipe	56	1.40
13.	Median Egret	54	1.35
14.	Eurasian Curlew	51	1.27
15.	Greater Sand Plover	41	1.02
16.	Andaman Little Green Heron	38	0.95
17.	Common Sandpiper	35	0.87
18.	Rufous-necked Stint	32	0.80
19.	Chinese Pond-Heron	31	0.77
20.	Yellow Bittern	22	0.55
21.	Little Ringed Plover	18	0.45
22.	Marsh Sandpiper	17	0.42
23.	Indian Pond-Heron	16	0.40
24.	Common Greenshank	16	0.40
25.	Chinese Egret	15	0.37
26.	Chestnut Bittern	13	0.32
27.	Bar-tailed Godwit	13	0.32
28.	Broad-billed Sandpiper	13	0.32
29.	Oriental Pratincole	12	0.30
30.	Kentish Plover	11	0.27
31.	Grey Heron	9	0.22
32.	Grey-headed Lapwing	9	0.22
33.	Terek Sandpiper	9	0.22
34.	Ruddy Turnstone	9	0.22
35.	Black-tailed Godwit	8	0.20
36.	Green Sandpiper	7	0.17
37.	Beach Stone- Plover	7	0.17
38.	Purple Heron	6	0.15
39.	Grey plover	4	0.10
40.	Spotted Redshank	4	0.10
41.	Black-winged Stilt	4	0.10
42.	Common Snipe	3	0.07
43.	Great Knot	3	0.07
44.	Little Stint	3	0.07
45.	Black Bittern	2	0.05
46.	Glossy Ibis	2	0.05
47.	Temminck's Stint	2	0.05
48.	Crab-Plover	2	0.05
49.	Jack Snipe	1	0.02

Pacific Golden Plover showed highest in dominance (17.09 %) in Middle Andaman, followed by Eastern Cattle Egret (15.52%), Common Redshank (8.06 %) and Ruddy Turnstone showed less than 1 % (Table 11).

Table 11. Species abundance and dominance of wading and shorebirds in Middle Andaman

Sl. No.	Common Name	Abundance	Dominance
1.	Pacific Golden-Plover	87	17.09
2.	Eastern Cattle Egret	79	15.52
3.	Common Redshank	41	8.06
4.	Lesser Sand Plover	41	8.06
5.	Large Egret	41	8.06
6.	Eurasian Whimbrel	37	7.27
7.	Greater Sand Plover	27	5.30
8.	Little Egret	25	4.91
9.	Andaman Little Green Heron	19	3.73
10.	Chinese Pond-Heron	18	3.54
11.	Pacific Reef-Egret	16	3.14
12.	Common Sandpiper	14	2.75
13.	Chestnut Bittern	13	2.55
14.	Wood Sandpiper	12	2.36
15.	Pintail Snipe	12	2.36
16.	Median Egret	9	1.77
17.	Eurasian Curlew	9	1.77
18.	Yellow Bittern	6	1.18
19.	Ruddy Turnstone	3	0.59

Little Egret showed highest in dominance (17.11 %) in North Andaman, followed by Large Egret & Pacific Golden Plover (10.13%), Common Redshank (8.61 %) and Little Stint, Chinese Pond-Heron, Ruddy Turnstone, Yellow Bittern, Terek Sandpiper, Chestnut Bittern, Beach Stone- Plover, Great Knot, Oriental Pratincole, Grey Heron, Grey plover, Black-winged Stilt and Crab-Plover were showed less than 1 % (Table 12).

Table 12. Species abundance and dominance of wading and shorebirds in North Andaman

Sl. No.	Common Name	Abundance	Dominance
1.	Little Egret	147	17.11
2.	Large Egret	87	10.13
3.	Pacific Golden-Plover	87	10.13
4.	Common Redshank	74	8.61
5.	Lesser Sand Plover	57	6.64
6.	Eurasian Curlew	56	6.52
7.	Bar-tailed Godwit	35	4.07
8.	Pintail Snipe	30	3.49
9.	Pacific Reef-Egret	29	3.38
10.	Rufous-necked Stint	27	3.14
11.	Greater Sand Plover	22	2.56
12.	Andaman Little Green Heron	22	2.56
13.	Long-toed Stint	21	2.44
14.	Eurasian Whimbrel	18	2.10
15.	Broad-billed Sandpiper	15	1.75
16.	Curlew Sandpiper	14	1.63
17.	Eastern Cattle Egret	14	1.63
18.	Common Sandpiper	14	1.63
19.	Median Egret	12	1.40
20.	Wood Sandpiper	11	1.28
21.	Indian Pond-Heron	10	1.16
22.	Little Stint	8	0.93
23.	Chinese Pond-Heron	7	0.81
24.	Ruddy Turnstone	7	0.81
25.	Yellow Bittern	6	0.70
26.	Terek Sandpiper	6	0.70
27.	Chestnut Bittern	4	0.47
28.	Beach Stone- Plover	4	0.47
29.	Great Knot	4	0.47
30.	Oriental Pratincole	3	0.35
31.	Grey Heron	2	0.23
32.	Grey plover	2	0.23
33.	Black-winged Stilt	2	0.23
34.	Crab-Plover	2	0.23

5.6. Similarity index

South Andaman and North Andaman were showed high similarity (58 Percent) followed by South Andaman and Middle Andaman (Table 13)

Table 13. Sørensen similarity index (C_S) of the avifauna between the survey locations of Andaman Islands

Location	Sørensen similarity index (C_S)		
	South Andaman	Middle Andaman	North Andaman
South Andaman	0	0.358	0.581
Middle Andaman		0	0.345
North Andaman			0

5.7. Seasonal variation of population of wading and shorebirds

Variation of species abundance in different parts of Andaman is presented in Table 14. Among the recorded species Eastern Cattle Egret, Little Egret, Pacific Golden Plover, Lesser Sand Plover, Common Redshank were the more abundant species in the study area.

Table 14. Variation of wading and shorebirds population (2015-2017)

Sl. No.	Common Name	South Andaman	Middle Andaman	North Andaman
1.	Little Egret	573	18	29
2.	Pacific Reef-Egret	70	32	115
3.	Grey Heron	26	1	2
4.	Purple Heron	14	-	2
5.	Great Egret	511	28	32
6.	Intermediate Egret	493	2	25
7.	Eastern Cattle Egret	877	173	461
8.	Chinese Egret	14	-	-
9.	Indian Pond-Heron	88	4	34
10.	Chinese Pond-Heron	163	11	21
11.	Andaman Striated Heron	248	31	79
12.	Black-crowned Night-Heron	1	-	-
13.	Yellow Bittern	71	9	8
14.	Chestnut Bittern	144	15	12
15.	Black Bittern	14	-	-
16.	Glossy Ibis	4	-	-
17.	Pheasant-tailed Jacana	6	-	2
18.	Pacific Golden-Plover	254	102	158
19.	Grey plover	2	-	2

20.	Little Ringed Plover	12	3	6
21.	Kentish Plover	3	2	6
22.	Lesser Sand Plover	583	168	312
23.	Greater Sand Plover	68	41	37
24.	Grey-headed Lapwing	13	-	-
25.	Pintail Snipe	119	21	47
26.	Common Snipe	8	-	-
27.	Black-tailed Godwit	3	-	-
28.	Bar-tailed Godwit	28	-	41
29.	Eurasian Whimbrel	149	21	84
30.	Eurasian Curlew	81	13	39
31.	Common Redshank	412	124	371
32.	Marsh Sandpiper	8	-	-
33.	Common Greenshank	8	-	-
34.	Green Sandpiper	12	-	-
35.	Wood Sandpiper	203	42	32
36.	Terek Sandpiper	8	-	16
37.	Common Sandpiper	62	26	81
38.	Ruddy Turnstone	13	3	29
39.	Great Knot	4	-	8
40.	Little Stint	3	-	18
41.	Rufous-necked Stint	37	18	42
42.	Temminck's Stint	2	-	-
43.	Long-toed Stint	135	36	108
44.	Curlew Sandpiper	364	139	113
45.	Broad-billed Sandpiper	22	-	38
46.	Black-winged Stilt	2	-	-
47.	Crab-Plover	2	-	2
48.	Beach Stone- Plover	8	-	6
49.	Oriental Pratincole	51	31	86
50.	Common Black headed Gull	1	-	-
51.	Common Gull-billed Tern	2	-	2
52.	Lesser Crested Tern	22	19	86
53.	Roseate Tern	8	-	16
54.	Black-naped Tern	132	39	192
55.	Little Tern	32	-	65
56.	Bridled Tern	2	-	4
57.	Whiskered Tern	52	92	82
58.	Brown Noddy	18	-	-

5.8. Overall diversity indices of wading and shore birds

Indices based on the proportional abundance of species are the best approach to measure diversity. Most widely used diversity indices like Shannon Index of diversity, Simpson's Index of diversity and Hill's numbers N1 and N2 have been determined. During the period of study, the Shannon Diversity index was (2.46), Simpson (0.15) (Table 15).

Table 15. Diversity indices for the wading and shore birds in mangrove ecosystem of south Andaman Islands

Richness Indices		Diversity Indices		Hill's Number		Evenness Indices	
R1	R2	λ	H'	N1	N2	E1	E2
8.51	0.23	0.15	2.46	11.72	6.65	0.53	0.11

5.9. Month wise species abundance and dominance of wading and shore birds

Overall month wise species abundance and dominance index of wading and shorebirds is presented in Table 16.

Table 16. Species abundance and dominance index of wetland birds in the tsunami inundated wetlands of south Andaman in different month (n=36)

Month	Species name	Abundance	Dominance Index	Frequency
January	Eastern Cattle Egret	304	24.40	2
	Little Egret	162	13.00	60
	Median Egret	121	9.71	25
	Large Egret	103	8.27	36
	Wood Sandpiper	96	7.70	41
	Whimbrel	72	5.78	28
	Chestnut Bittern	71	5.70	41
	Yellow Bittern	70	5.62	47
	Chinese Pond-Heron	60	4.82	20
	Andaman Little Green Heron	37	2.97	21
	Long-toed Stint	31	2.49	9
	Grey Heron	25	2.01	15
	Common Sandpiper	15	1.20	11
	Little Ringed Plover	14	1.12	6
	Marsh Sandpiper	14	1.12	7
	Common Redshank	13	1.04	8
	Indian Pond-Heron	9	0.72	7
	White-winged Black Tern	6	0.48	5
	Black Bittern	5	0.40	5
	Lesser Sand Plover	3	0.24	2
	Broad-billed Sandpiper	2	0.16	1
	Eurasian Curlew	2	0.16	1
	Little Stint	2	0.16	2
	Rufous-necked Stint	2	0.16	2

	Bar-tailed Godwit	1	0.08	1
	Black-naped Tern	1	0.08	1
	Green Sandpiper	1	0.08	1
	Pacific Golden-Plover	1	0.08	1
	Pheasant-tailed Jacana	1	0.08	1
	Purple Heron	1	0.08	1
	Whiskered Tern	1	0.08	1
February	Large Egret	29	25.66	20
	Curlew Sandpiper	24	21.24	4
	Chestnut Bittern	14	12.39	9
	Eurasian Curlew	13	11.50	6
	Common Sandpiper	12	10.62	12
	Chinese Pond-Heron	8	7.08	8
	Median Egret	6	5.31	1
	Common Greenshank	3	2.65	1
	Yellow Bittern	3	2.65	3
	Indian Pond-Heron	1	0.88	1
March	Pacific Golden-Plover	1101	26.23	152
	Eastern Cattle Egret	730	17.39	90
	Common Redshank	396	9.43	25
	Pintail Snipe	349	8.31	155
	Wood Sandpiper	259	6.17	47
	Median Egret	201	4.79	67
	Long-toed Stint	177	4.22	20
	Yellow Bittern	145	3.45	84
	Eurasian Curlew	124	2.95	13
	Little Egret	123	2.93	39
	Whimbrel	109	2.60	31
	Pheasant-tailed Jacana	96	2.29	64
	Chestnut Bittern	55	1.31	42
	Large Egret	48	1.14	15
	Common Sandpiper	43	1.02	10
	Little Ringed Plover	41	0.98	14
	Andaman Little Green Heron	33	0.79	14
	Common Snipe	30	0.71	10
	Oriental Pratincole	24	0.57	2
	Curlew Sandpiper	20	0.48	5
	Purple Heron	16	0.38	14
	Richard's Pipit	14	0.33	2
	Chinese Pond-Heron	13	0.31	9
	Indian Pond-Heron	10	0.24	5

	Grey Plover	8	0.19	4
	Rufous-necked Stint	6	0.14	2
	Common Greenshank	4	0.10	2
	Greater Sand Plover	4	0.10	1
	Collared Pratincole	3	0.07	1
	Grey-headed Lapwing	3	0.07	1
	Little Stint	3	0.07	1
	Little Tern	3	0.07	1
	Marsh Sandpiper	2	0.05	2
	Black Bittern	1	0.02	1
	Black-tailed Godwit	1	0.02	1
	Eurasian Wigeon	1	0.02	1
	Jack Snipe	1	0.02	1
	Terek Sandpiper	1	0.02	1
April	Lesser Sand Plover	3098	34.82	148
	Common Redshank	2100	23.61	95
	Curlew Sandpiper	1281	14.40	46
	Pacific Golden-Plover	549	6.17	78
	Large Egret	440	4.95	34
	Median Egret	279	3.14	60
	Little Egret	244	2.74	39
	Eurasian Curlew	182	2.05	41
	Whimbrel	161	1.81	34
	Eastern Cattle Egret	129	1.45	15
	Yellow Bittern	123	1.38	54
	Little Stint	99	1.11	25
	Greater Sand Plover	90	1.01	15
	Pintail Snipe	63	0.71	12
	Grey-headed Lapwing	10	0.11	3
	Temminck's Stint	9	0.10	2
	Kentish Plover	8	0.09	4
	Pheasant-tailed Jacana	7	0.08	6
	Common Greenshank	6	0.07	5
	Black-tailed Godwit	4	0.04	2
	Black-naped Tern	3	0.03	1
	Common Snipe	3	0.03	2
	Black Bittern	2	0.02	1
	Whiskered Tern	2	0.02	1
	Green Sandpiper	1	0.01	1
	Grey Heron	1	0.01	1
	Marsh Sandpiper	1	0.01	1
	Roseate Tern	1	0.01	1

May	Common Redshank	2845	37.59	254
	Curlew Sandpiper	1258	16.62	74
	Large Egret	339	4.48	78
	Common Sandpiper	314	4.15	161
	Lesser Sand Plover	181	2.39	31
	Broad-billed Sandpiper	168	2.22	42
	Andaman Little Green Heron	167	2.21	58
	Eurasian Curlew	154	2.03	35
	Chinese Pond-Heron	126	1.66	38
	Whimbrel	108	1.43	18
	Wood Sandpiper	90	1.19	23
	Common Greenshank	78	1.03	24
	Pacific Golden-Plover	77	1.02	14
	Grey Plover	48	0.63	15
	Purple Moorhen	43	0.57	10
	Eastern Cattle Egret	31	0.41	12
	Median Egret	30	0.40	9
	Black-tailed Godwit	26	0.34	5
	Indian Pond-Heron	20	0.26	11
	Common Snipe	19	0.25	9
	Bar-tailed Godwit	12	0.16	8
	Long-toed Stint	12	0.16	3
	Chestnut Bittern	8	0.11	5
	Little Ringed Plover	8	0.11	2
	Little Egret	6	0.08	3
	Little Stint	6	0.08	1
	Green Sandpiper	5	0.07	2
	Purple Heron	5	0.07	4
	Great Knot	4	0.05	2
	Pintail Snipe	4	0.05	3
	Black-winged Stilt	3	0.04	3
	Black-naped Tern	2	0.03	1
	Kentish Plover	2	0.03	1
	Ruddy Turnstone	2	0.03	2
	Rufous-necked Stint	2	0.03	1
	Blue-breasted Rail	1	0.01	1
	Grey Heron	1	0.01	1
June	Lesser Sand Plover	1104	28.21	79
	Curlew Sandpiper	1049	26.81	55
	Lesser Whistling-Duck	908	23.20	6
	Large Egret	564	14.41	146

	Eurasian Curlew	164	4.19	35
	Greater Sand Plover	87	2.22	13
	Indian Pond-Heron	15	0.38	11
	Grey Heron	12	0.31	4
	Green Sandpiper	4	0.10	3
	Garganey	3	0.08	1
	Grey Plover	3	0.08	2
July	Lesser Sand Plover	5200	76.93	343
	Large Egret	715	10.58	64
	Little Egret	349	5.16	58
	Little Stint	247	3.65	51
	Andaman Little Green Heron	147	2.17	100
	Little Ringed Plover	69	1.02	27
	Indian Pond-Heron	15	0.22	10
	Kentish Plover	4	0.06	2
	Jack Snipe	1	0.01	1
August	Long-toed Stint	1832	34.95	184
	Lesser Whistling-Duck	1550	29.57	98
	Pacific Golden-Plover	1040	19.84	122
	Median Egret	291	5.55	55
	Little Egret	279	5.32	81
	Common Sandpiper	100	1.91	46
	Pintail Snipe	50	0.95	30
	Marsh Sandpiper	38	0.72	27
	Pheasant-tailed Jacana	28	0.53	8
	Oriental Pratincole	16	0.31	7
	Little Stint	7	0.13	3
	Little Tern	7	0.13	2
	Pacific Reef-Egret	4	0.08	4
September	Wood Sandpiper	707	31.04	165
	Median Egret	584	25.64	164
	Whimbrel	240	10.54	74
	Eurasian Curlew	239	10.49	15
	Yellow Bittern	157	6.89	10
	Long-toed Stint	102	4.48	24
	Pintail Snipe	86	3.78	24
	Curlew Sandpiper	62	2.72	7
	Indian Pond-Heron	49	2.15	21
	Grey-headed Lapwing	11	0.48	3
	Ruddy Turnstone	10	0.44	10

	Purple Heron	7	0.31	6
	Grey Heron	5	0.22	1
	Terek Sandpiper	5	0.22	3
	Spotted Redshank	4	0.18	1
	Common Snipe	3	0.13	2
	Common Sandpiper	2	0.09	1
	Great Knot	2	0.09	1
	Green Sandpiper	2	0.09	1
	Garganey	1	0.04	1
October	Pacific Golden-Plover	590	40.25	102
	Curlew Sandpiper	256	17.46	8
	Andaman Little Green Heron	64	4.37	42
	Common Redshank	64	4.37	8
	Lesser Whistling-Duck	63	4.30	16
	Eastern Cattle Egret	54	3.68	8
	Little Egret	50	3.41	20
	Median Egret	50	3.41	22
	Long-toed Stint	41	2.80	6
	Black-naped Tern	27	1.84	15
	Common Moorhen	27	1.84	15
	Common Sandpiper	27	1.84	19
	Lesser Sand Plover	24	1.64	6
	Pintail Snipe	24	1.64	18
	Large Egret	22	1.50	9
	Wood Sandpiper	20	1.36	5
	Chestnut Bittern	16	1.09	11
	Pheasant-tailed Jacana	12	0.82	10
	Yellow Bittern	10	0.68	10
	Eurasian Curlew	7	0.48	2
	Little Tern	6	0.41	3
	Oriental Pratincole	4	0.27	2
	Chinese Pond-Heron	3	0.20	3
	Pacific Reef-Egret	2	0.14	2
	Purple Heron	2	0.14	1
	Whimbrel	1	0.07	1
November	Large Egret	4280	43.19	608
	Little Egret	1429	14.42	362
	Common Redshank	984	9.93	120
	Curlew Sandpiper	601	6.06	68
	Chestnut Bittern	401	4.05	32
	Long-toed Stint	323	3.26	19

	Lesser Sand Plover	234	2.36	31
	Eurasian Curlew	227	2.29	11
	Whimbrel	217	2.19	51
	Chinese Pond-Heron	106	1.07	46
	Wood Sandpiper	99	1.00	44
	Common Sandpiper	88	0.89	36
	Common Greenshank	87	0.88	43
	Median Egret	86	0.87	25
	Indian Pond-Heron	83	0.84	45
	Broad-billed Sandpiper	76	0.77	11
	Black-tailed Godwit	75	0.76	26
	Black Bittern	72	0.73	2
	Eastern Cattle Egret	65	0.66	15
	Yellow Bittern	54	0.54	29
	Marsh Sandpiper	46	0.46	30
	Andaman Little Green Heron	45	0.45	34
	Great Knot	41	0.41	1
	Eurasian Wigeon	28	0.28	9
	Pacific Golden-Plover	24	0.24	10
	Little Ringed Plover	22	0.22	6
	Grey Heron	21	0.21	21
	Yellow Wagtail	20	0.20	14
	Purple Moorhen	17	0.17	5
	Black-winged Stilt	16	0.16	16
	Garganey	8	0.08	8
	Terek Sandpiper	8	0.08	2
	Grey Plover	6	0.06	3
	Little Stint	6	0.06	2
	Black-naped Tern	4	0.04	3
	Green Sandpiper	3	0.03	2
	Ruddy Turnstone	3	0.03	3
	Bar-tailed Godwit	2	0.02	1
	Greater Sand Plover	2	0.02	1
	Grey-headed Lapwing	1	0.01	1
December	Median Egret	1759	28.18	378
	Large Egret	1389	22.26	104
	Common Redshank	855	13.70	37
	Lesser Sand Plover	423	6.78	24
	Little Egret	272	4.36	40
	Wood Sandpiper	223	3.57	77
	Pintail Snipe	210	3.36	14
	Pacific Golden-Plover	183	2.93	28

Common Sandpiper	149	2.39	78
Whimbrel	133	2.13	38
Little Stint	127	2.03	1
Chinese Pond-Heron	60	0.96	27
White-winged Black Tern	52	0.83	7
Pheasant-tailed Jacana	47	0.75	21
Yellow Bittern	44	0.71	28
Curlew Sandpiper	39	0.62	3
Andaman Little Green Heron	33	0.53	18
Rufous-necked Stint	33	0.53	4
Purple Heron	22	0.35	12
Grey Heron	21	0.34	6
Black-tailed Godwit	20	0.32	9
Chestnut Bittern	20	0.32	19
Little Tern	17	0.27	5
Common Greenshank	14	0.22	6
Marsh Sandpiper	13	0.21	6
Common Coot	11	0.18	9
Broad-billed Sandpiper	10	0.16	3
Bar-tailed Godwit	9	0.14	4
Garganey	9	0.14	3
Black-winged Stilt	7	0.11	6
Little Grebe	6	0.10	4
Oriental Pratincole	6	0.10	4
Eastern Cattle Egret	5	0.08	3
Eurasian Curlew	5	0.08	3
Long-toed Stint	4	0.06	1
Ruddy-breasted Crake	4	0.06	4
Ruddy Turnstone	3	0.05	3
Black Bittern	1	0.02	1
Grey Plover	1	0.02	1
Jack Snipe	1	0.02	1
Little Ringed Plover	1	0.02	1

5.10. Species abundance and dominance of wading and shore birds in intensive study area in South Andaman

Species abundance and dominance of wading and shorebirds in the intensive study are of South Andaman is presented in Table 17-21. Species abundance and dominance were high during migratory season due to influx of migratory bird species

and low during non-migratory season in all the study sites. Among the wading birds egrets showed high in dominance, and Plovers was high among the shore birds.

Table 17. Species abundance and dominance of wading and shorebirds birds in different study site in South Andaman (Sippighat)

Month	Species Name	Abundance	Dominance Index	Frequency
January	Eastern Cattle Egret	169	44.95	18
	Little Egret	37	9.84	11
	Large Egret	31	8.24	11
	Median Egret	22	5.85	3
	Yellow Bittern	19	5.05	18
	Whimbrel	18	4.79	4
	Long-toed Stint	16	4.26	5
	Marsh Sandpiper	14	3.72	7
	Wood Sandpiper	12	3.19	6
	Andaman Collared Kingfisher	8	2.13	7
	Chestnut Bittern	8	2.13	5
	Andaman Little Green Heron	5	1.33	5
	Andaman White-breasted Waterhen	5	1.33	3
	Lesser Sand Plover	3	0.80	2
	Lesser Whistling-Duck	3	0.80	2
	Watercock	3	0.80	2
	Black-naped Tern	1	0.27	1
	Pheasant-tailed Jacana	1	0.27	1
	Rufous-necked Stint	1	0.27	1
February	Curlew Sandpiper	24	21.82	4
	Eurasian Wiegeon	23	20.91	7
	Large Egret	21	19.09	15
	Eurasian Curlew	13	11.82	6
	Common Sandpiper	12	10.91	12
	Grey Heron	11	10.00	11
	Common Greenshank	3	2.73	1
	Common Swallow	2	1.82	2
	Indian Pond-Heron	1	0.91	1
March	Pacific Golden-Plover	711	30.91	121
	Eastern Cattle Egret	374	16.26	35
	Lesser Sand Plover	352	15.30	6
	Pintail Snipe	339	14.74	145
	Yellow Bittern	76	3.30	45

	Little Egret	64	2.78	21
	Long-toed Stint	60	2.61	5
	Median Egret	59	2.57	27
	Chestnut Bittern	55	2.39	42
	Wood Sandpiper	48	2.09	12
	Whimbrel	38	1.65	11
	Pheasant-tailed Jacana	36	1.57	22
	Andaman Little Green Heron	33	1.43	14
	Oriental Pratincole	24	1.04	2
	Chinese Pond-Heron	13	0.57	9
	Purple Heron	5	0.22	4
	Common Greenshank	4	0.17	2
	Collared Pratincole	3	0.13	1
	Little Ringed Plover	3	0.13	1
	Black Bittern	1	0.04	1
	Black-tailed Godwit	1	0.04	1
	Marsh Sandpiper	1	0.04	1
April	Lesser Sand Plover	1958	30.12	74
	Common Redshank	1932	29.72	87
	Curlew Sandpiper	584	8.98	22
	Large Egret	364	5.60	28
	Purple Moorhen	360	5.54	26
	Little Egret	209	3.21	34
	Rufous-necked Stint	187	2.88	19
	Yellow Wagtail	171	2.63	52
	Eurasian Curlew	140	2.15	28
	Andaman Little Green Heron	102	1.57	45
	Bar-tailed Godwit	75	1.15	15
	Pintail Snipe	63	0.97	12
	Yellow Bittern	51	0.78	29
	Eastern Cattle Egret	46	0.71	1
	Little Stint	44	0.68	11
	Pacific Golden-Plover	40	0.62	5
	Little Tern	27	0.42	5
	Little Ringed Plover	21	0.32	7
	Indian Great Reed-Warbler	20	0.31	15
	Common Sandpiper	16	0.25	7
	Greater Sand Plover	16	0.25	2
	Lesser Whistling-Duck	16	0.25	5
	Cotton Teal	9	0.14	1
	Indian Pond-Heron	9	0.14	7
	Dusky Warbler	8	0.12	7

	Grey-headed Lapwing	6	0.09	1
	Kentish Plover	4	0.06	2
	Pheasant-tailed Jacana	4	0.06	3
	Black-naped Tern	3	0.05	1
	Chestnut Bittern	3	0.05	3
	Common Snipe	3	0.05	2
	Ruddy-breasted Crake	2	0.03	1
	Whiskered Tern	2	0.03	1
	Andaman Collared Kingfisher	2	0.03	2
	Grey Heron	1	0.02	1
	Median Egret	1	0.02	1
	Roseate Tern	1	0.02	1
	Wood Sandpiper	1	0.02	1
May	Curlew Sandpiper	733	19.82	36
	Common Moorhen	577	15.60	40
	Common Redshank	559	15.12	38
	Curlew Sandpiper	394	10.65	32
	Lesser Sand Plover	181	4.89	31
	Large Egret	170	4.60	33
	Broad-billed Sandpiper	168	4.54	42
	Andaman Little Green Heron	166	4.49	57
	Common Sandpiper	161	4.35	69
	Eurasian Curlew	142	3.84	33
	Chinese Pond-Heron	113	3.06	32
	Wood Sandpiper	90	2.43	23
	Pacific Golden-Plover	68	1.84	10
	Grey Plover	38	1.03	11
	Black-tailed Godwit	26	0.70	5
	Bar-tailed Godwit	12	0.32	8
	Long-toed Stint	12	0.32	3
	Median Egret	12	0.32	2
	Purple Moorhen	10	0.27	3
	Little Ringed Plover	8	0.22	2
	Eurasian Curlew	7	0.19	2
	Chestnut Bittern	6	0.16	3
	Indian Pond-Heron	6	0.16	4
	Little Egret	6	0.16	3
	Little Stint	6	0.16	1
	Common Greenshank	5	0.14	3
	Whimbrel	5	0.14	4
	Black-winged Stilt	3	0.08	3
	Common Snipe	3	0.08	2

	Eastern Cattle Egret	2	0.05	2
	Kentish Plover	2	0.05	1
	Pintail Snipe	2	0.05	1
	Rufous-necked Stint	2	0.05	1
	Blue-breasted Rail	1	0.03	1
	Ruddy Turnstone	1	0.03	1
	White-winged Black Tern	1	0.03	1
June	Lesser Sand Plover	757	64.98	53
	Large Egret	356	30.56	88
	Eurasian Wiegeon	6	0.52	1
	Andaman Little Green Heron	34	2.92	24
	Greater Sand Plover	9	0.77	2
	Garganey	3	0.26	1
July	Lesser Sand Plover	1525	47.73	109
	Lesser Whistling-Duck	1018	31.86	56
	Large Egret	288	9.01	33
	Little Stint	163	5.10	26
	Little Egret	122	3.82	18
	Little Ringed Plover	48	1.50	18
	Indian Pond-Heron	15	0.47	10
	Common Sandpiper	11	0.34	3
	Kentish Plover	4	0.13	2
	Jack Snipe	1	0.03	1
August	Pacific Golden-Plover	518	59.40	42
	Little Egret	183	20.99	51
	Median Egret	89	10.21	37
	Median Egret	29	3.33	4
	Marsh Sandpiper	21	2.41	11
	Pintail Snipe	16	1.83	9
	Little Stint	7	0.80	3
	Little Tern	7	0.80	2
	Oriental Pratincole	2	0.23	1
September	Rufous-necked Stint	107	37.41	18
	Wood Sandpiper	80	27.97	26
	Whimbrel	44	15.38	14
	Andaman Little Green Heron	25	8.74	17
	Black-naped Tern	19	6.64	12
	Ruddy Turnstone	10	3.50	10
	Ruddy-breasted Crake	1	0.35	1

October	Pacific Golden-Plover	239	39.24	61
	Purple Moorhen	188	30.87	52
	Yellow Wagtail	77	12.64	24
	Common Redshank	25	4.11	3
	Lesser Whistling-Duck	18	2.96	3
	Median Egret	18	2.96	10
	Pheasant-tailed Jacana	12	1.97	
	Pintail Snipe	10	1.64	9
	Common Moorhen	9	1.48	5
	Large Egret	5	0.82	5
	Oriental Pratincole	4	0.66	2
	Little Egret	2	0.33	1
	Pacific Reef-Egret	2	0.33	2
November	Large Egret	904	36.15	122
	Curlew Sandpiper	468	18.71	32
	Little Egret	343	13.71	112
	Eurasian Curlew	227	9.08	11
	Whimbrel	196	7.84	34
	Common Redshank	91	3.64	16
	Black Bittern	72	2.88	2
	Common Sandpiper	58	2.32	20
	Common Swallow	32	1.28	15
	Pacific Golden-Plover	24	0.96	10
	Yellow Wagtail	20	0.80	14
	Black-tailed Godwit	17	0.68	8
	Purple Moorhen	17	0.68	5
	Yellow Bittern	12	0.48	7
	Terek Sandpiper	8	0.32	2
	Lesser Sand Plover	3	0.12	3
	Ruddy Turnstone	3	0.12	3
	Green Sandpiper	2	0.08	1
	Cotton Teal	1	0.04	1
	Grey Heron	1	0.04	1
	Grey Plover	1	0.04	1
	Grey-headed Lapwing	1	0.04	1
December	Median Egret	953	39.68	190
	Common Moorhen	682	28.39	14
	Little Egret	193	8.03	27
	Little Stint	127	5.29	1
	Purple Moorhen	86	3.58	20

	Andaman Teal	77	3.21	2
	Lesser Sand Plover	56	2.33	7
	House Swallow	50	2.08	14
	Chinese Pond-Heron	34	1.42	18
	Yellow Bittern	32	1.33	24
	Whimbrel	22	0.92	14
	White-winged Black Tern	16	0.67	4
	Indian Pond-Heron	15	0.62	15
	Large Egret	15	0.62	5
	Wood Sandpiper	13	0.54	7
	Bar-tailed Godwit	6	0.25	3
	Little Tern	5	0.21	4
	Long-toed Stint	4	0.17	1
	Andaman Stork-billed Kingfisher	4	0.17	3
	Common Sandpiper	3	0.12	3
	Broad-billed Sandpiper	2	0.08	1
	Common Greenshank	2	0.08	2
	Black Bittern	1	0.04	1
	Common Redshank	1	0.04	1
	Jack Snipe	1	0.04	1
	Little Ringed Plover	1	0.04	1
	Pacific Golden-Plover	1	0.04	1

Table 18. Species abundance and dominance of wading and shorebirds birds in different study site in South Andaman (Garacharma)

Month	Species Name	Abundance	Dominance Index	Frequency
January	Median Egret	57	38.00	13
	Whimbrel	48	32.00	18
	Chinese Pond-Heron	16	10.67	9
	Chestnut Bittern	6	4.00	5
	Wood Sandpiper	5	3.33	5
	Common Moorhen	4	2.67	3
	Common Stonechat	4	2.67	4
	Common Redshank	2	1.33	1
	Little Cormorant	2	1.33	2
	Little Egret	2	1.33	1
	Indian Pond-Heron	1	0.67	1
	Large Egret	1	0.67	1
	Pacific Golden-Plover	1	0.67	1
	Purple Moorhen	1	0.67	1

February	Yellow Bittern	3	100.00	3
March	Wood Sandpiper	151	42.78	30
	Long-toed Stint	117	33.14	15
	Pheasant-tailed Jacana	40	11.33	26
	Little Ringed Plover	29	8.22	8
	Pintail Snipe	10	2.83	10
	Little Stint	3	0.85	1
	Little Tern	3	0.85	1
April	Lesser Sand Plover	283	35.87	25
	Common Redshank	168	21.29	8
	Common Moorhen	92	11.66	18
	Chinese Pond-Heron	70	8.87	15
	Greater Sand Plover	68	8.62	11
	Eurasian Curlew	42	5.32	13
	Whimbrel	26	3.30	3
	Chestnut Bittern	14	1.77	14
	Andaman Teal	12	1.52	1
	Wood Sandpiper	7	0.89	7
	Common Greenshank	6	0.76	5
	Eastern Cattle Egret	1	0.13	1
May	Common Redshank	736	89.00	41
	Common Sandpiper	57	6.89	30
	Median Egret	18	2.18	7
	Pacific Golden-Plover	9	1.09	4
	Purple Heron	5	0.60	4
	Pintail Snipe	2	0.24	2
July	Lesser Sand Plover	495	69.13	43
	Large Egret	104	14.53	13
	Little Egret	69	9.64	14
	Andaman Little Green Heron	48	6.70	33
August	Long-toed Stint	591	64.03	29
	Pacific Golden-Plover	94	10.18	9
	Median Egret	91	9.86	20
	Common Sandpiper	89	9.64	43
	Pheasant-tailed Jacana	28	3.03	8
	Pintail Snipe	26	2.82	19
	Pacific Reef-Egret	4	0.43	4

September	Wood Sandpiper	268	38.62	80
	Eurasian Curlew	239	34.44	15
	Whimbrel	64	9.22	14
	Curlew Sandpiper	62	8.93	7
	Pintail Snipe	28	4.03	4
	Grey-headed Lapwing	11	1.59	3
	Purple Heron	7	1.01	6
	Grey Heron	5	0.72	1
	Common Snipe	3	0.43	2
	Common Sandpiper	2	0.29	1
	Great Knot	2	0.29	1
	Green Sandpiper	2	0.29	1
	Indian Pond-Heron	1	0.14	1
October	Little Egret	48	13.79	19
	Lesser Whistling-Duck	45	12.93	13
	Long-toed Stint	41	11.78	6
	Curlew Sandpiper	40	11.49	3
	Median Egret	32	9.20	12
	Lesser Sand Plover	24	6.90	6
	Common Sandpiper	22	6.32	16
	Large Egret	17	4.89	4
	Wood Sandpiper	16	4.60	4
	Andaman Little Green Heron	14	4.02	9
	Pacific Golden-Plover	13	3.74	7
	Chestnut Bittern	7	2.01	6
	Eurasian Curlew	7	2.01	2
	Little Tern	6	1.72	3
	Common Moorhen	4	1.15	4
	Common Redshank	4	1.15	2
	Eastern Cattle Egret	4	1.15	2
	Chinese Pond-Heron	3	0.86	3
	Whimbrel	1	0.29	1
November	Common Redshank	247	54.77	40
	Large Egret	190	42.13	25
	Common Sandpiper	7	1.55	6
	Chestnut Bittern	5	1.11	4
	Eastern Cattle Egret	2	0.44	1
December	Common Redshank	586	45.96	26
	Pacific Golden-Plover	164	12.86	20

	Watercock	160	12.55	14
	Purple Moorhen	94	7.37	16
	Median Egret	91	7.14	32
	Common Sandpiper	72	5.65	47
	Whimbrel	58	4.55	10
	Chestnut Bittern	16	1.25	16
	Pheasant-tailed Jacana	15	1.18	9
	Indian Pond-Heron	6	0.47	2
	Broad-billed Sandpiper	5	0.39	1
	Eastern Cattle Egret	5	0.39	3
	Chinese Pond-Heron	2	0.16	2
	Black-tailed Godwit	1	0.08	1

Table 19. Species abundance and dominance of wading and shorebirds birds in different study site in South Andaman (Stwartgunj)

Month	Species Name	Abundance	Dominance Index	Frequency
January	Grey Heron	10	21.28	7
	Chestnut Bittern	8	17.02	1
	Common Moorhen	8	17.02	1
	Common Redshank	6	12.77	6
	Common Sandpiper	6	12.77	6
	Median Egret	6	12.77	1
	Chestnut Bittern	2	4.26	2
	Chinese Pond-Heron	1	2.13	1
March	Pacific Golden-Plover	390	90.07	31
	Median Egret	40	9.24	9
	Marsh Sandpiper	1	0.23	1
	Terek Sandpiper	1	0.23	1
	Little Egret	1	0.23	1
April	Whimbrel	135	35.71	31
	Andaman Little Green Heron	108	28.57	30
	Rufous-necked Stint	76	20.11	10
	Terek Sandpiper	19	5.03	8
	Indian Pond-Heron	16	4.23	9
	Temminck's Stint	9	2.38	2
	Greater Sand Plover	6	1.59	2
	Grey-headed Lapwing	4	1.06	2
	Kentish Plover	4	1.06	2
	Green Sandpiper	1	0.26	1

May	Common Redshank	567	41.45	89
	Curlew Sandpiper	632	46.20	26
	Whimbrel	103	7.53	14
	Large Egret	28	2.05	13
	Common Sandpiper	14	1.02	12
	Indian Pond-Heron	12	0.88	6
	White-bellied Sea-Eagle	8	0.58	1
	Grey Plover	4	0.29	3
June	Eurasian Curlew	108	48.87	28
	Lesser Sand Plover	75	33.94	5
	Large Egret	38	17.19	14
July	Lesser Sand Plover	274	75.90	20
	Little Egret	87	24.10	31
August	Little Egret	108	60.00	28
	Long-toed Stint	31	17.22	14
	Pintail Snipe	24	13.33	11
	Marsh Sandpiper	17	9.44	16
September	Wood Sandpiper	253	52.38	22
	Yellow Bittern	157	32.51	10
	Median Egret	73	15.11	37
October	Pacific Golden-Plover	241	42.81	7
	Curlew Sandpiper	210	37.30	4
	Eastern Cattle Egret	43	7.64	5
	Purple Moorhen	26	4.62	9
	Andaman Little Green Heron	16	2.84	11
	Common Swallow	14	2.49	8
	Pintail Snipe	7	1.24	2
	Wood Sandpiper	4	0.71	1
	Common Moorhen	2	0.36	2
November	Large Egret	250	28.22	47
	Lesser Sand Plover	177	19.98	20
	Common Moorhen	162	18.28	47
	Curlew Sandpiper	132	14.90	35
	Median Egret	86	9.71	25
	Yellow Bittern	42	4.74	22
	Marsh Sandpiper	32	3.61	22

	Wood Sandpiper	3	0.34	3
	Bar-tailed Godwit	2	0.23	1
December	Common Redshank	268	26.67	10
	Lesser Sand Plover	201	20.00	3
	Cotton Teal	167	16.62	15
	Common Moorhen	139	13.83	2
	Pacific Swallow	47	4.68	10
	Curlew Sandpiper	39	3.88	3
	White-winged Black Tern	36	3.58	3
	Rufous-necked Stint	26	2.59	1
	Grey Heron	21	2.09	6
	Median Egret	20	1.99	12
	Pacific Golden-Plover	15	1.49	6
	Andaman White-breasted Waterhen	5	0.50	2
	Eurasian Curlew	5	0.50	3
	Oriental Pratincole	5	0.50	3
	Whimbrel	4	0.40	2
	Chestnut Bittern	3	0.30	2
	Ruddy Turnstone	3	0.30	3
	Grey Plover	1	0.10	1

Table 20. Species abundance and dominance of wading and shorebirds birds in different study site in South Andaman (Ograbraj)

Month	Species Name	Abundance	Dominance Index	Frequency
January	Eastern Cattle Egret	188	29.19	1
	Wood Sandpiper	79	12.27	30
	Little Egret	69	10.71	25
	Yellow Bittern	51	7.92	29
	Large Egret	49	7.61	16
	Chinese Pond-Heron	37	5.75	7
	Yellow Wagtail	35	5.43	21
	Median Egret	31	4.81	6
	Common Moorhen	23	3.57	8
	Grey Heron	15	2.33	8
	Long-toed Stint	15	2.33	4
	Pacific Swallow	15	2.33	6
	Little Ringed Plover	14	2.17	6
	Indian Pond-Heron	8	1.24	6
	White-winged Black Tern	4	0.62	4

	Blue-tailed Bee-eater	2	0.31	1
	Common Sandpiper	2	0.31	2
	Bar-tailed Godwit	1	0.16	1
	Common Stonechat	1	0.16	1
	Green Sandpiper	1	0.16	1
	Little Stint	1	0.16	1
	Purple Heron	1	0.16	1
	Rufous-necked Stint	1	0.16	1
	Whiskered Tern	1	0.16	1
March	Lesser Sand Plover	750	55.47	19
	Eastern Cattle Egret	137	10.13	19
	Eurasian Curlew	124	9.17	13
	Median Egret	102	7.54	31
	Yellow Bittern	69	5.10	39
	Large Egret	48	3.55	15
	House Swallow	39	2.88	6
	Common Snipe	30	2.22	10
	Curlew Sandpiper	20	1.48	5
	Indian Pond-Heron	10	0.74	5
	Grey Plover	8	0.59	4
	Grey Wagtail	8	0.59	3
	Greater Sand Plover	4	0.30	1
	Grey-headed Lapwing	3	0.22	1
	Lesser Sand Plover	633	39.91	35
	Pacific Golden-Plover	489	30.83	71
	Median Egret	150	9.46	26
	Yellow Wagtail	78	4.92	33
	Yellow Bittern	72	4.54	25
	Lesser Whistling-Duck	37	2.33	5
	Little Egret	35	2.21	5
	Wood Sandpiper	27	1.70	8
	Long-toed Stint	26	1.64	4
	Purple Moorhen	24	1.51	2
	Large Egret	4	0.25	4
	Little Stint	4	0.25	1
	Little Ringed Plover	3	0.19	2
	Pheasant-tailed Jacana	3	0.19	3
	Marsh Sandpiper	1	0.06	1
May	Common Redshank	854	66.25	77
	Curlew Sandpiper	232	18.00	16

	Large Egret	59	4.58	11
	Common Sandpiper	55	4.27	40
	Common Greenshank	30	2.33	5
	Common Snipe	16	1.24	7
	Chinese Pond-Heron	12	0.93	5
	Eurasian Curlew	12	0.93	2
	Greater Sand Plover	12	0.93	4
	Green Sandpiper	5	0.39	2
	Indian Pond-Heron	2	0.16	1
June	Lesser Sand Plover	167	75.91	9
	Large Egret	24	10.91	14
	Indian Pond-Heron	15	6.82	11
	Grey Heron	11	5.00	3
	Grey Plover	3	1.36	2
July	Lesser Sand Plover	789	87.38	59
	Little Egret	63	6.98	5
	Andaman Little Green Heron	30	3.32	18
	Little Ringed Plover	21	2.33	9
August	Long-toed Stint	303	74.26	34
	Median Egret	70	17.16	14
	Little Egret	21	5.15	6
	Oriental Pratincole	14	3.43	6
September	Median Egret	148	55.64	36
	Purple Moorhen	42	15.79	17
	Wood Sandpiper	54	20.30	19
	Whimbrel	22	8.27	10
October	Pacific Golden-Plover	71	61.21	21
	Common Moorhen	12	10.34	4
	Andaman Little Green Heron	9	7.76	5
	Black-naped Tern	8	6.90	3
	Eastern Cattle Egret	7	6.03	1
	Pintail Snipe	7	6.03	7
	Purple Heron	2	1.72	1
November	Large Egret	2288	65.86	294
	Long-toed Stint	323	9.30	19
	Little Egret	291	8.38	69
	Common Redshank	102	2.94	11

	Wood Sandpiper	96	2.76	41
	Indian Pond-Heron	83	2.39	45
	Lesser Sand Plover	54	1.55	8
	Eastern Cattle Egret	48	1.38	11
	Blue-tailed Bee-eater	34	0.98	8
	Chinese Pond-Heron	28	0.81	5
	Indian Great Reed-Warbler	22	0.63	1
	Little Ringed Plover	22	0.63	6
	Grey Heron	19	0.55	19
	Common Sandpiper	15	0.43	6
	Marsh Sandpiper	14	0.40	8
	Chestnut Bittern	12	0.35	11
	Whimbrel	10	0.29	6
	Little Stint	6	0.17	2
	Grey Plover	5	0.14	2
	Common Snipe	2	0.06	1
December	Lesser Sand Plover	166	17.22	14
	Large Egret	141	14.63	28
	Wood Sandpiper	135	14.00	45
	Yellow Wagtail	102	10.58	1
	Common Sandpiper	74	7.68	28
	Purple Moorhen	58	6.02	8
	Little Egret	52	5.39	10
	Whimbrel	49	5.08	12
	Pheasant-tailed Jacana	27	2.80	10
	Chinese Pond-Heron	24	2.49	7
	Black-tailed Godwit	19	1.97	8
	Andaman Little Green Heron	19	1.97	11
	Indian Pond-Heron	18	1.87	12
	Purple Heron	16	1.66	11
	Common Greenshank	12	1.24	4
	Little Tern	12	1.24	1
	Yellow Bittern	12	1.24	4
	Common Coot	10	1.04	8
	Black-winged Stilt	7	0.73	6
	Bar-tailed Godwit	3	0.31	1
	Broad-billed Sandpiper	3	0.31	1
	Pacific Golden-Plover	3	0.31	1
	Western Marsh-Harrier	2	0.21	2

Table 21. Species abundance and dominance of wading and shorebirds birds in different study site in South Andaman (Chouldhari)

Month	Species Name	Species Abundance	Dominance Index	Frequency
January	Little Egret	54	26.34	23
	Chestnut Bittern	49	23.90	30
	Andaman Little Green Heron	32	15.61	16
	Large Egret	22	10.73	8
	Median Egret	11	5.37	3
	Watercock	10	4.88	8
	Common Sandpiper	7	3.41	3
	Chinese Pond-Heron	6	2.93	3
	Whimbrel	6	2.93	6
	Common Redshank	5	2.44	1
	Eurasian Curlew	2	0.98	1
	Little Stint	1	0.49	1
February	Large Egret	8	100.00	5
March	Common Redshank	396	44.54	25
	Eastern Cattle Egret	219	24.63	36
	Whimbrel	71	7.99	20
	Wood Sandpiper	60	6.75	5
	Little Egret	58	6.52	17
	Common Sandpiper	43	4.84	10
	Pheasant-tailed Jacana	20	2.25	16
	Purple Heron	11	1.24	10
	Little Ringed Plover	9	1.01	5
	Common Moorhen	2	0.22	1
April	Lesser Sand Plover	224	27.15	14
	Median Egret	128	15.52	33
	Long-toed Stint	84	10.18	6
	Eastern Cattle Egret	82	9.94	13
	Large Egret	72	8.73	2
	Broad-billed Sandpiper	59	7.15	13
	Little Stint	51	6.18	13
	Chinese Pond-Heron	34	4.12	14
	Purple Moorhen	24	2.91	6
	Common Sandpiper	23	2.79	12
	Pacific Golden-Plover	20	2.42	2
	Chestnut Bittern	12	1.45	6
	Bar-tailed Godwit	6	0.73	3

	Black-tailed Godwit	4	0.48	2
	Black Bittern	2	0.24	1
May	Common Redshank	129	34.31	9
	Large Egret	82	21.81	21
	Common Greenshank	43	11.44	16
	Eastern Cattle Egret	29	7.71	10
	Common Sandpiper	27	7.18	10
	Greater Sand Plover	25	6.65	4
	Eurasian Wiegeon	24	6.38	5
	Grey Plover	6	1.60	1
	Great Knot	4	1.06	2
	Chestnut Bittern	2	0.53	2
	Andaman Little Green Heron	1	0.27	1
	Andaman Teal	1	0.27	1
	Chinese Pond-Heron	1	0.27	1
	Grey Heron	1	0.27	1
	Ruddy Turnstone	1	0.27	1
June	Curlew Sandpiper	316	45.21	19
	Large Egret	146	20.89	30
	Lesser Sand Plover	105	15.02	12
	Greater Sand Plover	78	11.16	11
	Eurasian Curlew	49	7.01	5
	Green Sandpiper	4	0.57	3
	Grey Heron	1	0.14	1
July	Lesser Sand Plover	2117	81.80	112
	Large Egret	323	12.48	18
	Little Stint	84	3.25	25
	Andaman Little Green Heron	35	1.35	25
	Little Egret	29	1.12	5
August	Pacific Golden-Plover	428	52.07	71
	Long-toed Stint	184	22.38	38
	Median Egret	101	12.29	17
	Lesser Whistling-Duck	57	6.93	13
	Blue-tailed Bee-eater	32	3.89	20
	Little Egret	20	2.43	5
September	Median Egret	274	25.07	54
	Rufous-necked Stint	156	14.27	18
	Whimbrel	110	10.06	36

	Long-toed Stint	102	9.33	24
	Wood Sandpiper	52	4.76	18
	Indian Pond-Heron	48	4.39	20
	Pintail Snipe	42	3.84	11
	Terek Sandpiper	5	0.46	3
	Spotted Redshank	4	0.37	1
October	Common Redshank	35	2.43	3
	Pacific Golden-Plover	26	1.80	6
	Cotton Teal	10	0.69	5
	Chestnut Bittern	9	0.62	5
	Changeable Hawk-Eagle	7	0.49	4
	Curlew Sandpiper	6	0.42	1
	Common Sandpiper	5	0.35	3
	Common Redshank	544	37.70	53
	Chestnut Bittern	384	26.61	17
	Common Greenshank	87	6.03	43
	Chinese Pond-Heron	78	5.41	41
	Broad-billed Sandpiper	76	5.27	11
	Black-tailed Godwit	58	4.02	18
	Great Knot	41	2.84	1
	Black-winged Stilt	16	1.11	16
	Eastern Cattle Egret	15	1.04	3
	Andaman Little Green Heron	15	1.04	11
	Whimbrel	11	0.76	11
	Common Sandpiper	8	0.55	4
	Black-naped Tern	4	0.28	3
	Eurasian Wiegeon	2	0.14	2
	Greater Sand Plover	2	0.14	1
	Common Snipe	1	0.07	1
	Curlew Sandpiper	1	0.07	1
	Green Sandpiper	1	0.07	1
	Grey Heron	1	0.07	1
December	Median Egret	400	47.45	87
	Purple Moorhen	212	25.15	25
	Wood Sandpiper	75	8.90	25
	Pacific Swallow	45	5.34	9
	Pintail Snipe	34	4.03	7
	Little Egret	27	3.20	3
	Yellow Wagtail	16	1.90	10
	Marsh Sandpiper	13	1.54	6
	Little Grebe	6	0.71	4

Purple Heron	6	0.71	1
Pheasant-tailed Jacana	5	0.59	2
Andaman Little Green Heron	3	0.36	1
Chestnut Bittern	1	0.12	1

5.11. Overall diversity indices of wading and shorebirds in different month

Diversity index (H') varied in different month and highest observed in the month of January (3.17), followed by April (2.57). Similarly, the other indices like Richness, Hill's Numbers, and Evenness also varied (Table 22).

Table 22. Diversity indices of wading and shorebirds in different month (n=36)

Month	Richness Indices		Diversity Indices		Hill's Numbers		Evenness Indices	
	R1	R2	λ	H'	N1	N2	E1	E2
January	7.71	1.08	0.06	3.17	23.79	15.45	0.76	0.37
February	3.16	0.18	0.39	1.11	3.04	2.55	0.32	0.09
March	6.71	0.52	0.20	2.22	9.18	5.08	0.53	0.14
April	7.43	0.57	0.15	2.57	13.01	6.84	0.60	0.18
May	6.83	0.68	0.16	2.41	11.14	6.09	0.58	0.18
June	1.81	0.25	0.22	1.70	5.45	4.60	0.61	0.34
July	1.67	0.18	0.46	1.30	3.68	2.19	0.47	0.23
August	1.75	0.22	0.25	1.67	5.31	4.07	0.60	0.33
September	3.80	0.54	0.15	2.22	9.17	6.70	0.64	0.29
October	4.23	0.27	0.82	0.56	1.75	1.22	0.15	0.04
November	6.42	0.31	0.24	1.84	6.31	4.10	0.43	0.09
December	7.16	0.48	0.16	2.34	10.39	6.28	0.55	0.14

5.12. Diversity indices of wading and shore birds in different intensive study area in south Andaman

Diversity index (H') of wading and shores birds in the intensive study area is presented in Table 23. All the indices are varied in different month and highest diversity observed from Sippighat, Garacharma.

Table 23. Diversity indices of wading and shore birds in different intensive study area in south Andaman in different month (n=36)

Month	Diversity Indices							
	Richness Indices		Diversity Indices		Hill's Number		Evenness Indices	
	R1	R2	λ	H'	N1	N2	E1	E2
				Garacharma				
January	3.46	1.17	0.13	2.30	10.01	7.88	0.76	0.48

February	0.86	0.14	0.43	1.02	2.76	2.31	0.49	0.35
March	1.17	0.30	0.24	1.61	5.00	4.17	0.73	0.56
April	2.66	0.65	0.17	2.14	8.51	5.74	0.73	0.45
May	1.33	0.34	0.74	0.65	1.91	1.35	0.28	0.19
July	0.75	0.21	0.42	1.23	3.42	2.36	0.69	0.57
August	1.31	0.32	0.41	1.34	3.83	2.46	0.58	0.38
September	2.85	0.63	0.23	1.75	5.73	4.28	0.57	0.27
October	2.88	0.30	0.88	0.42	1.52	1.14	0.13	0.06
November	0.88	0.09	0.80	0.48	1.62	1.26	0.22	0.18
December	2.76	0.32	0.23	1.79	5.96	4.30	0.55	0.24
				Sippighat				
January	5.07	1.07	0.13	2.58	13.19	7.51	0.71	0.36
February	2.12	0.19	0.45	1.09	2.96	2.24	0.36	0.14
March	4.69	0.45	0.27	1.88	6.55	3.72	0.50	0.15
April	5.73	0.57	0.16	2.31	10.12	6.30	0.58	0.19
May	6.02	0.75	0.09	2.76	15.81	10.96	0.70	0.30
June	0.98	0.23	0.45	1.04	2.84	2.20	0.50	0.35
July	1.58	0.23	0.27	1.61	5.02	3.67	0.61	0.36
August	1.35	0.27	0.32	1.42	4.15	3.15	0.59	0.38
September	1.03	0.12	0.88	0.35	1.41	1.14	0.15	0.14
October	2.77	0.74	0.23	1.93	6.86	4.44	0.65	0.36
November	4.14	0.33	0.33	1.59	4.89	3.06	0.43	0.12
December	5.18	0.80	0.20	2.20	9.00	5.03	0.59	0.21
				Chouldhari				
January	4.04	1.18	0.11	2.52	12.38	9.41	0.77	0.48
February	0.33	0.04	0.46	0.87	2.39	2.16	0.63	0.60
March	1.83	0.33	0.23	1.77	5.90	4.35	0.66	0.39
April	3.21	0.67	0.09	2.57	13.02	10.54	0.81	0.54
May	3.14	0.87	0.17	2.10	8.13	5.87	0.69	0.39
June	1.07	0.30	0.28	1.48	4.40	3.56	0.71	0.55
July	1.00	0.17	0.55	1.00	2.71	1.80	0.45	0.30
August	0.74	0.21	0.34	1.33	3.80	2.92	0.74	0.63
September	1.57	0.36	0.18	1.95	7.01	5.67	0.78	0.58
October	1.49	0.23	0.80	0.50	1.65	1.25	0.20	0.13
November	2.75	0.28	0.27	1.72	5.57	3.74	0.53	0.21
December	2.88	0.50	0.30	1.72	5.56	3.35	0.55	0.24
				Ograbraj				
January	5.68	1.14	0.09	2.81	16.64	10.88	0.75	0.40
February	0.99	0.10	0.53	0.84	2.32	1.90	0.37	0.23
March	2.47	0.43	0.25	1.80	6.02	3.92	0.60	0.30
April	2.59	0.33	0.33	1.55	4.73	3.04	0.50	0.21
May	1.85	0.34	0.32	1.45	4.28	3.15	0.54	0.29
June	1.11	0.47	0.57	0.95	2.57	1.77	0.49	0.37
July	1.36	0.28	0.36	1.31	3.71	2.74	0.55	0.34
August	0.50	0.20	0.58	0.79	2.21	1.72	0.57	0.55

September	0.54	0.25	0.38	1.15	3.15	2.64	0.83	0.79
October	1.36	0.16	0.89	0.30	1.35	1.12	0.12	0.10
November	3.06	0.23	0.40	1.40	4.05	2.47	0.41	0.13
December	3.96	0.36	0.36	1.55	4.71	2.79	0.43	0.12
				Stewartgunj				
January	2.69	0.59	0.49	1.24	3.46	2.03	0.41	0.17
March	1.41	0.32	0.44	1.06	2.88	2.27	0.44	0.26
April	2.24	0.66	0.15	2.13	8.42	6.52	0.79	0.56
May	1.11	0.24	0.38	1.20	3.32	2.65	0.55	0.37
June	0.43	0.12	0.66	0.69	2.00	1.51	0.50	0.50
July	0.49	0.19	0.42	1.08	2.95	2.37	0.78	0.74
August	0.58	0.30	0.41	1.10	3.01	2.43	0.79	0.75
September	0.32	0.14	0.40	0.99	2.69	2.49	0.90	0.90
October	1.43	0.33	0.31	1.47	4.33	3.26	0.61	0.39
November	1.93	0.33	0.36	1.54	4.67	2.74	0.56	0.29
December	3.02	0.68	0.15	2.21	9.12	6.55	0.72	0.41

5.13. Foraging behaviour

Feeding guilds of wading and shore birds is presented in Table 24. Among the recorded species all are carnivores and omnivores. Based the stratum, the egrets, herons, plovers, sandpipers are ground feeders, terns are aerial feeders.

Table 24. Feeding guild of different species of wading and shore birds

Sl. No.	Common Name	Food	Stratum	Behaviour
1.	Little Egret	C	S	WC
2.	Pacific Reef-Egret	C	S	WC
3.	Grey Heron	C	S	WC
4.	Purple Heron	C	S	WC
5.	Large Egret	C	S	WC
6.	Median Egret	C	S	WC
7.	Eastern Cattle Egret	C	G	WC
8.	Chinese Egret	C	M	WC
9.	Indian Pond-Heron	C	M	WC
10.	Chinese Pond-Heron	C	M	WC
11.	Andaman Little Green Heron	C	M	WC
12.	Yellow Bittern	C	G	WC
13.	Chestnut Bittern	C	G	WC
14.	Black Bittern	C	G	WC
15.	Glossy Ibis	C	G	WC
16.	Pheasant-tailed Jacana	C	M	WH

17.	Pacific Golden-Plover	C	M	WC
18.	Grey plover	C	M	WC
19.	Little Ringed Plover	C	M	WC
20.	Kentish Plover	C	M	WC
21.	Lesser Sand Plover	C	M	WC
22.	Greater Sand Plover	C	M	WC
23.	Grey-headed Lapwing	C	M	WC
24.	Pintail Snipe	C	M	WC
25.	Common Snipe	C	M	WC
26.	Jack Snipe	C	F	WC
27.	Black-tailed Godwit	C	M	WC
28.	Bar-tailed Godwit	C	M	WC
29.	Eurasian Whimbrel	C	G	WC
30.	Eurasian Curlew	C	M	WC
31.	Common Redshank	C	M	WC
32.	Marsh Sandpiper	C	M	WC
33.	Common Greenshank	C	M	WC
34.	Green Sandpiper	C	M	WC
35.	Wood Sandpiper	C	M	WC
36.	Terek Sandpiper	C	M	WC
37.	Common Sandpiper	C	M	WC
38.	Ruddy Turnstone	C	M	WC
39.	Great Knot	C	M	WC
40.	Little Stint	C	M	WC
41.	Rufous-necked Stint	C	M	WC
42.	Temminck's Stint	C	M	WC
43.	Long-toed Stint	C	M	WC
44.	Curlew Sandpiper	C	M	WC
45.	Broad-billed Sandpiper	C	M	WC
46.	Black-winged Stilt	C	S	WC
47.	Crab-Plover	C	M	WC
48.	Beach Stone- Plover	C	M	WC
49.	Collared Pratincole	C	M	WC
50.	Oriental Pratincole	C	G	WC
51.	Black headed Gull	C	A	AAqC
52.	Gull-billed Tern	C	A	AAqC
53.	Lesser Crested Tern	C	A	AAqC
54.	Roseate Tern	C	A	AAqC
55.	Black-naped Tern	C	A	AAqC
56.	Little Tern	C	A	AAqC
57.	Whiskered Tern	C	A	AAqC
58.	White-Winged Black Tern	C	A	AAqC
59.	Brown Noddy	C	A	AAqC

Food: C - Carnivore; Foraging Stratum: A - Aquatic; G - Ground; G - Ground Glean; S – Sally

5.14. Habitat use of bird species

Among the identified habitats highest number of species recorded from Tidal mudflat (43 species), followed by Swamp (42 species), and Shallow water (35 species) (Table 25)

Table 25. Habitat utilization of wading and shore birds

Variables	Habitats					
	Tidal mudflat	Shallow Water	Rocker y	Mangrove Creek	Swamp	Water Edge
Number of families	7	7	7	5	5	7
Number of genera	25	34	18	18	22	18
Number of species	43	35	15	34	42	18

5.15. Coefficient correlation of species richness and abundance with rainfall, temperature & humidity

Correlation of bird species richness in different location with environmental parameters showed that the minimum temperature and locations such as Chidiyatappu, Sippighat, Chouldhari, Ograbraj and Stewartgunj showed significant vatiation (Table 26). The species abundance also showed there is a considerable variation among the locations (Table 27).

Table 26. Correlation of bird species richness with rainfall, temperature & humidity

	Pearson Correlation	Chouldhari	Garacharma	Ograbraj	Sippighat	Stewartgunj
Rainfall	r	0.8796	0.7990	0.9604	0.9231	0.8035
	p value	0.000**	0.001**	0.000**	0.0000**	0.001**
Temp. (Max)	r	0.8898	0.7715	0.9232	0.9239	0.7765
	p value	0.000**	0.003**	0.000**	0.000**	0.002**
Temp. (Min)	r	0.9040	0.7994	0.9100	0.8676	0.7714
	p value	0.000**	0.001**	0.000**	0.000**	0.003**

** = Significant at 0.05 level

Table 27. Correlation of bird species abundance with Rainfall and Temperature

	Pearson Correlation	Chouldhari	Garacharma	Ograbraj	Sippighat	Stewartgunj
Rainfall	r	0.6108	0.0132	0.9698	0.9943	0.6375
	p value	0.0348**	0.9675^{NS}	0.000**	0.000**	0.025**
Temp (Max)	r	0.6333	-0.0116	0.9462	0.9961	0.6748
	p value	0.027	0.972^{NS}	0.000	0.000	0.0160
Temp. (Min)	r	0.6843	0.0375	0.9281	0.9753	0.7393
	p value	0.0141	0.907 ^{NS}	0.000	0.000	0.006

** - Significant at the 0.05; NS - Not significant at the 0.05 level

5.16. Correlation of bird species richness and abundance with water chemical parameters

Correlation of bird species richness and abundance with water chemical parameters is presented in Table 28.

Table 28. Correlation of species richness & abundance with water chemical parameters

	Pearson Correlation	Salinity PSU	pH	DO Ml/L	Nitrite NO_2 µM/L	Nitrate NO_3 µM/L	Phosphate µM/L	Silicate µM/L
				Sippighat				
Richness	r	.859**	.241	-.671*	-.089	-.629*	.027	.611*
	P- value	.001	.475	.024	.794	.038	.938	.046
Abundance	r	.798**	.041	-.661*	.290	-.259	.236	.677*
	P- value	.003	.906	.027	.387	.442	.485	.022
				Chouldhari				
Richness	r	.146	-.298	.410	.201	.197	-.242	.213
	P- value	.669	.374	.210	.553	.561	.474	.529
Abundance	r	-.656*	.037	-.325	-.235	-.154	.364	-.075
	P- value	.028	.913	.329	.487	.650	.271	.827
				Ograbraj				
Richness	r	-.030	.237	-.307	.116	-.638*	-.339	.398
	P- value	.931	.483	.359	.734	.035	.308	.226
Abundance	r	-.177	.379	-.077	.798**	-.249	.150	.949**
	P- value	.603	.250	.823	.003	.461	.659	.000

		Stewartgunj						
Richness	r	.372	.343	-.021	-.648*	-.476	-.292	.064
	P- value	.261	.302	.951	.031	.139	.384	.852
Abundance	r	.028	.049	.255	-.126	.053	.285	.578
	P- value	.935	.886	.449	.712	.878	.395	.063

* - Significant at the 0.05 level; ** - Significant at the 0.01 level

5.17. Food species observed in the study area

Eleven group of macro fauna observed in the study area (Table 29). Among the observed fauna, the Swamp and Tidal mudflat support more number of food species.

Table 29. Presence of macro fauna in different habitats (Above 500 microns)

Sl. No.	Faunal Group	Tidal mudflat	Shallow Water	Rockery	Mangrove Creek	Swamp	Water Edge
1.	Juvenile shrimps	+	+	+	+	+	+
2.	Juvenile fishes	+	+	+	+	+	+
3.	Amphipods	+	+	-	+	+	
4.	Isopods	+	-	-	+	+	+
5.	Oligocheates	+	-	-	-	+	
6.	Nematodes	+	-	+	-	+	+
7.	Polychaetes	+	+	+	-	+	-
8.	Foraminiferans	-	-	+	-	+	-
9.	Gastropods	+	+	+	+	+	+
10.	Anomopoda	+	+	-	+	-	+
11.	Halacarids	-	-	-	+	+	+
12.	Gnathostomulids	-	-	-	-	-	-
13.	Tardigrades	-	-	-	-	-	-
14.	Aschelminths	-	-	-	-	-	-
15.	Ostracodes	-	-	-	-	-	-

Nineteen group of meiofauna were observed in the study area (Table 30). Among the observed fauna, the Swamp and Tidal mudflat are support more number of food species.

Table 30 Food presence of meiofaunal group in the habitats (63 - 500 microns)

Sl. No.	Faunal Group	Tidal mudflat	Shallow Water	Rockery	Mangrove Creek	swamp	Water Edge
1	Juvenile shrimps	+	+	+	+	+	+
2	Juvenile fishes	+	+	+	+	+	+
3	Amphipods	+	-	-	+	+	-
4	Isopods	-	-	-	+	+	-
5	Oligocheates	+	+	+	+	+	+
6	Nemetodes	+	+	-	+	+	+
7	Polychaetes	+	+	+	+	+	+
8	Foraminiferans	+	-	+	+	+	-
9	Gastropods	+	+	+	+	+	+
10	Anomopoda	+	+	-	-	+	+
11	Gastropod larvae	-	-	-	-	-	-
12	Harpacticoides	-	-	-	-	-	-
13	Allogromids	+	+	-	+	+	-
14	Halacarids	+	+	+	+	+	+
15	Copepodes	-	-	-	-	-	-
16	Gnathostomulids	-	-	-	-	-	-
17	Tardigrades	-	-	-	-	-	-
18	Aschelminths	-	-	-	-	-	-
19	Ostracodes	-	-	-	-	-	-

5.18. Activity patterns of selected species of wading and shore birds in different seasons

The time activity pattern of selected species of wading and shorebirds namely, Andaman Little Green Heron, Median Egret, Eurasian Curlew, and Common Redshank were studied. The time the birds spent during day light at intertidal was used for different activities, *i.e.* foraging, resting, walking and comfort. For practical reasons, all the activities were grouped into four categories. Egret and heron spent little time for resting and comfort, while the Eurasian Curlew and Common Redshank required more time for resting (Fig. 8-19).

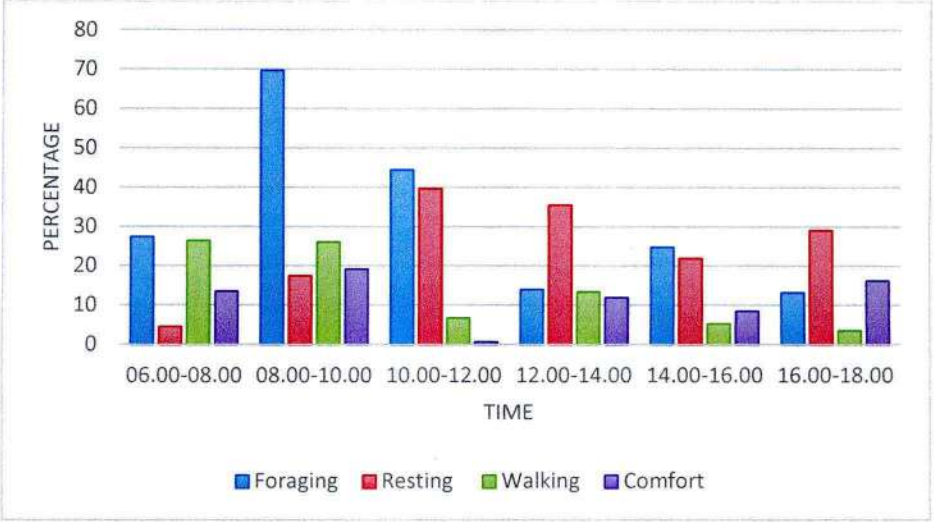

Fig. 8. Activity pattern of Andaman Little Green Heron during Dry Season (February - May)

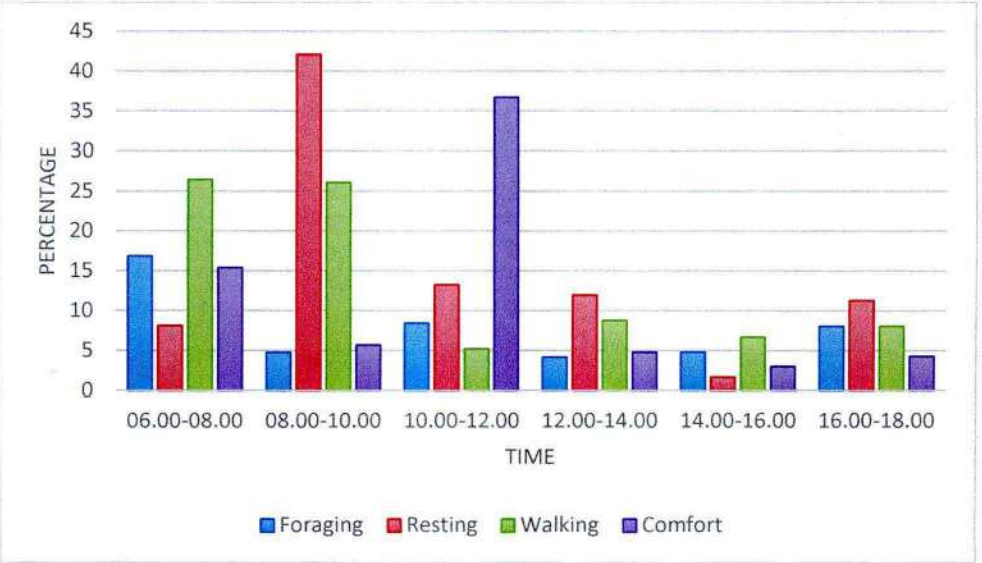

Fig. 9. Activity pattern of Andaman Little Green Heron during Wet-I Season (June - September)

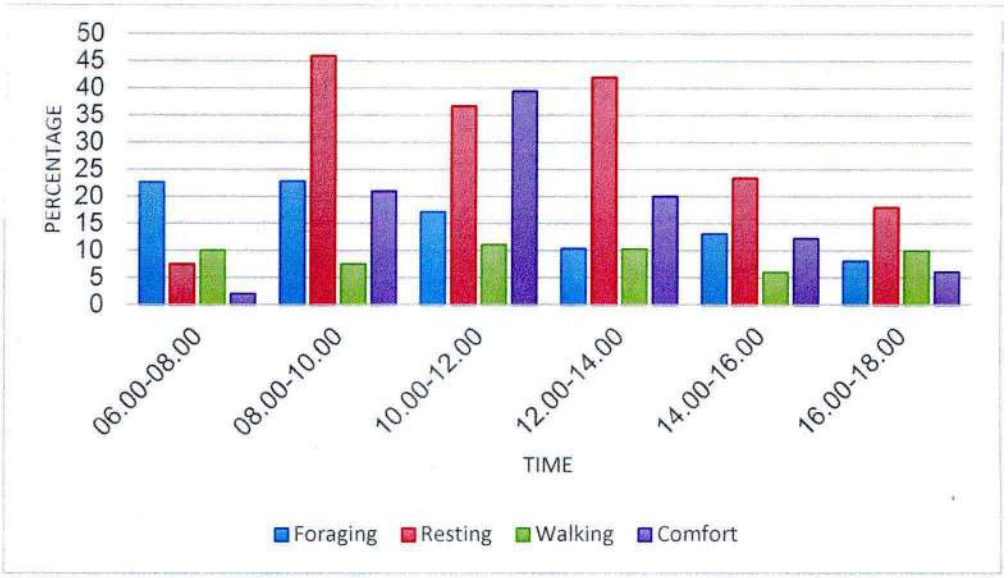

Fig. 10. Activity pattern of Andaman Little Green Heron during Wet-II Season (October - January)

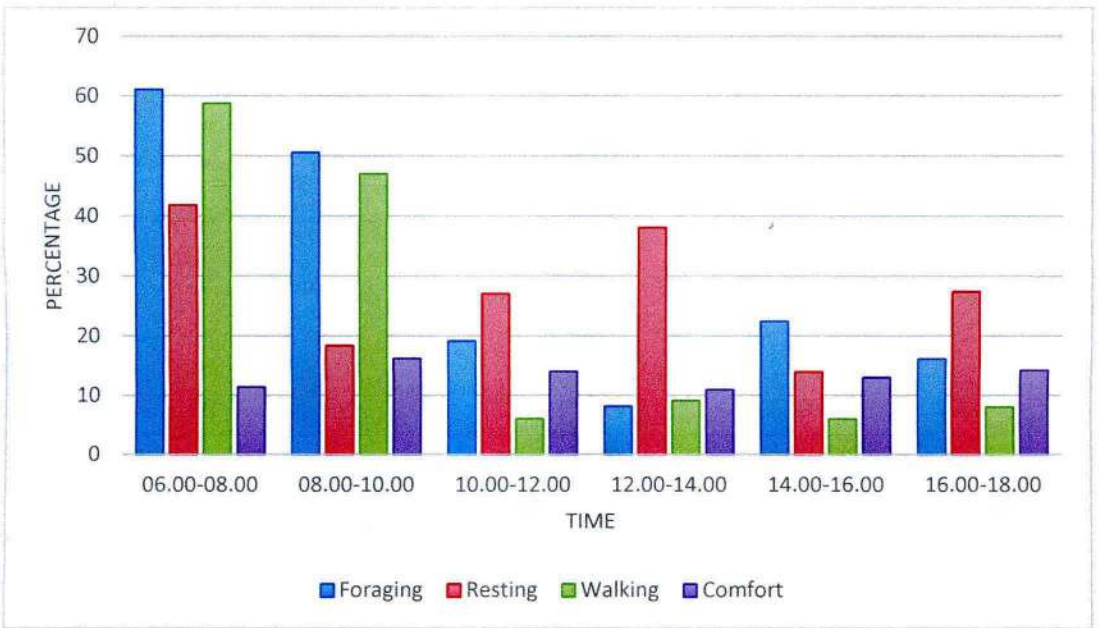

Fig. 11. Activity pattern of Median Egret during Dry Season (February - May)

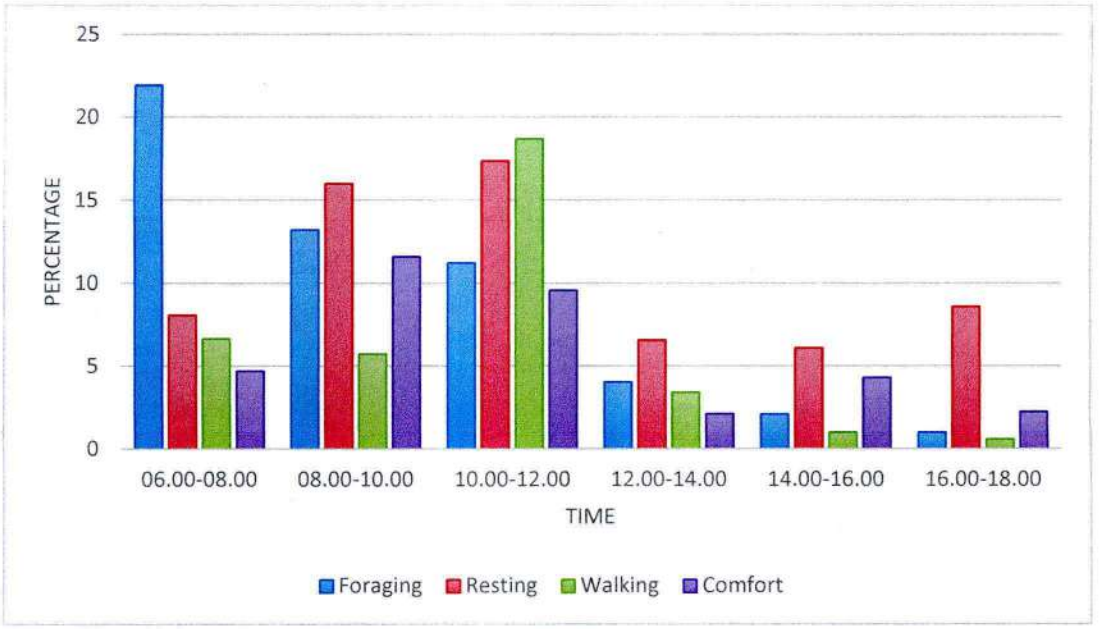

Fig. 12. Activity pattern of Median Egret during Wet-I Season (June - September)

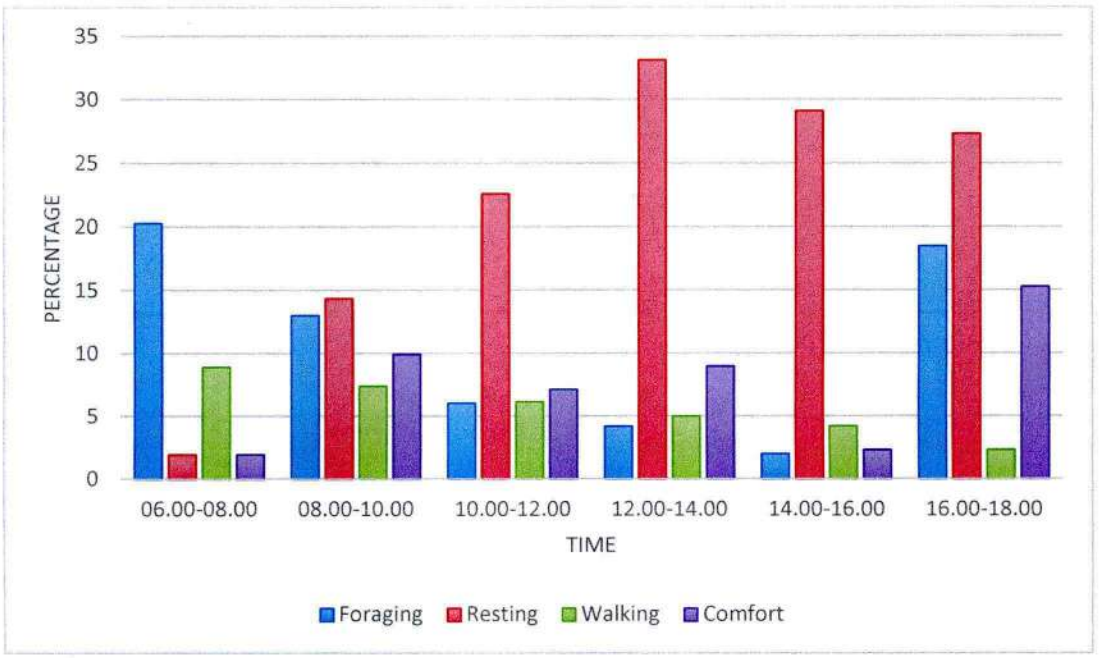

Fig. 13. Activity pattern of Median Egret during Wet-II Season (October - January)

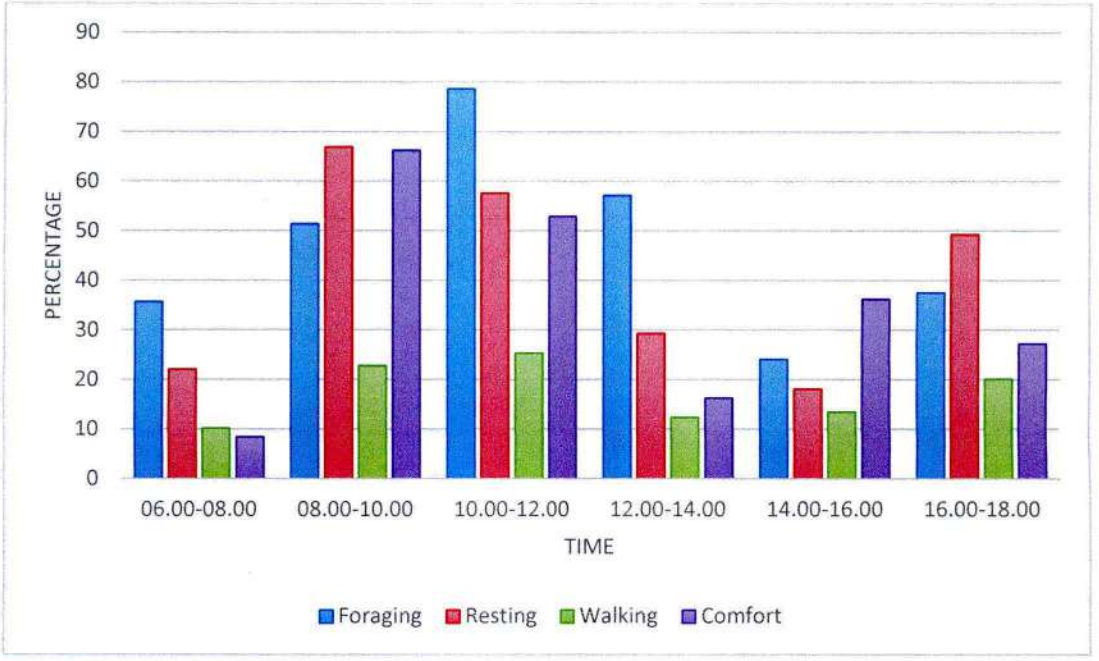

Fig. 14. Activity pattern of Eurasian Curlew during Dry Season (February - May)

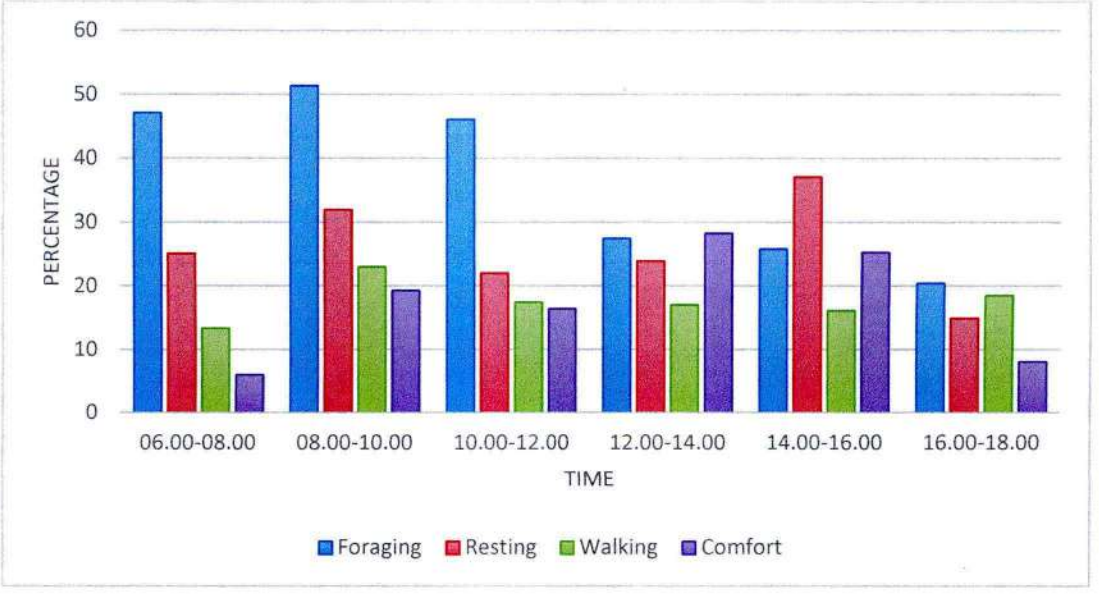

Fig. 15. Activity pattern of Eurasian Curlew during Wet-I Season (June - September)

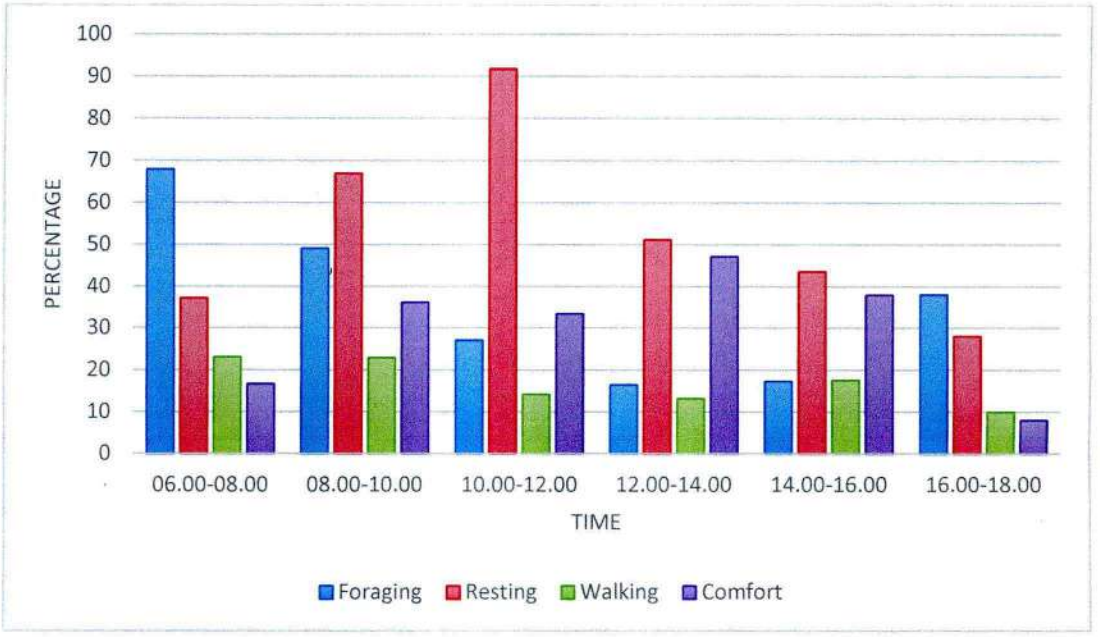

Fig. 16. Activity pattern of Eurasian Curlew during Wet-II Season (October - January)

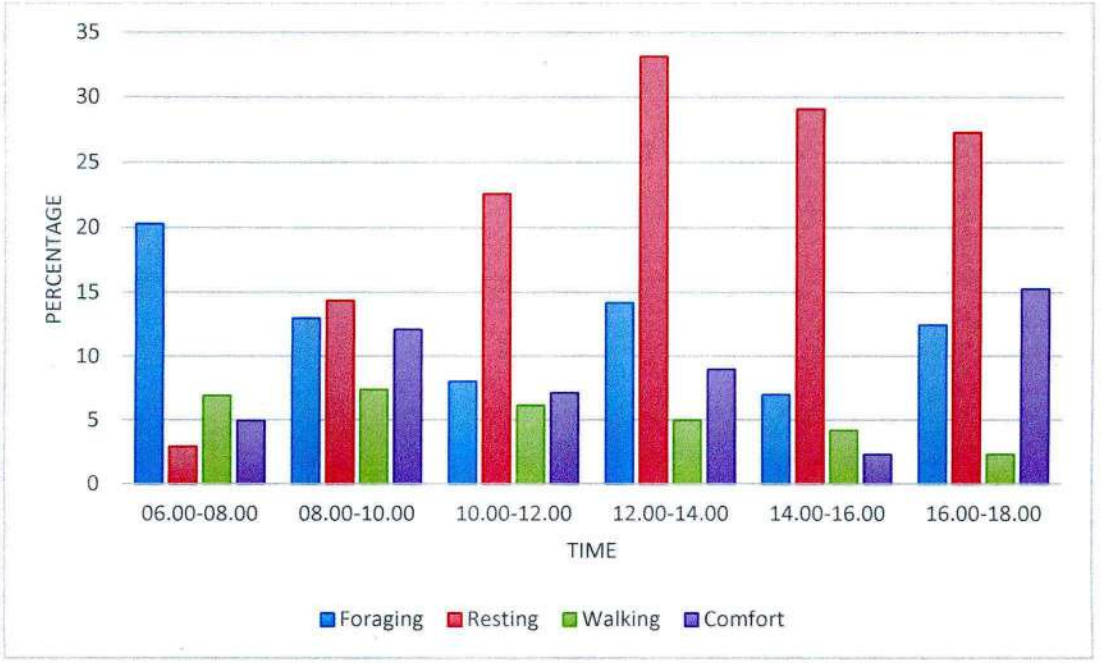

Fig. 17. Activity pattern of Common Redshank during Dry Season (February - May)

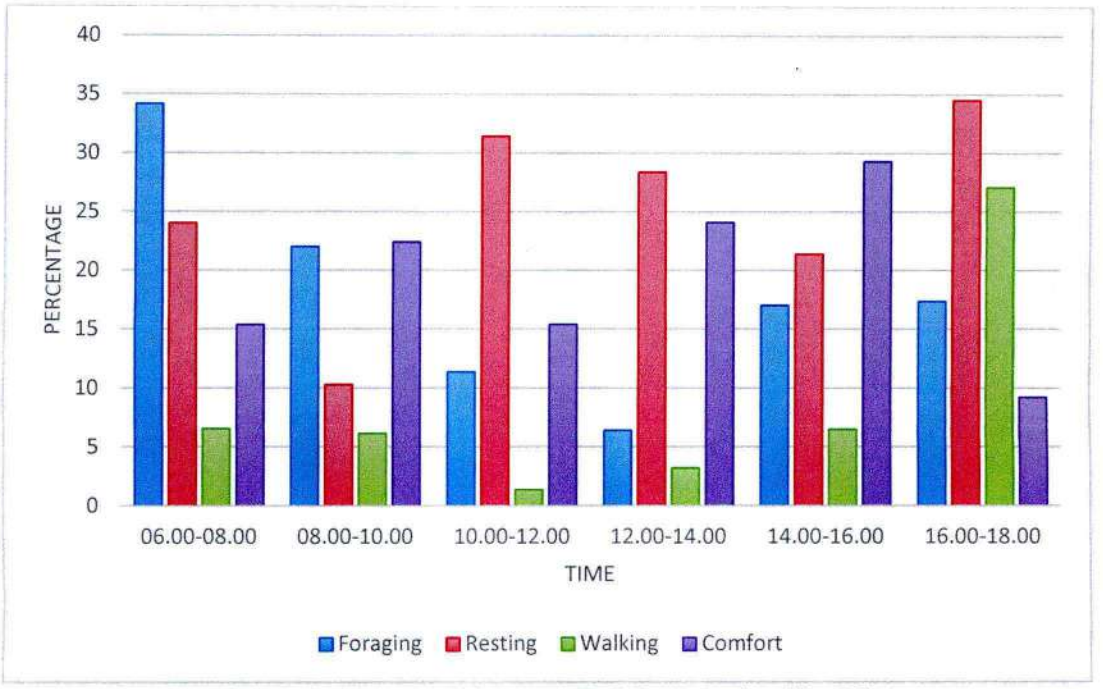

Fig. 18. Activity pattern of Common Redshank during Wet-I Season (June - September)

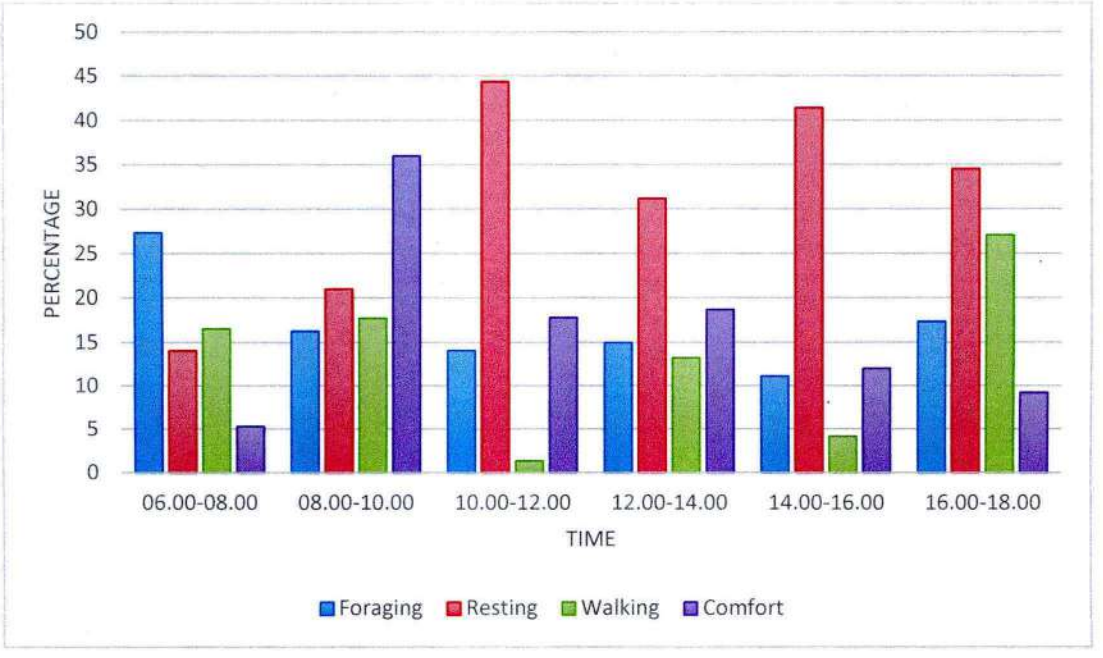

Fig. 19. Activity pattern of Common Redshank during Wet-II Season (October - January)

6. New Observations

During the period of survey eleven species of birds were recorded which are new to Andaman and Nicobar Islands. Of the eleven species **Chinese Egret recorded first time from India and South Asia and Corn Crake was the first photographic record to India**.

6.1. Marsh Sandpiper *Tringa stagnatilis* (Bechstein)

Six individuals of Marsh Sandpiper were recorded in the tsunami inundated wetlands at Chouldhari, South Andaman (Lat.: 11° 37.301' N; Long.: 92° 40.357' E) (Fig. 20) on 5th November 2013, along with a flock of Eurasian Curlew *Numenius arquata* (Linnaeus), Common Redshank *Tringa totanus* (Linnaeus), Pacific Golden Plover *Pluvialia gulva* (Gmelin) and Wood Sandpiper *Tringa glareola* Linnaeus. The Marsh Sandpiper is a true migratory wader and wintering in India, Africa and also parts of Southeast Asia and Australia (Ali and Ripley 1983; Arun Kumar *et al.*, 2005). The Marsh Sandpiper was sighted again on 16th & 18th, November 2013 in the same locality. Review of literature revealed that this species has not been reported from Andaman and Nicobar Islands.

Fig. 20. Marsh Sandpiper *Tringa stagnatilis*

6.2. Black-tailed Godwit *Limosa limosa* (Linnaeus)

Three individuals of Black-tailed Godwit were sighted on 1st October 2013 at Garacharma, South Andaman *(*Lat.: 11° 37.045' N; Long.: 92° 42.366' E*)* (Fig. 21) and again sighted from the same location on 15th, 16th, and 18th November 2013. The Black-tailed Godwit is a winter migrant and widely distributed all over India extending up to Pakistan, Nepal, Bangladesh, Sri Lanka and Maldives (Arun Kumar *et al.*, 2005). According to Ali and Ripley (1983), Tikader (1984), Kumar *et al.* (2005) and Grimmett *et al.* (2008), this species has not been reported this species from Andaman and Nicobar Islands.

Fig. 21. Black-tailed Godwit *Limosa limosa*

6.3. Pheasant-tailed jacana *hydrophasianus chirugus* (Scopoli)

During these surveys four individuals of Pheasant-tailed Jacana (Fig. 22) were recorded in the tsunami inundated wetlands at Sippighat, South Andaman (*Lat.: 11° 36.298' N; Long.: 92° 41.464'E; Lat.: 11° 36.207' N; Long.: 92° 41.477)* on 12th April 2013, along with a flock of Little Egret *Egretta garzetta* (Linnaeus), Median Egret *Mesophoyx intermedia* (Wagler), Common Moorhen *Gallinula chloropus* (Linnaeus), Purple Moorhen *Porphyrio porphyrio* (Linnaeus), Lesser Whistling-Duck *Dendrocygna javanica* (Horsfield) and Cotton Teal *Nettapus coromandelianus* (Gmelin). The Pheasant-tailed Jacana was also sighted again on 18th, 23rd and 30th April 2013 in the same locality. The sighted Pheasant-tailed Jacanas are adult non breeding with Chiefly dull brown and white with a black "necklace" on upper breast

without the long tail. The Pheasant-tailed Jacana is resident, and widely distributed throughout India, breeding in India, Southeast Asia and Indonesia (Ali and Ripley, 1983; Kumar *et al.*, 2005). Review of literature revealed that Ali and Ripley (1983), Tikader (1984) and Kumar *et al.* (2005) have not reported this species from Andaman and Nicobar Islands. The present sighting is the first report of Pheasant-tailed Jacana from South Andaman Islands.

Fig. 22. Pheasant-tailed jacana *hydrophasianus chirugus*

6.4. Glossy Ibis *Plegadis falcinellus* (Linnaeus)

We recorded three individuals of adult male and female Glossy Ibis *Plegadis falcinellus* (Fig. 23) in the tsunami inundated wetlands of south Andaman (Chouldhari; Lat. 11° 37' 18.4" N; Long. 92° 40'21.8" E) on 27th November 2013 along with the flock of Large Egret *Casmerodius albus* and Little Egret *Egretta garzetta.* On 10th August 2014, we sighted a single male at Garacharma, South Andaman (Lat.: 11° 87' 07.5" N; Long.: 92° 42' 24.7" E). The first observed individuals of Glossy Ibis was in non breeding plumage with down curved bill, extend slender neck. The second time sighted individual with breeding plumage, deep chestnut, glossed with purple and green has narrow white surround to bare lores. Literature review revealed that Ali and Ripley (1983), Tikader (1984) and Grimmett

et al. (2008) have not reported this species from this archipelago and the present sighting is the first report from Andaman & Nicobar Islands.

Fig. 23. Glossy Ibis *Plegadis falcinellus* (Linnaeus)

6.5. Black-winged Stilt *Himantopus himantopus* (Linnaeus)

One individual of Black-winged Stilt *Himantopus himantopus* (Fig. 24) was sighted on 6th November 2014, at Ograbraj, South Andaman (Lat.: 11° 39.431' N; Long.: 92° 39.491' E), along with the flock of Pacific Golden-Plover *Pluvialis fulva,* Lesser Sand Plover *Charadrius mongolus*, Whimbrel *Numenius phaeopus*, Common Redshank *Tringa totanus*, Marsh Sandpiper *Tringa stagnatilis*, Wood Sandpiper *Tringa glareola*, Common Sandpiper *Actitis hypoleucos* and Curlew Sandpiper *Calidris ferruginea.* On 14th November 2014 one individual of Black-winged Stilt observed at Chouldhari, South Andaman (Lat. 11° 37' 18.4" N; Long. 92° 40' 21.8" E). According to Arun Kumar *et al.* (2005), it is **a** widespread resident to suitable localities, migrating locally under stress of water conditions throughout India in the marshes tidal areas and freshwater habitats of India. Literature review reveal that Ali and Ripley (1983), Tikader (1984), Arun Kumar *et al.* (2005) and Grimmett *et al.* (2008) not reported this species from Andaman and Nicobar Islands.

Fig. 24. Black-winged Stilt *Himantopus himantopus* (Linnaeus)

6.6. Black-headed Gull *Chroicocephalus ridibundus* Linnaeus

We recorded two individuals of Black-headed Gull *Chroicocephalus ridibundus* Linnaeus (Fig. 25) in the tsunami inundated wetlands of south Andaman (Garacharma; Lat. 11° 37' 107' N; Long. 92° 42'437'E) on 10th March 2015 along with the flock of Pacific Golden-Plover *Pluvialis fulva* (Gmelin), Whimbrel Numenius *phaeopus* (Linnaeus), Common Redshank Tringa *totanus* (Linnaeus), Lesser Sand Plover *Charadrius mongolus* Pallas and Little Egret *Egretta garzetta* (Linnaeus). Literature review revealed that Ali and Ripley (1983), Tikader (1984); Kumar *et al.* (2005), Grimmett *et al.* (2011) and *Rasmussen and Anderton (2012)* have not reported this species from this archipelago and the present sighting is the first report from Andaman & Nicobar Islands.

Fig. 25. Black-headed Gull *Chroicocephalus ridibundus*

6.7. Chinese Egret *Egretta eulophotes* (Swinhoe)

We sighted and photographed four individuals of Chinese Egret *Egretta eulophotes* (Swinhoe, 1860) (Fig. 26) on 17 March 2015 at the tsunami-inundated wetlands at Sippighat, South Andaman (Lat.: 11° 36.749' N; Long.: 92° 41.583' E). The Chinese Egrets were foraging along with a flock of Little Egret *Egretta garzetta*, Large Egret *Casmerodius albus*, Median Egret *Mesophoyx intermedia*, Eurasian Curlew *Numenius arquata* and Whimbrel *Numenius phaeopus*. We confirmed our identification by comparison of our field photographs of Chinese Egret with information in Poole *et al.* (1999) and Robson (2008). Chinese Egret in breeding plumage is distinctive, but is much less so in non-breeding plumage. It can then be difficult to distinguish from white morph Pacific Reef Egret *Egretta sacra*, from which it differs in its yellower, more pointed bill, much longer tibiae, and distinctly more elegant proportions. At least one of the Chinese Egrets (see photographs) we photographed on the Andaman Islands had the long, bushy nape crest diagnostic of this species, and showed other breeding plumage attributes such as bright orange-yellow bill and green facial skin. Another individual photographed lacks the well-developed crest but is similar in size, proportions, and leg and foot coloration to the breeding-plumage bird.

This is the first record of Chinese Egret for the Andaman Islands, India and South Asia. The species might be expected to straggle there in winter, however, as the Andaman Islands are not very far from one of its regular wintering areas in Thailand and the avifauna of the Andaman and Nicobar islands show close affinities with Indo-Myanmar and Indo-Malayan regions (Ripley and Beehler, 1989). The Chinese Egret has been reported previously from islands of the eastern coast of Russia, Philippines, Malaysia, North Korea, South Korea, China, Taiwan, Hong Kong, Thailand, Singapore, Japan, Vietnam, Brunei and Indonesia (Lansdown, 1990; Lansdown *et al.*; 2000; Li *et al.*, 2007; Robson, 2008; BirdLife International, 2015). It is one of the rarest heron species in the world, breeding only in eastern Russia, China, North Korea, and South Korea (Redman, 1993; BirdLife International, 2015). During spring migration this species has been reported from Viet Nam (Pedersen *et al.*, 1998); Sumatra (Silvius, 1991); Java (Andrews, 1993) and the United States (Aleutian and Pribilof Islands) (Hoyer and Smith, 1997). The Chinese Egret generally prefers feeding on intertidal mudflats, often among mangroves, whereas the Pacific Reef Egret feeds mostly on rocky shores or reefs which are influenced by wave action (Poole *et al.*, 1999).

Our finding of four individuals of Chinese Egret in the Andaman Islands suggests that this species may have been over looked in the past due to its strong resemblance to the very common Pacific Reef Egret, as well as to the several other white egret species found in the area. Future observers should carefully identify all white egrets seen to better understand the status of this species in the Andamans.

Fig. 26. Chinese Egret *Egretta eulophotes*

6.8. Ruff *Philomachus pugnax* (Linnaeus)

On 10th September, 2016 while conducting our shore birds survey, GK sighted and photographed an individual of Ruff at Garacharma (11°37.117' N; 92°42.414' E). This bird was again sighted at Chouldhari (11°37.350' N; 92°40.108' E). It was a medium sized wader, different from other waders of our regular sightings. The bird was identified based on the photographs, and taxonomical features using standard field guides (Ali and Ripley, 1983; Kumar *et al.*, 2005; Grimmett *et al.*, 2008; Rasmussen and Anderton, 2012) (Fig. 27). The bird was initially observed to be foraging in small patches of grassy meadows and had a partial breeding plumage. This bird configuration from the accompanying Lesser Sand Plovers; Pacific Golden Plover, Wood Sandpiper, Rufous-necked Stint, Long-toed Stint, Curlew Sandpiper and Common Sandpiper. This is a noted vagrant to archipelagos, with a north–south

migration broadly from Siberia to Australia (Van Giles *et al.,* 2013) and first record of Ruff in the Andaman Islands.

Fig. 27. Ruff *Philomachus pugnax* (Linnaeus, 1758)

6.9. Heuglin's Gull *Larus fuscus* Linnaeus

One individual Heuglin's Gull was sighted on 24th December, 2017 from Katchal, Nancowry group of Islands (07°59.957'N, 93°22.768'E) (Fig. 28). Heuglin's Gull breeds in the northern latitudes, from northern Siberia, the Kola Peninsula eastwards to the Taymyr Peninsula, and winters from south-western Asia to eastern Africa, through the Indian Subcontinent, with records from South Africa, eastern China, South Korea, and a few scattered records from South-east Asia (Rasmussen and Anderton, 2012; Burger *et al.,* 2016). It has been recorded as a passage migrant in the Indian Peninsula (Rasmussen and Anderton 2012), with most birds wintering all along the Indian coasts. Records exist from the Maldives (Ash and Shafeeg, 1994), Sri Lanka (Lamsfuss, 1996), and the Chagos Archipelago (Carr, 2016). According to Ali and Ripley (1983), Rasmussen and Anderton (2012); Grimmett *et al.* (2008). This is the first sighting from this archipelago.

Fig. 28. Heuglin's Gull *Larus fuscus* Linnaeus, 1758

6.10. Grey-headed Lapwing *Vanellus cinereus* (Linnaeus)

On 10th October 2015, three adults Grey-headed Lapwing *Vanellus cinereus* were recorded from the marshland at Govind Nagar, Great Nicobar Island (Lat. 07° 00.242' N; Long. 93° 54.571' E) (Fig. 29). This species is characterized by grey head, yellow bill with black tip, yellow legs, blackish breast and red eyes. They generally prefer marshland for foraging. Grey-headed Lapwing are regular winter visitors to the Andaman group of Islands, however there is no reports from Great Nicobar Island. This species has not been reported from Nicobar group of Islands by previous researchers (Ali and Ripley, 1983; Tikader, 1984; Arun Kumar *et al.*, 2005; Grimmett *et al.*, 2008; Rasmussen and Anderton, 2012). This is the first sighting of *Vanellus cinereus* from Great Nicobar Island.

Fig. 29. Grey-headed Lapwing *Vanellus cinereus* (Linnaeus, 1758)

6.11. Corn Crake *Crex crex*

The Corn Crake breeds in much of Eurasia, and winters in sub-Saharan Africa (BirdLife International 2012). It is considered mostly a fall passage vagrant in the Indian subcontinent, with fall records from Gilgit, Ladakh, and Sri Lanka, and a May record from NW Afghanistan (Rasmussen & Anderton 2012). Other records include those of Prasad (2012) from Tso Moriri Lake and Delaney (2014) from Himalaya. The only record from the Andaman and Nicobar archipelago is based on a single sighting in the Andamans without photographic evidence (Pande *et al.* 2007).

Great Nicobar Island, lying between 6°45'- 7°15' N and 93°38'- 93°55' E, is the southernmost island of the Andaman and Nicobar archipelago. Great Nicobar is 55 km long, from Murray Point in the north to Indira Point in the south. Within the island there are Great Nicobar Biosphere Reserve and two National Parks, Campbell Bay and Galathea. Great Nicobar Island is approximately 1044.54 km^2 in total area, of which 1038.70 km^2 is formed by the biosphere reserve. The island holds unique, threatened evergreen forests, including seasonal rain forests in the low hills and tropical montane forest, as well as moist to dry deciduous forest. Most of its forest is undisturbed, and the island is home to the endangered Nicobar Megapode *Megapodius nicobariensis*. Other important avian species of Great Nicobar include Nicobar Pigeon *Caloenas nicobarica,* Great Nicobar Serpent-Eagle *Spilornis klossi*, Nicobar Scops-owl *Otus alius*, and Nicobar Parakeet *Psittacula caniceps*. In addition, an evidently

undescribed species of rail has been photographed recently on the island (Rajeshkumar *et al.*, 2012).

During fieldwork on the faunal diversity of Great Nicobar Island, CS, GG, and AJ sighted Corn Crake (*Crex crex*) in a marsh at Laxmi Nagar on 9 February 2016 (06° 49.967' N, 93° 53.438' E) at 0730 h. Almost certainly the same individual was relocated and photographed by CS (Fig. 3) on 10 February 2016 at the same location at 1830 h during owl surveys. This is the first record of *Crex crex* from Great Nicobar Island, and the first confirmed record for the Andaman and Nicobar archipelago. Given that this species is normally very difficult to detect when not calling, it seems likely that it remains under reported in South Asia. It has been found numerous times as a vagrant, especially in various Atlantic islands and eastern North America, but also Vietnam and Australia (Taylor 1998). It was recently recorded and photographed for the first time from the South American region, specifically from the island of Fernando de Noronha (de Burgos & Olmos 2013).

Fig. 30. Corn Crake *Crex crex*

7. Discussion and analysis

The number of species recorded from the mangrove ecosystems showed high species richness, which is comparable to other wetlands in India. In the present study, 59 species of wading and shorebirds were recorded, which showed the importance of the area as a wintering ground for migratory species. Among the trans-continental migrants, Bar-tailed Godwit, Great Knot and Whimbrel are apparently capable of long distance flights (Driscoll and Ueta, 2000). The sighting of Chinese Egret from the Andaman Islands was the first record of the species from India and South Asia. Reports on the other species of from this islands shows the importance of the conservation of wetlands. As this wetland is coming under 'East-Asian Australasian Flyway', protection of the migratory species is of highest priority. The wetland lands of Andaman is an ideal habitat for migratory and resident birds, especially for the winter visitors.

Species richness and abundance of birds showed high values in the wetlands and Andaman, which is comparable to other wetlands in Kerala (Kurup, 1996; Jayson and Easa, 2000; Sivaperuman, 2004, Sivaperuman and Jayson, 2010) and in India (Sampath, 1989; Nagarajan and Thiyagesan, 1996). The highest number of birds was recorded during November, December and January, which showed the influx of birds into the region due to the trans-continental migration. Population was low during June to July, when the migratory species were absent. The increase in the species from September to March implies the presence of their preferred microhabitat and higher production of benthic and macro fauna. As reported earlier from the Western Ghats, highest number of birds was recorded during the winter and there was a reduction in population size during the monsoon (Daniels, 1989).

Species richness in an area is dependent on the availability of food, climate evolutionary history and predation pressure. Diversity indices are dependent on two factors, species richness and evenness. It is directly correlated with the stability of the ecosystem. It will be higher in the biologically controlled systems and low in disturbed ecosystem. In the wetlands of Andaman Islands, diversity indices were higher. As the evenness measures also showed high values, it could be concluded that

species of individuals uniformly presented and this indicated the conservation value of the wetlands.

All the wading and shorebirds showed uniform pattern of population fluctuations. Herons and Egrets are recognized as important biological indicators of environmental change in wetlands. Reasons for this recognition include, their position as top carnivores, which can signal changes occurring at lower trophic levels; communal nesting which facilitates sampling of reproductive output; use of human altered landscapes; sensitivity to disturbance and pollution; and dependence on specific hydrologic and hydrographic functions with associated responsiveness to changes in fundamental physical ecosystem characteristics. The wetlands of Andaman is one of the important staging and wintering areas for migratory waterfowl in the East-Asian Australasian Flyway. This region supported waders similar to the known habitats such as Chilika Lake, Pulicate Lake and Great Vedaranyam Swamp.

According to Francklin (1989) long term studies are needed in ecology to understand the population dynamics. Despite a number of such studies on birds, controversy remains as to the nature and role of density dependent and density independent factors in regulating or controlling the population size (Krebs, 1991; Owen and Black, 1991). Density dependence is manifested in a reduced capacity for further increase in numbers as population size grows, and is the mechanism that stabilizes the population, that might otherwise increase or decrease without bounds (Newton, 1998). In recent years, many animal species throughout the world are threatened with extinction or are becoming increasingly endangered due to anthropogenic and other factors. Because of the natural and anthropogenic factors in the habitat, forecasting the effects of habitat degradation or impending global climate change on the dynamics of animal populations, community and biodiversity is of worldwide concern. Such studies are important because naturally occurring levels of biodiversity are critical to preserve, not only because of the potential economic or medical benefits yet to be uncovered, but also because, maintaining biodiversity is synonymous with maintaining an intact ecosystem within which we too live (Soule and Wilcox, 1980; Wilson, 1985).

Availability of microhabitats and various food resources were the determining factors, which controlled the seasonal changes of bird species composition. Species richness and abundance of waders were highest during the migratory season. Increase in the size of bird population in the second and third year could be due to the early exposure of the preferred microhabitat of waders. The peak population of birds was during the migratory season and a decrease was recorded during the non-migratory season, which is comparable with earlier studies (Saikia and Bhattacharjee, 1990b; Nagarajan and Thiyagesan, 1996; Acharya, 2000). Presence of 59 species of wading and shorebirds showed the importance of the wetlands for the trans-continental migratory species. This is comparable to the report of Wood Sandpiper from Gulf of Mannar Marine National Park in small numbers by Balachandran (1995). Abundance of Black-tailed Godwit, Great Knot and Marsh Sandpiper, which is compared to other wetlands of other States (Hoffmann, 1983; Balachandran, 1995; Acharya and Kar, 1996; Verma *et al.*, 2002).

The microhabitat utilisation pattern indicated that each species selected among the available habitats in relation to the foraging efficiency. The habitat utilisation of birds was depending on the abundance of food and habitat structure. The distribution of food is one of the most important factors influencing the selection of feeding sites by birds (Grant and Grant, 1987). Another hypothesis, which explain the foraging habitat selection pattern is that, the behavioural strategies may confine the distribution of birds in relation to features of individual habitat and landscapes. Maintenance of habitat diversity is essential for avian diversity, which requires various water regimes and plant communities. Less appreciated habitats such as the mud flats and the shallow waters proved especially attractive to a great diversity of birds, such as waders. Schoener (1971) suggested that inter specific competition in a habitat results in emigration of birds to species niches in which they will exploit the resources more efficiently than other birds. Such specialization and shifting of niches occur when food resources become scarcity (Holmes and Pitelka, 1968). Distribution of birds in response to change in feeding conditions and difference in food availability in various microhabitats rather than to the density dependent factors mediated through competition.

8. Likely impact of the work on the scientific potential of our country

Changes in climate may be the impact on the wading and shorebirds, the increased temperatures, sea level rise, changes in precipitation, and more frequent or intense extreme events. Climate change will affect individuals and groups differently. Wading birds are particularly sensitive to climate change impacts. Island birds, as well as seabirds, are also highly vulnerable to climate change. Because climate models predict El Nino to become more frequent in the future, climate change is expected to further reduce these small, restricted populations of island ecosystem.

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10. Executive Summary of the Project (Not exceeding 5-6 pages)

Wading and Shorebirds was studied from December 2015 – December 2017 to understand the structure, species composition and distribution. Fifty nine taxa of birds were recorded. Of these, fourteen species were Egrets and Herons, one species Ibis, 36 species were shorebirds and nine species of gulls & terns. The sighting of the Chinese Egret, Corn Crake was the first record from India and South Asia. The wetlands of Andaman Islands is an ideal habitat for migratory and resident birds, especially for the winter visitors. Species richness and abundance of birds showed high values, which is comparable to other wetlands in India. Species richness of avifauna varied in different months and the highest was recorded in December, and the lowest in June. Species richness increased during the migratory season and decreased during the southwest monsoon. The variation of the abundance in different months and the intensive study area showed the availability of microhabitats.

Presence of 59 species of wading and shorebirds showed the importance of the wetlands for the migratory birds. This region supported waders similar to the known habitats such as Chilika Lake, Pulicate Lake, Gulf of Mannar and Great Vedaranyam Swamp. Species richness and abundance of waders were maximum during the migratory season. Increase in the bird population during the second and third year was due to the early exposure of the preferred microhabitat of waders. The highest number of birds was recorded during November of all the three years, which showed the influx of birds into the region due to trans-continental migration. Abundance of Black-tailed Godwit, Great Knot and Marsh Sandpiper was high which is compared to the other wetlands of India.

During the migratory season, this islands supported more waders than the other sites in terms of species richness and abundance of birds. The area served many avian species for a wide variety of purposes such as nesting, roosting and wintering ground. Mud flats greatly influence the distribution and abundance of soil organisms and mud flats were good site for foraging due to the availability of prey. The study indicated a strong positive correlation between abundance of waders and benthic fauna. Waders fed on a wide variety of groups such as Insecta, Crustacea, Gastropoda and Polychaeta and the abundance of Curlew Sandpiper is closely related to Insecta

and Crustacea. The variation in the species richness, diversity and density of birds in different microhabitats were clear indication of their habitat preference. The appearance of mud flats attracted large number of waders during the migratory season. The distribution of birds depended on the abundance of food and habitat structure.

Important conservation problems identified from the area were habitat alteration, poaching, fire and fishing. The wetlands of south Andaman were reclaimed for various purposes like raising for constructing buildings. As this wetlands are serving as "Stepping stone" for the trans-continental migrants, urgent measures are needed to protect this wetland ecosystem for the conservation of migratory birds. As this wetland is coming under the 'East-Asian Australasian Flyway' protection of migratory bird species is of the highest priority.

PART - III

1. Recommendation including remedial measures relevant to the environmental problems studies under the scheme

Conservation of Habitat

Based on the study following action plan for the conservation of birds and tsunami inundated wetlands is suggested.

- All the development activities, which have a bearing on the wetland ecosystem should be regulated, screened, and monitored.
- Strict protection for birds in the wetlands should be enforced. Active patrolling should be carried out by involving the forest department in different locations of wetlands
- Specific projects and programme for the conservation of the wetland ecosystem of south Andaman should be initiated.
- Plans and proposals that concern the future of the wetland ecosystem of south Andaman should be evaluated in a holistic way.
- Warning boards showing details of punishment for poaching of birds and other animals should be displayed.
- Huge quantity of waste materials were dumped at Ograbraj, Stewartgunj areas. Waste materials deposited in the lake include hardened cement bags, polythene bags and floating materials. Efforts may be initiated to control the dumping of waste materials to this sites are there are the prominent site of migratory birds.
- Declaration of wetlands of south Andaman into community reserves in order to protect the migratory water birds.
- Deforestation of mangroves to be stopped and restoration of the same should be executed.

Research and Monitoring

- Annual water bird surveys should be undertaken in association with Zoological Survey of India, Port Blair.

- Research on migration strategies of water birds should be carried out.

Education, Information and Awareness

- Awareness camps on the importance of migratory birds coming to the wetlands should be conducted. Local people near by the wetlands should be given preference for attending the Nature education camp
- Mass awareness should be created and an Interpretation Centre in South Andaman
- Information on the birds visiting the area can be displayed as lists and charts with photographs.
- A watch tower can be built for observing the birds with telescopes. By doing this people coming to the region can watch the birds without much disturbance to the birds.
- An information bulletin should be prepared on the wetlands of south Andaman and migratory birds coming to the locality.

2. List of research papers published/accepted in journals / patent the research work done under the scheme

Book:

1. Sivaperuman, C., G. Gokulakrishnan, J. Dinesh and P.T. Rajan 2016. Birds of Andaman & Nicobar Islands, Zoological Survey of India, Kolkata. 106 p.

Journal:

2. Sivaperuman, C., C. Venkatraman G. Gokulakrishnan, and J. Dinesh 2016. Species Abundance and Distribution of Coastal and Marine Bird of India. *Vegetos* 29(Species): 89-95.
3. Sivaperuman, C., G. Gokulakrishnan, J. Dinesh and K. Venkataraman 2015. New record of Ferruginous Pochard *Aythra nyroca* (Guldenstadt, 1770) from A & N Islands. *J. Bombay Nat. Hist. Soc*. 112(1): 4-5
4. Sivaperuman, C., C. Venkatraman, G. Gokulakrishnan and J. Dinesh 2015. Diversity of coastal birds and their ecological significance in India. In: Lesser Known Marine Animals of India, (Eds.) Venkataraman *et al.* Zoological Survey of India, Kolkata. pp. 536-550.
5. Sivaperuman, C., P. Viswakannan, G. Gokulakrishnan and J. Dinesh, 2015. Avifaunal diversity in the proposed canopy Walkway at Chidiyatappu Biological Park, South Andaman. In: National seminar on Harmonizing Biodiversity and Climate Change: Challenges and

Opportunity. (Eds.) S. Dam Roy, A.K.Singh, B. Gangaiah, P.M. Mohan, A. Velmurugan, I. Jaisankar, T.P. Swarnam, Jai Sunder, S.K. Zamir Ahmed, Venkatesh R. Thakur and K. Saravanan. ICAR-Central Agricultural Research Institute. pp. 71.

6. Sivaperuman, C., J. Dinesh, G. Gokulakrishnan and K. Venkataraman 2015. Endemic avifauna of Nicobar Islands with special reference to Great Nicobar Biosphere Reserve. In: National seminar on Harmonizing Biodiversity and Climate Change: Challenges and Opportunity. (Eds.) S. Dam Roy, A.K.Singh, B. Gangaiah, P.M. Mohan, A. Velmurugan, I. Jaisankar, T.P. Swarnam, Jai Sunder, S.K. Zamir Ahmed, Venkatesh R. Thakur and K. Saravanan. ICAR-Central Agricultural Research Institute, Port Blair. pp. 71.
7. Sivaperuman, C, G. Gokulakrishnan, J. Dinesh and K. Venkataraman 2015 Three new sighting of birds from Andaman & Nicobar archipelago. *BirdingAsia* 24: 141-142.
8. Sivaperuman, C, G. Gokulakrishnan, J. Dinesh and K. Venkataraman 2015 Three new sighting of birds from Andaman & Nicobar archipelago. *BirdingAsia* 24: 141-142
9. Sivaperuman, C., Gokulakrishnan, J. Dinesh and P.C. Rasmussen 2016. Chinese Egret *Egretta eulophotes* on the Andaman and Nicobar Islands: the first record for India. *BirdingASIA* 25: 108-109.
10. Sivaperuman, C., Gokulakrishnan, P.C. Rasmussen and A. Jabestin 2016. First record of Corn Crake *Crex crex* from Great Nicobar Island, India. *BirdingASIA 25: 128.*
11. Sivaperuman, C., P. Naveen Kumar and G. Gokulakrishnan 2015. Sighting of Common Black-headed Gull *Chroicocephalus ridibundus* Linnaeus, and Wedge-tailed Shearwater *Ardenna pacifica* (Gmelin) from South Andaman, Andaman & Nicobar Island, India. *J. Bombay Nat. Hist. Soc.*, 112(2): 95-96
12. Sivaperuman, C., P. *Naveen Kumar*, G. Gokulakrishnan, and J. Dinesh 2015. Sighting of Black Headed Gull *Chroicocephalus ridibundus* Linnaeus, 1766 & *Wedge-tailed Shearwater Puffinus pacificus* Gmelin, 1789 from south Andaman. *J. Bombay Nat. Hist. Soc.* 112(2): 95-96.
13. Sivaperuman, C. and G. Gokulakrishnan 2017. Eight new records of birds from Great Nicobar Islands, Andaman and Nicobar Islands. *Rec. Zool. Surv. India* 117(1): 73-77.
14. Venkatraman, C., C. Sivaperuman, G. Maheswaran and G. Gokulakrishnan. Avifauna of Mangrove ecosystem in India. In: Faunal of Mangrove ecosystem in India. Zoological Survey of India.

Photographs of study area & study species

Fig. 31. View of mudflat at Sippighat, South Andaman

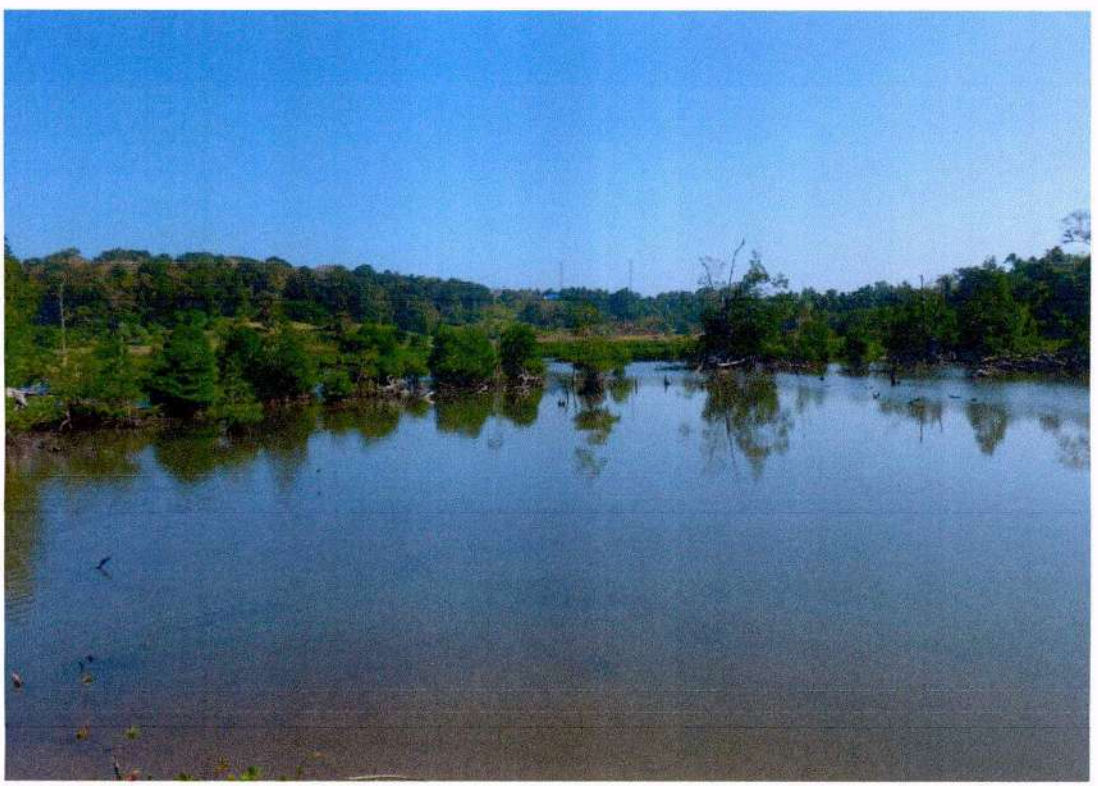


Fig. 32. View of Shallow Water habitat at Lohabarrake, South Andaman

Fig. 33. View of Mangrove Creek of Yeratta, Middle Andaman

Fig. 34. Water Edge of North Passage island, Middle Andaman

Fig. 35 habitats: Rocky Shore view of North Andaman (Kalipur)

Fig. 36. View of Coral Rubble of Brush Islands, North Andaman

Large Egret *Casmerodius albus*

Little Egret *Egretta garzetta*

Pacific Reef-Egret *Egretta sacra*

Purple Heron *Ardea purpurea*

Chinese Pond-Heron *Ardeo labacchus*

Yellow Bittern *Ixobrychus sinensis*

Plate 1. Wading birds of Andaman Islands

Black-winged Stilt *Himantopus himantopus*

Pintail Snipe *Gallina gostenura*

Greater Sand Plover *Charadrius leschenaultii*

Ruddy Turnstone *Arenaria interpres*

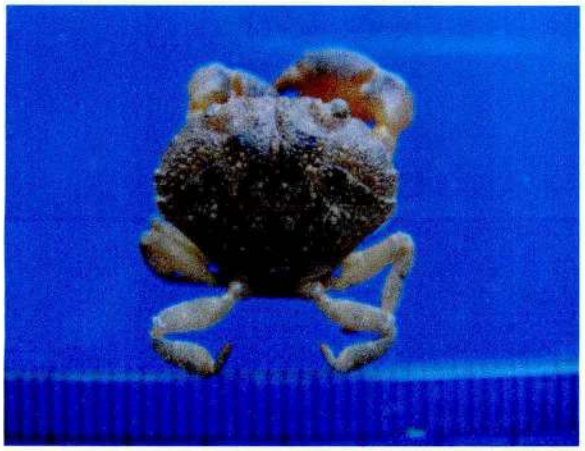
Long-toed Stint *Ereunetes subminutus*

Rufous-necked Stint *Ereunetes ruficollis*

Plate 2. Shore birds of Andaman Islands

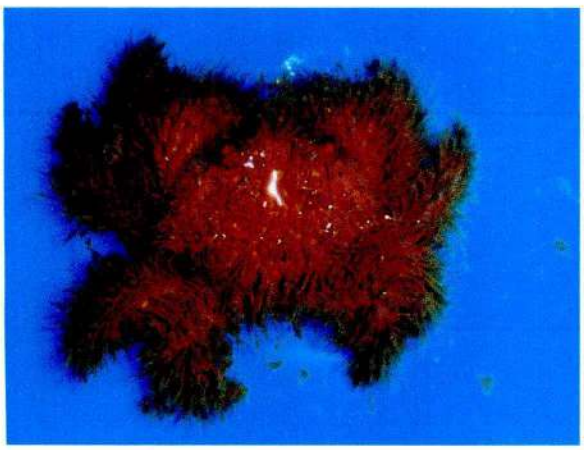
Plate 3. Shore birds of Andaman Islands

a - Common Greenshank, b - Lesser Sand Plover, c - Common Redshank, d - Pacific Golden-Plover, e - Common Sandpiper, f - Eurasian Whimbrel



Epixanthus frontalis (H. Milne Edwards)

Metasesarma obesum (Dana, 1851)



Pilumnus vespertilio (Fabricius, 1793)

Uca tetragonon (Herbst, 1790)

Portunus pelagicus (Linnaeus, 1758)

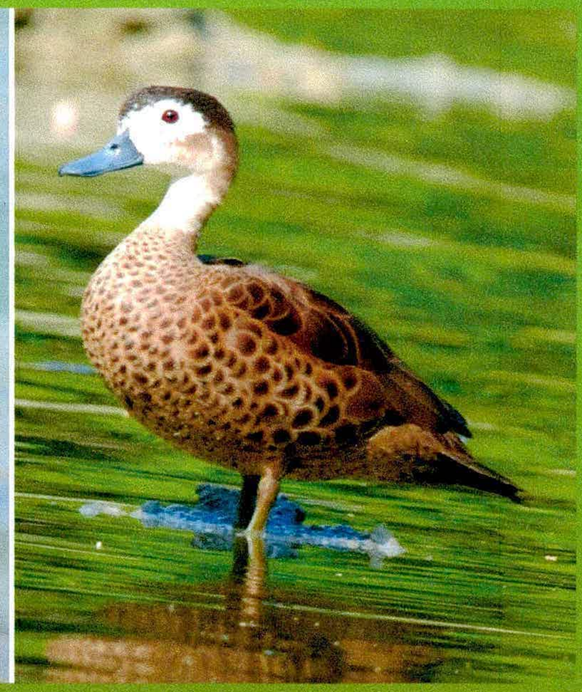
Portunus sanguinolentus (Herbst, 1783)

Plate 3. Mangrove crabs recorded during the period of the study

BIRDS

of

Andaman and Nicobar Islands



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ZOOLOGICAL SURVEY OF INDIA

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Chinese Egret *Egretta eulophotes* on the Andaman and Nicobar Islands: the first record for India

C. SIVAPERUMAN, G. GOKULAKRISHNAN, J. DINESH & P. C. RASMUSSEN

The Andaman and Nicobar Islands are known for their rich biodiversity, with Sivaperuman *et al.* (2010) reporting 284 avian species from the islands. We have been carrying out regular surveys of wetland bird communities on the Andaman Islands since 2012, and 16 further species have been recorded there for the first time (Sivaperuman *et al.* 2012, 2013, 2014a, b, 2015).

On 17 March 2015, CS, GG and JD observed four unusual egrets in the tsunami-inundated wetlands at Sippighat, South Andaman (11.612°N 92.693°E) foraging together with a flock of other egrets and shorebirds. Images were obtained and subsequently studied by all the authors when it was agreed that the birds were the Vulnerable Chinese Egrets *Egretta*

Plates 1 & 2. Chinese Egret *Egretta eulophotes*, Sippighat, South Andaman, India, 17 March 2015.

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eulophotes (BirdLife International 2015). The Chinese Egret in breeding plumage is distinctive, but much less so in non-breeding plumage, when it can be difficult to distinguish from white morph Pacific Reef Egret *E. sacra*, from which it differs in its yellower, more pointed bill, much longer tibiae and distinctly more elegant proportions. The Chinese Egret generally prefers to feed on intertidal mudflats, often among mangroves, whereas Pacific Reef Egret feeds mostly on rocky shores or reefs which are influenced by wave action. At least one of the Chinese Egrets at Sippighat had the long, bushy nape-crest diagnostic of the species, and showed other breeding plumage characters such as a bright orange-yellow bill and green facial skin (Plates 1 & 2). Another individual lacked the well-developed crest but was similar in size, proportions and leg and foot colouration to the bird in breeding plumage (Poole *et al.* 1999, Robson 2008).

This is the first record of Chinese Egret in the Andaman Islands, India and South Asia. However, the species might be expected to straggle there in winter, as the Andamans are not far from one of its regular wintering areas in Thailand, and the avifauna here shows close affinities with the Indo-Myanmar and Indo-Malay regions (Ripley & Beehler 1989). It is one of the rarest heron species in the world, breeding only in eastern Russia, China and the Korean peninsula (BirdLife International 2015), although wintering birds have been reported previously from many parts of East and South-East Asia.

The finding of four Chinese Egrets on the Andaman Islands suggests that the species may have been overlooked in the past, perhaps due to its strong resemblance to the very common Pacific Reef Egret, as well as to the several other egret species found in the area. Observers should carefully identify all white egrets seen in the Andaman and Nicobar Islands to better understand the status of the species in this area.

Plate 3. Chinese Egret observed at the same location, 23 January 2016.

C. SIVAPERUMAN

Postscript

The birds were not seen again in spring 2015. However, during winter 2015–2016, three individuals were seen at the same location on South Andaman Island on 22 and 23 January 2016 and further images obtained (Plate 3). It appears that the species may indeed be a previously overlooked regular winter visitor.

Acknowledgements

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Eight new records of birds from Great Nicobar Island, Andaman & Nicobar Islands

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Abstract

Great Nicobar Island is the largest island in the Nicobar group and this is the southernmost islands of this archipelago. The regular field surveys have been carried out as the major ecological studies on bird communities of this island. Recently, eight birds were sighted from this island which is first report to the Nicobar group of Islands.

Keywords: Avifauna, Distribution, Great Nicobar, New Record

The Great Nicobar Island is the southernmost Island of Andaman & Nicobar archipelago and lies between 6° 45' and 7° 15' N latitudes and 93° 38' and 93° 55' E longitudes. The Great Nicobar Island includes, Great Nicobar Biosphere Reserve, Campbell Bay National Park, Galathea National Park, Galathea Bay Wildlife Sanctuary and Megapode Island Wildlife Sanctuary. The total geographical area of this island is approximately 1044.54 km^2, of which the Biosphere Reserve consists of 1038.70 km^2 (UNESCO, 2013). The island is represented by tropical evergreen forest ecosystem including a host of forest system, ranging from seasonal rain forests in the low hills, tropical mountain forests and moist deciduous to dry deciduous forest. The Great Nicobar Island is located about 482 km south of Port Blair, the capital of the Union Territory. The length of this island is 55 km from Murray Point in the North to Indira Point in the South. This island has a rich heritage of faunal diversity and this area also inhabits one of the most endangered avian species Nicobar Megapode *Megapodius nicobariensis* (Sankaran, 1998).

The scientific studies on the birds in the Andaman and Nicobar islands have been initiated by Blyth (1845, 1846, 1863 and 1866) followed by Beavan (1867), Hume (1873, 1874a, 1874b, 1876), Butler (1899a, 1899b, 1899c, 1900). Followed by Abdulali, (1964, 1965, 1967, 1971, 1976, 1979, and 1981); Das, (1971); Tikader, (1984); Chandra and Rajan, (1996); Pande *et al.* (2007); Sankaran, 1995a, 1995b, 1995c, 1998), Sankaran, 2001. Recently, a number of research studies have been carried out on different aspects on the avifauna of these islands (Sivakumar, 2003, Yahya and Zaarri, 2003, Sivakumar and Sankaran, 2005a,b, Vijayan, 2007, Rasmussen and Anderton, 2012). Sivaperuman *et al.* (2010) reported 284 species of birds from the Andaman and Nicobar Islands, and since then sixteen species of birds have been reported by him and co-workers for the first time from this archipelago (Sivaperuman *et al.*, 2012; 2013; 2014a,b; 2015a-c). As a part of survey programme of faunal communities of Nicobar groups of Islands, we have carried out field survey in Great Nicobar Island, during the exploration eight species of birds were sighted from Great Nicobar Island which is first report to Nicobar group of Islands.

Vanellus cinereus

Grey-headed Lapwing (Linnaeus, 1758)

On 10th October 2015, three adults Grey-headed Lapwing *Vanellus cinereus* were recorded from the marshland at Govind Nagar, Great Nicobar Island (Lat. 07° 00.242' N; Long. 93° 54.571' E) (Figure 1). This species is characterized by grey head, yellow bill with black tip, yellow legs, blackish breast and red eyes. They generally prefer marshland for foraging. Grey-headed Lapwing are regular winter visitors to the Andaman group of Islands, however there is no reports from Great Nicobar Island. This species has not been reported from Nicobar group of Islands by previous researchers (Ali and Ripley, 1983;

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Tikader, 1984; Kumar *et al.*, 2005; Grimmett *et al.*, 2008; Rasmussen and Anderton, 2012). This is the first sighting of *Vanellus cinereus* from Great Nicobar Island.

Figure 1. Grey-headed Lapwing *Vanellus cinereus* (Linnaeus, 1758).

Dendronanthus indicus
Forest Wagtail (Gmelin, 1789)

On 12th October 2015, a single individual of Forest Wagtail *Dendronanthus indicus* was recorded from East-West Road of *Great Nicobar* Biosphere Reserve (Lat. 06° 59.923' N; Long. 93° 52.676' E) (Figure 2). This species is a typical evergreen forest dweller is characterized by pink legs, black breast, olive upper plumage and white under parts. This is the first sighting from the Great Nicobar Island and this has not been reported from Nicobar group of Islands (Ali and Ripley, 1983; Kumar *et al.*, 2005; Grimmett *et al.*, 2008; Rasmussen and Anderton, 2012).

Figure 2. Forest Wagtail *Dendronanthus indicus* (Gmelin, 1789).

Tringa glareola
Wood Sandpiper Linnaeus, 1758

Two individuals of *Tringa glareola* were sighted on 08th October 2015 from INS Baaz Airport, Campbell Bay (Lat. 07° 00.850' N; Long. 93° 52.435' E). This species generally prefers mudflats and shallow water and common winter visitor of Andaman group of islands. It is characterized by a long and straight bill, broad whitish supercilium, pale brown with white spots, white belly, greenish legs and a bold black tail (Figure 3). This is a new distributional record to the Nicobar group of Islands (Ali and Ripley, 1983; Kumar *et al.*, 2005; Grimmett *et al.*, 2008; Rasmussen and Anderton, 2012).

Figure 3. Wood Sandpiper *Tringa glareola* Linnaeus.

Egretta alba
Great Egret (Linnaeus, 1758)

Four individuals of Large Egret *Egretta alba* were sighted at Gandhi Nagar in Great Nicobar Island (Lat. 06° 50.334' N; Long. 93° 53.656' E) on 21st June 2015 (Figure 4). These are resident birds of the Andaman Islands with local migration but this has not been reported from the Nicobar group of Islands. These birds are characterized by their typical white plumage, long yellow bill, blue lores, flat forehead and long, black legs. Ali and Ripley (1983); Kumar *et al.*, (2005), Grimmett *et al.* (2008), Rasmussen and Anderton (2012) have not reported this species from Nicobar group of Islands.

Figure 4. Great Egret *Egretta alba* (Linnaeus).

Gallirallus striatus nicobariensis
Blue-breasted Rail Abdulali, 1967

One individual of Blue-Breasted Rail was recorded from Campbell Bay in Great Nicobar Island (Lat. 07°00.850' N; Long. 93°52.435 E) on 27th March 2016 from the flooded grasslands (Figure 5). These are resident birds of the Central Nicobar group of Islands this has not been sighted in the Southern group of Nicobar Islands. These birds are characterized by their darker, broader whitish bar, iris are greyish brown; blackish bill, legs and feet dark brown and larger. Ali and Ripley (1983), Grimmett *et al.* (2008), Rasmussen and Anderton (2012) not reported this species from this Island.

Figure 5. Nicobar Blue-Breasted Rail *Gallirallus striatus nicobariensis* Abdulali.

Eurystomus orientalis gigas
Dollar Bird Stesemann, 1913

On 24th March 2016 one individual of Broad-billed Roller perched on top of tree branch was sighted at East West Road, Great Nicobar Biosphere Reserve (06°59.468 N; 93°52.310 E) (Figure 6). This species has not been reported from the Great Nicobar Islands by previous workers Ali & Ripley (1983), Grimmett *et al.* (2008), Rasmussen & Anderton (2012).

Figure 6. Broad-billed Roller Eurystomus orientalis gigas Stesemann.

Saxicola stejnegeri
Common Stonechat (Linnaeus, 1766)

On 20th February 2016, while we were surveying INS BAAZ, Airport, Campbell Bay (07°00.850'N, 93°52.435'E), one individual of Common Stonechat was sighted. This is a regular winter visitor to Andaman Islands. However this species not reported by the previous researchers (Ali & Ripley, 1983; Grimmett *et al.*, 2008; Rasmussen & Anderton, 2012).

Figure 7. Common Stonechat *Saxicola stejnegeri* (Linnaeus, 1766).

Sturnus roseus
Rosy Starling (Linnaeus, 1758)

Single individual of Rosy Starling was sighted on 07 February 2016 on the Sastri Nagar of Great Nicobar Island (06°51.582'N, 93°53.318'E). This individual was resting on electric wire and characterized by head, throat and tail glossy black tail, yellowish beak, and pink legs (Figure 8). This species is a new distribution record to the Nicobar group of Islands (Ali and Ripley 1983; Grimmett *et al.*, 2008; Rasmussen and Anderton, 2012).

Figure 8. Rosy Starling *Sturnus roseus* (Linnaeus 1758).

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3. INDIAN BLACK IBIS *PSEUDIBIS PAPILLOSA* FEEDING ON CARRION

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The Indian Black Ibis *Pseudibis papillosa* is endemic to the Indian subcontinent and occurs in various habitats from desert to wetlands from south-east Sind, eastwards to Bangladesh and southwards, especially along the eastern Peninsula (Manakadan *et al.* 2011). It is reported to feed on a varied diet, ranging from frogs, small fish, earthworms, lizards, small snakes, scorpions, crustaceans, grain beetles, and other insects (Ali and Ripley 1987).

During a BNHS camp at Rajasthan, two birds were spotted at the Jor Beed carcass dump near Bikaner (27° 57′ 57″ N; 73° 22′ 43″ E). They seemed to be pecking at carcasses, and were spending a considerable amount of time at each spot. On observing with a spotting scope, it was seen that the birds were not feeding on the maggots, as presumed, but were tearing small pieces of flesh from the carcass, and feeding on it. The birds spent around 10–15 minutes on each carcass before moving on to the next. This is possibly the first record of the species feeding on carrion.

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4. NEW RECORD OF FERRUGINOUS POCHARD *AYTHYA NYROCA* (GÜLDENSTÄDT, 1770) FROM ANDAMAN & NICOBAR ISLANDS, INDIA

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The Andaman & Nicobar archipelago comprises 572 islands, islets, and rocky outcrops extending over 800 km and running north to south between 6° 45′–13°30′ N and 90° 20′–93° 56′ E with an area of 8,249 sq. km. The Andaman & Nicobar Islands can be broadly divided into two groups, namely the Andamans and the Nicobars. These two groups are separated by the ten-degree channel, which is about 150 km wide and 400 fathoms deep. Average annual temperature varies from 24° to 28° C and the rainfall is slightly higher in Nicobar, with an annual average of 3,000 to 3,500 mm. The elevations range from sea level to 732 m at Saddle Peak in North Andaman and 642 m at Mount Thulier in Great Nicobar Island, Nicobar group. The study on avifauna of Andaman & Nicobar Islands were initiated by Beavan (1867) listing the avifauna of Andaman Islands, followed by Hume (1873, 1874a,b, 1876), and Abdulali (1964, 1965, 1967, 1971, 1978, 1981). Recently, a few researchers contributed to the avifauna of Andaman & Nicobar Islands (Chandra and Kumar 1994; Chandra and Rajan 1994; Ezhilarasi and Vijayan 2006; Pande *et al.* 2007; Sankaran 1995, 1998, 2001; Sankaran and Vijayan 1993; Sivakumar 2007; Sivakumar and Sankaran 2002; Sivaperuman *et al.* 2010, 2012, 2013, 2014; Tikader 1984; Vijayan 1996, 2007; Yahya and Zarri 2003; Yoganand and Davidar 2000).

As a part of major ecological studies on wetland birds in south Andaman initiated during 2012, supported by the Science Engineering Research Board (SERB), Ministry of Science & Technology, and INS Utkrosh, Ministry of Defence, Government of India, we have been surveying the tsunami inundated wetlands of South Andaman to assess wetland bird communities. During these surveys a pair of Ferruginous Duck *Aythya nyroca* (Güldenstädt) was recorded at Sippighat, South Andaman (11° 36.230′ N; 92° 41.435′ E) on December 17, 2014, along with a flock of Lesser Whistling Teal *Dendrocygna*

javanica, Purple Moorhen *Porphyrio porphyrio*, Cotton Teal *Nettapus coromandelianus*, and Common Moorhen *Gallinula chloropus*. The Ferruginous Duck was sighted again on December 19 and 21, 2014, in the same location. The tsunami inundated wetlands in South Andaman have attracted larger numbers of waterbirds during these years; as a result the authors recently reported many new sightings of migratory birds from this region (Sivaperuman *et al.* 2012, 2013, 2014).

The Ferruginous Duck sighted were adult male and female. The head, neck and breast of male was deep chestnut while female had dull reddish head, neck and breast. According to Ali and Ripley (1983) and Arun Kumar *et al.* (2005), this species is common in North India, Pakistan, Nepal, Bhutan, Bangladesh, Sri Lanka, and Maldives. It breeds in Central Asia to Western China and Western Mongolia, Kashmir Valley and Ladakh in India, central and eastern Europe, and north Africa (Arun Kumar *et al.* 2005; Vinicombe 2000). The Ferruginous Duck is listed as Near Threatened (NT) in the IUCN Red List (BirdLife International 2012) and also listed in the Appendices I and II of the Convention on Migratory Species (CMS or Bonn Convention). Review of literature revealed that this species has not been reported from Andaman & Nicobar Islands and this is the first report of Ferruginous Duck from the Islands.

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7. WHITE-BREASTED WATERHEN *AMAURORNIS PHOENICURUS* NESTING ON A TREE

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There is a large tamarind tree behind my house in Chembur, Mumbai, which is frequented by arboreal bird species. In the middle of July 2013, distinct *krr-kwak-kwak, krr-kwak-kwak* calls of White-breasted Waterhen *Amaurornis phoenicurus* were heard from a bush near the tree. This was surprising as the closest waterbody was *c.* 1 km away and the next one *c.* 3 km from this site. After a week, we spotted the waterhen in our garden, and a couple of days later, the same(?) bird was sighted again with four hatchlings walking along with her.

In August 2013, contact calls of White-breasted Waterhen were heard again, one originating from the tamarind tree and the other from the ground. Later, it was observed that the waterhen on the ground flew to a height of about 6 m to the tree, and then climbed up the tree with difficulty to join the other bird in the dense foliage, where there was a nest, a dense compact structure made of reeds. Over the days, the pair could be occasionally seen from a distance, taking turns in plucking tamarind leaves and the leaves of a large bougainvillea growing on the tree to line the nest. It was even noted that one of the birds was in hot pursuit of a crow that came close to the nest.

The tree was about 18 m, and the nest was at a height of 12 m, and about one kilometre from the nearest wetland. The White-breasted Waterhen is reported to nest either on the ground in tangled undergrowth along wetlands or in a shrub or bamboo clump up to 2 to 3 m from the ground, sometimes well away from water (Ali and Ripley 1987; del Hoyo *et al.* 1996). Hence, sighting of nesting at a height of 10 m up in a tree is a new and significant record. Probably, the loss or disturbances to the nesting habitat is responsible for this pair opting to nest so high in a tree, and this may affect the survival chances of young from such nesting sites.

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8. SIGHTING OF COMMON BLACK-HEADED GULL *CHROICOCEPHALUS RIDIBUNDUS* LINNAEUS, AND WEDGE-TAILED SHEARWATER *ARDENNA PACIFICA* (GMELIN) FROM SOUTH ANDAMAN, ANDAMAN & NICOBAR IS., INDIA

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The Andaman & Nicobar Islands, popularly known as Bay Islands, are situated in the Bay of Bengal, midway between peninsular India and Myanmar, spreading like a broken necklace in a north-south direction. These islands

are located between 6° 45′–13° 41′ N and 92° 12′–93° 57′ E. The archipelago consists of 572 islands that lie 193 km away from Cape Negrais in Myanmar, 1,255 km from Kolkata and 1,190 km from Chennai. The total geographical area of Andaman & Nicobar Is. is 8,249 sq. km, and the climate is typical of tropical islands of similar latitude. It is always warm, but with sea-breezes. Andaman & Nicobar Is. constitute a globally important biodiversity hotspot. Due to isolation from the mainland, endemism is very high in all taxa including avifauna (Andrews 2001; Das 1999a, b; Rao *et al.* 1980). A total of 284 bird species were reported from Andaman & Nicobar Is., belonging to 56 families under 17 orders (Sivaperuman *et al.* 2010). As a part of major ecological studies on wetland bird communities in south Andaman, sponsored by the Science Engineering Research Board (SERB), Department of Science & Technology, Ministry of Science & Technology, and INS-Utkrosh, Ministry of Defence, Government of India, we have been monitoring this area regularly since 2012. During these surveys, we recorded two species of birds from South Andaman which are new records to the Andaman & Nicobar Is.

Common Black-headed Gull *Chroicocephalus ridibundus* Linnaeus, 1766

We sighted two individuals of Common Black-headed Gull *Chroicocephalus ridibundus* Linnaeus (Eds: photographic evidence provided) in the tsunami-inundated wetlands of South Andaman (Garacharma; 11°37′ 107″ N; 92° 42′ 437″ E) on March 10, 2015, along with a flock of Pacific Golden Plover *Pluvialis fulva* (Gmelin), Eurasian Whimbrel *Numenius phaeopus* (Linn.), Common Redshank *Tringa totanus* (Linn.), Lesser Sand Plover *Charadrius mongolus* Pallas, and Little Egret *Egretta garzetta* (Linn.). Literature review revealed that Ali and Ripley (1983), Tikader (1984), Kumar *et al.* (2005), Grimmett *et al.* (2011), and Rasmussen and Anderton (2012) have not reported this species from this archipelago and the present sighting is the first report from Andaman & Nicobar Islands.

Wedge-tailed Shearwater *Ardenna pacifica* (Gmelin 1789)

On May 19, 2015, one individual of Wedge-tailed Shearwater *Puffinus pacificus* (Eds: photographic evidence provided) was sighted at Buniyabad, South Andaman (11° 40′ 385″ N; 92° 43′ 237″ E). Its plumage was grey brown on the upperside, with entirely dark grey brown underparts. This species is a medium-sized shearwater belonging to the seabird family Procellariidae. It is sometimes referred to as Muttonbird. The Wedge-tailed Shearwater is widely distributed across the tropical Pacific and Indian Ocean between latitudes 35° N and 35° S. It breeds in oceanic islands: off Japan, Islas Revillagigedo, Hawaiian Islands, Seychelles, and off Western Australia (BirdLife International 2015; del Hoyo *et al.* 1992). Review of literature revealed that only a single individual of this species has been reported from the west coast of India (Praveen 2014), and none from Andaman & Nicobar Is. (Ali and Ripley 1983; Grimmett *et al.* 2011; Kumar *et al.* 2005; Rasmussen and Anderton 2012; Tikader 1984). The individual appears to be an accidental straggler, which landed on the South Andaman coast due to the onset of strong monsoon winds.

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VEGETOS

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Species Abundance and Distribution of Coastal and Marine Bird of India

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Abstract

The coastal wetlands are one of the most important habitats for a large number of flora and fauna.Atotal of 223 taxa of birds were recorded from the coastal wetlands of India, belonging to 30 Families under nine Orders. Highest number of species wasrecorded from East Coast, followed by West Coast, and Andaman & Nicobar Islands. The Order Charadriiformes was highest in dominance followed by Falconiformes and Ciconiiformes. Thirty one species of threatened bird species were recorded from the coastal wetlands. They are intimately related with the food chain and ecosystem services in the coastal areas. There is a need to protect these areas with high priority conservation for the future research on coastal marine bird communities.

Keywords: Avifauna - Coastal wetlands – Distribution- India - Islands

Introduction

Coastal wetlands include seasonal and relatively permanent coastal plain freshwater swamps and marshes, coastal beaches, rocky shorelines, estuarine salt marshes, mangrove swamps, sea grass beds, mud flats, and sand bars. The Convention on "Wetlands of International Importance Especially as Waterfowl Habitat" the so-called "Ramsar Convention" broadly defines coastal wetlands to include "the areas of marine water the depth of which at low tide does not exceed six metres". The marine and coastal wetlands include the enormous amount of marine and coastal species and open sea habitats and ecosystem. India has a coastline of 7,516 km of which the mainland account for 5,422 km, Lakshadweep coast extends 132 km and Andaman & Nicobar Islands have coastline of 1,962 km (Venkataraman 2008). The coasts are perhaps the most neglected biogeographic zone of India, mainly because charismatic species arenot found here. Nonetheless, the coasts do have fabulous birdconcentrations, as seen in the Chilika Lake (IBA) and Bhitarkanika inOrissa, Point Calimere Wildlife Sanctuary (IBA) in Tamil Nadu,Sunderbans (IBA) in West Bengal, Sewri mudflats (IBA) inMaharashtra and Kori Creek in Gujarat.Besides the sand beaches and rocky outcrops which are important asforaging sites for many waders, the mangroves serve as breeding groundfor many species of birds such as Egrets, Herons, Storks, Kingfishers and Raptors.According to Rodgers *et al.* (2000), the Coasts Bio-geographic zone covers about 83,000 km^2, which is 2.52 per cent of India's geographical area.

Coastal wetlands are special types of wetlands thatare influenced by the fluctuating water levels and provide a habitat for a vast array of organisms, including many endangered species. These critically important features act as water purifier, fish spawning area and feeding-grounds and habitat for many animal species. Some birds depend on wetlands almost totally for breeding, nesting, feeding, or shelter during their annual cycles. Birds that need functional access to a wetland or wet land products during their life cycle can be called "wet land dependent". The important migratory birds utilizing thecoastal wetlands are ducks, shorebirds, gulls, terns and flamingos. Many birds that inhabit intertidal habitats aremigrants and travel annually along the Central Asian-Flyway, this flyway which extends from Central Siberia through the Himalayas to the Indian subcontinent. During peak annual migration periods, hundreds of thousands of birds migrating along the Central Asian Flyway descend upon the coastal wetlands of India in search of refuge and food. Some spe-

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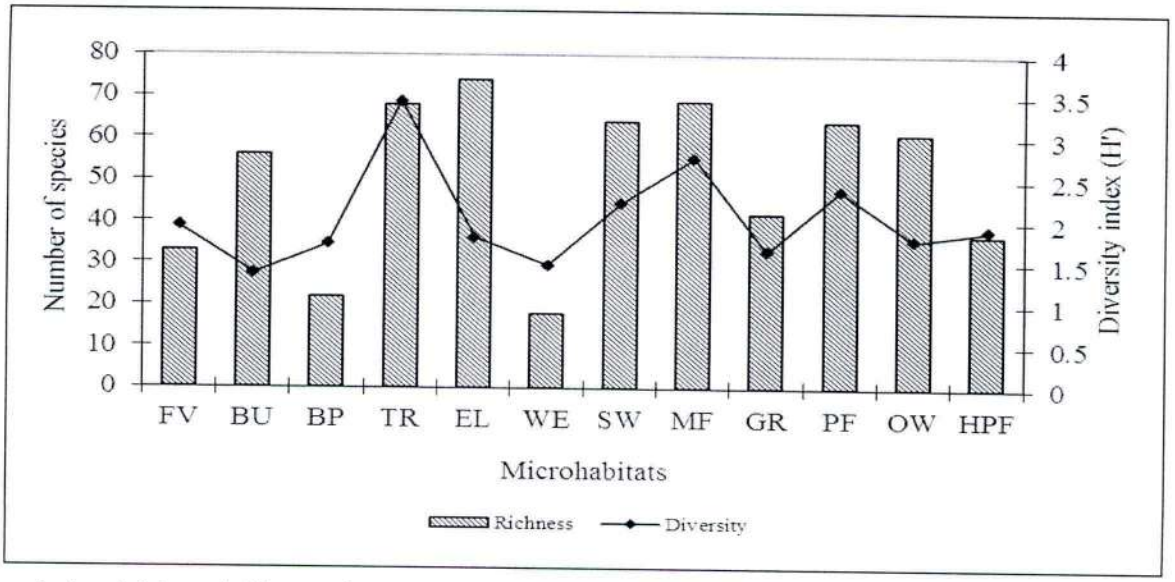
Fig 1. Bird species richness and diversity index (H') in different microhabitats in the Kole wetlands(n = 36)



cies of shorebirds weighing as low as 25g fly as far as9,000 km from the arctic breeding grounds to South Indian wintering grounds. Prior to breeding, they again fly northwards to their nesting grounds, thus, in one yearthey may fly 18,000 km (Balachandran, 2012).In this paper we made an attempt to compile the avifauna of coastal wetlands based on the field surveys and published information.

Methodology

This paper is prepared based on the field studies conducted in the East Coast, West Coast and Andaman & Nicobar Islands (Sivaperuman and Jayson, 2000; Jayson and Sivaperuman, 2003; Sivaperumanand Jayson 2009; Venkatraman, 2008). Birds were classified as migratory or resident species based on Ali and Ripley (1983). The Common and scientific names are after Manakadan and Pittie (2001).

Microhabitat utilisation of wetland birds was studied by recording the microhabitat of the bird at the first sight. Observations were made after sunrise up to 1000 hours. The microhabitats were identified as floating vegetation, bund, bamboo pole, trees, electric line, water edge, shallow water, mudflat, grass, paddy fields, open water and harvested paddy fields.

Categories of microhabitat

Microhabitats were classified into categories as given below.

Floating vegetation (FV): Open water with floating species such as *Eichhorniacrassipes*, *Pistiastratiotes* found in all the areas during monsoon and restricted to canals during summer months.

Bund (BU): Bunds erected mainly by earth and stones separate the canals and paddy fields. During the monsoon months, bunds were the only structure above water. Different types of bunds were considered together for collecting the data.

Bamboo pole (BP): Bamboo poles were used for constructing temporary bridges over the canal. Some bamboo poles were pitched in the paddy fields for putting up scaring devices like colored plastic bags.

Trees (TR): Some small and medium sized trees were seen on the bunds and the species *Alstoniascholaris* was common in the area.

Electric line (EL): Electric line of different voltages (11 KV to 400 KV), which pass through the wetlands is considered as a microhabitat.

Water edge (WE): Edges of water bodies like canals and paddy fields come under this category.

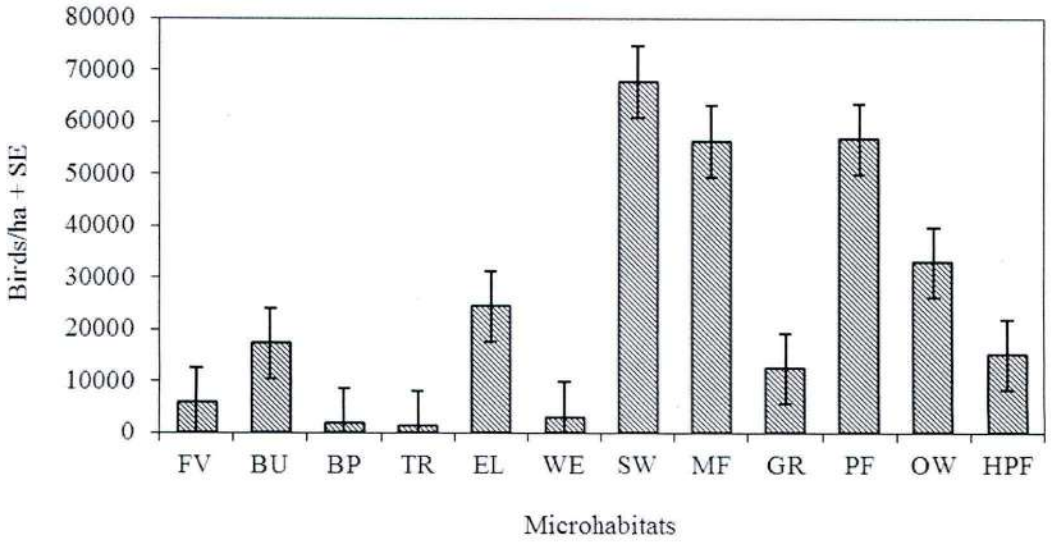
Shallow water (SH): Shallow water with a depth up to 20 cm usually free from the aquatic vegetation is a microhabitat. It usually emerged during summer months when the water is pumped to the canals for paddy cultivation. This microhabitat was found only in the summer months.

Mudflat (MF): Soft mud and water with a depth up to 10 cm was another microhabitat of the area. It was usually found in the paddy fields before replanting of the area.

Grass (GR): The Kole wetlands had patches of green grass and are usually seen on the bunds. *Arundinariadonax*,a tall grass was found in the area, which attained a height of 180 cm to 240 cm.

Paddy field (PF): Paddy cultivated areas in different stages *viz.* sown, replanted, flowering and panicle stages were considered as a microhabi-

Fig 2. Density of birds in different microhabitats in the Kole wetlands



(n = 36) FV = Floating vegetation, BU = Bund, BP = Bamboo pole, TR = Trees, EL =Electric line, WE = Water edge, SW = Shallow water, MF = Mud flats, GR = Grass, PF = Paddy fields, OW = Open water, HPF = Harvested paddy fields

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Open water (OW): Open water is defined as the vast expanse of water without vegetation. This was found mostly during monsoon.

Harvested paddy field (HPF): An area where paddy was harvested and the land ploughed later is another microhabitat.

Habitat utilisation of selected specie

The utilisation of microhabitats by bird species was determined by regular observations. Species on which at least 50 observations were recorded alone was included in the analysis and the sample size varied from 60 to 371. The mean value for each variable was calculated from the combined data of 36 months of the study for respective microhabitat type.

Microhabitat use in different seasons

Analysis of variance (ANOVA) and Student Newman KeulsTest (SNK) (Montogomery 1991) were performed to know the changes in the habitat and season on the variation of bird species richness, diversity and density using the SPSS 16.0. ANOVA was carried out using log-transformed data.

Results and Discussion

Two hundred and twenty three taxa of birds were recorded from the coastal wetlands of India, which belong to 30 Families under 9 Orders (Sivaperuman and Venkatraman 2015). Out of these, 91 species were residents, 90 were trans-continental migrants, 37 were resident migrants, four species were vagrant and one species is a straggler. Highest number of species recorded from East Coast (166), followed by West Coast (163), and Andaman & Nicobar Islands (143) (Table 1).

Diversity of wetland birdsin the Coastal wetlands of South Andaman

One hundred and sixty four species of birds were recorded from the tsunami inundated wetlands of South Andaman belonging to 51 Families under 19 Orders. Of the 164 species, 126 were resident, 38 migrants (Sivaperuman 2014). Among the recorded species, thirty seven species are trans-continental migratory. Of these, Pacific Golden Plover, Lesser Sand Plover, Eurasian Curlew, Common Sandpiper and Wood Sandpiper were most commonly observed in the study area. Total of thirty four species of shorebirds were recorded from the coastal wetlands (Gokulakrishnan *et al.* 2014). These belong to the order Charadriiformes and distributed into six families. The shorebirds constitute an important group of wetland species in Andaman and Nicobar Islands. The highest number of species of shorebirds was recorded from Garacharma (29) followed by Sippighat (25), Chouldhari, Stewartgunj & Ograbraj (23), Chidiyatappu (10) and Shoal Bay (9). Among the recorded species, Greater Sand Plover, Common Sandpiper, Pintail Snipe, Common Redshank, Whimbrel and Black-naped Tern were recorded from all the study sites.

Diversity of wetland birdsin VembanadKole wetland

Table 1. Order and family wise distribution of coastal birds.

Order & Family	East Coast	West Coast	A & N Islands
Podicipediformes			
Podicipedidae	1	2	1
Procellariiformes			
Procellariidae	-	-	3
Pelecaniformes			
Phaethontidae	-	-	3
Pelecanidae	1	3	1
Sulidae	1	1	1
Phalacrocoracidae	3	3	1
Anhingidae	1	1	-
Fregatidae	1	1	3
Ciconiiformes			
Ardeidae	17	13	16
Ciconiidae	5	6	-
Threskiornithidae	4	4	1
Phoenicopteriformes			
Phoenicopteridae	2	2	-
Anseriformes			
Anatidae	18	16	10
Falconiformes			
Accipitridae	23	24	29
Pandionidae	1	1	1
Falconidae	3	4	5
Gruiformes			
Gruidae	-	1	-
Rallidae	8	10	13
Charadriiformes			
Jacanidae	2	2	1
Rostratulidae	1	1	-
Haematopodidae	1	1	-
Charadriidae	13	10	8
Scolopacidae	30	28	28
Recurvirostridae	2	2	1
Phalaropidae	1	1	-
Dromadidae	1	-	1
Burhinidae	3	2	1
Glareolidae	2	3	2
Laridae	20	20	13
Rynchopidae	1	-	-

One hundred and eighty two taxa of birds were recorded from the Kole wetlands (Sivaperuman 2004) belonging to 50 Families under 16 Orders. Of these, 100 species were resident, 81 were migrants and one species is a straggler. Out of these, 48 species were new records for the area. The Little Egret *Egrettagarzetta*, Cattle Egret *Bubulcus ibis*, Little Cormorant *Phalacrocoraxniger*, Whiskered Tern *Chlidoniashybridus*, and Indian Pond-Heron *Ardeolagrayii* were the most abundant species in the Kole wetlands. Thirty six species of waders were recorded. These birds depend heavily on shallow waters and mud flats, normally observed from September onwards in the Kole wetlands. Of these, Black-winged Stilt *Himantopushimantopus*, Little Ringed Plover *Charadriusdubius*, Wood Sandpiper *Tringaglareola*, Red-wattled Lapwing *Vanellusindicus*, Common Greenshank *Tringanebularia*, Green Sandpiper *Tringaochropus*, Common Sandpiper *Actitishypoleucos* and Whiskered Tern *Chlidoniashybridus* were recorded commonly recorded from all the area.

Species richness, diversity and density in different microhabitats

Species richness of birds was highest in the electric line microhabitat (74) followed by mud flats (69). Species diversity index (H') was highest on trees (3.44) and lowest on bund (1.38) (Fig 1). The density of birds was highest in shallow water followed by paddy fields and mud flats (Fig. 2).

Habitat utilisation of selected bird species

Habitat utilisation pattern of 11 selected species of birds showed that except waders, all the wetland species utilised all the available microhabitats (Table 2). Shallow water was highly preferred among the 12 microhabitats by the birds. The utilisation pattern of microhabitats differed from species to species. The Little Egrets were utilising all the microhabitats except grass and the species frequented shallow water more followed by paddy fields. Observations indicated that Cattle Egret highly preferred paddy field and the species had a characteristic affinity for paddy field than other habitats. Indian Pond-Heron preferred paddy field and shallow water. The Cattle Egret and Indian Pond-Heron, Large Egret highly preferred paddy field than other microhabitats. Red-wattled Lapwing's preferred habitat was mud flats.

Similarly, Common Sandpiper preferred mud flats and shallow water. Wood Sandpiper was observed in mud flats followed by shallow waters. Black Winged Stilt preferred the shallow waters and Whiskered Tern preferred shallow waters and mud flats. Marsh Sandpiper preferred shallow water and mud flats for foraging. Median Egret preferred shallow water and paddy fields. Habitat overlapping was also observed among birds in the Kole wetlands. Most of the species like Little Egret, Median Egret, Black-Winged Stilt, Marsh Sandpiper and Common Sandpiper mainly used shallow water and mud flats, and other species like waders preferred single habitat.

Influence of microhabitat and seasons on bird

Table 2. Habitat utilisation of birds in the Kole wetlands (%)(n = 36)

Name of the species	Floating vegetation	Bund	Bamboo pole	Trees	Electric line	Water edge	Shallow water	Mud flat	Grass	Paddy field	Open Water	Harvested paddy field	Total no. of sighting (n)	Niche breadth	
														Levins (B)	Hulbert (B')
Little Egret	0.14	2.93	0.32	0.03	0.03	1.52	44.43	17.17	0	26.59	0.21	6.62	261	3.29	0.22
Little Cormorant	3.76	8.01	7.61	0.97	2.66	0.87	11.87	15.59	0	1.35	43.02	4.2	326	4.17	0.32
Pond Heron	7.54	11.24	0.43	0.54	0.15	0.12	16.92	12.22	0.01	40.86	1.43	8.53	371	4.23	0.29
Cattle Egret	0.69	0.9	0.05	0.05	0	0.54	8.73	4.4	0.03	52.35	0.18	32.09	214	2.58	0.16
Whiskered Tern	0.02	0.09	0.57	0.15	24.12	0	43.87	17.86	0	8.42	3.53	2.38	232	3.43	0.27
Lesser Whistling Teal	76.12	1.37	0	0	0.21	0	3.77	0	0.1	0	18.05	0.38	58	1.62	0.10
Median Egret	0.8	1.24	0	0	0.02	0.66	41.35	4.6	0	47.94	0.01	3.39	122	2.47	0.18
Common Sandpiper	0.39	7.32	0	0	0	0.32	18.41	56.48	0.39	12.96	0	3.73	104	2.65	0.24
Wood Sandpiper	0.01	1.75	0	0	0	0.13	19.42	46.56	0	28.2	0	3.92	152	2.98	0.33
Red-wattled Lapwing	1.06	26.31	0	0.77	1.55	0	9.48	29.79	0.19	17.7	7.74	5.13	170	4.83	0.43
Purple Moorhen	46.53	0	0.05	0.04	0	0.25	27.24	0.04	0.52	0.15	25.19	0	60	2.82	0.23

community parameters

Two-way analysis of variance performed on bird species richness, diversity and density showed statistically significant difference between the habitats and between the seasons. Similarly, interaction between the habitats and seasons was found to be statistically significant with respect to all the indices considered (Table 3).Two-way ANOVA was performed to find out significant difference between migratory and non-migratory seasons and habitats (Table 4). There was significant difference between the habitats and between the migratory and non-migratory seasons. Similarly, interaction between the habitats and seasons was found with respect to all the three indices considered.

Globally threatened bird species

Of recorded species, thirty one species were listed under IUCN threatened categories. Four species namely Christmas Island Frigatebird (*Fregataandrewsi*), Baer's Pochard(*Aythyabaeri*), Indian White-backed Vulture (*Gyps bengalensis*), and Spoonbill Sandpiper (*Calidrispygmeus*) were listed as Critically Endangered. The following species were listed as Endangered *viz.* Egyptian Vulture (*Neophronpercnopterus*), Saker (*Falco cherrug*), Spotted Greenshank (*Tringaguttifer*), and Black-bellied Tern (*Sternaacuticauda*). Fifteen species are Near Threatened and eight species are vulnerable.

Out of more than 9,000 species of birds of the world, the Indian subcontinent supports about 1,300 species, or over 13 per cent of the world's birds (Grimmett*et al.* 1998). This subcontinent, rich in avifauna also boasts of 48 bird families out of the total 75 families in the world. The coastal wetlands of east coast, west coast and Andaman & Nicobar Islands support 17 per cent of Indian avifauna. The high avian species richness recorded from the East and West Coast is due to the presence of diverse microhabitats and extensive surveys carried out in the past by various ornithologists and amateurs in the coastal wetlands. Among the species recorded, 90 were trans-continental migrants which showed the high influx of migratory birds during the migratory season. The coastal wetland avifauna is dominated, at least numerically, by large numbers of Anseriforms, Ciconiiforms, and Charadriiforms. Avian populations increase considerably during migratory periods in different sites in the east coast, when large numbers of waterfowl and shorebirds congregate to feeding and resting. Many coastal wetlands in the east and

Table 3. Analysis of Variance for bird community parameters (Dry, Wet-I and Wet-II)(n = 36)

Sources of Variation	DF	Species Richness			Species diversity Index			Density of birds		
		SS	MSS	F	SS	MSS	F	SS	MSS	F
HABITATS	11	40.37	3.67	8.56**	12.18	1.11	7.29**	115.63	10.51	3.96**
Seasons	2	28.03	14.01	32.69**	2.11	1.06	6.97*	200.84	100.42	37.86**
Habitats * Seasons	22	27.02	1.23	2.87**	9.37	0.43	2.81**	178.40	8.11	3.06**
ERROR	72	30.87	0.43		10.92	0.15		190.98	2.65	
Total	107	126.28			34.58			685.86		

** P = <0.001; * P = <0.05

Table 4. Analysis of Variance for bird community parameters (Migratory and Non-migratory)(n = 36)

Sources of Variation	DF	Species Richness			Species diversity Index			Density of birds		
		SS	MSS	F	SS	MSS	F	SS	MSS	F
Habitats	11	20.87	1.89	9.10**	9.27	0.84	5.91**	81.91	7.45	3.76**
Seasons	1	9.20	9.20	44.13**	1.99	1.99	13.93**	62.83	62.83	31.71**
Habitats * Seasons	11	7.95	0.722	3.47**	3.58	0.33	2.28*	46.49	4.23	2.13*
Error	48	10.00	0.21		6.85	0.14		95.11	1.98	
Total	71	48.03			21.69			286.34		

** P = <0.001; * P = <0.05

west coasts annually host significant portions of the world populations migratory species.

The coastal wetlands especially, the Point Calimere, Chilika Lake, and Pulicate Lake in the east coast support significant number of winter visitor. In the west coast, the Kadalundy estuary, and Vembanad-KoleRamsar site are the major feeding and roosting grounds. The tsunami inundated wetlands of Andaman and Nicobar Islands also provide feeding and resting site for many migratory shore birds in the East Asian-Australasian Flyway.Waterbirds are one of the most conspicuous fauna in these aquatic ecosystems, and they serve as both indicators and play major role in nutrient cycling.

Among the microhabitats identified, species richness was highest on the electric line and in the mud flats. Species diversity index was higher on the tree and density of birds in the shallow water followed by the paddy fields and the mud flats. The variation in species richness, diversity index and density of birds in different microhabitats indicated the habitat preference of bird species. Birds are known to exploit information about the habitat patches to choose sites for feeding, shelter or reproduction to increase their realised fitness (Krebs and Kacelnik 1991). Habitat selection is an evolved set of behaviour based on innate responses to stimuli or learned cues. The manner in which an organism interacts, behaves in relation to the resources it needs for its existence and reproduction, competes or cooperates with others of the same or different species seeking to use the same resources and still others seeking to prey upon it, constitute an enormous field of study.

Cattle Egrets were recorded preferring paddy field, which is in agreement with the earlier results reported (Nagarajan and Thiyagesan 1998, Lanes and Fujioka 1998). The use of paddy fields by Cattle Egrets also showed a strong seasonal pattern and the highest utilisation occurred during November, December and January. This was often associated with post-harvest ploughing of fields. Cattle Egrets were observed less in the open water habitat, as they were not able to catch prey in deep water (Katzir*et al.*, 1999)

The observations indicated that Little Egret and Median Egret preferred shallow water followed by paddy fields, which is comparable with the previous studies of Nagarajan and Thiyagesan (1998). According to Kushlan (1976), the wading birds whose habitat use is closely related to the water depth were most likely to select shallow water habitats. Paddy fields are now an integral part of wetland landscapes throughout the world and such areas are often viewed as important habitat for certain species of water birds, particularly in the region where the availability of natural marshes had diminished (Fasolaand Ruiz 1996). Esler (1992) had reported that Cormorant and Waterfowls preferred the utilisation of the floating vegetation and open water habitat. The present observations in the Kole wetlands confirm the finding.

In the Kole wetlands, periodical fluctuations in the extent of microhabitats were common, which was very evident in the shallow water and the mud flats. The appearance of mud flats attracted large number of waders during the migratory season. Among the waders, Common Sandpiper, Wood Sandpiper and Marsh Sandpiper preferred the mud flats for foraging and such preference was reported by Kushlan (1976) and Goss-Custard and Yates (1992). Other wading species were also observed in the marshy areas and they avoided feeding in the dry areas.

Overlap index between the 11 species of birds in different microhabitats showed only 50 per cent overlap. The overlap in the habitats between different species of egrets and herons is a usual phenomenon and they use diverse strategies to overcome the seasonal fluctuations of water levels (Kushlan 1986). Custer and Osborn (1978) reported that Snowy Egrets *Egrettathula*and Tricoloured Herons *Egrettatricolor* used the same sites on the North Carolina Coast. Kent (1986) reported similar habitat overlap among four species of herons. Although their habitat overlaps, they coexist in the same habitat by resource partitioning within the habitat and preying upon different species.

The microhabitat utilisation pattern at Kole wetlands indicated that each species selected among the available habitats in relation to the foraging efficiency. The habitat utilisation of birds was depending on the abundance of food and habitat structure. The distribution of food is one of the most important factors influencing the selection of feeding sites by birds (Grant and Grant 1987). Another hypothesis, which explains the foraging habitat selection pattern is that, the behavioural strategies may confine the distribution of birds in relation to features of individual habitat and landscapes.

Vast extent of mudflats available at Kole wetlands was the prime habitat for waders. According to Moser and Summer (1987), waders are attracted to the mudflats because these habitats support high densities of invertebrate prey. Weller (1994) also reported that the availability of mudflats is known to contribute to the high diversity of waders. The area serves many avian species for a wide variety of purposes such as nesting, roosting and wintering ground. The study indicated that the habitat selection by wetland birds at the Kole wetlands is influenced by the prey availability and accessibility, whereas the water depth influenced the accessibility of the birds to the prey species. Detailed studies on the water bird assemblages, diversity, habitat use and role in nutrient cycles is essential to developing and updating conservation and management plans for habitats with resident and migratory species.

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