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Bird-Ecosystem Relationship in an Urbanizing Habitat: Implications for Conservation and Ecosystem Stability

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Authors' contributions

This work was carried out in collaboration among all authors. Authors KM, JD and FY had collected the data. Authors RD and AKH had prepared the whole paper and author DD performed all the statistical works. All authors read and approved the final manuscript.

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ABSTRACT

This study explores the association between birds and their urbanizing ecosystems. The study area was divided into 4 quadrats of area 2700 m^2 each. Bird species as well as number of individuals of each species were counted using the Line Transect Method. Statistical analysis of the data was performed using Windows Microsoft Excel and SPSS v.28. The investigation revealed a significant correlation ($P < 0.05$) between bird species and the four distinct sites within the study area. These

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sites exhibit variations in vegetation composition and include notable features like water bodies. The findings underscore the heavy reliance of certain bird species in this region on specific types of vegetation for their survival and well-being. Removing even a single plant species could potentially disrupt the entire ecosystem. The study documented the presence of 42 bird species across 30 families, including one vulnerable species. Both local and seasonal migratory birds were observed during the research. Although the study identified a decline in bird diversity within the study area, it remains species-rich, displaying moderate to high diversity (Simpson's Dominance Index: 0.0319; Margalef's Richness Index: 4.0754). This research emphasizes the critical importance of conserving bird species and their associated vegetation to maintain ecosystem integrity. Strategic sustainable development practices along with habitat enrichment for birds is recommended to maintain the valuable avifaunal diversity of the study area. By highlighting the intricate relationship between birds and their habitat, the study highlights the significance of conservation efforts in safeguarding the overall health of the ecosystem.

Keywords: Bird-ecosystem relationship; disturbed ecosystem; conservation; species diversity; sustainable development.

1. INTRODUCTION

India is a mega biodiversity region. 13% of the total birds of the world is found in India [1]. Assam, which falls within the Indo-Burma Biodiversity Hotspot, has more than 900 species of birds [2]. The global distribution of 24 species is limited to the region, and the Eastern Himalayas and Assam Plains are known as the Endemic Bird Areas [3]. Bird diversity is widely used as an indicator of a healthy ecosystem [4,5,6,7]. Change in vegetation may alter the composition of the bird community [8]. Birds are one of the most common wildlife in urban areas. Bird populations have been declining as a result of landscape changes due to urban expansion to meet the growing needs of people [9].

Bird species abundance and vegetation characteristics are strongly associated and often show a nonlinear relationship [10]. Specific species of birds depend on specific plants and vice-versa. For example- the relationship between plants that offer food to birds, such as nectar or the pulp of fleshy fruits, and birds that in turn proide beneficial services to the plants, like pollen transfer or seed dispersal leading to reproduction, has intrigued biologists since Darwin's era [11]. Bird mutualistic linkages are highly heterogeneous, nested, and asymmetric. They are also highly sensitive to anthropogenic impact and are especially affected by habitat loss and fragmentation, defaunation and biological invasions [12]. Human activities such as farming, settlement, charcoal making, pole cutting and firewood collection have extensively damaged the natural habitat of birds, affecting their variety and variability [13]. A growing number of studies show that human disturbances induce behavioural responses in species. However, only a few species show behavioural adaptations that make them suitable for severely disturbed environments [14]. Currently, 12% of bird species are at threat of extinction due to anthropogenic impact [15].

The study area of Nowgong College campus, despite being disturbed, exhibits a variety of flora and fauna. Literature is very sparse regarding the avifaunal diversity of the campus and its interaction with the vegetation and ecosystem of the protected habitat in the middle of the busy town. It is important to document the recent status so that future researchers can compare the future data with it and thereby proper future conservation strategies can be made. It has a pond ecosystem which is seen to harbour several aquatic birds. Other types of habitat present are dense vegetation area and open field. The present investigation is a study of avifaunal diversity and the association of birds with the different habitats of the campus.

2. MATERIALS AND METHODS

Study area: The study has been carried out on the Nowgong College campus (declared as university in 2023) (Fig. 1), situated in the centre of the rapidly urbanizing Nagaon town, Assam, India. Nagaon is located at 26.3480˚ N latitude and 92.6838˚ E longitude. The town has an average altitude of the district is 60.6 m and an area of 42786.4 m^2. The pond in the study area covers an area of 8056.47 m^2; the institutional buildings cover 11868.5 m^2; the college garden covers 2737.71 m^2; the open space with scattered vegetation covers 15899.1 m^2. The study area has about 65 species different kinds

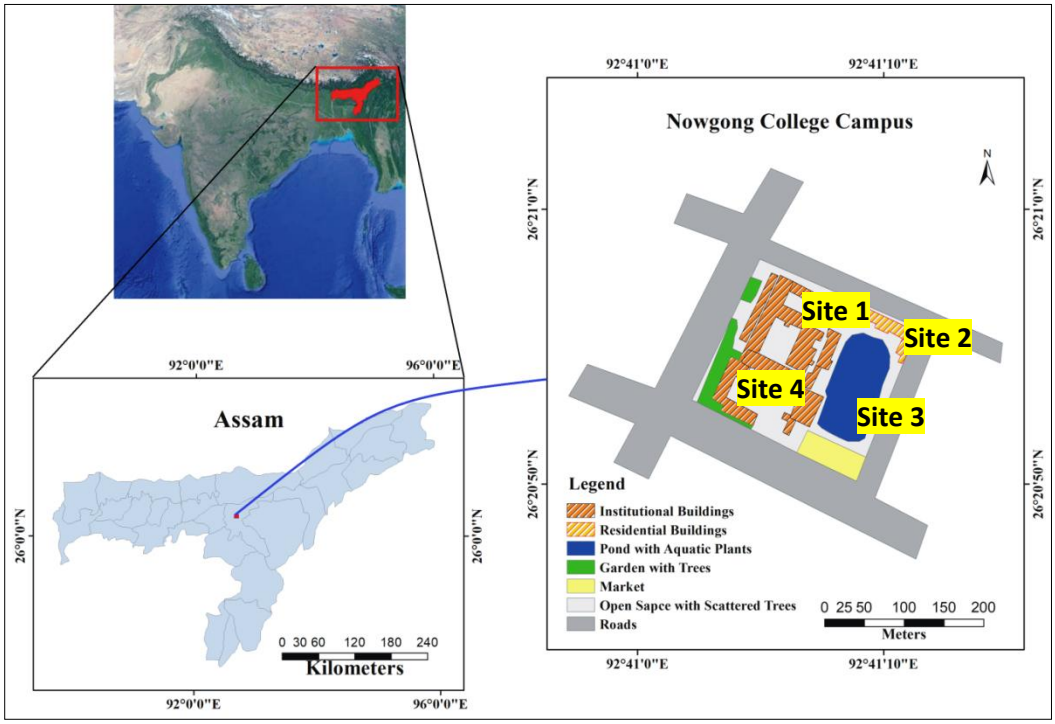

Fig. 1. Map of the study area

of vegetation. Nowgong College is situated just 72.7 km away from Kaziranga National Park. The Bura Chapori Wildlife Sanctuary is just 32.6 km away from the college campus.

Climate: The climate is tropical in Nagaon. The average annual temperature is 26.1°C (78.9°F) and rainfall here is around 2466 mm.

Data collection: The present study was carried out from April 2021 to March 2022. The study area was divided into 4 quadrats of area 2700 m^2 each: site 1, site 2, site 3 and site 4. Site 1 and 4 comprise of buildings, open habitat (fields) and most of the dense vegetation of the area. Site 2 is occupied partly by some portion of a pond and some shrubbery and trees. Most of site 3 is occupied by the pond. Birds were counted using the Line Transect Method. The data of birds were collected during morning and evening hours. Data were collected using binocular (10X50), camera (Nikon 3400, 70-300 mm lens) and noted down on field notebooks. Birds were identified by seeing their characteristics and features by the identification keys [1]. Records were not made on the days with fog, rain and strong wind to lessen the bias caused by the effect of extreme weather [16]. IUCN Red List Version 2023-1 was considered in preparation of the checklist of birds was followed.

Statistical Analysis: Statistical analysis of the data was performed using Windows Microsoft Excel and SPSS v.28. Simpson's Dominance Index, Margalef's Richness Index were calculated to assess diversity of bird species and dominance. Chi-square test was performed to determine the association between species of birds and the sites. Cannonical Correlation Analysis was performed to discern the association of each species to a particular site.

3. RESULTS AND DISCUSSION

A total of 42 species of birds, belonging to 30 families and orders were identified in the study area in the study (Table 1). The study revealed the presence of both local and seasonal migratory birds. Of the 42 species identified, 3 are winter visitors viz. *Motacilla alba, Dendrocygna javanica, Culicicapa ceylonensis,* and the rest 39 species are residential. Every winter, the seasonal migrants visit the campus in large numbers. The Lesser Adjutant Stork *(Leptoptilos javanicus)* found in the study area has been listed as Vulnerable (VU) in the IUCN Red List of Threatened Species. Among all the bird families, the most prevailing family is Sturnidae, which covers 10% of all the families in the studied area.

Table 1. Different species of birds in the study area, their individuals numbers at each site and their IUCN status

Sl. No.	Common Name	Scientific Name	Family Name	Site 1 (2700 $m^{2)}$	Site 2 (2700 $m^{2)}$	Site 3 (2700 $m^{2)}$	Site 4 (2700 $m^{2)}$	IUCN Status	No. of individuals
1	Jungle Myna	*Acridotheres fuscus*	Sturnidae	707	350	200	400	LC	1607
2	Common Myna	*Acridotheres tristis*	Sturnidae	919	297	90	584	LC	1890
3	Asian Pied Starling	*Gracupice contra*	Sturnidae	299	110	45	251	LC	705
4	Grey-headed Starling	*Sturnia malabarica*	Sturnidae	298	109	46	343	LC	796
5	House Crow	*Corvus splendens*	Corvidae	460	413	196	431	LC	1500
6	Large-billed Crow	*Corvus macrorhynchos*	Corvidae	279	109	55	211	LC	654
7	Rufous Treepie	*Dendrocitta vagabunda*	Corvidae	103	79	43	108	LC	333
8	Blue-throated barbet	*Megalaima asiatica*	Megalaimidae	89	19	7	75	LC	190
9	Coppersmith barbet	*Megalaima haemacephalae*	Megalaimidae	29	6	3	20	LC	57
10	Lineated barbet	*Megalaima lineata*	Megalaimidae	148	67	21	104	LC	340
11	Black drongo	*Dicrurus macrocercus*	Dicruridae	129	59	55	225	LC	468
12	Hair-Crested drongo	*Dicrurus hottentottus*	Dicrueidae	102	68	11	116	LC	297
13	Spotted dove	*Spilopalia chinensis*	Columbidae	492	180	22	401	LC	1095
14	Yellow-footed green pigeon	*Treron phoenicoptera*	Columbidae	96	9	3	52	LC	160
15	Red-vented bulbul	*Pycnonotus cafer*	Pycanonotidae	561	352	29	109	LC	1051
16	Spotted owlet	*Athene brama*	Strigidae	69	15	0	36	LC	120
17	Oriental magpie robin	*Copsuschus saularis*	Muscicapidae	591	197	33	455	LC	1276
18	Black kite	*Milvus migrans*	Accipitridae	46	11	4	90	LC	151
19	Common tailor bird	*Orthotomus sutorius*	Cisticolidae	90	245	622	89	LC	1046
20	Asian koel	*Eudynamys scolopaceus*	Cuculidae	49	21	2	24	LC	96
21	Black-hooded oriole	*Oriolus xanthornus*	Oriolidae	145	89	28	195	LC	457
22	Scaly-breasted munia	*Lonchura punctulata*	Estrildidae	66	9	6	31	LC	112
23	Rose-ringed parakeet	*Psittacula krameri*	Psittaculidae	212	215	521	72	LC	1020
24	White-breasted waterhen	*Amaurornis phoenicurus*	Rallidae	45	234	298	80	LC	657
25	Pheasant-tailed jacana	*Hydrophasianus chirurgus*	Jacanidae	31	260	328	39	LC	658
26	Indian pond heron	*Ardeola grayii*	Ardeidae	37	303	307	31	LC	677
27	White wagtail	*Motacilla alba*	Motacilidae	68	103	87	202	LC	416
28	Bronze-winged jacana	*Metopidius indicus*	Jacanidae	19	107	221	29	LC	376
29	Brown Shrike	*Lanius cristatus*	Laniidae	91	31	11	65	LC	198
30	Lesser adjutant storck	*Leptoptilos javanicus*	Ciconiidae	5	20	30	3	VU	60
31	Lesser whistling teal	*Dendrocygna javanica*	Anatidae	0	148	57	0	LC	1005
32	Fulvous- whistling duck	*Dendrocygna bicolor*	Anatidae	0	303	498	0	LC	801
33	Common Iora	*Aegithina tiphia*	Aegithinidae	48	29	6	27	LC	110
34	Cinereous tit	*Parus cinereus*	Paridae	94	67	33	62	LC	256
35	Purple sunbird	*Cinnyris asiaticus*	Nectariniidae	194	224	119	193	LC	750

Sl. No.	Common Name	Scientific Name	Family Name	Site 1 (2700 $m^{2)}$	Site 2 (2700 $m^{2)}$	Site 3 (2700 $m^{2)}$	Site 4 (2700 $m^{2)}$	IUCN Status	No. of individuals
36	Oriental white-eye	*Zosterops palpebrosus*	Zosteropidae	115	127	61	44	LC	347
37	Grey-headed canary flycatcher	*Culicicapa ceylonensis*	Stenostiridae	57	68	12	94	LC	231
38	Blue-tailed bee-eater	*Merops philippinus*	Meropidae	98	25	64	124	LC	311
39	Lesser golden-backed Woodpecker	*Dinopium benghalense*	Picidae	15	147	7	122	LC	289
40	Abbott's babbler	*Malacocincla abbotti*	Pellorneidae	82	20	11	43	LC	156
41	Crimson Sunbird	*Aethopyga siparaja*	Nectariniidae	82	91	71	86	LC	330
42	Common Kingfisher	*Alcedo atthis*	Alcedinidae	24	82	212	32	LC	350

(LC: Least Concern; VU: Vulnerable)

Table 2. Diversity Indices of bird species in the study area

Diversity Indices of bird species	Value
Simpson's Dominance Index (D)	0.0319
Margalef's Richness Index ®	4.0754

Table 3. Diversity indices of bird species in four different sites of the study area

Site	Simpson's index (D)
Site 1	0.0596
Site 2	0.0786
Site 3	0.0734
Site 4	0.0492

Table 4. Chi-square Test showing association between species of birds and sites

Dimension	Singular Value	Inertia	Chi Square	Sig.	Proportion of Inertia		Confidence Singular Value	
					Accounted for	Cumulative	Standard Deviation	Correlation 2
1	.635	.403			.839	.839	.005	.088
2	.203	.041			.086	.925	.006	
3	.190	.036			.075	1.000		
Total		.481	11285.254	.000[a]	1.000	1.000		

a. 123 degrees of freedom

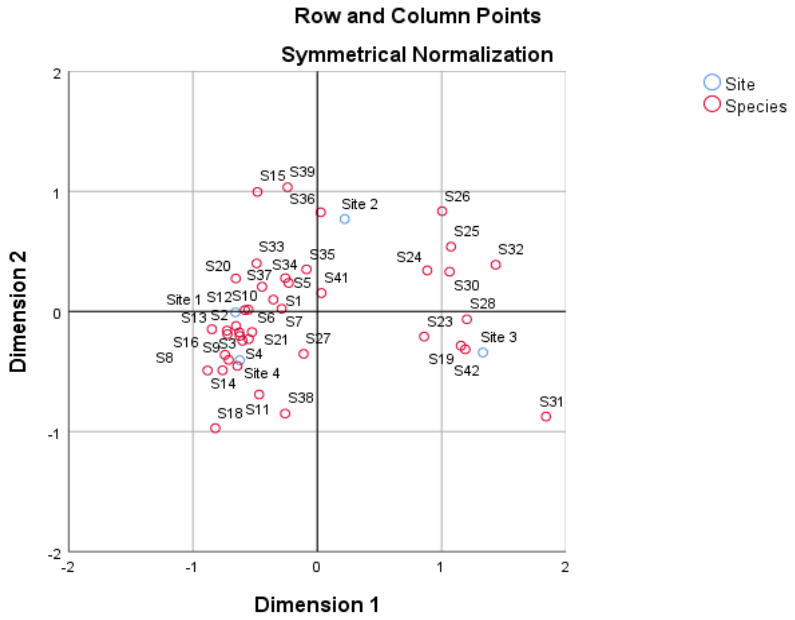

Fig. 2. Canonical Correlation Analysis (CCA) biplot showing relationship between the bird species and study sites

Birds utilize the surrounding vegetations like trees, herbs, shrubs of both terrestrial and aquatic areas for foraging, resting and nesting purposes. Frugivorous and omnivorous birds feed on fruits, grains, nectar, grass buds, etc. The migratory and residential birds utilize the vegetation of the campus. Large fruit bearing trees of our study area such *as Achras sapota L., Annona squamosa L., Artocarpus integrifolia L., Averrhoa carambola L., Carica papaya L., Mangifera indica L., Psidium guajava L., Nephelium litchi Camb.* Were seen to be utilized by Coppersmith Barbet, Lineated Barbet, Red-vented Bulbul, Asian Koel, Rose-ringed Parakeet, Common Iora, Cinerous Tit, Crimson Sunbird, Purple Sunbird, Oriental White-eye, Grey-headed Canary-flycatcher (occasionally), and woodpecker. The jungle myna, common myna, pied starling, and grey headed starling are omnivorous and consume fruits, nuts and seeds in addition to insects. These birds also feed on nectar and water which deposits on flowers such as poppy, Malabar nut, *Holmskioldia senguinea Retz.* flowers. In this process they facilitate pollination where their tuft of feathers acts as brush. All these four species of the starling family were often seen foraging on the ground for food. The Coppersmith barbet prefers berries and fig fruit. Red-vented bulbul feeds on all parts of plants. It feeds on fruits of trees of the study area and goes to shrubs and small plants for nectar and berries. The Spotted owlet nests inside holes of the *Caesalpinia pulcherrima* (L.) Sw. tree. The Oriental Magpie-robin is mainly insectivorous but was occasionally seen to feed on nectar from flowers of our study area. The pond in the study area is a haven for 8 species of water birds. The waterbirds seen were The White-breasted Waterhen, Pheasant-tailed Jacana, Indian Pond Heron, Bronze-winged Jacana, Lesser Whistling Duck, Fulvous Whistling Duck, Common Kingfisher, White Wagtail. These are dependent on the waterbody for foraging and nesting. They feed on fish, insects and aquatic macrophytes [17].

Table 2 shows the Simpson's Dominance index (D) for dominance and Margalef's index for evenness/equitability, which were calculated for bird species in the study area. A value of 0.0319 for Simpson's Index (D) indicates high species richness and diversity of birds in the study area. Margalef's index of 4.0754 indicates moderate to high diversity and moderate evenness. Table 3 represents diversity indices of species in four different sites. Site 2 and site 3 showed higher diversity as compared to site 1 and 2.

The Correspondence Analysis revealed relationship between different species of birds and different sites under study. Table 4 shows that the species of birds are positively correlated to the environmental changes with respect to the 4 study sites. The species-sites relationship was

quite evident for birds ($r = 0.088$, d.f. = 123, $P < 0.05$).

Fig. 2 shows the relative relationship between the species of birds and the 4 study sites. Species in the same quadrant implies similarities in their nature. From Fig. 2, Species 19, 23, 28, 31 and 42 are closely concentrated in site 3 implying that these species are visible in this site very frequently. Species 24, 25, 26, 30, 32, 36 and 41 are seen in the same quadrat with Site 2 implying that these species of birds prefer site 2 as compared to other sites. Again, it is observed that Species 15 and 39 are closer to site 1, hence there is evidence of association between these and site 1. Plot also depicts that Site 1 and Site 4 are similar in nature as the rest of the 17 species are very closely concentrated towards these two sites. Thus, more than 50% of the species under study have strong association with sites 1 and 4. This is expected as most of the vegetation falls under sites 1 and 4. The present study strongly recommends positive association between the two sets of multidimensional variables (species and sites). The association of bird species to sites of the study area may be attributed to the presence of respective favouring vegetation. For example, Species 1 (Jungle Myna) and 2 (Common Myna) are associated with sites 1 and 4 and this corresponds to the fact that vegetation such as *Annona squamosa L., Artocarpus integrifolia L., Averrhoa carambola L.,* which these species depend on, are present in sites 1 and 2. This observation is true for every species-site relationship in the study.

A decline in bird populations can be the result of climate change, habitat loss, fragmentation, pathogens, deterioration of habitat quality, and pollutants [18]. In urban areas many factors such as introduction of non-native species, alteration of vegetation species composition, human disturbance etc. determine avifaunal species diversity and the chance of certain species to flourish. Sometimes human interference such as the introduction of a bird feeder has been seen to indirectly increase the numbers of certain bigger avian species [19]. But in case of our study, the rapid urbanization of the surrounding area of the Nowgong College campus seems to be a threat to the bird species. It is noteworthy that the study area, despite being disturbed, is still species rich. A study by Blair (1996) described that along an urban gradient, species richness peaked in moderately disturbed areas and that the composition of the bird community shifted from predominantly native species in the undisturbed area to invasive and exotic species in the business district. The species observed in the present study were predominantly native except for 3 migratory species which were winter visitors.

Chettri [4] studied the relationship between birds and habitat in the Yuksom-Dzongri trekking corridor, Sikkim, India and found that bird species and diversity were significantly related to moderately disturbed habitats where vegetation heterogeneity was greater. This finding is in line with observations in the present study where we see greater number of species in site 2 and 3, where there is higher vegetation heterogeneity. Literature on bird and habitat relationships in Nowgong College campus is sparse. Rathod [20] had studied the avifaunal diversity of IIT Guwahati campus and had observed 152 bird species. The species diversity in that study was higher than the species diversity of the present study. This can be attributed to the fact that IIT Guwahati campus has mostly denser vegetation cover and is full of different habitats including several water bodies.

4. CONCLUSION

Birds play an essential role in maintaining the ecosystem and supporting biodiversity [21]. Due to urbanization, the landscape, distribution, abundance and resources of birds are all affected [22,23]. Birds are an excellent biological indicator. Species richness and evenness in the study area was found to be moderate to high. This is an interesting finding which is corroborated by literature suggesting that moderately disturbed urban landscapes show appreciable species richness [8,4]. The study area has dense vegetation, but this vegetation cover is decreasing gradually due to the construction of new buildings. The suitable climate and perfect habitat of the Nowgong College campus is the reason for the migration of seasonal migratory birds for breeding. The college authority needs to sustain these conditions. Conservation awareness programmes among the students and local people are required to sensitise the people to the conservation of birds and their significant role in nature. It is also pertinent to highlight the impact of anthropogenic activities like construction on bird habitats. There is a need for more research on habitat preference and habitat model of birds to give proper protection and conservation to the avian species.

Only strategic sustainable developmental activities around the study area are recommended to maintain its valuable avifaunal diversity. A study by Fernánd [24] illustrates that park size is the determining factor for species accumulation in urban parks. As increasing the size of parks is not always possible in urban areas, enhancement of habitat diversity and resource availability for birds within parks (e.g. nest boxes, winter feeding tables, etc.) might be an effective way of increasing urban bird diversity. A similar approach can be taken for increasing and maintaining bird diversity in our study area.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

We, hereby declare that NO generative AI technologies have been used during writing or editing the manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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