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UNVEILING THE AVIAN COMMUNITY STRUCTURE, HABITAT PREFERENCE, AND CONSERVATION CONCERNS IN THE SAL FOREST OF CENTRAL BANGLADESH

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Key words: Avifauna, community structure, deciduous forest, relative abundance, conservation

Abstract

A study on avifaunal diversity was conducted in Bhawal National Park, Gazipur, Bangladesh, from November 2020 to October 2021 using direct field observation. The study area was divided into five sites based on the habitat structure. A total of 138 bird species and 1,808 individuals were directly counted, representing 17 orders and 49 families. The order Passeriformes and the family Cuculidae had the highest number of species. During the winter season, the richness, abundance, and diversity was the maximum (116 species, 1132 individuals, H= 4.151, Ds= 0.976), with resident bird surpassing migratory species. Among the five study sites, the deep forest area exhibited the greatest number of bird species (75 species, H= 3.983, Ds= 0.975) and trees were the used microhabitat for the birds (101 species, 1521 individuals, H= 4.1, Ds= 0.977). Jungle Babbler (*Turdoides striata*) had the maximum relative abundance and the ten most abundant species constituted 36.7% of total individuals. A total of 25 habitat generalist species was observed using more than one habitat during the study, while the rest were found in single habitat. Among all the bird species, 136 were Least Concern, one was Near Threatened, and one was Data Deficient. Based on the observation status, it was determined that the majority of bird species (97 species, 70.28%) were classified as few, while 25 species (18.11%) were as uncommon, 12 species (8.69%) as common, and 4 species (2.89%) as very common. The area was noted for its widespread use for recreational activities, and the disturbance caused by visitors lacking awareness poses a significant threat to the local bird population and biodiversity.

Introduction

Avian diversity plays a crucial role in conservation efforts due to its multifaceted impact on ecosystem health, functioning, and resilience. Birds contribute to various ecological processes such as pollination, seed dispersal, and pest control, thereby influencing plant regeneration and maintaining biodiversity[1,2]. Furthermore, avian diversity serves as an indicator of overall ecosystem health, reflecting habitat quality and

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environmental conditions[3]. Monitoring bird populations allows conservationists to assess the effectiveness of conservation strategies and identify potential threats to ecosystems[4].

Bangladesh, a small country situated in South Asia, is home to 690 species of avifauna, which play a vital role in various sectors including the environment, ecology, culture, and economy[5,6]. The country's natural forests are divided into three vegetation types and among them decidious, forest holds a significant position in Bangladesh's central, northern and northwestern regions, with a distinct ecological diversity[7]. Deciduous forest is made up of 70-75 % 'Sal' trees (*Shorea robusta*), as well as a number of other valued species[8,9]. In the past, this forest was the habitat of several iconic wildlife species such as the Bengal tiger (*Panthera tigris tigris*) and Asian elephant (*Elephas maximus*). However, due to habitat fragmentation and degradation, these iconic wildlife species have become extinct from this forest, and the current wildlife in the area faces an existential crisis[7]. Presently, there are approximately 0.12 million hectares of deciduous forest distributed throughout the country. These forests, both protected and non-protected sites, serve as the habitat for numerous bird species[10]. During pre-monsoon period, this forest still come alive with different groups of resident and summer migratory bird species with their breeding territories (*e.g.,* Indian Pitta *Pitta brachyura* and Indian Paradise-flycatcher, Cuckoos *Terpsiphone paradisi*) and in winter they support a number of winter migratory bird species[10,11]. But, number of mature trees are gradually declining from those forest which were suitable habitat for livelihood of different groups of birds species[11].

Bangladesh possesses a network of protected areas administered by the Forest Department. However, there is a lack of comprehensive information regarding the birds inhabiting these areas, particularly in terms of their ecology, habitat utilization, and community composition. Furthermore, no previous efforts have been made to utilize birds as indicators of ecological changes within these protected areas despite their well-established reputation as excellent ecological indicators[12,13]. Bhawal National Park (locally known as Bhawal Sal forest or Rajendrapur Gajari forest) is one of the largest deciduous forests of Bangladesh[7]. Earlier a study was conducted on birds in Bhawal National Park from 2013 to 2015 only during monsoon season[14]. No detailed study and sufficient data across the year was found. Gaining knowledge about the population status, community structure, habitat utilization, and ecology of birds, as well as understanding the current threats they face in a specific forest area, is crucial for establishing conservation priorities and implementing effective management strategies. This study can contribute by providing comprehensive baseline information on the composition of avifaunal communities, their ecological dynamics, habitat preferences, and seasonal variations within the study area.

Materials and Methods

Study area: Bhawal National Park is located in Gazipur district (24.017°N 90.333°E), which is Bangladesh's second largest deciduous forest (50.22 km^2), and approximately 40 kilometers north of the Dhaka metropolitan area. The Bangladesh Wildlife Act of 1974

designated this forest as a national park on May 11, 1982[7,15]. Bhawal National Park contains several man-made lakes and secondary forested habitats[14]. The research area was divided into five sites based on habitat structure and vegetation (Fig. 1). Birds were recorded from three types of macrohabitats (terrestrial, arboreal, aquatic) and five microhabitats. These microhabitats were divided into grassland (GL), tree (T), Bush (BU), Waterbody (WB) and mudflats (MF).

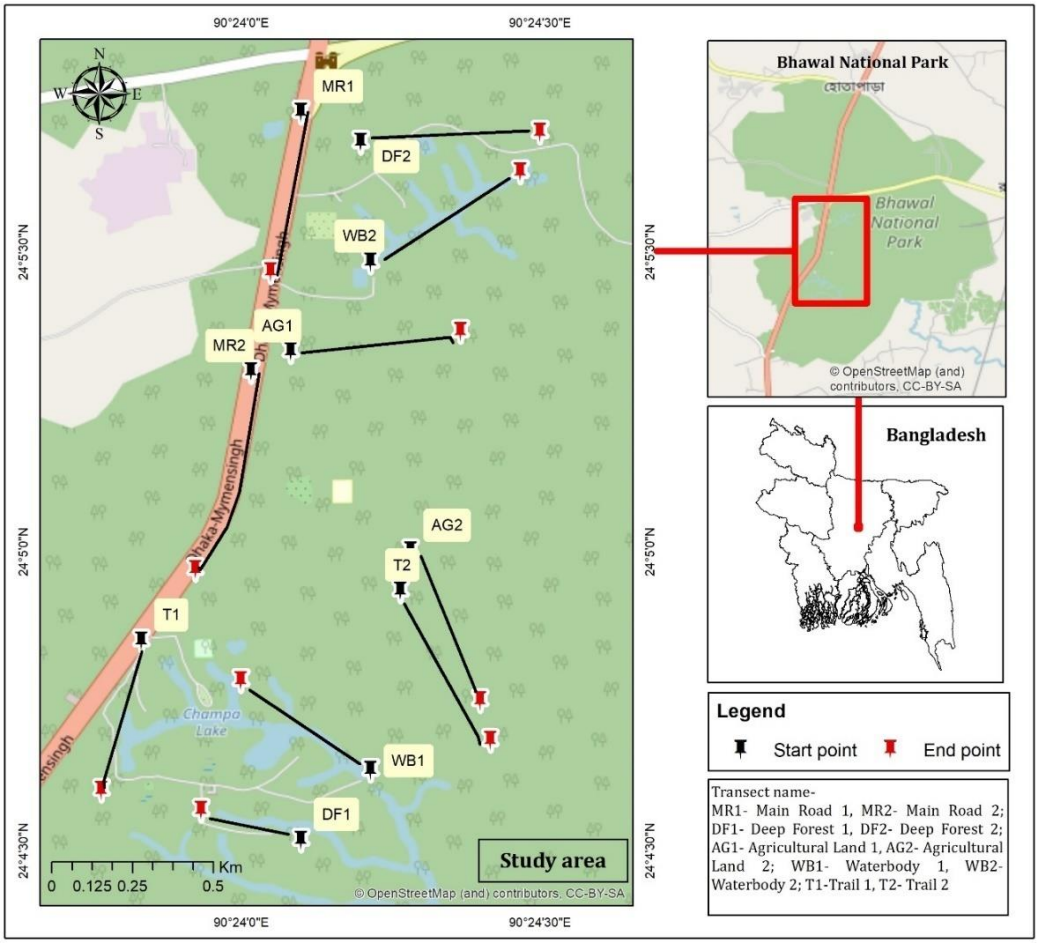

Fig. 1. Map of Bhawal National Park indicating the study locations with transects.

Data collection protocol: This year-long study was conducted from November 2020 to October 2021. A total of 45 days (15 days per season) was spent in the field for data collection. The study period was divided into three seasons, viz. summer (March-June), rainy (July-October) and winter (November-February)[16,17]. Direct field observation was used to conduct the survey. To ensure optimal bird observation, the survey was conducted during two distinct periods of the day. The first observation took place from 06:00 to 10:00

am, as this coincides with the peak activity of most bird species. The second observation occurred from 03:30 to 06:30 pm during the late afternoon[18]. For nocturnal species, the observation was conducted at night. These timings were chosen to coincide with the periods of maximum activity for the birds, allowing for the most effective observation of the various species present. To conduct the survey, we employed the line transect approach, implementing two lines at each site and a total of 10 transect lines across the entire study area (Table 1). The transect line was 500×100 m^2 in size. Repeated observation were done in each transect in every season.

Table 1. List of habitats surveyed at different study sites during the study period in Bhawal National Park, Bangladesh.

Site name	Transect Line	Location				Habitat type
		Starting Lat.	Starting Long.	Ending Lat.	Ending Long.	
Deep Forest Area	DF1	24°04'31"	90°24'06"	24°04'34"	90°23'56"	Dense forest with different types of vegetation and very limited human activity
	DF2	24°05'41"	90°24'12"	24°05'42"	90°24'30"	
Main Road Area	MR1	24°05'44"	90°24'06"	24°05'28"	90°24'03"	Area in front of national park, pollution, fast moving vehicles, dustbins and waste disposal area
	MR2	24°05'18"	90°24'01"	24°05'02"	90°24'57"	
Agricul t-ural Land	AG1	24°05'20"	90°24'05"	24°05'22"	90°24'22"	Cultivated land inside forest
	AG2	24°05'00"	90°24'17"	24°04'45"	90°24'24"	
Trail	T1	24°04'51"	90°23'50"	24°04'36"	90°23'46"	Forest pathway, different types of vegetation
	T2	24°04'56"	90°24'16"	24°04'41"	90°24'25"	
Water body	WB1	24°04'38"	90°24'13"	24°04'47"	90°24'00"	Ponds and lakes inside forest
	WB2	24°05'29"	90°24'13"	24°05'38"	90°24'28"	

Some avifauna were also identified by hearing their song and call sound which generally prefer the bushes, jungles, and branches of trees to conceal themselves. Sometimes calls were recorded using Huawei GT3 phone and later identified by experts in Wildlife Research Laboratory, Department of Zoology, University of Dhaka. A torch light was used for nocturnal bird detection, which we occasionally directed in tree branches. Photographs of birds were taken with a Nikon D500 DSLR camera with a 200-500 mm VR lens for identification. For bird identification, we used some renowned Bangladeshi field guides [7,11,19].

Data analysis: Observation status of birds was calculated by following the formula of Khan (2015)[19]. Based on the total number of sightings per survey attempt, the observation status was determined using the following criteria: species observed in 10-19% of the total sightings were categorized as few (F), 20-49% were as fairly common (FC), 50-79% were as common (C), and 80-100% were as very common (VC). The relative abundance of particular bird species was calculated following the formula-

$$\text{Relative abundance} = \frac{\text{Number of individuals of a species}}{\text{Total number of individuals of all species}} \times 100$$

According to Kindt and Coe (2005)[20], first and second-order Jackknife, Bootstrap, and Chao richness estimators were used to estimate the total number of species in the study area. This was done using the 'specpool' function from Vegan Package[21]. By using the mean of these four estimators, the estimated number of species (x) was calculated following Fils *et al*. (2014)[22]. Following the formula sampling completeness was calculated:

$$\text{Sampling completeness} = \frac{\text{Observed number of species (n)}}{\text{Estimated number of species (x)}} \times 100$$

Diversity index was calculated by following Shannon-Wiener index (1949)[23], Simpson's index (1949)[24] of diversity and evenness (quantifies how numerically equal the community is). Rank abundance plot was prepared to understand the patterns of dominance following Whittaker (1965)[25]. Habitat similarity plot or cluster analysis for the five sites were performed following the Bray-Curtis index method (1957)[26]. Using the correlation plot in the PAST program (version 4.03), the Pearson's correlation coefficient was computed to identify the commonness of bird diversity among different habitats. One-way ANOVAs were used to evaluate species richness and overall bird abundance in different habitats and seasons, with Tukey's Honest Significant Difference (HSD) test for multiple comparisons ($p = 0.05$). The combined sum of average species richness and abundance categorized by different habitats per season was represented through boxplots.

Results and Discussion

Community structure and species composition: A total of 138 species under 17 orders was observed directly during the field survey and among them, passerine and non-passerine species were equal in number (Appendix 1). The observed species in this study represents around one-fifth of birds of Bangladesh[27,28]. The study of Jahan et al. (2017)[14] recorded 146 species of bird which is a bit higher than this study. Species richness is often evaluated using repeated samples from a community. The total number of species seen is usually always an underestimate of the actual number of species in the assemblage; hence, numerous approaches for correcting this bias have been devised[29]. Richness estimators predicted a range of 121-152 species, which is relatively within the 138 species observed in

the field visits. This assertion is supported by the fact that 96% of the sampling was completed, indicating that species sampling in the study area was highly sufficient and comprehensive.

The Passeriformes order had the highest number of species (50%) which was followed by Piciformes (11 species, 7.97%), Cuculiformes (11 species, 7.97%), and Charadriiformes (9 species, 6.52%). Under the 49 families, the highest number of birds (11 species, 7.97%) was recorded for the family Cuculidae. Resident bird species (106 species, 76.82%) were mostly found in the study area. The study area supports a diverse array of insects across various taxonomic groups[30]. Additionally, the nearby agricultural lands act as a reliable source of grains, providing ample feeding opportunities and livelihood for birds belonging to the order Passeriformes. As a result, the abundance of passerine birds is relatively higher, as many species within this group are predominantly insectivorous and granivorous[31].

Among the observed birds, 23.18% were migratory indicating suitability for forest migratory bird species. Migratory species contribute significantly to resource fluxes, biomass transfer, nutrient transport, predator-prey interactions, and food-web structure within and between ecosystems, as well as to human culture [32]. This study found 27 (75%) winter migratory, 1 passage migratory and 4 (25%) summer migratory bird. Species such as Pied crested Cuckoo *Clamator jacobinus,* Indian Cuckoo *Cuculus micropterus,* Indian Pitta *Pitta brachyura,* and Blue-tailed Bee-eater *Merops philippinus* were identified as summer migrants, while Common Cuckoo *Cuculus canorus* was observed as the only passage migrant. Notably, the study area serves as a significant habitat and potential breeding ground for Indian Pitta *Pitta brachyura,* a summer migratory bird species that specifically breeds in the deciduous forests of Bangladesh[7]. Threats in any one part of a yearly migrant cycle can influence the entire population, hence environmental management activities for migrants must be coordinated across habitat types, seasons, and jurisdictions [33]. Therefore, conserving the habitat within this study area is of utmost importance to ensure the preservation of this particular bird species.

Relative abundance and rank abundances curve: In this study, a total of 1808 individuals of birds were counted from the study area and the highest number of bird individuals were under Passeriformes (n= 1180, 63.60%). Jungle Babbler *Turdoides striata* was the most abundant bird species in the study area (n= 110, 6.30%). It is a gregarious bird species, known to occur in small to medium-sized groups and commonly found in forested and well-vegetated areas[7,10,11,19]. This bird species exhibits a preference for feeding on insects, small vertebrates, seeds, berries, and worms[10,11]. The forest area provides an ample supply of these preferred food items, resulting in a higher abundance of Jungle Babbler *Turdoides striata* in the study area (Fig. 2A)[34]. The ten most abundant species (Jungle Babbler *Turdoides striata,* Small Minivet *Pericrocotus cinnamomeus,* Black Drongo *Dicrurus macrocercus,* Red-vented Bulbul *Pycnonotus cafer,* Oriental Magpie-robin *Copsychus saularis,* Asian Pied Starling *Sturnus contra,* Lineated Barbet *Psilopogon lineatus,* Common Myna *Acridotheres tristis,* Common Tailorbird *Orthotomus sutorius*) constituted for 36.7% of total

individuals and the least abundant 40 species constituted 3.81% of total bird population. This signifies an uneven distribution of species in the community which is explained in the rank abundance plot (Fig. 2A). In agricultural land and main-road area, high uneven distribution of birds were observed compared to other study sites (Fig. 2B). The relative abundance of bird species in a given area is related to the availability of basic living necessities (food, water, and shelter), as well as favorable abiotic conditions [35]. The distribution and abundance of many bird species are determined by the vegetation complexity. As the vegetation and habitat changes at geographical and environmental gradients, a particular species may appear or disappear, increase or decrease along the gradient. The top abundant species recorded in this study were observed using multiple canopies for their living and the distribution of these species signifies the importance of complex vegetation.

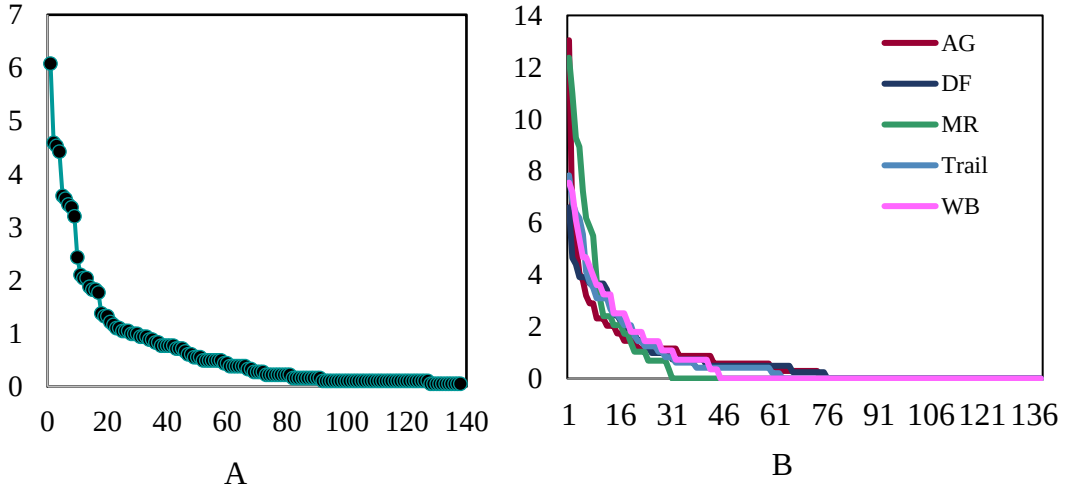

Fig. 2. Whittaker plot representing abundance pattern of (A) all bird species in Bhawal National Park (B) bird species in five sites. The y axis shows the relative abundance and the x axis ranks the species in order of their abundance from the highest to lowest.

Seasonal diversity: The highest number of bird species richness (116 species, 84.05%) and abundance (n= 1132, 62.61%) including diversity indices value (H= 4.151, Ds= 0.976) was found for the winter season (Table 2). Species was more evenly distributed during the summer (E= 0.738). In the study area, 33 species of birds were found throughout the year whereas 56 species of birds found only in winter season, 8 species in summer season and 6 species only in rainy season (Appendix 1). The occurrence of winter birds in the area indicates that the study area is important for migratory birds. Many bird species use late winter season for breeding purposes and can shift their feeding habit. The change in rainfall and seasonality is related with food and mate resource availability. Thus, the diversity was high during the winter season[27, 36]. The difference in species composition observed in three seasons could expalin the effect of seasons on bird diversity.

Table 2. Diversity indices in terms of season, habitats and study sites in Bhawal National Park, Bangladesh. Species richness (S), Species abundance (A), Simpson's Index (Ds), Shannon-Weiner Index (H), Evenness (E).

Categories	Sub-categories	S	A	Ds	H	E
Season	Rainy	50	239	0.955	3.591	0.725
	Summer	70	437	0.974	3.945	**0.738**
	Winter	**116**	**1132**	**0.976**	**4.151**	0.547
Study sites	Agricultural Land Area (AG)	73	345	0.966	3.926	0.695
	Deep Forest Area (DF)	**75**	409	**0.975**	**3.983**	0.716
	Main Road Area (MR)	30	291	0.937	3.027	0.688
	Forest Trail (FT)	62	**485**	0.966	3.707	0.657
	Waterbody (WB)	44	278	0.966	3.572	**0.808**
Macrohabitat	Aquatic	16	46	0.921	2.691	**0.922**
	Arboreal	**103**	**1444**	**0.978**	**4.145**	0.613
	Terrestrial	47	318	0.906	3.175	0.509
Microhabitat	Agricultural Land	32	190	0.916	3.011	0.635
	Bush	17	55	0.939	2.827	**0.994**
	Waterbody	5	24	0.757	1.484	0.882
	Mudflat	10	18	0.941	2.495	1.212
	Tree	**101**	**1521**	**0.977**	**4.1**	0.598

Diversity in five survey sites: The maximum number of species (75 species, 54.34%) was observed in the deep forest areas with 409 individuals, which is followed by agricultural land (73 species, 52.82%) (Table 2). Diversity indices showed the highest value for deep forest site (H= 3.983, Ds= 0.975). Within the deep forests, numerous tree species coexist alongside diverse vegetation types. As human disturbance is minimal in this area, the level of bird diversity was found at its peak. Conversely, the main road area exhibits the lowest number of species due to the presence of disturbances, pollution, and human activities. Price[37] suggested that birds are more likely to partially habituate to innocuous and recurrent human disturbance because they tend to overestimate the risk associated with humans rather than underestimate it. In the main road side, the highest number of bird species observed primarily consists of insectivores scavengers (Jungle Myna *Acridotheres fuscus,* Bank Myna *Acridotheres ginginianus,* Common Myna *Acridotheres tristis,* Jungle Crow *Corvus levaillantii,* House Crow *Corvus splendens* and Black Kite *Milvus migrans*). The maximum bird abundance was found for forest trail area (n= 485). The forest trail area has comperatively high plant diversity thus the number of individuals of birds are the highest in that area[38].

Diversity in different habitats: The avian communities observed in tree (T) and agricultural land (AG) exhibited a positive correlation (*r= 0.46, p-value< 0.05*). In contrast, the correlation between other pairs of habitats was found to be relatively weaker (Fig. 3). Among the three types of macrohabitats, most of the birds (103 species, 74.64%) were arboreal and they preferred trees as their suitable microhabitat. The boxplot and the diversity index (H= 4.10, Ds= 0.977) for tree showed that it was the most used microhabitat (Table 2, Fig. 4). Species evenness was the highest (E= 0.987) in waterbody in the study area (Table 2).

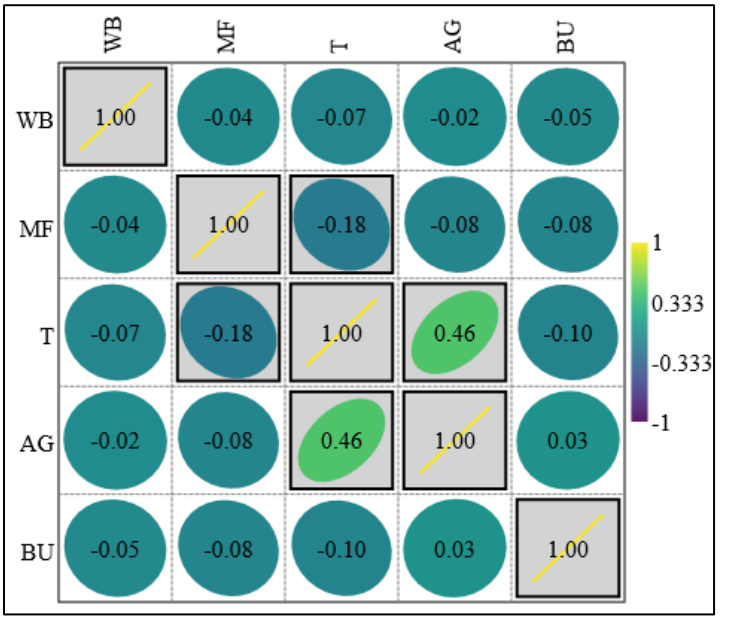

Fig. 3. Correlation plot showing correlations among the species observed in different habitats. (AG- Agricultural Land, BU-Bush, WB- Waterbody, MF- Mudflat, T- Tree).

The number of species among five microhabitats differed significantly (*F= 31.562, df= 4, p-value< 0.001*) along with the number of individuals (*F= 25.690, df= 4, p-value < 0.001*). The maximum number of species was found in trees and the pair-wise tests for habitats were significant only for tree. Similarly, the high population levels in tree caused significant pair-wise variation between the tree-agricultural land, tree-bush, tree-mudflat and tree-waterbody pair (Table 3). These findings agreed with Mengesha and Bekele [39]. They stated that avian diversity is an indicator of habitat variety, and the number of species and individuals in a given location indicates the area's importance. Each habitat contains a unique set of microenvironments that are ideal for a particular species. Bibi and Ali [40] depicted that the Shannon-Weiner Diversity index values typically range between 1.5 and 3.5, seldom exceeding 4.5. Tree is found as a significant microhabitat for birds in the study area which is supported by the diversity indices value. Variation in bird species diversity, richness, and abundance is connected with vegetation composition, which causes variations

in food supplies, nesting, and protection based on birds' habitat preference and feeding [10,11,19].

Table 3. One-way ANOVA results comparing species richness and abundance among habitats in Bhawal National Park, Bangladesh. (Tukey HSD multiple comparisons of means 95% family-wise confidence level. AG-Agricultural Land, BU-Bush, WB- Waterbody, MF- Mudflat, T-Tree).

Treatment pairs	Richness		Abundance	
	Tukey HSD Q statistic	p-value	Tukey HSD Q statistic	p-value
AG vs BU	0.931	0.899	1.049	0.899
AG vs MF	1.253	0.899	1.337	0.867
AG vs T	11.639	**0.001**	10.349	**0.001**
AG vs WB	1.289	0.885	1.290	0.885
BU vs MF	0.322	0.899	0.287	0.899
BU vs T	12.570	**0.001**	11.398	**0.001**
BU vs WB	0.358	0.899	0.241	0.899
MF vs T	12.893	**0.001**	11.686	**0.001**
MF vs WB	0.035	0.899	0.046	0.899
T vs WB	12.929	**0.001**	11.639	**0.001**

Being a protected deciduous forest, the study area is primarily characterized by the presence of "Sal" trees (*Shorea robusta*), along with various other planted tree species. Consequently, the trees within this forest serve as vital resources for the livelihood of a wide range of bird species. The trees provide essential opportunities for birds, including food sources, habitats, and breeding grounds[14]. Among the observed bird species, 81.88% birds were habitat specialist and 57.24% species particularly used tree as their microhabitat [41]. Agricultural land and tree habitat are closely situated thus they share higher number of similar species (Fig. 4, 6A). Forest trail and deep forest area also situated closely to each other and for this reason they also share the highest number of similar bird species (Fig. 6B). Furthermore, in the forest habitat, the number of birds was relatively higher due to the abundant availability of livelihood resources for birds[13,42].

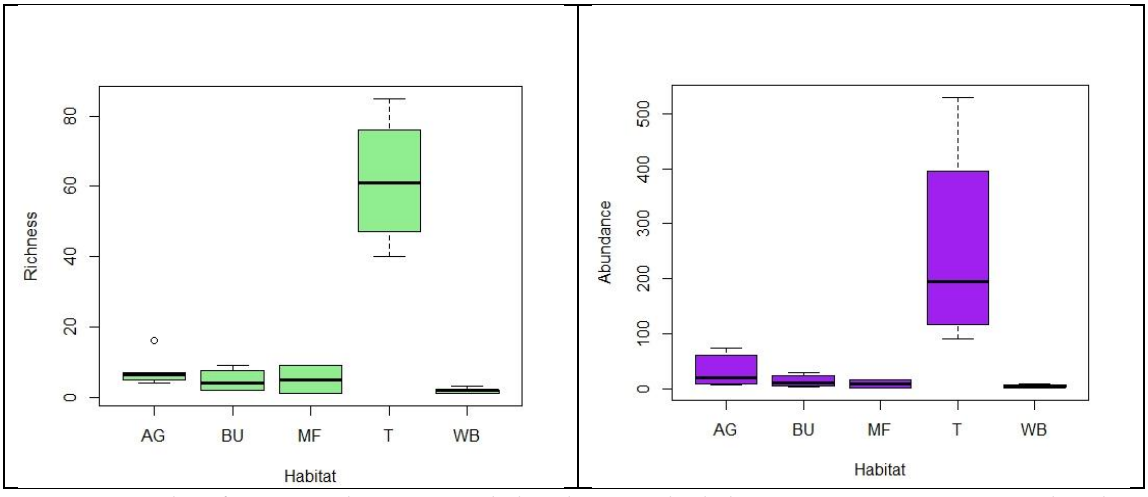

Fig. 4. Boxplot of species richness (A) and abundance (B) by habitats per season. (AG-Agricultural Land, BU-Bush, WB- Waterbody, MF- Mudflat, T-Tree).

Habitat usage of avian species in the study area is shown in fig. 5. A total of 25 generalist species were observed using more than one habitat during the study. Among them, one occurred (Oriental Magpie Robin *Copsychus saularis*) in bush, grassland and tree; one (Indian Pond Heron *Ardeola grayii*) in agricultural land, tree and waterbody; one (Grey-backed Shrike *Lanius tephronotus*) in agricultural land and bush; three (Dusky Warbler *Phylloscopus fuscatus*, Bluethroat *Luscinia svecica*, Brown Shrike *Lanius cristatus*) in bush and tree; three (White-breasted Kingfisher *Halcyon smyrnensis*, Little Cormorant *Microcarbo niger*, White-breasted Waterhen *Amaurornis phoenicurus*) in tree and waterbody; sixteen (Small Minivet *Pericrocotus cinnamomeus*, Red-vented Bulbul *Pycnonotus cafer*, Rock Dove *Columba livia*, Jungle Myna *Acridotheres fuscus*, Intermediate Egret *Ardea intermedia*, Black-naped Monarch *Picus guerini*, Lesser Whistling Duck *Dendrocygna javanica*, Common Myna *Acridotheres tristis*, Asian Pied Starling *Sturnus contra*, Cattle Egret *Bubulcus ibis*, Purple-rumped Sunbird *Nectarinia zeylonica*, Eastern Spotted Dove *Spilopelia chinensis*, Greater Coucal *Centropus sinensis*, Long-tailed Shrike *Lanius schach*, Jungle Babbler *Turdoides striata*, Taiga Flycatcher *Ficedula albicilla*) in agricultural land and tree. Considering single habitat use, 113 species were found in one habitat and among them tree was used mostly (69.9%) and waterbody was used the least (only one species, Bronze-winged Jacana *Metopidius indicus*) (details in Appendix 1). These findings may be related to the living habits of each bird species. Birds are dependent on the compositional complexity of trees, shrubs, and herbs, representing association between bird community and habitat diversity indexes. These findings imply that a bird community is strongly related to habitat heterogeneity and if heterogeneity increases there is a possibility of diversity increase in a community[35,39].

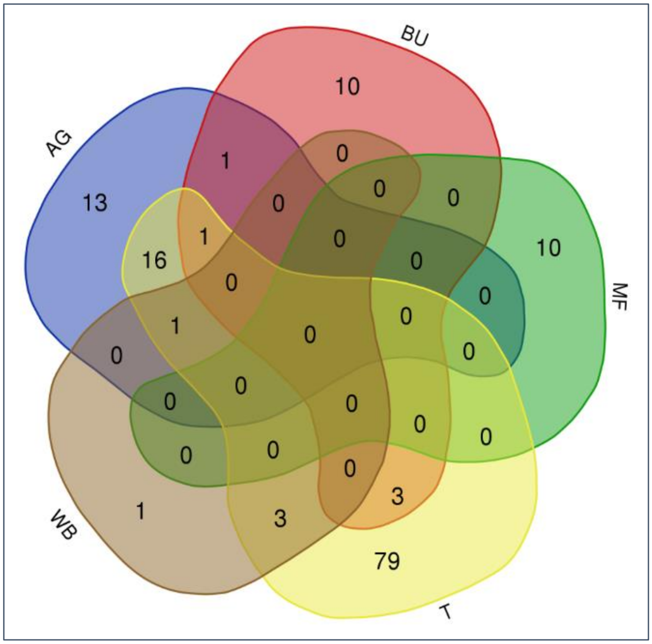

Fig. 5. Venn diagram showing the number of shared and unique species in five habitats (AG- Agricultural Land, BU-Bush, WB- Waterbody, MF- Mudflat, T-Tree).

Similarity index: Among the five microhabitats, trees and agricultural land shared more common species between them which made a cluster in the similarity plot. This spcies cluster had many common species with bushy areas making another cluster. These two clusters formed the third cluster with waterbody habitat. Species of mudflat share more dissimilar species with others (Fig. 6A). In terms of study sites, birds in the forest trail and deep forest area shared more common species between them compared to agricultural land and main road area. Birds in waterbody are found to be more dissimilar than any other study sites (Fig. 6B). Habitat use encourages both the similarity of assemblages from distant locations and the difference of assemblages from local areas. The result produced by the clustering are supported by findings regarding bird preferences for aggregate environments [43]. For "Agricultural Land Area", "Tree", and "Bush" the evidence is well corroborated, while it is weak for "waterbody" and "mudflat". This discrepancy might be a sign of habitat diversity in the study area.

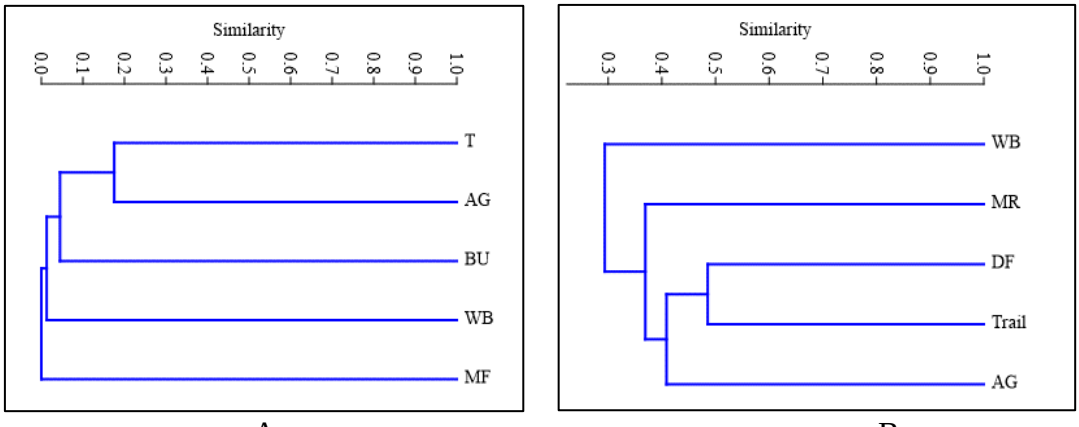

Fig. 6. Similarity profile test among microhabitats (A), study sites (B) using Bray-Curtis index. (Agricultural Land Area- AG, Deep Forest Area- DF, Main Road Area- MR, Waterbody- WB, Tree- T, Bush- BU, MF- Mudflat).

Bird community composition did not differ significantly among the five study sites (*R= 0.179, p-value> 0.003*) in analysis of similarity (ANOSIM) test with a stress level of 0.290 (>0.2) (Fig. 7).

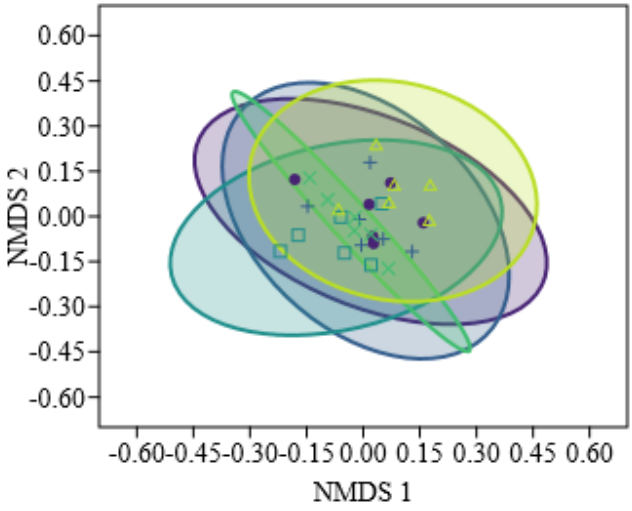

Fig. 7. Non-metric multidimensional scaling plot (NMDS) of bird species composition in study area representing five study sites. (Ordination is based on the Bray–Curtis similarity measure where Purple circle and dot: Agricultural Land Area, Blue: Deep Forest Area, Emeraled: Main Road Area, Green: Trail and Yellow:Waterbody)

Observation status and threatened status: Observation status showed that the highest number of bird species (97 species, 70.28%) was few, 25 species (18.11%) was uncommon, 12 species (8.69%) common and 4 species (2.89%) was very common (Appendix 1). The

forest habitat is facing severe threats from human activities, leading to its gradual disappearance. Tragically, many iconic species have already been eradicated from these areas, such as the Indian Peafowl *Pavo cristatus*[7,27,44]. Out of the total 138 bird species recorded, 136 species were assessed as Least Concern (LC), indicating a relatively stable conservation status. One species, Grey-headed Fisheagle *Ichthyophaga ichthyaetus*, was categorized as Near Threatened (NT), suggesting it may face potential risks in the near future. Additionally, one species, Indochinese Roller *Coracias affinis*, was Data Deficient (DD), indicating a lack of sufficient information to assess its' conservation status accurately, according to the IUCN Bangladesh assessment (2015). White-rumped Vulture *Gyps bengalensis* (CR), Indian Spotted Eagle *Clanga hastata* (EN), Greater Spotted Eagle *Clanga clanga* (VU) was observed in the previous study[14] but not found in the present study which indicates that those birds probably left this habitat due to increasing anthropogenic activities inside the park or lost their habitat[45].

Conclusion

This year-long study presents a comprehensive overview of the diversity, seasonality, and habitat preferences of birds within Bhawal National Park. Despite being a popular recreational spot attracting a significant number of visitors, there is a notable lack of awareness among them regarding the park's biodiversity, leading to disturbances. The improper disposal of waste, including plastics, polythenes, food containers, chips packets, and other litter in both aquatic and terrestrial habitats, along with issues like sound pollution and plastic pollution, poses a significant threat to the survival of bird species in the study area. Addressing these concerns requires immediate attention and calls for the implementation of proper planning and monitoring for avifauna, along with effective management of floral diversity in the park.

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Appendix: 1. List of avifauna observed from study area during the field observation. (Note: NI- Number of Individuals; RA-Relative abundance; MH- Microhabitat, AG-Agricultural Land Area, T-Tree, BU-Bush, MF- Mudflat; OS-Observation Status, VC- Very Common C-Common, UC- Uncommon, Few- F; W-Winter, S- Summer and R- Rainy Season, A- Year round)

Order	Family	Scientific name	NI	RA	MH	OS	Season
Accipitriformes	Accipitridae	*Accipiter badius*	1	0.06	T	F	W
Passeriformes	Sturnidae	*Acridotheres fuscus*	24	1.33	AG, T	UC	A
Passeriformes	Sturnidae	*Acridotheres ginginianus*	17	0.94	T	F	W
Passeriformes	Sturnidae	*Acridotheres tristis*	61	3.37	AG, T	C	A
Charadriformes	Scolopacidae	*Actitis hypoleucos*	2	0.11	MF	F	W
Passeriformes	Aegithinidae	*Aegithina tiphia*	20	1.11	T	F	A
Coraciformes	Alcedinidae	*Alcedo atthis*	16	0.88	T	C	A
Gruiformes	Rallidae	*Amaurornis phoenicurus*	7	0.39	FP, T	UC	R, W
Ciconiformes	Ciconidae	*Anastomus oscitans*	3	0.17	AG	F	S
Passeriformes	Motacilidae	*Anthus hodgsoni*	2	0.11	BU	F	W
Passeriformes	Motacilidae	*Anthus rufulus*	2	0.11	BU	F	W
Caprimulgiformes	Apodidae	*Apus nipalensis (A. affinis)*	3	0.17	BU	F	S
Pelecaniformes	Ardidae	*Ardea (Egretta) intermedia*	4	0.22	BU	F	S, W
Pelecaniformes	Ardidae	*Ardeola grayii*	13	0.72	AG, BU, T	UC	A
Passeriformes	Artamidae	*Artamus fuscus*	2	0.11	BU	F	W
Strigiformes	Srtigidae	*Athene brama*	10	0.55	BU	F	A

Order	Family	Scientific name	NI	RA	MH	OS	Season
Pelecaniformes	Ardidae	*Bubulcus ibis*	5	0.28	BU	F	S, W
Pelecaniformes	Ardidae	*Butorides striata*	2	0.11	BU	F	R,S
Cuculiformes	Cuculidae	*Cacomantis merulinus*	4	0.22	BU	F	S, W
Cuculiformes	Cuculidae	*Cacomantis passerinus*	2	0.11	BU	F	R
Caprimulgiformes	Cprimulgidae	*Caprimulgus macrurus*	2	0.11	BU	F	W
Cuculiformes	Cuculidae	*Centropus bengalensis*	2	0.11	BU	F	W
Cuculiformes	Cuculidae	*Centropus sinensis*	9	0.50	BU	UC	A
Coraciformes	Alcedinidae	*Ceryle rudis*	3	0.17	BU	F	W
Charadriformes	Chardridae	*Charadrius dubius*	2	0.11	BU, MF	F	W
Piciformes	Picidae	*Chrysocolaptes guttacristatus (lucidus)*	3	0.17	BU	F	S, W
Passeriformes	Cisticolidae	*Cisticola juncidis*	7	0.39	BU	F	S, W
Cuculiformes	Cuculidae	*Clamator jacobinus*	2	0.11	T	F	S
Columbiformes	Columbidae	*Columba livia*	13	0.72	AG, T	F	S, W
Passeriformes	Muscicapidae	*Copsychus malabaricus*	3	0.17	T	F	S, W
Passeriformes	Muscicapidae	*Copsychus saularis*	65	3.60	AG, BU, T	C	A
Coraciformes	Coracidae	*Coracias affinis*	6	0.33	T	F	S, W
Passeriformes	Campephagidae	*Coracina macei*	1	0.06	T	F	S
Passeriformes	Campephagidae	*Coracina melanoptera*	2	0.11	T	F	W
Passeriformes	Campephagidae	*Coracina melaschistos*	2	0.11	T	F	W
Passeriformes	Corvidae	*Corvus levaillantii*	34	1.88	T	C	A
Passeriformes	Corvidae	*Corvus splendens*	33	1.83	T	F	R, W
Cuculiformes	Cuculidae	*Cuculus canorus*	2	0.11	T	F	W
Cuculiformes	Cuculidae	*Cuculus micropterus*	13	0.72	T	UC	R, S
Passeriformes	Muscicapidae	*Culicicapa ceylonensis*	2	0.11	T	F	W
Passeriformes	Muscicapidae	*Cyornis rubeculoides*	1	0.06	BU	F	W
Caprimulgiformes	Apodidae	*Cypsiurus balasiensis*	14	0.77	T	F	S, W
Passeriformes	Corvidae	*Dendrocitta vagabunda*	14	0.77	T	UC	S, W
Piciformes	Picidae	*Dendrocopos macei*	12	0.66	T	UC	R, S
Anseriformes	Anatidae	*Dendrocygna javanica*	11	0.61	AG, T	F	R, S
Passeriformes	Dicaeidae	*Dicaeum erythrorhynchos*	4	0.22	T	F	W
Passeriformes	Dicruridae	*Dicrurus aeneus*	44	2.43	T	C	A
Passeriformes	Dicruridiae	*Dicrurus hottentottus*	14	0.77	T	UC	S
Passeriformes	Dicruridiae	*Dicrurus leucophaeus*	4	0.22	T	F	W
Passeriformes	Dicruridiae	*Dicrurus macrocercus*	82	4.54	T	VC	A

Order	Family	Scientific name	NI	RA	MH	OS	Season
Piciformes	Picidae	*Dinopium benghalense*	22	1.22	T	UC	A
Pelecaniformes	Ardidae	*Egretta garzetta*	1	0.06	AG	F	R
Accipitriformes	Accipitridae	*Elanus caeruleus*	1	0.06	T	F	W
Cuculiformes	Cuculidae	*Eudynamys scolopaceus*	7	0.39	T	F	S, W
Passeriformes	Muscicapidae	*Eumyias thalassina*	11	0.61	T	UC	W
Passeriformes	Muscicapidae	*Ficedula albicilla*	20	1.11	AG, T	UC	W
Charadriformes	Scolopacidae	*Gallinaga gallinaga*	1	0.06	MF	F	W
Galliformes	Phasianidae	*Gallus gallus*	2	0.11	BU	F	W
Coraciformes	Alcedinidae	*Halcyon smyrnensis*	18	1.00	FP, T	C	A
Accipitriformes	Accipitridae	*Haliastur indus*	7	0.39	T	F	A
Passeriformes	Vangidae	*Hemipus picatus*	2	0.11	T	F	W
Cuculiformes	Cuculidae	*Hierococcyx varius*	37	2.05	T	VC	A
Passeriformes	Monarchidae	*Hypothymis azurea*	9	0.50	AG, T	F	R
Accipitriformes	Accipitridae	*Ichthyophaga ichthyaetus*	7	0.39	T	UC	A
Piciformes	Picidae	*Jynx torquilla*	1	0.06	AG	F	W
Passeriformes	Lanidae	*Lanius cristatus*	5	0.28	BU, T	F	W
Passeriformes	Lanidae	*Lanius schach*	4	0.22	AG, T	F	S, W
Passeriformes	Lanidae	*Lanius tephronotus*	10	0.55	AG, BU	F	W
Passeriformes	Estrilidae	*Lonchura malabarica*	4	0.22	AG	F	S
Passeriformes	Estrilidae	*Lonchura punctulata*	10	0.55	T	F	R, W
Passeriformes	Estrilidae	*Lonchura striata*	3	0.17	T	F	R
Passeriformes	Muscicapidae	*Luscinia calliope*	4	0.22	T	F	W
Passeriformes	Muscicapidae	*Luscinia svecica*	5	0.28	BU, T	F	R, W
Passeriformes	Pellorneidae	*Malacocincla abbotti*	2	0.11	BU	F	W
Passeriformes	Motacilidae	*Maotacilla falva*	1	0.06	MF	F	W
Passeriformes	Motacilidae	*Maotacilla maderaspatensis*	2	0.11	MF	F	W
Coraciformes	Meropidae	*Merops orientalis*	19	1.05	T	F	W
Charadriformes	Jacanidae	*Metopidius indicus*	9	0.50	FP	F	S, R
Suliformes	Phalacrocoracidae	*Microcarbo niger*	25	1.38	FP, T	UC	A
Piciformes	Picidae	*Micropternus (Celeus) brachyurus*	8	0.44	T	UC	S, W
Accipitriformes	Accipitridae	*Milvus migrans*	38	2.10	T	UC	A
Passeriformes	Timalidae	*Mixornis gularis*	3	0.17	BU	F	R
Passeriformes	Motacilidae	*Motacilla alba*	2	0.11	MF	F	W
Passeriformes	Motacilidae	*Motacilla cinerea*	2	0.11	MF	F	W
Passeriformes	Motacilidae	*Motacilla citreola*	3	0.17	MF	F	W
Passeriformes	Nectarinidae	*Nectarinia asiatica*	6	0.33	T	F	S, W
Passeriformes	Nectarinidae	*Nectarinia zeylonica*	21	1.16	AG, T	F	S, W
Strigiformes	Srtigidae	*Ninox scutulata*	2	0.11	T	F	W
Accipitriformes	Accipitridae	*Nisaetus cirrhatus*	2	0.11	T	F	W
Passeriformes	Oriolidae	*Oriolus xanthornus*	32	1.77	T	C	A

Order	Family	Scientific name	NI	RA	MH	OS	Season
Passeriformes	Cisticolidae	*Orthotomus sutorius*	58	3.21	T	C	A
Passeriformes	Paridae	*Parus major*	17	0.94	T	UC	A
Passeriformes	Passeridae	*Passer domesticus*	9	0.50	T	F	R, W
Coraciformes	Alcedinidae	*Pelargopsis capensis*	19	1.05	T	C	A
Passeriformes	Pellorneidae	*Pellorneum ruficeps*	2	0.11	BU	F	R
Passeriformes	Campephagidae	*Pericrocotus cinnamomeus*	83	4.59	AG, T	UC	S, W
Passeriformes	Campephagidae	*Pericrocotus roseus*	18	1.00	T	F	W
Accipitriformes	Accipitridae	*Pernis ptilorhyncus*	1	0.06	T	F	W
Cuculiformes	Cuculidae	*Phaenicophaeus tristis*	18	1.00	T	UC	S, W
Passeriformes	Phylloscopidae	*Phylloscopus fuscatus*	15	0.83	BU, T	F	W
Passeriformes	Phylloscopidae	*Phylloscopus inornatus*	2	0.11	BU	F	W
Passeriformes	Phylloscopidae	*Phylloscopus reguloides*	2	0.11	BU	F	W
Passeriformes	Phylloscopidae	*Phylloscopus trochiloides*	2	0.11	T	F	W
Piciformes	Picidae	*Picoides canicapillus*	7	0.39	T	F	W
Piciformes	Picidae	*Picus guerini (canus)*	2	0.11	T	F	S
Piciformes	Picidae	*Picus xanthopygaeus*	9	0.50	T	UC	R, W
Passeriformes	Pittidae	*Pitta brachyura*	9	0.50	T	F	R, S
Passeriformes	Cisticolidae	*Prenia gracilies*	2	0.11	BU	F	S
Passeriformes	Cisticolidae	*Prenia hodgsonii*	2	0.11	BU	F	W
Passeriformes	Cisticolidae	*Prenia inornata*	2	0.11	BU	F	W
Piciformes	Megalaimidae	*Psilopogon (Megalaima) haemacephala*	14	0.77	T	F	A
Piciformes	Megalaimidae	*Psilopogon asiaticus*	16	0.88	T	UC	A
Piciformes	Megalaimidae	*Psilopogon lineatus*	62	3.43	T	C	A
Psittaciformes	Psittacidae	*Psittacula alexandri*	14	0.77	T	F	W
Psittaciformes	Psittacidae	*Psittacula kramer*	19	1.05	T	UC	A
Passeriformes	Pycnonotidae	*Pycnonotus cafer*	80	4.42	AG, T	C	A
Passeriformes	Pycnonotidae	*Pycnonotus jocosus*	15	0.83	T	F	W
Passeriformes	Rhipiduridae	*Rhipidura albicollis*	2	0.11	AG	F	S
Charadriformes	Rostratulidae	*Rostratula benghalensis*	1	0.06	AG	F	S
Passeriformes	Muscicapidae	*Saxicola caprata*	3	0.17	T	F	W
Columbiformes	Columbidae	*Spilopelia chinensis*	33	1.83	AG, T	C	A
Accipitriformes	Accipitridae	*Spilornis cheela*	5	0.28	T	UC	A
Columbiformes	Columbidae	*Streptopelia decaocto*	4	0.22	AG	F	W
Columbiformes	Columbidae	*Streptopelia tranquebarica*	4	0.22	AG	F	W
Passeriformes	Sturnidae	*Sturnus contra*	64	3.54	AG, T	VC	A
Cuculiformes	Cuculidae	*Surniculus lugubris*	2	0.11	T	F	S

Order	Family	Scientific name	NI	RA	MH	OS	Season
Passeriformes	Vangidae	*Tephrodornis gularis*	2	0.11	T	F	W
Passeriformes	Vangidae	*Tephrodornis pondicerianus*	17	0.94	T	UC	W
Columbiformes	Columbidae	*Treron bicinctus*	2	0.11	T	F	W
Columbiformes	Columbidae	*Treron phoenicopterus*	37	2.05	T	UC	S, W
Charadriformes	Scolopacidae	*Tringa glareola*	2	0.11	MF	F	W
Charadriformes	Scolopacidae	*Tringa ocropus*	1	0.06	MF	F	W
Passeriformes	Timalidae	*Turdoides striata*	110	6.08	AG, T	VC	A
Bucerotiformes	Upupidae	*Upupa epops*	3	0.17	AG	F	R, W
Charadriformes	Chardridae	*Vanellus cinereus*	2	0.11	AG	F	W
Charadriformes	Chardridae	*Vanellus indicus*	8	0.44	AG	UC	A
Passeriformes	Turdidae	*Zoothera citrina*	9	0.50	T	F	A
Passeriformes	Zosteropidae	*Zosterops palpebrosus*	24	1.33	T	F	S, W

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