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Ecological Study of Bird Hazards at Airport in Andaman

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Introduction

Birds cause serious hazards to the aviation safety. Since the early days of aviation, collisions of aircraft and birds have taken place, sometimes with fatal consequences. Generally, the damage increases with size and weight of the bird species involved and the aircraft's speed and impact location. Also, the behaviour of bird species influences the risks, for instance flocking or certain migration patterns and flying altitudes (Cleary, 1997; Jonkers and Spaans, 1997). Development of larger, faster and quieter aircraft, jet engines and intensification of air traffic caused an increase in the number of incidents (Project Mainport en Milieu, 1993; Klaver, 1999). Defence exercises involve flying at high speed and low altitude and are exposed to a more serious risk (Blokpoel, 1976).

Bird aircraft strikes represent a major safety hazard to pilots and passengers of both commercial and defence aircraft. In the United States, damage to aircraft from bird strikes has been estimated at over $400 million (Sodhi, 2002). Bird strikes have resulted in over 350 human deaths worldwide (Conover *et al*., 1995; Sodhi, 2002). The majority of bird strikes occur near airports, at low altitudes, and during the takeoff and landing phases of flights (Neubauer, 1990; Cleary *et al*., 1999). Defence aircraft are more susceptible to bird strikes because they often fly at low altitudes (30-300 m) and practice touch and go landings (Kuenzi and Morrison, 1998 and Sodhi, 2002). Airports near areas that attract birds, such as grasslands, water sources, waste disposal sites or agricultural areas may be particularly dangerous because of increased bird activity (Ellison *et al*., 1992; Dolbeer *et al*., 1993; Kuenzi and Morrison, 1998). Proper management techniques that reduce bird numbers in and around the airports are critical for safe airport operations, lethal control of birds to solve conflicts is often impractical (Dolbeet, 1986). Nonlethal frightening techniques to keep birds away from airports are available (Marsh *et al*., 1991), but birds quickly learn to ignore these techniques if no immediate risk to the birds is associated with the management action.

Most of these strikes involved by birds (97 per cent), although mammals (2 per cent) and other types of wild animals were also struck (Cleary *et al*., 2002). Bird strikes on aircraft are always possible as both occasionally fly in the same airspace. The degree of danger is proportional to the flight frequency of aircraft and bird density. In addition, migratory flocks, greater bird concentrations occur at lower altitudes, and therefore commercial aircraft mostly encounter birds near airfields while landing or taking off and rarely when cruising. Defence aircraft on the other hand, often fly at low altitude throughout their flight regime and may strike birds on or away from airfields. The bird strikes to commercial aircraft have been shown to decrease with increasing altitude (Fowler, 1967). The growth of bird populations and aviation is unquestionable. It is to be anticipated that conflict between aircraft and birds will increase. Therefore, effective mitigation to ensure the highest level of safety must be implemented (Eschenfelder, 2005). Adequate training and the use of appropriate aircraft operating techniques, play a significant role in reducing the risk of accidents due to bird strikes.

Avifaunal studies in Andaman and Nicobar Islands

Andaman and Nicobar Islands constitute a globally important biodiversity hotspot. Due to isolation from the mainland, the endemism is very high in all taxa including avifauna (Rao *et al*., 1980; Das, 1999a, 1999b and Andrews, 2001). This archipelago is one of the Endemic Bird Areas and nineteen sites are identified as Important Bird Areas and twenty eight species are considered endemic to these islands (Stattersfield *et al.,* 1998). Avifaunal explorations in Andaman and Nicobar Islands was started by many British researchers during

the middle of 19th century (Blyth, 1845, 1846, 1863 and 1866) followed by Beavan (1867), Hume (1873, 1874a, 1874b, 1876), Butler (1899a, 1899b, 1899c, 1900). Later, Bombay Natural History Society, conducted several surveys on the avifauna of Andaman and Nicobar Islands (Abduali, 1964, 1965, 1967, 1971, 1976, 1979, and 1981). Zoological Survey of India also carried out many surveys (Das, 1971; Tikader, 1984; Mukherjee and Dasgupta, 1975; Dasgupta, 1976; Saha and Dasgupta, 1980; Mukherjee, 1981; Chandra and Rajan, 1996; Sivaperuman *et al*., 2010, Sivaperuman, 2011a,b,c; 2012 and Sivaperuman and Venkataraman 2012). The Pondicherry University conducted few surveys on bird communities on various islands of Andaman (Davidar *et al*., 1996, 2001, 2002, and 2010) and Pandey *et al*. (2007) carried out an avifaunal survey in Andaman and Nicobar Islands.

Recently few researchers have been studied the population of ecology of particular species *e.g.* Distribution, geographical variation and migration of Sparrow-hawks of Andaman Islands and described three species by Mees, (1980). Ecological studies on the Narcondam Hornbill (*Rhyticeros narcondami*) has been carried out and enlightened certain feeding and breeding aspects by Hussain (1984); Yahya and Zarri (2003). Detailed study on the aspects of population ecology and conservation of Andaman Teal carried out by Vijayan (1996 and 2006). Sankaran (1998a) provided an annotated checklist of the endemic avifauna of the Nicobar Islands. The foraging ecology of Andaman Crake was examined by Ezhilarasi and Vijayan (2010). Population status, conservation and breeding biology of the Nicobar Megapode *Megapodius nicobariensis* carried out by Sankaran (1995a, b) and Sivakumar (2000). Sankaran (1998b and 2001) assessed the impact of nest collection on the Edible-nest Swiftlet *Collocalia fuciphaga* in the Andaman & Nicobar Islands. The objectives of the studies are to document the status, distribution and abundance of avifauna in the airport campus and 10 km radius from arerodrome; study the community composition in different season and year; study the habitat relationship of avian communities and provide suitable control measures.

Methods

Bird Census

Regular census of birds was conducted in the airport campus and outside the airport (10 km radius from aerodrome) in South Andaman. The counting of birds was concentrated at different locations in the airport and other study plots in south Andaman. The bird population was estimated by total count method (Hoves and Bakewell, 1989), Line Transect & Point Count method (Burnharm *et al*., 1980). In this method, birds were counted using telescope (15x - 45x). Birds were identified based on physical features with the help of field guides and reference books (Ali and Ripley, 1983; Tikader, 1984; Grimmett *et al*., 1998).

Species richness and abundance

Species richness and abundance of birds in every month in the study area were calculated from the census data and field observations. Species richness indices like Margalef Index (R1) and Menhinick Index (R2) were calculated using the formula given by Magurran (1988).

Species diversity indices

Shannon-Weiner (H') and Simpson's (λ) were calculated using the computer program SPDIVERS.BAS developed by Ludwig and Reynolds (1988).

Distribution models

Species-abundance model was constructed as explained in Magurran (1988). Species of birds were ranked in order of abundance, as represented by individuals seen for each species and this was plotted in decreasing order for all species against the number of individuals for the whole area. Truncated lognormal distribution was fitted to species-abundance data, using maximum likelihood estimation (Slocomb *et al*., 1977).

Dominance Index

The dominance of the each bird species in the study area was calculated using the dominance index.

Physical and chemical parameters of atmosphere

Atmospheric temperature was measured with conventional mercury and glass graduated centigrade thermometer and Relative humidity was measured directly using hygrometer.

Physical and chemical parameters of water

Surface water temperature was measured with conventional mercury and glass graduated centigrade thermometer and the water depth was measured by using a graduated nylon rope tied with a weight of 1 kg at its one end lowered down till touches the bottom. The following chemical variables were analysed to assess the changes in the water quality over the years namely, Salinity, pH, Dissolved oxygen, Nitrite, Nitrate, Inorganic phosphate, and Silicate. The samples were collected fortnightly interval randomly.

Study area and survey details

The study was conducted in Port Blair Airport campus and 10 km radius from the aerodrome in South Andaman. The following areas were surveyed to assess the avifauna intensively namely, Sippighat, Chouldhari, Stewartgunj, Ograbraj, Shoal Bay and Chidiyatappu. Summary of the field survey in different locations are provided in the Table 1.

Table. 1. Summary of the field survey

Details of the survey	Number of Survey
Survey for bird census in Airport campus	35
Survey for bird census in South Andaman (10 km radius from Aerodrome)	93
Survey for nocturnal birds	10
Survey for vegetation analysis	2
Survey for nocturnal insects	2
Aerial survey	3
Survey for benthic and macro fauna	12

Results And Discussion

Occurrence of species

One hundred and sixty four species of birds were recorded during the period of the study. These belong to 51 Families under 19 Orders (Sivaperuman, 2014). Of the 164 species, 126 were resident and 38 migrants. The species like Lesser Whistling Teal, Common Moorhen, Andaman Teal, Purple Moorhen, Lesser Sand Plover, Large Egret and Common Myna were the most common and abundant species in the study area.

Trans-continental migratory species

Thirty seven species of Trans continental migratory species were recorded (Table 2). Of these, Pacific Golden Plover, Lesser Sand Plover, Eurasian Curlew, Common Sandpiper and Wood Sandpiper were most commonly observed in the study area.

Table. 2. Trans-continental migratory species of birds recorded from the South Andaman

Common Name	Scientific Name
Eurasian Wigeon	*Anas Penelope* Linnaeus
Garganey	*Anas querquedula* Linnaeus
Chinese Sparrowhawk	*Accipiter soloensis* (Horsfield)
Pheasant-tailed Jacana	*Hydrophasianus chirurgus* (Scopoli)
Pacific Golden -Plover	*Pluvialis fulva* (Gmelin)
Grey Plover	*Pluvialis squatarola* (Linnaeus)
Greater Sand Plover	*Charadrius leschenaultii* (Lesson)
Grey-headed Lapwing	*Vanellus cinereus* (Linnaeus)
Pintail Snipe	*Gallinago stenura* (Bonaparte)
Black-tailed Godwit	*Limosa limosa* (Linnaeus)
Bar-tailed Godwit	*Limosa lapponica* (Linnaeus)
Whimbrel	*Numenius phaeopus* (Linnaeus)
Eurasian Curlew	*Numenius arquata* (Linnaeus)
Common Redshank	*Tringa totanus* (Linnaeus)
Marsh Sandpiper	*Tringa stagnatilis* (Bechstein)
Common Greenshank	*Tringa nebularia* (Gunner)
Green Sandpiper	*Tringa ochropus* Linnaeus
Wood Sandpiper	*Tringa glareola* (Linnaeus)
Terek Sandpiper	*Xenus cinereus* (Guldenstadt)
Common Sandpiper	*Actitis hypoleucos* Linnaeus
Ruddy Turnstone	*Arenaria interpres* (Linnaeus)
Great Knot	*Calidris tenuirostris* (Horsfield)
Little Stint	*Calidris minuta* (Leisler)
Rufous-necked Stint	*Calidris ruficollis* (Pallas)
Long-toed Stint	*Calidris subminuta* (Middendorff)
Curlew Sandpiper	*Calidris ferruginea* (Pontoppidan)
Broad-billed Sandpiper	*Limicola falcinellus* (Pontoppidan)
Oriental Pratincole	*Glareola pranticola* (Linnaeus)
Little Tern	*Sterna albifrons* (Pallas)
Lesser-crested Tern	*Sterna bengalensis* Lesson
White-Winged Black Tern	*Chlidonias leucopterus* (Temminck)
Grey Wagtail	*Motacilla cinerea* Tunstall
Blyth's Pipit	*Anthus godlewskii* (Taczanowski)
Brown Shrike	*Lanius cristatus* Linnaeus
Orange-headed Thrush	*Zoothera citrina* (Latham)
Dusky Warbler	*Phylloscopus fuscatus* (Blyth)
Red-throated Flycatcher	*Ficedula parva* (Bechstein)

Waders

Waders constitute an important group of wetland species. These birds depend heavily on shallow waters and mud flats, normally recorded from September onwards in the study area. The highest number of species of waders was recorded from Garacharma (29) followed by Sippighat (25), Chouldhari, Stewartgunj & Ograbraj (23), Airport (17), Chidiyatappu (10) and Shoal Bay (9). Among the recorded species, Greater Sand Plover and Common Sandpipers were recorded from all the study sites (Sivaperuman, 2014).

Order wise classification and feeding guild composition

Order wise classification of avian species observed during the period of study is given in Table 3. The Order Passeriformes had the highest number of species (53) followed by Charadriiformes (33), Ciconiiformes (13), Falconiformes & Coraciformes (12). Feeding guild analysis showed that majority of species were Omnivores (51) followed by Carnivores (47) and Insectivores (40) (Table 3).

Table. 3. Order wise classification and feeding guild composition of bird species

Sl. No.	Order	Status			Feeding Guilds						
		R	M	TOTAL	A	I	G	N/F	C	F	O
	Ciconiiformes	13	-	13	-	-	-	-	13	-	-
	Anseriformes	3	2	5	5	-	-	-	-	-	-
	Falconiformes	11	1	12	-	-	-	-	12	-	-
	Galliformes	1	-	1	-	-	-	-	-	-	1
	Gruiformes	8	-	8	-	-	-	-	-	-	8
	Charadriiformes	6	27	33	-	1	-	-	3	-	29
	Columbiformes	7	-	7	-	-	-	-	-	6	1
	Psittaciformes	4	-	4	-	-	-	-	-	4	-
	Cuculiformes	6	-	6	-	-	-	-	6	-	-
	Strigiformes	4	-	4	-	-	-	-	4	-	-
	Apodiformes	3	-	3	-	3	-	-	-	-	-
	Coraciformes	12	-	12	-	4	-	-	8	-	-
	Piciformes	2	-	2	-	2	-	-	-	-	-
	Passeriformes	45	7	53	-	30	3	3	1	1	15
	Total	**125**	**38**	**163**	**5**	**40**	**3**	**3**	**47**	**11**	**51**

R = Resident, M = Migrant; A = Aquatic feeders, I = Insectivores, G = Granivores, N/F = Nectar-Frugivores, C = Carnivores, F = Frugivores, O = Omnivores

Endemic and globally threatened species

Out of the 20 species of birds, which are endemic to Andaman Islands (Jathar and Rahmani, 2006), 18 species were recorded during the study period. According to BirdLife International (2001), one hundred and twenty nine threatened bird species occur in India, of these nine species were recorded in this survey (Table 4).

Table. 4. Comparison of bird species with different country/region in Southeast Asia

Country / region	Number of species	Number of Endemic	Number of Globally Threatened species	Number of Introduced species
Myanmar	1079	5	51	2
Loas	706	1	27	2
Vietnam	856	19	43	3
Cambodia	554	2	26	1
Thailand	1011	1	53	1
Malaysian Borneo	555	6	24	2
Malay Peninsula	685	2	34	4
Brunei	456	-	25	1
Singapore	390	-	16	17
Philippines	638	206	69	5
Mindanao	286	35	24	-
Indonesia	1663	421	123	6
Greater Sundas	1020	153	73	3
Sumatra	718	29	39	4
Kalimantan	540	1	27	1
Java and Bali	539	32	23	2
Sulawesi	477	102	25	2
Lesser Sunda	563	82	25	2
Maluku Islands	642	89	30	7
Irian Jaya	697	18	23	2
Andaman & Nico-bar Islands	284	28	15	4
South Andaman	164	18	09	05

Species-abundance relations of avifauna in airport campus

Species richness and abundance

Species richness of birds varied in different months and the highest of 39 species was recorded during January 2014 and the lowest of 15 during April 2013 (Fig. 1). Species richness increased during the migratory season and decreased during the southwest monsoon. The highest number of birds (653) was recorded during February 2014 and the lowest (122) during July 2013 (Fig. 1). As in the case of species richness, total number of birds was also low during the southwest monsoon.

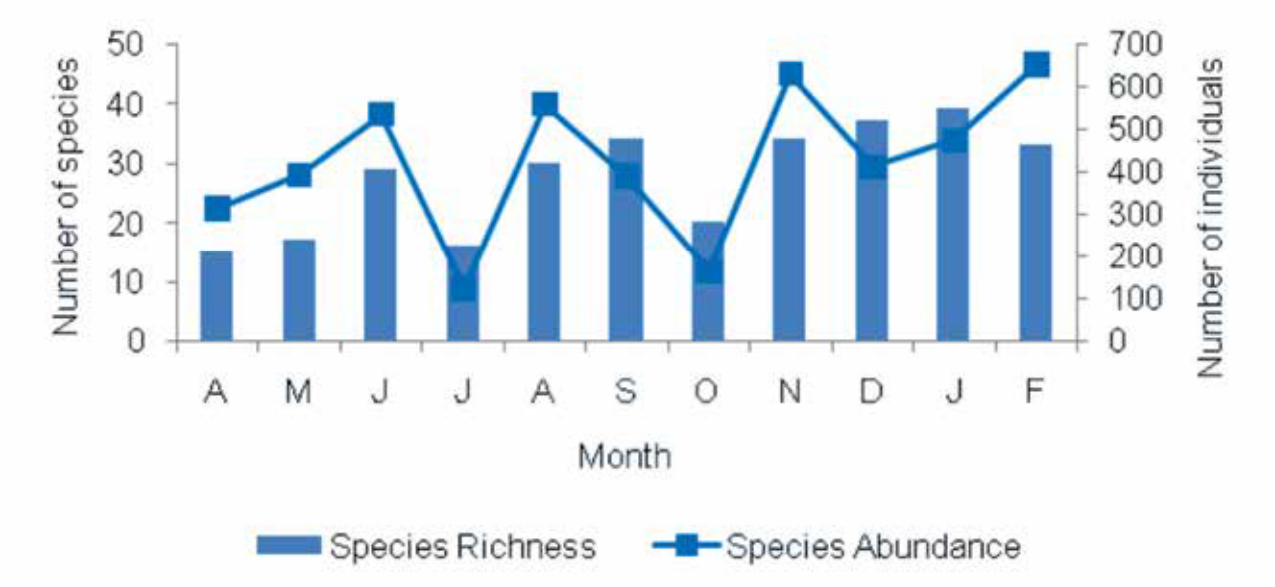

Fig. 1. Species richness and abundance of birds in the airport campus in different months (April 2013 - February 2014)

Diversity indices

Indices based on the proportional abundance of species are the best approach to measure diversity. Most widely used diversity indices like Shannon Index of diversity, Simpson's Index of diversity, Margaleff, Mackintozh and Alpha diversity have been determined. During the period of study, the highest diversity index (H') was recorded in the month of December 2013 (1.56), September 2013 (1.53) and the lowest H' value (1.18) was in July 2013 (Table 5). Similarly, other indices also varied in different months.

Table. 5. Diversity indices for different months in the airport campus (April 2013 - February 2014)

	Diversity Indices				
	Shannon	**Simpson**	**Margaleff**	**Mackintosh**	**Alpha**
April 2013	1.18	0.18	14.03	1.20	0.29
May 2013	1.20	0.14	13.49	1.20	3.35
June 2013	1.45	0.11	12.83	1.20	6.29
July 2013	1.20	0.10	16.78	1.19	4.93
August 2013	1.48	0.09	12.74	1.20	6.79
September 2013	1.53	0.09	13.51	1.20	8.96
October 2013	1.30	0.13	15.80	1.19	5.98
November 2013	1.52	0.13	12.50	1.20	7.41
December 2013	1.56	0.10	13.39	1.20	9.50
January 2014	1.26	0.24	14.36	1.20	4.32
February 2014	1.52	0.11	12.43	1.20	7.34

Dominance index of birds

Out of seventy species of birds were recorded from the airport campus, the Common Myna was showed highest in dominance (15.59), followed by White-bellied Swiftlet, Red-whiskered Bulbul and Spotted Munia. Twenty six species showed less than 1 per cent dominance (Table 6).

Table. 6. Dominance index of birds recorded from Airport Campus (n = 11)

Common Name	Dominance Index	Sighting frequency
Common Myna	15.59	244
White-bellied Swiftlet	9.59	150
Red-whiskered Bulbul	9.20	192
Spotted Munia	7.83	54
Jungle Crow	5.74	69
Pacific Golden-Plover	5.67	46
House Sparrow	5.36	55
Red-breasted Parakeet	4.43	16
Common Hill Myna	4.41	112
Red Collared-Dove	4.30	40
White-rumped Munia	3.02	1
Lesser Whistling-Duck	2.12	14
Richard's Pipit	2.05	3
White-breasted Waterhen	1.96	27
Common Moorhen	1.64	12
Andaman Crow pheasant	1.53	62
Indian Hanging-Parrot	1.46	16
House Crow	1.26	28
House Swallow	0.95	9
Brown Shrike	0.95	21
Common Swallow	0.92	38
Alexandrine Parakeet	0.90	8
Brown-backed Needletail -Swif	0.83	3
Watercock	0.68	16
White-breasted Kingfisher	0.65	23
Lesser Sand Plover	0.63	1
Red Collared-Dove	0.56	1
Yellow Wagtail	0.56	9
Blue Rock Pigeon	0.50	13
Red-Cheeked Parakeet	0.47	8
Olive-backed Sunbird	0.45	1
Red Collared-Dove	0.36	11
Common Sandpiper	0.25	7

Grey Wagtail	0.23	8
Blue-tailed Bee-eater	0.23	3
Grey-headed Lapwing	0.20	4
Pintail Snipe	0.20	2
House Swallow	0.18	6
Little Ringed Plover	0.16	4
Oriental Magpie-Robin	0.14	3
Wood Sandpiper	0.14	4
Asian Koel	0.14	5
Black Baza	0.11	1
Grey Plover	0.11	1
White-bellied Sea-Eagle	0.11	1
Indian Pond-Heron	0.11	5
Little Egret	0.09	4
Small Minivet	0.09	3
Purple Moorhen	0.09	3
White Blacked Munia	0.09	1
Wire-tailed Swallow	0.07	2
Black Drongo	0.07	2
Chestnut Bittern	0.07	3
Crow-billed Drongo	0.05	2
Indian Cuckoo	0.05	2
Large Egret	0.05	2
Oriental Pratincole	0.05	2
Collared Kingfisher	0.05	2
Asian Fairy-Bluebird	0.05	2
Black Kite	0.05	1
Blue-eared Kingfisher	0.02	1
Cattle Egret	0.02	1
Common Redshank	0.02	1
Eurasian Golden Oriole	0.02	1
Greater Racket-tailed Drongo	0.02	1
Little Egret	0.02	1
Oriental Great-Reed Warbler	0.02	1
Ruddy -breasted Crake	0.02	1
Blue-breasted Rail	0.02	1
White Wagtail	0.02	1

Species distribution model

Another way of describing diversity in a community is through species-abundance or distribution model introduced by Fisher *et al*. (1943). A species-abundance model utilises all information gathered in a community and is the most complete mathematical description of the data (Magurran, 1988). The data analysis showed that the truncated lognormal model is fitting to the bird community at the Airport Campus. The distribution model indicates the absence of a single dominant species or group of species and the presence of long series of very rare species at airport campus. The species, which is represented by less than 2 individuals, can be called as rare. The observed and expected number of species was compared using the χ^2 goodness of fit test. The test showed that there is no significant difference between the observed and expected distribution (χ^2 = 3.39; P = 0.8). Table 7 indicate that the bird community is following the truncated lognormal distribution pattern.

Table. 7. Truncated lognormal distribution at Airport Campus (χ^2 test)

Class	Upper boundary	Observed	Expected	χ^2
1	2.5	19	18.26	0.62
2	4.5	7	7.06	0.45
3	8.5	9	7.62	0.58
4	16.5	6	7.83	0.19
5	32.5	8	7.76	0.47
6	64.5	6	7.37	0.23
7	128.5	6	6.53	0.31
8	256.5	7	5.1	0.61
9	512.5	4	3.85	0.44
	Total	**72**	**71.38**	**3.39**

Height wise distribution of birds in Airport campus

Highest number of individuals recorded from 0-5 m level (2836), followed by 6-10 m level (509) and lowest from 41-45 m level (Table 8).

Table. 8. Height wise distribution of birds in the Airport Campus (n = 11)

Height(m)	No. of individuals	Abundance Index
0-5	2836	63.89
6-10	509	11.47
11-15	238	5.36
16-20	275	6.20
21-25	142	3.20
25-30	140	3.15
31-35	22	0.50
36-40	42	0.95
41-45	2	0.05
46-50	171	3.85
>51	62	1.40

Species abundance relations in South Andaman (10 km Radius from aerodrome) Diversity indices in different months

The diversity indices varied in different months, the detailed diversity indices observed during the study period is presented in the Table 9.

Table. 9. Diversity indices of bird communities in different months at various locations (April 2013 - February 2014)

Location	Diversity Indices				
	Shannon	Simpson	Margaleff	Mackintosh	Alpha
	April 2013				
Chouldhari	1.204	0.459	25.129	1.039	2.951
Ograbraj	1.342	0.404	23.018	1.029	3.822
Sippighat	1.519	0.345	19.311	1.014	4.791
Stewartgunj	1.176	0.146	34.148	1.09	4.527
Chidiyatapu	1.519	0.061	31.448	1.073	11.816
Shoalbay	1.322	0.085	35.9	1.1	8.343
	May 2013				
Chouldhari	1.342	0.291	24.72	1.036	4.259
Ograbraj	1.204	0.35	26.599	1.045	3.21
Sippighat	1.568	0.196	21.504	1.022	6.449
Stewartgunj	1.38	0.154	25.326	1.039	4.935
Chidiyatapu	1.602	0.055	27.414	1.049	11.185
Shoalbay	1.477	0.055	31.869	1.073	10.598
	June 2013				
Chouldhari	1.38	0.249	29.339	1.059	6.426
Ograbraj	1.362	0.294	31.832	1.072	7.174
Sippighat	1.602	0.091	26.054	1.042	10.035
Stewartgunj	1.322	0.106	35.656	1.091	8.197
Chidiyatapu	1.38	0.167	31.415	1.069	7.405
Shoalbay	1.602	0.062	26.599	1.044	10.477
	July 2013				
Chouldhari	1.204	0.148	34.713	1.086	5.13
Ograbraj	1.114	0.092	44.624	1.13	6.827
Sippighat	1.415	0.134	28.251	1.052	6.647
Stewartgunj	1.176	0.117	40.262	1.111	6.558
Chidiyatapu	1.38	0.117	34.031	1.081	8.939
Shoalbay	1.477	0.067	33.973	1.08	12.639
	August 2013				
Chouldhari	1.279	0.141	33.64	1.078	6.15
Ograbraj	1.38	0.079	32.715	1.074	8.115
Sippighat	1.58	0.109	24.569	1.034	8.376

Stewartgunj	1.322	0.105	35.983	1.089	8.394
Chidiyatapu	1.732	0.068	27.963	1.05	17.946
Shoalbay	1.462	0.052	37.202	1.094	16.169
	September 2013				
Chouldhari	1.716	0.143	25.152	1.037	13.207
Ograbraj	0.778	0.286	60.369	1.138	3.706
Sippighat	1.602	0.14	24.923	1.036	9.191
Stewartgunj	1.491	0.048	34.78	1.082	14.357
Chidiyatapu	1.826	0.052	25.471	1.038	19.172
Shoalbay	1.415	0.045	38.745	1.098	15.38
	October 2013				
Chouldhari	1.279	0.141	33.64	1.076	6.15
Ograbraj	1.255	0.158	33.278	1.074	5.563
Sippighat	1.556	0.104	28.515	1.052	10.561
Stewartgunj	1.204	0.076	42.231	1.108	8.402
Chidiyatapu	1.724	0.036	30.467	1.061	22.543
Shoalbay	1.431	0.098	36.422	1.087	13.183
	November 2013				
Chouldhari	1.653	0.104	25.835	1.039	11.533
Ograbraj	1.58	0.089	28.781	1.053	11.644
Sippighat	1.613	0.265	24.025	1.031	8.853
Stewartgunj	1.633	0.078	30.16	1.059	15.737
Chidiyatapu	1.806	0.034	28.191	1.05	23.659
Shoalbay	1.613	0.065	29.441	1.055	13.732
	December 2013				
Chouldhari	1.663	0.071	26.498	1.042	12.553
Ograbraj	1.732	0.07	25.835	1.039	14.747
Sippighat	1.748	0.294	20.415	1.018	9.779
Stewartgunj	1.491	0.161	30.21	1.058	9.765
Chidiyatapu	1.748	0.044	28.133	1.049	19.239
Shoalbay	1.663	0.12	30.26	1.058	17.622
	January 2013				
Chouldhari	1.568	0.061	27.23	1.045	9.91
Ograbraj	1.732	0.488	21.956	1.023	10.599
Sippighat	1.69	0.384	19.138	1.014	7.524
Stewartgunj	1.362	0.096	34.78	1.075	8.855
Chidiyatapu	1.623	0.057	33.035	1.069	20.233
Shoalbay	1.748	0.029	31.448	1.062	27.747
	February 2013				
Chouldhari	1.681	0.073	25.388	1.037	12.112
Ograbraj	1.813	0.671	18.467	1.012	9.931

Sippighat	1.845	0.178	21.059	1.02	13.55
Stewartgunj	1.556	0.192	25.777	1.038	8.553
Chidiyatapu	1.505	0.071	34.392	1.072	14.604
Shoalbay	1.653	0.038	29.807	1.055	16.31

Dominance index of birds

Of the recorded species, Lesser Whistling Teal (27.83), Common Moorhen (21.92), Andaman Teal (16.27), Purple Moorhen (3.58) and Lesser Sand Plover (2.84) were showed high in dominance. Seventeen species showed less than 0.01 per cent dominance (Table 10)

Table. 10. Overall species abundance in South Andaman (n = 11)

Name of the species	Dominance Index	Frequency
Lesser Whistling Teal	27.83	454
Common Moorhen	21.92	401
Andaman Teal	16.27	137
Purple Moorhen	3.58	315
Lesser Sand Plover	2.84	143
Large Egret	2.07	253
Inter-mediate Egret	1.42	237
Common Myna	1.40	227
Common Redshank	1.26	128
Pacific Golden-Plover	1.22	137
Red-whiskered Bulbul	1.22	218
Little Egret	0.96	185
White-breasted Kingfisher	0.88	369
Red Collared-Dove	0.82	85
Cotton Teal	0.72	59
White bellied Swiftlet	0.67	91
Red Collared-Dove	0.64	60
Cattle Egret	0.62	65
White-rumped Munia	0.61	43
Green Imperial Pigeon	0.45	34
Curlew Sandpiper	0.45	19
Whimbrel	0.45	76
White-headed Starling	0.42	57
White-bellied Sea-Eagle	0.40	160
Common Sandpiper	0.37	156
Common Hill Myna	0.34	85
Stork-billed Kingfisher	0.34	160

Little Stint	0.34	11
Asian Glossy Starling	0.31	33
Brown Shrike	0.29	102
Little Green Heron	0.29	129
Small Minivet	0.28	38
Red-Cheeked Parakeet	0.27	30
Wood Sandpiper	0.25	56
Oriental Magpie-Robin	0.25	100
House Swallow	0.24	69
Yellow Bittern	0.24	91
Red-Cheeked Parakeet	0.24	22
Yellow Wagtail	0.23	64
Olive-backed Sunbird	0.23	76
Jungle Crow	0.23	73
Common Swallow	0.22	55
Collared Kingfisher	0.21	73
Pintail Snipe	0.19	40
Greater Racket-tailed Drongo	0.19	72
House Sparrow	0.18	30
Chestnut-headed Bee-eater	0.18	41
Andaman Treepie	0.16	27
Eurasian Curlew	0.16	34
Scarlet Minivet	0.15	36
Long-toed Stint	0.15	15
Oriental Magpie-Robin	0.15	52
Indian Hanging-Parrot	0.13	42
Grey Plover	0.13	31
House Swallow	0.12	30
Andaman Drongo	0.12	37
Blue-tailed Bee-eater	0.12	34
Indian Pond-Heron	0.12	50
Black-naped Oriole	0.11	48
Emerald Dove	0.11	31
Watercock	0.11	34
Black Drongo	0.10	38
Pheasant-tailed Jacana	0.10	43
Eurasian Wigeon	0.10	11
Common Greenshank	0.10	25
Andaman Coucal	0.09	44
Fulvous-breasted Pied Woodpecker	0.09	32
Asian Fairy-Bluebird	0.09	27

Blue Rock Pigeon	0.09	12
Brown-backed Needletail -Swift	0.09	16
Eurasian Curlew	0.08	20
Black-naped Monarch-Flycatcher	0.08	29
Alexandrine Parakeet	0.08	10
Crow-billed Drongo	0.08	33
White-breasted Waterhen	0.07	36
White-Breasted Woodswallow	0.07	19
Chestnut Bittern	0.07	31
Greater Sand Plover	0.07	10
Little Ringed Plover	0.06	13
Common Coot	0.06	19
Blue-eared Kingfisher	0.06	30
Andaman Bulbul	0.05	21
Andaman Black Woodpecker	0.05	24
Andaman Green-Pigeon	0.05	9
Chinese Pond Heron	0.05	24
Black-naped Tern	0.05	16
Andaman Bulbul	0.05	16
Small Blue Kingfisher	0.05	23
Brahminy Kite	0.04	13
Chestnut Bittern	0.04	23
Andaman Wood-Pigeon	0.04	4
Andaman Serpent-Eagle	0.04	17
Dusky Warbler	0.04	19
Oriental White-eye	0.04	6
Asian Koel	0.03	14
Ruddy-breasted Crake	0.03	8
Black-tailed Godwit	0.03	5
Indian Great-Reed Warbler	0.03	17
Changeable Hawk-Eagle	0.03	17
Common Snipe	0.03	6
Orange-headed Thrush	0.03	17
Wire-tailed Swallow	0.03	3
House Crow	0.03	7
Andaman Serpent-Eagle	0.03	4
Oriental Pratincole	0.02	4
Eurasian Golden Oriole	0.02	13
Large Cuckoo-Shrike	0.02	8
Plain Flowerpecker	0.02	9
Swallow Shrike	0.02	11

Forest Wagtail	0.02	12
Little Tern	0.02	2
Bar-tailed Godwit	0.02	7
Blue-breasted Rail	0.02	5
Grey-headed Lapwing	0.02	9
Andaman Cuckoo-Dove	0.02	3
Plain Flowerpecker	0.01	4
Baillon's Crake	0.01	5
Marsh Sandpiper	0.01	6
Red-throated Flycatcher	0.01	5
Terek Sandpiper	0.01	5
Andaman Crake	0.01	2
Bar-bellied Cuckoo-Shrike	0.01	6
Black Bittern	0.01	5
Small Blue Kingfisher	0.01	7
Rufous-necked Stint	0.01	7
Indian Edible-nest Swiftlet	0.01	1
Oriental Dwarf Kingfisher	0.01	5
White-rumped Shama	0.01	2
Oriental Broad-billed Roller	0.01	4
Eurasian Golden Oriole	0.01	3
Asian Fairy-Bluebird	0.01	3
Garganey	0.01	5
Grey Heron	0.01	5
Pacific Reef-Egret	0.01	5
Ruddy Turnstone	0.01	3
Asian Brown Flycatcher	0.01	5
Besra Sparrowhawk	0.01	3
Black-capped Kingfisher	0.01	4
Crested Serpent-Eagle	0.01	4
Kentish Plover	0.01	3
Oriental Dwarf Kingfisher	0.01	2
Violet Cuckoo	0.01	3
Andaman Hawk-Owl	0.01	4
Common Starling	+	2
Greenish Leaf-Warbler	+	2
Mangrove Whistler	+	3
White-rumped Shama	+	2
Ashy Drongo	+	3
Ashy Minivet	+	2
Green Sandpiper	+	1

Great Knot	+	2
Ruddy Kingfisher	+	1
Ruddy Tern	+	2
Blue-breasted Rail	+	2
Wood Snipe	+	2
Beach Stone-Plover	+	1
Common Stonechat	+	1
Richard's Pipit	+	1
Rosy Pipit	+	1
Shikra	+	1

Distribution model of bird communities in South Andaman

The distribution model indicates the absence of a single dominant species or group of species and the presence of long series of very rare species at South Andaman. The bird species, which is represented by less than 2 individuals, can be called as rare. The observed and expected number of species was compared using the χ^2 goodness of fit test. The test showed that there is no significant difference between the observed and expected distribution ($\chi^2 = 5.7$; $P = 0.77$) (Table 11)

Table. 11. Truncated lognormal distribution at South Andaman (^{2} test)

Class	Upper Boundary	Observed	Expected	χ^2
1	2.5	13	35.95	0.00
2	4.5	12	13.95	0.30
3	8.5	21	15.12	0.82
4	16.5	11	15.68	0.15
5	32.5	22	15.81	0.83
6	64.5	22	15.55	0.84
7	128.5	18	14.79	0.68
8	256.5	20	13.28	0.87
9	512.5	9	10.67	0.30
10	1024.5	13	6.6	0.92
Total		**161**	**157.4**	**5.70**

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

Correlation of bird species richness in different location with environmental parameters showed that the minimum temperature and locations such as Chidiyatappu, Sippighat, Chouldhari, Ograbraj and Stewartgunj showed signicant varations (Table 12). The species abundance also showed there is a significant variation among the locations (Table 13).

Table. 12. Correlation of bird species richness with rainfall, temperature & humidity

	Pearson Correlation	Temperature (Maximum)	Temperature (Minimum)	Rainfall	Humidity
Chidiyatappu	r	-.543	-.608*	.139	.171
	P value	.084	.047	.683	.615
Sippighat	r	-.202	-.661*	-.711*	-.598
	P value	.551	.027	.014	.052
Chouldhari	r	-.434	-.865**	-.289	-.168
	P value	.182	.001	.389	.621
Ograbraj	r	-.399	-.895**	-.604*	-.450
	P value	.224	.000	.049	.165
Stewartgunj	r	-.586	-.921**	-.433	-.285
	P value	.058	.000	.184	.396
Shoalbay	r	-.109	-.555	-.550	-.448
	P value	.749	.076	.080	.167

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

Table. 13. Correlation of bird species abundance with rainfall, temperature & humidity

	Pearson Correlation	Chidiyatappu	Sippighat	Chouldhar	Ograbraj	Stewartgunj	Shoalbay
Temperature (Maximum)	r	-.136	-.144	.148	-.145	-.199	-.391
	P value	.691	.672	.664	.670	.558	.234
Temperature (Minimum)	r	-.244	-.125	.734*	-.233	.072	-.930**
	P value	.469	.714	.010	.491	.833	.000
Rainfall	r	.370	-.910**	-.110	-.659*	-.418	-.195
	P value	.263	.000	.748	.028	.200	.566
Humidity	r	.317	-.898**	-.320	-.557	-.449	-.049
	P value	.343	.000	.337	.075	.166	.887

The abundance and distribution of bird species in airport campus and 10 km radius from the aerodrome have been examined and the results of this study support that this area represents a unique and important habitat type. Of the recorded bird species, 37 were transcontinental migrants which are showed that this area is importat feeding ground for the migratory waders. Out of 20 endemic species to Andaman Islands, 18 were recorded during the study period namely, Andaman Teal *Anas albogulari,* Andaman Serpent-eagle *Spilornis elgini,* Andaman Crake *Rallina canningi,* Andaman Wood-pigeon *Columba palumboides,* Andaman Cuckoo-dove *Macropygia rufipennis,* Andaman Green-Pigeon *Treron chloroperus,* Andaman Barn-owl *Tyto deroepstorffi,* Andaman Hawk-owl *Ninox affinis,* Hume's Hawk-owl *Ninox obscura,* Andaman Scops-owl *Otus balli,* Andaman Woodpecker *Dryocopus hodgei,* Andaman Cuckooshrike *Coracina dobsoni,* Andaman Bulbul *Pycnonotus fuscoflavescens,* Andaman Shama *Copyschus albiventris,* Andaman Flowerpecker *Dicaeum virescens,* Andaman White-headed Starling *Sturnia erythropygia,* Andaman Drongo *Dicrurus andamanensis* and Andaman Treepie *Dendrocitta bayleyi*.

During this study period, bird species were observed 7,595 times in which 60,635 birds were counted. Species richness and abundance of birds showed high values in the wetlands of south Andaman, which is comparable to other wetlands in India (Kurup, 1996; Sampath, 1989; Nagarajan and Thiyagesan, 1996; Sivaperuman and Jayson, 2009). The highest number of birds was recorded during November, December and January, which showed the influx of birds into the region due to the trans-continental migration. Wetlands of Andaman and Nicobar archipelago are situated on the *East Asian-Australasian Flyway*. The East Asian-Australasian Flyway, stretching from Siberia and Alaska, southwards through east and south-east Asia, to Australia and New Zealand. This flyway supports over seven million shorebirds, of which some 5 million are migratory. As a results of this huge numbers of migratory birds pass through this flyway during migratory season. Migration takes place during both night and day time. The increase in wetland species from September to February implies the presence of their preferred microhabitat and higher production of benthic and macro fauna.

The species richness results from the dynamic equilibrium between immigration and extinction rates, which are dependent on island isolation and area respectively (MacArthur and Wilson, 1967). The bird species richness and abundance may be influenced by factors such as the composition of plant communities, habitat type and other environmental factors (Wiens and Rottenberry, 1981). The availability of micro habitats in the study area may influence the species diversity of South Andaman. According to a study conducted by Usher (1986) among the criteria used for evaluation of conservation schemes, diversity is the most frequently adopted criteria. In this study, the agricultural landscape features, rather than macro habitat or microhabitat, were the most important and frequent predictors of bird occurrence (Saab, 1999; Freemark *et al*., 1995 and Saab, 1999).

The cover-types and vegetation associations appear to be particularly important for bird species in this region. The forest and adjacent areas provide good habitats for rich avifaunal diversity in South Andaman. The local ecological factors are important in determining diversity and abundance of birds. The different features may influence the species distribution in this archipelago *viz.,* the vegetation structure or the floristic richness observed in the temperate archipelago (Martin and Lepart, 1989 and Martin *et al*., 1995), the number of habitat types on an islands or habitat diversity, is often considered a determinant of species richness (Murphy and Wilconx, 1986). Although this study was limited in duration and geographic area, our observations of South Andaman specific bird species suggest that the increase the regional avifaunal diversity by providing abundant resources, unique microhabitats and landscape level habitat heterogeneity that attract a diversity of bird species. The result shows that South Andaman support unique avian assemblages, comprising of many rare and endemic species and therefore it could be considered as an important "hotspot of avian diversity" in the Andaman and Nicobar Islands. In conclusion, the community composition appeared to be determined primarily by forest type and patchiness of Islands area.

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

an intact ecosystem within which we too live (Soule and Wilcox, 1980; Wilson, 1985).

Although all birds are potential hazards to aircrfts, each species poses a different level of risk. Habitat management programs are most effective when they take into account the comparative risks posed by problem species. For instance, control priorities are generally established according to the risk of collision and the impact damage potential posed by particular species. Ranking these species assists authorities in determining their wildlife control priorities and assigning resources to combat problem species. A successful habitat management plan reduces bird hazards to aircraft and minimizes maintenance problems by rendering airport property less attractive to avifauna. The safety benefits are real for all concerned such as airports, airlines, public and avifauna. The best long-term control can be achieved through appropriate habitat management. Birds are attracted to this airport for many reasons. The large, open grassland areas found on an airport provide perfect feeding, resting and nesting areas for diffetnt types of bird species. Short grass areas provide protection against predators such as snakes and raptors. Water canals and spillways on the airports provide a perfect environment for wading and shorebirds. In this airport, birds as big as a Purple Heron and as small as a White-bellied Swiftlet have been struck by aircraft, but most of the striked involved by Pacific Golden Plover during migratory season. Water Cock, Cattle Egret, Yellow Bittern, Lesser Whistling Teal and Blue Rock Pigeon are some of the other hazardous species at this airport.

Though the following diurnal raptors namely Black-crested Baza *Aviceda leuphotes*, Black Kite *Milvus migrans,* Brahminy Kite *Haliastur indus*, White-bellied Sea-Eagle *Haliaeetus leucogaster*, Greater Grey-headed Fish-Eagle *Icthyophaga icthyaetus,* Crested Serpent-Eagle *Spilornis cheela*, Andaman Serpent -Eagle *Spilornis elgini* and Changeable Hawk-Eagle *Spizaetus cirrhatus* have been observed within the airport campus, but there is no report on the attack of aircraft and also their density is very low compare with other passerines and water birds. The White-bellied Sea-Eagle maximum numbers of individuals were observed from the coastal and inland wetland habitat, but the sighting inside the airport campus were very less. All the bird species has the potential to cause major damage to the aircraft. The extent of damage to the aircraft by the small size bird species would be less and greater damage by large size birds from a single strike. There is a probability that, if large number of individuals of same species strike there will be a greater amount of damage to the aircraft. The birds observed in the airport can be classified into Small size (Swiftlet, Sparrows, etc.), Medium size (Myna, Dove, Plovers, etc.), and Large size (Teal, Pigeon, Egrets, etc.). Birds which are flying at high altitudes are also threat to the aircraft during take off and landing. The migratory shore birds which fly at high altitudes with large size flock are greatest threats *e.g.,* Plovers, Sandpipers, Curlews, Terns etc. The variety of birds on Port Blair airport is largely dependent upon the food availability and extent of foraing areas in the airfield. Bird control in the airport is required a specific type than the other bird control situations, especially bird control in agricultural crops. It is important that the air traffic contral staff should have ability to control where and when birds are dispersed. The most important requirement is the need for an airport bird control program to be effective over the long-term. In agricultural fields bird problems arise only during the ripening or harvet period. But, airports, bird hazards can be present twelve months of the year, or throughout day. The important aspect of a successful airport bird control is that, the airport should be designed for the specific problems at that airport. It is also important to understand the bird species richness and abundance in the airport premises and to determine those species which create the greatest threat to aircraft safety.

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