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PREDICTING AVIAN DIVERSITY WITH GEOSPATIAL TECHNOLOGIES

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ABSTRACT

Rapid urbanization accompanied by land use changes is affecting biodiversity worldwide specifically avian diversity. In the present study, the interactions of avian diversity with vegetation area were evaluated using geospatial technologies at different locations of Ludhiana city from April 2019 to March 2020. Integration of observations was done to analyze the avian diversity in relation to habitat components. Bird surveys conducted have recorded 46 bird species. There were 44 tree and 14 shrub species recorded, with vegetation and buildup area being the key determinants of diversity. Urban locations with balanced buildup area and vegetation were observed to support bird species diversity.

Key words: Avifauna, bird orders, Bray-Curtis dissimilarity index, buildup, correlation, feeding guilds, habitat, remote sensing, urbanization, vegetation

Bird diversity and its composition are affected by increase in urbanization at global level (Leveau et al., 2017). A city's biodiversity is linked to the habitat components and vegetation heterogeneity, which is influenced by the anthropogenic activities (Beninde et al., 2015). Urbanization expanding at global rate has affected bird diversity and composition drastically (Leveau et al., 2017). With considerable effect on biodiversity driven by increasing urbanization, there is a need to study the characteristics of urban green spaces which might be preserved or manipulated to improve biodiversity conservation outcomes (Lepczyk et al., 2017). Tree species assist in urban avifaunal maintenance and they provide food and water to birds and thus promote biodiversity of the city (Silva et al., 2020). Altaf et al. (2018) pointed about fragmentation of natural bionetwork of environment specifically the habitat preferred by avifaunal species in urbanized landscape because of removal of natural vegetation. Satellite based data on regionalization are more amendable to change as new remotely sensed data can be readily added to allow the regionalization to adapt to changes in terrestrial conditions either due to climate or land use change as this data captures fine-scale spatial patterns (Coops et al., 2018, Rocchini et al., 2018). A new approach for green space analysis in an urbanized environment has been presented in the form of a tool for mapping perceived quality of remote sensing (Stessens et al., 2020). In India, urbanization increased from 27.81% in 2001 to 31.16% in 2011 with an increase of 91 million in urban population leading to sudden rise in population growth rate and land use changes (Chandramouli 2016). Singh and Kalota (2019) deduced 8% growth rate of buildup area in Ludhiana by combining the remotely sensed data and geographic information system data in 2015. Thus, keeping this in view, geospatial technologies were utilized to analyze avian diversity in relation to vegetation and other habitat components in Ludhiana, Punjab.

MATERIALS AND METHODS

The study was carried out in Ludhiana city, Punjab (30.9010°N,75.8573°E) between April 2019 to March 2020. Ludhiana features a humid subtropical climate with roughly 890 mm of precipitation annually. Birds were studied along four selected locations taken as location 1, 2, 3 and 4. Rajguru Nagar (location 1) is a well-developed housing structure. Native and introduced vegetation observed. Agar Nagar (location 2) has maximum buildup area and least vegetation pertaining to highly urbanized residential area including high human disturbances. Dugri Estate (location 3) had modern housing structures with mature trees and newly planted saplings were observed. Residential houses lacking structural diversity and characterized by diversity of tree types both as rows along lanes and fruit trees dotting backyards were observed at Punjab Agricultural University Campus (PAU) (location 4).Two transects were taken per location and their data on bird species abundance and richness was pooled. The studied locations were categorized by buildup area, vegetation, parks, empty plots and road. Locations were visited four times in a month and line transect method was followed taking 1 km transect to record bird species using binoculars (7X50) (Verner 1985). The identification of birds was based on the keys given in Ali (1996). Identification of tree species at studied locations was done according to Sahni (1998). Birds species recorded were assigned to six broad feeding guilds: frugivore (F), carnivore (C), granivore (G), omnivore (O), insectivore (I), nectarivore (N) as classified by Shanahan et al. (2011). Remote sensing data was obtained from the Punjab Remote Sensing Centre, Ludhiana. It was processed through ArcGIS (Arc Map 10.4) to calculate various habitat components of the four selected locations. Each selected location was classified into buildup area, vegetation, parks, fellow land, road cover and divided into polygons and area of each cover type was calculated. To understand location wise bird diversity, comparison of species along with their feeding guilds was carried out. Pearson's Correlation analysis was used to evaluate the relationship between feeding guilds and their habitat components; also, between species richness and two set of variables (i.e. vegetation and buildup area). The dissimilarity across the studied locations using bird species richness was depicted by Bray-Curtis dissimilarity index (Bray and Curtis, 1957).

RESULTS AND DISCUSSION

A total of 46 bird species were recorded belonging to 29 families and 12 orders from April 2019 to March 2020 (Table 1). Columbiformes had five species namely eurasian collard dove, laughing dove, spotted dove, rock pigeon and yellow-legged green pigeon. Two raptor species black kite and shikra belonging to Accipitriformes were observed. Spotted owlet belonging to Strigiformes was observed only at location 3 (Table 1). Indian peafowl was observed only at location 3 and black francolin was observed only at location 4, both belonging to order Galliformes. Overall bird composition revealed that rock pigeon (28.13%) was the most abundant commensal species followed by common myna (14.92%) and house crow (10.60%). The structural features like road cover, vegetation cover, buildup, fellow land and park of all the studied locations were noted and their area was calculated. Road cover was maximum at location 3 (32.56%), followed by location 1 (27.75%), location 2 (18.48%) and location 4 (8.96%). Vegetation cover came out to be maximum at location 4 (61.92%), then location 3 (19.42%) followed by location 1 (15.06%) and location 2 (5.12%). Buildup was maximum at location 2 (68.59%) followed by location 1 (46.01%), location 3 (38.68%) and location 4 (21.20%). Fellow land was found covering maximum area at location 4 (5.88%), then location 1 (4.74%) followed by location 3(2.21%) and location 2 (2.14%). Parks covered most area at location 3 (7.13%) followed by location 1 (6.43%), location 2 (5.68%) and location 4 (2.05%). A total of 44 tree and 14 shrub species were recorded of which 30 tree species were native, one naturalized (gulmohar) and rest 13 were introduced. Among 14 shrub species, 6 species were native whereas one species is naturalized (earleaf acacia) and 8 species were introduced; 29 species were evergreen and 15 species were deciduous. 32 tree species out of 44 tree species were present at location 4 indicating rich vegetation heterogeneity and represented by maximum vegetation area (Table 2). From all the tree species recorded: banyan, peepal, banyan, chinaberry, mango and lemon were observed to be utilized by 25 bird species. Bray-Curtis dissimilarity index for bird orders revealed that maximum difference was observed between locations 1 and 3 followed by difference between locations 3 and 4, locations 2 and 4, locations 1 and 2, locations 2 and 3 and locations 1 and 4. Eight bird species were exclusive to location 4 and were not observed at other three locations. Rock pigeon and common myna were found in greater abundance at locations 1, 2 and 3 as these bird species seemed to be more adapted to buildup areas for their nesting, roosting, feeding and other requirements as was evident at location 2. Buildup area had been found to have a higher influence on the bird species richness. The correlation analysis between vegetation, buildup area and species richness showed a positive correlation of bird species richness with vegetation whereas it was vice versa for buildup area. Bird species observed belonged to various feeding guilds; frugivores (5), carnivores (4), omnivores (15), insectivores (14), nectarivores (1) and granivores (7). Correlation between feeding guilds and structural features revealed that carnivores were negatively correlated to vegetation as well as buildup. Frugivores and omnivorous were positively correlated to vegetation but negatively correlated to buildup (Table 3) as both frugivores and omnivoresseem to depend on vegetative cover for their feeding activities whereas granivores, insectivores and nectarivores were negatively correlated to vegetation but positively correlated to buildup. This study reflected that bird

Table 1. Bird diversity in Ludhiana, Punjab (April 2019 to March 2020)

S. No.	Common name	Scientific name	L1	L2	L3	L4	Trophic Group	Migratory Status
1	Asiankoel	*Eudynamys scolopaceus*	-	-	-	✓	F	R
2	Asian pied starling	*Gracupica contra*	-	-	✓	-	O	R
3	Bank myna	*Acridotheres ginginianus*	✓	-	✓	-	O	R
4	Blackdrongo	*Dicrurus macrocercus*	✓	✓	✓	✓	I	R
5	Black francolin	*Francolinus francolinus*	-	-	-	✓	O	R
6	Black kite	*Milvus migrans*	✓	✓	✓	✓	C	R
7	Black redstart	*Phoenicurus ochruros*	-	-	✓	-	O	WM
8	Brahminystarling	*Sturnia pagodarum*	-	✓	-	✓	O	R
9	Brown rock chat	*Oenanthe fusca*	-	✓	✓	-	I	R
10	Brown-headed barbet	*Psilopogon zeylanicus*	-	✓	-	✓	F	R
11	Cattle egret	*Bubulcus ibis*	✓	✓	✓	✓	O	R
12	Common chiffchaff	*Phylloscopus collybita*	✓	-	-	-	I	WM
13	Common hawk cuckoo	*Hierococcyx varius*	-	-	-	✓	I	R
14	Common hoopoe	*Upup aepops*	-	-	✓	✓	I	R
15	Common myna	*Acrido therestristis*	✓	✓	✓	✓	O	R
16	Common starling	*Sturnus vulgaris*	-	-	✓	-	O	WM
17	Common tailorbird	*Orthotomus sutorius*	✓	✓	✓	✓	I	R
18	Eurasian collared dove	*Streptopelia decaocto*	✓	✓	✓	✓	G	R
19	Greater coucal	*Centropus sinensis*	-	-	-	✓	O	R
20	Green bee-eater	*Merops orientalis*	-	-	✓	-	I	R
21	House crow	*Corvus splendens*	✓	✓	✓	✓	O	R
22	House sparrow	*Passer domesticus*	-	✓	-	✓	O	R
23	Indian grey hornbill	*Ocyceros birostris*	-	-	✓	✓	F	R
24	Indian peafowl	*Pavo cristatus*	-	-	✓	-	O	R
25	Indian robin	*Saxicoloides fulicatus*	✓	✓	✓	✓	I	R
26	Indian silverbill	*Euodice malabarica*	✓	✓	-	-	G	R
27	Jungle babbler	*Turdoides striata*	✓	✓	✓	✓	I	R
28	Large grey babbler	*Argyam alcolmi*	-	-	✓	-	I	R
29	Laughing dove	*Streptopelia senegalensis*	✓	✓	✓	✓	G	R
30	Lesser golden-backed woodpecker	*Dinopium benghalense*	-	-	-	✓	O	R
31	Oriental magpie robin	*Copsychus saularis*	-	✓	-	✓	I	R
32	Pied bushchat	*Saxicola caprata*	-	-	✓	-	I	R
33	Purple sunbird	*Cinnyrisasiaticus*	✓	✓	✓	✓	N	SM
34	Red-vented bulbul	*Pycnonotus cafer*	✓	✓	✓	✓	O	R
35	Red-wattledlapwing	*Vanellus indicus*	✓	✓	✓	✓	I	R
36	Rock pigeon	*Columba livia*	✓	✓	✓	✓	G	R
37	Rose-ringed parakeet	*Psittacula krameri*	✓	✓	✓	✓	F	R
38	Rufoustreepie	*Dendrocitta vagabunda*	-	✓	✓	✓	O	R
39	Scaly-breasted munia	*Lonchura punctulata*	-	✓	-	✓	G	R
40	Shikra	*Accipiter badius*	✓	-	✓	✓	C	R
41	Spotted dove	*Spilopelia chinensis*	✓	✓	✓	✓	G	R
42	Spotted owlet	*Athene brama*	-	-	✓	-	C	R
43	Tree pipit	*Anthus trivialis*	✓	✓	-	-	I	R
44	White-throated kingfisher	*Halcyon smyrnensis*	✓	✓	✓	-	C	R
45	Wire-tailed swallow	*Hirundo smithii*	✓	✓	✓	-	G	R
46	Yellow-legged green-pigeon	*Treron phoenicopterus*	-	-	-	✓	F	R

F=Frugivores; O=Omnivorous; N=Nectarivores; G= Granivores; C=Carnivores; I= Insectivorous; LC=Least Concern; R=Resident; SM=Summer Migrant; WM=Winter Migrant

Table 2. Association of bird species with tree species at selected locations

Tree Species → Bird Species ↓	Banyan (*Ficus benghalensis*)	Chinaberry (*Melia azedarach*)	Cluster Fig (*Ficus racemosa*)	Black Plum (*Syzygium cumini*)	Mango (*Mangifera indica*)	Peepal (*Ficus religiosa*)	Pilkhan (*Ficus virens*)
	Indian robin	House crow (L1, L3, L4)	Brown-headed barbet	Red-vented bulbul (L1)	House crow(L1)	Common myna (L1)	Asian koel
	Red-vented bulbul	Common myna (L1, L3)	Brahminy starling	Common tailorbird (L1, L4)	Purple sunbird (L1)	Red-vented bulbul (L2)	Rufoustreepie
	Common hoopoe	Red-vented bulbul (L1, L4)	Rose-ringed parakeet		Red-vented bulbul (L1, L2, L3)	House crow (L2)	Indian silverbill
	Black drongo	Rock pigeon (L2, L3)	Purple sunbird		Common tailorbird (L1, L3)	Common hoopoe (L4)	
	Black kite	Eurasian collard dove (L3)			House sparrow (L2, L4)	Yellow-legged green pigeon (L4)	
	Asian koel	Jungle babbler (L4)			Jungle babbler (L2)		
	Purple sunbird	Oriental magpie robin (L4)			Oriental magpie robin (L2)		
	Lesser golden-backed woodpecker						
	Indian grey hornbill						
	Common hawk cuckoo						

Table 3. Correlation coefficient: feeding guilds vs structural features

Structural features	Carnivores	Frugivores	Granivores	Insectivores	Nectarivores	Omnivores
Road	0.93	-0.88	0.10	0.95	0.22	-0.33
Vegetation	-0.48	0.91	-0.68	-0.87	-0.49	0.66
Buildup	0.05	-0.64	0.79	0.56	0.46	-0.62
Fellow land	-0.22	0.59	-0.15	-0.73	0.16	0.04
Park	0.81	-0.96	0.34	1.00	0.33	-0.47
Species Richness	-0.31	0.55	-0.92	-0.29	-1.00	0.98

distribution, composition and structure were affected by urbanization in Ludhiana city (Van Heezik et al., 2008). Kler (2006) recorded 29 bird species belonging to 15 orders from locations selected on periphery of the city. The present study showed that increase in urbanization affected the bird species richness, in which urban habitats were dominated by urban generalist species; thus, creating biotic homogenization as corroborated by Pal et al. (2019). Marzluff (2005) stated that extreme disturbances caused synanthropic bird species to become dominant. Heterogeneity in avifaunal composition was accentuated by Bray-Curtis dissimilarity index (Bray and Curtis, 1957) showing maximum difference between location 1 and 3. Presence of woodpeckers was only recorded at location 4 dominated by *Ficus* tree species providing sites for nesting. Urban areas having multistory buildings, high windows provide an easy site for nesting and also safeguarding the nests from predators (Akram et al., 2015). Frugivores were observed to be most abundant at location 4 with maximum vegetation. In the present study, urbanized area was numerically dominated by granivoresas well as omnivores as multistory buildings and window cliffs offered nesting sites and artificial food provisioning as corroborated by Pal et al. (2019) mentioning that species like common myna and red-vented bulbul also showed higher abundance values in studied urban areas which are likely to get benefitted from urbanization. Tresch et al. (2019) concluded that management actions in urban areas should improve landscape heterogeneity or reduce buildup area. Urban locations having balanced buildup area and vegetation might help in sustaining higher bird species richness and diversity in feeding guilds as found in studied location 3. Stessens et al. (2020) laid stress on appreciation of remote sensing techniques for urban design, planning and policy intervention which were also been corroborated by present study findings. The present study concluded that avian diversity and diverse feeding guilds were positively correlated to area under vegetation as compared to other habitat components utilizing geospatial technologies and field observations. Therefore, remote sensing and geospatial technologies might play a significant role in identifying urban areas for avian conservation.

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