



Original Article



Impact of Land Use Gradient on Bird Community Structure and Diversity at University of the Punjab, Quaid-e-Azam Campus, Lahore

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ABSTRACT

Growth and development in cities and alterations in land use have a considerable impact on the avian diversity in urbanized landscapes. **Objectives:** To assess current avian diversity, seasonal variation, and long-term changes (1997–2023) in relation to land-use modification within the campus. **Methods:** Fortnightly bird surveys were conducted from May 2022 to April 2023 using the 10-minute point count method at 40 fixed stations representing urban, agricultural, botanical, and wetland habitats. Diversity indices, including the Shannon–Wiener index, species richness, and evenness, were calculated. The methodologies and spatial coverage of these historical studies were not identical to the current survey, and some historical records lacked fine-scale spatial or seasonal data, which is a recognized limitation for direct comparison. **Results:** There were 64 species of birds of 16 orders and 34 families, 40 resident, 10 summer breeding, 8 winter visitor, 5 passage migrant, and 1 vagrant species. The dominance was Passeriformes (63%), non-passerines (37%). The scavenger and generalist birds *Corvus splendens*, *Milvus migrans*, and *Acridotheres tristis* formed more than half the total population. Comparison of trends over a long period revealed a decreasing common myna population and a house crow population, no changes in black kite population, and an increasing prevalence of plain-leaf warbler, yellow-footed green pigeon and cattle egret. Since 2012, urbanization has decreased agricultural habitats and homogenized bird communities. **Conclusions:** Urbanization and the environment of littering have altered the avian diversity, thus the necessity to incorporate biodiversity preservation into urban and campus landscape designs.

INTRODUCTION

The avian population in Pakistan is high and has been reported to comprise 729 species of birds in the land [1]. This is due to its geographical position at the border of the Oriental, Palearctic and Ethiopian zoogeographical regions giving it the importance of endemism in the conservation of the avian biodiversity [2]. Birds are regarded as significant components of the ecosystems since they are signs of the well-being of the environment and play a vital role in the ecosystem, including pollination, seed dispersal, and natural control of pests [3, 4]. The development of lands and human activities like urbanization, agricultural

practices, forest destruction and mining have resulted to a number of adverse consequences on the bird population in the globe [5, 6]. Previous research has been conducted to investigate the distribution, migration, and habitat preference of the avian in Pakistan [7, 8]. The studies on natural reserves, wetlands, and farmland in Punjab have evaluated the structure of bird communities and ecological value [9, 10]. Lahore, which is one of the largest urban areas, is studied as well, changing avifauna and the impact of urban growth [11, 12]. Lahore is a campus of the University of the Punjab, which has undergone massive



urbanization. The buildings, roads, and infrastructure have substituted the previous natural landscape. This notwithstanding, the region has biological value because of its diverse habitats, such as agricultural lands, wastewater pools, botanical gardens, rose gardens, and roadside plants, which favor birds, small mammals, and reptiles [13, 14]. Nevertheless, there is a lack of long-term monitoring. Knowledge of how birds react to the continued urbanization is essential in biodiversity management [15]. The study aims to give a comparative and modern evaluation of avian diversity (2022-2023) over ten years later, comparing long-term changes (1997-2023) and comparing the effect of land-use change on the richness of species and the composition of the species community in the campus.

METHODS

This was a descriptive cross-sectional study conducted to assess the avian community structure and diversity. A systematic sampling technique was employed, with 40 fixed survey stations strategically placed across the major habitat types (urban, agricultural, botanical, and wetland) within the campus. The number of survey stations ($n=40$) was determined to ensure comprehensive coverage of the major habitat types (urban, agricultural, botanical, and wetland) within the University of the Punjab, Quaid-e-Azam Campus, Lahore. The stations were distributed proportionally to the area of each habitat type. This is the common method in descriptive ecological census whose emphasis is on representative spatial coverage rather than on formal power calculation. The campus is separated into two different environmental zones, an urban habitat and an agricultural habitat. The urban area (387 ha) has the following in it, teaching departments, hostels, administrative and residential quarters, paved ways, and green belts. Comparatively, the agricultural (284 ha) area includes cultivated agricultural land, botanical garden, and ornamental plants cultivation areas as well as two wastewater management ponds amounting to 2.6 ha. The main sources of wastewater that is collected and treated in these ponds are those produced on campus. Site 1 Teaching Departments (258.5 ha); Site 2 Residential Colony and Hostels (129 ha); Site 3 Cultivated Land with wastewater ponds (264 ha); Site 4 Botanical Garden (20.23 ha). The survey of birds was conducted every fortnight between May 2022 and April 2023. During dawn and dusk (summer: 05:00-09:00 and 17:00-20:00; and winter: 07:00-10:00 and 15:30-18:00) which were the times of the greatest avian activity they were observed. The identification of the species and geolocation were carried out with the help of binoculars (10x50) and GPS respectively. Standard field guides helped in identification. Being a descriptive cross-sectional study, the analysis was

aimed at showing these indices, frequencies, and percentages to describe and compare the avian communities of the two landscapes. Significant inferential statistical tests were not utilized because the purpose of the study was to explain the current community structures and not to test a hypothesis that had been determined beforehand. Five trained observers took part in the survey. To ensure reduced observer variability, two weeks of calibration were carried out prior to data collection where all the participants performed the joint observations in order to harmonize the data collection methods, species recognition, estimation of distance, and counting techniques. This standardization guaranteed the inter-observer reliability during the survey interval. The abundance and diversity of birds were determined by the 10-minute point count technique. The radius of every survey station was 100 meters and the spacing between the stations was a minimum of 500 meters to avoid recording the same individual in two stations. There were 40 survey stations that were distributed randomly in all habitats, which should be urban, agricultural, botanical, and wetlands. All the birds recorded at each station were classified according to the type of habitat and their behavior. The spatial mapping and sampling repeated in various seasons were noted by record of the GPS coordinate of each station. A relative abundance index determined the local occurrence status of the bird's species consisting of the percentage of the number of a given species of birds to the overall number of birds that were seen. To prevent the influence of raw counts, classification was done using relative abundance thresholds. Species that had a percentage of more than 10 of the total individuals were considered as very abundant, those with percentage of 5-10 as abundant, 2-5 as common, 1-2 as occasional and those with less than 1 percent were considered rare or vagrant. This relative method offers a standard level of comparison of abundance among the habitats and seasons. IBM SPSS version 25.0 was used to analyze all the data (Version 20). Biodiversity indices (such as species richness (S), Shannon-Wiener diversity index (H'), species evenness (E), relative abundance (π_i), and census index (CI)) were calculated based on conventional ecological procedures.

RESULTS

A total of 64 bird species belonging to 16 orders and 34 families were recorded at the Quaid-e-Azam Campus, University of the Punjab, Lahore, from May 2022 to April 2023. Out of these, 40 species were residents, 8 were winter visitors, 10 were summer breeders, 5 were passage migrants, and 1 was an accidental vagrant. The order Passeriformes was dominant, comprising 63% of the total avifauna, while non-passerines represented 37% (Figure 1).

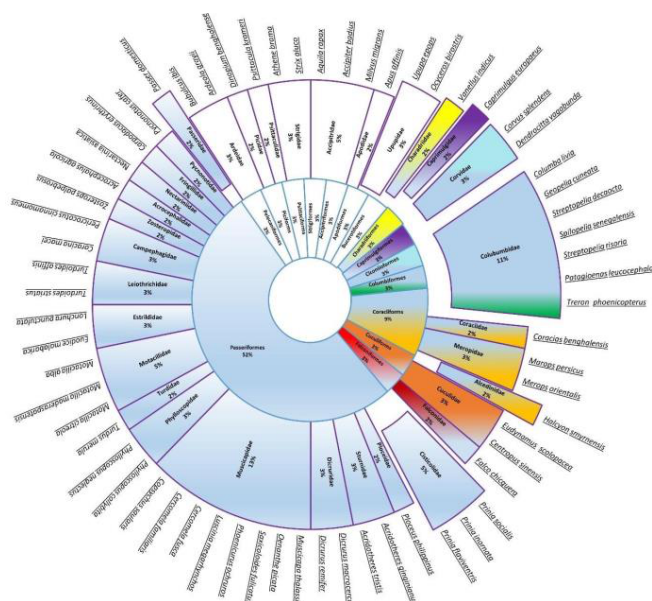


Figure 1: Avian Fauna in Punjab University Based on Taxonomic Distribution

Trends in Urban Bird Populations included Teaching Departments (Site 1): During the summer season, 1,813

Table 1: Seasonal Variation in Bird Populations at Urban Sites

Site	Season	Total Individuals	Total Species	Dominant Species (Pi)	Least Observed Species
Teaching Departments (Site 1)	Summer	1,813	34	House Crow (<i>Corvus Splendens</i>)(0.267), Black Kite (<i>Milvus Migrans</i>)(0.161), Common Myna (<i>Acridotheres Tristis</i>)(0.111)	Rufous treepie, Asian koel, Variable wheatear
	Winter	2,060	42	Common Crow (0.183), Common Myna (0.156), Black Kite (0.138)	—
	Spring	2,002	42	Common Crow (0.188), Black Kite (0.175), Blue Rock Pigeon (<i>Columba Livia</i>)(0.132)	Rufous treepie, Asian koel, Variable wheatear
Residential Area (Site 2)	Summer	1,752	34	Common Crow (0.258), Common Myna (0.210), Black Kite (0.170)	Indian robin, Verditer flycatcher, Variable wheatear
	Winter	1,397	37	Black Kite (0.208), Common Crow (0.160)	—
	Spring	1,424	39	Black Kite (0.209), Common Crow (0.206)	Indian robin, Verditer flycatcher, Variable wheatear

Cultivated Area (Site 3): During summer, 1,800 birds of 23 species were recorded, dominated by common myna (Pi=0.22), black kite (Pi=0.16), and common crow (Pi=0.155). In winter, 1,061 birds of 37 species were observed, with common myna (Pi=0.191) and black kite (Pi=0.171) most common. During spring, 1,304 individuals of 41 species were sighted; common myna (Pi=0.241) and black kite (Pi=0.216) dominated. Least abundant species across seasons included ashy prinia, plain-leaf warbler, and shikra. Botanical Garden (Site 4): During summer, 1,273 birds of 39 species were recorded, with black kite (Pi=0.305) and common myna (Pi=0.178) as the most abundant. In winter, 1,426 birds of 37 species were sighted, with black kite (Pi=0.264) and laughing dove (Pi=0.170) dominant. During spring, 1,255 birds of 38 species were recorded; laughing dove (Pi=0.194) and black kite (Pi=0.171) were the most common. Least abundant species included the Asian koel, the white-browed wagtail, and the spotted owl (Table 2).

Table 2: Trends in Green Area Bird Populations

Site	Season	Total Individuals	Total Species	Dominant Species (Pi)	Least Observed Species
Teaching Departments (Site 1)	Summer	1,813	34	House Crow (<i>Corvus Splendens</i>)(0.267), Black Kite (<i>Milvus Migrans</i>)(0.161), Common Myna (<i>Acridotheres Tristis</i>)(0.111)	Rufous treepie, Asian koel, Variable wheatear
	Winter	2,060	42	Common Crow (0.183), Common Myna (0.156), Black Kite (0.138)	—

	Spring	2,002	42	Common Crow (0.188), Black Kite (0.175), Blue Rock Pigeon (Columba Livia)(0.132)	Rufous treepie, Asian koel, Variable wheatear
Residential Area (Site 2)	Summer	1,752	34	Common Crow (0.258), Common Myna (0.210), Black Kite (0.170)	Indian robin, Verditer flycatcher, Variable wheatear
	Winter	1,397	37	Black Kite (0.208), Common Crow (0.160)	—
	Spring	1,424	39	Black Kite (0.209), Common Crow (0.206)	Indian robin, Verditer flycatcher, Variable wheatear
Cultivated Area (Site 3)	Summer	1,800	23	Common Myna (0.220), Black Kite (0.160), Common Crow (0.155)	Ashy prinia, Plain-leaf warbler, Shikra
	Winter	1,061	37	Common Myna (0.191), Black Kite (0.171)	—
	Spring	1,304	41	Common Myna (0.241), Black Kite (0.216)	Ashy prinia, Plain-leaf warbler, Shikra
Botanical Garden (Site 4)	Summer	1,273	39	Black Kite (0.305), Common Myna (0.178)	Asian koel, White-browed wagtail, Spotted owl
	Winter	1,426	37	Black Kite (0.264), Laughing Dove (0.170)	—
	Spring	1,255	38	Laughing Dove (0.194), Black Kite (0.171)	Asian koel, White-browed wagtail, Spotted owl

Comparative Trends and Long-Term Changes were done. Overall, black kite, common myna, and house crow remained dominant across all habitats and seasons. However, long-term comparison (1997–2023) shows a stable trend for black kite, declining trends for common crow and common myna, and increasing trends for species such as plain-leaf warbler, yellow-footed green pigeon, and cattle egret (Table 3).

Table 3: Total Seasonal Diversity of the Birds at the University of the Punjab, Quaid-e-Azam Campus, Lahore

Order	Family	Representative Species	Summer (Mean count)	Winter (Mean count)	Spring (Mean count)	Trend 1997–2023
Accipitriformes	Accipitridae	<i>Milvus migrans</i> (Black kite)	1265	1134	1146	Stable
Columbiformes	Columbidae	<i>Spilopelia senegalensis</i> (Laughing dove)	503	540	540	Stable
Passeriformes	Corvidae	<i>Corvus splendens</i> (Common crow)	1198	594	884	Declining
Passeriformes	Sturnidae	<i>Acridotheres tristis</i> (Common myna)	1194	986	888	Declining
Passeriformes	Phylloscopidae	<i>Phylloscopus neglectus</i> (Plain leaf warbler)	—	9	9	Increasing
Passeriformes	Pycnonotidae	<i>Pycnonotus cafer</i> (Red-vented bulbul)	353	205	198	Stable
Columbiformes	Treronidae	<i>Treron phoenicopterus</i> (Yellow-footed green pigeon)	54	89	107	Increasing
Psittaciformes	Psittaculidae	<i>Psittacula krameri</i> (Rose-ringed parakeet)	190	99	98	Stable
Pelecaniformes	Ardeidae	<i>Bubulcus ibis</i> (Cattle egret)	44	108	104	Increasing
Passeriformes	Nectariniidae	<i>Cinnyris asiatica</i> (Purple sunbird)	81	29	38	Stable

The maps indicate a marked increase in built-up areas, particularly after 2012, leading to habitat loss and disturbance. Green patches such as lawns, roadside vegetation, and botanical gardens, though maintained, fail to fully compensate for natural habitat loss. Urban expansion and increased anthropogenic activity were found to negatively affect avian diversity. Regression analysis (to be applied) can quantify the relationship between urbanization intensity and species richness decline. Major changes that occurred after the year 2000 have been marked (Source: Google Earth). The formation of the road is clear. Results indicate a single land without habitat fragmentation (Figure 2).



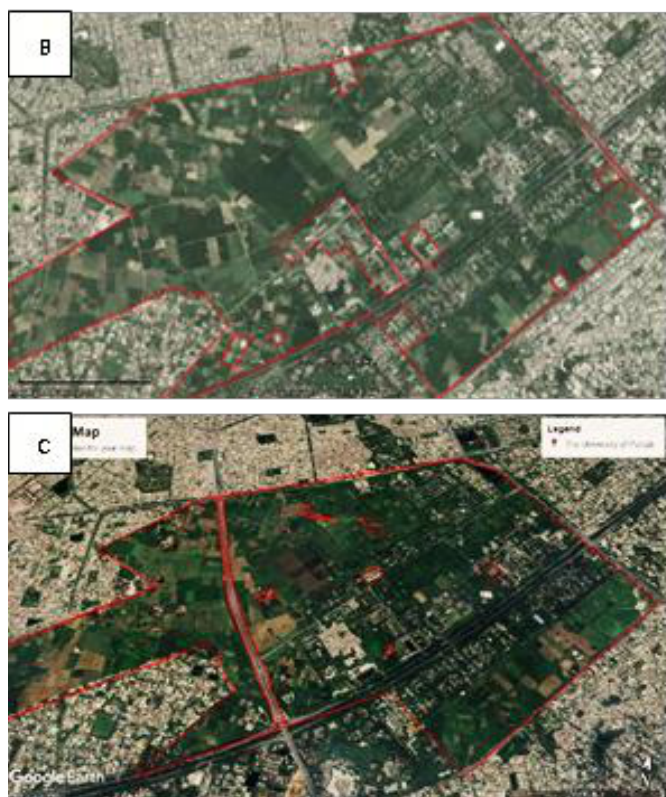


Figure 2: Aerial View of the Study Area, University of the Punjab, During the years 2000(A), 2012(B), and 2023(c)

DISCUSSION

Increased urbanization can significantly strain the natural environment, leading to habitat modification, fragmentation, and loss for numerous species. Consequently, biodiversity becomes restricted to limited green spaces within urban areas. The Quaid-e-Azam Campus of the University of the Punjab now serves as a constrained refuge for various bird species. Compared with the earlier study, substantial ecological and structural changes have occurred over time [16]. The total number of recorded bird species has declined from 76 to 65, primarily due to land-use changes. The agricultural area decreased from 426.25 ha to 264 ha, while the urban built-up area expanded from 182.5 ha in 2013 to 387 ha. This decline can be attributed to urban expansion, altered migratory patterns, reduced food availability, and loss of nesting sites affecting specialist species [17]. According to Tanveer et al. 64 species of birds were recorded, of which 42 were residents, 6 wintering, and 12 summer breeders that had 2 occasional all-year-round birds [13]. Out of the latter, 33 were passerines and 31 were non-passerines. This was followed by 76 species, 49 of which were residents, 17 winter visitors, 7 summer breeders, 2 passage migrants and 1 vagrant as recorded by Sidra et al. [16]. Table 2 in Appendix gives the comparative occurrence and composition of the species. Shannon-Wiener diversity

index ($H = 2.548$) showed that the measure of diversity was moderate with the census density of 2,795 birds/km². The rise of the species was not necessarily an increase in the diversity but could have been the result of wastewater sites being added to the survey by Sidra et al. [16]. Species movement was also found, with some of the birds not being found in Sidra et al. [16], again found in the 2023 survey, indicating temporary displacement and recolonization processes. Table 1 reveals the comparative changes in species. Increase in the scavenger birds especially house crows and black kites may be the result of poor waste disposal habits as residential places attract foraging birds and exterior waste collection sites. The Master Plan of the university shows that the agrarian lands are under gradual transformation in academic and residential structures to allow institutional growth. Such a shift can cause additional species displacement and homogenization of communities [18, 19]. Generalist species like blue rock pigeon, house sparrow, yellow-footed green pigeon, babblers (*Turdoides* spp.), red-vented bulbul, common myna and black kite are common in urban ecosystems and generally adapt to human alterations [20]. With the increase in the number of these adaptive species, they can outcompete or displace specialists that inhabit the habitat, leading to a net decrease in the diversity of avian species on the campus ecosystem. Moreover, waste management information (e.g., volume of garbage, the presence of open waste areas, food waste in the vicinity of hostels and cafeterias, etc.) must be added to compare it with the abundance of scavenger birds (in particular, *Corvus splendens* and *Milvus migrans*).

CONCLUSIONS

In conclusion, many species of birds can be found in the Quaid-e-Azam Campus of Punjab University due to its varying habitats. Nonetheless, the growing construction and development demand jeopardizes this biodiversity to the extent of destroying it drastically. The shift of the ecosystems may facilitate the growth of generalist species, as in the case of the omnivorous garbage feeding birds. Such flexible species might also prosper in the case of the suggested modification in land use. Usually, the urban areas are homogeneous in terms of fauna. Changing agricultural areas into buildings can significantly reduce the existing bird species repertoire, even with existing lawns, plantations on the roads, and residential areas.

Authors Contribution

Conceptualization: BNK, MAM

Methodology: BNK, MAM, MNF

Formal analysis: AK, MN, HA

Writing review and editing: BNK, MAM, AK, MN, AT

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

All the authors declare no conflict of interest.

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