

**BIRD COMMUNITY OF ANDAMAN ISLANDS WITH EMPHASIS
ON HUMAN ASSOCIATED AND INTRODUCED BIRDS**

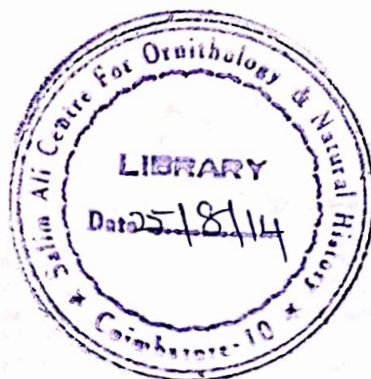
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Submitted to the Bharathiar University
in partial fulfillment of the requirements for the degree of

**DOCTOR OF PHILOSOPHY
IN
ZOOLOGY**

By

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October 2013

CERTIFICATE

This is to certify that the thesis, entitled “ **Bird Community of Andaman Islands with Emphasis on Human Associated and Introduced Birds**” submitted to the Bharathiar University, in partial fulfillment of the requirements for the award of the Degree of Doctor of Philosophy in Zoology is a record of original work done by **Mr. P. Rajan** during the period of September 2009 – October 2013 of his research in the department of Nature education at Sálím Ali Centre for Ornithology and Natural History, under my supervision and guidance and the thesis has not formed the basis for the award of any Degree /Diploma /Associateship /Fellowship or other similar title to any candidate of any University.



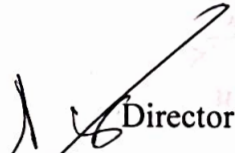
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DECLARATION

I, **Rajan. P** hereby declare that the thesis, entitled “**Bird Community of Andaman Islands with Emphasis on Human Associated and Introduced Birds**” submitted to the Bharathiar University, in partial fulfillment of the requirements for the award of the Degree of Doctor of Philosophy in Zoology is a record of original and independent research work done by me during the period of September 2009 – October 2013 under the supervision of Dr. P. Pramod. Senior Scientist at Sálím Ali Centre for Ornithology and Natural History (SACON) and it has not formed the basis of the award of any Degree /Diploma /Associateship /Fellowship or other similar title to any candidate of any University.



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BIRD SPECIES CODE USED IN FIGURES

No.	Bird species	Code used	No.	Bird species	Code used
1	Andaman Teal	ANTL	24	Jungle Crow	JGCW
2	Andaman Wood-Pigeon	ANWP	25	Kentish Plover	KTPV
3	Asian Fairy Bluebird	AFBB	26	Greater Racket-tailed Drongo	GRDG
4	Asian Glossy Starling	ASGS	27	Lesser Sand Plover	LSSV
5	Barn Swallow	BASW	28	Lesser Whistling-duck	LWDK
6	Black-headed Bulbul	BHBB	29	Little Stint	LLST
7	Black-napped Oriole	BNOR	30	Long-tailed Parakeet	LTPK
8	Brown Shrike	BRSK	31	Long-toad Stint	LTST
9	Cattle Egret	CTEG	32	Oriental Magpie Robin	OMRB
10	Chestnut-headed Bee-eater	CHBE	33	Olive-backed Sunbird	OBSB
11	Collared Kingfisher	CLKF	34	Pacific Golden Plover	PGPV
12	Common Myna	CMMN	35	Pacific Swallow	PSSW
13	Common Sandpiper	CMSP	36	Purple Swaphen	PRSH
14	Great Egret	GREG	37	Red-breasted Parakeet	RBPK
15	Edible-nest Swiftlet	ENSW	38	Red Collard Dove	RCDV
16	Glossy Swiftlet	GLSW	39	Red Shank	RDSK
17	Green Imperial-pigeon	GIPG	40	Red-whiskered Bulbul	RWBB
18	Grey Plover	GRPV	41	Rock Pigeon	RKPG
19	Hill Myna	HLMN	42	Scarlet Minivet	SRMV
20	House Crow	HSCW	43	Small Minivet	SLMV
21	House Sparrow	HSSR	44	Whimbrel	WMBL
22	Indian Peafowl	IDPF	45	White-headed Starling	WHS�
23	Intermediate Egret	IMEG	46	White-rumped Munia	WRMU

ABSTRACT

This study was initiated with the objectives of understating a) The bird community attributes and their patterns in Andaman Islands, b) The structure, composition and variations of bird community of human influenced areas in Andaman Islands and c) The status, Distribution and population trends of introduced birds in Andaman Islands.

At first, this study synthesized the existing knowledge, collected primary data to update and analyzed to know the present situation of bird fauna with the study objectives in focus. All the published information on distribution of birds in the Andaman Islands were collated, synthesized and analyzed to elucidate the characteristics of Andaman Bird fauna. Then, systematically 221 transect counts of birds from ten human inhabited islands which can be classified into 6 habitats were collected. These collected field observation data on birds were analyzed with special emphasis on the introduced birds and discussed. The thesis is organized in four technical chapters including a review of literature with more emphasis on introduced birds and their impacts on native ecosystem especially on Islands.

The result shows, 259 species (297 taxa including subspecies) of birds belonging to 18 orders and 58 families recorded from this Archipelago. First, study updated the check list of birds of Andaman and Nicobar Islands with addition of 31 species to the last published comprehensive list. Then it analyzed the bird fauna for its characteristics and discussed.

Further, the bird community attributes of Andaman group of Islands were examined with emphasis on human influenced areas and introduced birds. During this study, a total 15859 individuals of 126 species of birds belonging to 35 families and 13 orders were encountered from the ten Islands of Andaman during this study. This study reveals that, bird species diversity from this human associated landscape was different among different habitats. Of the 19 introduced birds of this archipelago, six bird species were recorded during this study period and others are believed to be locally extinct. A detailed study focusing the distribution and population of surviving introduced species' reveal that the population and ranges were increasing as a result of ongoing habitat degradation, especially human mediated changes. It is also observed that the introduced birds dominate in number in the human influenced areas of the Islands.

As expected in a tropic oceanic archipelago, Andaman and Nicobar Islands are very important with regard to the conservation planning in India, due to the high species diversity and endemism. Though there were many localized studies carried out at various time scales, comprehensive and updated study about the species richness and diversity of Andaman avifauna was lacking. Increasing tourism and human mediated landscape transformation is affecting the rich biodiversity of these islands. This study vouches for that.

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GENERAL INTRODUCTION

1.1. INTRODUCTION

Islands, fascinated biologists and ecologists from the days of Darwin and continue to this days. As islands' species communities are isolated, life in islands work as real time laboratories for the observer. Island Biogeography evolved as a specialized branch of science over the period of last one century. Many theories came with the birth and development of island biogeography. Observations and experiments were conducted in many islands across the world. Many islands were spared – may be just by chance, or for enquiries yet to emerge.

Andaman and Nicobar Islands is one such archipelago which has lots of potentials to ask many scientific questions – but not much has been done so far. In most of the cases the basic scientific information is missing. Relatively better documented group are the birds. These Islands are rich in avifauna with nearly 297 taxa of birds with around 40 percent endemism. Of the land mass, disproportional to the size of the Islands 86% of area are unexplored forests and this natural vegetation supports high avifaunal diversity and abundance. (Sankaran & Vijayan 1993; DES 2009). Birds are widely regarded as powerful monitoring tools in environmental management because of their wide distribution, abundance and easy to monitor (Bibby et al. 2000).

The avifauna of Andaman and Nicobar Island is one of the richest in India in terms of species diversity and composition (Sankaran & Vijayan 1993), reflecting a diverse range of habitats from evergreen forest to coastal areas. Ornithological research in Andaman and Nicobar Island done by many researchers from 1846 onwards and still studies are going on. But there is an information gap about ecological work of endemic species and introduced species. The avifauna of Andaman and nicobar Islands are traditionally treated as an insular subdivision of the Indian Subregion (Oates & Blanford 1889-98; Ripley & Beehler 1989). The major path of colonisation of the islands took place along a single route from southwestern Burma, via a series of overwater barriers that acted as filters (Ripley & Beehler

1989). The two island groups share a single insular avifauna, however Nicobar bird species are considered as a subset of that of the Andaman Islands' avifauna. The Andaman and Nicobar avifauna is close to that of southwestern Burma and has 78% shared species and should be considered Indochinese and not Indian (Wallace 1876; Udvardy 1969; Ripley & Beehler 1989). Andaman and Nicobar Island is one of the endemic bird areas in the world (Islam & Rahmani 2004) and 106 species and sub species of birds were endemic to this archipelago (Vijayan et al. 2000).

Ecological studies of biological communities in the recent days range between simple natural history observations to complicated mathematical procedures, to understand the complex systems. In all the aspects such as explaining the patterns of distribution, abundance and interaction of species and in understanding their role as indicator of larger ecology of the land, what we require is a judicious mix of natural history and life history observations of organisms along with theoretical enquiry.

Simberloff (2004) argued that traditional community ecological studies of local communities anywhere are often highly effective in understanding environmental problems. Further, community ecology also have an impressive record in guiding ecological management. Understanding nature process is not simple, and it needs continuous systematic effort, it may be able to answer questions about a natural phenomenon by referring to certain patterns, relationships of a different species of an area especially in Islands (Pickett et al. 1994).

It is necessary to study seriously about each species, their distribution, ecology and behavior to understand their interactions with other species and environment. Many literatures available on species' interactions (Murdoch & Oaten 1975; Holt 1977; Kuno 1987; Abrams & Walters 1996; Holt & Polis 1997), as well as food web interactions that may be seen in any local communities (Holt et al. 1994; Leibold 1996; Holt & Polis 1997; McCann et al. 1998; Holt 2002; Bolker et al. 2003). As species of the same genus have usually, though by no means invariably, some similarity in habits and constitution, and always in structure. The struggle will generally be more severe between species of the same genus, when they come into competition with each other, than between species of distinct

genera (Darwin 1859). However, basic knowledge about the natural history is lacking in many groups of organisms, even in the well studied groups in many locations.

A main objective of equilibrium theory of island biogeography was to predict patterns of species richness as a function of island area and distance from mainland and experimental approaches to island biogeography mainly deals with community rather than population aspects (MacArthur & Wilson 1967). There are many variables that contribute towards species communities and their successful survival. Species diversity mainly depends on the favourable environmental factors. Vegetation height gives a substantially stronger correlation with survival than size of the area and Islands with higher vegetation are especially attractive to birds (Schoener et al. 2007).

It is clear that habitat degradation is one of the main reasons for species extinction especially in island ecosystems (Diamond 1976). It is necessary to give more attention for viability of protected populations and spatial considerations such as habitat fragmentation, connectivity and spatial distribution of each constituent species (Cabeza 2003). Habitat can be degrading in number of ways; major degradation is because of anthropogenic pressure. The human population of Andaman Islands is increasing drastically and habitat is consequently under mounting pressure from landscape transformation through their activities. Physical or structural alteration may effect negatively on each species. Though Andaman and Nicobar Islands are rich with high avifaunal diversity, anthropogenic pressure is also increasing over time especially after the devastating tsunami of 2004. Immediately after Tsunami, many physical changes happened to the landscape of this archipelago. Andaman and Nicobar Islands have high importance in conservation planning in India because of species endemism and species diversity it harbours.

One of the important ecological and conservation problems in Andaman and Nicobar Islands is the relatively high exposure to the human mediated species introduction. These introduced species can have serious effects on the native biodiversity and it can be the agent for the decline of native species populations. This is the background of this study. This study was planned and undertaken with the focus on understanding the patterns in bird species composition, distribution and diversity in Andaman Islands with the special emphasis on human influenced areas. In the human influenced areas, introduced birds have a special

significance due to the role they potentially play in the ecosystem process. Therefore a special focus is given to them and their ecology

1.2 OBJECTIVES

The objectives of the study can be listed as follows.

1. To study the bird species composition and their patterns in Andaman Islands.
2. To study the structure, composition and variations of bird community of human influenced areas in Andaman Islands.
3. To assess the status, distribution and population trends of introduced birds in Andaman Islands.

1.3 STRUCTURE OF THE THESIS

This thesis is organized into seven chapters including three technical result chapters. Chapter I presents the broad overview and background of this study. Taking Introduced species as main focus of the thesis, chapter II gives an extensive literature review. Details about study area and methodology are explained in chapter III and IV respectively. Of the three technical chapters, first chapter -Chapter V answer the first objectives of this study. Second technical chapter - Chapter VI describes bird community of human influenced landscapes of Andaman Islands. Outcome of the study of introduced birds of Andaman Island is described in the third technical chapter – chapter VII. This chapter is containing current status of Population and distribution of introduced bird species. Special focus with details of the Common Myna *Acridotheres tristis* as it is the most successful invasive species based on this study. Chapter VIII summarizes the finding of this study and finishes with a brief conclusion. References and annexure were given after the technical chapters.

REVIEW OF LITERATURE

2.1. INTRODUCTION

Native species play an important ecological role in the natural ecosystem; they play a major role in maintaining the natural web of life of an environment especially in Island ecosystem. Removing or adding a certain species may cause cascading effect on the environment. Islands are hotspots of endemism, but also shows high rates of extinction requiring urgent conservation action (Trainer 2002), Gaston & Blackburn (1995) showed that, 89% of 116 known bird extinctions since AD 1600 have occurred on islands.. Studies conducted in Australian biodiversity highlighted that the islands play a significant role in the conservation of Australia's flora and fauna (Anon 2005). The isolation of islands protects their inhabitants from threatening processes occurring on the mainland. Crowell (1973) and MacArthur & Wilson (1967) have interpreted these patterns as the result of a dynamic equilibrium. Moulton & Pimm (1983) suggested that, smaller Islands have smaller population and have higher chance of extinction than larger populations of Large Islands.

Bradbury et al. (2005) suggested that bird species composition in an area can be predicted by foliage diversity. Habitat diversity, fewer competitors, fewer predator, etc., are less on Islands than main lands, which might allow for greater ecological and other behavioural variations on an Island population over time and space. On the other hand Island species shows less genetic diversity. Because, if an Island is colonized by one or a few individual birds from main land, the Island birds population starts with only few portion of the total genetic diversity. According to the "Taxon Cycle" hypothesis (Wilson 1961; Greenslade 1968; Ricklefs & Cox 1972), niche expansion is prevalent among colonizers, but isolated species tend towards the long term differentiation, narrowing of their niche, restriction of their range, and eventual extinction. Bird species are known to exhibit selective utilization of their environment. That species often tend to occupy a larger spectrum of habitat on islands than on the mainland is a commonly recognized feature of the "Island Syndrome" (Prodon et al. 2009).

2.2. BIRDS OF ANDAMAN & NICOBAR ISLANDS

Scientific studies on the avifauna of Andaman and Nicobar started in 1846 by Blyth and is still continuing (Abdulali 1965). Many researchers published with many articles regarding different aspects of the Andaman and Nicobar avifauna but only a few of them have listed the birds of these islands. During the early period, most of the researchers concentrated on bird specimen collections instead of scientific studies and later they published bird species list with some notes on these collected specimens. During 1872-73, Hume himself collected about 2000 bird specimens from these Islands (Hume 1874a, 1874b, 1876) and 520 bird specimens were collected from Great and Little Nicobar Islands by Dr. W. L. Abbott and Mr. C. B. Kloss, it represented nearly 100 species, includes nine species that are described as new (Richmond 1902). Abdulali collected about 312 specimens in 1964 (Abdulali 1965). Zoological Survey of India have made many expedition trips to Andaman to collect specimens (Abdulali 1965). Tikader (1984) has come up with one book titled "Birds of the Andaman and Nicobar Islands" based on the Zoological Survey of India collections.

The first annotated list of birds of these archipelago was published by Abdulali in 1965 with inclusions of existing literature. He made a trip to these Islands during 1963 (preliminary visit) and from 9th February to 6th March 1964 (main trip) and collected 312 specimens, which included 35 specimens from Car Nicobar and Nancowry. Later he described these 312 specimens as 112 species and subspecies of birds, of these 4 subspecies were new descriptions (Abdulali 1964). A total of 225 species and subspecies of birds were described, which includes several introduced birds. Some bird species such as Spot-billed Pelican *Pelecanus philippensis* and Brahminy Duck or Ruddy Shelduck *Tadorna ferruginea* were based on single report, which could be the result of storm diversions (Abdulali 1965). In additions, Abdulali's article on Birds of Andaman and Nicobar Islands, there were few articles on new species reports were published during the 1960s and 1970s (Abdulali 1964, 1966, 1967, 1981, 1970; Das 1971; Dasgupta 1976).

Sankaran & Vijayan (1993) published the checklist of birds of Andaman and Nicobar Islands and it is considered as the existing avifaunal checklist in these Islands. A total of 270

species and subspecies of birds were listed, including 105 species and subspecies as endemics (38.9%); and of these, five species were added to Nicobar and three species were added to Andaman as new records (Sankaran & Vijayan 1993). Further, 82 subspecies of species are found on neighboring main lands. Of the total 14 endemic species, five species were exclusively endemic to the Nicobar, six species were exclusive to Andaman and three species were common to both Island groups. 126 species and subspecies were exclusive to Andaman Islands and 56 species and subspecies were exclusive to Nicobar Islands (Sankaran & Vijayan 1993).

Of this total list of birds', Ashy Drongo *Dicrurus leucophaeus* has subspecies in these islands which is *Dicrurus leucophaeus leucogenys* and is found only in Andaman Islands. But later Ashy Drongo *Dicrurus leucophaeus* distribution in Nicobar Islands was confirmed by Sivakumar & Sankaran in 2002. Dusky Leaf Warbler *Phylloscopus fuscatus mariae* was listed as two times in their list i.e: Manipur Dusky Leaf Warbler and Siberian Leaf Warbler but scientific names are same This confusion gives one addition to the number of species in the present list Buffy fish owl has no any confirmed report from these Islands, though this species is distributed from Central and eastern Assam Valley, Bangladesh, Sunderbans, Myanmar to Indonesia (Rasmusen & Anderton 2012). Spotted Wood-owl also has no any confirmed records from these Islands. It has been reported in 1840s from Nicobars, but no specimen known (Rasmusen and Anderton 2012). After these clarifications, it was clear that the total bird species and subspecies mentioned here are 267 (Table 2.1). Of the 267 taxa, 69 were subspecies split by 31 species of the birds on the basis of morphology and all these subspecies have occupied the different islands as well as same islands of the Andaman and Nicobar group (Sankaran & Vijayan 1993). The eight species such as Dark Serpent-eagle *Spilornis cheela*, White-breasted Waterhen *Amaurornis phoenicurus*, Cuckoo-Dove *Macropygia rufipennis*, Hawk Owl *Ninox affinis*, Stork-billed Kingfisher *Pelargopsis capensis*, White-headed Myna *Sturnus erythropygius*, Black-naped Monarch Flycatcher *Hypothymis azurea* and Olive-backed Sunbird *Nectarina jugularis* were split into three subspecies for each (annexure.3). These splits are from the main land to show their differences in the Islands. Among these subspecies, Andaman White-breasted Waterhen

Amaurornis phoenicurus insularis and Andaman Cuckoo-Dove *Macropygia rufipennis andamanica* were distributed in both Island group.

Table 2.1: Total number of birds species in the Andaman and Nicobar Islands after clarification of Sankaran & Vijayan 1993 list.

Description	Total number	Remarks
Total species and subspecies	267	Removed two species such as <i>Strix seloputo</i> and <i>Ketupa ketupa</i> because of no confirmed record (Rasmussen & Anderton 2012) and <i>one</i> repeated count.
Total subspecies	69	All subspecies of 30 species occupied in these Islands, subspecies of mainland species is not considered. Some of the subspecies recognized as species by Birdlife International and excluded those species from the subspecies list.
Total split species	31	8 species were split into 3 subspecies, 22 species split into two subspecies & Ashy Drongo split into another subspecies.
Total species	228	Subspecies are not considered

An avifaunal survey of Andaman and Nicobar was conducted from 8th January to 29th January 2007 by Pande et al. (Pande et al. 2007). They reported 126 species and subspecies from South Andaman, Little Andaman, Car Nicobar, Camorta, Great Nicobar and Narcondam islands. Five species such as Little Grebe *Tachybaptus ruficollis*, Corn Crake *Crex crex*, Oriental Plover *Charidrius veredus*, Spotted Redshank *Tringa erythropus* and Marsh Sandpiper *Tringa stagnatilis* were given as possible new records to the Andaman and Nicobar Islands. Eleven species including five possible species and the five such as Brahminy Kite *Haliastur*, Temminck's Stint *Calidris temminckii*, Small Bee-eater *Merops orientalis*, Crimson-throated Barbet *Megalaima rubricapilla*, Orphean Warbler *Sylvia hortensis* and Eurasian Golden Oriole *Oriolus oriolus* are new to the list of Sankaran and Vijayan 1993 list ((Pande et al. 2007; Sankaran & Vijayan 1993). Corn Crake was listed here with a single individual report from Little Andaman. Except Marsh Sandpiper the other three species were listed because of few individual reports from one place. Marsh Sandpiper was recorded from South Andaman, Little Andaman, Camorta and Great Nicobar and other four

species are to be confirmed. Temmenick's Stint *Calidris temminckii*, Small Bee-eater, Crimson-fronted Barbet and Orphean Warbler are new to these islands and mentioned in their list without any notes. Authors did not mention any new records of these species. Crimson-fronted Barbet was recorded from Western Ghats and Sri Lanka; authors reported this species' distribution in South Andaman, Little Andaman and Camorta. All these species mentioned here are without any explanatory notes or photographic evidence, since it is a new report in Andaman and Nicobar islands that is essential to authenticate the observations.

Recently a bird community study was done by Rajamamannan in the five major and 52 outer islands in the Andaman group during 2003-04 and 2007-08 and reported 153 species of birds in Andaman Islands. This also includes three bird species new to Andaman and Nicobar Islands and seven new records specifically to Andaman group (Rajamamannan 2010). The three new bird records were Tickell's Blue Flycatcher *Cyornis tickelliae*, Grey-headed Flycatcher *Culicicapa ceylonensis* and Blue-fronted Robin *Cinclidium frontale* were published on the basis of single individual sighting from South Andaman Islands, but without any photographic or any other evidences. Red-footed Booby *Sula sula* has been mentioned as new records to Andaman Islands (Rajamamannan 2010) but Sankaran & Vijayan (1993) mentioned Red-footed Booby *Sula sula* in the Andaman.

Other new bird records to Andaman and Nicobar Islands are two individual reports of European Roller *Coracias garullus* from Rangat and Tushanabad of Andaman Islands (Rajan & Pramod 2010) and new species of Great Nicobar Crane *Rallina spp.* (Rajeshkumar et al. 2012). Both these observations were published with photographic evidences. Great Nicobar Crane is yet to be described with specimens and present status of this species is unknown. A few more notable bird surveys were done by experts (Davidar et al. 2001; Raman et al. 2013) and those studied are not discussed here. Only studies with new recordings, contributing towards updating information of the overall checklist of Andaman and Nicobar avifauna were included here.

2.3. HUMAN INFLUENCE ON AVIFAUNA

Human influence on the distribution of birds and their habitats has not been studied well in Andaman and Nicobar Islands, however these kinds of studies are well known in

pacific Islands (Dye & Steadman 1990). Human activities such as deforestation, hunting, introduction of non-native species highly influence the bird species population (Steadman 1995; Freifeld 1999). Not only Island size and isolation from nearest landmass, habitat diversity and resource availability for each taxa also affect population size of the species (Simberloff 1974; Connor & McCoy 1979; Abbott 1980; Boecklen & Gotelli 1984; Wright 1988). Exotic species contributed major role in ecological change along with global warming and habitat fragmentation (Vitousek et al. 1996).

An introduced species is a non indigenous organism that has accidentally or intentionally reached a new location by human activity or naturally (Colautti & MacIsaac 2004). One of the simple definition for introduced species is given by Stanley Temple (Temple 1992), defined as “the exotic species as one that exists outside its natural range as a result of human activities”. There are two types of species introductions such as intentional and non intentional introductions. Non intentional introductions can take place naturally or accidentally, but most of the accidental introduction is accelerated by human activities. Most of the species introductions are intentionally done by human activities rather than accidental and these translocation mimics the natural colonization of species (Veltman et al. 1996). Successful species introduction is a series of actions such as transportation, introduction, establishment and spread of the species (Williamson 1996, Blackburn & Duncan 2001). Only some introduced species can become invasive. These invasive species must succeed after release or escape and it has to successfully establish and spread beyond its’ release point (Williamson 1996). Invasive species as “an alien (or non-native) species whose introduction does, or is likely to cause economic or environmental harm or harm to human health (Moutou and Pastoret 2010).

There are potentially many factors involving the determination of successful establishment of introduced species in alien environment. Flexibility in behaviour, and mutualistic interactions, can aid in the success of invaders in their new environment (Mooney & Cleland 2001; Mooney & Hobbs 2000). Introduction effort is the most important factor of colonization success and number of species introduction is directly proportional to the chance of colonization success (Groves & Burdon 1986; Veltman et al. 1996). However, habitat utilization may vary depending on each species. Species invasion represent the

combination of four factors such as 1) colonization opportunity in new areas, 2) avoidance of demographic problems of small population size early in the establishment of invasive populations, 3) Suitable ecological condition of the new environment and 4) extension of contagion across the landscape (Hobbs & Humphries 1995; Williamson 1996, Richardson et al. 2000; Daehler 2001, Kolar & Lodge 2001; Duncan et al. 2003. Elton (1958) suggested that in “Ecology of invasions by animals and plants”, the establishment of non-native species is ‘so frequent nowadays in every continent and island, and even in the oceans, that we need to understand what is causing and try to arrive at some general viewpoint about the whole business’. However, success of introduced species is mainly associated with the suitable ecological conditions and species adaptation to the new environment. These introductions may place many unique species or natural communities at risk.

Majority of species introduction was done by settlers for hunting, aesthetic, bio control and economical reasons. Some of the introductions were done for the conservation purpose (Griffith et al. 1989; Duncan et al. 2003) such as re-introduction of species where they were occupied early, or as bio control of conservation importance. Greater Bird of Paradise *Paradisaea apoda* was introduced to the Island of Little Tobago from New Guinea for the conservation purpose and the endemic New Zealand Saddleback or Tieke *Creadion carunculatus* was locally introduced in different offshore islands of New Zealand within its’ natural range (Lever 1987). But this kind of species introduction can lead to the cascade effect on that area and the results will be beyond our intention and finally it will lead to marked changes on alien environment such as species extinction and landscape transformation as in the case of plant invasion. Introducing species to new location is not a new story; people are deliberately introducing new species to alien environment with their activities. The dynamics of introduced species on islands have aroused a lot of concern worldwide (Donlan et al. 2003). Most of the scientists believe that most of the introduced species have potential to establishment in alien ecosystems and act as agents of change. They have a great role in altering species equilibrium and in extinction of native species of the areas where they occur. In the last few decades we can see that invasive species played a major role in island ecosystem where species introduction was performed.

Extension of species' distribution may sometimes result into genetic variation among the introduced species populations as shown in the case of House sparrow *Passer domesticus* population in Hawaii Islands and North America (Lever 1987). Introducing species to new regions far from their native range and with different environmental conditions sets an ideal stage for evolutionary diversification through introgressive hybridization among populations of exotic species as well as native species (Anderson 1949; Stebbins 1959; Schlaepfer et al. 2005; Vellend et al. 2007; Whitney & Gabler 2008). Many research done on the introduced plants all over the world suggested that introduction of plants can alter the niches of native species, alter the structure and function of ecosystem and finally it may lead to disrupt the evolutionary process (D'Antonio & Vitousek 1992; Williamson, 1996; Mack et al. 2000). After a long time, it will ended with allopatric speciation either by modification within species or by environmental influences. Exotic species can contribute simultaneously to decreases in biodiversity via a variety of ecological or evolutionary interactions with other species, and to increases in biodiversity via evolutionary diversification (Vellend et al. 2007). According to Whitney & Gabler (2008), rapid evolutionary change commonly occurs during species invasions, with numerous examples of changes in the invaders themselves, in particular traits associated with invasiveness, and in communities of native species challenged by the invaders.

Species distribution are not static, many native species ranges also fluctuate as a consequences of habitat alteration (Vitousek et al. 1997; Cassey 2001; Lockwood et al. 2009). Climate change is the major reason for these habitat alterations and species introduction can also be a part of these changes. However humans are the main agent responsible for this change. Steadman (1989) suggested that, most of the extinction in the highly endemic avifauna of Hawaii and New Zealand, postdates the arrival of people during the past two millennia. Humans seem to be responsible for these extinctions.

2.4. INTRODUCED BIRDS: Worldwide scenario

Many of the researchers have reported that native species especially on islands are vulnerable due to impacts of introduced species and introduced species have played a major role in island ecosystem to determine species diversity. Most of the bird introductions occurred in the eighteenth and nineteenth centuries during the period of European expansion

and settlement (Duncan et al. 2003). Lever (1987) delineated major bird introductions across the world in his book “Naturalized Birds of the World”. There were more than 1400 introduction attempts to introduce about 400 species of birds (Long 1981; Lever 1987; Duncan et al. 2003; Lockwood 1999). Some of the exotics established well and became invasive. But some unsuccessful birds can be established in other region. For example Collared Dove *Streptopelia decaocto* could not establish in Hawaiian Islands, but they colonized successfully in Europe and other countries (Long 1981; Hengeveld & Bosch 1991).

There were many bird introductions that are remarkable in the World, such as Ostrich *Struthio camelus* from Africa to Australia; Cattle Egret *Bubulcus ibis* to Hawaii, Mauritius and Seychelles; Rose-ringed Parakeet *Psittacula krameri* to all over the world except Australia and South America, House Sparrow *Passer domesticus* to all over the World other than its natural distribution, Common Myna *Acridotheres tristis* to all islands in the southern hemisphere including Australia and South Africa, European Starling *Sturnus vulgaris* to North America, South Africa, Australia, New Zealand, etc (Lever 1987). Most of these introduced species naturalized well and become invasive species.

Three species of birds were included in “The World’s 100 most invasive species” by Invasive species Specialist Group (ISSG), they were Common Myna *Acridotheres tristis*, Red-vented Bulbul *Pycnonotus cafer* and Common Starling *Sturnus vulgaris* (IUCN 2000). Birds are highly mobile and they can travel long distance around the world without being aided by humans. Transportation and domestication by humans is the major reason for the distribution of introduced birds; many birds have escaped from captivity (Long 1981 and Lever 1987). Red-vented Bulbul *Pycnonotus cafer* is native to south Asia and introduced to Hawaiian Islands, Australia, Tonga Island, Samoa Island and Society Islands (Lever 1987). Now it becomes a serious pest in agricultural area, fruit trees, vegetables (Lever 1987; Berger 1975). Common Myna is native to South-east Asia and introduced to all the Islands in the southern hemisphere (Lever 1987). This invasive Common Myna is directly and indirectly impacting negatively on the native birds especially hole nesting birds. Attempt to eradicate Common Myna from different islands has already been done by different agencies and these efforts could control the local Common Myna population (Dhami & Nagle 2009;

Feare 2010; Feare et al. 2011). Another invasive bird was Common Starling, naturally distributed in Palaearctic region and introduced to North America, South Africa and New Zealand (Lever 1987).

Hawaii Islands are one of the remarkable Islands in the case of bird introductions than anywhere else in the world (Long 1981). In case of abundance, avifauna of Hawaii islands is dominated by exotic species and of the total bird species, more than 59 birds were introduced a total of 125 times (Moulton & Pimm 1983). These islands are also famous for the endemic avifauna; about 71 birds were exclusively endemic to these islands. On the other hand about 23 birds are recorded as locally extinct from these islands. There were no extinctions until 1920s (Moulton & Pimm 1983). Out of 59 introduced bird species of Hawaii, seven species were introduced before 1920. Native birds' mostly preferred native habitats and these native habitats were being replaced by cultivated land, pasture land for other allied purposes (Day 1995). However introduced birds are commonly preferring these disturbed habitats and extending their habitat along with extension of disturbed forest. Mountainspring & Michael (1985) suggested that, Hawaiian birds are exactly following the Taxon Cycle in operation, because of the broad, diffused and stochastic manner in which exotic birds compete with native birds.

Table 2.1: Introduced birds Vs Native birds in main islands

Island	# species	# endemic species	#established exotic birds	#Locally extinct	Area-km²
Hawaii	324	71	59	23	16944.6
New Zealand	250	61	33	48	268676
Australia	815	16	28	16	7686850
Madagascar	293	108	5	<5	587042

(Source: Extracted and combined data from different journals and websites)

New Zealand and Australia are the other main geographical areas facing the serious problem in Avifauna from exotic invasive species. History of avifauna of New Zealand was well documented by Thomson (1922). Of the total 250 birds of New Zealand, 33 species of birds were generally accepted as introduced in this island (Wodzicki and Wright 1984). Only 18 species of those introduced species have established in these Islands (Lodge 1993; Veltman et al. 1996; Russel 2002). In Galapagos, most avian extinctions have occurred only on the particular islands. The extinction of birds in the Galapagos is less extensive than in Hawaii, or in New Zealand and Australia because of less human impact in most of the Islands and the introduced species are absent in many of these islands (Steadman 1989; Harris 1973).

2.5. INTRODUCED BIRDS: Indian scenario

Despite many studies done on the exotic flora of India, still there is an information gap on exact number of naturalized alien/exotic species in India (Reddy 2008). According to Reddy (2008), of the total plant species of India, exotic species may be around 2000. Ramaswamy & Rajendran (2012) suggested that, 40% of the Indian flora are exotic; of these 20% of exotic plant species are invasive. A catalogue of invasive alien flora of India was done by Reddy (2008) based on history, species origin, species behaviour and field observations, he has explained a total of 173 invasive alien plant species belonging to 117 genera under 44 families. In this study he has reported almost 80% of the species were introduced from neotropics followed by Tropical America (74%) and Tropical Africa (11%). Sharma et al. (1997) listed 221 species of exotic plants from Nilgiris, Tamilnadu. It includes seven plant species which are considered as serious invasive species.

Introduced birds in India have not been studied to the same extent as introduced plants. Only a few birds were introduced to India from other countries (Lever 1987). Java Sparrow *Padda oryzivora* was introduced to Madras before 1910 and to Calcutta by 1931 from its' natural habitat Java and Bali (Lever 1987). Tree Sparrow *Passer montanus* was believed to be introduced in India, because of its' natural habitat was in the Eurasia, China, North-east India, Malaysia, Indonesian islands (Lever 1987). Tree Sparrow was reported from Hyderabad in 1973 and estimated population in 1979 was under 500 (Raju & Price 1973, 1979).

There were two species known to be introduced in Lakshadweep from mainland India (Lever 1987; Ali & Ripley 1978). Common Myna occurring in some of the islands in Lakshadweep is a result of species introduction and House Crow were probably established recently as a result of introduction through natural colonization from neighboring Maldives.

Andaman and Nicobar Island is the place in India which is exposed to higher number of introduced species of flora and fauna. But compared to the other islands in the world, this number is very low. Mohanraj et al. (1999) have given a detailed account of species introduction in Andaman and Nicobar Islands in the book “Perilous Aliens”. In this book they have explained different phases of colonization of people, as people are the main agents responsible for species introduction. There were total 566 plant species, 3 snail species, 4 insect species, 19 bird species, 12 mammal species, 13 marine fish species and one virus introduced intentionally to Andaman and Nicobar Islands (Mohanraj et al. 1999).

A study on introduced herbivores in the Andaman Islands was done by Ali in 2004, reported that Elephant *Elephas maximus*, Chital *Axis axis* and Barking deer *Muntiacus muntjak* were established well in these Islands. Sivaganesan & Kumar (1995) have conducted a detailed study on introduced elephants of Interview Islands in Andaman. Approximately 40 elephants were released in 1962 to the Interview islands and after 30 years it was estimated about 70 individuals of Elephants (Sivaganesan 1993; Sivaganesan & Kumar 1995). However, Kumara et al. (2012) reported that, the elephants’ population has declined to below 15 individuals.

A total of 19 species of birds were introduced to Andaman and Nicobar Islands from mainland India during the first half of the 19th century (Lever 1987; Mohanraj et al. 1999; Kazmierczak 2000; Rajan & Pramod 2013). Of these introduced species, only six species Common Myna, House sparrow, Rock Pigeon, Grey Francolin, House Crow, Indian Peafowl were surviving here now. Of these six species, Grey francolin population was very restricted to one place and Indian Peafowl was restricted to Ross Island (Rajan & Pramod 2012). According to Ali (2004), introduced Common Myna may compete with native birds especially with hole nesting birds, which might be a limited resource in Andaman and Nicobar Islands. There were no detailed studies on these introduced species on these islands, but lists are available in different articles. Bump & Bump reported, Chinese Francolin was

introduced to Andaman during early 19th century, but there was no further report on that. Grey Francolin was introduced to Port Blair about 1890 and it has not established well in all places, however this species is still surviving as small population (Abdulali 1965; Ali & Ripley 1978; Lever 1987; Rajan & Pramod 2012, 2013). According to Kloss (1903), Rock Pigeon was introduced to Car Nicobar. Abdulali (1967) suggested that, this species established in Nicobar Islands as well as in Port Blair. Rajan & Pramod (2012) reported that, Rock Pigeon was common in most of the main human settled islands of Andaman especially in large numbers in urban areas.

Lever (1987) reported that, Red-whiskered Bulbul *Pycnonotus jocosus* was introduced to Nicobar Islands from Port Blair. In about 1860s, Colonel R. C. Tytler introduced three species of birds, Common Myna, House Crow and Jungle Myna to Port Blair (Lever 1987; Mohanraj et al. 1999). Except Common Myna, the other two species such as Jungle Myna and House Crow could not establish populations. However, a small population of the House Crow was reported by Pittie (1988), and has been recorded more recently in 2002 with seven individuals; their numbers are now increasing rapidly in Port Blair and nearby areas (Ali 2003; Rajan & Pramod 2012, 2013). According to Abdulali (1965), House Sparrow and Indian Pea Fowl were introduced to Ross Islands in South Andaman. Indian Pea Fowl was introduced in about 1868 and they were destroyed during the Japanese colonization in these Islands, but after the liberation of Andaman and Nicobar Islands, re-introduced to these Islands and still there is Indian Pea Fowl population in Ross Islands (Lever 1987; Rajan & Pramod 2012). House Sparrow was introduced by Mr. O. H. Brookes in two attempts, six individuals were brought first in 1882 followed by 20 more in 1895 (Lever 1987). Common Myna and House Sparrow were the most successful bird species in the Andaman and Nicobar Islands. Most of the surviving exotic avifauna have maintained their self-sustaining populations near urbanized areas of Andaman Islands.

Introduced species can have serious effects on native species and habitats; and biological invasions are a widespread and significant component of human caused global environmental change through breakdown of the regional distinctiveness of Earth's flora and fauna and there is good evidence that biological invasions contribute substantially to extinction (Vitousek 1994; Vitousek et al. 1997). The Convention on Biological Diversity

(CBD) 1992 suggested that, biological invasion is the second worst threat to biodiversity after habitat destruction (Jenkins 1999). Introduced species are one of the major threats to island biodiversity and the Andaman and Nicobar Islands is not different from other Islands (Mohanraj et al. 1999; Ali 2004). Impacts of species invasion and importance of their prevention have been repeatedly addressed at international and regional levels. Recently, the International Union for Conservation of Nature and Natural Resources (IUCN) requested the “Species Survival Commission” to look after invasive species a primary focus for its global action, supported by the Invasive Species Specialist Group (ISSG). Thus recently produced the “Guidelines for the Prevention of Biodiversity Loss caused by Alien Invasive Species” (IUCN 2000). There are many eradication attempts also made by different agencies worldwide especially Common Myna eradication programme (Feare et al. 2011). According to Simberloff (2002), control of the invasive species can be done through three stages, (1) keeping them out; (2) if they get in, finding and trying to eradicate them quickly; and (3) if they cannot be eradicated, managing them at low levels.

3.1. INTRODUCTION

The Andaman and Nicobar Islands were constituted into a Union Territory in November 1956, and are located in the Bay of Bengal, mid way between peninsular India and Myanmar. These islands are located between 6° 45' and 13° 41' North latitudes, and 92° 12' and 93° 57' East longitude and spreading like a broken necklace in the North-south direction. There are 572 islands which can be distinguished into two groups geographically. Islands located north of 10° N latitude are known as Andaman group of Islands while islands located south of 10° N latitude are called Nicobar group of islands. Of the total 572 islands, only 39 islands are inhabited. The sandy beaches on the edge of oblique coastline are fringed with coconut trees that swing to the rhythm of the sea. Of the 306 named islands of this archipelago, large parts are designed as protected areas in the categories of 94 sanctuaries, four national parks, two marine national parks, one biosphere reserve (Great Nicobar Biosphere Reserve) and tribal reserved area. The land area of 6408 km² in the Andaman constitutes 88.2% as reserves and protected areas of which 36% is tribal reserve.

The Andaman has Indo-China affinities and the Nicobar has Indo-Malayan affinities (Ripley & Beehler 1989). The nearest land mass is ~1350 km away from west main land India, ~630 km east from Peninsular Malaysia, ~190 km South from Sumatran Coast. Andaman Islands are also home to four aboriginal tribes of humans in India, all of who still use bows and arrows and are struggle to safeguard their territories from the outside world. Islands tend to evolve a set of species endemic to them because of long isolation from other large land- masses. The rare flora and fauna, underwater marine life and corals, with crystal clear water and mangrove-lined creeks, offer a dream-view of the rare gifts of nature.

About 50% of the forests have been set aside as Tribal Reserves, National Parks and Wildlife Sanctuaries, which are inviolate. Luxuriant mangroves, perhaps the richest in the world, occupy most of the coastal belts of the Islands. Andaman and Nicobar Islands have 144 species of flowering plants and 75 species of land snails and birds like Narcondam

Hornbill *Aceros narcondmi* and Nicobar Megapode *Megapodius nicobariensis* which are not found anywhere else in the world (Hussain 1984; Sankaran 1995).

3.2. CLIMATE

The climatic conditions of Andaman and Nicobar Islands are similar to that of the Western Ghats of peninsular India and Sri Lanka. As all these areas lie in the tropical zone and experience high rain fall from the South-West and North-East monsoon. The proximity of sea and abundant rainfall prevents extreme of heat. During the S-W monsoon winds are moderate. There were no constant rainy days during the year, but sometimes Islands are exposed to cyclones with heavy rain and strong wind. Usually Northern part of Andaman Islands is exposed to higher amount of annual rainfall than Southern part of Andaman (DES 2009). During 2008 to 2011, North and Middle Andaman received high amount of annual rainfall in (2011 - 5361.3 mm) followed by South Andaman (2008 - 4152.6 mm) and Hutbay (2011 - 3350.0mm). The Andaman received highest rainfall in the September of 2011. The period of December to February is comparatively cool due to effect of North-Eastern monsoon. The warm weather extends from March to April with low precipitation. The average annual rainfall is 3000-3500 mm. Temperature ranges for 20 to 32 degree Celsius. So far, highest temperature received is in April'2010 (34.2 degree Celsius). Humidity varies from 60% to 85% (DES 2009).

3.3. LAND USE PATTERN

Most of the inhabited area is used for agricultural purpose or township area. In Andaman Islands, about 224 sq.km area is under cultivation (Paddy, Plantation, spices, fruits, vegetables, etc). Areca nut and Coconut are the main terrestrial crop (~103 sq.km), while paddy is the main food crop (120sq.km) followed by vegetables. Settlers of these Islands are cultivating vegetables in large quantity during particular season.

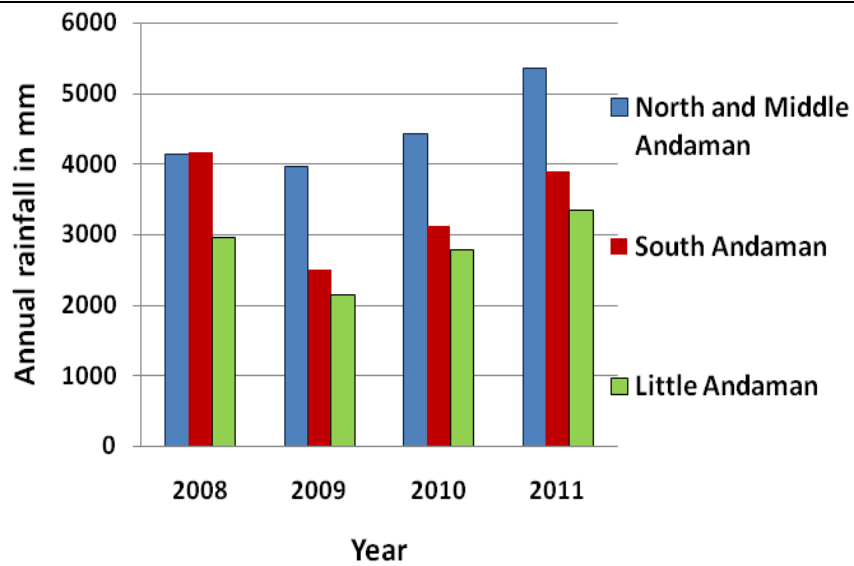


Figure 3.1: Annual rainfall of Andaman Islands during 2008 to 2011

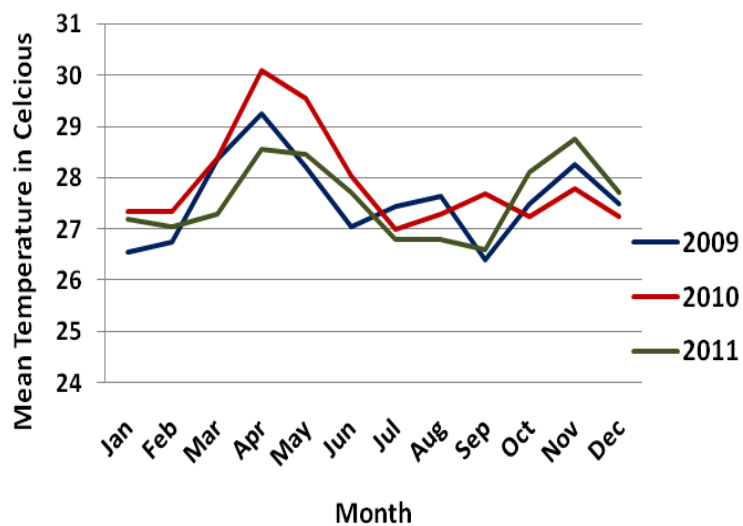


Figure 3.2: Temperature variations of Andaman Islands during 2008 to 2011

(Source: DES 2009)

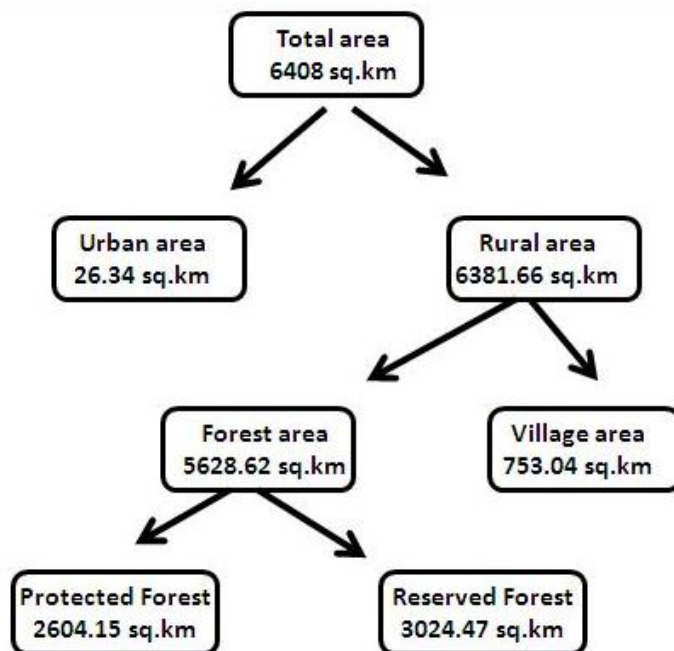


Figure 3.3: Land use pattern in Andaman Islands

(Source: DES 2009)

3.4. FLORA AND FAUNA OF THE STUDY AREA

Andaman and Nicobar Islands constitute one of the hot spots of biodiversity with a variety of ecosystems. The forests of the Islands are one of the richest in the country in terms of biodiversity and a large part of them are still unexplored. Insular nature and physical isolation of the Andaman and Nicobar Islands from main land is the reason for evolution of rare and distinct flora & fauna. The biodiversity of these Islands shows marked changes from one Island to another. Adjoining islands may have forest types of their own, and compositions of one island may not be same as the other.

The close proximity of Andaman and Nicobar groups of Islands to the equator and good amount of rain fall, in addition to rather fertile soil, have generally contributed to the formation of rich forests, both littoral and inland vegetation. The littoral vegetation includes mangroves, strand or beach forest and swamp or tidal forest. However, in Nicobar Island swamp forest is almost absent.

The flora of Andaman group of islands is distinctly different from that of the Nicobar group which is evident from the fact that the genera *Pterocarpus* and *Dipterocarpus* are common in Andaman Islands, are not found in Nicobar Islands. While the Melastomaceous genera *Otanthura* and *Astronia*, the Gesneriaceous genus *Cyrtandra*, *Stemonurus* of the Icacinaceae, *Bentinckia* and *Rhopoloblaste* of the Arecaceae, *Spathoglottis* of the Orchidaceae and many more species occurring in the Nicobar Islands are locally absent in the Andaman Islands. There is one endemic genus in the Andamans, namely *Pubistylus*. Endemic species in Andaman include *Ailanthus kurzii*, *Amoora mannii*, *Dichapetalum andamanicum*, *Mangifera andamanica*, *Planchonia andamanica*, *Pubistylus andamanensis* and *Strobilanthes glandulosus* (Thothathri 1962). The discovery of a wild relative of rice, *Oryza andamanica* (Ellis 1985), indicates that the islands contain potentially important genetic resources. Sea grasses are also found along the coastal line of these island. The long coastal line of Andaman and Nicobar Islands is 1962 km and it is one fourth of the Indian coastal line. The mangrove forest of Andaman are rich in species composition and highly diversified, about 60 mangrove species were reported from Andaman and Nicobar Islands, distributed among 27 families and 17 genera in the Andaman and Nicobar Islands. The species like *Avicennia officinalis*, *Bruguiera gymnorrhiza*, *Heritiera littoralis*, *Rhizophora apiculata*, *Rhizophora mucronata* are very common species, but *Cynometra iripa* and *Xylocarpus gangeticus* are very low in abundance.

About 62 mammals are reported in the Andaman and Nicobar Islands. Of them, 32 species of them are endemic, including the Andaman Wild Boar *Sus scrofa andamanensis*. Rodents are the largest group with 26 species, followed by 14 species of bat. Among the larger mammals there are two endemic subspecies of wild boar, *Sus scrofa andamanensis* from Andaman and *S. s. nicobaricus* from Nicobar, which are protected by the Wildlife Protection Act 1972 in schedule- I. Most of these mammals are understood to have been brought it from outside and are now considered endemic due to their prolonged insular adaptation. 301 species of butterflies in 116 genera, five families and three sub families were identified in Andaman and Nicobar Islands. Out of them, 136 species are seen only in Andaman and 100 species are seen only in Nicobar group, and remaining 65 are seen in both Islands (Ferrar 1951; Khatri 1989). Birds are another group of fauna with good diversity in this archipelago. There were 259 species (297 species and subspecies) reported from these

Islands by various researchers (Abdulali 1964; Sankaran & Vijayan 1993; Yahya & Zarri 2002a; Pande et al. 2007; Rajamamannan 2010; Rajan & Pramod 2011).

3.5. INTENSIVE STUDY AREA

Andaman Island is a group of big and small picturesque islands in the form of narrow broken arc which is in north-south in direction. Andaman Island group consists of four large islands such as Little Andaman, South Andaman, Middle Andaman and North Andaman. Of these, South, Middle and North Andaman Islands are located very closely and divided by about 100 meters wide sea between them. Richie's Archipelago located in Andaman Sea and Little Andaman is located 120 km south of South Andaman. The present study was carried out in the ten islands of the Andaman group, which include Little Andaman, South Andaman, Ross Island, Baratang Island, Middle Andaman, North Andaman, Interview Islands, South Button Island, Neil Island and Havelock Islands. Of these, seven Islands are inhabited. These ten study sites were clubbed into five groups. The five clubbed groups are Little Andaman Island, South Andaman Islands includes Ross Island, Middle Andaman Islands (which include aratang and Interview Island), North Andaman Islands and Richie's Archipelago (which include Havelock, Niel and South Button Islands).

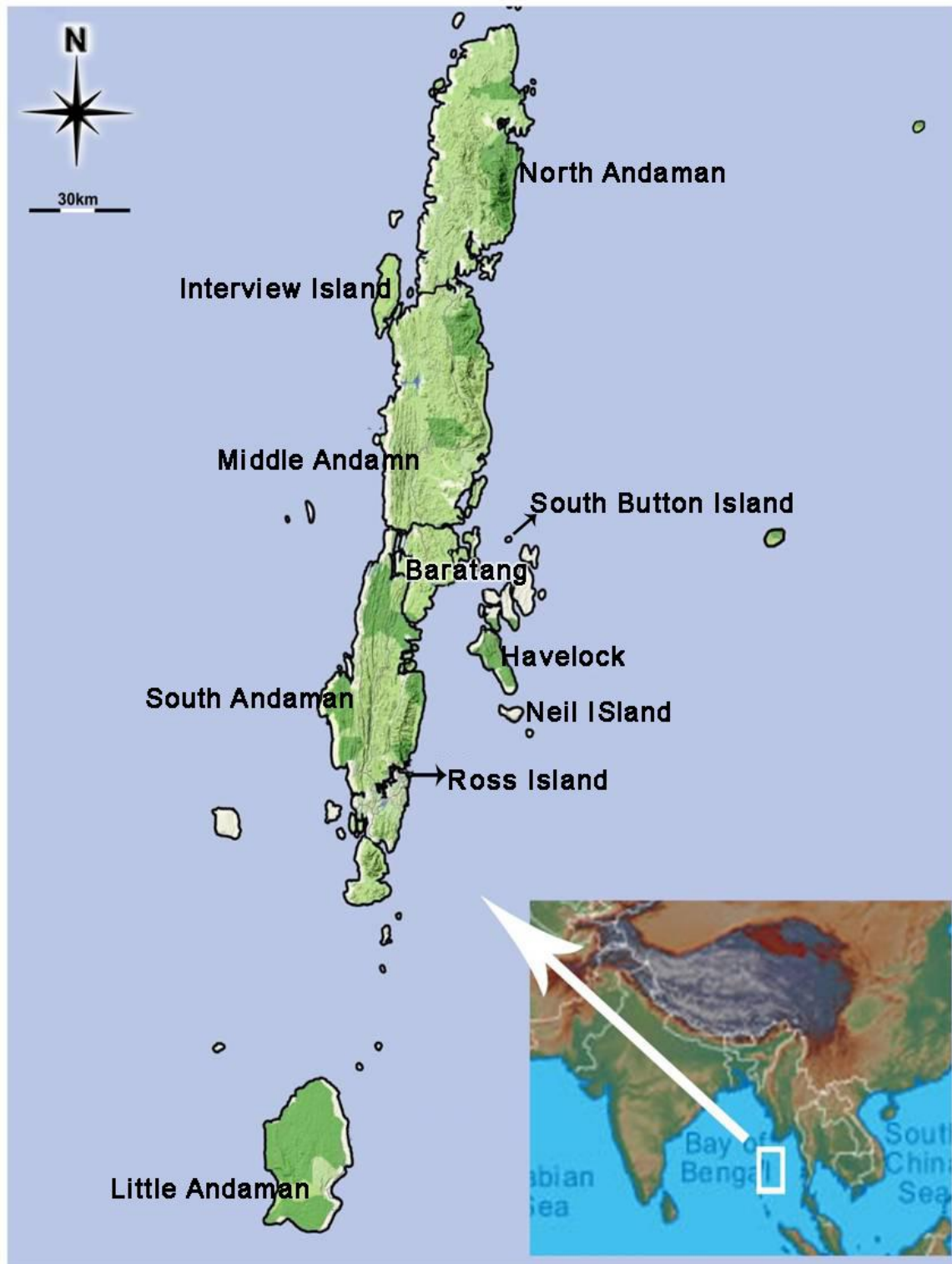


Figure 3.4: Map of Andaman Islands (Source: www.maps.google.com)

3.5.1. Little Andaman Island

Little Andaman Islands is located between 92°21' to 92°38'E Longitude and 10°28' to 10°54' N Latitude and 120 km away from Port Blair by ship route, but only 68 km distance between South and Little Andaman Islands. Population is 17528 as per the 2001 census and total area is 734.39 sq.km. Of the total area, nearly 700 sq.km area is under reserved forest cover, all other area is inhabited. The main plantations in the inhabited area were Areca nut *Areca catechu*, Coconut *Cocos nucifera*, Red Oil Palm plantations. Little Andaman is long isolated from all other Islands in Andaman and Nicobar Islands and south 10 degree channel separating this Islands from Nicobar Group. Dugong Creek is located here and it is the only place where the aboriginal tribes Onges' settlement. This Island is also famous for Red Oil Palm Plantation, which spread over an area of 15.93 km². The main villages are Hutbay, Rabindra Nagar, Vivekanandapur, Ramakrishnapur, Herminder Bay and Dugong Creek.

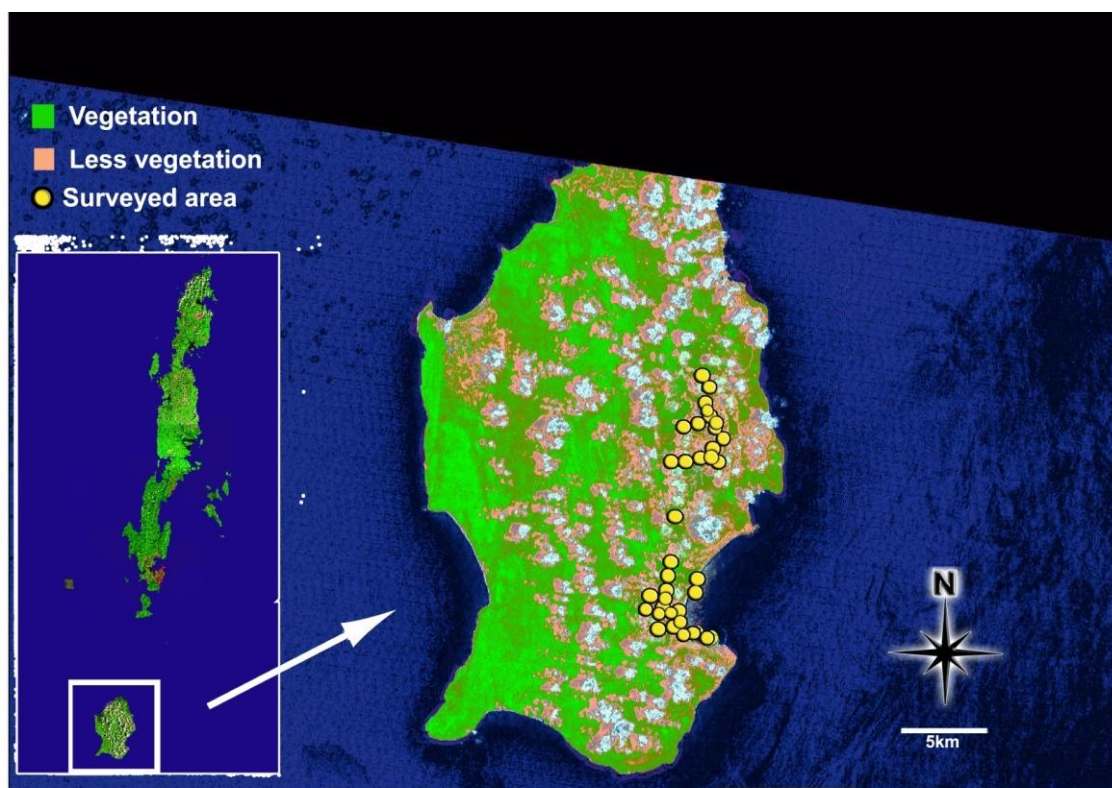


Figure 3.5: Little Andaman island with survey points

3.5.2. South Andaman Island

South Andaman Island is the most populated island in the Andaman and Nicobar group of Islands located between 92°30' to 92°59'E Longitude and 11°27' to 12°16'N Latitude. Port Blair is the only urban area 1347.7 km² in these islands. More than 65% area is under the thick canopy cover because of Jarawa reserved area in Northern part and Mount Harriet National park in Eastern side of Andaman. Southern parts are mostly settlement areas with high population and most of the people in Port Blair area are Government servants. As per 2001 census, the South Andaman Island population was 1,81,949. Mount Harriet National Park, Chidiyatapu Biological Park and Mahatma Gandhi Marine National Park, Wandoor are some of the notable protected areas in this Island. Second highest peak in Andaman is located in Mount Harriet National Park. This area has thick evergreen vegetation which is a good place for birding, butterflies watching and trekking. The capital of Andaman and Nicobar Islands is located in the South Andaman and it has all Government office head quarters including Navy, Air force and Army stations. Ross Islands is ~1km away from Port Blair and it is the place where British penal colony was situated.

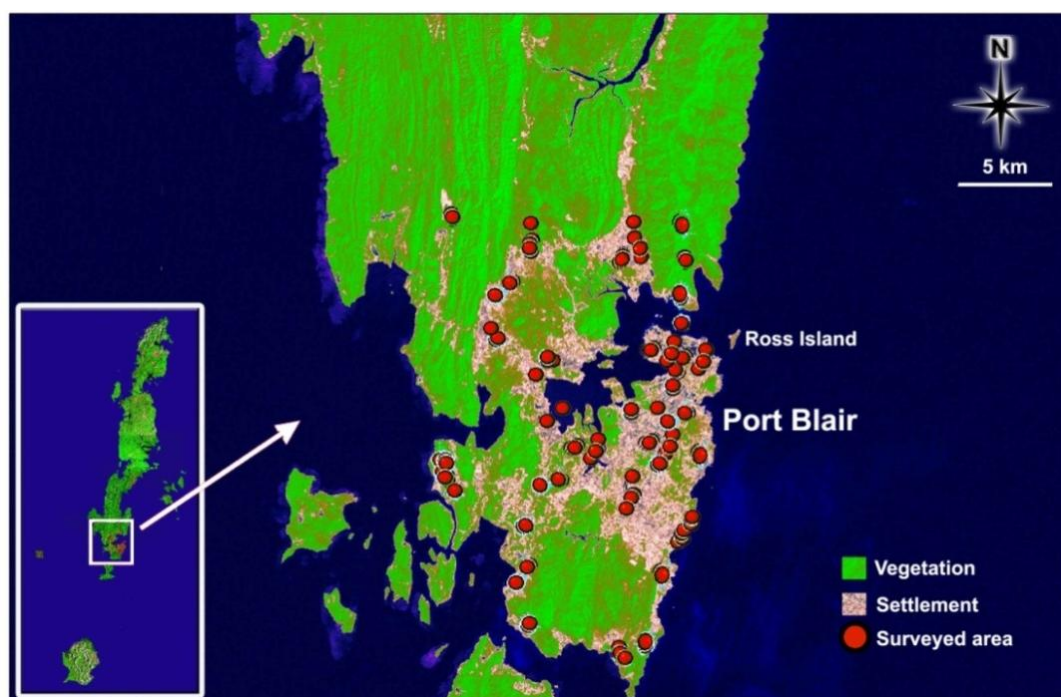


Figure 3.6: South Andaman Island with surveyed points

3.5.3. Middle Andaman Islands

Middle Andaman Island group is located between 92° 38' to 93° 00'E Longitude and 12° 03' to 13° 00'N Latitude. Middle Andaman Island is the largest islands (1535 km²) in the Andaman and Nicobar Island. Baratang Island (297 km²) and Interview Island (133 km²) are also included in the Middle Andaman group in the present study. The South-west part of Middle Andaman is also reserved area for aboriginal tribes “Jarawa” other than Jirkatang to Middle Staright area. As per the 2001 census, the population is 54385 peoples residing in 101 revenue villages, the main places in this island are Kadamtala, Rangat, Betapur, Billy ground and Mayabunder. But 1535 km² area is under reserved forest (mainly deciduous forest) and 82.61 km² under cultivations. Baratang is situated south of Middle Andaman and this Island is connecting South and Middle Andaman Islands. Baratang Island has nearly 283 km² under protected forest and onegood tourist spot (Limestone Cave and Mud Volcano) in the Andaman. Interview Island was declared Wildlife Sanctuary and has only forest camp and one police outpost. This island has good evergreen forests includes inland and mangrove patches, land of feral elephants, birds and butterflies.

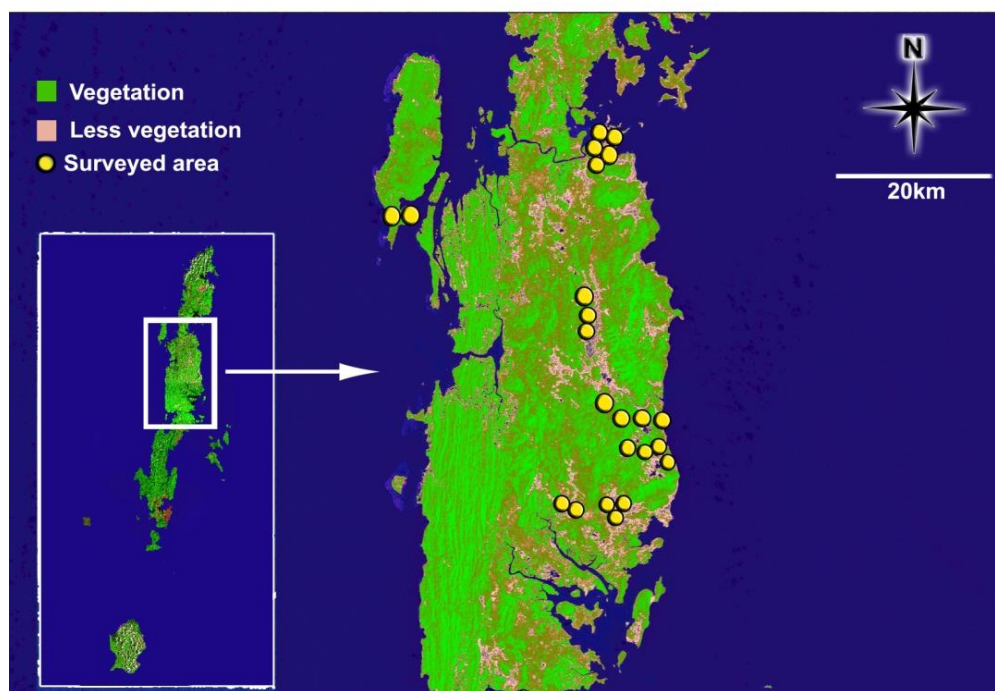


Figure 3.7: Middle Andaman Island with survey points

3.5.4. North Andaman Islands

North Andaman Island is located between 92° 40' to 93° 08'E Longitude and 12° 52' to 13° 36'N Latitude, population is 42163 as per the 2001 census in 1375.99 km² area. Of the total area, 87.5 km² is under cultivation and settlement (Island wise statistical Outline, 2008). Diglipur is the heart of the North Andaman with most of the population and market. Panigat bridge connects between Middle Andaman and North Andaman Islands. According to Statistical department of Andaman and Nicobar islands, there were 68 inhabited villages including 30 revenue villages and 34 forest encroached villages. Southern part of North Andaman Islands still has good forest areas. The highest peak (738m) and only one Hydroelectric Power plant (Kalpong) in the Andaman and Nicobar Islands is located in this Island. Coral reefs in the Northern coastal area of this Island is exposed above the water due to 2004 Tsunami tilts of the Andaman and Nicobar plate.

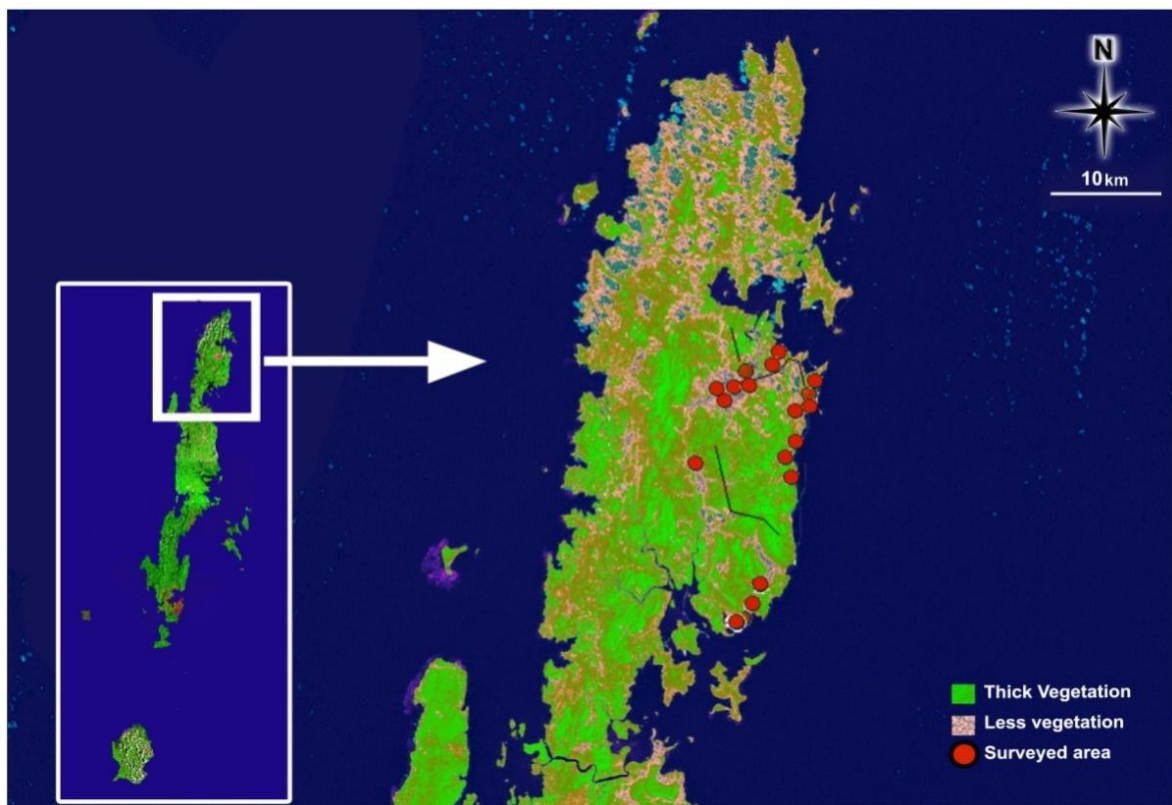


Figure 3.8: North Andaman Island with survey points

3.5.5. Ritchie's Archipelago

Ritchie's archipelago is located ($92^{\circ} 54'$ to $93^{\circ} 10'E$ Longitude and $11^{\circ} 48'$ to $12^{\circ} 15'N$ Latitude) East of South Andaman Islands and geographically 18 km away from North of South Andaman Island. It comprises of a cluster of small Islands, Havelock and Neil Islands are the main inhabited islands in this archipelago. Havelock Island is the biggest Island in this group with 113.93km^2 area and five villages with population of 5354 (2001 census). Neil Island is small, 18.9km^2 area with 5 inhabited villages and population is 2868 (2001 census). Of the total area of archipelago only small area is under the forest (6.47 km^2), however Havelock Island has more than 75% under the thick forest.

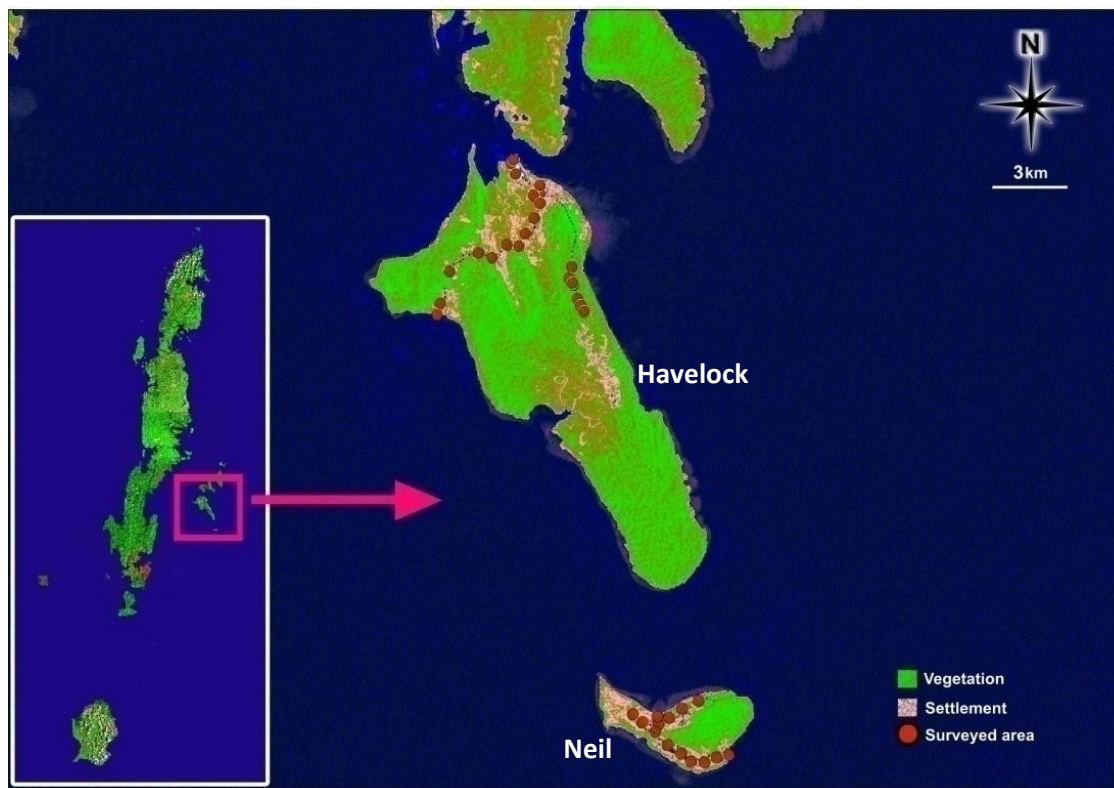


Figure 3.9: Ritchie's Archipelago with survey points

STUDY DESIGN AND METHODOLOGY

4.1. INTRODUCTION

Birds of Andaman and Nicobar Islands have been studied by various researchers from early parts of 1860s and still bird studies in Andaman and Nicobar Islands are being conducted by many researchers. However detailed scientific studies on species composition, distribution and community structures are lacking. Abdulali (1965) made list of Birds of Andaman and Nicobar Islands, later Sankaran & Vijayan (1993) have done updated bird listing (270 taxa including Subspecies) of these Islands. Recently some of the researchers reported a few new site records on species to these Islands.

At first, this study has attempted to compile all the secondary data related to the birds of Andaman and Nicobar Islands and makes a clear picture about the bird species composition of Andaman Islands. It is subjected to analysis for community attributes of bird fauna. Secondly, a systematically planned field study was conducted on the birds of human associated areas of Andaman Islands. . Thirdly, introduced bird species of Andaman Islands. Thus, for the convenience of analysis, birds considered in this study are categorized into three groups such as (1) Total bird fauna, (2) Birds of human associated areas and (3) Human introduced birds.

4.2. STUDY DESIGN

4.2.1. Plan of study

This study has been divided into three levels each level is dealt with in a separate chapter in the thesis (Figure 4.1)

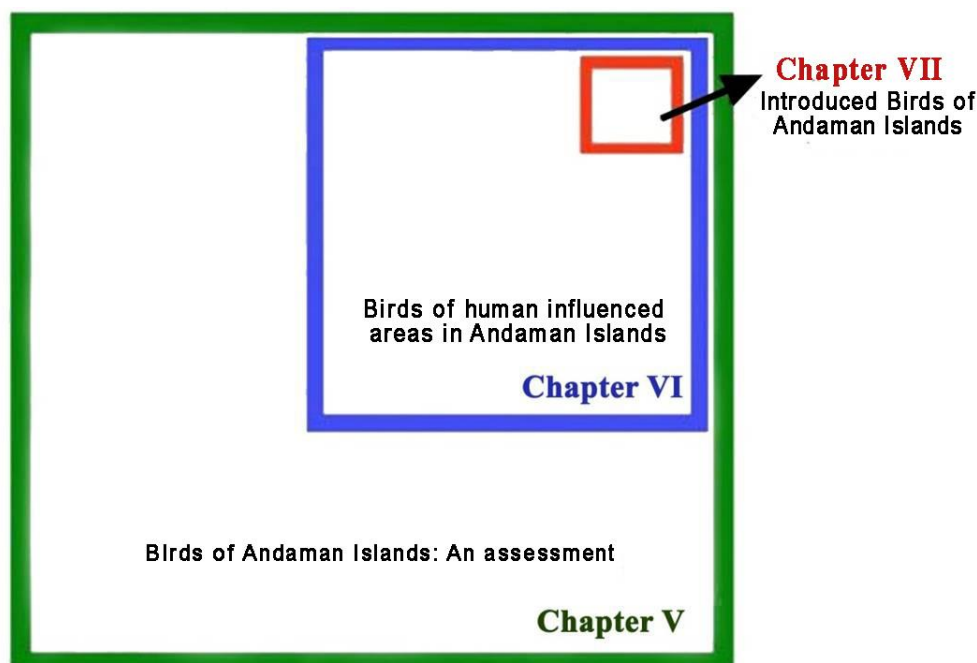


Figure 4.1: Organization of three result chapters

In the first level, primary and secondary data collected were used to update the checklist of Andaman and Nicobar Avifauna. Then compositional analysis of birds of Andaman and Nicobar Islands were done. All the literature related to bird list information and new species reports of Andaman and Nicobar Islands published till 2012 were compiled to make the updated list of Birds of Andaman and Nicobar Islands. Then community attributes of the Andaman birds were analyzed and broad patterns were studied. Emphasis was also given to island wise distribution and species composition between islands.

In the second level, primary data collected through systematic field study is analyzed to understand the community attributes of birds in human modified areas in Andaman Islands. Six different habitats such as Urban, Rural, Inland wetland associated area, Coastal associated area, Disturbed forest area and Undisturbed forest area were surveyed using line transects, point counts and total count methods to study the bird species composition, diversity and population patterns. The six different habitats were considered for analysis and in some case; they are grouped into three categories according to the similarity in substratum and human influences. In this chapter, comparison of bird species composition with respect to different Islands and habitats are attempted.

In the next and third level, a detailed study of the introduced species of the Andaman Islands is attempted with standardized field techniques. This chapter includes relative population analysis and distribution of six surviving introduced bird species in the six different habitats of selected Islands. Line transect method and point count methods were used to study the distribution of the introduced bird species in the selected Islands and different habitats in the Andaman Islands. Roost count method and nest searching method were used to study the possible impacts of Common Myna *Acridotheres tristis* and their possible competitors in Andaman Islands.

4.3.SAMPLING STRATEGY

4.3.1. Bird Fauna of Andaman and Nicobar Islands

The list of birds in Sankaran&Vijayan (1993) was considered as the basic list because they have compiled all the previous available literature, after that nobody did any compilation of birds of Andaman and Nicobar Islands. There was a lot of confusion in the literature regarding species and subspecies status of the birds and the numbers in the available list. A compilation of bird list is attempted based on the available list and recent peer reviewed publication. Classification adopted in this study was according to Birdlife International check list 2012 (BirdLife International 2012). Species level and subspecies level resolutions were considered separately to make further taxonomic clarifications.

4.3.2. Stratified sampling

An appropriate sampling strategy was decided, keeping in mind the objectives of the study. To study the Island-wise and habitat-wise distribution pattern of birds and population changes, it was decided to adopt stratified sampling procedure. The efforts were distributed representatively according to the human influenced areas under the habitats available in the islands under study.

4.3.2.1. Island wise data collection

In this study, ten Islands namely Little Andaman, Ross Islands, South Andaman, Baratang, Middle Andaman, Neil Islands, Havelock Islands, South Button Island, Interview Islands and North Andaman were surveyed. Of these eight Islands are inhabited and two (South Button Island and Interview Island) are non inhabited islands. These ten Islands are grouped into five main Island groups such as Little Andaman, South Andaman, Middle Andaman, Ritchie's Archipelago and North Andaman Island, on the basis of geographical distance between Islands. The four Andaman groups of Islands are comparatively big in size but size of the Ritchie's Archipelago is very small as compared to other Island groups, but for this study, Ritchie's Archipelago taken as separate island group because of long isolation between main Islands and this archipelago.

4.3.2.2. Habitat wise data collection

Classification of habitat into different groups on the basis of habitat characters is very important, because it would make multivariate data into simple and understandable. On the basis of this assumption, six different habitats namely Urban area, Rural area, Inland wetland associated area, Coastal associated area, Disturbed forest and Undisturbed forest of each Islands were surveyed for the present study to test habitat preferences of bird species of each habitat. Details of each habitat studied are given below

i) Urban area: These are the areas with maximum human built-up areas. It includes mainly township and industrial areas, high number of land-cover types, including areas with a mixture of constructed materials and vegetation. It can almost be described as transformed habitats where there are more buildings, parks in the city. Weeks (2010) states that, urban is a place-based characteristic that incorporates elements of population density, social and economic organization, and the transformation of the natural into a built environment. Urban area of present study included town center such as Port Blair, Hutbay, Rangat, Mayabunder, Barathpur in Neil Island, Havelock and Diglipur town.

ii) Rural area: Rural areas has Small Population, sparse settlement, and remoteness are the main features of rural areas (Hewitt 1989). These are the areas away from the urban areas but have human settlements, agricultural lands and rural areas with small shops.

iii) Wetland associated area: Wetland associated areas are the landscape characterized by water submerged land, whether swamp, bog, marsh. Some dries up seasonally. The shallow water can be fresh, brackish or salty. It can be mudflat, grassy or marshy land. In Andaman Islands, flooded wetlands of Andaman are with mixture of different micro habitat such as grassland, marshy, mudflats, stagnant water area. Present study conducted in the Grassy wetland, Tidal mudflats, wetland cultivated area such as rice field and Tsunami inundated areas of Andaman Islands.

iv) Coastal associated area: Coastal areas are commonly defined as the interface or transition areas between land and sea also characterized by the vertical accretion of near-shore land (Scialabba 1998). Coastal associated areas in this study are the rocky or sandy land edges that face the sea. These are complex and diverse habitats that lie above the sea water line, exposure to salty spray, wind, sun and rain. Present study covered sandy beaches and rocky beaches along the west and east coast of Andaman Islands.

v) Disturbed forest: These are forests that contain a few very dominant species in their canopies and show very little floristic differentiation after disturbance (Kappelle et al. 1996; Guariguata et al. 1997). In other words, these are the woodlands with regular human activities and hence they are close to the rural landscapes.

vi) Undisturbed forest: These are the forest with very minimal human activity especially in terms of woods and vegetation, which have been excluded from human intervention for a long (Schuck 1994). These locations have the floristic compositions almost similar to the totally undisturbed forest far away from all external human activity; however they are nearer to the rural area.

4.4. METHODS

4.4.1. Study area selection

To study the human associated and introduced birds of Andaman Islands, mainly inhabited Islands of Andaman group were selected because of 98% human population of Andaman Islands occupied in the main seven Islands such as Little Andaman, South Andaman, Baratang Island, Middle Andaman, Havelock Island, Neil Island and North Andaman. Six habitats on the basis of availability were selected for point count survey. In a specific habitat of an island, the study spots were decided randomly through a lot system. The location of the transect were not prefixed with a prior design. However the study ensured maximum coverage of the area and habitats in each island through transect counts.

4.4.2. Field methods

A wide range of methods have been used to conduct avian monitoring, each designed to meet a different set of objectives. Details of selected field methods used in this study are given below.

i) Line transect method

Line transect is one of the most commonly used sampling techniques to estimate avian species composition and density (Whitworth et al. 2007). In this study, birds were counted using 1 km line transect (following Bibby et al. 2000). A single transect was of one hour duration between 06.00 hrs to 09.30 hrs and 15.00 hrs to 17.30 hrs. The study was conducted during the period of 2008 to 2011. The width of transect was 100 meter (50 meter each side). Numbers of individuals were noted for the relative abundance and diversity estimation. Bird species were identified in the field and unidentified individuals were photographed and identified with help of field guide and literature. Transects were systematically placed in five inhabited Island groups of Andaman. Total 221 transect counts were conducted, maximum transects (102 transects) were laid in South Andaman group of Islands because this island has more than 50% human population of the Andaman Island group. Year wise distribution effort is nearly equal in all the years (2008-69 transects, 2009-62 transects, 2010-62 transects), except 2011 (28 transects). Line transects were laid in six habitat of these Islands representatively. This includes Urban area (31), Rural area (65), Inland wetland associated area (47), Coastal associated area (25), Disturbed forest (31) and Undisturbed forest (22).

ii) Point count method

A fixed radius point count is the basic method recommended for many bird monitoring studies, and is widely used (Ralph et al. 1993; Ralph et al. 1995; Bibby et al. 2000). These can provide a cost-effective method of estimating the relative abundance of birds. Distribution according to habitat was done using this method. In this method, the observer records the individual bird species within a radius where the observations are taking place. Point counts are essentially strip transects of zero length in which the observer performs the count in a 360° arc around a fixed survey station (Whitworth et al. 2007). Point stations were placed in transect with 100m interval along the transect line. Fragmented habitat of Andaman Islands forced to take random point stations in the study area. Birds were sampled systematically with five minutes point count in 30 meter radius (following Bibby et al. 2000) during 2009 – 2011 from six habitats in eight islands. Points were scanned for any new birds while entering and leaving the point count. Total 299 point counts were done in all six habitats and these counts were distributed representatively in all Islands and in all habitats except undisturbed forest.

iii) Total count method

The goal of a total count is to conduct a complete count of all the birds present over a specified area to obtain an unbiased estimate of abundance without statistical inferences or underlying assumptions (Bibby et al. 2000; Whitworth et al. 2007). Inland wetland birds of Andaman Islands were surveyed with one hour duration. Inland wetland areas of Andaman are very small as compared to mainland and are easy to count completely. All birds of Inland wetland associated area surveyed by scanning flocks of birds which usually comprise several species, with a spotting scope or with binoculars as appropriate and details were recorded in the field note. All birds were identified from the field itself using field guide (Kazmierczak 2000). Total 12 total counts were done to estimate the species in the wetland of Andaman Islands.

iv) Roost count method

Roost count method was adopted to count colonial roosting of Common Myna and Parakeets in the Andaman Islands. It is very difficult to estimate exact number of colonial roosting birds such as Common Mynas and Parakeets because of their huge flocks. This

study followed block count to estimate number of birds of each species during roosting time. Block count is easy to count large number of birds at a time and experienced counters can accurately estimate 10, 20, 50, 100 or more birds almost instantly (Wetlands International 2010). Total 15 roost counts were conducted seasonally in the mangrove of Sippighat to study the possible impacts of Common Myna to other native species such as starlings and parakeets

v) Nest searching method

After the systematic counts and surveys, search for active nests were conducted in all the locations. Nest searching method was conducted for only selected species, mainly the major introduced species like Common Myna and their competitors. When a new nest was found, the first priority was to ensure that the nest is active or abandoned. Total 78 active nests of Common Myna and Asian Glossy Starling *Aplonis panayensis* were observed. After that all the nest associated variables to study the bird preferences for nesting location were noted down.

4.5. STRUCTURE OF DATA

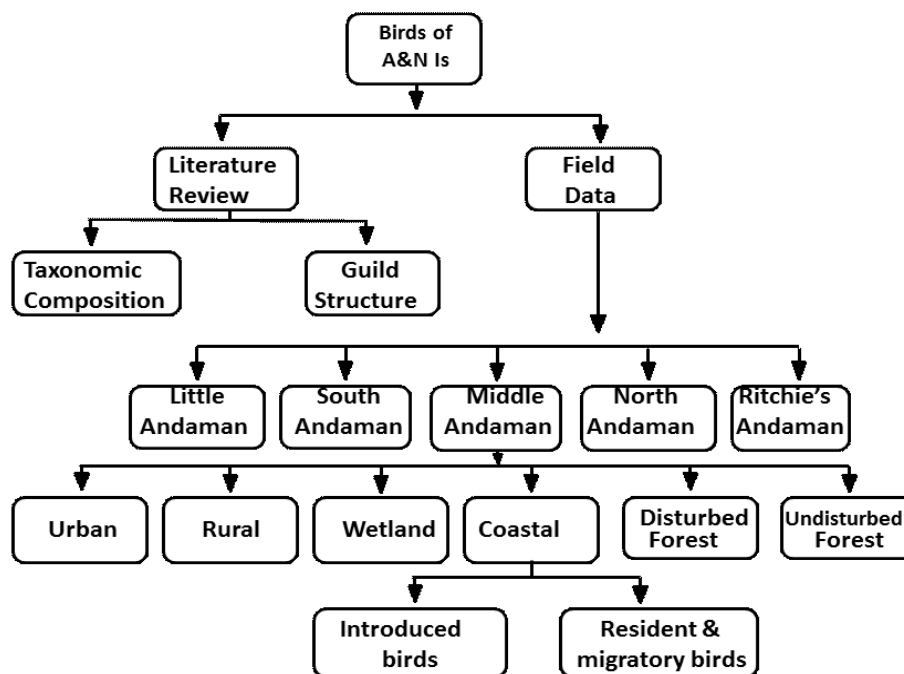


Figure 4.2: Structure of the data

4.6. METHOD OF ANALYSIS

Data are subjected to analysis for attributes such as Species diversity (Simpson and Shannon-Wiener index), community composition, recognition of patterns, comparisons between and within groups and testing of significance of pattern. This study used significant statistical tests such as Wincoxon Signed-rank test, Principal Component analysis (PCA), Cluster Analysis (Jaccard Similarity Index), Man-Whitney U test, etc. Appropriate statistical tests using different software such as IBM SPSS 20, PAST, XLSTAT, Estimate S, Open Q-gis and Microsoft Excel were conducted.

Six selected habitats for the study in Andaman Islands



1. Urban area
2. Rural area
3. Inland wetland area

4. Coastal area
5. Disturbed forest
6. Undisturbed forest

BIRDS OF ANDAMAN ISLANDS: AN ASSESSMENT

5.1. INTRODUCTION

Andaman and Nicobar Islands have a rich and diverse avifauna. Though many researchers have done studies on avifauna of this Archipelago since 1846, studies on birds' species composition of this Island group still remaining incomplete. Andaman Islands are more human populated compared to Nicobar and exposed to drastic landscape changes as a result of this human pressure and development. The fundamental questions on the species composition of the bird community in terms of its niches, guilds and taxonomic positions have not been analyzed to elucidate the community structure of Andaman birds. This chapter attempts to analyze and present these community attributes of Andaman bird community and compares it with Nicobar Islands.

5.2. METHOD OF ANALYSIS

Data were collected through the available literature which was published in peer-reviewed scientific, containing new species reports and distribution in the Andaman and Nicobar Islands. As mentioned in Chapter 2 (Literature Review), comprehensive checklist published by Sankaran & Vijayan in 1993 presented 228 species of birds for Andaman & Nicobar Islands. If we include the subspecies information, there are about 267 distinct taxa of birds that they have listed in the publication. There were many studies and observations after that which were discussed in chapter 2. Considering all those new findings particularly the authentic ones, the final distribution data of birds with observation locality of Andaman and Nicobar Islands were compiled.

This updated information about species is analyzed to explore the bird community structure and composition in these islands. For nomenclature and classification, the list of BirdLife International 2012 is followed (BirdLife International 2012).

5.3. RESULTS

5.3.1. Over view of Birds of Andaman and Nicobar Islands

A total of 259 species (Annexure 1) (297, species and subspecies together) of birds have been reported from Andaman and Nicobar Islands (Table 5.1). Of these 259 species, 31 species were split into two or more subspecies and all these subspecies occur in these Islands (Annexure 3). 31 species of birds were additional to the available list (Sankaran & Vijayan 1993) and ten species were reported recently (Annexure 2). Common Coot *Fulica atra* one among the 31 species which was recorded recently from South Andaman Islands (Sivaperuman. et al. 2012). Some of the records were based only on single individual records especially some of the new records such as Little Grebe *Tachybaptus ruficollis*, Corn Crake *Crex crex*, Crimson-throated Barbet *Megalaima rubricapilla*, Orphean Warbler *Sylvia hortensis*, Tickell's Blue Flycatcher *Cyornis tickelliae*, Grey-headed Flycatcher *Culicicapa ceylonensis* and Blue-fronted Robin they have to be confirmed with repeated sightings because these records are based only on single sightings without any photographic evidence, so chances of misidentification cannot be ruled out. As they were published in peer reviewed journals, this study included these species into the updated checklist of bird species of the Andaman and Nicobar Islands and put under the category of “confirmation needed”.

Table 5.1: Overview of birds of Andaman and Nicobar Islands

Bird species of A&N Islands	259
Total distinct taxa (including Species and subspecies)	297
Number of Orders	18
Number of Families	58
Additional species to the Sankaran & Vijayan 1993 list	31
Total bird species of Andaman Islands	235
Total bird species of Nicobar Islands	138
Only in Andaman	119
Only in Nicobar Islands	24

Andaman Islands is a vast stretch of lands and providing more numbers of bird species compared to Nicobar Islands. Bird species of Andaman Islands are largely related to Burma-Malayan region, whereas Nicobar avifauna can be considered as subset of Andaman Islands (Ripley & Beehler 1989). A total of 235 bird species were recorded from the Andaman Islands. Among these, 119 were not observed from Nicobar Islands. Sixteen birds were pelagic birds and 61 species were migratory, of which 38 species are waders and 23 species are terrestrial migratory birds. Andaman Nightjar *Caprimulgus andamanicus* and Oriental Reed-warbler *Acrocephalus orientalis* are included in the list, but these species are under “species review” by Birdlife International and so far not recognized as a full species. Nicobar Scops-owl *Otus salius* (Rasmussen & Anderton 2012) is split from the Oriental Scops-owl *Otus sunia* which is found in Andaman Islands and this species is given as Data Deficient by Birdlife International 2012 (BirdLife International 2012).

There were 105 taxa including subspecies that are endemic to Andaman and Nicobar Islands. Of these 105, Andaman island groups have a greater number of endemic species (66 species) as compared to Nicobar group (56 species) (Sankaran & Vijayan 1993), this high degree of endemism is prevalent among subspecies. Total 31 species were split into 69 subspecies of birds (Annexure 3). Of these 53 subspecies are endemic and 39 subspecies were found in Andaman group of Islands. With regard to Ashy Drongo, along with *Dicrurus leucophaeus* there was another subspecies *Dicrurus leucophaeus leucogenys* reported from Andaman and Nicobar Islands (Sivakumar & Sankaran 2002). When comparing endemism, Nicobar Islands are showing a higher degree of endemism (28 exclusive endemic subspecies) whereas only 17 endemic subspecies were occupied exclusive to Andaman Islands. Of the 69 subspecies, 16 subspecies of birds were common to both Islands.

5.3.2. Taxonomic Composition of Andaman Birds

The total bird species of Andaman Islands belong to 18 orders. Passeriformes were the highest number of bird species (75 species), though it is much less compared to the percentage in among all Indian birds or in global level (59%). This is followed by Charadriiformes (46 species), Falconiformes (17 species), Coraciiformes (14 species) and Ciconiiformes (13 species) (Figure 5.1). Little Grebe was the only species in the order

Podicipitiformes. Procellariiformes and Caprimulgiformes are with two species . Andaman Nightjar is under review species in the order Caprimulgiformes.

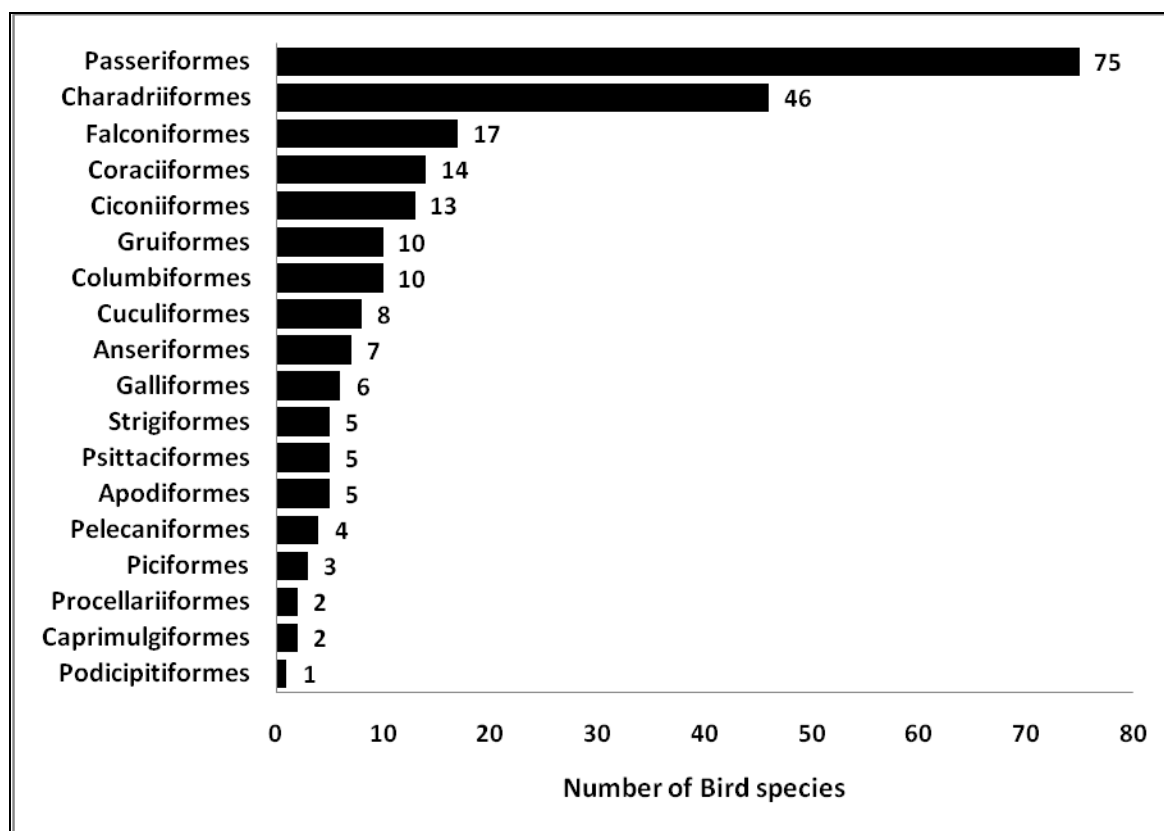


Figure 5.1: Number of bird species in each order of Andaman group of Islands

Avifauna of the Andaman come under 55 families of 18 orders. Scolopacidae is the most species family compared to other families with respect to the presence in Andaman Islands. Scolopacidae family has 24 bird species followed by Acciptridae (15), Ardeidae (12) and Sylviidae, Muscicapidae and Laridae families were 11 species respectively. There are 19 families in Andaman Islands with single species (Table 5.2). Of these 19 single species family, Beach Thick-knee *Esacus giganteus* (Family: Burhinidae) is near threatened species (BirdLife International 2012). 24 families come under the order Passeriformes followed by 6 families in the order Charadriiformes.

According to Birdlife International (BirdLife International 2012), there were six bird species included in the threatened category (two species were exclusive to Andaman, three species were exclusive to Nicobar and one species was common to both Island groups). Endemic Narcondam Hornbill *Aceros narcondami* was the only one endangered species in these Islands. There are five species such as Nicobar Sparrowhawk *Accipter butleri*, Nicobar Megapode *Megapodius nicobariensis*, Great Knot *Calidris tenuirostris*, brown-chested Jungle-flycatcher *Rhinomyias brunneatus* and Yellow-breasted Bunting *Emberiza aureola* included in the Vulnerable category. Of these vulnerable species, Nicobar Sparrowhawk and Nicobar Megapode are the endemic species to Nicobar Islands. Andaman Nightjar and Oriental Reed-warbler were under review species. Twenty species of these Islands were under threatened category (Figure 5.2). Among these threatened birds, 11 species are endemic to these Islands.

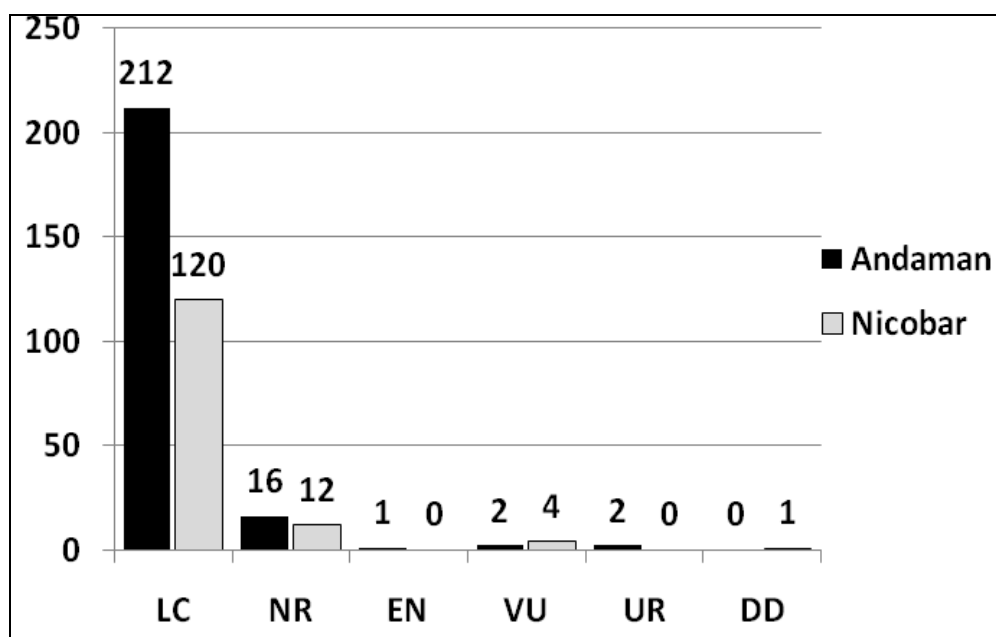


Figure 5.2: IUCN status 2012 of Birds of Andaman Islands: a comparison with Nicobar Islands (LC-Least Concern; NR-Near Threatened; EN-Endangered; VU-Vulnerable; UR-Under Review; DD-Data Deficient)

Table 5.2: List of family with number of bird species in each families in Andaman Islands

No	Family	Number of Species	No	Family	Number of Species
1	Scolopacidae	24	29	Falconidae	2
2	Accipitridae	15	30	Hydrobatidae	2
3	Ardeidae	12	31	Monarchidae	2
4	Laridae	11	32	Nectariniidae	2
5	Muscicapidae	11	33	Passeridae	2
6	Sylviidae	11	34	Phaethontidae	2
7	Columbidae	10	35	Picidae	2
8	Rallidae	9	36	Pycnonotidae	2
9	Alcedinidae	8	37	Artamidae	1
10	Charadriidae	8	38	Bucerotidae	1
11	Cuculidae	8	39	Burhinidae	1
12	Anatidae	7	40	Ciconiidae	1
13	Motacillidae	7	41	Cisticolidae	1
14	Sturnidae	7	42	Dicaeidae	1
15	Phasianidae	6	43	Dromadidae	1
16	Apodidae	5	44	Emberizidae	1
17	Psittacidae	5	45	Fregatidae	1
18	Campephagidae	4	46	Glareolidae	1
19	Dicruridae	4	47	Irenidae	1
20	Strigidae	4	48	Laniidae	1
21	Corvidae	3	49	Pachycephalidae	1
22	Estrildidae	3	50	Podicipedidae	1
23	Hirundinidae	3	51	Ramphastidae	1
24	Meropidae	3	52	Sulidae	1
25	Oriolidae	3	53	Turnicidae	1
26	Turdidae	3	54	Tytonidae	1
27	Caprimulgidae	2	55	Zosteropidae	1
28	Coraciidae	2			

5.3.3. Foraging Guild Structure of Birds of Andaman Islands

The foraging guilds of bird species were grouped into three habitat structures to determine the feeding behaviours of different bird species and the food resources of the study area. Result showed that Insectivore (36.9%), Carnivore (24.9%) and Omnivore (16.7%) were the three most abundant feeding guilds (Table. 5.4; Figure 5.3), which comprises of both aquatic and terrestrial birds. All insectivore birds are terrestrial birds, whereas 21 wetlands associated bird species were grouped as insectivore/vermivore, They consisted mainly of migratory waders such as Plovers and Sandpipers (Table 5.4). Out of 27 pelagic birds of Andaman and Nicobar Islands, 24 species were reported from Andaman Islands and they have been included in the carnivore group. Out of 233 species in Andaman Islands, 150 bird species preferred to feed in terrestrial environments whereas 59 species were related to wetland environment and 24 species were in marine water . Mann-Whitney test showed that, there was no statistically significant difference in guild composition of birds of Andaman Islands and Nicobar Islands ($U = 147.5$, $P < 0.05$)

Table 5.3: Foraging guild structure of birds of Andaman and Nicobar Islands

Guilds	Andaman	Nicobar	Total.sps
Carnivore	58	46	68
Herbivore	8	4	8
Omnivore	39	19	44
Insectivore	86	28	92
Molluscovore/Vermivore	14	9	15
Piscivore/ Insectivore	3	1	3
Frugivore	16	13	18
Granivore	9	5	11
Total species	233	125	259

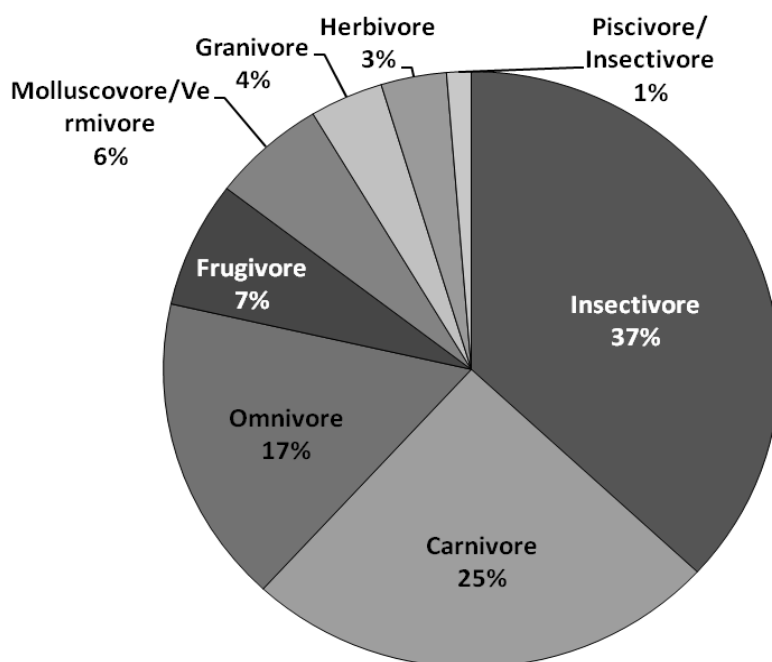


Figure 5.3: Foraging guild structure of birds of Andaman Islands

5.4. DISCUSSION

Birds of Andaman and Nicobar Islands have very high species diversity as compared to the land size and still scientific studies are relatively less. The avifauna of these archipelago are traditionally treated as an insular subdivision of the Indian Subregion (Oates & Blanford 1889-98; Ripley & Beehler 1989), but in the case of avifaunal diversity, the major path of colonisation of the islands might have taken place along a single route from southwestern Burma, via a series of overwater barriers that acted as filters (Ripley & Beehler 1989). Birds of Nicobar Islands can be considered as a subset of Andaman Islands. High proportion of endemism (38.2%) largely due to the high number of endemic subspecies (Sankaran & Vijayan 1993). Of the total breeding species, more than half of the breeding population is racially different between Andaman and Nicobar group of Islands (Ripley & Beehler 1989). Within these group of islands, many species were showing isolated distribution. Narcondam Hornbill *Aceros narcondmi* is present only in one Island with reasonable population (Ripley & Beehler 1989).

The birds of Andaman and Nicobar Islands are enriched with 259 bird species (species and subspecies together 297). Of these 297 bird taxa 31 species are additional to the last comprehensive list published by Sankaran and Vijayan (Sankaran & Vijayan 1993). Some of the birds have been added to the recorded as single individual report or anecdotal reports such as Spot-bill Pelican, Brahminy Duck or Ruddy Shelduck *Tadorna ferruginea*, Tickell's Blue Flycatcher, Grey-headed Flycatcher and Blue-fronted Robin. Sightings of migratory bird as new records are quite possible to take into account. Pheasant-tailed Jacana *Hydrophasianus chirurgus* was recorded twice from Sippighat Tsunami inundated wetland in South Andaman and it has been published as personal tour report by Lister (2010). In another tour report by Bishop (2012) he claims that, he has seen a flock of six Asian Openbill *Anastomus oscitans* from Ograbranj Tsunami created wetland and a Little Grebe with breeding plumage from Sippighat, South Andaman Island. In Indian subcontinent, Corn Crake was recorded from Sri Lanka and Kashmir area with few reports and it is very difficult to identify this species from Baillon's Crake *Porzana pusilla* in the field. Tickell's Blue Flycatcher is a resident bird in India except restricted area in Gujarat. These new records of bird species such as Little Grebe, Corn Crake and Crimson-fronted Barbet, Tickell's Blue Flycatcher, Grey-headed Canary-flycatcher and Blue-fronted Robin (needs further confirmation) are showing the possibilities of more bird species occurring in these islands. As it needs further confirmation, these species at present, can only be considered as doubtful records.

Bird diversity of islands comes from habitat related morphological differences within species on oceanic islands (Coyne & Price 2000). Allen (1920) explained how morphological pattern of birds' changing over time and space. In Andaman and Nicobar Islands, these types of subspecies are very common. 69 taxa were considered as subspecies of 31 species (Sankaran & Vijayan 1993). For example, White-breasted Waterhen and Crested Serpent-eagle are divided into three subspecies based on morphological changes (Abdulali 1967; Sankaran & Vijayan 1993). Most remarkable species is the Serpent-eagle. recognized as two endemic species in Andaman and Nicobar Islands *Spilornis elgini* and *Spilornis klossi*. which is widespread in Indian subcontinent also occur in Andaman Islands (Thiollay 1997; Ripley & Beehler 1989; BirdLife International 2012). Andaman and Nicobar Islands are considered as one of the endemic bird area with 38.2% endemism

(Sankaran & Vijayan 1993). The high ratio of endemism can also be attributed to the high rate of sympatric speciation in these islands (Coyne & Price 2000).

Species never live in isolation (Hirzel & Lay 2008), whenever several species co-exist; biotic interactions like competition, predation, parasitism, and mutualism affect their fitness and behaviour and may drastically affect their niches (Pearson & Dawson 2003; Hirzel & Lay 2008). 297 taxa including species and subspecies of birds are distributed in Andaman and Nicobar Islands and these Islands shows good bird species composition with 17 pelagic birds, about 65 migratory species including 33 waders and 105 endemic species and subspecies. Zooplankton distribution is the major factor for distribution of pelagic birds (Hunt & Schneider 1987). Water currents may also carry different prey communities into an area (Hunt 1990). Vast areas of sea around this archipelago provides good habitat for pelagic birds. 17 species of pelagic birds include recent records of Common White Tern *Gygis alba* (Yahya & Zarri 2002a) and have been recorded so far from these Islands (Annexure 1). Few individuals of Common White Tern have been reported from Narcondam Island by Yahya & Zarri (2002a), it was the confirmed report of Common White Tern from Bengal Sea after Hume's single individual collection (Ali & Ripley 1987). Christmas Frigatebird *Frigata andrewsi* was recorded from Andaman Islands (Saxena 1994), this is the only confirmed record of this species in these Islands.

Migratory birds are another big group contributing towards the overall avifauna of these Islands. Seasonal changes in bird composition is very evident because of winter migratory birds especially waders (Chopra & Kamal 2012). A total of 61 species of birds are confirmed as migratory birds in Andaman and Nicobar Islands, of which 59 species are recorded from Andaman Islands and 34 species recorded from Nicobar Islands. Two species of winter migratory birds such as single individual record of Spot-billed Pelican and Sanderling *Calidris alba* were exclusively recorded from Nicobar Islands and Spot-billed Pelican record was listed because of single specimen collected by Hume (Abdulali 1964). Coastal wetlands in India provide winter refuge for migratory water fowl from different parts of the World such as different parts of the Asia, Europe and Mediterranean regions (Balachandran 2012). Andaman and Nicobar Islands also play a major role in India to

provide refuge for migratory waterfowls. Out of 61 migratory species in these islands, 38 species are winter migratory water birds.

Andaman Island is one of the endemic bird areas in the World (Islam & Rahmani 2004). According to Sankaran & Vijayan (1993), 106 (38.2%) species and sub species of birds were endemic to this archipelago. This high percent of endemism is due to high number of endemic subspecies (Sankaran & Vijayan 1993; Vijayan et al. 2000). 31 species of birds have been split into 69 subspecies (Annexure 2) on the basis of morphological characters (Abdulali 1964, Sankaran & Vijayan 1993). Of the 69 subspecies, 36 endemic subspecies were distributed in Nicobar Islands and only 18 subspecies are distributed in Andaman Islands. Seven subspecies are common to both island groups. A basic rule of ecology is Gause's principal of competitive exclusion (Gause 1934), which explains that, whenever two sympatric species have similar niches, one will compete with another for their resource (Tilman 1982). Resident bird like two subspecies of Common Quail *Turnix tanki* and two subspecies of Black-backed Kingfisher *Cyex erythacus* are distributed in Andaman and Nicobar group. But the actual distribution of these subspecies in particular island was unknown. According to Alley (1982), sympatric species have evolved so as to minimize niche overlap and inter-specific competition. According to Rasmussen and Anderton (2012), total six species of owls and two species of nightjars were identified from the Andaman archipelago. Of these, Andaman Barn Owl *Tyto deroepstorffi*, Andaman Scops-owl *Otus balli*, Andaman Hawk-owl *Ninox affinis* and Humes's Hawk-owl *Ninox obscura* are endemic species to Andaman Islands. Among the two Nightjar species Andaman Nightjar is endemic to Andaman Islands.

Though Andaman and Nicobar Islands are rich in forest foliage and aquatic environment, many bird groups such as Babblers, Prinias, Barbets are absent in these Islands. It is important to understand functional relationship between species and environment (Simberloff and Dayan 1991). We need special studies to know why some groups are completely absent in these islands.

In the case of Andaman and Nicobar Islands, 19 species were introduced species (Rajan & Pramod 2012) out of total 146 confirmed resident species. Introduced birds have also giving on reasonable contribution towards guild structure of Andaman bird community.

Out of nine granivores recorded from Andaman, six species were introduced species. Resident birds category includes, the bird occurring naturally and breeding in these Islands except pelagic birds. Introduced birds are also included in this category and those species which are currently established as viable populations reproducing in the wild (Pyle 2002). Evaluating the influence of an added species involves not only determining the effect of the species, but also considering other potential causes of the same outcome (Fritts & Rodda 1998). The Nicobar Islands fortunately doesn't have too much population of introduced species, only Common Myna and Rock Pigeon are distributed in few Islands especially on Car Nicobar. Domestic strain of Rock Pigeon is distributed in Great Nicobar (Sankaran & Vijayan 1993). Though very less introduced birds in Nicobar, some endemic subspecies such as Red-whiskered Bulbul and White-headed Starling were introduced to Nicobar Group from Andaman Islands and these species have established well in Nicobar Islands (Sankaran & Vijayan 1993). 176 bird species in the world have been qualified as critically endangered in 1994 (Brooke et al. 2008) and it has been updated with 197 species in 2012 (BirdLife International 2012). Threatened birds are facing many threats at a time, notably habitat degradation, unsustainable exploitation and an alien invasive species (Brooke et al. 2009; BirdLife International 2012). Wildlife researchers are always trying to address these issues and solution for the conservation of these species. Islands are hotspots of endemism, extinction and urgent require for conservation action (Trainer 2002). About 89% of bird extinctions since AD 1600 have occurred on islands (Gaston & Blackburn 1995).

In Andaman and Nicobar Islands, there were seven species of birds listed in IUCN threatened birds (BLI 2011). Of these, three species such as Narcondam Hornbill (Endangered), Nicobar Sparrowhawk (Vulnerable) and Nicobar Megapode (Vulnerable) are endemic species to these Islands. Christmas Island Frigatebird was the critically endangered bird and there is no confirmed record of this species other than one observation (Kazmierczak 2000). Andaman Teal *Anas gibberifrons albugularis* is a race of Sunda Teal *Anas gibberifrons* and endemic to Andaman Islands (Vijayan 2006; Kazmierczak 2000; Rasmausen 2012). Once abundant Andaman Teal population has dramatically declined and presently the population is coming up after Tsunami (Osmaston, 1906; Ali & Ripley 1987; Vijayan & Sankaran 1996; Rajamamannan 2010; Rajan & Pramod 2013). Though Narcondam Hornbill is in endangered category, considering the size of the Narcondam

Island, Narcondam Hornbill population is stable with reasonable numbers (Abdulali 1971; Hussain 1984; Yahya & Zarri 2002b; Raman 2013; Rahmani 2013).

Rates of movement of bird species from one category to higher risk category are lowest in least concern species and rate will increase for higher risk category (Brooke et al. 2008). There were 20 near threatened bird species of Andaman and Nicobar Islands that have higher chance for uplift into threatened species. J. Bombay Nat. Hist. Society 99(3): 434-445. Conservation of birds of these islands is not under immediate threat (Sankaran & Vijayan 1993), however 20 near threatened species of Andaman and Nicobar Islands especially endemic species have higher chance to get under threat. The main threat for the birds of Andaman and Nicobar Islands is because of human disturbance followed by threats from introduced species (Rajan & Pramod 2012). Invasive species are the problems because they can affect ecosystem properties, ecosystem processes, and community structure (Perrings et al. 2000; Levine et al. 2003; Lodge et al. 2006; Hellmann 2008). Main conservation threat and hence the urgency of intervention in these Islands are with regard to the habitat destruction by settlers of mainland and effect of introduced species (Sankaran & Vijayan 1993; Rajan & Pramod 2012). Conservation actions are needed to control introduced species, which can become invasive species and give real threat to native biota of Andaman and Nicobar Islands.

This study has reported European Roller *Coracias garrulus* first time from Andaman and Nicobar Islands.



BIRDS OF HUMAN INFLUENCED AREAS IN ANDAMAN ISLANDS

6.1. INTRODUCTION

In the Andaman and Nicobar archipelago, the maximum human settlements are in Andaman, of which about 780 sq.km areas is under human utilization including urban and rural areas. The majority of human settlers are concentrated in South Andaman around Port Blair and these areas have large scale human modified habitats. In this chapter, systematically collected data from the selected human inhabited areas in the Andaman Islands to study the species composition and bird community attributes of human associated areas of Andaman Islands.

6.2. METHOD OF ANALYSIS

Transects were laid in 10 Islands of Andaman and later these 10 Islands were grouped into five groups such as Little Andaman, South Andaman, Middle Andaman, North Andaman and Ritchie's archipelago (see Chapter II) for analysis. Total 221 transect counts of birds (1km/1hr) were conducted in the Andaman Islands between July 2008 to July 2011. Of the 221 transects, 151 transects were performed during 5.30 & 9.30 hrs and remaining 70 were during 15.30 & 17.30 hrs. Habitats of Andaman Islands are highly fragmented and patchily distributed due to human disturbances. The areas under study were classified into six habitats such as Urban area, Rural area, Inland wetland associated area, Coastal associated area, Disturbed forest and Undisturbed forest (See chapter II). These six habitats were also grouped into three categories during analysis, as Human associated area (Urban and Rural areas), Water associated area (Inland wetland and Coastal associated areas) and Forest associated area (Disturbed forest and Undisturbed forest). Sampling efforts were made according to the size and human population of the islands (Table 6.2). Species dominance curve is used to express the pattern of dominance among bird species in the different Islands as well as different habitat. These three groups were plotted in Venn diagram and Pie diagram to demonstrate the species composition and partitioning of birds in among habitats. Relation of bird species composition between each Islands as well as each habitat were tested with Wilcoxon Signed Rank test in SPSS software. Simpson diversity

Index (S) and Shannon-Weinner Diversity Index (H) were used to present diversity attributes such as species richness and species evenness in each habitat and Islands separately.

6.3. RESULTS

Total 126 species of birds are identified during this study, it included seven opportunistic records. In total 15859 individuals of 119 species of birds belonging to 38 families (Table 6.1) and 14 orders were encountered from 221 transects in the human associated landscape of Andaman Islands (Annexure 5). Seven species such as Cotton Pygmy-goose *Nettapus coromandelianus*, Beach Thick-knee *Esacus giganteus*, Purple heron *Ardea purpurea*, Marsh Sandpiper, Andaman Hawk-owl, Oriental Scops-owl and Dusky Warbler were detected as opportunistic observation. The number of birds encountered per transect ranged between 12 and 419 ($S = 9.02$; Mean = 3.41). Out of 18 orders of birds from the Andaman and Nicobar Islands, 14 orders were recorded in the present study. As expected Passeriformes was the highest encountered with 41 species (33%). Charadriiformes are the second species order with 25 species (20%), then Coraciiformes 12 species (10%) and Phoenicopteriformes 12 species (10%) (Figure 6.1). There were five orders with less than five bird species observed. Total 58 bird families have been reported from Andaman & Nicobar Islands by various researchers including rarities. Of these 58 families, 38 families of birds have been recorded from human associated landscape of Andaman Islands during this study period (Table 6.1). Missing families from this study mostly belongs to pelagic birds, forest birds and nocturnal birds. Highest numbers of bird species were included in the Scolopacidae with 16 bird species followed by Ardeidae 12 species, Charadriidae and Alcedinidae with eight species each and Columbidae with seven species. From 10 families, only single species is recorded.

There are different methods to measure the dominance of species. Here the rate of encounter is considered as surrogate for abundance and in turn population. It varies according to habitat and time period. The most dominant species was House Sparrow (2768 encounters) in human associated landscapes. Second best is Common Myna (1264 encounters), followed by Glossy Swiftlet (1248 encounters), Rock Pigeon (1224 encounters) and Red-whiskered Bulbul (874 encounters) (Figure 6.2).

Table 6.1: Total number of bird species recorded in each family

Sl.No	Family	Total	Sl.No	Family	Total
1	Scolopacidae	16	20	Meropidae	2
2	Ardeidae	12	21	Monarchidae	2
3	Charadriidae	8	22	Motacillidae	2
4	Alcedinidae	7	23	Muscicapidae	2
5	Columbidae	7	24	Phasianidae	2
6	Rallidae	6	25	Picidae	2
7	Sturnidae	5	26	Pycnonotidae	2
8	Sylviidae	5	27	Strigidae	2
9	Campephagidae	4	28	Artamidae	1
10	Psittacidae	4	29	Burhinidae	1
11	Accipitridae	3	30	Dicaeidae	1
12	Anatidae	3	31	Estrildidae	1
13	Apodidae	3	32	Irenidae	1
14	Corvidae	3	33	Laniidae	1
15	Cuculidae	3	34	Laridae	1
16	Dicruridae	3	35	Nectariniidae	1
17	Oriolidae	3	36	Passeridae	1
18	Coraciidae	2	37	Turdidae	1
19	Hirundinidae	2	38	Zosteropidae	1

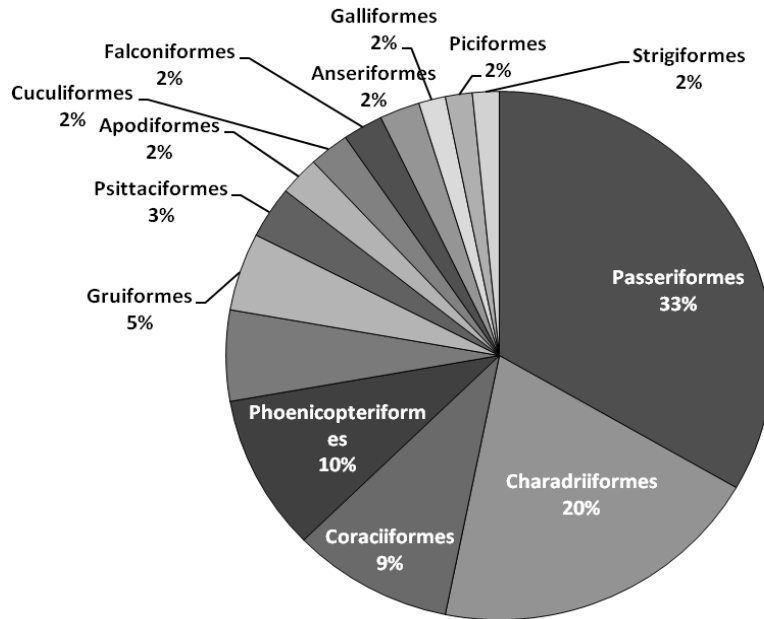


Figure 6.1: Order wise composition of birds

With respect to abundance of birds recorded during the study transects, result were different. This aspect represents the iniquitousness of the species and in turn its versatility to the island habitats. Out of the total 221 transects, House Sparrow was detected maximum followed by Common Myna and Glossy Swiftlet (Figure 6.2). Species accumulation curve showed that, this study has reasonable samples and all species richness estimators have reached upper asymptote (Figure 6.3). Introduced species plays a major role in the avifaunal diversity and dominance structure of Andaman Islands. Among the five most abundant and distributed bird species, two of them are introduced species (Common Myna and House Sparrow). House Sparrow and Common Myna together registered 25.43% of encounters in the study. Some of the species such as Asian Paradise Flycatcher *Terpsiphone paradise* from Ferrargunj; Oriental Plover from Chouldary, Port Blair; Ruddy Kingfisher *Halcyon coromanda* from Dashrathpur, Rangat and European Roller from Dashrathpur were recorded as single individual and are considered the rarities in this study.

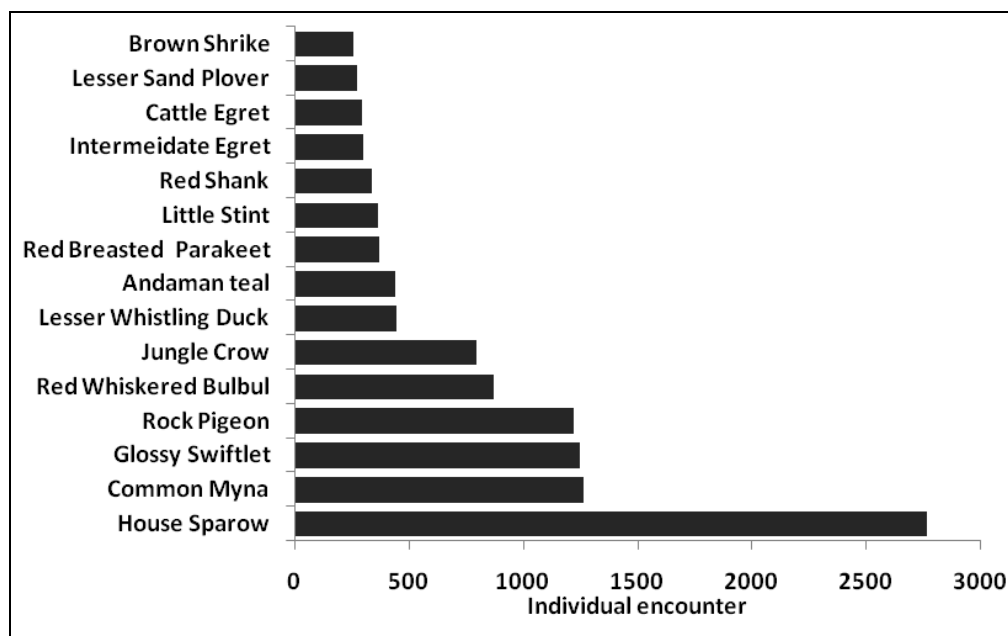


Figure 6.2: Species dominance based on abundance

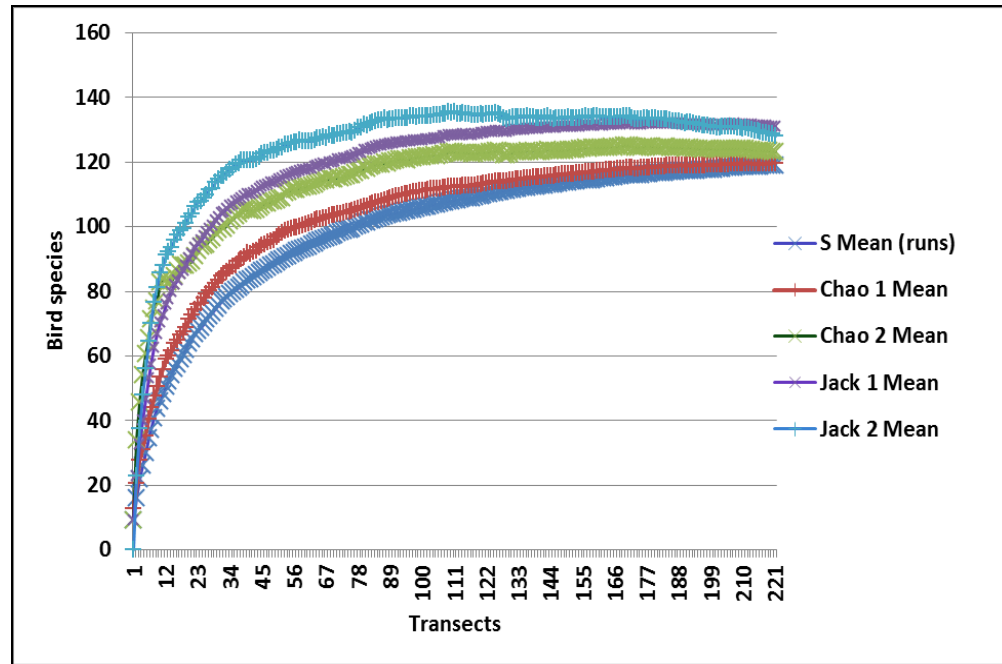


Figure 6.3: Species accumulation curve along the transects

6.3.1. Island wise avifaunal diversity in Andaman Islands

Bird species composition of Andaman Islands varies among the different Islands, and it depends on the size of the Islands and its distance from nearest landmass. Geographically Andaman Islands are three groups clearly isolated by long distances. Little Andaman is about 168 km away from South Andaman Island, Ritchie's Archipelago is 18 km away from main Andaman Island stretch. Chances of species immigration and emigration are very less from the nearest land mass except long migratory species. This part of the study examines the island wise diversity and composition of birds of Andaman Islands based on the four year study.

6.3.1.1. Little Andaman Island

2089 individuals belonging to 70 species were encountered from 39 transects; of these, two species Andaman Teal and Purple Heron were recorded out of the transect counts in this Island. The maximum species encounter per transect was 13 and minimum was three

(mean = 8.1; SD = 2.67). Diversity of bird species was moderate in this island ($S = 0.8667$ and $H = 2.735$). House was the dominant species in human inhabited area with high encounter rate (643 individuals) followed by Large-billed Crow (206 individuals), Red-breasted Parakeet (197 individuals), Glossy Swiftlet (189) and Red-whiskered Bulbul (167) (Figure 6.4a). Red-whiskered Bulbul was the most widely distributed species in this Islands and was recorded in 27 transects in this island. The other most distributed bird species were Large-billed Crow (26 transects), Red-breasted Parakeet (23 transects), House Sparrow (20 transects) and Glossy Swiftlet (19 transects). There were 21 bird species that were recorded as single individuals only.

6.3.1.2. South Andaman Islands

Human influence and habitat transformation is maximum in the southern part of South Andaman Island. A high total of 9518 individuals belonging to 103 species have been recorded from 96 transects in this island. Per transect a maximum of 21 species and minimum of five species encountered from here. The maximum number of individual encounters was 419 while the minimum was 12. This maximum encounter was because of large flocks of migratory waders. Birds like Little Stint *Calidris minuta*, Whimbrel *Numenius phaeopus* were observed in flocks with more than 100 birds. Though it is a smaller size when compared to the flocks in mainland India in the ecology and limited resources of Andaman Islands they have significance. South Andaman harbours rich bird diversity with Simpson index, SD = 0.9155 and $H = 2.999$.

Species dominance curve shows House Sparrow was the most dominant species in terms of abundance with 1571 individuals followed by Common Myna (1094 individuals), Rock Pigeon (982 individuals), Glossy Swiftlet (479 individuals), Lesser Whistling Duck (412 individuals) and Red-whiskered Bulbul (385 individuals) (Figure 6.4b). The first three dominant species are introduced species with high abundance; they have been contributing 38.32% to total encounters of South Andaman birds. Unlike abundant species, the most widely distributed species was Common Myna and it was detected in 83 transects out of 96 total transect from South Andaman Islands. Other most distributed species were Red-whiskered Bulbul (68 transects), Glossy Swiftlet (62 transects), House Sparrow (46 transects) and Large-billed Crow (39 transects). Of the five most dominant and distributed

species, four species such as House Sparrow, Common Myna, Red-whiskered Bulbul and Glossy Swiftlets were common and it was easy to conclude that, these four species were the most common species in human habituated areas of south Andaman Islands. There were five species includes Asian Paradise Flycatcher and Oriental Plover recorded as single individual records during this study period, and considered as rare.

6.3.1.3. Middle Andaman Islands

2883 individuals belonging to 77 species were recorded from the largest Island of Andaman Islands from 53 transects. Compared to South Andaman Islands human population is less. The main inhabited areas are Mayabunder, Rangat, Billy ground and Kadamtala. Of these areas, I have surveyed all the areas except Kadamtala. Inhabited areas of these Islands also showed House Sparrow (15.2% of total population) is the most dominant species in terms of encounter and this species was mainly concentrated in urban areas as small flocks. Other dominant species were Glossy Swiftlet - 12.5%, Large-billed Crow - 9.7 %, Red-whiskered Bulbul - 8.8% and Rock Pigeon - 8% (Figure 6.4c). Among the most dominant species, two species were introduced species. While the Rock Pigeon was distributed mainly in Rangat town. Diversity of birds was very high in this Island with Simpson Diversity index, $S = 0.9155$ and Shannon-Weiner Diversity Index, $H = 2.999$.

Most widely distributed bird species was Red-whiskered Bulbul and was present in 43 transects out of 53 transects followed by Glossy Swiftlet in 31 transects, Large-billed Crow in 30 transects, Brown Shrike *Lanius cristatus* in 24 transects and House Sparrow in 22 transects. Common Myna was observed only in Mayabunder and Rangat with less than five individuals during 2009 and after that there was no further detection of this species from this Island except one individual from Bakultala. House Sparrow, Red-whiskered Bulbul, Large-billed Crow and Glossy Swiftlet were the most common species in Middle Andaman Islands.

The rare ones are the eight species of birds recorded as single individuals. Among them are Ruddy Kingfisher and European roller. European Roller was recorded as a new report to the Andaman and Nicobar Islands. The European Roller is classified as Near-threatened due to moderately rapid declines across its range, with the northern populations particularly badly affected (BLI2011). Single individual of European Roller was recorded

from Dashrathpur, Rangat and another individual from Tushnabad, South Andaman Islands for the first time in Andaman and Nicobar Islands (Rajan & Pramod 2011). Four species of birds Black-hooded Oriole *Oriolus xanthornus*, Black-backed Kingfisher, Pale-footed Bush Warbler *Cettia pallidipes* and Ruddy Kingfisher were observed only from Middle Andaman during this study period.

6.3.1.4. North Andaman Island

Total 1158 individuals belonging to 51 species from 23 transects have been recorded from the North Andaman Islands. Of the total species, wetland associated birds were very less. This island was exposed to very less natural wetland area, most of the Inland wetlands were converted as agricultural field by settlers. Bird species diversity of this Islands is relatively high with Simpson Diversity index, $S = 0.9189$ and Shannon-Weiner Diversity Index, $H = 2.967$. Glossy Swiftlet was the most encountered species in this Island with 17.36% contribution to the whole recordings followed by Common Myna (12.69%), House Sparrow (10.02 %), Large-billed Crow (9.15%) and Asian Glossy Starling (6.3%) (Figure 6.4d). Unlike other Islands, Asian Glossy Starling was detected as one of the dominant species in this Island. This Island is not different from other Islands, two introduced species such as Common Myna and House Sparrow were listed among the first five dominant species.

Common Myna was the most widely distributed species in North Andaman Islands and encountered in 18 transects out of 23 total transects. Red-whiskered Bulbul (17 transects), Glossy Swiftlet (16 transects) and Large-billed Crow (13 transects) were the most distributed bird species. Introduced Common Myna was one of the most distributed species in North Andaman Islands. House Sparrow was distributed along the township area mainly in Diglipur town and Ariel Bay town. There was no Rock Pigeon recorded during the study period, but in 2012, I have observed two individuals of Rock Pigeon in the Sitanagar area as pet animal. It may establish well and have potential to become a big feral population in this Island.

6.3.1.5. Ritchie's Archipelago

A total of 606 individuals belonging to 56 species have been recorded from this Archipelago in 12 transects. In this Archipelago, the surveyed locations are Havelock Island, Neil Island and South Button Island. Species diversity was high (Simpson Diversity index, $S = 0.9485$ and Shannon-Weiner Diversity Index, $H = 3.296$). Unlike other islands, this group of Islands has different bird species composition. Most abundant species was Alexandrian Parakeet with 13.04% population followed by Small Minivet *Pericrocotus cinnamomeus* (9.74%), Red-breasted Parakeet (5.62%) and Red-whiskered Bulbul (4.95%) (Figure 6.4e). Parakeets were the most abundant species because they were observed in a very huge population in agricultural area. Olive-backed Sunbird *Nectarina jugularis* was the most distributed species all over the Island group followed by Red-whiskered Bulbul, Glossy Swiftlet and Alexandrian Parakeet. This Archipelago is the only Island group with very less population and distribution of introduced species. Only two introduced species House Sparrow and Rock Pigeon were recorded and not even a single individual of Common Myna was observed during this study period. There were ten species such as White-bellied Sea-eagle *Haliaeetus leucogaster*, White-headed Myna, Thick-billed Warbler *Acrocephalus aedon*, Common Sandpiper *Actitis hypoleucos*, Edible-nest Swiftlet *Collocalia fuciphaga*, Stork-billed Kingfisher *Pelargopsis capensis*, Olive-backed Sunbird, Malayan Night Heron *Gorsachius melanolophus*, Asian Glossy Starling and Collared Kingfisher *Todiraphus chloris* was recorded from the South Button Island and this Island is one of the un-inhabited islands included in the study.

6.3.2. Island-wise bird population of Andaman Islands: A comparison

Human inhabited Islands of Andaman are very rich in bird diversity, all these Islands have more than 0.9 Simpson diversity index (S) except Little Andaman Island (Table 6.2). However, as compared to other islands group, Ritchie's Archipelago is high in bird diversity ($S = 0.9514$ and $H = 3.431$) and bird encounter was very less in this Island group. Maximum individual encounter was 94 individuals ($S = 23.7904$ and Mean = 23.3077) in a transect. South Andaman Island has the highest bird encounter with 419 individuals ($S = 85.2012$ and mean = 93.3137) in transect. This high abundance was due to the shore birds' aggregation in

Sippighat wetland area. Little Andaman Island is in a relatively lower side of bird diversity records in the study ($S = 0.8667$ and $H = 2.735$).

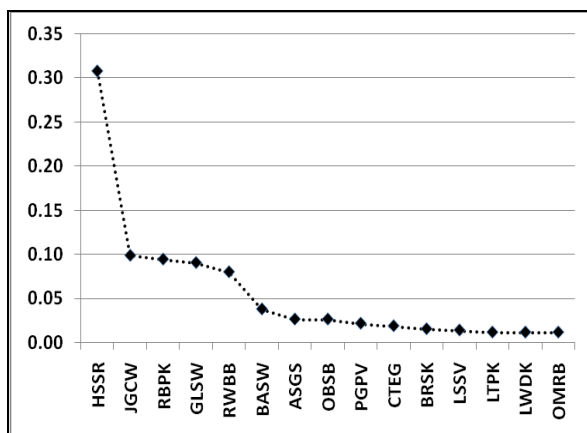
Wilcoxon Signed-rank test performed for overall data suggested that, there was a significant difference between the birds species composition of each Islands ($Z = >3.5$; $P = 0$). However bird species composition of Little Andaman and Middle Andaman; Little Andaman and North Andaman Islands were not significantly different with $Z = 1.316$, $p = 0.188$ and with $Z = 1.833$, $p = 0.067$ respectively).

6.3.3. Habitat-wise avifaunal diversity in Andaman Islands

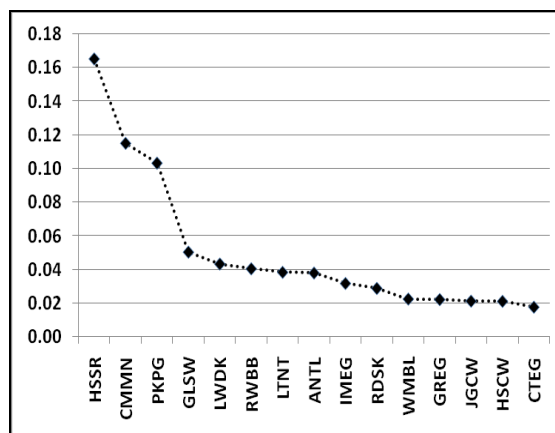
Bird species composition was different in each habitat in Andaman Islands and it varies from urban to undisturbed forest area. Human inhabited islands of Andaman Islands are with complex habitat types and these human modified habitats support more diversity in species composition. This section of the study examine six major habitat wise bird compositions in Andaman Islands.

6.3.3.1. Urban area

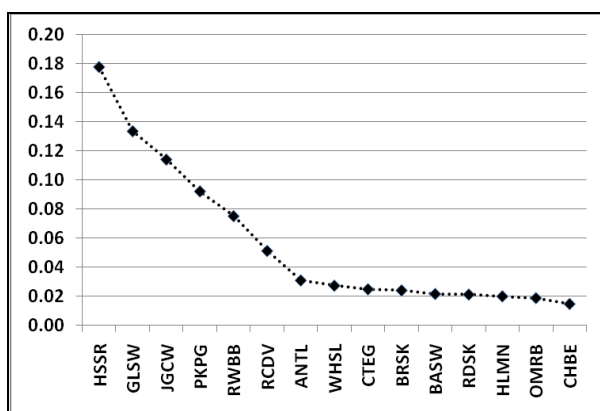
3741 individuals coming under 31 species have been recorded from urban area. Maximum species encounter per transect was 11 species from Port Blair area and minimum was 3 species (Mean = 7.2581, $S = 1.7695$). But individual abundance was high due to some species aggregation, especially Rock Pigeon. Maximum of 363 individuals were recorded in a transect. Species such as Red whiskered Bulbul, Glossy Swiftlet *Collocalia esculenta* and House Sparrow were distributed all along the transect with good numbers. Species diversity in urban area was moderately low as compared to other habitats in Andaman Islands ($S = 0.7676$ and $H = 1.842$). Brown Coucal *Centropus andamanensis* was the only endemic bird recorded from urban area. Wetland associated species like Bar-tailed Godwit *Limosa lapponica* and Grey plover *Pluvialis fulva* were recorded from township area of Hutbay, Little Andaman.



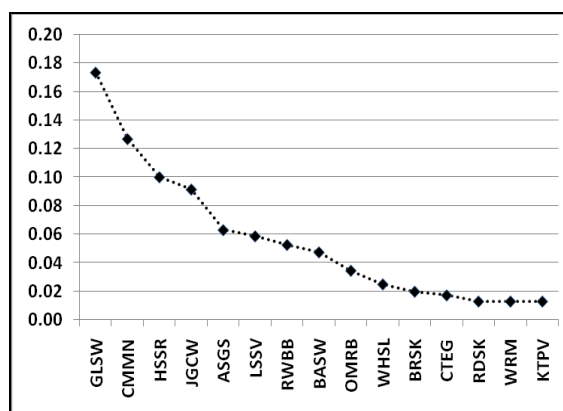
a) Little Andaman Island



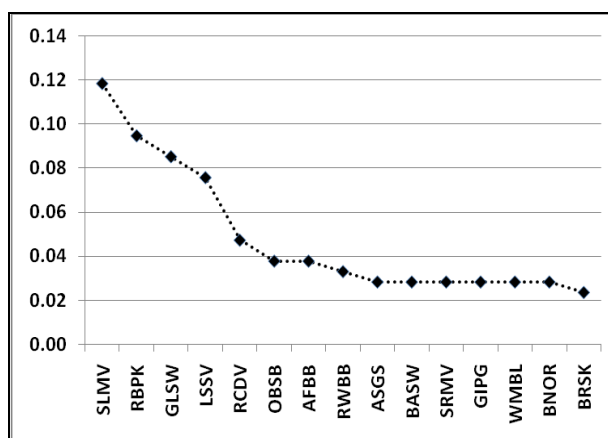
b) South Andaman Islands



c) Middle Andaman Islands



d) North Andaman Islands



e) Ritchie's Archipelago

Figure 6.4: Species dominance curve of most 15 dominant species based on abundance in each study area (Bird species on X axis and Relative abundance on Y axis)

Table 6.2: Island wise analysis

Name of the Island		Little. A	South. A	Middle. A	North. A	Ritchie's A
Total transects		39	96	53	23	12
Total area (sq.km)		734.39	1347.7	1535.5	1375.99	132.83
Total species		70	103	77	51	56
Total birds encounter		2089	9518	2883	1158	606
Species (Transect)	Mean	8.0769	10	8.4889	8.2609	6.0385
	SD	2.6694	3.5152	3.0123	1.8882	3.7038
	Min	3	5	3	4	3
	Max	13	21	16	12	16
Individuals (Transect)	Mean	53.5128	93.3137	54.8222	50.3478	23.3077
	SD	30.8979	85.2012	46.4269	22.5058	23.7904
	Min	12	12	13	13	15
	Max	143	419	222	100	94
Diversity Indices						
Simpson		0.8667	0.9341	0.9155	0.9189	0.9514
Shannon-Weiner		2.735	3.326	2.999	2.967	3.431
Evenness		0.2267	0.2702	0.2867	0.3811	0.5519

Of the total 3741 individuals, House Sparrow was the highest abundant species with 33.76% followed by Rock Pigeon (31.38%), Glossy Swiftlet (9.28%), Common Myna (7.97%), Large-billed Crow (4.36%) and House Crow (4.17%) (Figure 6.6a). House Crow was recorded only from Port Blair, South Andaman. Of the highest abundant birds of urban area, four species namely House Sparrow, Rock Pigeon, Common Myna and House Crow are introduced species.

6.3.3.2. Rural area

A total of 3443 individual of 55 species have been recorded from Rural area. Maximum species encounter per transect was 13 and minimum was three species (Mean = 7.569; S = 2.121). Maximum individual encounter per transect was 220 individuals and minimum was 12. This maximum individual detection was due to the huge population of Glossy Swiftlet with 193 individuals from Mayabunder area. Bird species richness was not

high in Rural area when compared to urban area, Rural area was high in bird diversity with Simpson index, $S = 0.8468$ and Shannon-Weininger Index, $H = 2.141$. Rural area also supported introduced species such as House Sparrow and Common Myna. House Sparrow was the most abundant species with contribution of 30.18% population towards the total population detected followed by Glossy Swiftlet (16.29%), Common Myna (12.75%), Large-billed Crow (9.76%) and Red-whiskered Bulbul (8.02%) (Figure 6.6b). There were seven species detected as single individual and it included endemic species Andaman Crake *Rallina canningi* and Black-headed Bulbul *Pycnonotus atriceps*.

6.3.3.3. Inland-Wetland associated area

Among the habitats, maximum bird encounters happened in the Inland-Wetland associated areas from 221 transects. There were 88 species (5067 individuals) of birds that were recorded from this habitat. Of this 88 species, 23 species were migratory waders. Andaman Teal was the highest abundant species with 8.62% of total birds detected from this habitat followed by Lesser Whistling-duck (8.03%), Common Myna (7.99%), Little Stint (7.20%) and House Sparrow (6.67%) (Figure 6.6c). Introduced birds such as Common Myna and House Sparrow were observed utilizing the Inland wetland for roosting as well as feeding purpose. There were nine species recorded as single individuals, it includes terrestrial bird such as Asian Koel *Eudynamys scolopaceus*, Asian Brown Flycatcher and Indian Cuckoo *Cuculus micropterus*. It was observed that House Sparrow was roosting on bushes in Inland wetland area at Little Andaman Islands. Maximum species encountered per transect was 21 species and minimum was six species, whereas 419 was the maximum individual encountered per transect and minimum was 19 individual. Diversity indices showed, bird species richness was high in inland-wetland associated area (Simpson diversity index, $S = 0.956$ and Shannon-Weininger Index, $H = 3.495$).

6.3.3.4. Coastal associated area

A total of 1268 individuals coming under 60 species have been recorded from Coastal associated areas of Andaman Islands. Maximum species per transect recorded was 17 and minimum was 5 species. Maximum individuals encountered per transect was from Chidiyatapu Coastal associated area with 187 individuals. Diversity index of bird species in

wetland associated area showed high species richness with Simpson diversity index, $S = 0.9375$ and Shannon-Weinner Index, $H = 3.173$. Lesser Sand Plover was the highest abundant species with 11.2% encounter in total encounters followed by Common Redshank (10.09%), Whimbrel (9.54%), Large-billed Crow (9.28%) and Common Myna (6.7%) (Figure 6.6d). All these abundant species were distributed along the transects of Andaman coast. There were eight species recorded as single individual and it includes endemic Andaman Teal . Broad-billed Sandpiper and Ruddy Turnstone were sighted only from coastal associated areas in the study.

6.3.3.5. Disturbed forest area

There were 65 species (1493 individuals) recorded from the disturbed forest area. Disturbed forest area has less species richness (Simpson diversity index, $S = 0.9261$ and Shannon-Weinner Index, $H = 3.114$) as compared to the Undisturbed forest area. 15 species were the maximum number of species encountered in a transect and the minimum was 6 species. Whereas a maximum of 128 individuals were recorded in a single transect and minimum individuals recorded was 12. Unlike other habitats, Red-whiskered Bulbul was the highest dominant species with 18.41% of total encounters. Red-whiskered Bulbul was distributed in all the transects. Other most dominant species was Red-breasted Parakeet (9.9%) followed by Glossy Swiftlet (9.58%), House Sparrow (7.37%) and White-headed Starling (6.7%) (Figure 6.6e). There were 15 species recorded as single individuals from this habitat, and it includes Asian Paradise Flycatcher which was a very rare bird in the Andaman Islands. Four species such as Asian Paradise Flycatcher, White-breasted Wood-swallow *Artamus leucorhynchus*, Asian Dollarbird *Eurystomus orientalis* and Indian Peafowl were recorded exclusively from the disturbed area during the study period.

6.3.3.6. Undisturbed forest area

A total of 848 individuals coming under 64 species were recorded from the undisturbed forest area. As compared to any other habitats, undisturbed area have high bird species richness (Simpson diversity index, $S = 0.9571$ and Shannon-Weinner Index, $H = 3.522$). A maximum of 17 species were encountered in a transect and the minimum was five species. Unlike other habitats, the bird species abundance is also very less, but distribution was almost stable along the transects. Maximum individuals encountered were 85 from

Havelock Island and minimum was 15 individuals. Species like Andaman Cuckoo Dove *Macropygia rufipennis*, Pompadore Green-pigeon *Treron pompadora*, Black-hooded Oriole *Oriolus xanthornus* and Andaman Wood-pigeon *Columba palumboides* were found only in this habitat. There were 30 species that were recorded as single individual; the highest abundant species was Green Imperial Pigeon with 12.4% encounter to total encounter followed by Red Whiskered Bulbul (6.6), Glossy Swiftlet (5.1), Long-tailed Parakeet (5.1) and Olive-backed Sunbird (4.6%) (Figure 6.6f). There weren't any introduced birds in undisturbed forest areas.

6.3.4. Habitat wise avifaunal diversity in Andaman Islands: A comparison

Bird species diversity was different among habitats, maximum species richness was recorded from forest area with $S = 0.9571$ and $H = 3.522$ followed by wetland associated area ($S = 0.956$ and $H = 3.495$), Coastal associated area ($S = 0.9375$ and $H = 3.173$). Lowest species richness was recorded from Urban area with $S = 0.7676$ and $H = 1.842$ followed by Rural area ($S = 0.8468$ and $H = 2.414$) (Table 6.3). Maximum numbers of 88 were recorded in wetland associated areas and lowest from Urban area with 31 species. Thirty species of birds that were found in only one habitat, of these 30 species, Asian Paradise Flycatcher, Oriental Plover, Ruddy Kingfisher were recorded as single individual during the three year study period. Purple Swamphen, Long-toad Stint, Little Stint were found only in wetland area with more than 100 individuals. There wasn't any exclusive bird species detected in urban area. Ruddy Kingfisher and Orange-headed Thrush *Zoothera citrine* were recorded only from the rural area during the survey period. Maximum exclusive species were recorded from Wetland associated area with 18 exclusive species (Figure 6.5).

Table 6.3: Habitat wise analysis

Habitat		Urban	Rural	Wetland	Coastal	D.forest	Un.D.Forest
No: Transect		31	65	47	25	31	22
No: species		31	55	88	60	65	64
Bird encounter		3741	3443	4618	1716	1493	848
Mean		7.2581	7.5692	12.0638	9.08	9.3548	11.3636
Species SD		1.7695	2.1211	3.6440	2.9710	2.4705	2.8376
(Transect) Min		3	3	6	5	6	5
Max		11	13	21	17	15	17
Mean		120.6774	52.9692	98.2553	68.64	48.64	39.5455
Bird SD		78.5071	36.4829	89.4574	75.2545	26.5193	18.6872
Encounter Min		33	12	19	13	12	15
(Transect) Max		363	220	419	373	128	85
Diversity Indices							
Simpson		0.7676	0.8468	0.956	0.9375	0.9261	0.9571
Shannon-Weiner		1.842	2.414	3.495	3.173	3.114	3.522
Evenness		0.2035	0.2033	0.3746	0.3981	0.3464	0.5292

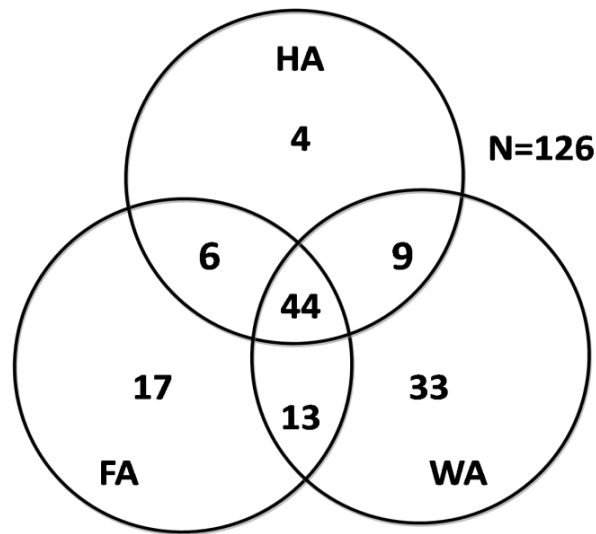
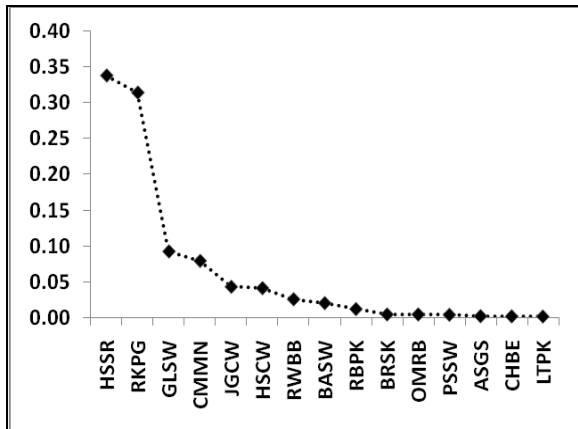
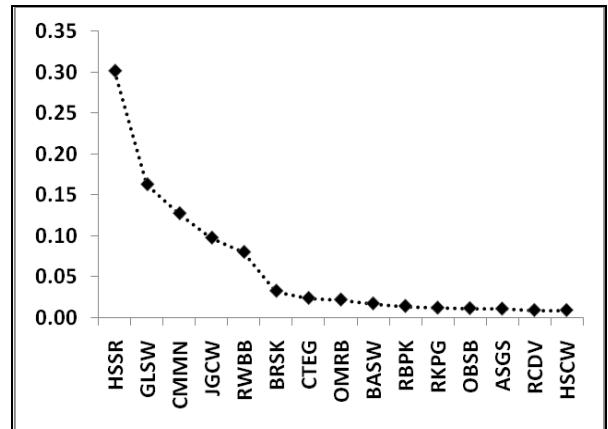


Figure 6.5: Bird species composition of different habitat groups of Andaman Islands

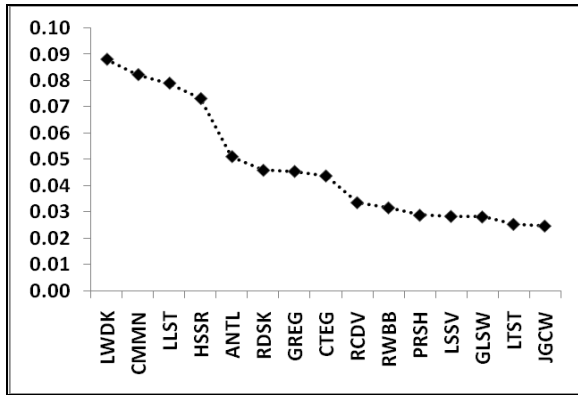
HA- Human associated birds, FA- Forest associated birds, WA- Water associated birds (Opportunistic observations of six species excluded)



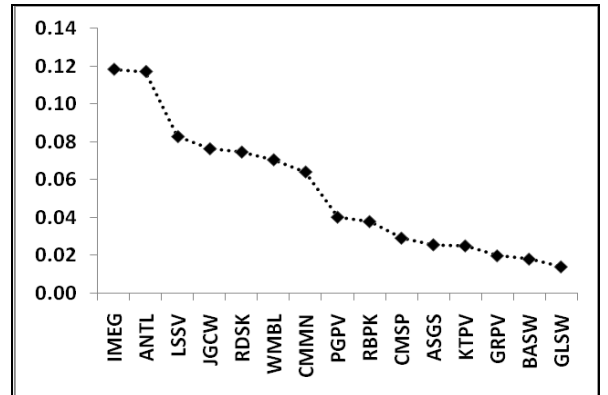
a) Urban area



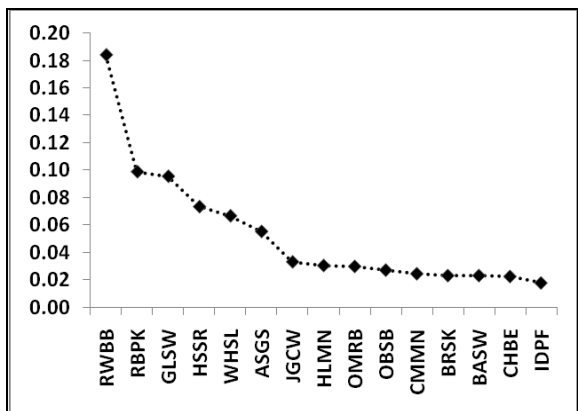
b) Rural area



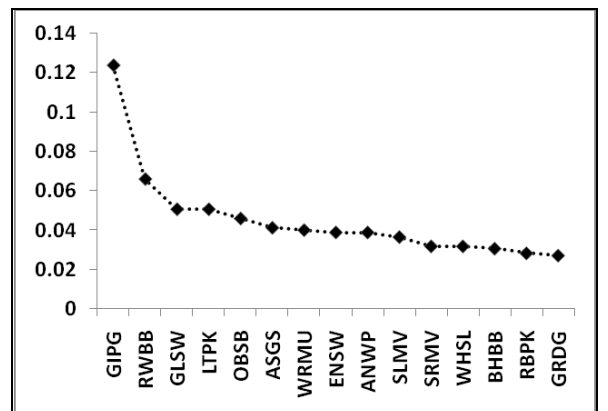
c) Wetland associated area



d) Coastal associated area



e) Disturbed Forest



f) Undisturbed forest

Figure 6.6: Species dominance curve of most 15 dominant species based on abundance in each habitat type (Bird species on X axis and Relative abundance on Y axis)

Of the total 121 species, recorded from 221 transects, 16 species were distributed in all six habitats (Table 6.4) and 44 species were found in all the three groups of habitats. 96 species were recorded from water associated areas followed by 80 species from forest associated area and 61 species from human associated areas (Figure 6.7). Water associated areas such as wetland and coastal associated areas had 30 exclusive species. Orange-headed Thrush and Ruddy Kingfisher were recorded only from the rural area. A total of 80 species of birds were recorded from forest associated area, of which 49 species were common to undisturbed forest and disturbed forest habitat, 13 species were found in water associated areas and six species were found in human associated area as well. There were 41 species found in water and human associated areas, among which nine species were common to water and human associated areas (Figure 6.6). Clustering of habitats using Jaccard similarity index showed that, Bird species composition of urban areas was totally different from other habitats especially from disturbed and undisturbed forest bird species composition. Whereas Rural areas showed similar kind of bird species composition with urban areas. As these are the most human influenced areas in the gradient, this was expected. Similarly coastal associated areas and wetlands; and disturbed and undisturbed forest have better relation in bird species composition (Figure 6.7)

Table 6.4: widely distributed bird species in all six habitats (*-Endemic, **- migratory)

No.	Common Name	Scientific Name	Relative abundance
1	Common Sandpiper**	<i>Actitis hypoleucos</i>	0.024
2	Red-breasted Parakeet	<i>Psittacula alexandri</i>	0.077
3	Brown Coucal*	<i>Centropus andamanensis</i>	0.014
4	Glossy Swiftlet	<i>Collocalia esculenta</i>	0.256
5	Black-capped Kingfisher	<i>Halcyon pileata</i>	0.003
6	Collared Kingfisher	<i>Todiramphus chloris</i>	0.010
7	Chestnut-headed Bee-eater	<i>Merops leschenaulti</i>	0.015
8	Brown Shrike**	<i>Lanius cristatus</i>	0.054
9	Large-billed Crow	<i>Corvus Imacrorhynchus</i>	0.163
10	Red-whiskered Bulbul	<i>Pycnonotus jocosus</i>	0.179
11	Asian Glossy Starling	<i>Aplonis panayensis</i>	0.044
12	White-headed Starling	<i>Sturnus erythropygius</i>	0.033
13	Olive-backed Sunbird	<i>Nectarinia jugularis</i>	0.031
14	Greater Racket-tailed Drongo	<i>Dicrurus paradiseus</i>	0.013
15	Oriental Magpie-robin	<i>Copsychus saularis</i>	0.038

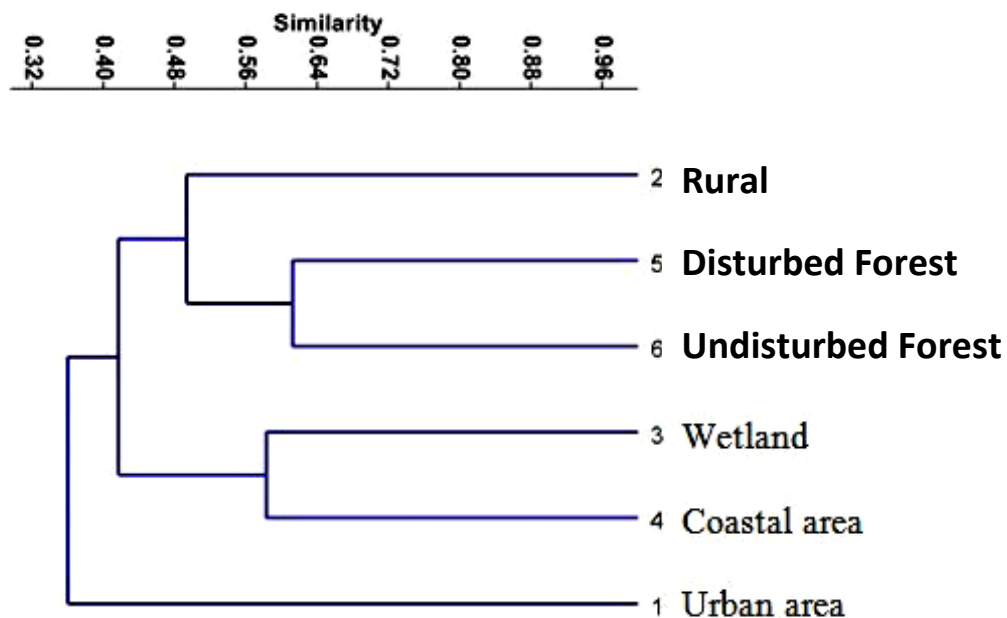


Figure 6.7: Bird species composition similarities (Jaccard index) between habitats

6.4. DISCUSSION

Andaman Islands show a higher degree of habitat destruction and degradation in the human influenced areas. These habitats are distributed patchily because of patchily distributed human settlements. Avifaunal study of human inhabited Islands of Andaman have given an idea of relationship between birds and human activities in these Islands. A total of 126 species were recorded from the eight inhabited islands of Andaman. The diversity of birds in different islands varies with different factors like size of the Islands, distance from nearest land mass and diversity in habitat. Island size and species richness is positively correlated. However isolation of islands from nearest landmass is negatively correlated and this has been widely proved in different taxa (MacArthur 1972; Wright 1981, 1988; Haila 1983), although the complex relationships between island area, population size, habitat suitability and extinction are still not adequately explored. Human disturbance in forest area especially roads significantly inhibited total movement of birds across roads and it has been observed in most of the area (Laurance et al. 2004). The bird diversity recorded in the human impacted area such as large green parks and reserves in urban areas are very high because these areas are the habitat fragments of highly diverse ecosystem (Schaefer

1994). Most human impacted areas in Andaman Islands also shows high diversity, but the magnitude of these effects and whether they are positive or negative varies among species (Marzluff et al. 2001).

Passeriformes are the most diverse bird group in the World and estimated more than 50% population (BirdLife International 2012). Among the 13 orders, more than 50% birds species belong to Passeriformes and Charadriiformes. 33% (41 species) of birds in the study area belong to the order Passeriformes which represents 41% (82 species) of the total Passeriformes of Andaman and Nicobar Islands. Charadriiformes is another big group with 20% (25 species) of bird species. Out of 55 bird families in Andaman Islands, 35 families were recorded during this study. Ten families were represented by a single species such as White-breasted Woodswallow Plain Flowerpecker, White-rumped Munia, Asian Fairy-bluebird, Brown Shrike, Black-naped Tern, Olive-backed Sunbird, House Sparrow, Orange-headed Thrush and Oriental White-eye. Of these House Sparrow is an introduced bird and Brown Shrike is migratory bird. None of these species are under threatened category.

The period of development in human habitat is an important consideration in the variation in habitat use by birds. Habitat ecology is best understood as interplay between the relation of habitat and preference of the each habitat for individuals, populations, and species (Jones et al. 1995). Studies of habitat selection of birds showed an assumption that each species or individual select high quality habitat (Cody 1985). Habitat diversity and availability of particular habitat type is important for species distribution and abundance (Welter-Schultes & Williams 1999; Yoganand & Davidar 2000). Results of this study showed that, inhabited areas of Andaman Islands highly support introduced species such as Common Myna, House Sparrow and Rock Pigeon. Out of total bird detections, more than 32% population detected were introduced species. However, species distributions in the different habitats of the study area were different. Red-whiskered Bulbul is the most distributed species in inhabited areas of Andaman Islands followed by Glossy Swiftlet *Collocalia esculenta* and Large-billed Crow. Introduced species such as Common Myna and House Sparrow are the other most distributed bird species in the study area. Though this study is in inhabited areas of Andaman Islands, Pelagic birds and forest birds were very less in the list. A flock of Brown Noddy has been recorded from the Mahatma Gandhi Marine

National Park, Wandoor, South Andaman. Nocturnal birds such as Andaman Hawk Owl and Andaman Scops Owls were recorded opportunistically from the study area.

Bird diversity of each Island is determined by the availability of habitat and isolation from nearest land mass (Hodgson et al. 2007). Species diversity of Andaman Islands was observed as very rich. Result of Wilcoxon Signed-rank test showed that, there is a significant difference in species composition in each Island. Very high species diversity in the inhabited Islands of Andaman can be the result of the diversity in habitat and their patchy distribution. The same trend has been noted earlier by Davidar et al.(2001). They have suggested that habitat diversity is positively correlated with bird species richness in Andaman Islands. Many species were probably responding more directly to habitat structure than area (Raman 2001), it could be the reason for highest species diversity in Andaman Islands. Unlike other Islands, Alexandrine Parakeet followed by Small Minivet and Red-breasted Parakeet dominates in number of birds in Ritchie's Archipelagos. In South Andaman Islands, both area size and habitat types influence bird species diversity and fragmented habitats have isolated pools of bird species diversity.

Maximum number of species from South Andaman can be the result of diverse and defragmented habitat types. More than 50% of migratory waders were recorded from tidal and inland wetland of South Andaman. Though Middle Andaman Island is biggest island in this group and encounter rate of birds were less as compared to North and South Andaman Islands. Similarly though the Little Andaman is also a big Island, introduced bird encounters were less there. Common Myna could not establish their population in Little Andaman and Middle Andaman Islands so far, few individuals were recorded during whole study period. Local villagers explained that, recently some settlers of Hut Bay, Diglipur and Havelock brought Rock Pigeon from Port Blair as pet and this population has been increasing drastically and has become feral birds in these Islands.

Identifying causes of variability in habitat utilization may serve to increase our understanding of the functional aspects of a species' habitat ecology (Liao et al. 2007). However, favorability of a particular habitat feature depends on each species' demands (Block & Brennan 1993). Species diversity was different in each habitat of Andaman Islands. Highest species diversity was detected from wetland associated area due to

migratory waders. 88 species were recorded from wetland associated areas, including nine single individual records. Oriental Plover was recorded as single individual from Ograbranj Tsunami inundated area. Forest species such as Asian Brown Flycatcher, Hill Myna, Asian Koel and Indian Cuckoo were recorded as single individual from wetland area. Small size of the wetland and presence of small trees in the wetland area is the reason for the detection of forest species in wetland associated area. All five habitats of the study were exposed to human disturbance except undisturbed forest area. Out of 126 species recorded, 123 species of birds have been recorded from these human exposed habitats such as Urban, Rural, Wetland associated, Coastal associated and Disturbed forest areas.

As expected, urban areas were not supporting high avifaunal diversity in these islands even though the bird encounters are considerably high. The low species diversity may be due to low suitability of the transformed habitats to native species. The high encounter rate of introduced species in urban environment also indicates that local species with similar niches are facing stiff competition and may be unsuccessful to win over the invaders. The data shows that the exotic and human associated species appears to be succeeding in the urban ecosystem, while many native species are avoiding it. This might lead to an erosion of species diversity in urban areas and human associated landscapes in these Islands in the future. Introduced species such as House Sparrow and Rock Pigeon are highly dominant in urban area of Andaman. This study shows that, House Crows have increased drastically in Port Blair and surrounding areas. During the last few decades urban ecosystems have therefore become ecological challenges in conservation and restoration of ecosystems (Rosenzweig 2003). Being islands with limited resources, Andaman & Nicobar Islands showcase the problem with much more contrast and explicitness.

Southern part of South Andaman has many wetlands created by the Tsunami and maximum numbers of individuals were recorded from these areas. Tsunami inundated wetlands provides one of the best habitat for migratory species available in this islands. There were four main Tsunami inundated wetlands in Andaman which provides a good feeding ground for wetland birds (Rajan and Pramod 2010). Sippighat wetland is one of the good tidal mudflats used by waders as wintering ground. 63 species of birds were recorded from these Tsunami inundated wetlands, which includes resident water birds like Lesser

Whistling-duck, Common Moorhen, Sunda Teal, White-breasted Waterhen and Purple Swamphen. The Ograbranj and Hutbay wetlands provide good feeding ground for Andaman Teal and the Lesser-whistling Duck. Andaman Teal is considered as an endemic species derived from Sunda Teal to these Islands (Rasmussen & Anderton 2012) and a large population of these live in these wetlands, in particular Sippighat and Ograbranj. All the four wetlands are facing serious threat from human activities especially due to habitat destruction (Rajan & Pramod 2010). This may lead to the disappearance of this wetland in the near future. These areas were used as agricultural land prior to inundation and this is one of the main reasons for the current human interferences in this wetland. It is important to initiate awareness among the rural people, those who are living around these wetlands on the value of the wetlands and the waterfowl species.



Brown Coucal *Centropus andamanensis*: Widely distributed Endemic bird in human associated landscape of Andaman Islands



Andaman Crake *Rallina canningi*: Rarely distributed Endemic bird in human associated landscape of Andaman Islands



Lesser-whistling Ducks in Tsunami inundated wetland in Sippighat, Port Blair



Lesser-whistling Ducks, Intermediate Egret, Common Moorhens and Purple Swamphens in Tsunami inundated wetland in Sippighat, Port Blair.

INTRODUCED BIRDS OF ANDAMAN ISLANDS

7.1. INTRODUCTION

A species is considered “introduced” when it is transported into a new area outside its’ native range through human process (Cassey 2001). There are two types of introduction; Intentional/deliberate introduction and accidental or unintentional introduction. Both of these kinds of introductions are regulated by human movements. Intentional introductions have been motivated by individuals or some groups in some way beneficial to humans. The most common reason for intentional species introductions to new places is related to aesthetic gain. Birds have been deliberately introduced to new locations by human agencies with a variety of reasons. These species might be released directly into the wild or may have escaped from the captivity. Many birds have been introduced throughout the World as a form of biological control of insects and other pests. Best examples are Common Myna and House Sparrow. House Sparrow was introduced to the United States in the nineteenth century partly to control the larvae of the Snow-white Linden Moth *Eunomos subsiganarius*, which was defoliating trees (Lever 1987) and Common Mynas were introduced to Australia to reduce cane-beetles in sugar cane plantations and increased its population and distribution in Australia since introduction in 1862 (Pell & Tidemann 1997). Accidental or unintentional species introductions also mediated by humans and humans’ movements acting as vectors.

Andaman and Nicobar Islands is a significant place in India which is exposed to relatively high human mediated introduction of flora and fauna. There were total 566 plant species, 3 snail species, 4 insect species, 12 mammal species, 13 marine fish species and one virus introduced intentionally to Andaman and Nicobar Islands (Mohanraj et al. 1999). There may be many other introduced species in these Islands unknown to science. A study on introduced herbivorous in the Andaman Islands done by Rauf Ali in 2004, reported that Elephant *Elephas maximus*, Chital *Axis axis* and Barking Deer *Muntiacus muntjak* were established well in these Islands. Approximately 40 elephants were released in 1962 to the

Interview islands and after 30 years it was estimated about 70 individuals of Elephants (Sivaganesan & Kumar 1995). Kumara et al.(2012) reported that, these Elephants population has declined now to below 15 individuals. No systematic study has been done on introduced birds of Andaman and Nicobar Islands. This part of the study is documenting the detailed account and current scenario of introduced birds in the Andaman Islands.

7.2. METHOD OF DATA ANALYSIS

Major eight inhabited islands were surveyed with appropriate field methods (See chapter 4) to study the introduced birds of Andaman Islands. Two uninhabited Islands such as South Button Islands and Interview Islands were also surveyed and data was collected to understand the distribution of introduced birds in undisturbed area. Survey data was classified into Island and habitat wise to study the distribution in different habitat and different islands. Standard statistical procedures and SPSS software were used in analysis.

7.3. RESULTS

A total of 19 species of birds were introduced to Andaman and Nicobar Islands from main land India during the first half of the 19th century (Annexure 4) (Sankaran & Vijayan 1993; Mohanraj et al. 1999; Kazmierczak 2000; Lever 1987). There were no systematic studies on these introduced species of Andaman and Nicobar Islands, but experts mentioned the introduced birds of these islands in different books and articles as anecdotal references. The list presented here (Table 1) contains the synthesized information available on the introduced birds of Andaman and Nicobar Islands as on date with the comments on its present status. Red-whiskered Bulbul and White-headed Myna are excluded from this list because, it was an inter Island introduction.

Of these introduced species, only six species such as Common Myna s, House sparrow, Rock Pigeon, Grey Francolin, House Crow and Indian Peafowl are surviving now in these Islands (Rajan & Pramod 2012). Grey francolin and Indian Peafowl populations are very small population and restricted to one particular place (Rajan & Pramod 2012).

7.3.1. Current status of surviving introduced birds of Andaman Islands

Of the 19 introduced birds of Andaman Islands, six birds namely Common Myna *Acridotheres tristis*, House Sparrow *Passer domesticus*, Rock Pigeon *Columba livia*, Grey Francolin *Francolinus pondicerianus*, House Crow *Corvus splendens* and Indian Peafowl *Pavo cristatus* have been recorded during this study period.

7.3.1.1. Common Myna *Acridotheres tristis* (Linnaeus 1766)

Common myna native to Central and South Asia, but it is introduced to most of the countries and islands. Common Mynas were intentionally introduced to Port Blair on South Andaman in 1867 by Colonel R. C. Tytler (Lever 1987; Sankaran & Vijayan 1993) and these birds have established well in most of the human settled Islands in Andaman. This study examines the distribution and potential impact of the Common Myna in Andaman Islands.

Common Myna has established well in Andaman Island with good population especially in Southern part of South Andaman Islands and Northern Part of North Andaman Island. It was not established well in Middle and Little Andaman Islands. Of the total bird encounters (15859 individuals) recorded during the bird survey, 7.97% (1264 individuals) encounter was of Common Myna. The preferred habitat of Common Myna is Rural area (34.7%) followed by Inland - Wetlands associated areas (30%), Urban (23), Coastal associated areas (8.7%) and disturbed forest (2.9%). But no individual was recorded from undisturbed forest (Figure 7.1a).

Of the total 1264 individuals encountered during this study, 86.55% individuals were recorded from South Andaman Islands followed by North Andaman (11.63%). High detections from South Andaman showed that human settlements provided good habitats for Common Mynas. Northern part of North Andaman is a highly human populated area and Most of the records come from areas like Ariel Bay, Diglipur and Khalipur area. Though Middle Andaman is the largest island area wise, but only 1.19% of birds were recorded especially from Mayabunder and Baratang area. Not a single individual was recorded from Rangat and Southern part of Middle Andaman. This may be the result of patchily distributed human settlements. Little Andaman is another area with very low Common Myna population, only 8 (0.63%) individuals have been recorded from Hutbay area of Little

Andaman Island. There wasn't a single detection of Common Myna from surveyed Islands in Ritchie's Archipelago such as South Button, Havelock and Neil Islands (Figure 7.1: b).

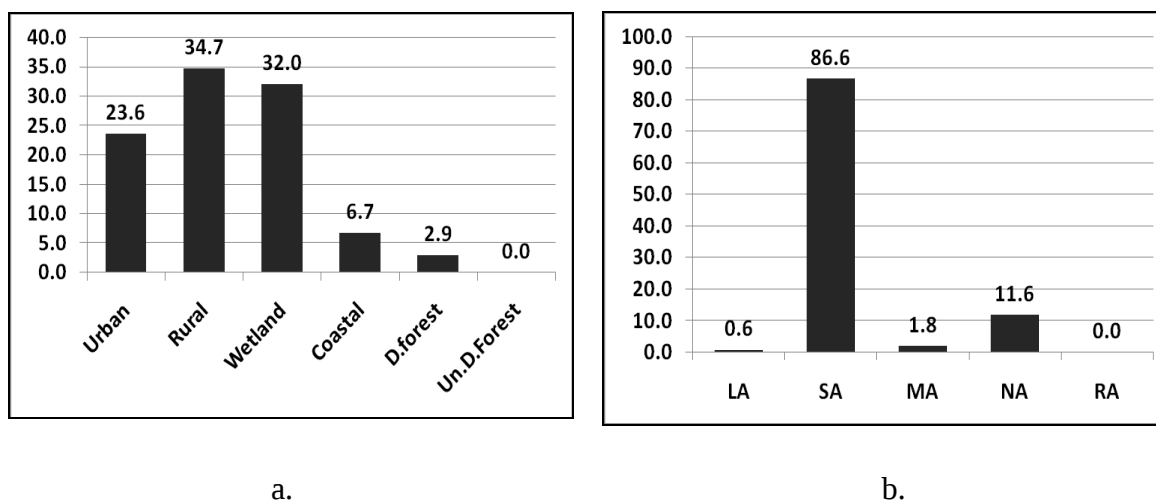


Figure 7.1: Common Myna *Acridotheres tristis* abundance (%) and distribution in a) different habitats and b) different Islands. (LA-Little Andaman; SA-South Andman; MA-Middle Andman; NA-North Andaman; RA-Ritchie'e Archipelago)

7.3.1.2. House Sparrow *Passer domesticus* (Linnaeus, 1758)

The House Sparrows are distributed naturally in Northern Africa, Asia, and Europe (Khera et al. 2009) and it was introduced in most of the Islands in southern hemisphere, south Africa, Australia, North America and South America (Lever 1987). This species has become one of the most widely distributed land birds in the world (Summers-Smith 1988). According to Summer Smith 1988, two subspecies of House Sparrow were recognized, *Passer domesticus domesticus* from the Palearctic region and *Passer domesticus indicus* from Asian region. The House sparrows are introduced to Ross Islands in the South Andaman Island by Mr. O.H. Brookes during 1882 and 1895 (Lever 1987; Abdullali 1964). There were six individuals introduced to Ross Islands in 1882 followed by 20 more individuals in 1895 (Lever 1987). According to Abullali 1964, this species was common in and around Port Blair and Chouldary. Because of insufficient study on avifauna of Andaman and Nicobar Islands, There wasn't any report of these species from other Island groups.

House Sparrow has contributed 17.45% (2768 individuals) to the total bird encounter (15859 individuals) during this study. House Sparrow was the highest abundant species followed by Common Myna in this study. Of the total population of this species, 45.62% of population was occupied in urban areas especially in town centers. Rural area was another habitat with high abundance of House Sparrow with 37.54% encounter followed by wetland associated area (12.21%) and Disturbed forest area (3.97%). Coastal associated areas have reported only few individuals with 0.65% population (Figure 7.2a). None of the birds were observed in undisturbed forest area. Ross Island was the actual site of House Sparrow introduction (Lever 1987) and now this species has expanded to almost all Andaman Islands along with human settlement. House Sparrow was recorded in all the surveyed Islands (Figure 7.2b). Maximum population was recorded from South Andaman Islands with 56.31% followed by Little Andaman (15.69%, Middle Andaman Islands (15.69%), North Andaman (4.16%) and Ritchie's Archipelago (0.79%). Same as mainland population, introduced House Sparrows activities are mainly concentrated in urban and rural areas. An observation made during the survey period was 6 individuals that were recorded as feeding in new the Tsunami shelter in Hut bay which is away from the town area and after one year, House Sparrows have established well in this Tsunami shelter with nests. These birds roost colonially on small trees in the town centre, bushes and small trees in the Rural areas and in bushes located near wetland.

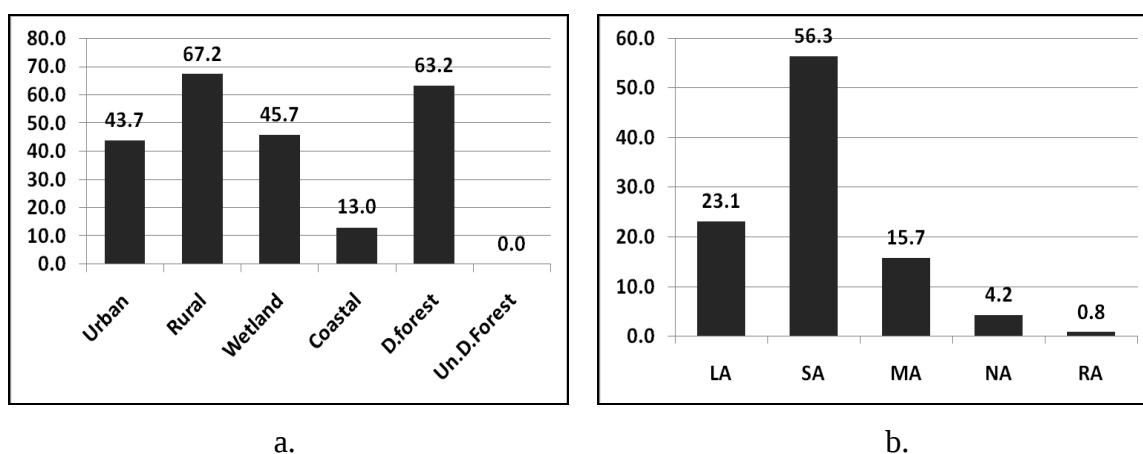


Figure 7.2: House Sparrow *Passer domesticus* abundance and distribution in percentage a) different habitats and b) different Islands. (LA-Little Andaman; SA-South Andaman; MA-Middle Andaman; NA-North Andaman; RA-Ritchie's Archipelago)

7.3.1.3. House Crow *Corvus splendens* (Vieillot, 1817)

House crows are naturally distributed southern Asia from southern Iran through Afghanistan, Pakistan, India, Sri Lanka, Southern China, Nepal and Southern Myanmar (Lever 1987). According to Lever 1987, it has been introduced to Gulf countries, North Eastern Africa, Eastern Africa, Malayan region, Mauritius, Seychelles and Andaman Islands. The House Crows are widespread and considered as a notorious pest species in Asia and Africa (Brooke et al. 2009).

The House crows were intentionally introduced to Port Blair between 1862 and 1864 by Col. R. C. Tytler for sanitary purpose especially to scavenge on the settlement's refuse, but failed to survive in these islands (Lever 1987; Mohanraj et al. 1999). It was reported that House crows accidentally reached in the Port Blair less than one decade ago by ship. Currently, it is restricted to Port Blair and day by day population of the House Crows is increasing and spreading drastically around Port Blair. This species shares feeding, nesting and roosting sites with Large-billed Crow. A total 201 House Crows were encountered during this study. Of this, 77.61% of population was recorded from Port Blair town area. Port Blair was also habitat for Large-billed Crow or Large-billed Crow. 12.94% of population of House Crow was recorded from nearest Rural areas and the remaining population was recorded from wetland and coastal associated areas with less than 5% (Figure 7.3a). During 2008 and 2009, there weren't any House Crows recorded from Sippighat wetland area but during 2010, some of the House Crows were observed as feeding in the Sippighat wetlands with Large-billed Crows. Other surveys from this wetland have observed House Crow with reasonable individuals. So far the House Crow was not found in any other Islands except South Andaman (Figure 7.3b). Nests of House Crows were observed in tall trees in Port Blair especially in the town centre trees in Aberdeen Bazaar, Marine, Haddo and Junglighat areas. It was observed that, some of the crows were roosting as colonies in the trees at Port Blair along with Common mynas.

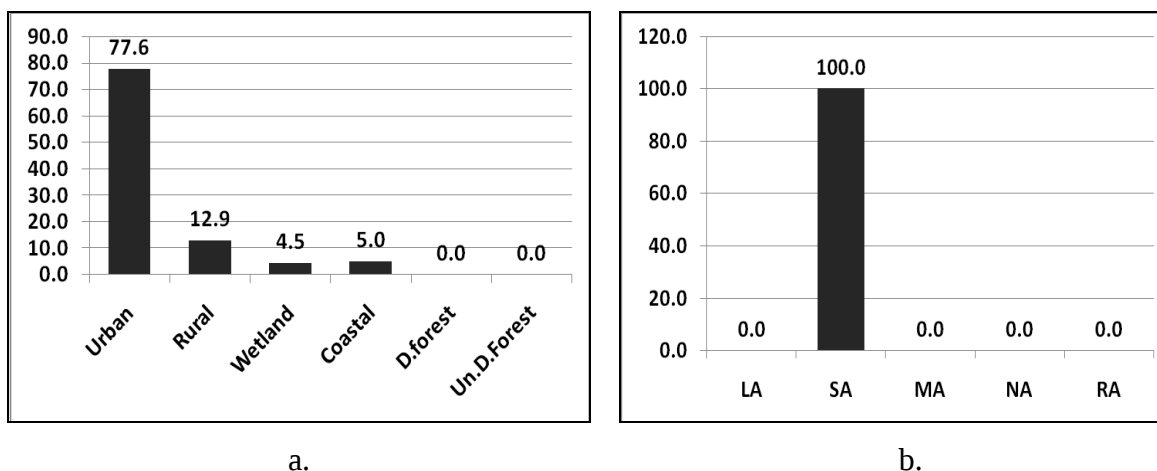


Figure 7.3: House Crow *Corvus splendens* abundance (%) and distribution in a) different habitats and b) different Islands. (LA-Little Andaman; SA-South Andman; MA-Middle Andman; NA-North Andaman; RA-Ritchie'e Archipelago)

7.3.1.4. Grey Francolin *Francolinus pondicerianus* (Gmelin, 1789)

Grey Francolins are naturally distributed in Southern Iran, Southern Afghanistan, West Pakistan, India and Srilanka (Lever 1987). The global population size has not been quantified, but the species is reported to be common in most parts of its range (del Hoyo et al. 1992). It has been introduced to Hawaii, UAE, Mauritius, Reunion, Rodrigues, Seychellus, Amirante, Oceania, Guam and Andaman Islands (Lever 1987).

Grey francolin had been introduced to South Andaman about 1890 from Southern India (Lever 1987). According to Abdulali 1967, this species was recorded from Haddo during 1963 and 1964 and he could not report this species again thereafter. However, Ali and Ripley in 1969 found that, Grey Francolin had established small populations in the neighborhood of Port Blair especially on grassy deforested Hill top areas.

This study showed that Grey francolin is still surviving in deforested areas in Dollygunj, near Port Blair where Ali & Ripley (1969) reported. During this study, only four individuals were observed in grassy wetland near Dollygunj, Port Blair and South Andaman Islands. These four individuals were observed many times as opportunistic sight from same place. Distribution and habitat wise abundance of this species is given in Figure 7.4a,b.

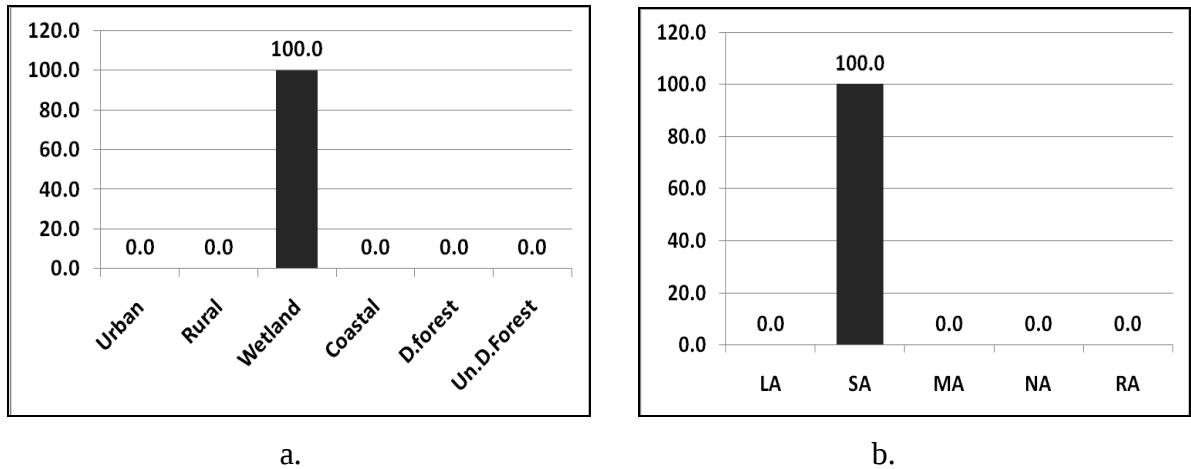


Figure .7.4: Grey Francolin *Francolinus pondicerianus* abundance and distribution in percentage a) different habitats and b) different Islands.

7.3.1.5. Indian Peafowl *Pavo cristatus* (Linnaeus, 1758)

Indian Peafowl is naturally distributed in Pakistan, India, Nepal, Bangladesh and Sri Lanka and it has been introduced to Hawaii, Australia, New Zealand, North America and Andaman Islands (Lever 1987). In Andaman Islands, Indian Peafowl was introduced to Ross Island off Port Blair on South Andaman and Port Blair in about 1868 (Abdulali 1964 and 1967). Hume (1873) reported that, Indian Peafowls in South Andaman had flourished. The birds on Ross Island were destroyed by Japanese when they occupied Andaman and Nicobar Islands between 1942 to 1945 during World War II, but after the archipelago's liberation few were introduced to Ross Islands (Lever 1987). Ross Island is highly human disturbed area with vegetation and remains of British penal colony and this bird is still surviving in this Island (Figure 7.5a, b). The population size was about 16 individuals (maximum detection in a transect) and has almost become domesticated. They were also seen near humans and pecking for food discarded by tourists and bird seed offered by administrative workers.

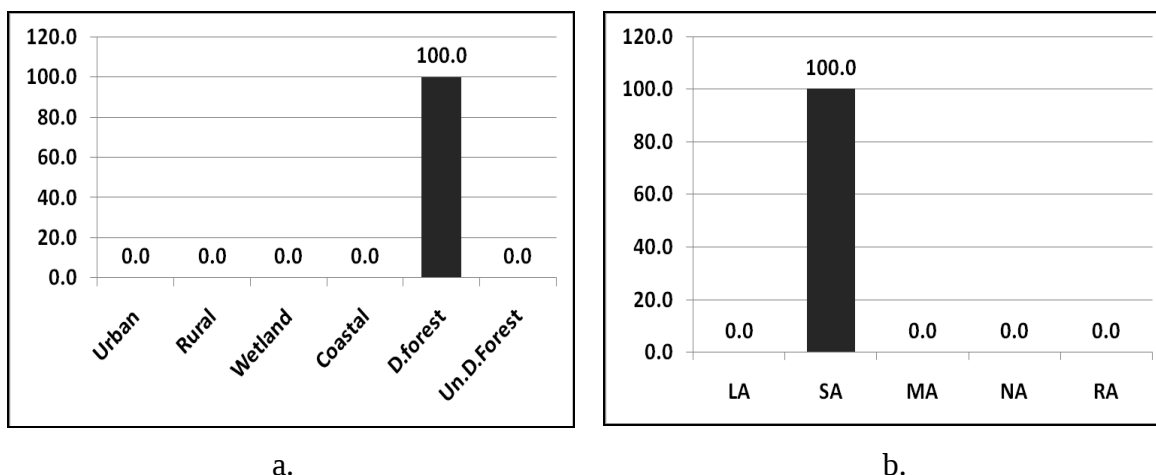


Figure 7.5: Indian Peafowl *Pavo cristatus* abundance and distribution in percentage a) different habitats and b) different Islands. (LA-Little Andaman; SA-South Andman; MA-Middle Andman; NA-North Andaman; RA-Ritchie'e Archipelago)

7.3.1.6. Rock Pigeon *Columba livia* (Gmelin, 1789)

Rock Pigeon is widely distributed in western Palaearctic, northern Ethiopian regions and to Indian subcontinent and it has been introduced to most of the countries other than native places (Lever 1987). Rock pigeons were introduced to South Andaman and Car Nicobar in 1898 (Kloss 1903). Abdulali (1967) reported that, feral Pigeons were established well in Nancowry and Camorta Islands in Nicobar and Port Blair in South Andaman Island. Present study showed that, Rock Pigeon has established well in Andaman Islands especially in Port Blair and Rangat town. They are often seen in large flocks in crowded streets in Port Blair and Rangat. People still keep this species as a pet and after few months it will multiply well and become a huge feral population. Of the total bird detection of this study, Rock Pigeons were contributing 7.72% (1224 individual encountered) of abundance. Of this 1224, 95.93% encounters were from Urban areas. Only 3.35% encounters were from Rural area followed by 0.74% from Wetland associated (Figure 7.6a). There wasn't any individual sighted in Coastal associated, Disturbed forest and Undisturbed forest.

This species was observed in all five island groups; however 78.75% of population was encountered from South Andaman Island especially in Port Blair. There was a huge

group of Rock Pigeons with about 300 individuals observed in Port Blair town. 18.44% of this species were recorded from Middle Andaman followed by 1.20% from Little Andaman, 0.96% from North Andaman and 0.64% from Ritchie's Archipelago (Figure 7.6b). During the period of 2008 to 2010, there wasn't any Rock Pigeon detected from Little Andaman.

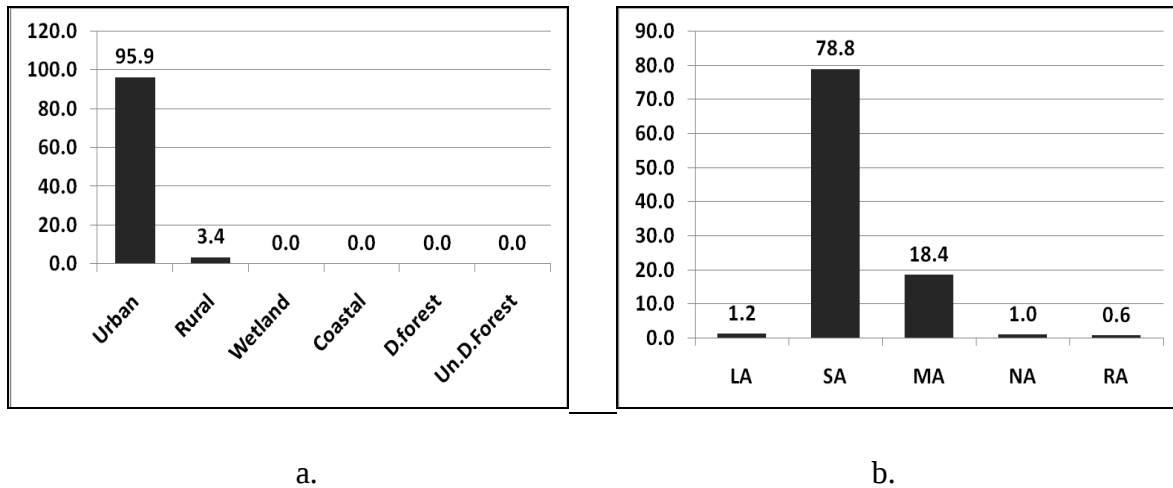
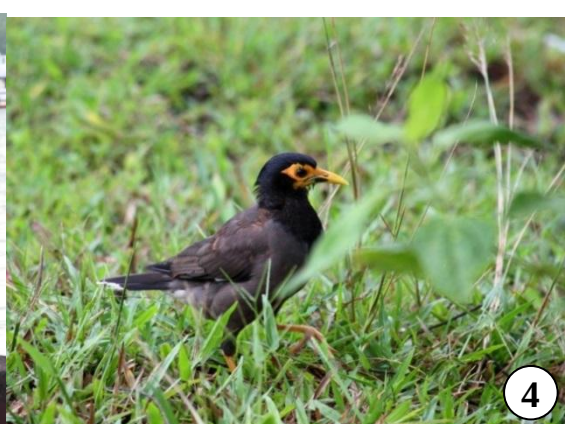


Figure 7.6: Rock Pigeon *Columba livia* abundance and distribution in percentage a) different habitats and b) different Islands.

Surviving introduced birds of Andaman Islands



1. House Sparrow *Passer domesticus*

2. Rock Pigeon *Columba livia*

3. Indian Peafowl *Pavo cristatus*

4. Common Myna *Acridotheres tristis*

5. House Crow *Corvus splendens*

6. Grey Francolin *Francolinus pondicerianus*

7.3.2. Distribution and abundance of introduced birds in Andaman Islands: A comparison

A total of 5518 individuals of introduced birds have been encountered during this study. House Sparrow was the most abundant introduced birds in Andaman Islands (2790 individuals encountered) and this species was distributed in all the human settled Islands of Andaman. Common Myna was the second most abundant introduced bird with 1264 encounter followed by Rock Pigeon (1232 encounter) and House Crow (201 encounter). South Andaman had the maximum number of introduced birds; whereas Ritchie's Archipelago has the lowest number in introduced bird abundance. Middle Andaman and Little Andaman were almost the same in introduced bird population (Table 7.1). Established introduced birds of Andaman Islands are mostly distributed in disturbed habitat especially human associated areas. Of the six surviving introduced birds, House Sparrow and Rock Pigeon were strictly associated with human activities; however Common Myna was utilizing maximum human disturbed areas. There wasn't any introduced bird species observed in undisturbed forest like Mount Harriet National Park, Saddle Peak National Park. In other five habitats of this study such as urban, rural, wetland associated, coastal associated and disturbed area, Common Myna and House Sparrow were detected in the entire five habitats (Figure 7.7). Main habitat of Rock Pigeon in Andaman was urban area, although this species has been recorded from Rural where actual introduction happens as pet bird and some has been recorded from wetland also. House Crow was recorded from urban and coastal associated areas in Port Blair. Habitat wise abundance of six introduced species is given in Figure 7.7.

Clustering using Jaccard Similarity index showed that, Common Myna and House sparrow have more similarities in composition and distribution followed by House Crow population and Rock Pigeon respectively. Whereas Grey Francolin and Indian Peafowl were more dissimilar with other introduced species by abundance and distribution (Figure 7.8). Out of 221 total transects, introduced species were encountered in 150 transects. Of these, Common Myna encountered in maximum transects with 107 transects followed by House Sparrow (98 transect), Rock Pigeon (29 transect), House Crow (17 transects), Indian Peafowl (four transects) and Grey Francolin (one transect). Rock Pigeon was detected as

huge groups from Port Blair where as House Sparrow and Common Myna encountered almost stable in all the transects.

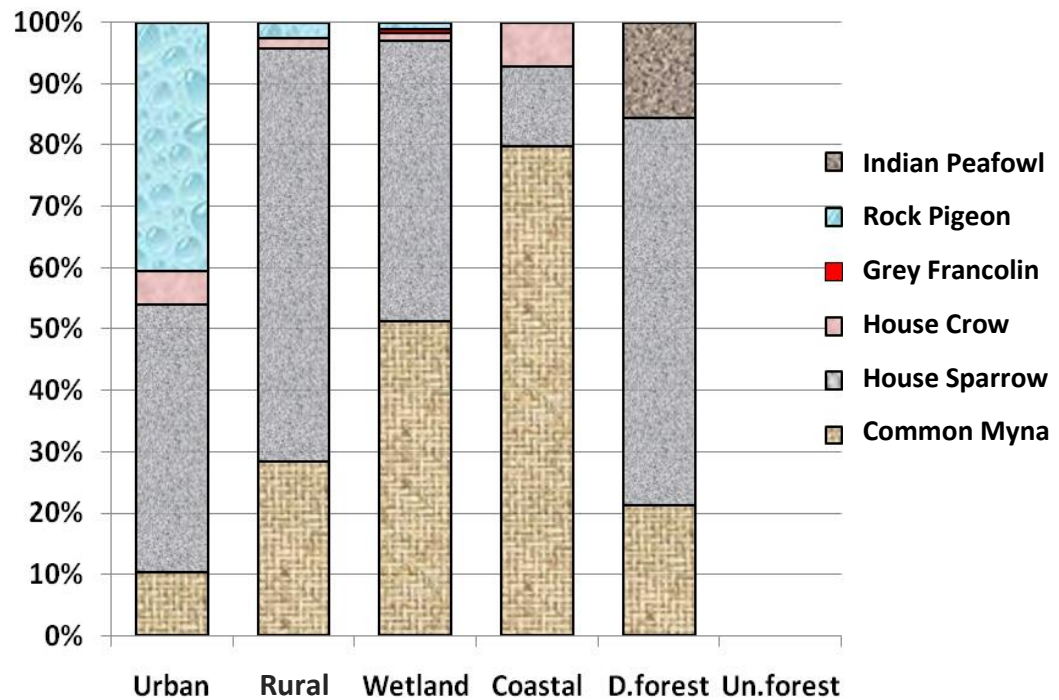


Figure 7.7: Abundance of introduced birds species in different habitats in Andaman Islands.

Table 7.1: Introduced species distribution and abundance in each Islands group.

Species	LA	SA	MA	NA	RA	Total
Common Myna	8	1094	15	147	0	1264
Grey Francolin	0	4	0	0	0	4
House Crow	0	201	0	0	0	201
House Sparrow	643	1571	438	116	22	2790
Indian Peafowl	0	27	0	0	0	27
Rock Pigeon	0	982	230	12	8	1232
No: transects	39	98	51	23	10	221
Total	651	3879	683	275	30	5518

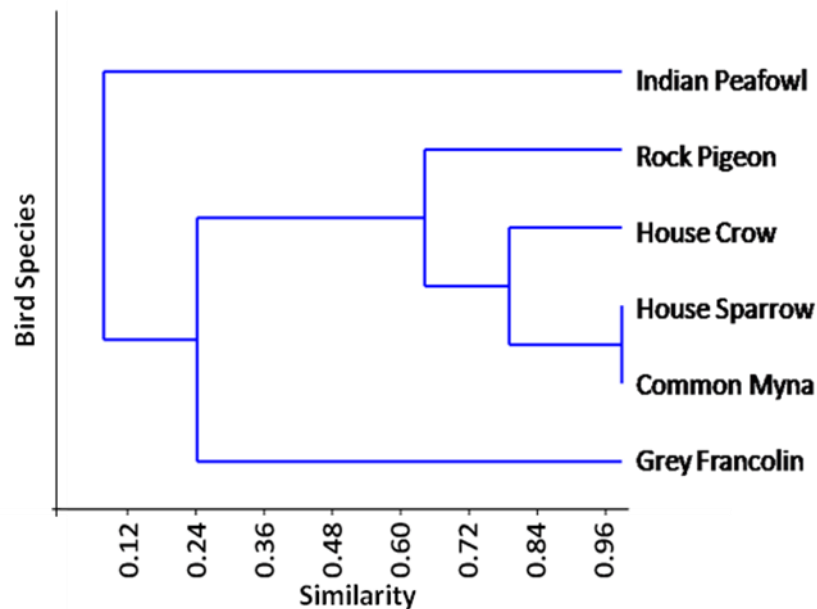


Figure 7.8: Clustering of introduced species using Jaccard Similarity index in Andaman Islands

Principal Component analysis (Kaiser-Meyer-Olkin (KMO) = 0.537; Eigenvalue = 90.98% of variance) showed that Rural, Disturbed forest and urban areas have high factor score (0.897, 0.881 and 0.855 respectively) in first principal component and it showed that Urban, Rural and Disturbed forest have good affinity towards introduced species. Coastal wetland (factor score 0.970) and Inland wetland (factor score 0.804) are the other two habitat which was providing habitat for introduced species, whereas Undisturbed forest areas of Andaman islands does not have any relation with introduced bird with factor score zero in both components (Figure 7.9 and Table 7.2).

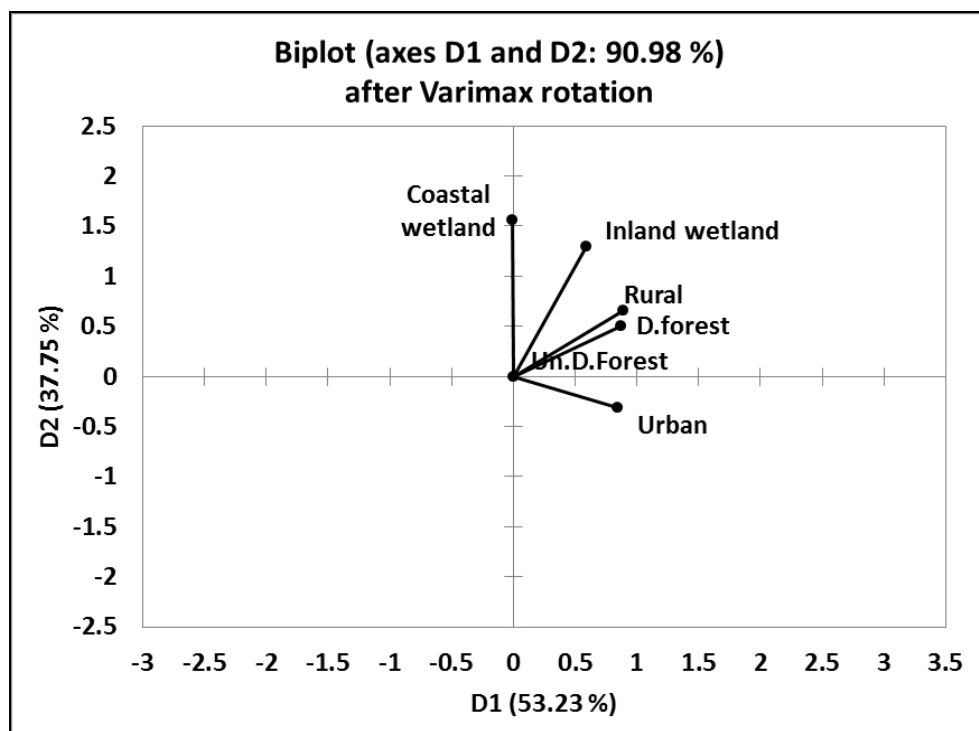


Figure 7.9: Principal Component Analysis (Varimax rotation with Kaiser Normalization):
Introduced bird species affinities towards the each habitat.

Habitat	D1	D2
Urban	0.855	-0.192
Rural	0.897	0.407
Inland wetland	0.593	0.804
Coastal wetland	-0.006	0.970
Disturbed forest	0.881	0.314
Undisturbed Forest	0.000	0.000

Table 7.2: Principal Component Analysis (Varimax rotation with Kaiser Normalization):
Factor score of introduced species towards the each habitat.

Common Myna is one of the 19 introduced bird species of Andaman and Nicobar Islands and this species has been nominated as one of the 100 "World's Worst invaders" by Invasive Species Specialist Group (ISSG) of IUCN. The population and range of Common

Myna is observed as increasing as result of ongoing habitat degradation, especially human mediated change. Common Myna has already established well in South Andaman, North Andaman and Baratang Islands with huge populations but could not establish well in Little Andaman Island. In all these places they are strongly associated with human settlement area. These studies showed that Common Myna has become one of the dominant species in this archipelago and have potential to become competitor for other native bird species. Hence in this study, a special attempt is made to focus more time on the ecology of Common Myna.

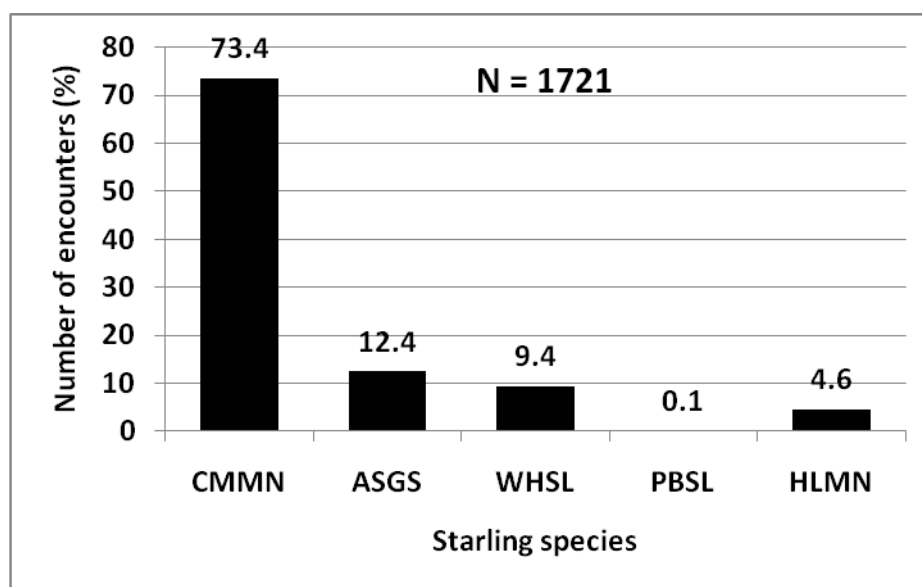
7.3.3. Common Myna *Acridotheres tristis* :Ecological Implications of an Invasive Species in Andaman Islands' Biodiversity

Common myna is native to Central and South Asia, but it is introduced to most of the countries and islands. Studies on introduced Common Myna in Islands are rigorously establishing the negative effect on native fauna (Dhami & Nagle 2009). Many studies showed that, introduced Common Myna is spreading throughout the Pacific Islands. Mynas are communal and commensal in behavior, highly vocal throughout the year. Therefore this species has been considered as nuisance bird around human habitations (Dhami & Nagle 2009). This species has been nominated as one among the 100 “World's Worst invaders” along with European Starling and Red-vented Bulbul by Invasive Species Specialist Group (ISSG) 2006 of IUCN. Though, this species has been introduced to Andaman and Nicobar Islands. This species become one of the successful exotic birds other than House Sparrow and Rock Pigeon in Andaman Islands. Common Mynas have established their population very well along the disturbed habitats. Presently, free-ranging populations have established over most of Andaman Islands. However, this species could not establish well on some islands such as Middle Andaman and Little Andaman.

7.3.3.1. Population and distribution of Common Myna in Andaman Islands

The population range of Common Myna is observed to be increasing as result of ongoing habitat degradation, especially human mediated changes. They are strongly associated with human settlement area where they are established. Common Myna has abundant population in these Islands as compared to other starling species such as Asian Glossy Starling, White-headed Starling *Sturnus erythropygius*, Purple-backed Starling *Sturnus sturninus* and Hill Myna *Gracula religiosa*. Of the total 1721 individual detections

of starling species, 73.4% population contributed by Common Myna followed by Asian Glossy Starling (12.4%) (Figure 7.10). These two species were sharing mostly same habitat for nesting in many areas. Only seven individuals of Purple-backed Starling were detected in a single transect from Port Blair and they were feeding on Casuarina tree. It has been observed that, Common Myna and Asian Glossy Starling population were very high in disturbed woody areas.



CMMN-Common Myna; **ASGS**-Asian Glossy Starling; **WHSL**-White-headed Starling; **PBSL**-Purple-backed Starling; **HLMN**-Hill Myna

Figure 7.10: Species encounter rate comparison between starling species of Andaman

Common Myna established well in South and North Andaman Islands; however it has been recorded from all the study islands except Ritchie's Archipelago (Figure 7.11). Only few individuals were recorded from Little Andaman in 2009. Less than ten individuals were recorded from Baratang Island near to Lime Stone cave in 2009, but there wasn't any individuals were observed in 2011 and 2012. Presently this species is distributed in most of the human habitation in South, and North Andaman Islands. Rangat is the big human inhabited area other than Diglipur and Port Blair. Interestingly there wasn't any Common Myna recorded from Rangat area. Six individuals were observed from Mayabunder area (Northern tip of Middle Andaman Island) was the only record of Common Myna from

Middle Andaman Islands. Common Myna was distributed in all habitats except undisturbed forest in the Island. Tsunami disturbed areas such as damaged mangroves, damaged coconut plantations, coastal associated areas have become favorite places for this species.

7.3.3.2. Possible impacts of Common Myna on other native species

Common Myna is considered an invasive species in several Islands like New Zealand, Australia, Hawaii, Singapore, etc. where they have been introduced. Also Common Myna was reported to be responsible for decline of native threatened birds in several places (Blanvillain et al. 2003; Dhami & Nagle 2009). In Andaman Islands, this species have clear overlapping in their activities with other native species like Asian Glossy Starling. Common Mynas compete with other birds for food, nesting and territory and appears to be replaced the Asian Glossy Starling (Ali 2003). There are many factors that are contributing towards the invasiveness of Common Myna local biodiversity in Andaman Islands.

7.3.3.3. Roosting

The communal roost of Common Myna was observed in different habitats selectively in mangrove, trees in town centre and rural area. It has been observed that each morning flocks of these birds were seen flying out of the roosting trees and returning again in the late afternoon. During the study period, two large communal roost site of Common Myna in Trees in Aberdeen Bazaar (N11°39'90"N 92°44'57"E) and Mangroves in Sippighat (11°36'23"N & 92°41'17"E) were observed. In Aberdeen Bazaar, Port Blair, approximately 400 Common mynas were observed coming to the roosting tree and they were very noisy during this time. It was observed in 2009 and 2010 that, same trees were also used by Large-billed Crow and House Crow together for roost. Unlike mainland India, Common Myna roost has been observed in mangroves in Sippighat tidal wetland with large number. There were about 250 mynas roosting here along with other species like Red-breasted Parakeet and Asian Glossy Starling. There was no recent observation of Asian Glossy Starling roosts in mangroves of Sippighat area whereas Red-breasted Parakeet still managed to roost here with small group. Common Mynas roost with small group or as pairs in remaining places in Andaman Islands.

7.3.3.4. Nesting

There are 78 active nests of Common Myna and Asian Glossy Starling were recorded, of these 31 nests were used by Common Myna and remaining 47 nests were used by Asian Glossy Starling. Nests of Common Myna were strictly distributed near to human settlements and don't show large range from human disturbed area, whereas Asian Glossy Starling nests were showed greater range in the distances from Human settlements (Figure 7.12a,c). Average nest height of Common Myna was between 12.5mts, however some nests were in about 25 meters height and pointed as outlier in the box-whisker plot (Figure 7.12b).

Table 7.3: Nest character comparison between Common Myna and Asian Glossy Starling

	Common Myna	Asian Glossy Starling	Total No. of nests
Habitat			
Urban	3	0	3
Rural	5	1	6
Coastal associated areas	5	15	20
Undisturbed Forest	0	2	2
Disturbed Forest	3	4	7
Wetland associated areas	15	25	40
Substratum			0
Dried tree	9	29	38
Dried Coconut tree	16	14	30
Tree	0	4	4
Building	6	0	6
Nest Type			
Ventilator	4	0	4
Hole	9	37	46
Top	18	10	28

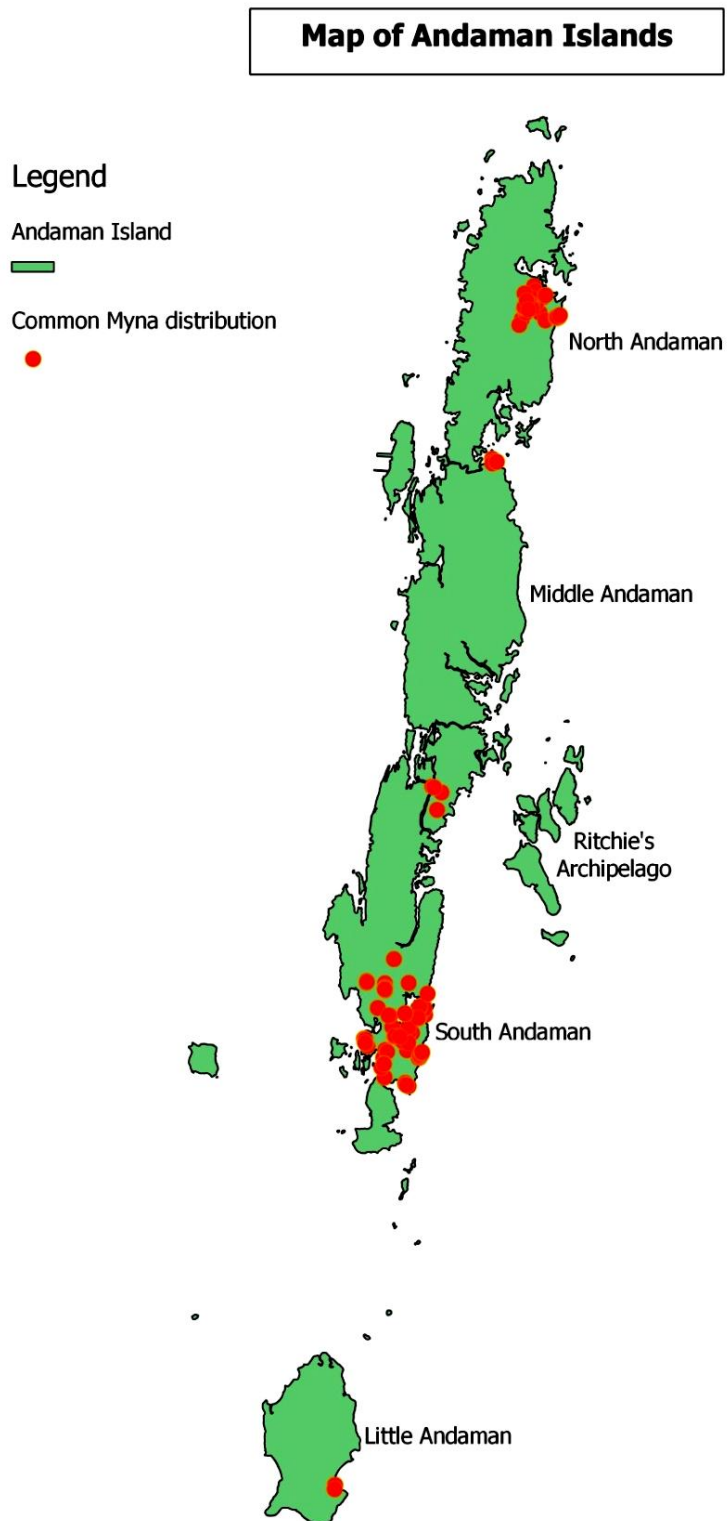
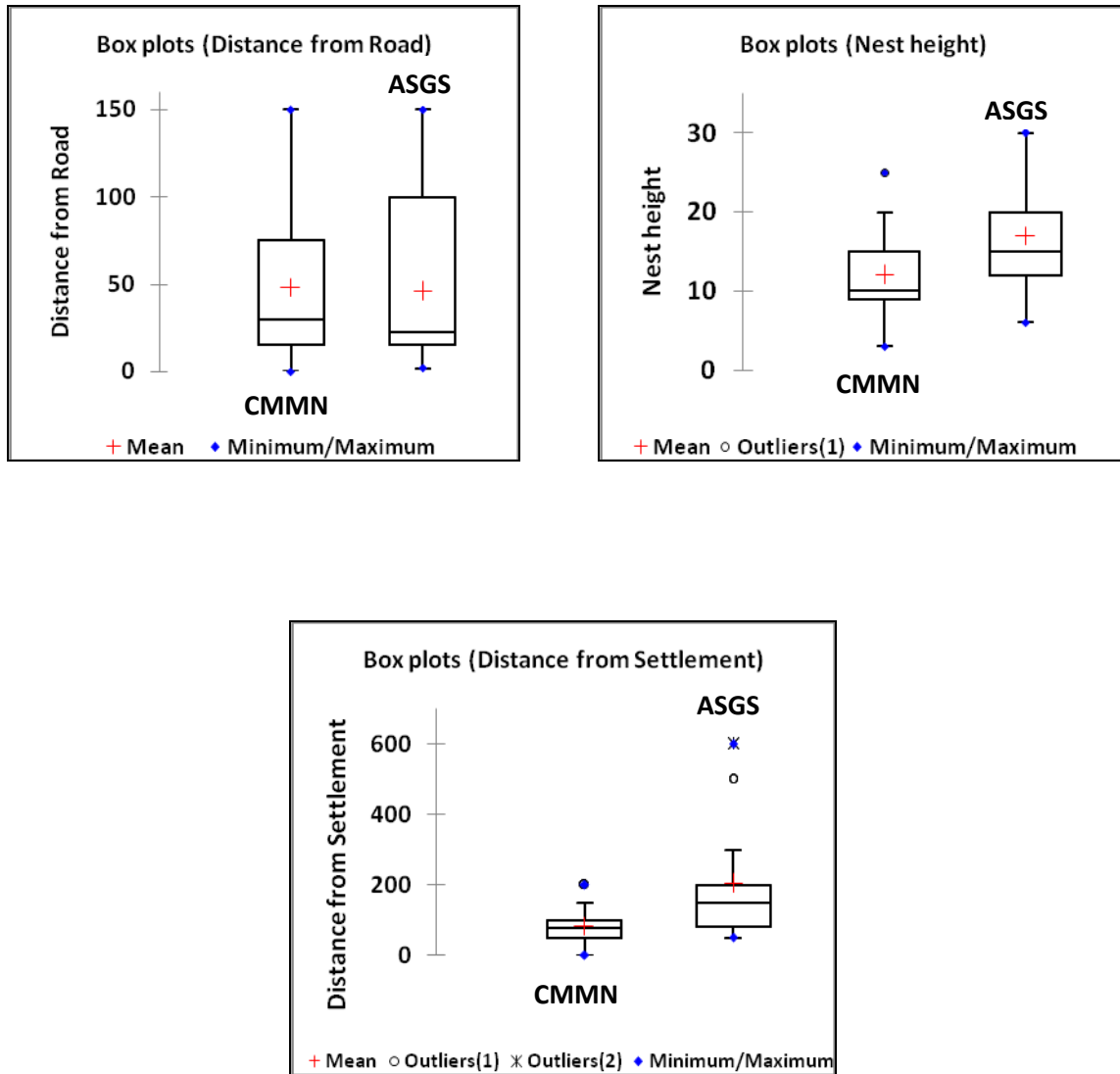


Figure 7.11: Current distribution of Common Myna *Acridotheres tristis* in Andaman Islands

These two species preferred wetland associated areas as good nesting location than any other habitat (51.28% nests) because of presence of dried trees, however Asian Glossy Starling also preferred trees in coastal associated areas for nesting. Interestingly, most of the nests of these two species presented here were located in same places. Tsunami affected mangrove trees and coconut trees have provided excellent sites for nesting for these two species. Of the total nests, 63 nests were placed on dead coconut tree and dead trees which are affected by Tsunami. 18 nests of Common Myna were placed in top cavity of dried coconut tree, whereas maximum nests of Asian Glossy Starling located on side hole of these dried trees (Table 7.3). Mann-Whitney U test (Two tailed) performed for nest variables of Common Myna and Asian Glossy Starling data suggested that, there was no significant difference between the nest characters such as nesting habitats ($U = 17$; $P = 0.872$), Nest substratum ($U = 7.5$; $P = 0.885$) and nest type ($U = 4$; $P = 0.827$) of both bird species in these Islands. Mann-Whitney U test (Two tailed) suggested that, there was a clear nest variables' overlapping among Common Myna and Asian Glossy Starling in the Andaman Island.



Figur. 7.12: Comparison between nest charecteristics of Common Myna and Asian Glossy Starling

7.4. DISCUSSION

Biological introduction is one of the major threats to alter the environment along with air, land and water pollution. Some of the major introductions are domesticated plants and animals. Though these kind of deliberate introductions are planned for good purpose, it may have negative impacts on the native environment silently (Gurevitch Padilla 2004). Many of these species introductions can be for economic benefits (Pimentel 2010). Researchers considered the introduction of exotic species into new environments as biological pollution (Boudouresque & Verlaque 2002). Introduced species can have serious effects on native ecosystem and native species. Biological invasions are widespread and significant components of environmental changes. There are many good studies showing that biological invasions contribute substantially to extinction (Vitousek 1994; Vitousek et al. 1997; Simberloff 2003). The Convention on Biological Diversity (CBD), 1992 suggested that, biological invasion is the second worst threat to biodiversity after habitat destruction (Jenkins 1999).

Though 40% of the flora of India are alien species, of which 25% are considered as invasive species (Rao & Murugan 2004; Raghubanshi et al. 2005). Andaman and Nicobar Islands is one of the significant places in India which is exposed to very high human mediated introduction of fauna. As per the records, 19 species of birds were introduced to these archipelagos during the first half of nineteenth century. However, only six species are surviving here now (Rajan & Pramod 2012). Inter-island introductions were also performed in these islands, Red-whiskered Bulbul and White-headed Starling were introduced to Nicobar Islands from Andaman. Details of these intra-island introductions are not easily available. It is clear that some species have been successful nearly everywhere in the world wherever they have been introduced (Long 1981). However other introduced species are highly specialized for restricted environments and are expected to be unsuccessful and it doesn't matter where they are introduced (Moulton & Pimm 1983).

It is widely accepted that, repeated introduction attempts will increase the probability of successful establishment of non-native species (Williamson 1996; Williamson & Fitter 1996; Grevstad 1999). Unlike New Zealand, North America and Hawaii, repeated attempts of introduction were not made in Andaman and Nicobar Islands. However, only two species:

House Sparrow in 1882 & 1895 and House Crow in 1862 & 1864 were introduced repeatedly in Andaman Islands. Other 17 species birds were introduced only once with small groups and 13 species were believed to have died out in these Islands. Most of the studies on introduced birds around world showed that, initial failure of introduced bird establishment was not due to environmental factors and interaction with other native species, but it is because of insufficient numbers that allow the initial propagule to breed successfully in alien environment (Green 1997; Pimm 1991; Moulton et al. 2001).

Of the surviving six introduced birds of Andaman Islands, House Sparrow, Common Myna and Rock Pigeon were established successfully with significant population. Duncan et al. (2003) explained that, the establishment of introduced species is related to four transitions in the process of invasion. First, the exotic species must be transported to a new location 2) species must be released or escaped into the environment, 3) species must be established with self-sustaining wild population and 4) species that establish successfully may increase in abundance and spread beyond the release point. Considering this as four transitions in the process of invasion, Common Myna, House Sparrow and Rock Pigeon have passed these transitions and it is possible to consider these three species as invasive species in Andaman Islands. However, impact of House Sparrow and Rock pigeon to local species and environment is unknown. These two species were commensal with human and does not spread their activities outside human settlement.

Largely because of its close association with man-made habitats and human activity (Summers-Smith 1988), the House Sparrow is one of the most widespread and abundant species in many parts of the World. That is true for the human influenced areas of Andaman Islands. But there are many reports on House Sparrows' in mainland India indicating, House Sparrow population is declining because of habitat destruction and failure of nesting success (Dhanya 2010). Urban and Rural area are important habitats for House Sparrow population in Andaman Islands. This species was also observed in reasonable population in urban parks, wetland associated areas and disturbed forests. Therefore, the preference for such habitats would be a consequence of its role in providing food resources and roost sites. House Sparrow nests were observed mainly in the thatched woods made of tales and leaves. It has been observed that House Sparrows were roosting in small bushes in wetland associated area

of Hut Bay, Little Andaman. It was note worthy that House Sparrows were at a maximum abundance at medium levels of built up land cover (Marzluff et al. 2001). The available nesting opportunities might be the reason for high abundance of house Sparrow in Andaman Islands.

High numbers of feral pigeons live in almost every large city in the world and they are frequently encountered by humans (Haag-Wackernagel & Moch 2004). Rock Pigeon was established well in the Islands with huge population. Feral pigeon populations increased drastically in the last three years in Andaman due to food discarded by humans and accidental food spillage. This species was not recorded in 2008-2010 from Little Andaman and North Andaman Islands. Presently this species has been established very well in all the human settled Islands including Neil and Havelock Islands. In Port Blair, this species has very huge population with about 1000 individuals and are spreading their population drastically. People taking this species as pet and numbers will be increasing drastically due to favourable condition especially for breeding and nesting, after that it will become feral population is the main reason behind their distribution and abundance in Andaman Islands.

Indian Peafowl thrives only in Ross Island where they were introduced. They could not extend their population to nearby places because of their inability to fly above the sea even it is only 1km Isolation of Ross Island from Port Blair. This species almost become domesticated in this Island, even the main food source is provided daily by appointed administration workers. During the feeding, there was a total count of 16 birds and possibly it was the total population of Indian Peafowl here. Grey Francolin was distributed in deforested grasslands at Dolly Gunj, South Andaman Island where Ali & Ripley (1969) reported.

Recent range expansions and the status of new populations of House Crow in Andaman Islands have been documented and summarized in this study. Though it was the first introduced species to these islands in 19th century, it could not survive here for long time. But recent accidental introduction of this species brought about the drastic expansion of House Crow in South Andaman Islands (Ali 2003). This species presents great ecological flexibility, as well as an obligate association with human presence, to the extent that no population is known to live independent of mankind (Ryall& Peterson 2006). House Crows

were observed mainly in urban or semi urban areas of Port Blair where they benefit from improper human food and refuse handling. Recently, House crows have extended their activities in Sippighat Tsunami inundated wetland and feedings along with native Large-billed Crow and can be a potential competitor for local Large-billed Crow (Ryall & Peterson 2006).

The population and range of Common Myna is observed as increasing as a result of ongoing habitat degradation, especially human mediated changes. Common Myna is already established well in South Andaman, North Andaman and Baratang Islands with huge populations but could not establish well in Little Andaman Island. Local settlers used to carry this species as pet and it can be the reason behind patchily distribution of Common Myna in these Islands. In all these places they are strongly associated with human settlement area.

Roosting places of Common mynas in Andaman Islands were located in different habitats especially in mangrove, trees in town centre and Rural area. Roosting mangroves of Sippighat initially was shared between Common myna, Asian Glossy Starling and Red-breasted Parakeet and later the Asian Glossy Starling completely shifted their roosting place to somewhere else. Tsunami affected mangrove trees and coconut trees have provided excellent sites for nesting of birds. Common Myna is the species that captured the opportunity well, out-competing the local Asian Glossy starling. There are many records of direct conflicts for the space and in many of their recorded conflicts for nesting and roosting places. This study records that in many instances, Common Mynas have fought and won against native species such as Asian Glossy Starling and Red-breasted Parakeet. The ecological implications of these conflicts on the population of other species needs further detailed study.

It is clear that introduced species are dominated in human influenced areas of Andaman Islands. Common Myna, House Sparrow and Rock Pigeon are the most successful introduced bird species in the Andaman and Nicobar Islands. Not only have they maintained their self-sustaining populations near urbanized and Rural areas of these Islands, both these species have extended their range of distribution to many other places within the islands.

Results suggest that, distribution of Common mynas and House sparrows have more similarities than other introduced species. Indian peafowl and Grey francolin were not showing any similarities in composition with other species because of their isolated distribution in these Islands.

Common Myna, House Sparrow and Rock Pigeon are the three species of birds those can be considered as Alien Invasive Species (AIS) with respect to these islands. Within the last four years, this study recorded many observations of direct competitions by the Common Myna, with the native species for nesting holes and roosting places. The two groups of native species observed that were directly affected with the competition of this invasive species are native starlings and parakeets. Common Myna, is one of the hundred “worst global invasive alien species” according to the IUCN’s Global Invasive species data base. In Andaman Islands also, they have shown their potential but the real ecological effects on the native species needs to be evaluated with specific study designed for it.

The need of prevention and control of species introduction and the severe threats posed by these invasions have been documented by various experts in many studies at international and regional levels. International Union for Conservation of Nature and Natural Resources (IUCN) has formed “Species Survival Commission” to look after invasive species as a primary focus. Invasive Species Specialist Group (ISSG) of IUCN has provided the “Guidelines for the Prevention of Biodiversity Loss caused by Alien Invasive Species” (IUCN 2000). There are also many eradication attempts made by different agencies worldwide especially to eradicate major AIS like Common Myna, (Feare 2010). Invasive species eradication have achieved important conservation gains world over (Zavaleta 2004). Invasive species may lead to the extinction of native species and later it may end with a major cascade process that can make ecological imbalance. Eradication will always be single, unreplicated experiments, so there will always be some surprise outcomes (Simberloff 2002). According to Simberloff (2002), control of the invasive species can be done through three stages, (1) keeping them out; (2) if they get in, finding and trying to eradicate them quickly; and (3) if they cannot be eradicated, managing them at low levels. With respect to Andaman Islands and Common Myna, the first two options are not possible

now. The question is how to adopt the management strategies that can maintain the population at low levels. For this we need to have focused studies on the ecological impact of this introduced species so that informed decisions can be made by the wildlife managers in the islands.



Common Myna & Asian Glossy Starlings *Aplonis panayensis* nesting on the top of the Coconut tree damaged by Tsunami



Coastal nesting trees of Common Myna *Acridotheres tristis* in Chidiyatapu



Communal roost of Common Myna *Acridotheres tristis* in Mangroves at Sippighat



Tsunami inundated site: Good nest site for Common Mynas and Asian Glossy Starlings

SUMMARY AND CONCLUSION

Andaman and Nicobar Islands are very rich in bird diversity and hence have high importance in conservation planning. Both in species endemism and species diversity these islands are notable. Andaman and Nicobar Islands is also a significant place in India which is exposed to very high human mediated species introduction. These introduced species can have serious effects on the native biodiversity and it can be the agent for the breakdown of native species equilibrium. On the background of this context, this study was undertaken to examine the bird species composition of Andaman Islands especially on human influenced areas and the role of introduced birds among the avifauna of these Islands. The study was carried out in nine inhabited islands in the Andaman group and later these nine study sites were clubbed into five groups for easy analysis. This thesis is organized in four technical chapters including a review of literature with more emphasis on introduced birds and their impacts on native ecosystem especially on Islands.

Both secondary and primary data collection methods are employed in the study. All the published information on distribution of birds in Andaman Islands were collated, synthesized and analyzed to elucidate the characteristics of Andaman Bird fauna. Systematically 221 transect counts of birds from nine human inhabited islands which can be classified into 6 habitats were collected. These collected field observation data on birds were analyzed with special emphasis on the introduced birds.

The result recorded, 259 species (297 taxa including subspecies) of birds belonging to 18 orders and 58 families from this Archipelago. Of these 31 species were split into two or more subspecies. This study made an updated check list of birds of Andaman and Nicobar Islands with an addition of 31 species to the last published comprehensive list and synthesized the information from publication in peer reviewed journals so far. Scolopacidae is the most abundant family with 25 bird species (9.7%) followed by Acciptridae (7.0%), Ardeidae (5.8%), Sylviidae (4.7%), Columbidae (4.3%) and Muscicapidae (4.3%). There are 20 families in these Islands with single species. Of these 21 single species' family, Beach Thick-knee (Family: Burhinidae) is a near threatened species. According to Birdlife

International (BirdLife International 2012), there are six bird species considered as threatened (Two species are exclusive to Andaman, three species were exclusive to Nicobar and one species is common to both Island group). Unlike main land India, only 32% birds were in the order Passeriformes which is 59% of the total Indian avifauna.

In this archipelago, maximum human settlements are in Andaman Islands. About 780 sq.km area is under human utilization including Urban and Rural areas. Southern part of South Andaman Island has large scale human modified landscape because of high developmental activities and heavy human population. Influence of human on distribution of birds and their habitats is not studied well in Andaman and Nicobar Islands, however these kinds of studies are well known in pacific Islands.

In total 15859 individuals of 127 species of birds belonging to 35 families and 13 orders were encountered from the nine Islands of Andaman during this study. Of these, six species namely Cotton Pygmy-goose, Beach Thick-knee, Purple Heron *Ardeapurpurea*, Marsh Sandpiper, Andaman Hawk-owl and Dusky Warbler were detected during the systematic sampling procedure.

Species dominance varied according to habitat and time period. Out of 15859 individuals, most common species was House Sparrow (2768 detections) in terms of abundance followed by Common Myna (1264 encounters), Glossy Swiftlet (1248 encounters), Rock Pigeon (1224 encounters) and Red-whiskered Bulbul (874 encounters). Out of the total 221 transect, Red-whiskered Bulbul was detected in 157 transects in all the habitats and Islands followed by Glossy Swiftlet (131transects), Large-billed Crow (109transects). Some transects have the highest encounter rate due to high aggregation of shore birds, Parakeets and Rock Pigeon. Among the five most abundant and distributed bird species, two species such as Common Myna and House Sparrow were introduced species and contributed 25.43% population towards total bird population in the study.

Birds of human inhabited Islands of Andaman are very rich in diversity. However, as compared to other islands group, Ritchie's Archipelago was high in bird diversity ($S = 0.9514$ and $H = 3.431$). Wilcoxon Signed-rank test showed that, there was a significant difference between the birds species composition of each Islands ($Z = >3.5$; $P = 0$). However

bird species composition of Little Andaman and Middle Andaman; Little Andaman and North Andaman Islands were not significantly different with $Z = 1.316$, $p = 0.188$ and with $Z = 1.833$, $p = 0.067$ respectively).

Bird species diversity was different among habitats, maximum species richness was recorded from forest area with $S = 0.9571$ and $H = 3.522$ followed by wetland associated area ($S = 0.956$ and $H = 3.495$, Coastal associated area ($S = 0.9375$ and $H = 3.173$), Village area $S = 0.8468$ and $H = 2.414$) and Urban area ($S = 0.7676$ and $H = 1.842$). Of the total species recorded, 16 species were observed in all six habitats. Jaccard similarity index showed that, Bird species composition of urban areas were totally different from other habitats, whereas village areas showed closer bird species composition with urban areas. Tsunami inundated wetlands provides one of the best habitat for migratory species. Sippighat wetland one of the Tsunami inundated tidal mudflats were used by waders as major wintering grounds. 63 species of birds were recorded from these Tsunami inundated wetlands which also includes resident water birds like Lesser Whistling Duck, Common Moorhen, Andaman Teal, White-breasted Waterhen and Purple Swamphen.

Many studies have been done on the exotic flora of India, but there is an information gap on the naturalized alien/exotic faunal elements in India. Only two birds such as Java Sparrow and Tree Sparrow were introduced to India from other countries, but local introduction has been carried out across India. However introductions have been done to the Lakshadweep and Andaman and Nicobar Islands from mainland India. Andaman and Nicobar Islands is the place in India which is exposed to significant number of introduced species of flora and fauna. But compared to the other islands in the world, this number is very low. A total of 19 species of birds were introduced to Andaman and Nicobar Islands from mainland India during the first half of the 19th century. Of these introduced species, only six species Common Myna, House sparrow, Rock Pigeon, Grey Francolin, House Crow, Indian Peafowl are surviving now. The population and ranges of introduced birds such as Common Myna, House Sparrow, Rock Pigeon and House Crow were observed as increasing as result of ongoing habitat degradation, especially human mediated changes. Other two species such as Indian Peafowl and Grey Francolin were surviving with few individuals in Ross Islands and Port Blair respectively.

Grey francolin is distributed in deforested grasslands in Dollygunj, near Port Blair and only four individuals were observed during the study period. Indian Peafowl is surviving only in Ross Island which is a highly human disturbed area with low vegetation. The population size was about 16 individuals (maximum detection in a transect and possibly maximum number) and has become almost domesticated. They were also seen near humans and pecking for food discarded by tourists and bird seed offered by administrative workers.

House Sparrow was the most abundant species in terms of encounter in transects followed by Common Myna in this study. House Sparrows encountered 17.45% (2768 individuals) in total bird encounter (15859 individuals) during this study. Of the total population of this species, 45.62% of encountered were from urban areas especially in town centers. Village area was another habitat with high abundance of House Sparrow with 37.54% encounter followed by wetland associated area (12.21%) and Disturbed forest area (3.97%). Rock Pigeon has established well in Andaman Islands especially in Port Blair and Rangat town. Of the total bird encounters of this whole study, Rock Pigeons were 7.72% (1224 individuals encountered). Of this 1224, 95.93% encounter was from urban areas. Common Myna is already well established in South Andaman, North Andaman and Baratang Islands with huge populations but has not established well in Little Andaman Island. Though Middle Andaman is largest island but only 1.19% of Common Myna encounters have been recorded especially from Mayabunder and Baratang area. There wasn't a single encounter of Common Myna from surveyed Islands in Ritchie's Archipelago. It was reported that House crows accidentally reached Port Blair less than one decade ago by ship. Currently, it is restricted to Port Blair and the population of House Crows is increasing and spreading drastically to nearer areas of Port Blair.

A total of 5518 individuals of introduced birds were encountered during this study contributing 34.8% of total bird population. House Sparrow was the most abundant introduced bird in Andaman Islands (2790 individuals encountered). Common Myna was the second abundant introduced bird with 1264 encounter followed by Rock Pigeon (1232 encounter) and House Crow (201 encounter). South Andaman has a maximum of introduced bird abundance; whereas Ritchie's Archipelago has the lowest number in introduced bird abundance. Jaccard Similarity index showed that, Common Myna and House sparrow have more similarities in distribution and distribution followed by House Crow and Rock Pigeon

respectively. Whereas Grey Francolin and Indian Peafowl was more dissimilar against other introduced species by abundance and distribution. Principal Component Analysis (Varimax rotate) analysis suggests that, House Sparrow population has more affinities towards Urban, Village and Disturbed forest area with positive factor score, whereas Common myna has more affinities to coastal and wetland associated areas. Rock Pigeon is largely restricted to urban area.

Common Myna, one among the 100 nominated "World's Worst" invaders by Invasive Species Specialist Group (ISSG) of IUCN, is one of the most successful introduced species in Andaman Islands. Population distribution and its relationship with other native species were especially given emphasis in observation and analysis in this study. Introduced and Invasive species are known to cause disturbances to native species and local biodiversity. Common Mynas were intentionally introduced to Port Blair on South Andaman in 1867 by Colonel R. C. Tytler and this bird was established well in most of the human settled Islands in Andaman. Of the total bird population (15859 individuals) recorded during the survey, 7.97% (1264 individuals) encounter was of Common Myna. The preferred habitat of Common Myna was Village area (34.7%) followed by Wetlands associated areas (30%), Urban (23), Coastal associated areas (8.7%) and Disturbed forest (2.9%). But not a single individual was recorded from undisturbed forest. Roosting places of Common Mynas in Andaman Islands were located in different habitats especially in mangrove, trees in town centre and village area. Similar roost site was used by Common Myna and native bird species such as Asian Glossy Starling and Red-breasted Parakeet in Andaman Islands. Tsunami affected dried mangrove trees and coconut trees have provided excellent sites for nesting for birds. In many locations was observed that Common Myna has captured the opportunity for nesting and roosting well out-competing the local Asian Glossy starling. In some places, Common Myna was recorded nesting on top of the maximum damaged and dried coconut trees and damaged mangrove trees. Buildings are the other nesting site for the Common Myna. There are many records of direct conflicts for the space and in many of their recorded conflicts for nesting and roosting places, Common Mynas have fought and won against native species such as Asian Glossy Starling and Red-breasted Parakeet. The ecological implications of these conflicts on the Island biodiversity needs a more focused study before it goes out of hand.

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PUBLISHED ARTICLES

FIRST RECORD: ANDAMAN ISLANDS

First records of European Roller *Coracias garrulus* from the Andaman Islands, India

P. RAJAN & P. PRAMOD

The European Roller *Coracias garrulus* is classified as Near Threatened due to moderately rapid declines across its range, with the northern populations particularly badly affected (BirdLife 2011). It is mostly a passage migrant in India, mainly the north-west (Grimmett *et al.* 1999) but in the last two decades has been reported more frequently further south and east in peninsular India. The most easterly records to date were two from near Thirupathi (13.65°N 79.42°E) in the Chittoor district of Andhra Pradesh (Narayanan *et al.* 2008). The species is a long-distance migrant and birds are found in tropical or subtropical woodland, most types of open country including grassy hillsides with scattered trees, scrublands, cultivated fields, and urban parks or gardens. Rollers often perch prominently on trees, posts or overhead wires watching for the large insects, small reptiles, rodents and frogs that make up their diet.

Two races are recognised, the nominate which breeds in Morocco, south-west and central Europe and Asia Minor, east through north-west Iran to south-west Siberia, and *semenowi* which breeds in Iraq, Iran (except the north-west), east to Kashmir (Ali & Ripley 2001) and north to Turkmenistan, south Kazakhstan, and north-west China (west Sinkiang). The species migrates across the Arabian Sea to winter in two parts of sub-Saharan Africa. (BirdLife 2011).

The Andamans lie in the Bay of Bengal some 1,300 km from mainland India and close to Myanmar (285 km), Malay Peninsula (571 km) and Sumatra (189 km) (Ripley & Beehler 1989). On 31 October 2009 at 05h30, a European Roller was seen perched on a power line alongside a Collared Kingfisher *Todiramphus chloris* at Tushnabad (11.70°N 92.64°E) near the centre of South Andaman. The area is a grassy wetland surrounded by human settlement and forest patches. The bird was clearly identified as a European Roller and this was confirmed with the help of photographic images taken at the time.

On the following morning, 1 November 2009 at 07h30, a European Roller was seen at Rangat (12.5°N 92.93°E) in the south of Middle Andaman. This bird was perched on a pole located in an open area, part of which was cultivated as padi and part was grassy wetland with many bushes; there are settlements nearby. It was observed for about 15

minutes, during which time it also perched on a power line several times, feeding on insects; photographs were taken (Plate 1). Grey Plover *Pluvialis squatarola*, Slaty-legged Crake *Rallina eurizonoides*, Barn Swallow *Hirundo rustica*, Grey Wagtail *Motacilla cinerea*, Black-naped Tern *Sterna*

Figure 1. Andaman Islands showing locations where European Rollers *Coracias garrulus* were sighted in October and November 2009.

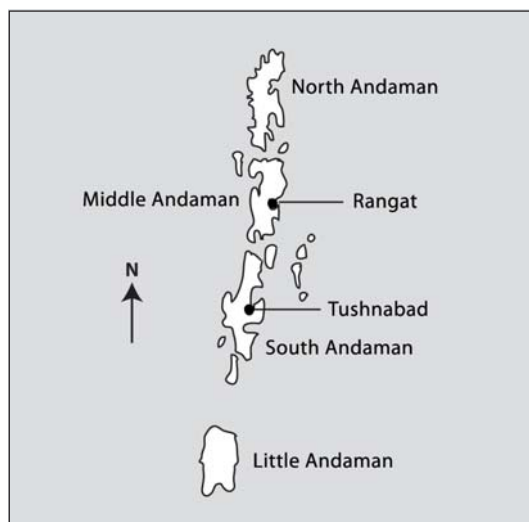


Plate 1. European Roller *Coracias garrulus*, Rangat, Middle Andaman, 1 November 2009.



sumatrana, Red Collared Dove *Streptopelia tranquebarica*, Little Egret *Egretta garzetta* and Common Greenshank *Tringa nebularia* were noted in the same area.

Narayanan *et al.* (2008) recorded the first sighting of the species from Kerala and reviewed 19 sightings from peninsular India; 15 of these were in the last decade. The oldest record was from Uttara Kannada in 1898 and the majority of the latest are also from the western coast, primarily from Goa and Uttara Kannada. These new records raise some interesting questions about the post-breeding movements of European Roller in recent times. Are new wintering grounds being sought out and is climate change influencing movements of birds? Clearly birdwatchers should carefully confirm the identity of rollers seen during the migration and wintering period to obtain more data on possible changes and trends.

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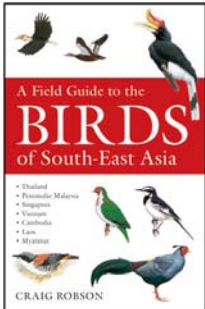
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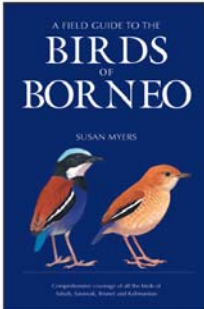
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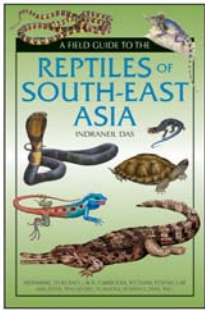
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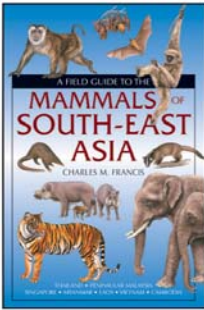
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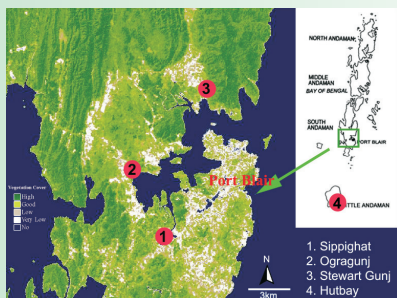
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Four potential wetlands for waterfowl Conservation in South and Little Andaman Islands

The Andaman and Nicobar islands are embodied with tropical rain forests. Although they are isolated from adjacent land masses the Islands are astonishingly enriched with more than 270 species of birds. The Tsunami inundated low level lands in particular agriculture fields and modified the wetlands of Andaman Islands. We explored four potential wetlands in South and Little Andaman Islands depending on the waterfowl abundance. A record of all birds and the human interferences in the wetlands were made. Of this we identified four wetlands, Hutbay, Ograbrang, Sippighat and Stewart Gunj wetlands that are good habitat for waterfowl conservation. Among these four wetlands, Hut Bay and Stewart Gunj are fresh water wetlands and the other two are tidal wetlands. Andaman Teal, Common Moorhen, Purple Swampfen and Lesser-whistling Duck were the main waterfowl species using these inundated wetlands. We used online Google map to measure the area of wetland as well as the area presently used by the waterfowls.



Location of wetlands at South and Little Andaman Islands

Sippighat wetland is one of the good tidal mudflats used by waders as wintering ground. We have record of 57 bird species from this wetland including 21 migratory birds and 16 resident water birds like Lesser Whistling Duck, Common Moorhen, Andaman Teal, Waterhen and Purple Swampfen. The Stewart Gunj and Hutbay wetlands provide good feeding ground for Andamn Teal and the Lesser-whistling Duck. Andaman Teal is considered as an endemic species to these Islands and a large population of these visit these wetlands in particular Sippighat and Ograbranj.

All the four wetlands are facing serious threat from human activities especially due to habitat destruction; this may lead to the disappearance of these wetland in the near future. Prior to inundation, this area was used as agricultural land and this is one of the main reasons for the current human interferences in this wetland. It is required to initiate awareness among the villagers living around these wetlands on the value of the wetlands and the waterfowl species.

Sippighat.

Islands : South Andaman
Location : N 11° 36' 47" E 92° 41' 32"
Total area : 1.14 sqkm
Presently used by waterfowls: 0.72 sqkm

Wetland Character : Grass with stagnant water (~1m depth), tidal mudflat (0.5m water depth during high tide). One side is mangroves and other side Andaman Trunk Road.

Major waterfowls: Lesser Whistling Duck, Common Moorhen, Andaman Teal, White-breasted waterhen and Purple Swampfen

Other Common birds : Migratory birds (Waders), Egrets, Common Mynas, Jungle Crows and Andaman Teal.

Main threats : Hunting and fishing



Photo courtesy Mr. P. Rajan



Photo courtesy Mr. P.Rajan

Hutbay

Islands : Little Andaman
 Location : N10° 35'64" E 92° 31'95"
 Total area : 0.34 sqkm
 Presently used by waterfowls: 0.10 sqkm
 Wetland Character: Grass and water lilies with water (~1m depth), fresh water; road divides this wetland into two and is surrounded by human settlement.
 Major waterfowls: Lesser Whistling Duck, Common Moorhen, Andaman Teal, White-breasted Waterhen.
 Other Common birds : Little Egrets, Large egrets, Pond heron, Pacific Swallow.
 Main threats : Fishing



Photo courtesy Mr.P. Rajan

Stewart Gunj

Islands : South Andaman
 Location : N 11° 43' 62" E 92° 42' 52"
 Total area : 0.47 sqkm
 Presently used by waterfowls: 0.26 sqkm
 Wetland Character: Grass land, some parts grass with stagnant water. This wetland is surrounded by human settlement.
 Major waterfowls: Lesser Whistling Duck, Common Moorhen, Andaman Teal, White-breasted Waterhen and Purple Swampphen
 Other Common birds : Little Egret, Large egret, Cattle Egret, Median Egret, Pond heron, White-bellied Sea-eagle.
 Main threats : Cattle grazing



Photo courtesy Mr. P. Rajan

Ograbrani

Islands : South Andaman
 Location : N 11°39'34" E 92°39'76"
 Total area : 0.63 sqkm
 Presently used by waterfowls: 0.25 sqkm
 Wetland Character: Tidal mudflat, tsunami inundated area with dead trees, surrounded by human settlement, mangrove. Road is dividing this wetland into two.
 Major waterfowls: Andaman Teal
 Common birds : Little Egret, Large egret, Cattle Egret, Median Egret, Pond heron, Common Myna, Asian Glossy Starling
 Main threats : Fishing

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COMMON BIRDS OF ANDAMAN ISLANDS WITH SPECIAL REFERENCE TO INTRODUCED BIRDS

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We surveyed the common birds on eight human inhabited islands of the Andaman Island group, and identified 15 species as the most common bird species on the basis of abundance and extent of distribution. Of these, the introduced species – House Sparrow *Passer domesticus* (19.8% abundance) and Common Myna *Acridotheres tristis* (9.8% abundance) – were the most abundant species, and were distributed in human associated habitats. Out of 188 transects walked, the White-bellied Swiftlet *Collocalia esculenta* and Red-whiskered Bulbul *Pycnonotus jocosus* were recorded in more than 100 transects.

Key words: common birds, introduced birds, Andaman Islands

INTRODUCTION

Commonness is a relative concept and varies as global, local, relative and observed, or sample abundance (Preston 1948). It varies according to habitat and temporally. Many different factors that may determine rarity or commonness have been considered (Preston 1948). According to Grytnes *et al.* (1999), a species is defined as rare or common based on its abundance and extent of distribution; they have pointed out problems of defining rare and common species. Davidar *et al.* (1996) noted that rarity of bird species in the Andaman Islands is not because of external threats, but probably because of their intrinsic ecological requirements, biology, and limited size of the island.

The Andaman and Nicobar Islands are rich in avifauna, with more than 270 species reported from the islands (Sankaran and Vijayan 1993), of which 29% are endemics. Nineteen species were introduced to these islands in the early 20th century (Kazmierczak 2000; Lever 1987; Mohanraj *et al.* 1999; Sankaran and Vijayan 1993). Of these, only the Common Myna *Acridotheres tristis*, House Sparrow *Passer domesticus*, Indian Peafowl *Pavo cristatus*, Grey Francolin *Francolinus pondicerianus*, Blue Rock Pigeon *Columba livia*, and House Crow *Corvus splendens* now survive in these Islands. Some of these introduced species are believed to have caused disturbances to native bird species and other biodiversity.

This study was undertaken to identify the common bird species on human inhabited islands of the Andaman group, and to explore to what extent the introduced species have spread throughout the islands bird communities. Preliminary observations showed that the introduced birds have not been able to go deep into the Andaman jungles, such as Jarawa reserves, and are absent from large stretches of forest. However, many of them have successfully colonised human

habitations and the natural habitats near the habitations. Hence, we restricted our study to human habitations, and natural habitats near human habitations.

METHODOLOGY

The study was conducted in eight human inhabited islands of the Andaman Island group (12° 30' N; 92° 45' E), namely South Andaman, Middle Andaman, Baratang, North Andaman, Ross Island, Little Andaman, Neil Island, and Havelock (Fig.1). Surveys were conducted from July 2008 to March 2010 employing line transect method (1km/1hr). A total of 188 transects were surveyed in six habitats: urban, village, disturbed forest, coastal, undisturbed forest near human habitations, and wetland.

Commonness of a species was calculated based on the observed or sample abundance and considering the number of detections of each species during the study (Preston 1948). To study introduced species, each bird species was accounted for separately in transects and their activities such as breeding, roosting, distribution, wherever possible, were explored. Available literature of each introduced species was also collated.

RESULTS AND DISCUSSION

In all, 12,329 individuals of 127 species of birds were recorded during the study. Among the habitats, highest numbers of species (63) were recorded in wetlands and the lowest numbers (20) were recorded in urban areas (Fig. 2). Of the total wetland species, 24 were winter migratory waders. Based on their respective abundance, we considered 15 species as 'most common' (Table 1). Of these, the first two and the fourth species were introduced species: House Sparrow (19.8%), Common Myna (9.8%), and Blue Rock

Pigeon (7.9%) respectively. These three species were distributed in all the main islands of the Andaman Islands (Table 2). Some widely distributed bird species in the Andaman Islands are Common Sandpiper *Actitis hypoleucos* (60 detections on transects), White-breasted Kingfisher *Halcyon smyrnensis* (63 detections), and the endemic Andaman Coucal *Centropus andamanensis* (52 detections) with less abundance. Introduced birds of Andaman Islands were strongly associated with human disturbed area. Of the total observations, 39.2% of bird sightings were of introduced species. Among them House Sparrow (51.27%) was the most dominant (Table 2). Common Mynas and House Sparrows were the most successful introduced birds in these islands. Other widely distributed 'most common' native species include Red-whiskered Bulbul, Large-billed Crow, and White-bellied Swiftlet (Table 1), contributing more than 5% species abundance. A brief account of the surviving introduced species is given below.

1. Common Myna *Acridotheres tristis*

The Common Myna was intentionally introduced by Colonel R.C. Tytler in Port Blair on South Andaman immediately after the settlement of a penal colony in 1858 (Lever 1987). Wood (1924) indicated that Common Mynas were released on Ross Island during 1880. Presently, free-ranging populations are established over most of the Andaman Islands. However, this species has not established well on large islands, such as Middle Andaman and Little Andaman.

Roosting areas of Common Myna in Andaman Islands were located in mangroves and vegetated sites in town centres and villages. Disturbed forests provide an excellent environment for mynas. In Port Blair, these species roost on

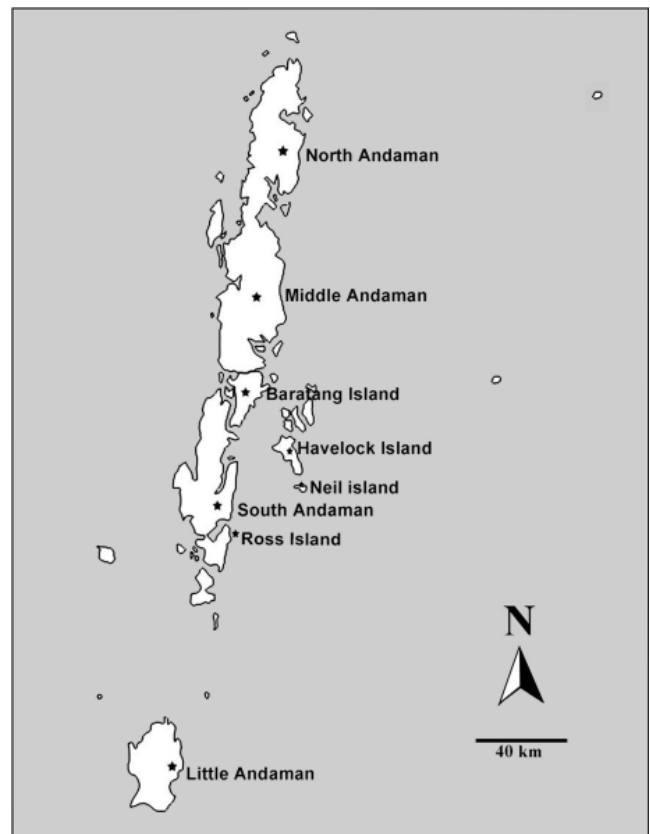


Fig. 1: Map of Andaman Islands showing surveyed islands

two or three trees located in the centre of the city and in mangroves near Sippighat. They roost communally with other species such as Red-breasted Parakeet *Psittacula alexandri* and House Crow. In Port Blair, roosting trees were shared by Large-billed Crow *Corvus japonensis* and House Crow

Table 1: Common bird species recorded in Andaman Islands from July 2008 to March 2010

No	Common Name	Scientific Name	Abundance (%)	Detections	Present in No. of transects
1	House Sparrow	<i>Passer domesticus</i> *	19.8	552	87
2	Common Myna	<i>Acridotheres tristis</i> *	9.8	528	95
3	White-bellied Swiftlet	<i>Collocalia esculenta</i>	8.6	259	112
4	Blue Rock Pigeon	<i>Columba livia</i> *	7.9	67	24
5	Red-whiskered Bulbul	<i>Pycnonotus jocosus</i>	6.2	374	134
6	Jungle Crow	<i>Corvus macrorhynchos</i>	5.2	277	90
7	Red-breasted Parakeet	<i>Psittacula alexandri</i>	2.4	78	40
8	Lesser Sand Plover	<i>Charadrius mongolus</i>	2.3	20	10
9	Cattle Egret	<i>Bubulcus ibis</i>	2.0	50	26
10	Brown Shrike	<i>Lanius cristatus</i>	1.9	188	73
11	Common Redshank	<i>Tringa totanus</i>	1.9	29	18
12	Whimbrel	<i>Numenius phaeopus</i>	1.7	8	8
13	Lesser Whistling-Duck	<i>Dendrocygna javanica</i>	1.7	14	9
14	Red Collared-Dove	<i>Streptopelia tranquebarica</i>	1.7	35	26
15	Andaman Teal	<i>Anas albogularis</i> **	1.7	10	9

* Introduced species, ** Endemic species

Table 2: Current distribution of six introduced bird species in Andaman Islands in 188 transects surveyed

No	Species	Present in No. of transects	Current distribution	% Among introduced species
1	House Crow	16	SA	3.92
2	Common Myna	95	SA, NA, BT, RI	24.4
3	Indian Peafowl	4	RI	0.55
4	House Sparrow	87	SA, MA, NA, BT, HV, NL, LA, RI	51.27
5	Grey Francolin	1	SA	0.08
6	Blue Rock Pigeon	24	SA, MA, NA, BT, HV, NL	19.8

Note: SA=South Andaman, NA=North Andaman, BT=Baratang, RI=Ross Island, MA=Middle Andaman, HV=Havelock, NL=Neil Island, LA=Little Andaman

C. splendens. Tsunami affected mangrove trees and coconut trees provide excellent nesting sites for Common Myna and Asian Glossy Starling *Aplonis panayensis* (a native species). In Andamans, Common Myna *Acridotheres tristis* mainly nested on the crown of dead coconut trees and mangroves (snags) in tidal wetlands and coastal areas. It also nested in buildings. This species has the potential to compete with other species such as parakeets and Asian Glossy Starling for roosts and nests.

2. House Sparrow *Passer domesticus*

The House Sparrow was introduced twice in South Andaman Islands during 1882 and 1895 (Lever 1987). Now they have spread to almost all the inhabited Andaman Islands along with human settlements. They nest on buildings, street lights, roofs of houses, and shutters of shops. These birds roost colonially in towns, villages, and in bushes located near wetlands.

3. House Crow *Corvus splendens*

The House Crows were intentionally introduced to Port Blair during 1862 and 1864 by Col. R.C. Tytler due to their scavenging habit, but failed to survive on these islands (Lever 1987). It is reported that House Crows reached Port Blair less than a decade back accidentally by ship and are currently restricted to Port Blair. The species shares feeding, nesting, and roosting sites with the Large-billed Crow. It may compete with the Large-billed Crow and other local species, but more information is needed to substantiate this.

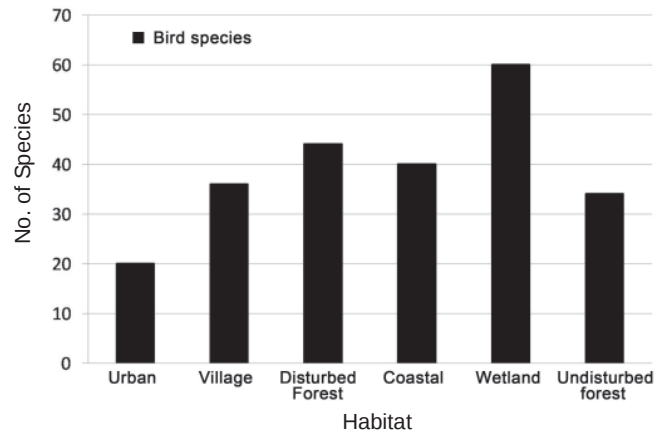


Fig. 2: Number of bird species recorded in each habitat of Andaman Islands along the 188 transects surveyed

4. Grey Francolin *Francolinus pondicerianus*

The Grey Francolin was introduced to South Andaman during 1890 and is seen only in Port Blair. During this study, only four individuals were observed at one location. The impact of this species on other fauna is unknown.

5. Indian Peafowl *Pavo cristatus*

The Indian Peafowl was introduced on Ross Island by the British in 1868. The species was decimated during the Japanese occupation (1942–43), but after the liberation of the archipelago, more were imported (Lever 1987). Currently, fewer than 10 birds survive on Ross Island.

6. Blue Rock Pigeon *Columba livia*

Blue Rock Pigeon were introduced to South Andaman and Car Nicobar in 1898 (Kazmierczak 2000; Lever 1987). The species has established well in the Andaman Islands, especially in Port Blair and Rangat. It lives in urban areas. Its impact on other species is unknown.

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COMMON BIRDS OF ANDAMAN ISLANDS

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Introduced birds of the Andaman & Nicobar Islands, India

P. Rajan & P. Pramod

Rajan, P., & Pramod, P., 2013. Introduced birds of the Andaman & Nicobar Islands, India. *Indian BIRDS* 8 (3): 71-72

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Introduced alien (or exotic) species can have serious negative effects on native ecosystems and populations. Biological invasions are a widespread and significant component of human-induced global environmental change through breakdown of regional distinctiveness of the Earth's flora and fauna. There is substantial evidence that biological invasions contribute substantially to extinction (Vitousek 1994; Vitousek *et al.* 1997; Simberloff 2003). In 1992 the Convention on Biological Diversity (CBD) recognised that biological invasion is the second most serious threat to biodiversity after habitat destruction (Jenkins 1999). Most of the introduced species have the potential to establish in an alien environment, and they can act as agents of change in species equilibrium and extinction of native species of the area where they are introduced (Fritts & Rodda 1998; Donlan *et al.* 2003; Ali 2004).

The Andaman and Nicobar Islands are exposed to high levels of human-mediated introduction of non-native plant and animal species. In all, 566 plant, three snail, four insect, 12 mammal, 13 marine fish species, and one virus are known to have been introduced to these islands (Mohanraj *et al.* 1999). There may be many more introduced species not yet documented in these islands. The primary objective of this paper is to prepare a complete list of wild avifauna that was intentionally introduced by humans into the Andaman and Nicobar Islands.

A total of 19 species of birds (Table 1) were introduced to the Islands from mainland India during the first half of the 19th Century (Lever 1987; Sankaran & Vijayan 1993; Mohanraj *et al.* 1999; Kazmierczak 2000). Bird surveys by Rajan on most inhabited islands, during the last four years, reveal that these introduced species, only six—Common Myna *Acridotheres tristis*, House Sparrow *Passer domesticus*, Blue Rock Pigeon *Columba livia*, Grey Francolin *Francolinus pondicerianus*, House Crow *Corvus splendens*, and Indian Peafowl *Pavo cristatus* now survive in these islands. Grey Francolin and Indian Peafowl populations are small and restricted to one particular site (Rajan & Pramod 2011).

The Grey Francolin was introduced through Port Blair in c. 1890 but did not successfully establish a population; however, it continues to survive in very small numbers in defrosted areas of Dolly Gunj, Port Blair (Abdulali 1965; Lever 1987; Rajan & Pramod 2011). Bump & Bump (1964) reported that the Chinese Francolin *F. pintadeanus* was introduced to Andaman in the 19th century but has not been included in the list of introduced bird species of these islands by many subsequent authors (Lever 1987). There have been no further reports of these birds from the Andamans. According to Kloss (1903), the Blue Rock Pigeon was introduced in Car Nicobar. Abdulali (1965) reported that it had established populations in the Nicobar Islands as well as in Port Blair. The Blue Rock Pigeon is now very common in most of the main inhabited islands of the Andaman group, especially in

the urban areas (Rajan & Pramod 2011).

Around the 1860s, Col. R. C. Tytler introduced three species of birds—Common Myna, House Crow, and Jungle Myna *A. fuscus*—in Port Blair (Pittie 1988; Lever 1987; Mohanraj *et al.* 1999). Except for the Common Myna, the other two could not establish populations. However, a small population of the House Crow was reported by Pittie (1988), and has been recorded more recently in 2002 with seven individuals, their numbers are now increasing rapidly in Port Blair and nearby areas (Ali 2003; Rajan & Pramod 2011). According to Abdulali (1965), House Sparrow and Indian Peafowl were introduced to Ross Island in South Andaman. Indian Peafowl was introduced in 1868 and were apparently killed off during the Japanese colonisation of these Islands during the Second World War. After India's independence in 1947, birds were re-introduced to these Islands and there is now a viable population of Indian Peafowl on Ross Island (Lever 1987; Rajan & Pramod 2011). O. H. Brookes introduced the House Sparrow in two attempts; six birds were brought first in 1882, followed by 20 more in 1895 (Lever 1987). Sankaran & Vijayan (1993) reported that the Red-whiskered Bulbul *Pycnonotus jocosus whistleri* and the White-headed Myna *Sturnus erythropygus* were both introduced to the Nicobar Islands from Port Blair.

The Common Myna and House Sparrow are the most successful among the introduced bird species in the Andaman and Nicobar Islands. Not only have they maintained their populations near urbanised and rural areas, but also have extended their range of distribution to many other locations. These are two of the introduced species that may be considered as Alien Invasive Species (AIS) with respect to these islands. During the last four years, we have recorded several instances of direct competition of the Common Myna with native species for nesting holes and roosting places. The two native avian families that are directly affected by the competitive nature of this alien invasive species are starlings (Sturnidae) and parakeets (Psittacidae). Common Myna is one of the hundred worst global invasive alien species according to the IUCN's Global Invasive species database. In the Andaman Islands too, they have lived up to their negative reputation but ecological effects on the native species need to be more critically evaluated.

Introduced species are a major threat to island biodiversity. The impact of such alien species, particularly on islands, is well documented (Savidge 1987), and the situation in the Andaman & Nicobars is not different from other islands (Mohanraj *et al.* 1999; Ali 2004). The need for prevention and control of species being introduced, and severe threats posed by invasions have been documented by various experts at international and regional levels. The IUCN constituted the Species Survival Commission to look at invasive species as primary focus for its global action. Invasive Species Specialist Group (ISSG) of IUCN has provided 'Guidelines for the Prevention of Biodiversity Loss caused by

Alien Invasive Species' (IUCN 2000). Many eradication attempts have been made by different agencies worldwide on major AIS like the Common Myna (Feare 2010). According to Simberloff (2002), control of invasive species is possible in three stages, (1) keeping them out; (2) if they get in, finding and trying to eradicate them quickly; and (3) if they cannot be eradicated, managing them at low levels. With respect to the Common Myna in the Andaman Islands, the first two options are not considered practical now. The question is of adopting management strategies that can maintain the population at low levels. For this we need to have focused studies on the ecological impact of these introduced species so that wildlife managers in the islands can make informed decisions.

There is neither a complete list nor detailed studies on the introduced species of Andaman & Nicobar Islands, but experts have mentioned the introduced birds of these islands in different books and articles as anecdotal references. The list presented here (Table 1) is an up to date synthesis of all available information on the introduced birds of Andaman & Nicobar Islands with comments on their present status. Red-whiskered Bulbul and White-headed Myna are excluded from this list because their introduction was inter-island.

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Table 1. List of introduced bird species of Andaman and Nicobar Islands

No	Species	Year Introduced	Notes
1	Jungle Myna <i>Acridotheres tristis</i>	1860s	Introduced from Burma in Port Blair by Col. R. C. Tytler. Possibly died out.
2	House Crow* <i>Corvus splendens</i>	1862 & 1864	Introduced for sanitary purposes, but failed to establish. Accidentally reached recently and established well in Port Blair.
3	Rose-ringed parakeet <i>Psittacula krameri</i>	< 1863	Possibly died out
4	Eurasian Tree Sparrow <i>Passer montanus</i>	<1866	Possibly died out
5	Common Myna* <i>Acridotheres tristis</i>	1867	Introduced in Ross Island. Established well in different habitats of main inhabited Islands except evergreen forests.
6	Peafowl* <i>Pavo cristatus</i>	1868	Introduced in the Ross Island. About 16 individuals still surviving.
7	Red Avadavat <i>Amandava formosa</i>	< 1873	Possibly died out
8	House Sparrow* <i>Passer domesticus</i>	1882 & 1895	Introduced in the Ross Island. Established well in main inhabited islands.
9	Little Brown Dove <i>Streptopelia senegalensis</i>	1899	Possibly died out
10	Black headed Munia <i>Lonchura malacca</i>	< 1906	Possibly died out
11	Grey Partridge* <i>Francolinus pondicerianus</i>	1890	Now established around in Port Blair with very less number.
12	Spot-billed Duck <i>Anas poecilorhyncha</i>	1960	Escaped from iron–mesh enclosure on Ross Islands during a storm, no sightings after that. Possibly died out
13	Common Quail <i>Coturnix coturnix</i>	1961	Brought from Madras and released into Ross Island. No recent records. Possibly died out.
14	Jungle Bush Quail <i>Perdica asiatica</i>	1961	No recent records. Possibly died out
15	Painted Bush Quail <i>Perdica erythrorhyncha</i>	1961	No recent records. Possibly died out
16	Comb Duck <i>Sarkidiornis melanotos</i>	1961	Brought from Calcutta and released into Neil Island. No recent records. Possibly died out
17	Open-billed Stork <i>Anastomus oscitans</i>	1964	Introduced from Calcutta and released into South Andaman for the control of African giant snail. But failed to establish in these Islands. Died out.
18	Blue Rock Pigeon* <i>Columba livia</i>	–	Distributed in town center in Port Blair, Rangat, Hut Bay and Diglipur and also in villages as small groups.
19	Chinese Francolin <i>Francolinus pintadeanus</i>	<1964	Has been taken to Andaman (Bump & Bump, 1964), Possibly died out.

*Surviving introduced species

ANNEXURES

Annexure 1: Birds of the Andaman and Nicobar Islands: Species level list

No:	Common Name	Scientific Name	Distribution		Group	IUCN status
1	Black-bellied Storm-petrel	<i>Fregetta tropica</i>	A	?	P	LC
2	Wilson's Storm-petrel	<i>Oceanites oceanicus</i>	A		P	LC
3	Little Grebe*	<i>Tachybaptus ruficollis</i>	A		R	LC
4	Asian Openbill	<i>Anastomus oscitans</i>	A		I	LC
5	Red-billed Tropicbird	<i>Phaethon aethereus</i>	A		P	LC
6	White-tailed Tropicbird	<i>Phaethon lepturus</i>		N	P	LC
7	Red-tailed Tropicbird	<i>Phaethon rubricauda</i>	A		P	LC
8	Christmas Frigatebird	<i>Fregata andrewsi</i>	A		P	CR
9	Lesser Frigatebird	<i>Fregata ariel</i>	A	N	P	LC
10	Spot-billed Pelican	<i>Pelecanus philippensis</i>		N	M	NT
11	Red-footed Booby	<i>Sula sula</i>	A		P	LC
12	Purple Heron	<i>Ardea purpurea</i>	A	N	R	LC
13	Great-billed Heron	<i>Ardea sumatrana</i>		N	?	LC
14	Striated Heron	<i>Butorides striata</i>	A	N	R	LC
15	Chinese Pond-heron	<i>Ardeola bacchus</i>	A		R	LC
16	Indian Pond-heron	<i>Ardeola grayii</i>	A	N	R	LC
17	Cattle Egret	<i>Bubulcus ibis</i>	A	N	R	LC
18	Great Egret	<i>Casmerodius albus</i>	A		R	LC
19	Little Egret	<i>Egretta garzetta</i>	A	N	R	LC
20	Malaysian Night-heron	<i>Gorsachius melanolophus</i>		N	R	LC
21	Pacific Reef-egret	<i>Egretta sacra</i>	A	N	R	LC
22	Cinnamon Bittern	<i>Ixobrychus cinnamomeus</i>	A	N	R	LC
23	Black Bittern	<i>Ixobrychus flavicollis</i>	A	?	R	LC
24	Yellow Bittern	<i>Ixobrychus sinensis</i>	A	N	R	LC
25	Intermediate Egret	<i>Mesophoyx intermedia</i>	A	N	R	LC
26	Black-crowned Night-heron	<i>Nycticorax nycticorax</i>		N	R	LC
27	Common Teal	<i>Anas crecca</i>	A	N	R	LC
28	Sunda Teal	<i>Anas gibberifrons</i>	A		R	LC
29	Western Spot-billed Duck	<i>Anas poecilorhyncha</i>	A		I	LC
30	Lesser Whistling-duck	<i>Dendrocygna javanica</i>	A	N	R	LC
31	Cotton Pygmy-goose	<i>Nettapus coromandelianus</i>	A		R	LC
32	Comb Duck	<i>Sarkidiornis melanotos</i>	A		I	LC
33	Ruddy Shelduck	<i>Tadorna ferruginea</i>	A		R	LC
34	Shikra	<i>Accipiter badius</i>		N	R	LC
35	Nicobar Sparrowhawk	<i>Accipiter butleri</i>		N	R	VU
36	Japanese Sparrowhawk	<i>Accipiter gularis</i>	A		R	LC

No:	Common Name	Scientific Name	Distribution		Group	IUCN status
37	Eurasian Sparrowhawk	<i>Accipiter nisus</i>	A		R	LC
38	Chinese Goshawk	<i>Accipiter soloensis</i>	A	N	R	LC
39	Black Baza	<i>Aviceda leuphotes</i>	A		R	LC
40	Western Marsh-harrier	<i>Circus aeruginosus</i>	A	?	?	LC
41	Pallid Harrier	<i>Circus macrourus</i>	A	?	?	NT
42	Montagu's Harrier	<i>Circus pygargus</i>	A	N	?	LC
43	White-bellied Sea-eagle	<i>Haliaeetus leucogaster</i>	A	N	R	LC
44	Brahminy Kite	<i>Haliastur indus</i>	A		R	LC
45	Grey-headed Fish-eagle	<i>Ichthyophaga ichthyaetus</i>	?		?	NT
46	Black Kite	<i>Milvus migrans</i>	A		V	LC
47	Changeable Hawk-eagle	<i>Nisaetus cirrhatus</i>	A		R	LC
48	Crested Serpent-eagle	<i>Spilornis cheela</i>	A	N	R	LC
49	Andaman Serpent-eagle	<i>Spilornis elgini</i>	A		R	NT
50	South Nicobar Serpent-eagle	<i>Spilornis klossi</i>		N	R	NT
51	Peregrine Falcon	<i>Falco peregrinus</i>	A		M	LC
52	Common Kestrel	<i>Falco tinnunculus</i>	A		M	LC
53	Osprey	<i>Pandion haliaetus</i>	A	N	M	LC
54	Nicobar Megapode	<i>Megapodius nicobariensis</i>		N	R	VU
55	Common Quail	<i>Coturnix coturnix</i>	A		I	LC
56	Blue Quail	<i>Coturnix chinensis</i>		N	R	LC
57	Grey Francolin	<i>Francolinus pondicerianus</i>	A		I	LC
58	Chinese Francolin	<i>Francolinus pintadeanus</i>	A		I	LC
59	Jungle Bush-quail	<i>Perdica asiatica</i>	A		I	LC
60	Painted Bush-quail	<i>Perdica erythrorhyncha</i>	A		I	LC
61	Indian Peafowl	<i>Pavo cristatus</i>	A		I	LC
62	Yellow-legged Buttonquail	<i>Turnix tanki</i>	A	N	R	LC
63	White-breasted Waterhen	<i>Amaurornis phoenicurus</i>	A	N	R	LC
64	Corncrake*	<i>Crex crex</i>	A		R	LC
65	Watercock	<i>Gallicrex cinerea</i>	A	N	R	LC
66	Common Coot	<i>Fulica atra</i>	A		R	LC
67	Common Moorhen	<i>Gallinula chloropus</i>	A		R	LC
68	Slaty-breasted Rail	<i>Gallirallus striatus</i>	A	N	R	LC
69	Purple Swampphen	<i>Porphyrio porphyrio</i>	A	N	R	LC
70	Ruddy-breasted Crake	<i>Porzana fusca</i>	A		R	LC
71	Baillon's Crake	<i>Porzana pusilla</i>	A		R	LC
72	Great Nicobar Crake	<i>Rallina spp.</i> (Not described)		N	R	--

No:	Common Name	Scientific Name	Distribution		Group	IUCN status
73	Andaman Crake	<i>Rallina canningi</i>	A		R	NT
74	Eurasian Curlew	<i>Numenius arquata</i>	A	N	M	NT
75	Whimbrel	<i>Numenius phaeopus</i>	A	N	M	LC
76	Ruddy Turnstone	<i>Arenaria interpres</i>	A	N	M	LC
77	Sanderling	<i>Calidris alba</i>		N	M	LC
78	Curlew Sandpiper	<i>Calidris ferruginea</i>	A		M	LC
79	Little Stint	<i>Calidris minuta</i>	A	N	M	LC
80	Red-necked Stint	<i>Calidris ruficollis</i>	A	N	M	LC
81	Long-toed Stint	<i>Calidris subminuta</i>	A		M	LC
82	Temminck's Stint	<i>Calidris temminckii</i>	A		M	LC
83	Great Knot	<i>Calidris tenuirostris</i>	A		M	VU
84	Common Snipe	<i>Gallinago gallinago</i>	A		M	LC
85	Swinhoe's Snipe	<i>Gallinago megala</i>	A		M	LC
86	Pintail Snipe	<i>Gallinago stenura</i>	A	N	M	LC
87	Jack Snipe	<i>Lymnocyrtus minimus</i>	A		M	LC
88	Eurasian Woodcock	<i>Scolopax rusticola</i>	A		?	LC
89	Bar-tailed Godwit	<i>Limosa lapponica</i>	A	N	M	LC
90	Common Greenshank	<i>Tringa nebularia</i>	A	N	M	LC
91	Common Redshank	<i>Tringa totanus</i>	A	N	M	LC
92	Spotted Redshank	<i>Tringa erythropus</i>	A		M	LC
93	Wood Sandpiper	<i>Tringa glareola</i>	A	N	M	LC
94	Green Sandpiper	<i>Tringa ochropus</i>	A	N	M	LC
95	Marsh Sandpiper	<i>Tringa stagnatilis</i>	A	N	M	LC
96	Common Sandpiper	<i>Actitis hypoleucos</i>	A	N	M	LC
97	Terek Sandpiper	<i>Xenus cinereus</i>	A		M	LC
98	Broad-billed Sandpiper	<i>Limicola falcinellus</i>	A	N	M	LC
99	Kentish Plover	<i>Charadrius alexandrinus</i>	A	N	M	LC
100	Little Ringed Plover	<i>Charadrius dubius</i>	A		M	LC
101	Greater Sand Plover	<i>Charadrius leschenaultii</i>	A	N	M	LC
102	Lesser Sand Plover	<i>Charadrius mongolus</i>	A	N	M	LC
103	Oriental Plover	<i>Charadrius veredus</i>	A		M	LC
104	Pacific Golden Plover	<i>Pluvialis fulva</i>	A	N	M	LC
105	Grey Plover	<i>Pluvialis squatarola</i>	A	N	M	LC
106	Grey-headed Lapwing	<i>Vanellus cinereus</i>	A		M	LC
107	Beach Thick-knee	<i>Esacus giganteus</i>	A	?	R	NT

No:	Common Name	Scientific Name	Distribution		Group	IUCN status
108	Crab Plover	<i>Dromas ardeola</i>	A	N	M	LC
109	Oriental Pratincole	<i>Glareola maldivarum</i>	A	?	M	LC
110	Common White Tern	<i>Gygis alba</i>	A		P	LC
111	Lesser Noddy	<i>Anous tenuirostris</i>	A	N	P	LC
112	Brown Noddy	<i>Anous stolidus</i>	A	N	P	LC
113	White-winged Tern	<i>Chlidonias leucopterus</i>	A	N	P	LC
114	Bridled Tern	<i>Sterna anaethetus</i>	A	N	P	LC
115	Lesser Crested Tern	<i>Sterna bengalensis</i>	A	N	P	LC
116	Great Crested Tern	<i>Sterna bergii</i>	A	N	P	LC
117	Roseate Tern	<i>Sterna dougallii</i>	A	N	P	LC
118	Sooty Tern	<i>Sterna fuscata</i>	A	N	P	LC
119	Gull-billed Tern	<i>Sterna nilotica</i>	A	N	P	LC
120	Black-naped Tern	<i>Sterna sumatrana</i>	A	N	R	LC
121	Emerald Dove	<i>Chalcophaps indica</i>	A	N	R	LC
122	Rock Pigeon	<i>Columba livia</i>	A	N	I	LC
123	Andaman Wood-pigeon	<i>Columba palumboides</i>	A	N	R	NT
124	Green Imperial-pigeon	<i>Ducula aenea</i>	A	N	R	LC
125	Pied Imperial-pigeon	<i>Ducula bicolor</i>	A	N	R	LC
126	Andaman Cuckoo-dove	<i>Macropygia rufipennis</i>	A	N	R	NT
127	Spotted Dove (Burmese)	<i>Stigmatopelia chinensis</i>		N	?	LC
128	Laughing Dove	<i>Stigmatopelia senegalensis</i>	A		I	LC
129	Red Collared-dove	<i>Streptopelia tranquebarica</i>	A		R	LC
130	Pompadour Green-pigeon	<i>Treron pompadora</i>	A	N	R	LC
131	Nicobar Pigeon	<i>Caloenas nicobarica</i>	A	N	R	NT
132	Vernal Hanging-parrot	<i>Loriculus vernalis</i>	A	N	R	LC
133	Red-breasted Parakeet	<i>Psittacula alexandri</i>	A		R	LC
134	Nicobar Parakeet	<i>Psittacula caniceps</i>		N	R	NT
135	Alexandrine Parakeet	<i>Psittacula eupatria</i>	A		R	LC
136	Rose-ringed Parakeet	<i>Psittacula krameri</i>	A?		I	LC
137	Long-tailed Parakeet	<i>Psittacula longicauda</i>	A	N	R	NT
138	Brown Coucal	<i>Centropus andamanensis</i>	A	?	R	LC
139	Asian Emerald Cuckoo	<i>Chrysococcyx maculatus</i>	A	N	R	LC
140	Violet Cuckoo	<i>Chrysococcyx xanthorhynchus</i>	A		?	LC
141	Common Cuckoo	<i>Cuculus canorus</i>	A		V	LC
142	Indian Cuckoo	<i>Cuculus micropterus</i>	A	N	R	LC

No:	Common Name	Scientific Name	Distribution		Group	IUCN status
143	Lesser Cuckoo	<i>Cuculus poliocephalus</i>	A		R	LC
144	Himalayan Cuckoo	<i>Cuculus saturatus</i>	A	N	R	LC
145	Large Hawk-cuckoo	<i>Cuculus sparverioides</i>		N	?	LC
146	Asian Koel	<i>Eudynamys scolopaceus</i>	A	N	?	LC
147	Drongo Cuckoo	<i>Surniculus lugubris</i>		N	?	LC
148	Barn Owl	<i>Tyto alba</i>	A		R	LC
149	Andaman Hawk-owl	<i>Ninox affinis</i>	A	N	R	NT
150	Oriental Scops-owl	<i>Ninox obscura</i>	A	N	R	LC
151	Common Scops-owl	<i>Otus sunia</i>	A		R	LC
152	Nicobar Scops-owl	<i>Otus alius</i>		N	R	DD
153	Andaman Scops-owl	<i>Otus balli</i>	A		R	NT
154	Andaman Nightjar	<i>Caprimulgus andamanicus</i>	A		R	UR
155	Grey Nightjar	<i>Caprimulgus indicus</i>	A		R	LC
156	Common Swift	<i>Apus apus</i>	A		V	LC
157	Himalayan Swiftlet	<i>Collocalia brevirostris</i>	A		?	LC
158	Glossy Swiftlet	<i>Collocalia esculenta</i>	A	N	R	LC
159	Edible-nest Swiftlet	<i>Collocalia fuciphaga</i>	A	N	R	LC
160	Brown-backed Needletail	<i>Hirundapus giganteus</i>	A	N	R	LC
161	Common Kingfisher	<i>Alcedo atthis</i>	A	N	R	LC
162	Blue-eared Kingfisher	<i>Alcedo meninting</i>	A		R	LC
163	Black-backed Kingfisher	<i>Ceyx erithaca</i>	A	N	R	LC
164	Ruddy Kingfisher	<i>Halcyon coromanda</i>	A		R	LC
165	Black-capped Kingfisher	<i>Halcyon pileata</i>	A	N	R	LC
166	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	A	?	R	LC
167	Stork-billed Kingfisher	<i>Pelargopsis capensis</i>	A	N	R	LC
168	Collared Kingfisher	<i>Todiramphus chloris</i>	A	N	R	LC
169	Chestnut-headed Bee-eater	<i>Merops leschenaulti</i>	A		R	LC
170	Little Green Bee-eater	<i>Merops orientalis</i>	A		?	LC
171	Blue-tailed Bee-eater	<i>Merops philippinus</i>	A	N	M	LC
172	European Roller	<i>Coracias garrulus</i>	A		M	NT
173	Asian Dollarbird	<i>Eurystomus orientalis</i>	A		R	LC
174	Narcondam Hornbill	<i>Aceros narcondami</i>	A		R	EN
175	Crimson-fronted Barbet*	<i>Megalaima rubricapillus</i>	A		R	LC
176	Fulvous-breasted Woodpecker	<i>Dendrocopos macei</i>	A		R	LC
177	Andaman Woodpecker	<i>Dryocopus hodgei</i>	A		R	NT

No:	Common Name	Scientific Name	Distribution	Group	IUCN status
178	Hooded Pitta	<i>Pitta sordida</i>		N R	LC
179	Red-rumped Swallow	<i>Hirundo daurica</i>	A	V	LC
180	Barn Swallow	<i>Hirundo rustica</i>	A N	M	LC
181	Pacific Swallow	<i>Hirundo tahitica</i>	A	R	LC
182	Brown Shrike	<i>Lanius cristatus</i>	A N	M	LC
183	Black-naped Oriole	<i>Oriolus chinensis</i>	A	R	LC
184	Eurasian Golden Oriole	<i>Oriolus oriolus</i>	A	M	LC
185	Black-hooded Oriole	<i>Oriolus xanthornus</i>	A	?	LC
186	Andaman Drongo	<i>Dicrurus andamanensis</i>	A	R	NT
187	Crow-billed Drongo	<i>Dicrurus annectans</i>		N ?	LC
188	Ashy Drongo	<i>Dicrurus leucophaeus</i>	A N	?	LC
189	Black Drongo	<i>Dicrurus macrocercus</i>	A	?	LC
190	Greater Racket-tailed Drongo	<i>Dicrurus paradiseus</i>	A N	R	LC
191	White-breasted Woodswallow	<i>Artamus leucorhynchus</i>	A	R	LC
192	Common Myna	<i>Acridotheres tristis</i>	A N	I	LC
193	Jungle Myna	<i>Acridotheres fuscus</i>	A	I	LC
194	Asian Glossy Starling	<i>Aplonis panayensis</i>	A N	R	LC
195	Hill Myna	<i>Gracula religiosa</i>	A N	R	LC
196	White-headed Starling	<i>Sturnus erythropygius</i>	A N	R	LC
197	Rosy Starling	<i>Sturnus roseus</i>	A	V	LC
198	Purple-backed Starling	<i>Sturnus sturninus</i>	A N	?	LC
199	Large-billed Crow	<i>Corvus macrorhynchos</i>	A N	R	LC
200	House Crow	<i>Corvus splendens</i>	A	I	LC
201	Andaman Treepie	<i>Dendrocitta bayleyi</i>	A	R	NT
202	Large Cuckooshrike	<i>Coracina macei</i>	A	R	LC
203	Bar-bellied Cuckooshrike	<i>Coracina striata</i>	A	R	LC
204	Pied Triller	<i>Lalage nigra</i>		N R	LC
205	Small Minivet	<i>Pericrocotus cinnamomeus</i>	A	R	LC
206	Scarlet Minivet	<i>Pericrocotus flammeus</i>	A	R	LC
207	Asian Fairy-bluebird	<i>Irena puella</i>	A N	R	LC
208	Nicobar Bulbul	<i>Hypsipetes nicobariensis</i>		N R	NT
209	Black-headed Bulbul	<i>Pycnonotus atriceps</i>	A	R	LC
210	Red-whiskered Bulbul	<i>Pycnonotus jocosus</i>	A N	R	LC
211	Red-breasted Flycatcher	<i>Ficedula parva</i>	A	M	LC
212	Asian Brown Flycatcher	<i>Muscicapa dauurica</i>	A	M	LC

No.	Common Name	Scientific Name	Distribution Group			IUCN status
213	Brown-chested Jungle-flycatcher	<i>Rhinomyias brunneatus</i>	A	N	M	VU
214	Asian Paradise-flycatcher	<i>Terpsiphone paradisi</i>	A	N	R	LC
215	Black-naped Monarch	<i>Hypothymis azurea</i>	A	N	R	LC
216	Mangrove Whistler	<i>Pachycephala grisola</i>	A		R	LC
217	Zitting Cisticola	<i>Cisticola juncidis</i>	A	N	R	LC
218	Thick-billed Warbler	<i>Acrocephalus aedon</i>	A	N	M	LC
219	Oriental Reed-warbler	<i>Acrocephalus orientalis</i>	A		M	UR
220	Clamorous Reed-warbler	<i>Acrocephalus stentoreus</i>	A		M	LC
221	Pale-footed Bush-warbler	<i>Cettia pallidipes</i>	A		R	LC
222	Pallas's Grasshopper-warbler	<i>Locustella certhiola</i>	A	N	M	LC
223	Lanceolated Warbler	<i>Locustella lanceolata</i>	A	N	M	LC
224	Inornate Warbler	<i>Phylloscopus inornatus</i>	A		M	LC
225	Dusky Warbler	<i>Phylloscopus fuscatus</i>	A		M	LC
226	Large-billed Leaf-warbler	<i>Phylloscopus magnirostris</i>	A		?	LC
227	Pale-legged Leaf-warbler	<i>Phylloscopus tenellipes</i>		N	?	LC
228	Greenish Warbler	<i>Phylloscopus trochiloides</i>	A		M	LC
229	Orphean Warbler	<i>Sylvia hortensis</i>	A		?	LC
230	Bluethroat	<i>Luscinia svecica</i>	A		M	LC
231	White-rumped Shama	<i>Copsychus malabaricus</i>	A		R	LC
232	Oriental Magpie-robin	<i>Copsychus saularis</i>	A		R	LC
233	Tickell's Blue-flycatcher*	<i>Cyornis tickelliae</i>	A		?	LC
234	Grey-headed Canary-flycatcher*	<i>Culicicapa ceylonensis</i>	A		?	LC
235	Blue-fronted Robin*	<i>Cinclidium frontale</i>	A		?	LC
236	Common Stonechat	<i>Saxicola torquatus</i>	A		R	LC
237	Blue Rock-thrush	<i>Monticola solitarius</i>	A	N	V	LC
238	Eyebrowed Thrush	<i>Turdus obscurus</i>	A	N	R	LC
239	Orange-headed Thrush	<i>Zoothera citrina</i>	A	N	R	LC
240	Siberian Thrush	<i>Zoothera sibirica</i>	A		?	LC
241	Richard's Pipit	<i>Anthus richardi</i>	A		M	LC
242	Red-throated Pipit	<i>Anthus cervinus</i>	A	N	M	LC
243	Blyth's Pipit	<i>Anthus godlewskii</i>	A		V	LC
244	Forest Wagtail	<i>Dendronanthus indicus</i>	A		M	LC
245	White Wagtail	<i>Motacilla alba</i>	A		M	LC
246	Grey Wagtail	<i>Motacilla cinerea</i>	A	N	M	LC
247	Yellow Wagtail	<i>Motacilla flava</i>	A	N	M	LC

No:	Common Name	Scientific Name	Distribution		Group	IUCN status
248	Plain Flowerpecker	<i>Dicaeum concolor</i>	A		R	LC
249	Crimson Sunbird	<i>Aethopyga siparaja</i>		N	R	LC
250	Little Spiderhunter	<i>Arachnothera longirostra</i>	A		R	LC
251	Olive-backed Sunbird	<i>Nectarinia jugularis</i>	A	N	R	LC
252	Oriental White-eye	<i>Zosterops palpebrosus</i>	A	N	R	LC
253	House Sparrow	<i>Passer domesticus</i>	A	N	I	LC
254	Eurasian Tree Sparrow	<i>Passer montanus</i>	A		I	LC
255	Yellow-breasted Bunting	<i>Emberiza aureola</i>		N	?	VU
256	Little Bunting	<i>Emberiza pusilla</i>	A		?	LC
257	Red Avadavat	<i>Amandava amandava</i>	A		I	LC
258	Tricoloured Munia	<i>Lonchura malacca</i>	A		I	LC
259	White-rumped Munia	<i>Lonchura striata</i>	A	N	R	LC

Abbreviations: A- Andaman; N- Nicobar; P- Pelagic bird; R- Resident bird; I- Introduced bird; ?- Distribution is doubt; M- Migratory bird; V- Vagrant bird; LC- Least Concern; VU- Vulnerable; UR- Under review; NT- Near threatened; EN- Endangered; DD- Data deficient; *- Needs further reports for conformation.

Annexure 2: List of additional bird species to the Sankaran and Vijayan 1993 list

Sl No.	Common name	Scientific name	Remarks
1	Little Grebe*	<i>Tachybaptus ruficollis</i>	6 individuals from LA; R
2	Lesser Frigatebird**	<i>Fregata ariel</i>	28 individuals from GN, 11 individuals from SA
3	Christmas Frigatebird	<i>Fregata andrewsi</i>	Reported from Andaman Islands
4	Black Bittern	<i>Ixobrychus flavicollis</i>	1 individual from NA, MA, R
5	Brahminy Kite	<i>Haliastur indus</i>	4 individuals from SA; R
6	Corn Crake*	<i>Crex crex</i>	1 individual from LA; R
7	Ruddy-breasted Crake	<i>Porzana fusca</i>	4 detections from SA during the present study.
8	Spotted Redshank*	<i>Tringa erythropus</i>	6 individuals from GN; W
9	Marsh Sandpiper*	<i>Tringa stagnatilis</i>	Reported from SA, LA, CM & GN; W
10	Temminck's Stint	<i>Calidris temminckii</i>	2 individuals from GN; W
11	Common White Tern*	<i>Gygis alba</i>	10+ individuals from NI,
12	Green Bee-eater **	<i>Merops orientalis</i>	62+ individuals from SA, LA & CM; W
13	Crimson-fronted Barbet*	<i>Megalaima rubricapilla</i>	10 individuals from SA, LA & CM; R
14	Black Drongo	<i>Dicrurus macrocercus</i>	20 detections from SA during the present study.
15	Large Hawk-cuckoo	<i>Cuculus sparverioides</i>	Two sightings from GN
16	Orphean Warbler **	<i>Sylvia hortensis</i>	2 individuals from CM; R
17	Eurasian Golden Oriole	<i>Oriolus oriolus</i>	8 individuals from SA, CM & CN; R
18	House Crow	<i>Corvus splendens</i>	I, Very common in Port Blair
19	Tickell's Blue Flycatcher*	<i>Cyornis tickelliae</i>	1 individual From SA
20	Grey-headed Flycatcher*	<i>Culicicapa ceylonensis</i>	1 individual From SA
21	Blue-fronted Robin*	<i>Cinclidium frontale</i>	1 individual From SA
22	European Roller*	<i>Coracias garullus</i>	2 individuals from MA, W
23	Great Nicobar Crake*	<i>Rallina spp</i> (yet to described)	1 individual From GN, R, Photographed.
24	Jungle Myna	<i>Acridotheres tristis</i>	I, SA, No records after that
25	Common Quail	<i>Coturnix fuscus</i>	I, SA, No records after that
26	Jungle Bush-quail	<i>Perdica asiatica</i>	I, SA, No records after that
27	Painted Bush-quail	<i>Perdica erythrorhyncha</i>	I, SA, No records after that
28	Comb Duck	<i>Sarkidiornis melanotos</i>	I, SA, No records after that
29	Asian Openbill	<i>Anastomus oscitans</i>	I, MA, Died out
30	Chinese Francolin	<i>Francolinus pintadeanus</i>	I, SA, Died out
31	Common Coot	<i>Fulica atra</i>	Andaman Island

(References: Pande *et al.* 2007, Rajamaman 2010, Lever 1987, Bump & Bump 1964, Rajan & Pramod 2010 and Kumar *et al.* 2012).

Abbreviations: *- First records; SA-South Andaman; ** - Possible new records; LA- Little Andaman; MA- Middle Andaman; CM- Camorta; CN- Car Nicobar; GN- Great Nicobar; NI- Narcondam Island; R- Resident; W-Winter visitor; I – Introduced.

Annexure 3: Subspecies list of Andaman and Nicobar Islands according to Sankaran and Vijayan List 1993.

Sps No	Species name	Subspecies name	A	N	S
1	<i>Spilornis cheela</i>	1, <i>Spilornis cheela burmanicus</i>	A		NE
		2, <i>Spilornis cheela davisoni</i>	A	N	E
		3, <i>Spilornis cheela minimus</i>		N	E
2	<i>Falco peregrinus</i>	4, <i>Falco peregrinus japonensis</i>	A		NE
		5, <i>Falco peregrinus peregrinator</i>		N	NE
3	<i>Megapodius nicobariensis</i>	6, <i>Megapodius nicobariensis nicobariensis</i>		N	E
		7, <i>Megapodius nicobariensis abortti</i>		N	E
4	<i>Turnix tanki</i>	8, <i>Turnix tanki tanki</i>	A	N	NE
		9, <i>Turnix tanki albiventris</i>	A	N	?
5	<i>Rallus striatus</i>	10, <i>Rallus striatus obscurior</i>	A	N?	E
		11, <i>Rallus striatus nicobarensis</i>		N	E
6	<i>Amaurornis phoenicurus</i>	12, <i>Amaurornis phoenicurus insularis</i>	A	N	E
		13, <i>Amaurornis phoenicurus leucocephalus</i>		N	E
		14, <i>Amaurornis phoenicurus midnicobaricus</i>		N	E
7	<i>Treron pompadora</i>	15, <i>Treron pompadora chloroptera</i>	A	N	E
		16, <i>Treron pompadora andamanica</i>	A		E
8	<i>Ducula aenea</i>	17, <i>Ducula aenea andamanica</i>	A		E
		18, <i>Ducula aenea nicobarica</i>		N	E
9	<i>Columba palumboides</i>	19, <i>Columba palumboides palumboides</i>	A		E
		20, <i>Columba palumboides nicobarica</i>		N	E
10	<i>Macropygia rufipennis</i>	21, <i>Macropygia rufipennis andamanica</i>	A	N	E
		22, <i>Macropygia rufipennis rufipennis</i>		N	E
		23, <i>Macropygia rufipennis tiwarii</i>		N	E

Sps No	Species name	Subspecies name	A	N	S
11	<i>Chalcophagus indica</i>	24, <i>Chalcophagus indica maxima</i>	A		E
		25, <i>Chalcophagus indica augusta</i>		N	E
12	<i>Psittacula longicauda</i>	26, <i>Psittacula longicauda tytleri</i>	A		E
		27, <i>Psittacula longicauda nicobarica</i>		N	E
13	<i>Ninix affinis</i>	28, <i>Ninix affinis affinis</i>	A		E
		29, <i>Ninix affinis isolata</i>		N	E
		30, <i>Ninix affinis rexpimenta</i>		N	E
14	<i>Collocalia brevirostris</i>	31, <i>Collocalia brevirostris brevirostris</i>	A?		NE
		32, <i>Collocalia brevirostris innominata</i>	A		NE
15	<i>Ceyx erithacus</i>	33, <i>Ceyx erithacus macrocarus</i>	A	N	E
		34, <i>Ceyx erithacus erithacus</i>	A	N	NE
16	<i>Pelargopsis capensis</i>	35, <i>Pelargopsis capensis osmastonii</i>	A		E
		36, <i>Pelargopsis capensis intermedia</i>		N	E
		37, <i>Pelargopsis capensis shekari</i>	A		E
17	<i>Halcyon chloris</i>	38, <i>Halcyon chloris davisoni</i>	A		E
		39, <i>Halcyon chloris occipitalis</i>		N	E
18	<i>Lanius cristatus</i>	40, <i>Lanius cristatus cristatus</i>	A	?	NE
		41, <i>Lanius cristatus lucionensis</i>	A	?	NE
19	<i>Dicrurus leucophaeus</i>	* <i>Dicrurus leucophaeus</i>	A	N	NE
		42, <i>Dicrurus leucophaeus leucogenys</i>	A		NE
20	<i>Oriolus chinensis</i>	43, <i>Oriolus chinensis andamanensis</i>	A		E
		44, <i>Oriolus chinensis macrourus</i>		N	E
21	<i>Dicrurus andamanensis</i>	45, <i>Dicrurus andamanensis dicruiformis</i>	A		E
		46, <i>Dicrurus andamanensis andamanensis</i>	A		E
22	<i>Dicrurus paradiseus</i>	47, <i>Dicrurus paradiseus otiosus</i>	A		E
		48, <i>Dicrurus paradiseus nicobariensis</i>		N	E

Sps No	Species name	Subspecies name	A	N	E
23	<i>Aplonis panayensis</i>	49, <i>Aplonis panayensis lytleri</i>	A	N	E
		50, <i>Aplonis panayensis albiris</i>		N	E
24	<i>Sternus erythropygius</i>	51, <i>Sternus erythropygius andamanensis</i>	A		E
		52, <i>Sternus erythropygius erythropygius</i>		N	E
		53, <i>Sternus erythropygius katchalensis</i>		N	S
25	<i>Gracula religiosa</i>	54, <i>Gracula religiosa andamanensis</i>	A	N	E
		55, <i>Gracula religiosa halibretha</i>		N	E
26	<i>Hypothymis azurea</i>	56, <i>Hypothymis azurea tytleri</i>	A		E
		57, <i>Hypothymis azurea idiochroa</i>		N	E
		58, <i>Hypothymis azurea nicobarica</i>		N	E
27	<i>Zoothera sibirica</i>	59, <i>Zoothera sibirica davisoni</i>	A		NE
		60, <i>Zoothera sibirica sibirica</i>	A		NE
28	<i>Zoothera citrina</i>	61, <i>Zoothera citrina andamanensis</i>	A		E
		62, <i>Zoothera citrina albogularis</i>		N	E
29	<i>Motacilla flava</i>	63, <i>Motacilla flava thunbergi</i>	A	N	NE
		64, <i>Motacilla flava beema</i>	A	N	NE
30	<i>Nectarina jugularis</i>	65, <i>Nectarina jugularis andamanica</i>	A		E
		66, <i>Nectarina jugularis klossi</i>		N	E
		67, <i>Nectarina jugularis procelia</i>		N	E
31	<i>Lonchura striata</i>	68, <i>Lonchura striata fumigata</i>	A	N	NE
		69, <i>Lonchura striata semistriata</i>		N	E

Abbreviations: A- Andaman; N- Nicobar; E- Endemic; NE- Non endemic; S- Status, ?- Doubt, *- Species

Annexure 4. List of introduced bird species of Andaman and Nicobar Islands

No	Species	Scientific Name	Year of In'	Remaks
1	Jungle Myna	<i>Acridotheres fuscus</i>	1860s	Introduced from Burma to port Blair by Col. R. C Tytler. Possibly died out
2	House Crow*	<i>Corvus splendens</i>	1862 & 1864	Introduced for sanitary purpose, but failed to establish. Accidentally reached recently and established well in Port Blair.
3	Rose ringed parakeet	<i>Psittacula krameri</i>	< 1863	Possibly died out
4	Eurasian Tree Sparrow	<i>Passer montanus</i>	<1866	Possibly died out
5	Common Myna*	<i>Acridotheres tristis</i>	1867	Introduced to Ross Island. Established well in different habitats of main inhabited Islands except evergreen forests.
6	Pea fowl*	<i>Pavo cristatus</i>	1868	Introduced to Ross Island. Living in Ross Island with about 16 individuals.
7	Red Avadavat	<i>Amandava formosa</i>	< 1873	Possibly died out
8	House sparrow*	<i>Passer domesticus</i>	1882 & 1895	Introduced to Ross Island. Established well in main inhabited islands.
9	Little Brown Dove	<i>Streptopelia senegalensis</i>)	1899	Possibly died out
10	Black headed Munia	<i>Lonchura malacca</i>	< 1906	Possibly died out
11	Grey partridge*	<i>Francolinus pondicerianus</i>	1890	Now established around in Port Blair with very less number.
12	Spotbill Duck	<i>Anas poecilorhyncha</i>	1960	Escaped form iron-mesh enclosure on Ross Islands during a storm, no sightings after that. Possibly died out

No	Species	Scientific Name	Year of In'	Remarks
13	Common Quail	<i>Coturnix coturnix</i>	1961	Brought from Madras and released into Ross Island. No recent records. Possibly died out.
14	Jungle Bush Quail	<i>Perdica asiatica</i>	1961	No recent records. Possibly died out
15	Painted Bush Quail	<i>Perdica erythrorhynchos</i>	1961	No recent records. Possibly died out
16	Comb Duck	<i>Sarkidiornis melanotos</i>	1961	Brought from Calcutta and released into Neil Island. No recent records. Possibly died out
17	Openbill Stork	<i>Anastomus oscitans</i>	1964	Introduced from Calcutta and released into South Andaman for the control of African giant snail. But failed to establish in these Islands. Died out
18	Rock Pigeon*	<i>Columba livia</i>	--	Distributed town centre in Port Blair, Rangat, Hutbay and Diglipur and also in villages as small group
19	Chinese Francolin	<i>Francolinus pintadeanus</i>	<1964	Has taken to Andaman (Ref:Bump & Bump, 1964), Possibly died out

*surviving introduced species

Annexure 5: List of bird species recorded from Human influences landscape of Andaman Islands.

No:	Common Name	Scientific Name	Status	Distributions
1	Purple Heron	<i>Ardea purpurea</i>	R	L - - -
2	Striated Heron	<i>Butorides striata</i>	R	- S M - H
3	Indian Pond-heron	<i>Ardeola grayii</i>	R	L S M N H
4	Cattle Egret	<i>Bubulcus ibis</i>	R	L S M N H
5	Great Egret	<i>Casmerodius albus</i>	R	L S M - H
6	Little Egret	<i>Egretta garzetta</i>	R	L S - N -
7	Pacific Reef-egret	<i>Egretta sacra</i>	R	L S M N H
8	Cinnamon Bittern	<i>Ixobrychus cinnamomeus</i>	R	- S - - -
9	Black Bittern	<i>Ixobrychus flavicollis</i>	R	- S - - -
10	Yellow Bittern	<i>Ixobrychus sinensis</i>	R	L S - - -
11	Intermediate Egret	<i>Mesophoyx intermedia</i>	R	- S - - -
12	Sunda Teal	<i>Anas gibberifrons</i>	R	- S M - -
13	Lesser Whistling-duck	<i>Dendrocygna javanica</i>	R	L S M - -
14	Cotton Pygmy-goose	<i>Nettapus coromandelianus</i>	R	- S - - -
15	White-bellied Sea-eagle	<i>Haliaeetus leucogaster</i>	R	L S M - H
16	Brahminy Kite	<i>Haliastur indus</i>	R	- S - - -
17	Andaman Serpent-eagle	<i>Spilornis elgini</i>	R	L S M N H
18	Grey Francolin	<i>Francolinus pondicerianus</i>	I	- S - - -
19	Indian Peafowl	<i>Pavo cristatus</i>	I	- S - - -
20	White-breasted Waterhen	<i>Amaurornis phoenicurus</i>	R	L S M - H
21	Common Moorhen	<i>Gallinula chloropus</i>	R	L S - - -
22	Slaty-breasted Rail	<i>Gallirallus striatus</i>	R	L S M - -
23	Purple Swampphen	<i>Porphyrio porphyrio</i>	R	L S - - -
24	Ruddy-breasted Crake	<i>Porzana fusca</i>	R	- S M - -
25	Andaman Crake	<i>Rallina canningi</i>	R	- S - - -
26	Eurasian Curlew	<i>Numenius arquata</i>	M	L S - N -
27	Whimbrel	<i>Numenius phaeopus</i>	M	L S M - H
28	Ruddy Turnstone	<i>Arenaria interpres</i>	M	L S - N -
29	Curlew Sandpiper	<i>Calidris ferruginea</i>	M	- S - - -
30	Little Stint	<i>Calidris minuta</i>	M	- S - - -
31	Long-toed Stint	<i>Calidris subminuta</i>	M	- S - - -
32	Common Snipe	<i>Gallinago gallinago</i>	M	L S M - -
33	Jack Snipe	<i>Lymnocyrtus minimus</i>	M	- S - - -
34	Bar-tailed Godwit	<i>Limosa lapponica</i>	M	L S M - -
35	Common Greenshank	<i>Tringa nebularia</i>	M	L S - - -
36	Common Redshank	<i>Tringa totanus</i>	M	L S M N -
37	Wood Sandpiper	<i>Tringa glareola</i>	M	- S - - -
38	Green Sandpiper	<i>Tringa ochropus</i>	M	L S M - -
39	Marsh Sandpiper	<i>Tringa stagnatilis</i>	M	- S - - -

No:	Common Name	Scientific Name	Status	Distributions				
40	Common Sandpiper	<i>Actitis hypoleucos</i>	M	L	S	M	-	-
41	Terek Sandpiper	<i>Xenus cinereus</i>	M	-	S	-	-	-
42	Broad-billed Sandpiper	<i>Limicola falcinellus</i>	M	L	-	-	-	-
43	Kentish Plover	<i>Charadrius alexandrinus</i>	M	L	S	-	N	-
44	Little Ringed Plover	<i>Charadrius dubius</i>	M	L	S	-	-	-
45	Greater Sand Plover	<i>Charadrius leschenaultii</i>	M	-	S	-	N	-
46	Lesser Sand Plover	<i>Charadrius mongolus</i>	M	L	S	M	N	H
47	Oriental Plover	<i>Charadrius veredus</i>	M	-	S	-	-	-
48	Pacific Golden Plover	<i>Pluvialis fulva</i>	M	L	S	M	N	-
49	Grey Plover	<i>Pluvialis squatarola</i>	M	L	S	M	N	-
50	Grey-headed Lapwing	<i>Vanellus cinereus</i>	M	-	S	-	-	-
51	Beach Thick-knee	<i>Esacus giganteus</i>	R	-	-	M	-	-
52	Black-naped Tern	<i>Sterna sumatrana</i>	R	-	S	M	-	-
53	Emerald Dove	<i>Chalcophaps indica</i>	R	L	S	-	-	H
54	Rock Pigeon	<i>Columba livia</i>	I	L	S	M	N	H
55	Andaman Wood-pigeon	<i>Columba palumboides</i>	R	L	S	M	-	-
56	Green Imperial-pigeon	<i>Ducula aenea</i>	R	L	S	M	N	H
57	Andaman Cuckoo-dove	<i>Macropygia rufipennis</i>	R	-	S	-	N	-
58	Red Collared-dove	<i>Streptopelia tranquebarica</i>	R	L	S	M	N	H
59	Pompadour Green-pigeon	<i>Treron pompadora</i>	R	-	S	-	-	-
60	Nicobar Pigeon	<i>Caloenas nicobarica</i>	R	-	S	-	-	-
61	Vernal Hanging-parrot	<i>Loriculus vernalis</i>	R	L	S	M	N	H
62	Red-breasted Parakeet	<i>Psittacula alexandri</i>	R	L	S	M	N	H
63	Alexandrine Parakeet	<i>Psittacula eupatria</i>	R	L	S	-	-	H
64	Long-tailed Parakeet	<i>Psittacula longicauda</i>	R	L	S	M	N	H
65	Brown Coucal	<i>Centropus andamanensis</i>	R	-	-	M	N	H
66	Indian Cuckoo	<i>Cuculus micropterus</i>	R	-	S	M	-	-
67	Asian Koel	<i>Eudynamys scolopaceus</i>	?	L	S	M	-	-
68	Andaman Hawk-owl	<i>Ninox affinis</i>	R	-	S	-	N	-
69	Oriental Scops-owl	<i>Otus sunia</i>	R	-	-	-	N	-
70	Glossy Swiftlet	<i>Collocalia esculenta</i>	R	L	S	M	N	H
71	Edible-nest Swiftlet	<i>Collocalia fuciphaga</i>	R	-	S	M	-	-
72	Brown-backed Needletail	<i>Hirundapus giganteus</i>	R	-	-	M	N	H
73	Common Kingfisher	<i>Alcedo atthis</i>	R	L	S	M	-	H
74	Blue-eared Kingfisher	<i>Alcedo meninting</i>	R	-	S	-	-	-
75	Black-backed Kingfisher	<i>Ceyx erithaca</i>	R	-	-	M	-	-
76	Ruddy Kingfisher	<i>Halcyon coromanda</i>	R	-	-	M	-	-
77	Black-capped Kingfisher	<i>Halcyon pileata</i>	R	L	S	M	N	-
78	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	R	-	S	M	N	H
79	Stork-billed Kingfisher	<i>Pelargopsis capensis</i>	R	-	S	-	-	-

No:	Common Name	Scientific Name	Status	Distributions
80	Collared Kingfisher	<i>Todiramphus chloris</i>	R	L S M N -
81	Chestnut-headed Bee-eater	<i>Merops leschenaulti</i>	R	- S M N H
82	Blue-tailed Bee-eater	<i>Merops philippinus</i>	M	- S M - -
83	European Roller	<i>Coracias garrulus</i>	M	- S M
84	Asian Dollarbird	<i>Eurystomus orientalis</i>	R	- - M - H
85	Fulvous-breasted Woodpecker	<i>Dendrocopos macei</i>	R	L S M - H
86	Andaman Woodpecker	<i>Dryocopus hodgei</i>	R	- S M - -
87	Barn Swallow	<i>Hirundo rustica</i>	M	L S M N H
88	Pacific Swallow	<i>Hirundo tahitica</i>	R	L S - - -
89	Brown Shrike	<i>Lanius cristatus</i>	M	L S M N H
90	Black-naped Oriole	<i>Oriolus chinensis</i>	R	L S M - H
91	Eurasian Golden Oriole	<i>Oriolus oriolus</i>	M	- S - - -
92	Black-hooded Oriole	<i>Oriolus xanthornus</i>	?	- S M - -
93	Andaman Drongo	<i>Dicrurus andamanensis</i>	R	L S - - H
94	Black Drongo	<i>Dicrurus macrocercus</i>	?	L S M - H
95	Greater Racket-tailed Drongo	<i>Dicrurus paradiseus</i>	R	L S M N H
96	White-breasted Woodswallow	<i>Artamus leucorhynchus</i>	R	- - M - H
97	Common Myna	<i>Acridotheres tristis</i>	I	L S M N -
98	Asian Glossy Starling	<i>Aplonis panayensis</i>	R	L S M N H
99	Hill Myna	<i>Gracula religiosa</i>	R	L S M N -
100	White-headed Starling	<i>Sturnus erythropygius</i>	R	L S M N H
101	Purple-backed Starling	<i>Sturnus sturninus</i>	?	- S - - -
102	Large-billed Crow	<i>Corvus macrorhynchos</i>	R	L S M N H
103	House Crow	<i>Corvus splendens</i>	I	- S - - -
104	Andaman Treepie	<i>Dendrocitta bayleyi</i>	R	- S - - -
105	Large Cuckooshrike	<i>Coracina macei</i>	R	- - - N H
106	Bar-bellied Cuckooshrike	<i>Coracina striata</i>	R	L S - - -
107	Small Minivet	<i>Pericrocotus cinnamomeus</i>	R	- S M N H
108	Scarlet Minivet	<i>Pericrocotus flammeus</i>	R	- S - N H
109	Asian Fairy-bluebird	<i>Irena puella</i>	R	- S - N -
110	Black-headed Bulbul	<i>Pycnonotus atriceps</i>	R	L S - N -
111	Red-whiskered Bulbul	<i>Pycnonotus jocosus</i>	R	L S M N H
112	Asian Brown Flycatcher	<i>Muscicapa dauurica</i>	M	L S M N -
113	Asian Paradise-flycatcher	<i>Terpsiphone paradisi</i>	R	- S - - -
114	Black-naped Monarch	<i>Hypothymis azurea</i>	R	L S M N -
115	Thick-billed Warbler	<i>Acrocephalus aedon</i>	M	L - - - H
116	Pale-footed Bush-warbler	<i>Cettia pallidipes</i>	R	- - M - -
117	Dusky Warbler	<i>Phylloscopus fuscatus</i>	M	- S - - -
118	Oriental Magpie-robin	<i>Copsychus saularis</i>	R	L S M N -
119	Orange-headed Thrush	<i>Zoothera citrina</i>	R	- S M - -

No.	Common Name	Scientific Name	Status	Distributions				
120	Grey Wagtail	<i>Motacilla cinerea</i>	M	L	S	M	-	-
121	Yellow Wagtail	<i>Motacilla flava</i>	M	L	S	M	N	H
122	Plain Flowerpecker	<i>Dicaeum concolor</i>	R	L	S	M	-	-
123	Olive-backed Sunbird	<i>Nectarinia jugularis</i>	R	L	S	M	N	H
124	Oriental White-eye	<i>Zosterops palpebrosus</i>	R	L	S	M	N	-
125	House Sparrow	<i>Passer domesticus</i>	I	L	S	M	N	H
126	White-rumped Munia	<i>Lonchura striata</i>	R	-	S	M	N	-

Abbreviations: **R**-Resident; **I**-Introduced; **M**-Migrant; **?**-Not known; **L**-Little Andaman;
S-South Andaman; **M**-Middle Andaman; **N**- North Andaman; **H**- Ritchie's Archipelago.