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Prayas Auddy
[1] Department of Zoology, Asutosh College, Shyamaprasad Mukherjee Road, Kolkata, West Bengal, India
[2] Department of Animal Ecology and Conservation Biology, Wildlife Institute of India, Chandrabani, Dehradun, Uttarakhand, India

Corresponding Author:
Prayas Auddy
[1] Department of Zoology, Asutosh College, Shyamaprasad Mukherjee Road, Kolkata, West Bengal, India
[2] Department of Animal Ecology and Conservation Biology, Wildlife Institute of India, Chandrabani, Dehradun, Uttarakhand, India

A preliminary assessment on the seasonal dynamics of avian assemblages and feeding guilds in an urban lake ecosystem: A case study from Rabindra Sarobar Lake, Kolkata, West Bengal, India

Prayas Auddy

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Abstract
This study explores seasonal variations in avian diversity and feeding guild distribution at a human-altered lake ecosystem, i.e., Rabindra Sarobar Lake in Kolkata, West Bengal. Using the Point Count Method. 56 bird species were recorded across two seasons: Pre-Winter (August-October 2018) and Winter (November 2018-January 2019). Species richness declined by 22% in winter, with significant seasonal variation ($\chi^2 = 4.82$, $p < 0.05$). Common Crow densities increased significantly in winter, while House Crow showed a 50.2% decline. Insectivorous birds were the dominant feeding guild in both seasons, comprising 43.5% in pre-winter and 50% in winter, followed by frugivores and piscivores. A notable 62.5% decrease in frugivores during winter may be attributed to reduced fruit availability. The continued presence of insectivores and piscivores highlights the ecological value of urban habitats in supporting complex food webs. These findings highlight the importance of habitat heterogeneity and the preservation of green spaces in sustaining avian diversity in urban environments.

Keywords: Human-modification, urbanization, relative abundance, bird diversity, feeding behavior

1. Introduction

Urbanization represents one of the most profound human-induced changes to the environment, transforming landscapes through habitat fragmentation, increased impervious surfaces, altered resource availability, and introduced species (McKinney, 2002) [1]. These modifications significantly impact avian communities across multiple ecological dimensions, including species richness, community composition, and functional diversity (Chace and Walsh, 2006) [2]. While urban areas generally support lower bird diversity compared to natural habitats, the effects vary considerably depending on urbanization intensity, landscape context, and local habitat features (Marzluff, 2001) [3]. Urban green spaces like parks, gardens, and water bodies can serve as biodiversity refuges within the urban matrix, but their ecological value depends heavily on their size, structure, and connectivity (Auddy *et al*., 2025) [4].

The response of birds to urbanization varies dramatically across feeding guilds, with specialists typically showing greater sensitivity than generalists (Kark *et al*., 2007) [5]. Insectivores often decline in urban environments due to reduced arthropod abundance and diversity, particularly those species dependent on leaf-gleaning or bark-foraging (Sekercioglu, 2006) [6]. Conversely, omnivores and granivores frequently thrive in urban areas due to their dietary flexibility and ability to exploit anthropogenic food sources (Kark *et al*., 2007; Leveau, 2013) [5, 7]. Frugivores show mixed responses, with some species benefiting from ornamental fruiting plants while others struggle with the seasonal inconsistency of urban fruit resources (Corlett, 2005) [8]. These guild-specific responses to urbanization create novel community structures in urban ecosystems, with potential cascading effects on ecosystem functioning, including seed dispersal, pest control, and pollination (Whelan *et al*., 2008) [9].

Seasonal dynamics add further complexity to urban bird communities, particularly in regions with distinct wet and dry periods or significant temperature fluctuations. Temporal resource availability in urban ecosystems often differs from natural habitats, affecting both resident and migratory bird populations (Leveau and Leveau, 2016) [10].

For example, irrigation practices in parks and gardens can buffer seasonal drought effects, potentially creating resource oases for certain species during harsh periods (Caula *et al*., 2008) [11]. Conversely, the often-simplified vegetation structure in urban areas may exacerbate seasonal resource bottlenecks for specialists (Sandström *et al*., 2006) [12]. Understanding these seasonal patterns in guild structure is crucial for effective conservation planning in urban environments, where management decisions can significantly influence resource availability for different functional groups throughout the year (Beninde *et al*., 2015) [13]. The relationship between species diversity and habitat heterogeneity is fundamental to understanding spatial ecology, particularly within urban ecosystems where anthropogenic modifications create complex mosaics of habitat types. Habitat heterogeneity affects key ecological processes in various ways (Fahrig & Nuttle, 2005) [14], including influencing species population size (Cramer & Willig, 2005; Tews *et al*., 2004) [15, 16] and altering the structure and composition of feeding guilds (Sekercioglu *et al*., 2004) [17], which determine the dynamics of pollination, seed dispersion, and predation (Bailey *et al*., 2004; Ferrer & Donazar, 1996) [18, 19].

Urban green spaces represent critical islands of habitat heterogeneity within otherwise developed landscapes, potentially supporting diverse avian communities despite anthropogenic pressures (Auddy *et al*., 2021) [20]. Previous studies have demonstrated that birds respond variably to habitat heterogeneity in modified landscapes (Estrada *et al*., 2000; Graham & Blake, 2001; Luck & Daily, 2003; Gardner *et al*., 2009; Scales & Marsden, 2008) [21, 22, 23, 24, 25], but less attention has been given to seasonal variations in feeding guild distribution within urban ecosystems. In tropical and subtropical environments like Kolkata, urban water bodies such as Rabindra Sarobar Lake may stimulate certain habitat resources (Anderson, 2001, Koh *et al*., 2006) [26, 27], producing positive correlations with species diversity when suitable conditions are maintained (Tscharntke *et al*., 2008, Tylianakis *et al*., 2008; Bocelli *et al*., 2023) [28, 29, 30]. The heterogeneous nature of such urban lakes—featuring both aquatic zones and terrestrial vegetation—may provide varied microhabitats supporting different feeding guilds throughout seasonal cycles (Chakraborty & Majumder, 2018) [31]. This study aims to evaluate the seasonal distribution patterns of avian feeding guilds within Rabindra Sarobar Lake, an urban green space of national importance in Kolkata. We test the hypothesis that habitat heterogeneity significantly explains the variation in species abundance and composition across feeding guilds in this human-modified landscape. We predict that feeding guilds with diverse resource utilisation capabilities or wide ecological tolerance (e.g., omnivores) respond positively to increases in habitat heterogeneity, whereas more specialised guilds (e.g., frugivores, insectivores) may demonstrate more pronounced seasonal fluctuations based on resource availability. Understanding these patterns is crucial for urban conservation planning that aims to enhance biodiversity within increasingly urbanised landscapes.

2. Materials and Methods

Rabindra Sarovar, a lake of national importance, is the second largest water body in Kolkata and is situated in the southern part of the city (22°30′.30″ -22°30′.42″ N, 88°21′-88°22′ E). Rabindra Sarovar and its vicinity are a haven for floristic diversity, both aquatic and terrestrial, that provides a natural CO^2 sink for the metropolitan city, apart from its pristine beauty and aesthetic value. It also serves as a suitable habitat for a variety of amphibians, fish, reptiles, waterfowl, and migratory birds (Fig.1).

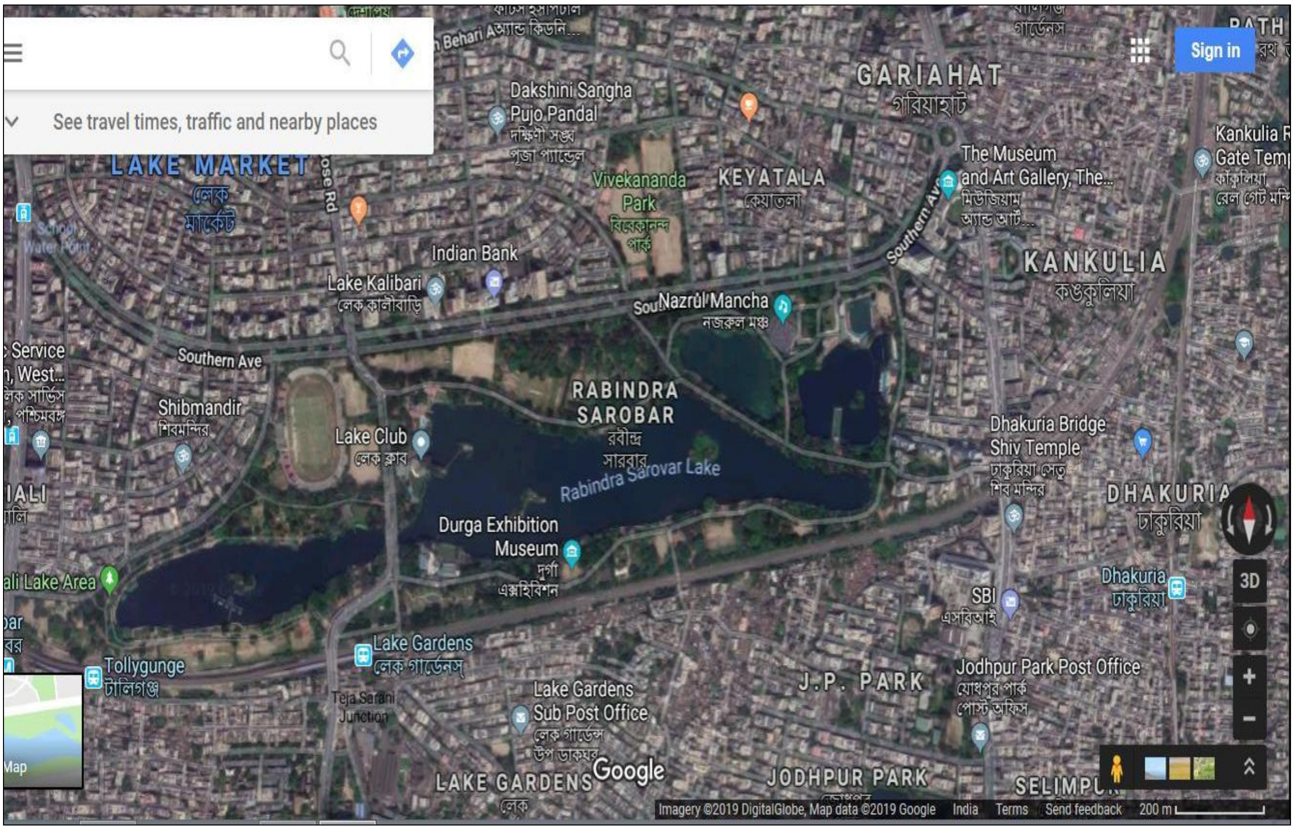

Fig 1: Google Earth view of the entire Rabindra Sarobar Lake showing all the development and infrastructure

There are four islands in the lake, one of which is connected to the shore by a hanging bridge. The remaining three islands are uninhabited and serve as important roosting and nesting grounds for resident water birds like cormorants, egrets, night herons, pond herons, painted storks, Asian openbills, and others. A stadium with a seating capacity of 30, 000 surrounds a football field, as well as athletic and cycling tracks. Land on the banks of the main lake has been leased since 1937 to several rowing clubs and to various swimming clubs, including the Indian Life Saving Society and Calcutta Sports Association, to promote swimming alongside a public swimming pool. There are two children's parks in the area equipped with seesaws, swings, and a lily pool on the south bank, including a miniature zoo. Additionally, there are two football grounds and one hockey ground in addition to the football field within the stadium. A fish sanctuary under the hanging bridge leading to the Mosque is one of the highlights of the area. The lake carries immense importance as an urban green space of the growingly urbanised city of Kolkata. It supports plentiful of urban biotic communities. The Ministry of Environment and Forests, Government of India, has recently included this lake under the National Lake Conservation Plan.

2.1 Bird diversity assessment: According to Sutherland (2006) [32], the Point Count Method (PCM) is the most efficient sampling technique for estimating avian density in most habitats, such as agricultural lands, gardens, orchards, plantations, and human settlements. PCM, or fixed radius methodology (FRM), requires observers to remain at one point while recording fixed distances in terms of concentric zones around that point (for example, 50 m, 100 m) up to a certain limit, beyond which the birds cannot be reliably identified. During August to October, 2018 (pre-winter) and December, 2018 to February, 2019 (winter), four to seven point-count stations were randomly selected at each site, starting from the islands through binoculars, to the fish sanctuary under the hanging bridge, ensuring a minimum distance of 500 m between them. Two study teams, each consisting of two members, simultaneously recorded avifaunal diversity at every site. At each point, observations were made for 10 minutes to spot, prepare checklists, and photograph birds that were difficult to identify immediately. After every 10 minutes, teams would change their positions while maintaining a minimum distance of 500 m. Thus, six individual readings were obtained by each team during their two-hour surveys in the morning and the afternoon. Sampling was conducted every weekend throughout the study period. The birds were identified using Olympus 10x50 DPSI binoculars and the field guides of Ali and Ripley (1983) [33], Grimmett *et al*., (2011) [34], and Kazmierczak (2000) [35].

2.2 Feeding guilds observation

Avifauna exploit resources from the habitat in various ways and feed on various types of natural components to avoid nutritional competition. Several feeding guilds have been reported from Rabindra Sarobar Lake and its adjoining areas, which tend to differ seasonally. We have referred to suitable literature to assign feeding guilds against each species.

3. Results & Discussion

The study documented a total of 56 avian species across the urban landscape, with statistically significant differences in species richness between pre-winter (PW) and winter (W) periods ($\chi^2 = 4.82$, $p < 0.05$). During the pre-winter period, 46 species were recorded, while the winter period yielded 36 species, representing a decline of ~22% in species richness (Table 1). This reduction in diversity corresponds with documented seasonal fluctuations in urban avifauna within the biogeographic region.

3.1 Abundance Patterns and Dominant Species

Quantitative analysis of abundance patterns revealed a pronounced dominance of certain species within the urban matrix. *Corvus splendens* (Common Crow) exhibited the highest density across both seasons (PW: 0.54 ha^-1^; W: 0.64 ha^-1^), showing a statistically significant increase of 18.5% in winter density ($t = 2.36$, $p < 0.05$). Among non-corvids, *Pycnonotus cafer* (Red-vented Bulbul) demonstrated the highest pre-winter density (0.15 ha^-1^), followed by *Acridotheres tristis* (Common Myna) at equal density. *Passer domesticus* (House Sparrow) maintained consistent density (0.10 ha^-1^) across both seasons, suggesting stable resource utilisation despite seasonal changes (Fig 2).

3.2 Feeding Guild Structure

Trophic guild analysis revealed a non-random distribution of feeding strategies within the urban avian community (Table 2). Insectivorous birds constituted the dominant feeding guild, comprising 43.5% (20 species) during pre-winter and 50.0% (18 species) during winter periods. This was followed by frugivores (PW: 17.4%, 8 species; W: 8.3%, 3 species) and piscivores (PW: 15.2%, 7 species; W: 16.7%, 6 species). Carnivores (PW: 8.7%, 4 species; W: 8.3%, 3 species), omnivores (PW: 6.5%, 3 species; W: 5.6%, 2 species), and aquatic feeders (PW: 4.3%, 2 species; W: 5.6%, 2 species) showed moderate representation, while granivores (2.2%, 1 species) and nectarivores (2.2%, 1 species) exhibited the lowest guild representation.

Table 1: Species composition, conservation status, and seasonal abundance of birds recorded in the urban landscape

Sl. No.	Common Name	*Scientific Name*	IUCN Status	PW (Average count per visit)	Density (ha-1)	W (Average count per visit)	Density (ha-1)
1	Asian Openbill Stork	*Anastomus oscitans*	LC	0	0	10	0.125
2	Cattle Egret	*Bubulcus ibis*	LC	2	0.025	2	0.025
3	Intermediate Egret	*Ardea intermedia*	LC	1	0.012	0	0
4	Black Kite	*Milvus migrans*	LC	1	0.012	1	0.012
5	Spotted Owlet	*Athene brama*	NT	1	0.012	1	0.012
6	Brown Hawk Owl	*Ninox scutulata*	LC	0	0	1	0.012
7	Crested Serpent Eagle	*Haliaeetus leucocephalus*	LC	1	0.012	0	0
8	Shikra	*Accipiter badius*	LC	1	0.012	0	0
9	Blue-throated Barbet	*Megalaima asiatica*	LC	3	0.037	0	0
10	Coppersmith Barbet	*Megalaima haemacephala*	LC	4	0.05	2	0.025
11	Eurasian Collared Dove	*Streptopelia decaocto*	LC	1	0.012	1	0.012
12	Spotted Dove	*Spilopelia chinensis*	LC	2	0.025	0	0
13	Rose Ringed Parakeet	*Psittacula krameri*	LC	5	0.062	0	0
14	Alexandrian Parakeet	*Psittacula eupatria*	LC	2	0.025	1	0.012
15	Yellow-footed Green Pigeon	*Treron phoenicoptera*	LC	1	0.012	0	0
16	House Sparrow	*Passer domesticus*	LC	8	0.1	8	0.1
17	Asian Koel	*Eudynamys scolopaceus*	LC	1	0.012	0	0
18	Black Drongo	*Dicrurus macrocercus*	LC	3	0.037	0	0
19	Black hooded Oriole	*Oriolus xanthornus*	LC	2	0.025	1	0.012
20	Black-naped Monarch	*Hypothymis azurea*	LC	0	0	2	0.025
21	Black-naped Oriole	*Oriolus chinensis*	LC	1	0.012	0	0
22	Brown breasted Flycatcher	*Muscicapa muttui*	LC	0	0	2	0.025
23	Common Tailor Bird	*Orthotomus sutorius*	LC	2	0.025	1	0.012
24	Eyebrowed Thrush	*Turdus obscurus*	LC	0	0	1	0.012
25	Fulvous-breasted Woodpecker	*Dendrocopos macei*	LC	2	0.025	0	0
26	Green bee-eater	*Merops orientalis*	LC	3	0.037	1	0.012
27	Common Hoopoe	*Upupa epops*	LC	0	0	1	0.012
28	Golden Oriole	*Oriolus kundoo*	LC	2	0.025	1	0.012
29	Jungle Babbler	*Argya caudata*	LC	6	0.075	3	0.037
30	Lineated Barbet	*Megalaima lineata*	LC	2	0.025	1	0.012
31	Olive-backed Pipit	*Anthus hodgsoni*	LC	0	0	1	0.012
32	Orange-headed Thrush	*Geokichla citrina*	LC	2	0.025	0	0
33	Oriental Magpie Robin	*Copsychus saularis*	LC	3	0.037	0	0
34	Pied Starling	*Lamprotornis bicolor*	LC	4	0.05	1	0.012
35	Purple Sunbird	*Cinnyris asiaticus*	LC	3	0.037	3	0.037
36	Red Vented Bulbul	*Pycnonotus cafer*	LC	12	0.15	4	0.05
37	Red-whiskered Bulbul	*Pycnonotus barbatus*	LC	1	0.012	2	0.025
38	Rufous Treepie	*Dendrocitta vagabunda*	LC	6	0.075	2	0.025
39	Scaly-breasted Munia	*Lonchura punctulata*	LC	1	0.012	0	0
40	Taiga Flycatcher	*Ficedula albicilla*	LC	0	0	1	0.012
41	Verditer Fycatcher	*Eumyias thalassinus*	LC	0	0	1	0.012
42	Common Crow	*Corvus splendens*	LC	43	0.54	51	0.64
43	Greater Coucal	*Centropus sinensis*	LC	1	0.012	0	0
44	Black-crowned Night Heron	*Nycticorax nycticorax*	LC	1	0.012	1	0.012
45	Great Cormorant	*Phalacrocorax carbo*	LC	0	0	3	0.037
46	Indian Cormorant	*Phalacrocorax fuscicollis*	LC	5	0.062	4	0.05
47	Indian Pond Heron	*Ardeola grayii*	LC	7	0.087	3	0.037
48	Little Cormorant	*Microcarbo niger*	LC	2	0.025	6	0.075
49	Stork-billed Kingfisher	*Pelargopsis capensis*	LC	1	0.012	0	0

50	White -throated Kingfisher	*Halcyon smyrnensis*	LC	4	0.05	2	0.025
51	Common Flameback woodpecker	*Dinopiun benghalense*	LC	3	0.037	0	0
52	Common Hawk Cuckoo	*Hierococcyx varius*	LC	1	0.012	0	0
53	Common Kingfisher	*Alcedo atthis*	LC	2	0.025	0	0
54	Blue Rock Pegion	*Columba livia*	LC	4	0.05	0	0
55	Common Mayna	*Acridotheres tristis*	LC	12	0.15	0	0
56	Little Egret	*Egretta garzetta*	LC	1	0.012	1	0.012

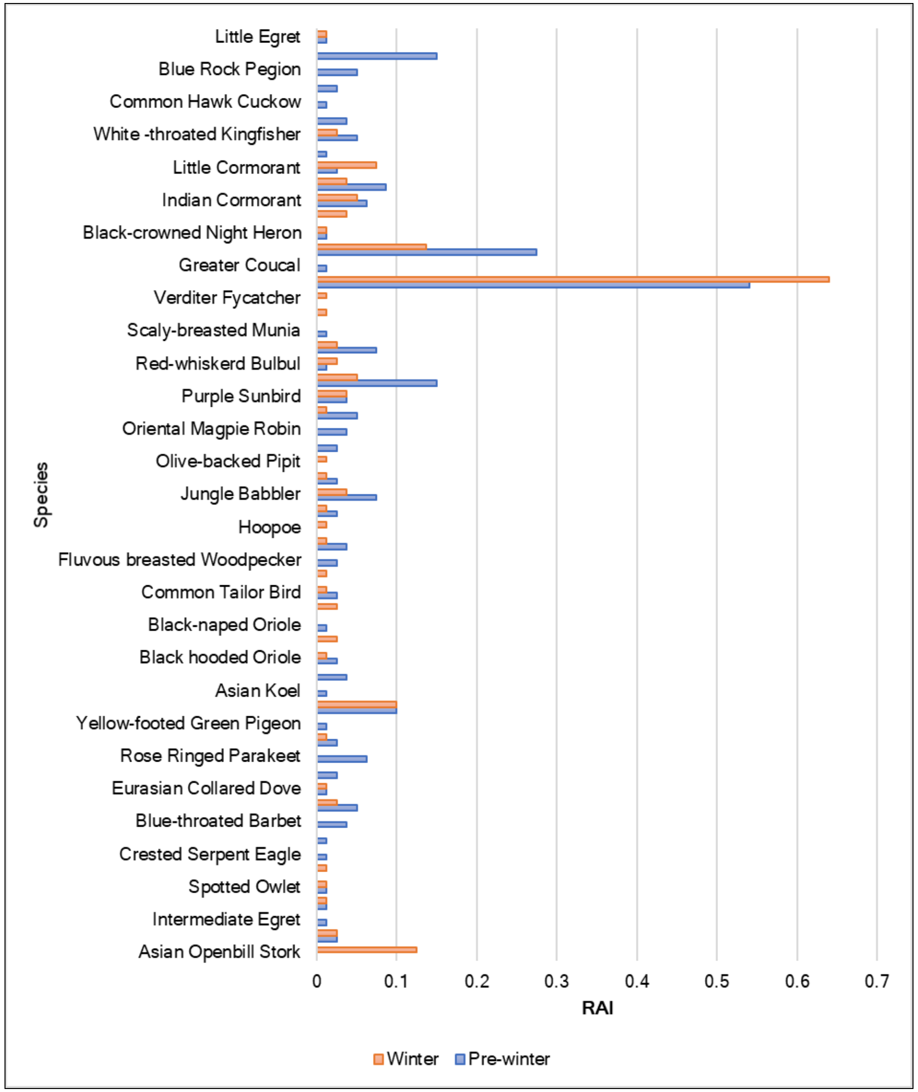

Fig 2: Seasonal comparison of abundance for dominant bird species in the urban landscape during pre-winter and winter periods

Table 2: Distribution of feeding guilds across pre-winter and winter seasons in the lake

Feeding Guilds	No. of species	
	Pre Winter	Winter
Aquatic	2	2
Carnivore	4	3
Frugivore	8	3
Granivore	1	1
Insectivore	20	18
Nectarivore	1	1
Omnivore	3	2
Piscivore	7	6
Total	46	36

4. Conclusion
The pronounced dominance of insectivorous birds in the urban avian community (43.5-50.0% of species) suggests that arthropod prey resources remain sufficiently abundant within the urban matrix to support specialised feeders. This finding contradicts the general assumption that urbanization severely depletes insect populations and indicates that urban green spaces maintain partial ecological functionality despite anthropogenic modifications (Panda *et al*., 2021) [36]. The substantial presence of piscivores (15.2-16.7%) further supports the ecological value of urban water bodies in maintaining aquatic food chains within the urban landscape. The significant reduction in frugivore representation during winter (62.5% decrease) may be attributed to seasonal fluctuations in fruit availability within the urban landscape. Many fruiting trees in the region exhibit reduced fruiting during winter months, potentially driving resource-tracking behavior among frugivorous birds. Conversely, the increased representation of certain insectivorous species during winter suggests potential influx of migratory insectivores utilizing urban resources during this period. The observed patterns of avian diversity and guild structure reflect complex ecological dynamics within urban ecosystems. The persistence of multiple trophic levels, from granivores to apex predators like *Haliaeetus leucocephalus* (Crested Serpent Eagle), suggests that urban landscapes maintain sufficient ecological complexity to support diverse avian communities (Hassall, 2014) [37]. The documented seasonal shifts in species composition and guild structure demonstrate that urban bird communities are dynamic assemblages responding to temporal changes in resource availability (Kler *et al*., 2015) [38].

Bird populations in fragmented landscapes respond resiliently to complex environmental combinations. Several distinct groups were formed based on their habitat relationships. The land-use cover associations of native species indicate that resource conditions are effectively met in natural as well as in human-modified environments (Karjee *et al*., 2022) [39]. For example, secondary forests (representing 5% of the study area) explained changes in species numbers (63% of the variance) for the entire bird community and key feeding guilds of insectivores, frugivores and nectarivores. High diversity in secondary forests results from their mixed composition, where 'weedy' plant species provide conditions for generalists and forest edge species, such as *Turdus grayi*. As expected, urban and suburban environments negatively affected species richness for insectivores and frugivores. This finding is consistent with previous evidence suggesting a reduction in native species and an increase in non- native or invasive species (Clergeau *et al*., 2001) [40]. Other landscape elements such as railway station, fields, children park and around the lake did not appear to be associated with changes in bird diversity, probably due to their small areas or because they represent low- quality habitat for most birds and other taxa (Caballero & León-Cortés, 2012; Pinkus-Rendón *et al*., 2006) [41, 42]. More information about bird abundance and the suitability of specific habitats is needed to better understand these functional relationships. An important implication of these findings is that certain cover types represent key landscape elements for increases in local bird diversity and for maintaining ecological guilds (Sekercioglu, 2006) [6]. The maintenance of diverse feeding guilds, particularly specialized feeders such as piscivores and carnivores, indicates that urban ecosystems can support complex trophic networks and ecological processes, contrary to the perception of urban areas as simplified ecosystems. The maintenance of diverse feeding guilds, particularly specialized feeders such as piscivores and carnivores, indicates that urban ecosystems can support complex trophic networks and ecological processes (Sangeetha & Sivachandran, 2024) [43], contrary to the perception of urban areas as simplified ecosystems. The differential seasonal responses across feeding guilds indicate that urban habitats do not affect all avian functional groups uniformly, with resource specialization playing a critical role in determining seasonal patterns of urban habitat utilization. Urban planning that incorporates habitat heterogeneity and preserves natural elements that support diverse feeding strategies may enhance the conservation value of urban landscapes for avifauna, including species of conservation concern (Murray *et al*., 2014) [44]. Despite anthropogenic pressures, the urban environment exhibits ecological resilience, supporting multi-level trophic interactions and accommodating seasonal dynamics in avian community structure, challenging simplified perspectives of urban ecosystems as solely degraded habitats.

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6. Author's contribution statement
PA conceived and supervised the study. PA, along with volunteers and students, conducted the data collection, and PA did the data analysis. PA wrote and formatted the manuscript. PA prepared the final draft and approved the final version of the manuscript.

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