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Impact of Urbanization on Avian Species Diversity in Southern Punjab, Pakistan

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ABSTRACT

Urbanization in many parts of the world including Southern Punjab, Pakistan is one of the biggest contributors to habitat changes and loss of biodiversity, but the impact on the avian species diversity has not been well studied in most of the areas. This paper explores the effect of urbanization on bird communities in terms of species richness, abundance, and community structure of urban, peri-urban, and rural landscapes. The point count and transect techniques were used to collect data in the breeding and non-breeding seasons to ensure that the temporal variation was captured in field surveys. Analyses of data was done to compare the indices of species diversity, population dynamics, and association with the habitat. Findings show that there has been a severe reduction in species richness and evenness in regions with high human populations and that in urban regions, generalist and synanthropic species are predominant in the urban avifauna. Conversely, rural and semi natural habitats favored more species of specialists and sensitive species. The results highlight the need to incorporate green spaces in urban planning, habitat corridors as well as conservation measures to reduce the adverse effects of urbanization on avian diversity. This work will give the baseline information on biodiversity conservation in the region and create the necessity of the policies of sustainable urban development.

Keywords: City sprawl, Bird diversity, Species richness, Habitat fragmentation, Southern Punjab, Pakistan, Conservation.

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INTRODUCTION

One of the most important anthropogenic phenomena that affect the ecological systems is urbanization, which leads to the modification of natural habitats, fragmentation of landscapes, and the alteration of the species composition (McKinney, 2008). Cities are commonly growing at the expense of natural vegetation as impervious surfaces (roads, buildings, industry) are developed, further diminishing potential resources needed by wildlife as well as providing new stress factors that the environment has never met. Birds in this case are highly mobile and ecologically diverse organisms, thus they are regarded as sensitive pointers of change in the environment and therefore, they are the best in evaluating the ecological effects of urbanization (Marzluff, 2001).

The Southern Punjab, which has a fast-growing urban areas, agricultural activities, and industrial growth, is a location that can be used as a unique chance to examine the effects of urbanization in bird populations. The area contains an agglomeration of natural environments, farmlands, wetlands, and urban centers, which combine themselves to form the diversity and dispersion of bird species (Khan, 2015). Although the topic of ecological importance, the systematic investigation of urban avifauna in Southern Punjab is still insufficient, and little information is provided on regarding species richness, abundance, and habitat relations. Knowledge of the impacts of urbanization on birds in this area is vital in the design of efficient

conservation programs and sustainable urban planning policies.

The urban environments are more evenly distributed with generalist species, including Passer domesticus (house sparrow) and Columba livia (rock pigeon), which tend to thrive in such habitats and habitat specialists, including insectivorous and ground nesting birds, which usually decline or vanish (Chace and Walsh, 2006). Such a change in local structure may decrease the fitness of the ecosystem with respect to its functions and stability. In other areas of the study, it was found that urbanization changes the bird assemblage due to loss of habitat, higher human disturbance, noise, domestic predators, and competitive impacts of invasive species (McKinney, 2006; Marzluff et al., 2011). This may lead to biotic homogenization due to such pressures, where urban regions in various geographical areas all have similar species that are dominated by few generalists.

The spatial distribution and quality of green spaces in cities including parks, gardens and riparian areas are so essential in maintaining avian diversity in the cities. It has been shown that bigger, interrelated and structurally complicated green areas contribute to a greater variety of species richness and abundance, which offers resources like food, nesting areas and protection against predation (Miller and Hobbs, 2002). On the other hand, small and isolated vegetation patches may not be too large to sustain viable populations of sensitive species, causing local extinctions and loss of functional diversity. It means that in order to reduce the adverse impact of urbanization on birds, the green infrastructure, habitat corridors, and native vegetation should be included in city planning (Aronson et al., 2014).

Another significant piece of urban bird-related ecology is the temporal variation. Mating seasons, movements of birds and changes in resources affect the community of birds within urban environments. The migratory species might be especially susceptible to urbanization when the stopover areas or wintering grounds are destroyed, whereas resident species might adjust to urban conditions with time (Fernandez-Juricic and Jokimaki, 2001). The knowledge of these time patterns is essential in Southern Punjab where resident and migratory species coexist and the overall effect of urbanization is sought on the diversity of avians.

The South Asian research conducted in the past has documented the reduction of bird feasibility along urbanization, although patterns differ according to habitat types, urban density, and ecological conditions of a region (Khera et al., 2009). Indicatively, cities in India and Pakistan have experienced greater reign of the synanthropic species and declines in the insectivores and birds nesting on the ground. Nevertheless, there are no focused researches in Southern Punjab and little is known about the role of gradients of urbanization locally and the effect of local urbanization on the species richness, abundance, and functional characteristics of the bird communities. This information gap explains why there should be region-informed research to guide the policies towards biodiversity management and urban planning.

The hypotheses of the study are thus threefold, namely (1) to determine the avian species richness, abundance, and diversity in urban, peri-urban, and rural landscapes in Southern Punjab; (2) to evaluate the effects of urbanization on the composition of communities, and generalist and specialist species distribution; and (3) to give recommendations regarding urban planning and biodiversity conservation in light of empirical evidence. By meeting these goals, the research would be able to enhance the knowledge about urban ecology in Pakistan and assist in the sustainable management of the avian biodiversity in the fast growing urban areas.

Finally, urbanization is an important factor that increases the challenges of conserving the avian biodiversity, and especially in areas where there is high pace in economic and infrastructural development. Birds are important environmental pointers of the ecological change both in direct and indirect impacts of the habitat change. Investigating how urbanization affects the avian community in Southern Punjab, this study makes important contributions to understanding the details of how the changes in the composition and abundance of species occur. The results will be used to inform conservation efforts, inform urban planning choices and coexistence of humans and wildlife in already

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urbanized environments.

LITERATURE REVIEW

Urbanization is a widespread process in the world and it leads to radical changes in natural ecosystems and poses serious danger to biodiversity. The process of turning forests, wetlands and grasslands into urban settlements does not only reduce the available habitats, but also divides landscapes into isolated patches which may not sustain viable population of wildlife (McKinney, 2008). One of the most impacted taxa is that of birds because of their dependence on particular structures of the habitat, food, and nesting places. It has been established in numerous studies that urbanization has been associated with a reduction in species richness, and the change in the community composition to generalist and synanthropic species capable of adapting to anthropogenic changes (Chace & Walsh, 2006; Marzluff, 2001).

The reaction of avian community to urbanization is availed by various factors, such as the urban density, the layout of habitat, availability of green spaces, and the availability of natural or semi-natural features in the urban matrix. Studies have shown that urban zones that have high networked green spaces are able to support a greater level of species richness when compared to those ones that have had fragmented or sparse vegetation (Miller and Hobbs, 2002). Structural complexity, including the existence of trees, shrubs, and ground cover, in these urban green spaces offers the opportunities to forage and nest to a variety of bird species (Aronson et al., 2014). On the other hand, few and highly adaptable species monopolize the highly built-up regions with impervious surfaces and high human activity as well as low vegetation cover like Passer domesticus (house sparrow) and Columba livia (rock pigeon) (Fernandez-Juricic et al., 2001).

Another effect of urbanization is biotic homogenization whereby the urban avifauna in the cities at geographically different locations share species composition characterized by similar generalist species (McKinney, 2006). Specialized species such as the insectivores, ground nesters and cavity nesters are likely to die because of being deprived of their habitats and food sources. South Asian research has demonstrated that urban growth has led to local extinction of vulnerable species and invasive or exotic species tend to flourish in the altered habitat (Khera et al., 2009). In Pakistan, urbanization in cities like Lahore, Multan, and Faisalabad has also been linked to a decline in birds diversity with native experts being replaced by common synanthropic species (Khan, 2015).

The effects of urbanization on birds are ecological in nature. Habitat fragmentation is known to cause disruption of movement patterns, breeding success, and access to resources and even anthropogenic disturbances like noise, light pollution and vehicle traffic further add stress to avian populations (Marzluff et al., 2011). Pollution of noise in this area especially disrupts communication and mating call causing behavioral alterations and reduced reproductive success (Slabbekoorn and Ripmeester, 2008). Artificial light has an impact on the night species and can disorient the movement of migratory birds leading to further death during migration (Gaston et al., 2013). These pressures may lead to a cumulative effect that changes the population dynamics and reduces the functional diversity, which may affect the processes of the ecosystem, including pollination, seed dispersal, and insect population control.

The temporal dynamics are also very important in the ecology of urban birds. Species composition and abundance is affected by seasonal variations, breeding, and non-breeding seasons. An example of this is migratory birds whose stopover sites could be disturbed or destroyed by the development of urban areas (Fernandez-Juricic & Jokimaki, 2001).

Behavioral plasticity, change in diet, and adjustment of nesting patterns allow resident species to gradually adapt to urban conditions, although not all species have been found to be able to survive in highly urbanized areas. Research on other cities that are rapidly developing reveals that more adaptable species of resident birds in terms of diet and nesting behavior have a higher probability of surviving, whereas niche species lose their populations (McKinney, 2006; Marzluff, 2001).

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Besides the direct destruction of habitats, urbanization may in turn have an indirect and negative impact on avian diversity by altering prey availability and competition. Urban environments also significantly decrease insect populations which form the major diet of many bird species since there is a simplification of their habitat, use of pesticides, and pollution (Baker et al., 2002). The low availability of prey compels insectivorous birds to either change their food or go local extinct. Likewise, fragmented urban environments provide more competition over nesting sites and resources that are usually more aggressive with generalist species replacing more vulnerable ones (Chace & Walsh, 2006).

Urbanization also combines with other anthropogenic stressors such as the climate change, pollution and the invasion of exotic species, which increases its impact on the avian communities. As an illustration, the urban heat islands can result in microclimates, which can modify the breeding phenology, foraging behavior, and species interactions (Shochat et al., 2006). The health and reproductive success of birds may be impacted by pollution in the form of chemical contaminants and litterfall, and invasive species may surpass native species in resource competition (Czech et al., 2000). These complicated interactions need to be known to manage urban biodiversity.

The importance of the green infrastructure, habitat restoration, and urban planning that is friendly to the biodiversity have become more prominent in conservation plans in urban landscapes. By incorporating native plants, not making corridors difficult to cross, and creating urban parks in a form that resembles natural habitat vegetation, it is possible to greatly increase the avian diversity in cities (Aronson et al., 2014). The awareness and engagement of people in urban bird conservation by programs dealing with citizen science and environmental education can subsequently lead to long-term sustainability (Miller and Hobbs, 2002).

In Southern Punjab, urbanization is taking place at a very high rate owing to increase in population, development of industries and expansion of infrastructure. There are however limited empirical studies on urban avifauna in this area. This is preliminarily observed to show a decrease in native species, especially habitat specialists, and an upsurge in generalist and synanthropic species in urbanized zones (Khan, 2015). The systematic surveys are badly needed to measure the species richness, community composition, and the impacts of the urbanization gradients on the avian diversity. These studies play a crucial role in enlightening urban planning, effective conservation intervention design and ecosystem service delivery by birds in human-dominated environments.

General, the literature shows that urbanization has very powerful adverse effects on avian diversity, such as habitat loss, habitat fragmentation, and human-made disturbance. Nevertheless, these effects could be reduced and favorable ecological conditions could be created through the availability of well-planned green areas, habitat corridors, and conservation-oriented urban design that could support various bird populations. The proposed study seeks to complement the existing literature by offering region-specific information in Southern Punjab analyzing the impacts of urbanization in urban, peri-urban, and rural environments, and out-lining the measures to co-exist between urban growth and the biodiversity of birds.

METHODOLOGY

Study Area

The research was done in Southern Punjab, Pakistan, which covers urban, peri-urban and rural landscapes so as to capture a continuum of urbanization. Major urban places were Multan, Bahawalpur and Dera Ghazi Khan whereas the peri-urban areas were the peri-urban areas that surrounded these cities and had mixed agricultural and semi-natural habitation. The rural sites were chosen in the less-developed regions with minimum anthropogenic disturbances, such as natural plants or fields, and wetlands. These locations have been taken to symbolize the presence of all the types of habitats within Southern Punjab and to determine the impact of different levels of urbanization on the bird population (Khan, 2015).

Sampling Design

A stratified sampling method was employed so that there was sufficient representation of urbanization gradients. Five study sites were chosen in each type of landscape (urban, peri-urban and rural) on the basis of heterogeneity of the habitat, accessibility and the history of bird occurrence. They were sampled in one year, both during breeding (March-June) and non-breeding (October-January) periods to consider seasonal changes in the species composition (Marzluff et al., 2011).

Data Collection Methods

Two complementary techniques of survey, which included point counts and line transects, were used.

Point Counts:

At each site, point count stations were set at least 200 meters apart so that those were not counted twice. All birds visible or audible within a radius of 50 meters were noted by the viewer in 10 minutes. The point counts were performed in the early morning (06:00-09:00) when the birds are the most active, following the standardized procedures (Bibby et al., 2000).

Line Transects:

Each site had transected that were 1-2 km in length. The observers strolled in transects and noted all the birds they saw within a 25 meters' perpendicular radius. The transects were surveyed after every two seasons to consider the temporal variability and to enhance the probability of detection (Sutherland, 2006).

Species Identification

The identification of birds to species level was done through field guides, such as Birds of Pakistan by Grimmett et al. (2011) and the use of local checklists. Identification was also done by vocalizations especially the cryptic or visually elusive species. Different ecological categories of species (resident, migratory, generalist, specialist) were developed to determine the effect of urbanization on various functional groups.

Habitat Assessment

To measure the relationships between the habitat factors and avian diversity, habitat features were measured at each site. The recorded variables were:

Percentage of vegetation cover: Machine translated to mean percentage of trees, shrubs, and ground cover.

- **Green space size:** Size of parks, gardens or semi natural areas.
- **Urban distance:** This is computed by the use of GPS coordinates.
- **Human disturbance:** The frequency of the vehicles, pedestrians, and industry.

Habitat assessment adhered to the procedures identified by Fernandez-Juricic and Jokimaki (2001) and Miller and Hobbs (2002), which allows comparisons between the degrees of urbanization.

DATA ANALYSIS

Ecological indices were used to measure diversity of the avian. Data abundance was also to be determined to reveal the dominant and rare species in each landscape type. The relationship between the urbanization intensity and the habitat variables with species diversity was evaluated using generalized linear models (GLMs). One-way ANOVA and Tukey post hoc tests were used to compare the indices of diversity of the urban and peri-urban and rural sites.

All the statistical tests were done on the basis of R software (4.3.0) and the significance level was set at

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$p < 0.05$. To visualize the effects of urbanization, graphical visualization of species richness, abundance and diversity between sites was produced.

Ethical Considerations

The field surveys were carried out in accordance with ethical principles of conducting wildlife research. Birds and their habitats were not disturbed to make observations. There was no capturing or harming of any specimen and all the operations were in accordance with the local wildlife laws and conservation policies (Pakistan Wildlife Act, 1974).

DATA ANALYSIS & FINDINGS

Richness and Abundance of Species.

It has been observed that 92 bird species in total were observed in all the study sites and this is a representation of 56 genera and 27 families. The richness and abundance of species differed greatly in urban, peri-urban, and the rural environment. The greatest number of species was observed in rural environments (S = 78 species), then peri-urban (S = 64 species) and urban environments (S = 41 species). On the same note, total abundance had a maximum in rural habitats (N= 1,842 individuals), intermediate in peri-urban habitats (N= 1,215 individuals), and minimum in urban centers (N= 732 individuals).

Table 1: Species Richness and Abundance Across Urbanization Gradients

Landscape Type	No. of Sites	Species Richness (S)	Total Abundance (N)	Dominant Species
Urban	5	41	732	*Passer domesticus*, *Columba livia*
Peri-Urban	5	64	1,215	*Corvus splendens*, *Streptopelia decaocto*
Rural	5	78	1,842	*Turdoides caudatus*, *Acridotheres tristis*

Interpretation: The negative relationship between urbanization and species richness and abundance is an indication that urban habitats are more favorable to generalist and synanthropic species and not habitat specialists. The urban areas were dominated by the species that were essentially the omnivores and granivores and they were adapted to changes that human beings had brought about.

Diversity Indices

The values of Shannon-Wiener diversity index (H ') and evenness (E) were obtained in all sites. Rural locations were the most diverse (H' = 3.87) and even (E = 0.82) whereas urban locations were the least diverse (H' = 2.11) and even (E = 0.61). The intermediate values were peri-urban (H' = 3.21; E = 0.74).

Table 2: Diversity Indices Across Urbanization Gradients

Landscape Type	Shannon-Wiener Index (H')	Evenness (E)
Urban	2.11	0.61
Peri-Urban	3.21	0.74

Rural	3.87	0.82

Interpretation: Reduced diversity and evenness in cities implies supremacy of a small group of generalist species, which causes biotic homogenization. The country environment had a more equal distribution of people between the species, there were more specialists and sensitive species.

Functional Group Analysis

The species of birds were classified as generalists, specialists, residents and migrants. In urban locations, generalists (72% of people) and residents (65%) dominated the site whereas in rural places, there were more specialists (48%), and migrants (32%).

Table 3: Proportion of Functional Groups Across Landscapes

Landscape Type	Generalists (%)	Specialists (%)	Residents (%)	Migrants (%)
Urban	72	28	65	35
Peri-Urban	55	45	60	40
Rural	39	61	52	48

Interpretation: Reduced diversity and evenness in cities implies supremacy of a small group of generalist species, which causes biotic homogenization. The country environment had a more equal distribution of people between the species, there were more specialists and sensitive species.

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Table 4: ANOVA Results for Shannon-Wiener Diversity

Source of Variation	df	F	p-value
Between Groups	2	28.67	<0.001
Within Groups	12	—	—
Total	14	—	—

Interpretation: Statistical results prove the fact that urbanization has negative impacts on avian diversity and urban centers have the lowest diversity indices.

Habitat Correlations

The relationship between habitat variables and species diversity was analyzed using Pearson correlation analysis. The vegetation covers and Shannon-Wiener diversity ($r = 0.82$, $p < 0.01$) as well as green space size and species richness ($r = 0.77$, $p < 0.05$) showed significant positive correlations. Diversity had a negative relationship with human disturbance ($r = -0.69$, $p < 0.05$).

Table 5: Correlations Between Habitat Variables and Avian Diversity

Habitat Variable	Species Richness (S)	Shannon-Wiener Index (H')
Vegetation Cover (%)	0.75*	0.82**

Green Space Size (ha)	0.77*	0.79*
Human Disturbance Index	-0.63*	-0.69*

- $p < 0.05$; ** $p < 0.01$

Implication: These associations indicate that the adverse effects of urbanization on the diversity of birds can be addressed by preserving sufficient vegetation cover and larger green areas. Intrusion by humans in form of traffic, building, and noise minimizes habitat suitability of vulnerable species.

Community Composition Analysis

Cluster analysis and non-metric multidimensional scaling (NMDS) were used to visualize variations in the community structure of birds in urban, peri-urban and rural locations. NMDS plots depicted that there was distinct separation of urban and rural communities with peri-urban locations taking the intermediate position. There was greater species turnover at the urban and rural locations, and this points to the homogenizing influence of urbanization.

Theoretical implications: Urbanization leads to new communities having specialist-dominated communities being replaced by simplified ones dominated by generalists. Peri-urban environments are semi-permeable areas which sustain a kind of mix of generalists and specialists.

KEY FINDINGS

Reduction in Species Richness and Diversity: The indices of species richness, abundance and diversity were lowest in urban locations.

Dominance of Generalists: Generalists and resident species were dominant in urban sites, whereas rural areas were homelier to more specialists and migratory birds.

Matter of Habitat Variables: The positive relationships between avian diversity and the vegetation cover and the size of green spaces were found, but human disturbance had a negative impact.

Community Composition Shift: Urbanization caused Biotic homogenization and therefore decreased functional diversity and community composition.

Peri-Urban Zones as Buffers: Peri-urban locations still had some of the specialist species implying their relevance in conservation planning.

The results have shown that urbanization in Southern Punjab has an adverse effect on the diversity of avian species and thus there is a need to control the habitat and plan conservation and the incorporation of green infrastructure to the urban environment.

CONCLUSION

This paper shows that urbanization has serious negative effects on the diversity of the avian species in Southern Punjab, Pakistan. The urban regions had the lowest levels of species richness, abundance and diversity with the peri-urban and rural regions being the most diverse with dominance of a few generalist and synanthropic species across the urban, peri-urban and rural gradations. Conversely, the rural locations were more diverse, with more habitat specialists and migratory birds, making natural and semi-natural locations important to the avian biodiversity sustainment.

The correlation of habitat variables showed that the amount of vegetation covers and green space was positively related to the species richness and diversity and the human disturbance had a negative impact on bird communities. The analysis of functional groups also showed that the impact of urbanization affects specialists and migratory species disproportionately, whereas the generalists are more adaptive

and can adjust to the anthropogenic environment. The community composition studies showed that urban landscapes are linked with the Biotic homogenization and the peri-urban zones operate as an interchange zone, which endorses a mixture of generalists and specialists.

In general, these results highlight the importance of habitat construct, connection and control in curbing the adverse impacts of urbanization on birds. The research gives empirical data that planning choices in urban areas have a direct impact on preservation of avian species and ecosystem activities in fast urbanizing areas such as the Southern Punjab.

RECOMMENDATIONS

On the basis of the obtained results, the following recommendations can be made to facilitate the avian biodiversity and the sustainable urban development:

Improvement of Green Areas in Urban areas

Development and preservation of parks, gardens, and semi-natural patches of high structural complexity should be given priority by the urban planners. Vegetation, trees, and shrubs can be used to offer foraging and nesting opportunities to various bird species (Aronson et al., 2014).

Habitat Connectivity

Movement of birds can be achieved through the development of ecological corridors and linking fragmented green areas which will mitigate the adverse impacts of habitat isolation. Green areas between cities and peri-urban can accommodate resident and migratory species.

Minimization of Human disturbance

Noise, light, and traffic should be restricted in the major urban green spaces. Human activity can be regulated with the help of zoning policies and sensitization to ensure less pressure on delicate species of birds.

Preservation of Peri-Urban and Rural Habitats:

Peri-urban areas can be used as buffers and safe havens of specialists. It is essential to protect agricultural lands, wetlands, and natural vegetation around urban centers in order to ensure the functioning of the diversity and ecology.

Native Vegetation

Native vegetation should be encouraged around the huts and residences. <|human|>Promotion of Native Vegetation:

The use of native tree and shrub plant species can experience insectivorous, nectarivorous, and frugivorous birds, which increases interactions with the ecology and provides ecosystem services in urban landscapes.

Surveillance and Citizen Science

Setting up multiple monitoring programs over the long run and involving local communities in citizen science can present useful data regarding population dynamics, species location, and habitat quality, which can contribute to adaptive management.

Biodiversity as an Urban Planning Policy

Policies on urban development need to put a specific focus on biodiversity and growth should not proceed at the cost of the ecological integrity. New infrastructure projects should have indicators of avian diversity in the environmental impact assessment before they are approved.

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Education and Awareness

The target group of spreading awareness among residents, policymakers, and developers regarding the significance of urban biodiversity can lead to the development of conservation-related behavior and the sustainability of coexistence between people and wildlife.

To sum up, urbanization poses a great threat to the avian life, and its adverse effects can be alleviated through active planning, habitat management, and participation of the community. These recommendations can be put into practice in order to conserve the richness of species, sustain functional groups and ecosystem services offered by birds in the urbanizing landscapes of Southern Punjab.

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