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Research Paper

Bird community assemblage under various urbanization types in district Vehari, South Punjab, Pakistan

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Abstract

Vehari is a densely populated district in Punjab, Pakistan. A study was carried out to evaluate bird diversity in four land-use categories including urban with vegetation (UWV, Site 1), urban without vegetation (UWOV, Site 2), rural with less vegetation (RWLV, Site 3), and rural with more vegetation (RWMV, Site 4) during a period of one year. In total, 34 species and 33,452 individuals of birds were documented from the study sites. Species richness and diversity were found to be highest in Site 3 (RWLV/Fadda Town; S = 34; individuals = 11,918; Shannon H = 2.094; Simpson 1-D = 0.7251) and lowest in Site 4 (RWMV/Basti Hassan Abad; S = 20; individuals = 5,354; H = 1.832; Simpson 1-D = 0.7131). In terms of alpha diversity, Site 1 (UWV) recorded S = 23, H = 1.863 while Site 2 (UWOV) harbored S = 25, H = 1.921. The PCA ordination revealed a strong gradient of avian community composition along the habitat/urbanization axis explaining 98.72% of the total variations (PC1 = 95.812%; PC2 = 2.9154%). The current investigation suggests that the relationship between bird diversity and vegetation coverage might not be linear. It appears that the structure of the landscape, its closeness to canals, and to a certain extent, the local habitat use, are important regulators of the bird community structure in an urbanized habitat. Therefore, conservation strategies need to focus on habitat configuration and not only on the amount of vegetation cover, including the maintenance and restoration of small and isolated vegetation patches in urbanized areas.

1. Introduction

Urbanization presents a significant threat to bird species (Khan et al., 2022; Khan et al., 2024). Additionally, fragmentation (Danturai et al., 2025), and degradation of natural ecosystems are also impacts on avian species (Lakatos et al., 2025). While green in urban areas serve as

important landscape for bird species (Hassan and Altaf, 2023) and also offer a variety of benefits to the avian community (Mansfield et al., 2024). Insect-eating avian species, like those in forests and city green areas, can efficiently manage pest populations by preying on them (Wu et al., 2024). Birds that eat fruit and grains aid in distributing seeds and pollinating crops in vegetated regions (Bernat-Ponce et al., 2023). Thus, the strategic safeguarding of urban green spaces (Wong et al., 2023), such as parks, gardens, and green belts, is essential for maintaining wildlife coexistence and biodiversity (Adrianzen Abanto, 2025), leading to meaningful ecological service benefits (Jahangeer et al., 2023). Research has demonstrated that urban biodiversity is consistently declining (Rahman et al., 2023). A clear trend toward homogenization is observed across the spectrum from urban to suburban areas. This trend results in a decrease in specialized species (Patankar et al., 2021) and an increase in the proportion of generalist species within cities (Ali et al., 2018; Ashraf et al., 2018; Rahman et al., 2021; Pena et al., 2023).

While some species are capable of flourishing in highly urbanized environments and can endure the effects of habitat fragmentation, most species are particularly vulnerable to urbanization (Bernat-Ponce et al., 2024; Liu et al., 2025). These species typically inhabit natural and semi-natural environments found in suburban or urban areas (Pithon et al., 2021). Such changes are critical indicators of ecological pressure, prompting birds to migrate without actively searching for optimal territory in forest patches, woodlands, or agricultural areas (Ashraf et al., 2018; Umair, 2020; Hussain and Tanveer, 2023). Additionally, bird populations in urban parks (Katoh and Matsuba, 2021) and natural woodlands respond differently to variations in habitat size and structure across multiple spatial scales (Khan et al., 2022; Haider et al., 2024), with these responses carrying functional and ecological implications related to the changes brought about by urbanization (Katoh and Matsuba, 2021; Bailey et al., 2022).

In urban areas, the species diversity of bird communities is often lower compared to forest or undamaged locations within the same geographic region (Basile et al., 2021; Kebrle et al., 2021; Altaf et al., 2024; Altaf et al., 2025; Irshad et al., 2025). Additionally, avian communities at the functional level respond differently to urbanization across various latitudes (Altaf et al., 2015; Ali et al., 2016; Xu et al., 2022; Zhang et al., 2023; Peng et al., 2024). Therefore, understanding how urbanization affects the clustering tendencies of bird populations is essential for managing green spaces and guiding local government decision-making. A thorough understanding of the key factors that influence the composition and functioning of bird communities on a larger scale can offer valuable insights for managing urban landscapes and developing future planning strategies. Hence. the goal of this research was to evaluate bird variety in the urban areas of the Vehari district, Punjab.

2. Materials and methods

2.1 Study Area

The district of Vehari is located on the eastern bank of the Sutlej River Punjab province of Pakistan at 29.36° N to 30.22° N latitude, and 71.44° to 72.53° E longitude. District Vehari consists of three tehsils, Mailsi, Vehari and Burewala. The primary area of this study, Mailsi, is a municipality with 31 union councils situated at 29°48'1" N and 72°10'33" E with an elevation of 126 meters (416 feet) above sea level. The incorporation (Iqbal et al., 2024).

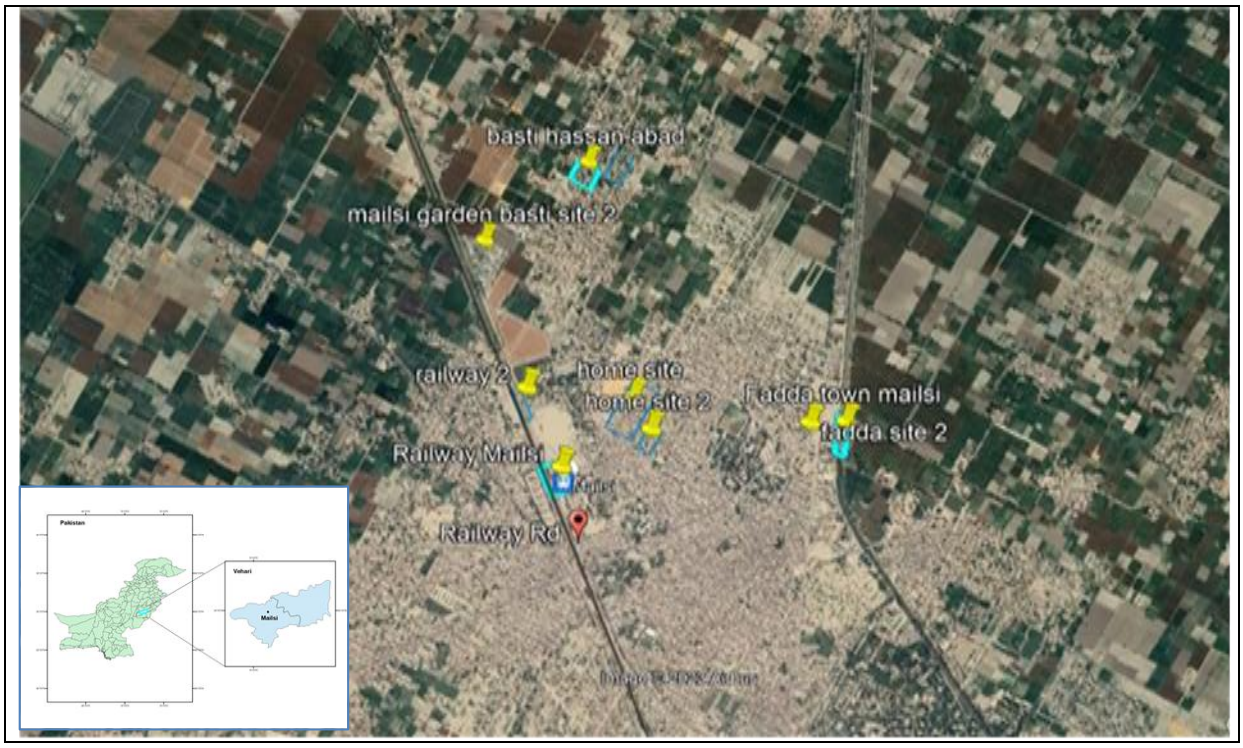


Figure 1: Map of District Vehari (Punjab, Pakistan)

Vehari is located in the Indus Valley, as shown in Figure 1. The city has plains, making it highly conducive to horticultural activities. The effectiveness of the irrigation system depends on the functionality of the canal network throughout the tehsil. However, declining water levels in the river significantly affect the region's flora and fauna. The region experiences distinct climatic conditions, and the summer temperatures can reach a peak of 54 °C (129 °F), while winter temperatures can drop to a low of -1 °C (30.2 °F). Average annual precipitation is 127 millimeters (5.0 inches), often accompanied by dust storms (Ghouri et al., 2022).

2.2 Methods

The study sites (summarized in Table 1) were surveyed systematically. The data was collected during the early morning (6:00 to 9:00 A.M.) and late afternoon (4:00 to 6:00 P.M). Bird diversity was assessed using the point count technique at the 8 randomly defined locations. Bird's species were identified using field guides. To reduce individual variability, each bird survey was conducted with a consistent number of observers. Upon reaching their assigned points, observers waited five minutes before commencing the survey. At each survey point 10 minutes observations were taken. Prior to the official bird survey, observers conducted two preliminary rounds of trials at eight specific locations from August 2022 to September 2023 to ensure accurate future projections of bird species. The data collected during these initial trials were not included in the official survey. The formal avian survey took place from September 4, 2022, to August 4, 2023, coinciding with the non-breeding season for birds, which corresponds with the winter migration period to Vehari. This timeframe reflects the typical duration assigned for studying the spatial distribution patterns of bird species along the urbanization continuum. Past Software (version 3) was used to calculate various metrics, including Shannon diversity, principal component analysis (PCA).

Table 1: Study areas of Mailsi District Vehari

Study Area	Name of study areas (A)	Characteristics	Coordinates	Name of study areas (b)	Coordinates
Urban with vegetation (UWV)/ site 1	Houses (A)	Housing sites with 40-45% green cover	29°48'17.41"N 72°10'54.14"E	Houses (B)	29°48'16.67"N 72°10'51.56"E
Urban without vegetation (UWOV)/ site 2	Railway station (A)	Railway site with 30-40% of green cover	29°48'25.69"N 72°10'37.50"E	Railway station (B)	29°48'36.66"N 72°10'47.12"E
Rural with less vegetation (RWLV)/ site 3	Fadda Town (A)	Canal infrastructure with 55-60% green cover	29°47'51.12"N 72°11'10.15"E	Fadda town (B)	29°47'55.86"N 72°11'6.78"E
Rural with more vegetation (RWMV)/ site 4	Basti Hassan Abad (A)	Rural areas with 70% greenery and diverse range of bird species	29°48'46.48"N 72°11'29.04"E	Mailsi garden (B)	29°48'54.17"N 72°11'7.26"E

3. Results

This one-year study documented a total of 34 species from different habitats in district Vehari (Table 2). The urban area with greenery exhibited the highest species richness. The urban habitat without vegetation recorded the lowest richness, as observed in Site 1 and Site 2. A comparative analysis was conducted to investigate functional diversity and identify indicator species. The species count in Site 1 was 23, for Site 2 was 25, for Site 3 was 34, and for Site 4 was 20. The population sizes for each site were 8,858 individuals (Site 1), 7,322 individuals (Site 2), 11,918 individuals (Site 3), and 5,354 individuals (Site 4). The value of Simpson's index for Site 1 was 0.7106, while its values for Site 2, Site 3, and Site 4 were 0.7162, 0.7251, and 0.7131, respectively. Site 4 has an evenness of 0.312 followed by the Site 1 (0.2801), Site 2 (0.2732) and Site 3 (0.2388, Table 3).

Table 2: Diversity of urban birds in study area.

Common name	Scientific name	Distribution	Status	Feeding type	Total	RA/Pi
Alexander Parakeet	*Psittacula euptaria*	R	LC	Omnivore	26	0.006
Asian Koel(M+F)	*Eudynamys scolopaceus*	P	LC	Omnivore	71	0.015
Bay back Shrike	*Lanius vittatus*	R	LC	Carnivorous	181	0.039
Black Drongo	*Dicrurus macrocercus*	R	LC	Insectivore	160	0.034
Black Kite	*Milvus migrans*	R	LC	Omnivore	7	0.001
Black Partridge	*Francolinus francolinus*	R	VU	Omnivore	25	0.005
Brown Rockchat	*Cercomela fusca*	P	LC	Carnivorous	151	0.032
Cattle Egret	*Bubulcus ibis*	R	LC	Piscivore	185	0.04
Common Myna	*Acredotheres tristis*	R	LC	Omnivore	118	0.025
Common Quail	*Coturnix coturnix*	SB	LC	Omnivore	52	0.011
Common wheatear	*Oenanthe oenanthe*	WV	LC	Insectivore	84	0.018
Eurasion Hoopoe	*Upupa epops*	PM	LC	Carnivorous	40	0.009
Green Bee eater	*Merops orientalis*	R	LC	Insectivore	163	0.035
Grey Partridge	*Francolinus pondicerianus*	R	LC	Granivore	46	0.01
House Crow	*Corvus splendens*	R	LC	Omnivore	352	0.075
House Sparrow	*Passer domesticus*	R	LC	Omnivore	323	0.069
Indian ring Dove	*Streptopelia decaocto*	R	LC	Granivore	170	0.036
Indian Robin	*Saxicoloides fulicatus*	R	LC	Insectivore	187	0.04
Indian Roller	*Coracias benghalensis*	R	LC	Carnivorous	171	0.037
Intermediate Egret	*egretta intermedia*	P	LC	Omnivore	201	0.043
jungle Babbler	*Turdoides striatus*	R	LC	Insectivore	211	0.045

Common name	Scientific name	Distribution	Status	Feeding type	Total	RA/Pi
Jungle Prinia	*Prinia sylvatica*	R	LC	Insectivore	176	0.038
King Fisher	*Halcyon smyrnensis*	R	LC	Omnivore	109	0.023
Laughing Dove	*Streptopelia Senegalensis*	R	LC	Granivore	230	0.049
Plain Prinia	*Prinia inornata*	R	LC	Insectivore	212	0.045
purple sunbird (male)	*Nectarinia asiatica*	SB	LC	Insectivore	165	0.035
Red vented Bulbul	*Pycnonothus cafer*	R	LC	Omnivore	125	0.027
Red wattled Lapwing	*Haplopterus indicus*	R	LC	Omnivore	210	0.045
Rock Pigeon	*Columba livia*	R	LC	Granivore	137	0.029
Spotted Owl	*Athene brama*	R	LC	Omnivore	7	0.001
White Wagtail	*Motacilla alba*	W	LC	Insectivore	63	0.013
Wire tailed Swallow	*Hirundo smithii*	R	LC	Insectivore	226	0.048
Yellow Bittern	*Ixobrychus sinensis*	R	LC	Omnivore	99	0.021

Table 3: Statistical analysis summary of avian fauna in different study sites in Vehari

Diversity Indices	Site 1	Site 2	Site 3	Site 4
Taxa/ species (S)	23	25	34	20
Individuals	8858	7322	11918	5354
Simpson_1-D	0.7106	0.7162	0.7251	0.7131
Shannon_H	1.863	1.921	2.094	1.832
Evenness (E)	0.2801	0.2732	0.2388	0.3122
Brillouin (B)	1.855	1.911	2.085	1.821
Menhinick (M)	0.2444	0.2922	0.3114	0.2733
Margalef (R)	2.42	2.697	3.516	2.213
Equitability (J)	0.5942	0.5968	0.5939	0.6114
Fisher_alpha	2.861	3.236	4.287	2.624
Berger-Parker	0.5	0.5	0.5	0.5
Chao-1	23	25	34	20

The initial two principal components (PCs) of the Principal Component Analysis (PCA) accounted for 98.72% of the observed variation in the avian community sample. Specifically, component 1 explained 95.812% of the variation, while component 2 accounted for 2.9154%. The variables present in component 1 are UWV (correlation coefficient = 0.58628), UWOV (correlation coefficient = 0.44583), RWMV (correlation coefficient = 0.58761), and RWLV (correlation coefficient = 0.33501). The amount and direction of component 1 can be determined by analyzing the response of bird communities to urban and suburban habitats. This can be documented as a gradient representing the extent of development. The two variables for component 2 are as follows: UWV has a correlation coefficient of -0.7696, UWOV has a correlation coefficient of 0.06724, RWMV has a correlation coefficient of 0.47941, and RWLV has a correlation coefficient of 0.41641. Each principal component is independent of previously calculated data, and similarly, the variables of habitats are not significantly associated with other PCA components. This suggests that the fundamental factor shaping the community of birds is distinct from these variables, as shown in Figure 2.

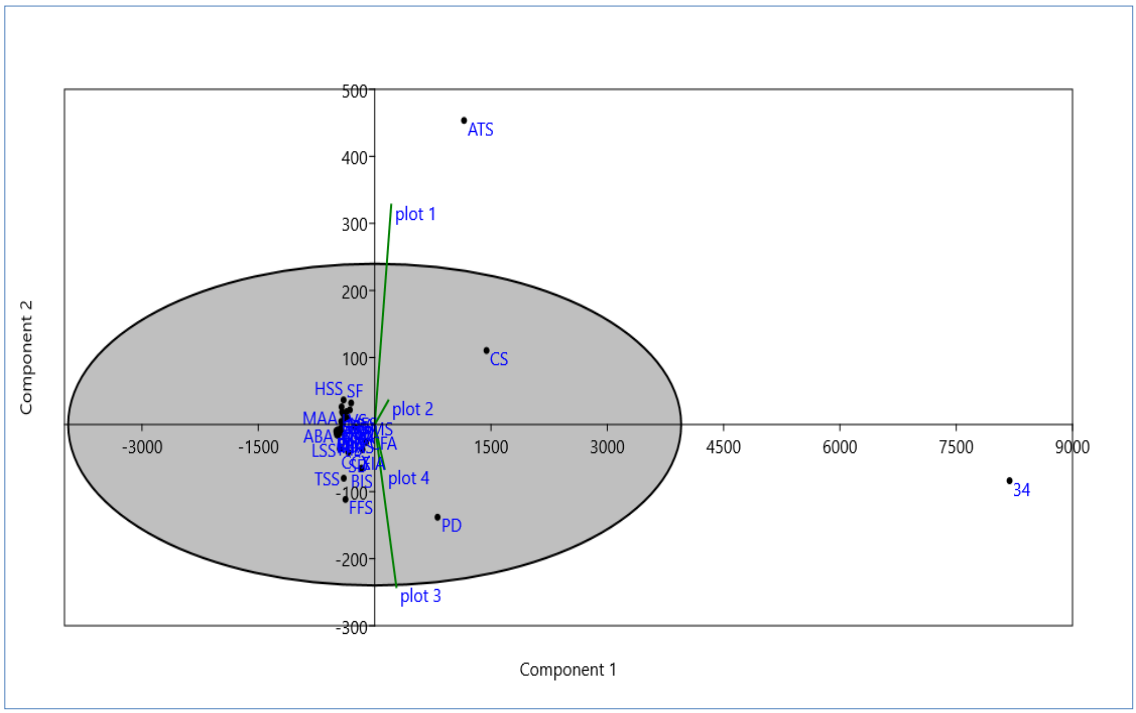


Figure 2. Principal component analysis (PCA) for distribution of birds in Vehari.

4. Discussion

Urban parks and gardens provide habitats for a variety of bird species. Birds play important role in urban ecosystems. However, unmanaged urban ecosystems can significantly reduce the avian fauna. This study investigated the avian diversity in district Vehari. Main findings of the study are discussed below:

Urban With vegetation

While exploring the canal region of Fadda Town, a diverse range of flora and numerous bird species were found likely due to the close proximity to the canal. Among the bird species house crow (*Corvus splendens*), white wagtail (*Motacilla alba*), common myna (*Acridotheres tristis*), house sparrow (*Passer domesticus*), laughing dove (*Streptopelia senegalensis*), intermediate egret (*Egretta intermedia*), red wetland lapwing (*Haplopterus indicus*), black drongo (*Dicrurus macrocercus*), wire-tailed swallow (*Hirundo smithii*), yellow bittern (*Ixobrychus sinensis*), black partridge (*Francolinus francolinus*), and kingfisher (*Halcyon smyrnensis*). The area is also home to a variety of plants, with the most commonly grown crops including cotton (*Gossypium herbaceum*), wheat (*Triticum aestivum*), groundnut (*Arachis hypogaea*), sugarcane (*Saccharum officinarum*), maize (*Zea mays*), and rice (*Oryza sativa*).

Urban without vegetation

During my survey of the area, I observed a decline in vegetation. I encountered a diverse array of plant life and bird species. The location is currently uninhabited by humans. My survey included several avian species, such as the Indian roller (*Coracias benghalensis*), Indian robin (*Saxicoloides fulicatus*), jungle prinia (*Prinia sylvatica*), bay-backed shrike (*Lanius vittatus*), black drongo (*Dicrurus macrocercus*), green bee-eater (*Merops orientalis*), red-vented bulbul (*Pycnonotus cafer*), brown rock chat (*Cercomela fusca*), and purple sunbird (*Nectarinia asiatica*).

Rural with more vegetation

This page focuses on the geographic region of Basti Hassanabad. Through my observations, I have noted a significant presence of people and their interactions with various bird species. The area is home to a diverse range of plants, which explains the abundance of avian species often not seen in other locations. Common bird species found in urban environments here include the house crow (*Corvus splendens*), house sparrow (*Passer domesticus*), intermediate egret (*Egretta intermedia*), black drongo (*Dicrurus macrocercus*), Eurasian hoopoe (*Upupa epops*), Asian koel (*Eudynamys scolopaceus*), red-wattled lapwing (*Haplopterus indicus*), spotted owl (*Athene brama*), green bee-eater (*Merops orientalis*), common myna (*Acridotheres tristis*), purple sunbird (*Nectarinia asiatica*), brown rockchat (*Cercomela fusca*), yellow bittern (*Ixobrychus sinensis*), jungle prinia (*Prinia sylvatica*), bay-backed shrike (*Lanius vittatus*), black partridge (*Francolinus francolinus*), grey partridge (*Francolinus pondicerianus*), jungle babbler (*Turdoides striatus*), Alexandrine parakeet (*Psittacula eupatria*), common quail (*Coturnix coturnix*), kingfisher (Halcyon smyrnensis), rock pigeon (*Columba livia*), common wheatear (*Oenanthe picata*), and black kite (*Milvus migrans*).

Rural with less vegetation

Plants in residential settings are typically confined to this specific spot. The location in question displays a mostly concentrated human population. I have conducted observations on a diverse range of avian species. Common bird species found in urban areas include the house crow (*Corvus splendens*), common myna (*Acridotheres tristis*), house sparrow (*Passer domesticus*), Indian ring dove (*Streptopelia decaocto*), purple sunbird (*Nectarinia asiatica*), green bee-eater (*Merops orientalis*), brown rock chat (*Cercomela fusca*), kingfisher (*Halcyon smyrnensis*), spotted owl (*Athene brama*), intermediate egret (*Egretta intermedia*), jungle prinia (*Prinia sylvatica*), and Alexander parakeet (*Psittacula eupatria*).

Bird Diversity in different sites of urbanization

Our study findings demonstrate that urbanization significantly influenced the overall species diversity of birds in different areas. Previous studies have indicated that higher levels of urbanization promote the rapid expansion and strong ability of species to invade, leading to a unique composition of species compared to other areas. Moreover, the substandard sanitary conditions commonly found in urban areas have the ability to foster a higher population of tree sparrows because the urban environment does not provide any significant barriers to their nesting operations. Urban environments contain a multitude of nesting sites.

Urbanization Affects Bird Guilds in different sites

The findings of our study provide evidence that urbanization has a substantial impact on the diversity and abundance of insect-eating species in different regions. The aforementioned discovery aligns with the research, which revealed a higher diversity of avian species in undisturbed (Bashir et al., 2025; Hussain et al., 2025), less in urbanized habitats (Hughes et al., 2022). Rural regions possess the ability to draw in a greater assortment of bird species due to their ability to sustain the forest canopy and offer vertical vegetation refuges, which are recognized as beneficial for bird populations (Pithon et al., 2021). However, the omnivorous and insectivorous groups have a negligible impact on the modification or urbanization of habitats (Wu et al., 2024). The omnivorous population thrives due to the inadequate control of urban waste, which becomes more readily available to them (Panda et

al., 2021). Furthermore, the substantial quantity of plant life found in elevated parks, together with the plentiful occurrence of arthropods in various ecosystems such as woodlands and grasslands, offers a diverse array of nourishment and dwellings for insectivorous creatures (Lakatos et al., 2025).

Limitations of this Study

Changes in the urban environment might potentially impact the development of bird populations, with the main concern currently being the loss of diversity in urban bird communities. Therefore, additional investigation is necessary to ascertain the potential impacts of urban constructed environments on bird diversity, considering factors such as bird movement, predation, and evolution. Due to funding limitations, this study could not assess the entire area thoroughly and there is a possibility of bias in findings, particularly when it comes to assessing the variety of bird species. Moreover, due to the proximity of the study sites, there is a possibility of sampling overlap, leading to several non-independent observations of the same individuals across different study sites.

Conclusions

Landscape gradients had a significant effect on bird abundance and distribution. The highest species richness and Shannon diversity were recorded at Site 3 (RWLV/Fadda Town; S = 34, H = 2.094), while the lowest species richness and Shannon diversity were detected at Site 4 (RWMV/Basti Hassan Abad; S = 20, H = 1.832). At Site 1 (UWV; S = 23, H = 1.863) and Site 2 (UWOV; S = 25, H = 1.921), intermediate landscape gradient values were detected, which suggests that the presence of vegetation is not a determining factor for avian diversity. A swift avian community response to anthropogenic disturbance was observed, which implies that conservation and restoration strategies should consider the structure of a particular site, its proximity to water bodies, and the context of the landscape. It is especially important for the urban ecosystem, where a considerable number of natural habitats have already been lost. Even small patches of vegetation are essential for maintaining avian diversity; however, the management strategy should take into account the complexity of the processes rather than postulating the general positive influence of any green area on biodiversity.

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