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Avian diversity and density estimation of birds of the Indian Institute of Forest Management Campus, Bhopal, India

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Abstract: A study to find out the bird diversity at the Indian Institute of Forest Management (IIFM), Bhopal, was carried out over a period of nine months from July 2012 to March 2013. IIFM is located on a hill facing Bhadbhada barrage in Bhopal. Physiographically the area is classified as Vindhayan Hills. A total of 106 bird species belonging to 52 families were recorded during the study covering an area of about 93 hectares. The study area was divided into three major habitat types: open scrub, dry deciduous, and urbanized. Bird species were classified into eight feeding guilds: carnivore, ground insectivore, sallying insectivore, canopy and bark insectivore, nectar insectivore, general insectivore, frugivore and water birds. Of the total 106 species observed, 27 species were recorded as winter visitors. Density analysis was done using DISTANCE software and density was found out to be 32.7 birds per hectare. Rank abundance curve was used for assessing species composition in different habitats and during different seasons. In terms of both richness and evenness, open scrub scored the highest rank (72 species, and most even distribution of species). Higher species richness with lower species evenness was recorded during winter season for all the habitats.

Keywords: Bhopal, density, avian diversity, evenness, feeding guilds, habitat, richness.

Abbreviations: AIC- Akaike information criterion; C - Carnivore; C&B - Canopy and bark insectivore; F - Frugivore; GI - General insectivore; GrI - Ground insectivore; NI - Nectar insectivore; SE - Standard error; SI - Sallying insectivore; WB - water birds.

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Author Details: Author Details: Sprih Harsh is currently working in Satpuda Maikal Landscape, Tiger Conservation Programme (WWF-India). She is looking after conservation of corridors in the landscape for providing a secure dispersal to tiger, co-predators and prey species between different tiger reserves. Anjali Aggarwal worked for Gujarat Tourism Opportunity Limited and Nature Conservation Foundation as a research affiliate in Pakke Tiger Reserve, Arunachal Pradesh on a study to understand factors affecting hornbill breeding success during the breeding season. Govind Tiwari worked with FES and involved in various development and conservation oriented projects in southern Rajasthan. He has also been involved in a study to understand the ecology of Sloth Bear in southern Rajashtan near Phulwari and Kumbhalgarh Wildlife sanctuaries.

Author Contribution: SH contributed in carrying out the study in the field and in the analysis part and played a major role in documenting and preparing the research paper. AA contributed in analysis part and the field survey. GT played a major role in carrying out this study in the field and assisted in the writing part.

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INTRODUCTION

Birds are some of the most prominent species of the Earth's biodiversity and being sensitive to environmental changes they act as key indicators for assessing the status of ecosystem health (Taper et al. 1995; Olechnowski 2009). Assessing the bird diversity of a habitat over time and space is one of the key issues for avian community ecologists. Richness, abundance and community composition are often used by ecologists to understand the diversity of species in their natural occurrence (Magurran 2004).

The bird community structure is affected by changes in vegetation structure either due to natural or any human induced disturbances (Maurer 1981; Wiens 1989; Rahayuninagsih et al. 2007). Talking about disturbances when two such disturbances occur simultaneously or in quick succession they might lead to a compound disturbance that by impacting ecological resilience and recovery (Buna & Wessman 2011; Harvey et al. 2014) may result in ecological surprises (Paine et al. 1998). Wild fire and simultaneous outbreak in insects like bark beetle can be categorized as one such disturbance. Contrary to general belief of this disturbance having a negative impact on the abundance of bird species, many studies have found that bird species were more abundant post fire when compared with burn free areas (Hutt 1999; Kotliar et al. 2002). This also leads to a change in composition of bird species by addition of certain sallying, canopy and bark insectivorous species.

The change in vegetation composition could impact the quality and quantity of habitat for birds in terms of food, water and cover which can further affect the diversity, abundance and distribution of birds (Western & Grimsdell 1979).

In order to prioritize the future conservation of species, understanding the effect of habitat on bird community structure is important (Zakaria et al. 2011). In the long run, the relative value of different habitats and conservation importance of sites can be assessed by investigating the diversity of birds present at those sites (Bensizerara et al. 2013).

Many researchers have already documented the response that avian diversity shows to different vegetation composition structure (MacArthur & MacArthur 1961), and have also demonstrated that avian diversity increases with an enhanced level of vegetation (Wiens 1969).

This study aims to investigate the bird community structure, bird diversity and density at the IIFM campus. An effort has also been made to prepare a checklist of its bird species. In this paper the bird community structure and composition in different habitats of the campus has been documented. The study also demonstrates the change in density and composition of bird species after an outbreak of fire. There are areas in the campus where human disturbances like logging, grazing are being practiced. The study will assess the differences in avian community among these areas and how are they being impacted by them.

MATERIALS AND METHODS

Study area

The study was done in the Indian Institute of Forest Management, Bhopal (23.208371^{0}N & 77.384417^{0}E), from July 2012 to March 2013. The location of the campus, built on a hill surrounded by water on three sides, along with a wide range of climatic conditions that it passes through brings in diverse structure of habitats. The major types of vegetation include grasslands, open scrub forest, dry deciduous forest and bamboo groves. The study was conducted in 12 transects covering an area of 93 hectare campus (Image 1).

For our study, transects were divided into three habitats according to general landscape attributes and vegetation present there. The chief habitat types were:

(i) Open scrub comprising mainly grasslands and scarce vegetation of *Leucaena leucocephala.*

(ii) Dry deciduous comprising grass species, *Hardwickia binata*, scrubs, *Azadirachta indica.*

(iii) Urbanized human inhabited areas like the faculty block, academic block and so on.

The details about transects and habitats into which the campus was divided is given in Table 1. These habitats are also structured by different levels of human disturbance varying from activities like logging, cattle grazing, human settlements and presence of domestic dogs.

Bird survey

The bird population was recorded using the belt transect method (Cunningham et al. 2006). During a transect walk, the observer recorded data on the sightings of bird species, number of individuals sighted and perpendicular distance from the line at which the species was sighted. Only those observations lying within 20m of either side of the transect line were recorded. The survey was conducted either during the morning time zone (between 07:00–09:00 hr) or during the evening time zone (between 16:00–18:00 hr) when

Image 1. Google image showing the transects on IIFM campus

Table 1. Details of transects and habitat types of IIFM Campus

Code	Name	Perimeter (in meters)	Area (in hectares)	No. of survey counts	Total length walked (in meters)	Habitat
DD1	Bamboo Plantation	346	0.39	14	4844	Dry Deciduous
DD2	Behind Mess	211	0.22	12	2532	
DD3	Football Field	246	0.24	12	2952	
DD4	Mess Staff Quarters	112		5	560	
DD5	Treatment Plant	426		4	1704	
OS1	Andergali	894	4.24	14	12516	Open Scrub
OS2	Andergali Grassland	520		14	7280	
OS3	Director's Residence	317	0.49	8	2536	
OS4	Grassland Wall	234	0.33	8	1872	
OS5	Waterbody	481	1.35	9	4329	
U1	Academic Block	353	0.63	10	3530	Urbanized
U2	Faculty Residence	342	1.60	12	4104	
	TOTAL	**4482**	**9.54**	**122**	**48759**	**3**

there is maximum bird activity (Cunningham et al. 2006; Simons et al. 2006).

Feeding guilds

The study of avian feeding guilds is important for understanding the complexity of ecosystem structure and for providing updated information on each type of habitat in the ecosystem (Azman et al. 2011). A feeding guild may be defined as a group of species that have similar feeding or foraging habits (Hutto 1985).

Eight feeding guilds were identified in the study area: carnivore (C), frugivore (F), canopy and bark insectivore (C&B), general insectivore (GI), ground insectivore (GrI), nectar insectivore (NI), sallying insectivore (SI) and water birds (WB).

Density estimation

The Distance sampling method was used to estimate bird density using detection probability as a function of distance (Simons et al. 2006; Somershoe et al. 2006;

Broekema & Overdyck 2012). The detection function was fitted for uniform models with cosine and simple polynomial function as well as half-normal models with cosine and hermite polynomial expansion. AIC value was further used to select the best fitting model. DISTANCE 6.0 was used to calculate density estimates. (Norvel et al. 2003).

For this study, the data was segmented on the basis of season - monsoon (from August to September), autumn (from October to November), winter (from December to 2nd week of February) and spring (from 3rd week of February to March) and on the basis of feeding guilds within different habitat types.

Bird species diversity and abundance

To assess the distribution and differences in the abundance of birds between different habitats, the rank abundance curve (Magurran 1988) was plotted to assess the structure of bird communities in different habitats using the percent of total sample for each species as its index of abundance (Simons et al. 2006). Rank abundance curves were generated for avian assemblages at each site. The diversity of site increases as the slope of curve approaches zero. Steepness of the slope defines evenness at a site; if it is less steep it means a more even distribution of species.

RESULTS

We recorded a total of 106 species of birds, in which, 10 carnivore, 21 ground insectivore, 27 general insectivore, one frugivore, four canopy and bark insectivore, three nectar insectivore, 13 sallying insectivore and 27 water birds were recorded.

Density estimate

A half normal key estimator was selected by DISTANCE as detection model. The result was found for the whole campus in terms of density of clusters, individual density and mean cluster size (Table 2).

The population density for cluster was found to be 18.64 (SE=4.49) birds per hectare while individual density was found to be 32.75 (SE=7.92) per hectare. The mean cluster size was 1.84 birds per hectare. Fig. 1 shows the detection probability distribution for the whole campus.

The population was further estimated on the basis of habitat and seasons (Tables 3, 4). In the dry deciduous habitat, which combined DD1 to DD5 transects, the population density for the cluster was found to be 36.22 (SE 11.67) birds per hectare while individual density was found to be 60.52 (SE 19.55) per hectare. The mean cluster size was 1.64 birds per hectare. In open scrub, which combined OS1 to OS5 transects, the population density for the cluster was found to be 14.52 (SE 3.88) birds per hectare while individual density was found to be 25.79 (SE 6.91) per hectare. The mean cluster size was 1.93 birds per hectare. In the urbanized habitat which combined U1 and U2 transects, the population density for the cluster was found to be 13.82 (SE 2.28) birds per hectare while individual density was found to be 26.81 (SE 4.72) per hectare. The mean cluster size was 2.15 birds per hectare. Detection probability distribution for all three habitats can be found in Appendix 2 which shows that distribution was quite similar in the dry deciduous and the open scrub habitat compared to that of the urbanized habitat.

In the autumn season the density of birds was found to be 12.65 birds per hectare while the mean cluster size was estimated to be 1.93. For the winter season the density of birds was found to be 14.93 birds per hectare with the mean cluster size as 1.82. For the monsoon season the density was estimated to be 2.54 birds per hectare with the mean cluster size of 1.63. In the spring the density was found to be 3.42 birds per hectare and the mean cluster size was found to be 1.92. Appendix 3 shows the detection probability distribution in all the four seasons in campus which indicates that the autumn and the winter have quite similar probability distribution compared to the monsoon and the spring's distribution.

Table 2. Population density of the IIFM campus

IIFM (1300)	Estimate	Percent CV	95% Confidence Interval	
DS	18.65	24.12	11.61	29.96
D	32.76	24.18	25.16	52.69
Mean cluster Size	1.84	2.35	1.76	1.93

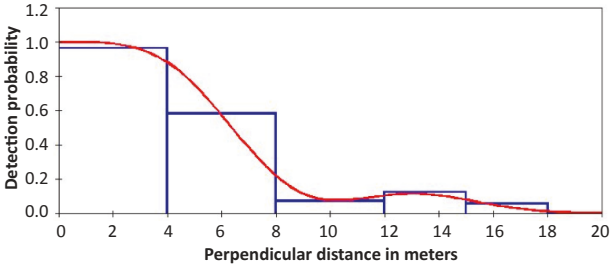

Figure 1. Detection probability distribution for IIFM campus

Table 3. Habitat wise population density of IIFM campus

Dry deciduous - 550	Estimate	Percent CV	95% confidence interval	
DS	36.22	32.22	19.42	67.57
D	60.52	32.30	32.40	113.05
Mean Cluster Size	1.64	2.99	1.55	1.75
Open scrub – 596	**Estimate**	**Percent CV**	**95% confidence interval**	
DS	14.52	26.68	8.68	24.31
D	25.79	26.82	15.37	43.28
Mean cluster size	1.93	3.71	1.80	2.09
Urbanized – 154	**Estimate**	**Percent CV**	**95% confidence interval**	
DS	13.82	16.49	4.52	42.30
D	26.81	17.57	11.46	62.74
Mean cluster size	2.149	7.11	1.87	2.48

Table 4. Season wise population density of IIFM campus

Monsoon - 243	Estimate	Percent CV	95% Confidence Interval	
DS	2.54	42.41	1.13	5.69
D	3.75	42.56	1.66	8.42
Mean Cluster Size	1.63	5.19	1.47	1.81
Autumn - 419	**Estimate**	**Percent CV**	**95% Confidence Interval**	
DS	6.90	18.03	4.74	10.06
D	12.65	18.30	8.64	18.51
Mean Cluster Size	1.93	4.13	1.78	2.10
Winter - 450	**Estimate**	**Percent CV**	**95% Confidence Interval**	
DS	8.22	25.12	4.78	14.14
D	14.93	25.29	8.57	25.43
Mean Cluster Size	1.82	3.82	1.69	1.96
Spring - 188	**Estimate**	**Percent CV**	**95% Confidence Interval**	
DS	3.42	21.88	2.13	5.49
D	5.68	22.43	3.52	9.17
Mean Cluster Size	1.92	6.86	1.67	2.20

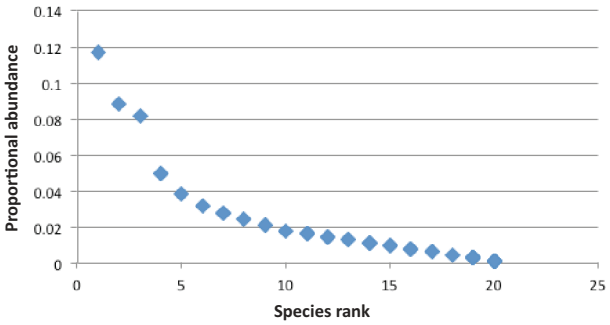

Figure 2. Bird species rank abundance in open scrub

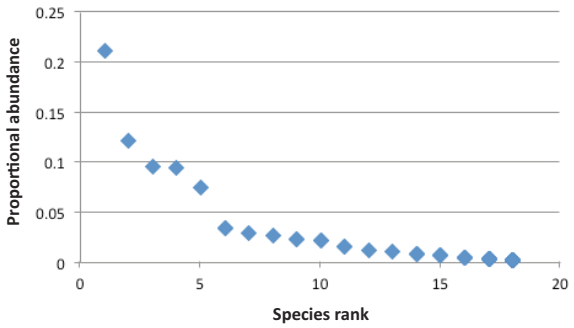

Figure 3. Bird species rank abundance in dry deciduous

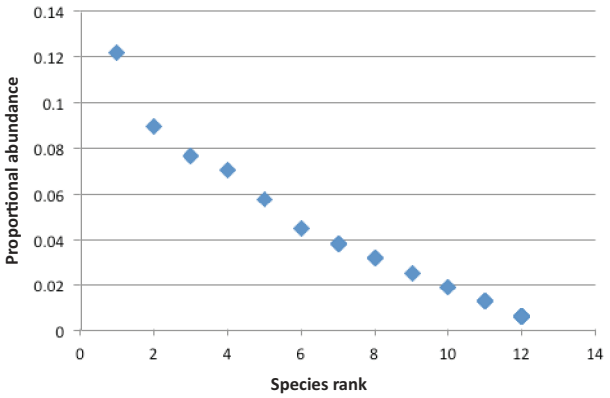

Figure 4. Bird species rank abundance in urbanized

Bird species diversity

The rank abundance curve indicates that the species diversity and composition differed in the entire habitat. The open scrub, with the highest number of individuals (596) and the highest number of species (72) ranks as the most diverse habitat as the distribution is also very even (Fig. 2). The number of individuals in the dry deciduous was 550 with 51 species while in the urbanized habitat, the number of individuals was 156 with 35 species (Figs. 3, 4).

Thirty-eight species were common to both the open scrub and the dry deciduous. Open scrub was populated with a higher number of species belonging to the carnivore and the ground insectivore guild while the dry deciduous was populated with more species in the nectar insectivore guild, with the rest remaining almost the same. In the urbanized habitat, there were no species belonging to the canopy and bark insectivore guild and relatively a very low number of individuals in other categories too (Table 5).

Table 5. Guild wise distribution of birds among different habitats in IIFM campus

Urbanized habitat		Open scrub habitat		Dry deciduous habitat	
Guild	Number of individuals	Guild	Number of individuals	Guild	Number of individuals
General insectivore	76	General insectivore	274	General insectivore	330
Canopy and bark insectivore	0	Canopy and bark insectivore	3	Canopy and bark insectivore	4
Carnivore	4	Carnivore	30	Carnivore	9
Frugivore	2	Frugivore	10	Frugivore	3
Ground insectivore	28	Ground insectivore	92	Ground insectivore	36
Nectar insectivore	18	Nectar insectivore	32	Nectar insectivore	71
Sallying insectivore	24	Sallying insectivore	94	Sallying insectivore	73
Waterbirds	2	Waterbirds	61	Waterbirds	23

Table 6. Effect of fire on density

	Estimate	Percent CV	95% Confidence interval	
Before fire	1.35	56.07	0.28352	6.5080
After fire	8.80	34.53	2.6533	29.190

Table 7. Comparative densities of fire affected and unaffected area

	Estimate	Percent CV	95% Confidence interval	
Fire affected	13.65	56.07	0.28352	6.5080
Fire unaffected	6.47	14.56	4.8511	8.6250

Density estimate during an outbreak of fire in the open scrub habitat

Before the fire took place, the density of birds was found to be 1.35 birds per hectare while after this event the density increased to 8.80 birds per hectare (Table 6).

Table 7 shows the density of birds in the fire affected area and in the area unaffected by fire one month after the outbreak of fire. Fire affected area had density of 13.65 birds per hectare while fire unaffected area had density of 6.47 birds per hectare (Table 7).

DISCUSSION

The present study produced a reliable estimate of birds through direct observations on line transects that were repeatedly walked for over a considerable period of time (Anderson 1983; Kumara 2012; Laure 2007).

The campus has a rich variety of strata and guilds owing to its topography and different habitats like water bodies, open scrub area, dry deciduous area and areas of human settlement, which enhanced the diversity of birds.

In terms of bird community structure, it was largely similar in the open scrub and the dry deciduous habitats as compared to that of the urbanized habitat. The open scrub and the dry deciduous shared 38 common species. There were more numbers of ground insectivore in the open scrub than in the dry deciduous. This high number of species was attributed to the forest fire (Raphael et al. 1987; Adeney et al. 2006; Martin et. al 2006) that took place in October, 2012 in the open scrub. It also affected the diversity of the grassland in terms of a reduction in sightings of nightjars and the addition of a whole new feeding guild of ground insectivores. This was the direct result of an increase in the number of insects after the fire (Russell et al. 2009) which led to the arrival of birds like larks—Ashy Crowned Sparrow Lark *Eremopterix griseus*, Rufous-tailed Lark *Ammomanes phoenicura*, Oriental Sylark *Alauda gulgula*, Skykes's Lark *Galerida deva*, Indian Bushlark *Mirafra erythroptera* in groups of 10–20, Common Hoopoe *Upupa epops*, and Pipits—Paddyfield Pipit *Anthus rufulus*, Tree Pipit *Anthus trivialis*. The analysis of the data of one month before and one month after the fire showed an increase in density by 6.51 times after the fire took place.

To account for changes in the density due to seasonal variations, the after fire density of two adjacent transects, i.e., one affected by the fire and one not affected by the fire was carried out. Both of these transects were in the grassland area. The data taken into consideration was for the duration of one month after the fire.

The bird density in the fire affected area was 2.11 times greater than the unaffected area for the same duration for the same habitat.

Habitat to a large extent determined the species composition (Fig. 5). Out of the three studied habitats,

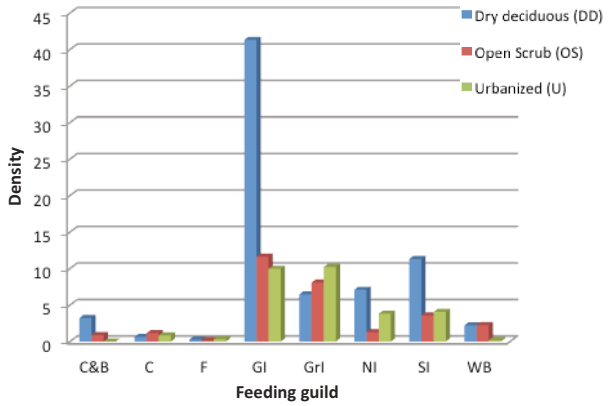

Figure 5. Habitat-wise distribution of bird density for different feeding guilds

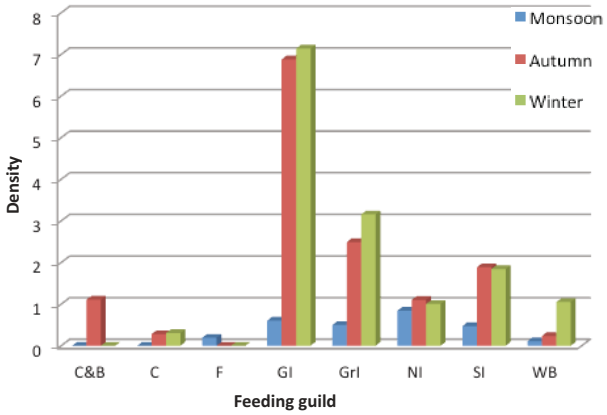

Figure 6. Season-wise distribution—in terms of density—for different feeding guilds

the dry deciduous habitat was found to have a maximum density of canopy and bark insectivores. This can be attributed to the presence of suitable tree species in the habitat apart from its close proximity to an agricultural area (Abdar 2014).

The presence of canopy and bark insectivores can also be favored by the presence of appropriate vegetation cover with trees having appropriate dimensions for different activities of these species (Rajpar & Zakaria 2011).

The urbanized habitat showed the highest density of ground insectivores due to the abundant presence of Jungle Babblers *Turdoides striata* in the academic block and faculty residence transects, which can be attributed to the presence of tree species providing appropriate fruit and seed to the species. Black Drongo *Dicrurus macrocercus*, Ashy Prinia *Prinia socialis* were seen in all the transects and the habitat types. Red-vented Bulbul *Pycnonotus cafer*, Jungle Babbler *Turdoides striata* were seen all over the major habitat types except the grassland area. Their presence all over the campus can be explained on the basis of their generalist nature and good adaptation capability to any environment and even to human settlements (Sharat et al. 2011).

The water birds were mostly recorded from the open scrub habitat due to the presence of the Bhadbhada barrage surrounding the grassland area of IIFM.

The differences in bird community structure among the habitats can also be explained by the different levels of human disturbances experienced by these habitats. Among the three habitats, the urbanized area experienced the highest level of disturbance mostly due to the location of this habitat. Between the open scrub and the dry deciduous, the latter was more disturbed due to the high level of logging and cattle grazing (Gregory et al. 2010). Logging can change forest structure in terms of an increase in gap areas and a decrease in cover (Johns 1985). Birds are generally the first group of vertebrates to respond to any logging (Johns 1988). Many studies have reported changes in species diversity with higher species richness in less disturbed forests as compared to disturbed forests (Johns 1985, 1991; Thiollay 1992; Riffell et al. 1996; Marsden 1997). This also supports the result that we obtained in our study in terms of different bird community structure.

Barring a few exceptions, the maximum feeding guild density was observed in the winter season (Fig. 6). The canopy and bark insectivores were found to be at a maximum in the autumn season.

The frequency at which Rose-ringed Parakeet *Psittacula krameri* was seen was the greatest in the Monsoon season which gradually reduced towards the winter season. During the winter season species like Common Kestrel *Falco tinnunculus* and Harrier spp. Eurasian Marsh Harrier *Circus aeruginosus*, Montagu's Harrier *Circus pygargus*, Pallid Harrier *Circus macrourus* visited the campus, particularly in the open scrub habitat. These birds, apart from being winter visitors (Riegert 2005), were also favored by the outbreak of fire which took place in the open scrub habitat in October owing to the creation of open areas and suitable perching points to capture aerial prey and small mammals in open areas (Wiles et al. 2000; Narwade et al. 2011; Himanshu et al. 2012).

CONCLUSION

In the present study we have showed that seasonality along with change in the habitat structure may influence bird assemblage organization over time. The abundant populations of the Jungle Babbler, the Black Drongo and the Red-vented Bulbul shows an increasing urbanization in the vicinity and even inside the campus. An increase in human settlements will cause more danger to avian species. A more eco-friendly urbanization is essential to curb any more negative human interferences in the areas. Further research on appropriate conservation mechanisms and management techniques with the ultimate conservation goal of changing urban environments into species rich ecosystems are required.

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Appendix 1. Complete checklist of the birds

	Family	Name	Latin Name	Conservation status	Distribution	Frequency/ abundance	Feeding guilds
1	Accipitridae	Black-winged Kite	*Elanus caeruleus*	LC	WR	FC	Ca
2	Accipitridae	Black Kite	*Milvus migrans*	LC	WR	C	Ca
3	Pandionidae	Osprey	*Pandion haliaetus*	LC	WWV	Ir	Ca
4	Falconidae	Common Kestrel	*Falco tinnunculus*	LC	WWV	FC	Ca
5	Accipitridae	Shikra	*Accipiter badius*	LC	WR	C	Ca
6	Accipitridae	Eurasian Marsh Harrier	*Circus aeruginosus*	LC	WWV	Ir	Ca
7	Accipitridae	Montagu's Harrier	*Circus pygargus*	LC	WWV	Ir	Ca
8	Accipitridae	Indian Spotted Eagle	*Aquila hastata*	V	R	Ir	Ca
9	Accipitridae	Egyptian Vulture	*Neophron percnopterus*	E	R	U	Ca
10	Strigidae	Spotted Owlet	*Athene brama*	LC	WR	FC	Ca
11	Monarchidae	Asian Paradise Flycatcher	*Terpsiphone paradisi*	LC	WR	U	SI
12	Muscicapidae	Verditer Flycatcher	*Eumyias thalassinus*	LC	WWV	U	SI
13	Muscicapidae	Tickell's Blue Flycatcher	*Cyornis tickelliae*	LC	R	U	SI
14	Muscicapidae	Red-breasted Flycatcher	*Ficedula parva*	LC	WWV	Ra	SI
15	Muscicapidae	Bluethroat	*Luscinia svecica*	LC	WWV	Ra	GI
16	Nectariniidae	Purple Sunbird	*Cinnyris asiaticus*	LC	WR	C	NI
17	Passeridae	Chestnut-shouldered Petronia	*Gymnoris xantocollis*	LC	R	Ra	GrI
18	Zosteropidae	Oriental White Eye	*Zosterops palpebrosus*	LC	WR	FC	NI
19	Phylloscopidae	Common Chiffchaff	*Phylloscopus collybita*	LC	WWV	FC	GI
20	Phylloscopidae	Greenish Warbler	*Phylloscopus trochiloides*	LC	WWV	FC	GI
21	Alaudidae	Ashy-crowned Sparrow Lark	*Eremopterix griseus*	LC	WR	FC	GrI
22	Alaudidae	Rufous-tailed Lark	*Ammomanes phoenicura*	LC	R	FC	GrI
23	Alaudidae	Syke's Lark	*Galerida deva*	LC	R	FC	GrI
24	Upupidae	Common Hoopoe	*Upupa epops*	LC	WWV	FC	GrI
25	Motacillidae	Paddyfield Pipit	*Anthus rufulus*	LC	WR	FC	GrI
26	Motacillidae	Tree Pipit	*Anthus trivialis*	LC	R and WWV	Ra	GrI
27	Caprimulgidae	Savanna Nightjar	*Caprimulgus affinis*	LC	WR	FC	SI
28	Muscicapidae	Common Stonechat	*Saxicola torquatus*	LC	WWV	C	GI
29	Tephrodornithidae	Common Woodshrike	*Tephrodornis pondicerianus*	LC	WR	U	GI
30	Laniidae	Bay-backed Shrike	*Lanius vittatus*	LC	WR	FC	SI
31	Laniidae	Brown Shrike	*Lanius cristatus*	LC	WWV	Ra	SI
32	Ploceidae	Baya Weaver	*Ploceus philippinus*	LC	WR	U	GrI
33	Cisticolidae	Common Tailorbird	*Orthotomus sutorius*	LC	WR	U	NI
34	Cisticolidae	Ashy Prinia	*Prinia socialis*	LC	WR	C	GI
35	Cisticolidae	Jungle Prinia	*Prinia sylvatica*	LC	WR	FC	GI
36	Cisticolidae	Plain Prinia	*Prinia inornata*	LC	WR	U	GI
37	Cisticolidae	Grey-breasted Prinia	*Prinia hodgsonii*	LC	WR	U	GI
38	Estrildidae	Scaly-breasted Munia	*Lonchura punctulata*	LC	WR	Ra	GrI
39	Estrildidae	Indian Silverbill	*Euodice malabarica*	LC	WR	C	GrI
40	Estrildidae	Red Avadavat	*Amandava amandava*	LC	WR	Ir	GrI
41	Coraciidae	Indian Roller	*Coracias benghalensis*	LC	WR	U	GI

	Family	Name	Latin Name	Conservation status	Distribution	Frequency/ abundance	Feeding guilds
42	Anatidae	Northern Pintail	*Anas acuta*	LC	WWV	Ir	WB
43	Anatidae	Ruddy Shelduck	*Tadorna ferruginea*	LC	WWV	C	WB
44	Anatidae	Indian Spot-billed Duck	*Anas poecilorhyncha*	LC	WR	FC	WB
45	Podicipedidae	Little Grebe	*Tachybaptus ruficollis*	LC	WR	Ra	WB
46	Ciconiidae	Painted Stork	*Mycteria leucocephala*	NT	WR	FC	WB
47	Ciconidae	Wooly-necked Stork	*Ciconia episcopus*	LC	WR	U	WB
48	Cerylidae	Pied Kingfisher	*Ceryle rudis*	LC	WR	Ra	WB
49	Alcedinidae	Common Kingfisher	*Alcedo atthis*	LC	WR	Ra	WB
50	Halcyonidae	White-throated Kingfisher	*Halcyon smyrnensis*	LC	WR	FC	WB
51	Halcyonidae	Stork-billed Kingfisher	*Pelargopsis capensis*	LC	WR	Ra	WB
52	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	LC	WR	FC	WB
53	Charadriidae	Yellow-wattled Lapwing	*Vanellus malabaricus*	LC	WR	Ir	WB
54	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*	LC	WWV	FC	WB
55	Jacanidae	Bronze-winged Jacana	*Metopidius indicus*	LC	WR	U	WB
56	Motacillidae	White-browed Wagtail	*Motacilla maderaspatensis*	LC	WR	FC	GrI
57	Motacillidae	Grey Wagtail	*Motacilla cinerea*	LC	WWV	FC	GrI
58	Motacillidae	White Wagtail	*Motacilla alba*	LC	WWV	U	GrI
59	Motacillidae	Yellow Wagtail	*Motacilla flava*	NR	WWV	U	GrI
60	Phallacrocoracidae	Little Cormorant	*Phalacrocorax niger*	LC	WR	C	WB
61	Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*	LC	WR	FC	WB
62	Ciconiformes	Intermediate Egret	*Mesophoyx intermedia*	LC	WR	FC	WB
63	Ciconiformes	Little Egret	*Egreta garzetta*	LC	WR	U	WB
64	Ciconiformes	Grey Heron	*Ardea cinerea*	LC	WWV	FC	WB
65	Ciconiformes	Indian Pond Heron	*Ardeola grayii*	LC	WR	FC	WB
66	Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	LC	WWV	FC	WB
67	Scolopacidae	Wood Sandpiper	*Tringa glareola*	LC	WWV	U	WB
68	Sternidae	Whiskered Tern	*Chlidonias hybrida*	LC	WWV	Ra	WB
69	Sternidae	River Tern	*Sterna aurantia*	NT	WR	FC	WB
70	Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*	LC	WR	Ra	WB
71	Rallidae	Common Moorhen	*Gallinula chloropus*	LC	WR and WWV	U	WB
72	Muscicapidae	Oriental Magpie Robin	*Copsychus saularis*	LC	WR	C	GI
73	Muscicapidae	Indian Robin	*Saxicoloides fulicatus*	LC	WR	C	GI
74	Corvidae	Rufous Treepie	*Dendrocitta vagabunda*	LC	WR	C	GI
75	Oriolidae	Indian Golden Oriole	*Oriolus (oriolus) kundoo*	LC	R	FC	CBI
76	Meropidae	Green Bee-eater	*Merops orientalis*	LC	WR and WSV	C	SI
77	Cuculidae	Greater Coucal	*Centropus sinensis*	LC	R	C	GI
78	Megalaimidae	Coppersmith Barbet	*Megalaima haemacephala*	LC	R	C	GI
79	Phasianidae	Rose-ringed Parakeet	*Psittacula krameri*	LC	WR	FC	F
80	Bucerotidae	Indian Grey Hornbill	*Ocyceros birostris*	LC	WR	FC	GI
81	Phasianidae	Indian Peafowl	*Pavo cristatus*	LC	R	C	GI
82	Columbidae	Laughing Dove	*Stigmatopelia senegalensis*	LC	WR	C	GI
83	Columbidae	Spotted Dove	*Stigmatopelia chinensis*	LC	WR	U	GI

	Family	Name	Latin Name	Conservation status	Distribution	Frequency/ abundance	Feeding guilds
84	Columbidae	Common Pigeon	*Columba livia*	LC	WR	C	GrI
85	Muscicapidae	Brown Rock Chat	*Cercomela fusca*	LC	R	C	GI
86	Sturnidae	Asian Pied Starling	*Gracupica contra*	LC	R	U	GI
87	Cuculidae	Asian Koel	*Eudynamys scolopaceus*	LC	WR	FC	GI
88	Dicruridae	Black Drongo	*Dicrurus macrocercus*	LC	WR	C	SI
89	Timaliidae	Jungle Babbler	*Turdoides striata*	LC	WR	C	GrI
90	Timaliidae	Large Grey Babbler	*Turdoides malcolmi*	LC	R	U	GrI
91	Sylviidae	Yellow-eyed Babbler	*Chrysomma sinense*	LC	WR	Ir	GrI
92	Campephagidae	Small Minivet	*Pericrocotus cinnamomeus*	LC	WR	FC	CBI
93	Phasianidae	Grey Francolin	*Francolinus pondicerianus*	LC	WR	FC	GrI
94	Aegithinidae	Common Lora	*Aegithina tiphia*	LC	WR	U	CBI
95	Picidae	Lesser Goldenback	*Dinopium benghalense*	LC	WR	U	CBI
96	Charadriidae	Little-ringed Plover	*Charadrius dubius*	LC	WR and WWV	Ir	WB
97	Rhipiduridae	White-browed Fantail	*Rhipidura aureola*	LC	WR	Ra	SI
98	Sylviidae	Lesser Whitethroat	*Slyvia curruca*	LC	WWV	Ir	GI
99	Hirundinidae	Wire-tailed Swallow	*Hirundo smithii*	LC	WR	U	SI
100	Hirundinidae	Streak-throated Swallow	*Petrochelidon fluvicola*	LC	R	Ir	SI
101	Muscicapidae	Black Redstart	*Phoenicurus ochruros*	LC	WWV	U	SI
102	Muscicapidae	Pied Bushchat	*Saxicola caprata*	LC	WR	U	GI
103	Passeridae	House Sparrow	*Passer domesticus*	NT	WR	Ra	GrI
104	Corvidae	House Crow	*Corvus splendens*	LC	WR	Ra	GI
105	Sturnidae	Common Myna	*Acridotheres tristis*	LC	WR	Ra	GI
106	Pycnonotidae	Red-vented Bulbul	*Pycnonotus cafer*	LC	WR	C	GI

Note: LC - Least concern; V - Vulnerable; E - Endangered; NT - Not Threatened; NR - Not Recognized; WR - Widespread Resident; R - Resident; WWV - Widespread Winter Visitor; WSV - Widespread summer visitor; FC - Fairly Common; C - Common; Ra - Rare; Ir - Irregular; U - Uncommon; CBI - Canopy and Bark Insectivore; GI - General Insectivore; GrI - Ground Insectivore; WB - Water Birds; SI - Sallying Insectivore; Ca - Carnivore; F - Frugivore; NI - Nectar Insectivore

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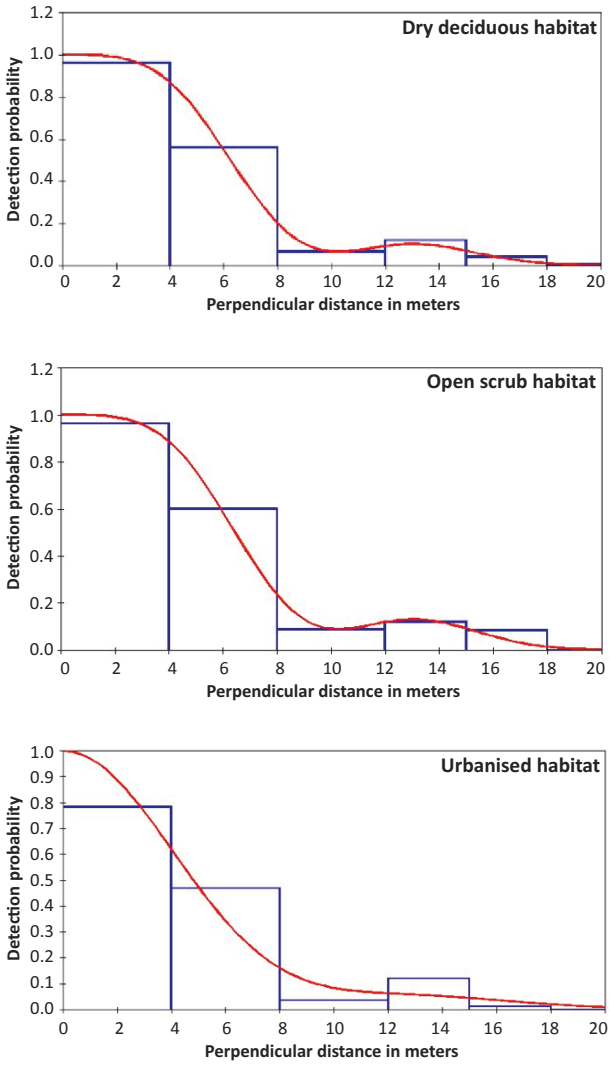
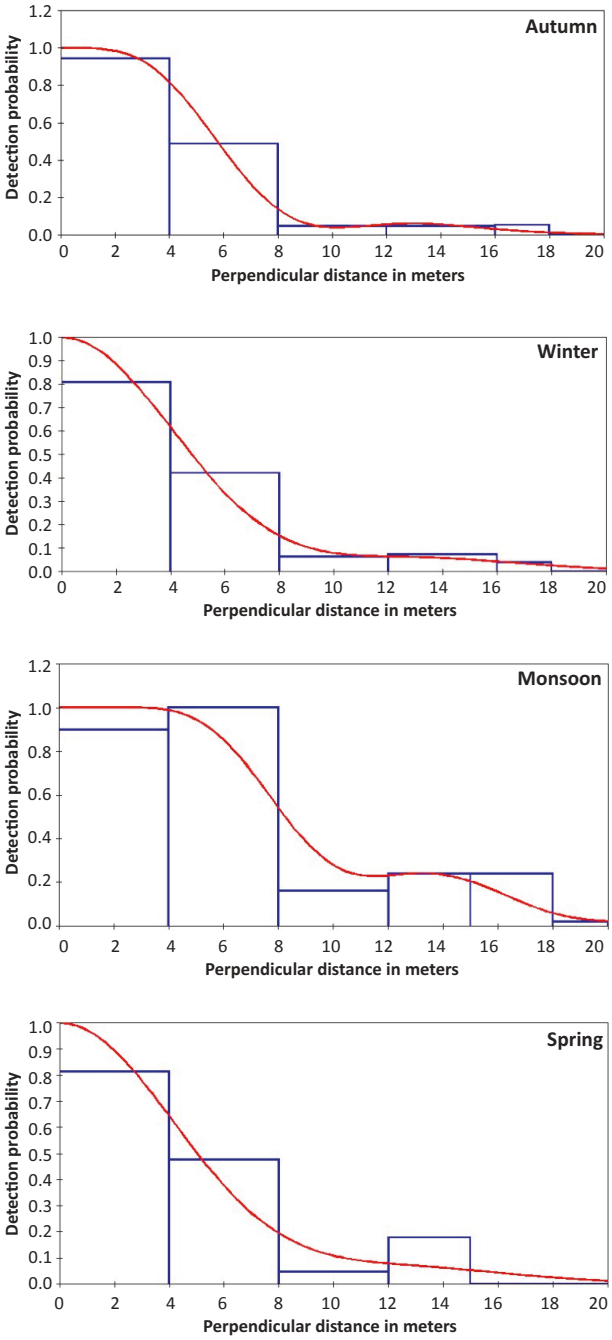


Appendix 2. Detection probability distribution of three habitats



Appendix 3. Detection probability distribution of species in four different seasons