Journal of Wildlife and Ecology (2024). 8(2):109-132

Research Paper **Open Access**

Green Spaces Impacts on Avian Diversity in Residential Land of Dera Ghazi Khan, Punjab, Pakistan

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Citation: Laraib, T., M. Altaf, T. Hussain, J. Naseer, S. Batool, U. Ali, M. Khan, Z. Shaheen, H. Ayoub, S. R. Z. Naqvi, I. Nawaz, and M. Jahangeer. 2024. Green Spaces Impacts on Avian Diversity in Residential Land of Dera Ghazi Khan, Punjab, Pakistan. Journal of WIldlife and Ecology. 8: 109-132.

SUMMARY

Urban green spaces enhance the quality of life in cities and influence people's attitudes towards the environment and protection. The landscape designers to increase bird variety. In Dera Ghazi Khan nine sites selected, we looked at the relationship between bird species diversity, richness, and community structure. There were 57 species of birds recorded in total, of which 68% were residents, 14% were summer breeders, 9% were passage migrants, and 9% were winter visitors. There were 7226 birds in all that were observed. Omnivores made up the majority of the birds that were spotted, while herbivores made up the least. Due to the availability of food, the diversity of birds was much higher in the summer season than it was in the spring, autumn and winter. The most birds observed over the course of a year were the house crow, house sparrow, and common myna. I discovered that the diversity of plant species was strongly correlated with bird species variety. The majority of bird species were found in areas with high tree and shrub species diversity and moderate to low tree and grassland cover. Only a few bird species were attracted by tall trees or high lawn cover. Contrasting to foreign birds, native birds preferred to browse on native trees. The abundance of birds was negatively impacted by dogs and people. As a result, we advise landscape designers to avoid using a lot of lawn space, choose native trees and shrubs, and designate specific places that are off-limits to both people and dogs. Finally, we stress the significance of interdisciplinary research done in coordination with wildlife biologists and landscape architects.

Keywords: Urban bird diversity, Green spaces, Richness, Landscape, Dera Ghazi Khan

Received: 07-01-2024	**Revised**: 19-02-2024	**Accepted**: 02-05-2024

INTRODUCTION

A vast majority of individuals on Earth reside in urban areas and a huge deal depend upon greenery in city areas to keep an association to nature and the ecosystem. The preservation of these isolated pockets of native environment in cities has grown more important for the well-being of people as well as the floral, animal, and microbial species that reside there (Mexia et al., 2018). Millions of species may exist in green spaces in cities even though the fact that urbanized areas frequently have much lesser

diversity than rural and ecological areas (Lepczyk et al., 2017b). Birds are shown to be excellent indicators of the current condition of global diversity in cities on a global basis (Nielsen et al., 2014; Peris and Montelongo, 2014). The association among dimension, habitat framework, and connectivity/isolation as it relates to biodiversity (the range of species in a certain place) has been the subject of numerous studies on the variety of birds in urban green areas (Dale, 2018).

According to numerous studies, the variety of urban bird species is influenced by the vegetation's area of coverage (Kang et al., 2015; Altaf, 2016; Dale, 2018). As they often have more resources and more complicated habitats (niche space), greater green spaces can support more species in general. Bird species are consequently more diversified in terms of taxonomy and behavioral variation (Jasmani et al., 2017; Shakil et al., 2023). The conception of island biogeography claims (Wilson and MacArthur, 2016) the more distant the greenery is to its beginning area and the residents away from cities, the less variety of species one might anticipate. Thus it makes sense that grassland next to densely inhabited cities would have less biological biodiversity (Chamberlain et al., 2007) than those situated in suburbs that are nearer to rural natural deposits. Even though the fact that several studies support this highly urbanized difference (Nielsen et al., 2014). It is not used by many individuals (Dale, 2018). It is probable that these other factors, such as the climate, have a greater influence on variety and society than geographical area, given the fact that distance may not be an important barrier to bird dispersion (Dale, 2018). Depending on their size and shape, green spaces can either fill in gaps in the urban fabric or fit neatly between buildings and roads (for example, such as small patches or enormous parks and gardens). Dimensions might not be the most component, but it occasionally has a limit variety. In two identically sized parks but vastly different designs, the value of the habitat may vary substantially, with one park having a smaller ecosystem along its borders than in its central region (Collinge and planning, 1996).

Despite extensive study into species diversity in urban environments, other variety metrics, such as population, are less widely employed. Considering accessibility affects bird abundance compared to wildlife, it may present an alternative picture of changes in urban biodiversity. For instance, population growth and foliage decrease may occur as urbanization develops (Faeth et al., 2011). A substantial increase in the population of a foreign bird category as well as some native ones that are more suited to urban situations may be the cause of these modifications in richness. Additionally, the placement of urban gardens may have an impact on other factors, such as behavioral changes, which could modify the level of diversity (Faeth et al., 2011). For example, increasing block size improved the biological diversity and density in South Korean residential forest areas, whereas vegetation connectedness only affected plentiful resource (Kang et al., 2015). However, neither the species variety nor their abundance differed much over grassland in Sacramento County, California, outside of Rancho Cordova. However, in Rancho Cordova, the area of the grassland had a strong correlation with the variety of species, but manufactured cover inside the grassland had a stronger correlation with frequency (Haas et al., 2020). These variations highlight the need to consider a number of variables in order to fully comprehend the factors influencing urbanized bird species. Environment on Earth are being altered by humans at an unparalleled rate. More

than 50% of people live in towns today, despite the fact that only the world's urbanized areas occupy 3% of its surface (UNEP, 2012).

Urban regions frequently analyze bird richness since it is very simple to keep a watch on (Ralph et al., 1995) because it serves as a reliable predictor of whether a city's environment is suitable for biodiversity (Benstead et al., 1999). Evaluation of avian biodiversity thus offers insight into how land use management and urban planning affect ecosystem. Prior studies have demonstrated that urban parks and green spaces improve bifrd biodiversity (Su et al., 2010; Sorte et al., 2013; Aida et al., 2016).

However, the majority of previous research have neglected birds, particularly those that live in urban environments, in preference for studying creatures with poor dispersal abilities (Gilbert-Norton et al., 2010; Lepczyk et al., 2017a; Resasco, 2019). Furthermore, it is crucial to investigate if a variety of species, such as city avoiders, who are less common in cities, use these ecological pathways to colonize areas of urbanization.

These watershed pathways frequently contain waterbodies (such as rivers and ponds), which might provide crucial food and water supplies for animals that are particularly restricted by urban environments (Shih et al., 2020), This might greatly increase biodiversity in cities (Tilghman and planning, 1987). Last but not least, taking into account how different species are distributed from the city's outside to its centre might reveal further details about how well the route has worked to increase bird variety within the city (LaPoint et al., 2015). In this study, we assessed how the variety of birds is impacted by urban land use and greenways. We also made a distinction between uncommon species, which are less frequent in cities, and the most prevalent species to see whether they benefited in various ways from green infrastructure and corridors. In order to achieve this, we used data from a thorough study of bird biodiversity (102 sites) conducted in the Spring time in Niort, a tiny French city in the west with around 60,000 residents and a surrounding agricultural area. It's interesting to note that during the past ten years, this city has established ecologically friendly management practises, which are characterized by the construction of numerous Environmental infrastructure (parks, plantings along the edges of roadways), as well as the preservation of a significant green corridor that runs through the entire town. The communication between various parts of the city and the nearby farms is ensured by this pathway, which is made up of a watershed route with nearby parks and densely forested banks of rivers. This condition offers a rare chance to assess how a significant green corridor would affect the species of birds. The specific environmental characteristics for each demographic site (such as the proportion of green space), Along with the assessment of bird species, its range from the biological corridor previously indicated, as well as its length from the limits of the town, were all measured.

Besides the vegetation that gives rise to the urban environment, the various urbanized elements are expected to affect diversity differentially (Alberti, 2010). Given that birds are one of the most conspicuous elements of diversity in cities, there is growing interest in bird populations in ecosystems in cities and suburbs (Caula et al., 2014). Even though urban areas provide abundant food, constant temperature (Compared to their rural and natural surroundings, they are substantially hotter.), as

well as appropriate habitat for wildlife, there are drawbacks to increasing urbanization, such as an increase in traffic noise, light pollution, waste, and human disturbance. As a result, the number of urban adaptations dramatically grew, and the number of birds that eat rubbish increased. However, variety clearly decreased (Corcuera and Zavala-Hurtado, 2006; Altaf et al., 2018; Khan et al., 2022) confirmed that as a result of changes in resource quality and quantity, urban birds' dispersion tended to be individualized (Ali et al., 2020; Rahman et al., 2021). Additionally, its breeding habits and tactics will change with time.

Birds serve as a sign of urban welfare and are threatened by urbanization, which is prevalent and increasing (Koskimies, 1989; Yuan and Liu, 1994; Khan et al., 2022). It offered guidance for urban planning and programming as well (Shui-hua et al., 2000). The link between species adaptability and urban conditions has been the subject of much investigation. The collection of traits has been documented in urban communities of rock doves (*Columba livia*) and blackbirds (*Turdus merula*), for example Rahbek and Graves' multiscale assessment of avian species richnes (Allen et al., 2000; Fernandez-Juricic et al., 2001; Hostetler et al., 2003). The geographic distribution and quantity of birds were compared across urban and rural settings, as well as along a gradient of urban categories (Palomino et al., 2006), where their findings revealed factors impacting bird varieties range and richness in urban environments. This study was designed to know the green spaces impacts on avian diversity in residential land of Dera Ghazi Khan, Punjab, Pakistan.

MATERIALS AND METHODS

STUDY AREA

The Dera Ghazi Khan district is near the Indus River and is situated on the edge of the Suleiman Mountain range. The irrigation and agriculture of the area are greatly influenced by the Indus River. The data was collected from July 2022 to June 2023. The information was collected every month for weekly bases in the early morning and just before sunset in District Dera Ghazi Khan, Punjab, Pakistan. (Figure 1) The total area of Dera Ghazi Khan is 11,294km sq. In 9 public spaces and gardens in the cities, we looked into the bird species. The coordinates of District Dera Ghazi Khan is 30° 1′ 59″ N, 70° 38′ 24″ E.

During the study, choose locations with various plant compositions and site sizes. Because there aren't many large-scale gardens in the city, a selection of small and medium-sized gardens was made. The vegetation types in these gardens vary. For example Several tree plantings, many had sizable lawns, while the other ones featured a variety of vegetation patches. These locations were dispersed throughout the city (Paker et al., 2014). The average distance between the sites was around about 0.25 to 3km.

BIRD SURVEYS

According to Bibby et al. (2000) observed that the environment nearby the point counts is vital to the investigation, we used fixed-radius point counts, a valuable technique. With the exception of one site that had 10 acceptable locations, we chose 2 stationary observation points at 4 sites and 4 stationary observation points at the remaining 4 sites, totaling 34 points.

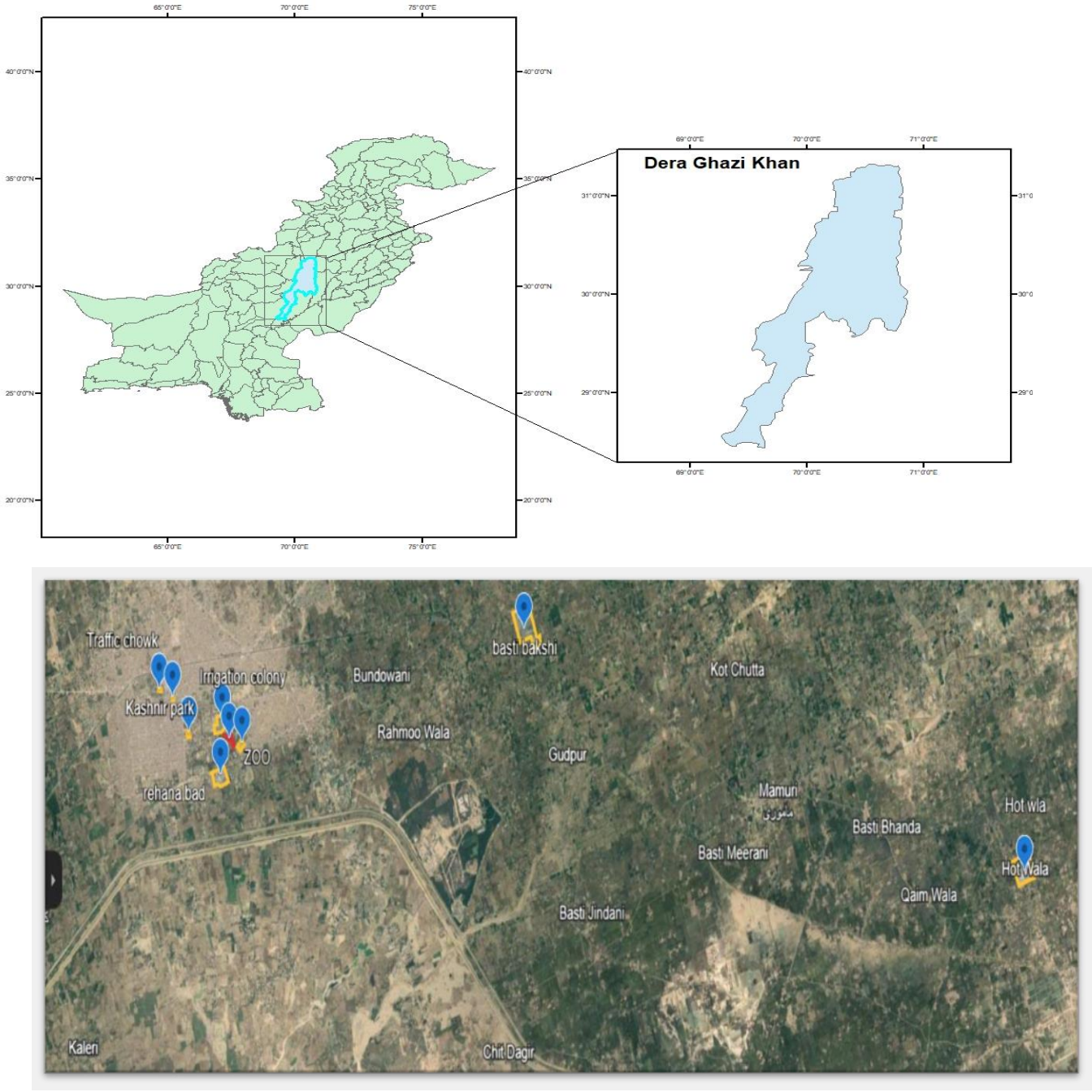

Figure 1: Map of my study site Sites of Research Zones in D.G Khan, Punjab, Pakistan.

According to the design of garden, the distance between the two places varied (from 100 to 400 m) to prevent any overlap of the regions under observation. There was a bird counting. In some places, we chose a circle and divided it into two halves. In other places, we chose a circle and divided it into four sections. The observer sat still for five to ten minutes at the start of each point count to collect data then kept track of the birds for an extra ten minutes. With the exception of species that can browse while flying, birds that flew over the garden were not listed.

A total of 21–25 visits were made to each point count: two to four times per month during the fall and spring migrations (August–October and March–May, respectively), and once per month for the remainder of the year. There was just one point count that deviated from this trend, totaling only 11 monthly visits because of various issues. A single observer made all of the sightings in the hours around sunrise as well as before sunset throughout the periods of July 2022 to June 2023. Additionally, we noticed how certain plant species were used by birds for food. Exploring activities were noted whether we saw birds eating fruit (whole or in part), collecting insects from leaves and hanging on wires on buildings and towers. We observed four different bird types: year-round inhabitants (Residents), winter visitors, passage migrants and summer breeders. While passage migrants arrive in the places where they exist for a brief period between the origin and destination, residents are species that remain year-round in Pakistan. Winter visitors are birds that just spend the winter in a given place and does not breed there. A summer breeder is a bird that only spends the summer in a particular place and does not reproduce there. They typically grow in cities as commensals to the extent that they become depend on urban supplies (Kark et al., 2007).

VEGETATION AND OTHER ENVIRONMENTAL VARIABLES

Site 1 (Horticulture Garden)

An observer first went to a horticulture garden with a about 510-meter radius. The observer observed many fruit-bearing trees, including *Mangifera indica, Grewia Asiatica, Psidium guajava, Ziziphus Mauritania,* and *Citrus sinensis*, throughout the visit. The garden also has various different bird species and well-kept grass. The observer did a computation and found that there was vegetation on 80% of the area.

Site 2 (Kashmir Park)

An observer conducted a visit to a park with the aim of identifying an approximate area with a radius of 125 units. During the visit, the observer focused on observing the variety of bird species present and took note of the predominant tree types. The most common tree species observed were *Acacia nilotica, Eucalyptus camaldulensis*, and *Azadirachta indica*. The estimated green coverage of the park was found to be 65%. It's worth noting that the park is located in a densely populated and busy area.

Site 3 (Commisioner Office)

In order to select a region with an estimated radius of roughly 150 units, an observer went to the Commissioner's office. They were there to examine the many bird species that lived there and to make a list of the various tree species. They discovered that *Eucalyptus camaldulensis, Phoenix dactylifera* (date palm), *Pongamia pinnata*, and *Bougainvillaea spectabilis* were the four most prevalent tree species. They calculated that green vegetation made up around half (50%) of the area. It's vital to note that this neighbourhood is situated in a crowded and heavily inhabited area.

Site 4 (Irrigation colony)

An observer went to an irrigation colony to determine the general location of a region with a radius of around 200 units. Their main goals were to study the different bird species that were there and record the kinds of trees they came across. They noted that *Azadirachta indica* (neem*), Eucalyptus camaldulensis, Acacia nilotica* (babul), and *Moringa oleifera* (drumstick tree) were the four most prevalent tree species. The colony had an about 45% green covering, according to estimates. It is important to note that this region has a sizable population.

Site 5 (Zoo Area)

A visitor to a zoo made the decision to focus on a region with a radius of around 480 metres. Their primary objective was to observe and catalogue the many bird species that were present there while also documenting the diverse species of trees. They discovered that *Pongamia pinnata, Moringa oleifera, Ziziphus mauritiana,* and *Conocarpus erectus* were the four most prevalent tree species in the region. They calculated that there was green vegetation on around 75% of the land.

Site 6 (Traffic chowk Junction)

In order to locate a region with a radius of around 60 metres, an observer went to a busy traffic intersection. Their main goal was to study the local bird species, of which there are relatively few varieties. They also took note of the surrounding trees. However, they discovered that there were not many trees in the region and that the most of them were *Acacia nilotica* and *Eucalyptus camaldulensis*. Only 15% of this land is thought to be covered in greenery, according to the estimate. It's also crucial to remember that this location is located in the major city's centre.

Site 7 (Hoat Wala)

An observer went to a location called "Hoat Wala" and made a guess about a region having a radius between 500 and 1400 metres. Their primary objectives were to see various bird species and observe the local trees. They discovered that there were numerous trees, including *Syzygium cumini, Dalbergia sissoo, Eucalyptus camaldulensis, Acacia nilotica*, and *Moringa oleifera*. They also saw several kinds of flowers, including roses, and crops including wheat, millet, maize and rice. There were several canals in this location, but they chose distinct segments with radii ranging from 200 to 700 metres. They saw a vast variety of birds in this location, and 90% of the land was covered with greenery, including trees and plants. This neighbourhood had a typical population that was not overcrowded.

Site 8 (Basti Bakshi)

An observer went to a location near a semi-urban region and selected an approximated area with a 400–1200 metre radius. Their primary objective was to observe various bird species, as well as to count the number of trees and other forms of greenery present, such as *Acacia nilotica, Eucalyptus camaldulensis,* and *Calotropis procera*. Additionally, they saw the existence of certain crops like rice and wheat. Approximately 75% of the land in this area was estimated to be covered with

vegetation by greenery. It is significant to notice that fewer individuals resided in this location than in other areas, which indicates a smaller population density**.**

Site 9 (Rehana Bad)

An observer went to an area close to railway lines and chose an estimated area with a radius of about 600 meters. They were there to watch different kinds of birds and make a record of the different types of trees present. Some of the tree species they noted were *Acacia nilotica, Phoenix dactylifera* (date palm), *Calotropis procera*, and *Prosopis cineraria*. They also observed the cultivation of wheat and rice in the area. They estimated that approximately 85% of the land in that area was covered with green vegetation. It's important to mention that this area had a relatively lower population density, meaning there were fewer people living there compared to other places (Figure 1).

In addition to other environmental factors, the observer reported the presence of cats, dogs, and other human activity in these areas. These factors seem to have a detrimental effect on the variety of birds in the area. We also counted the total quantity of vegetation surrounding each garden using Google Earth. (Figure1)

DATA ANALYSIS

The Shannon-Wiener index was used to determine the number of bird species present in each area. By determining, for each garden type, for each bird kinds, the diversity in bird species is varied and similar gardens was contrasted (Symonds and Johnson, 2008).

The Shannon-wiener Index was recorded using a formula in Microsoft Excel (Weaver, 1963).

H'=- ["PI In P"]

H' is the Diversity Index.

ANALYSIS OF THE RELATIONSHIP BETWEEN SITE SIZE AND LAWN COVERAGE

Variability in Green covering

As shown by the findings, the sampled sites' green covering percentages differed widely. The percentage of greenery in site 3 and 6 was the lowest, at 50% and 15% respectively, while the percentage of greenery in site 7 was the greatest, at 90%.

Influence of site Size

Site size tends to have an impact on the amount of greenery present, with bigger sites often having higher percentages of greenery. For instance, site 8, which measures 2,422.27 m^2 and is the largest, had a green coverage of 75%, suggesting a substantial area covered with vegetation.

Efficiency of Space Utilization

Site 6 (116.48 m^2), a smaller site, offered the chance for a more effective use of space with 15% green covering. These tiny locations might not have a lot of green space, but with proper landscaping, they can have as much green as possible.

These findings have significance for both urban and suburban development since they show how critical it is to maximize the amount of green space relative to the available area. While bigger garden sites can take use of their size to produce rich, green landscapes, smaller garden sites may profit from creative landscaping approaches to maximise green covering (Table 1).

Table 1: Area, Green coverage percentage and Coordination's of Research Sites.

Sites Name	Sites size	Green coverage	Location
1-Horticulture garden	1,076.21 m	80%	30°02'34"N 70°37'48"E
2-Kashmir Park	245.05 m	65%	30°03'23"N 70°38'31"E
3-Commisioner Office	300.57 m	50%	30°03'06"N 70°37'53"E
4-Irrigation Colony	411.32 m	45%	30°02'21"N 70°37'26"E
5-Zoo Area	980.92 m	75%	30°02'31"N 70°37'34"E
6-Traffic Chowk	116.48 m	15%	30°03'13"N 70°38'21"E
7-Hot Wala	1,468.83 m	90%	29°51'14"N 70°31'17"E
8-Basti Bakshi	2,422.27 m	75%	29°57'49"N 70°36'55"E
9-Rehana Bad	1,370.99 m	85%	30°02'46"N 70°37'14"E

RESULTS

We collected data from gardens of various sizes, apart from some colonies and some areas in the middle of the city where there was heavy traffic. There were a total of 9 sites for the selection of my observation where we saw different types of trees which were some *Eucalyptus trees*, *Dalbergia sissoo*, *Azadirachta indica* and in some places, there were fruit trees, mostly oranges, mango, banana, pomegranate, and Chinese dates and they were some herbs shrubs and wild plants.

OBSERVED BIRD SPECIES

We observed 57 of bird species and their total number of individuals was 7226, Dominance was 0.1148, Simpson Diversity Index was 0.8852, Shannon Diversity Index was H: 2.698, and Evenness was 0.2605 as shown in Tables 2 and 3. This observation was for a period of one year. We started in July 2022 and ended in June 2023. During this period, the highest number of birds we saw at Site 1 was recorded in the month of July 2022. Most of them were resident birds. They were seen in mostly gardens, colonies, zoos, offices, and traffic areas. The most common bird of all species was the crow. Most of these birds belonged to 14 orders and 31 families.

These birds include there are 32% omnivorous birds, 30% insect-eating birds (insectivores), 25% carnivorous birds,5% grain-eating birds (granivores),5% seed-eating birds (piscivores) and 3% herbivorous birds (Figure 2).

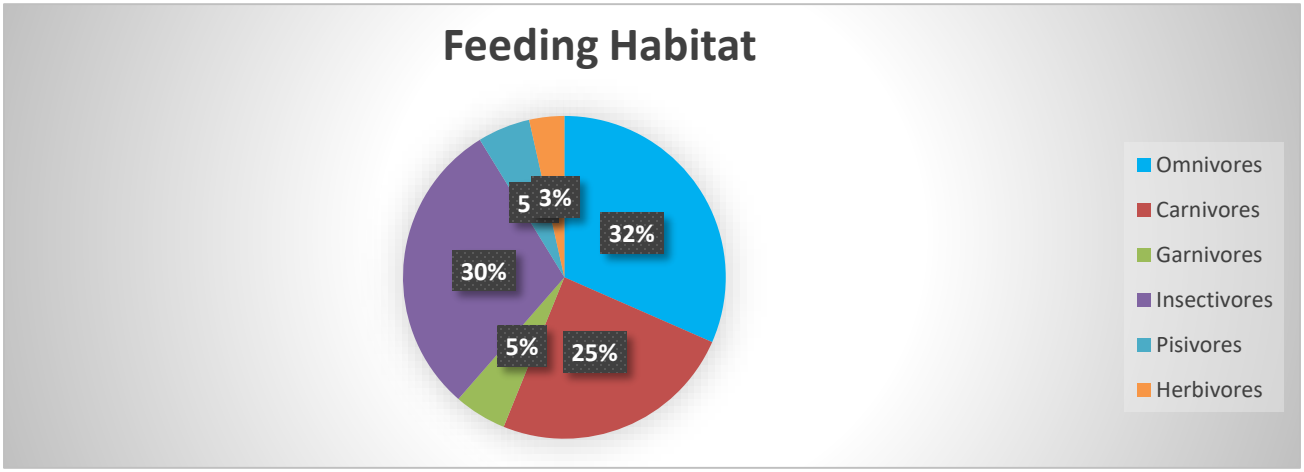

Figure 2: Feeding Habits of birds.

In these 9 sites the distribution of birds are 68% Residents,14% summer breeders,9% winter visitors and 9% passage migrant. The graphically distribution of birds shown as (Figure 3).

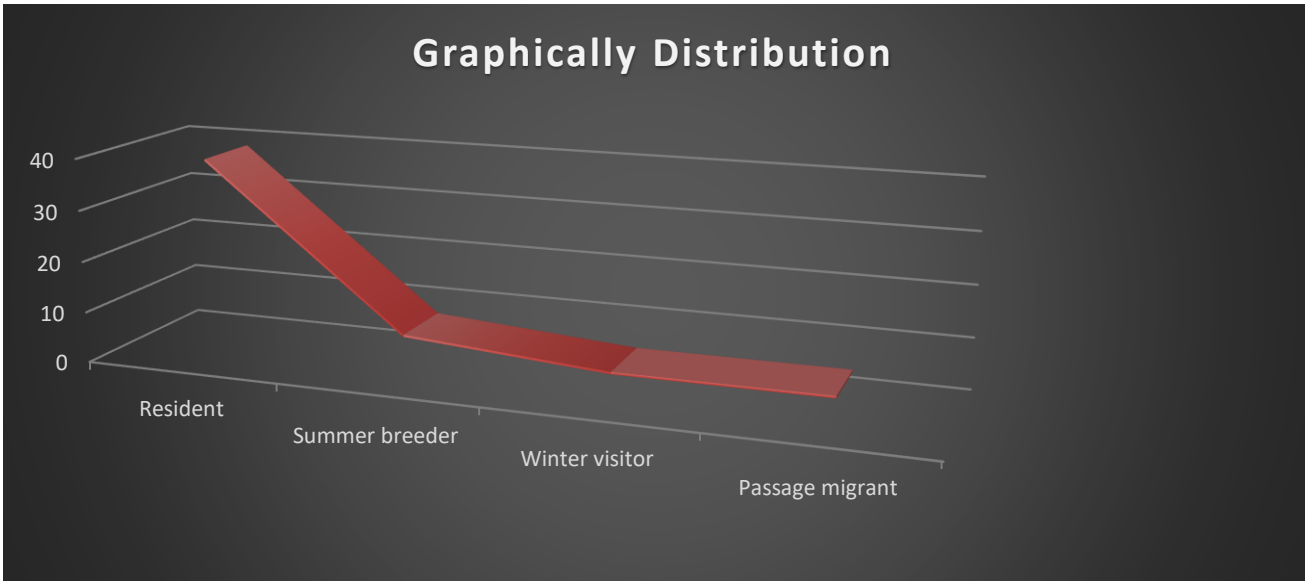

Figure 3: Graphically distribution of birds.

EFFECT OF ENVIRONMENTAL VARIABLES ON BIRD DIVERSITY AND SPECIES RICHNESS

Many environmental variables affect bird diversity, and in my observations, I have noticed that trees and plants play a significant role in this. In spring, flowers bloom, and trees become lush green. During that time, I observed a greater diversity of birds, which seemed to change with the seasons. The most abundant bird species I noticed

during summer, spring, and then again in fall. In contrast, the diversity of birds was the lowest during winter."(Figure 4).

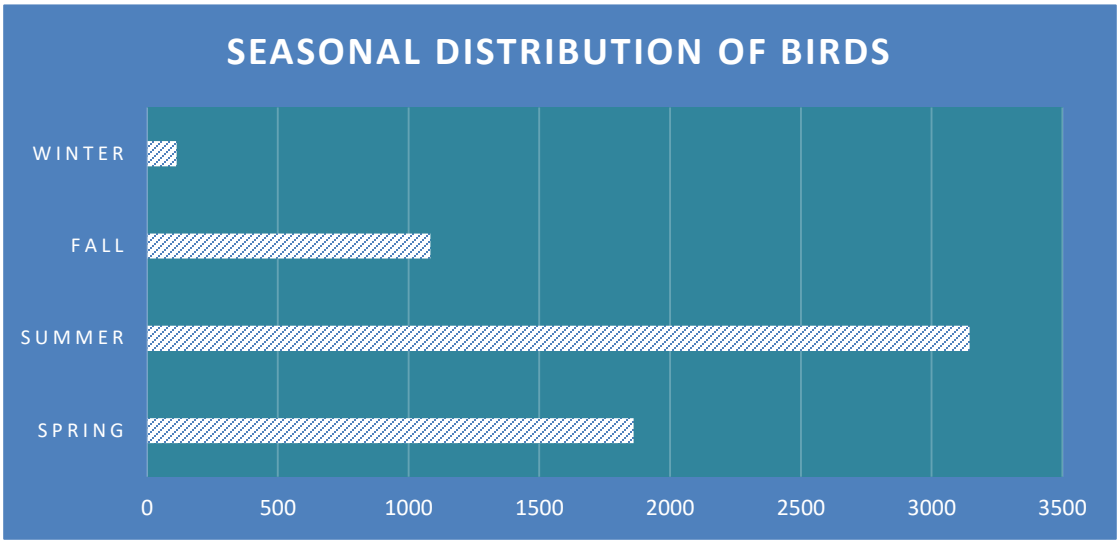

Figure 4: Seasonal Distribution of birds.

Effects of birds on these variables

The effect of these variables are shown in the (Table 2). The Shannon-Wiener index was used to determine the number of bird species present in each area. By determining, for each garden type, for each bird kinds, the diversity in bird species in varied and similar gardens was contrasted (Symonds and Johnson, 2008).

Monthly Site Wise Diversity of birds

According to the monthly diversity of birds site wise data are shown in the (Figures 5 and 6) appear to be information on different sites (S1 to S9) and the number of bird species seen at each site. We may look at each of these locations separately and analyze the available data to determine the effects on bird diversity.

In a site 1 site a total of 681 bird species were spotted there. The number of species that have been observed at this location points to a modest level of bird diversity and the site 2 with 922 species recorded, Site 2 has a larger bird diversity. Compared to Site 1, this suggests a rather rich bird habitat. The next site 3 is a significant degree of bird variety was observed at Site 3 due to the presence of 1025 bird species. The site seems to be very diversified. The site 4 is 721 different bird species were spotted there. This figure points to a degree of bird diversity that is comparable to Site 1 and is modest. The Site 5 had greater diversity compared to Sites 1 and 4 in terms of variety, with 754 species of birds present here. The next site 6 is 534 bird species were discovered there. In comparison to other sites, this value suggests a considerably lower degree of avian diversity.

In a site 7 With 1263 species recorded, Site 7 showed an astonishingly high avian diversity. Regarding the variety of bird species, this location distinguishes out as one of the best and the site 8 at 658 bird species were documented , which indicates a modest degree of bird diversity.

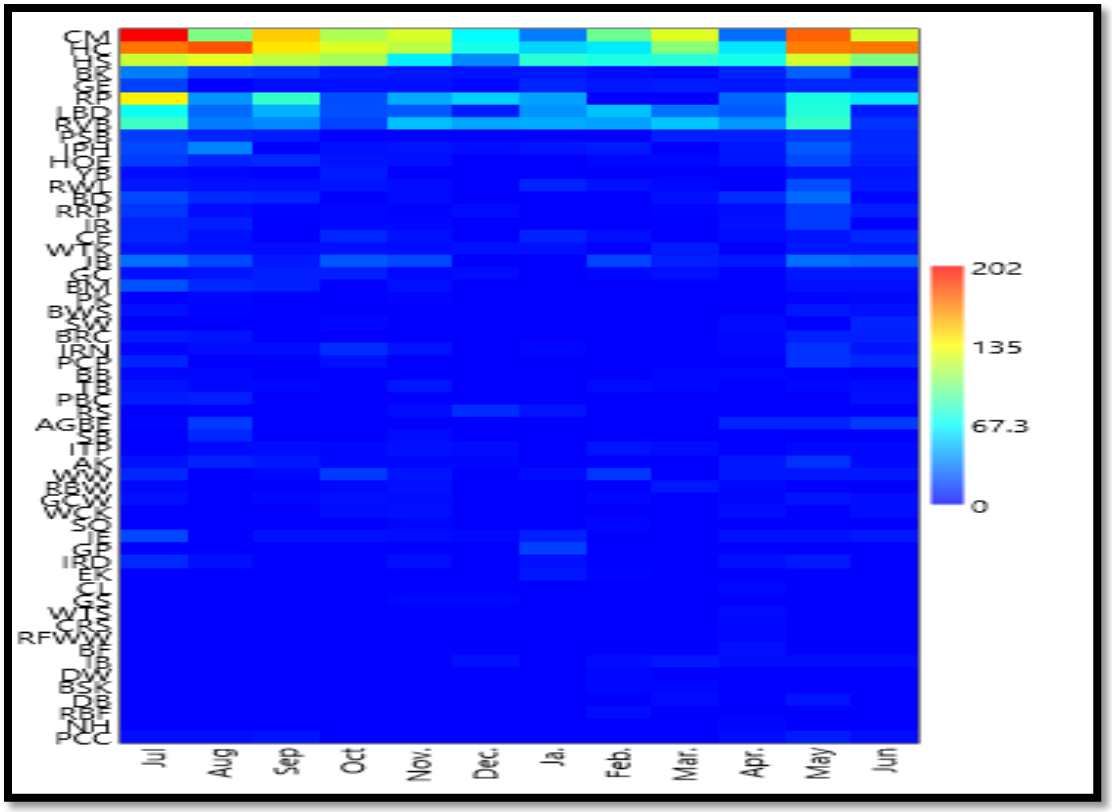

Figure 5: Diversity of bird's species.

In a site 9 the number of bird species seen at Site 9 (S9) was 579, which is comparable to the bird diversity levels at Sites 1, 4, and 5. In conclusion, the statistics show that various places have different levels of avian diversity. The biggest diversity of bird species may be found in Sites 3 and 7, while moderate diversity can be found at Sites 1, 4, 5, and 9. Site 6 exhibits a comparatively smaller diversity of birds. These results are crucial for comprehending the ecological importance of these locations and might direct conservation and research efforts to save and improve bird diversity in these regions.

PCA analysis

The Principal Component Analysis (PCA) findings are compiled in a chart that is shown. PCA is a statistical method for reducing the number of dimensions in data and exposing hidden patterns. The chart lists the proportion of variance that each primary component contributes to explaining, and the connections between these components and the original variables. Let's analyze the values in the chart:

Principal Component (PC): The PCA analysis found many principal components as PC1, PC2, and so on. Each component is an axial (uncorrelated) combination of the original variables in a linear fashion.

Percentage of Variance (% Variance)

This column shows the percentage of the total variance in the data that is explained by each principal component. PC1 explains approximately 99.807% of the total

variance, suggesting that it is highly significant in representing the data's variability. PC2 and the following components contribute much less to the overall variance explained.

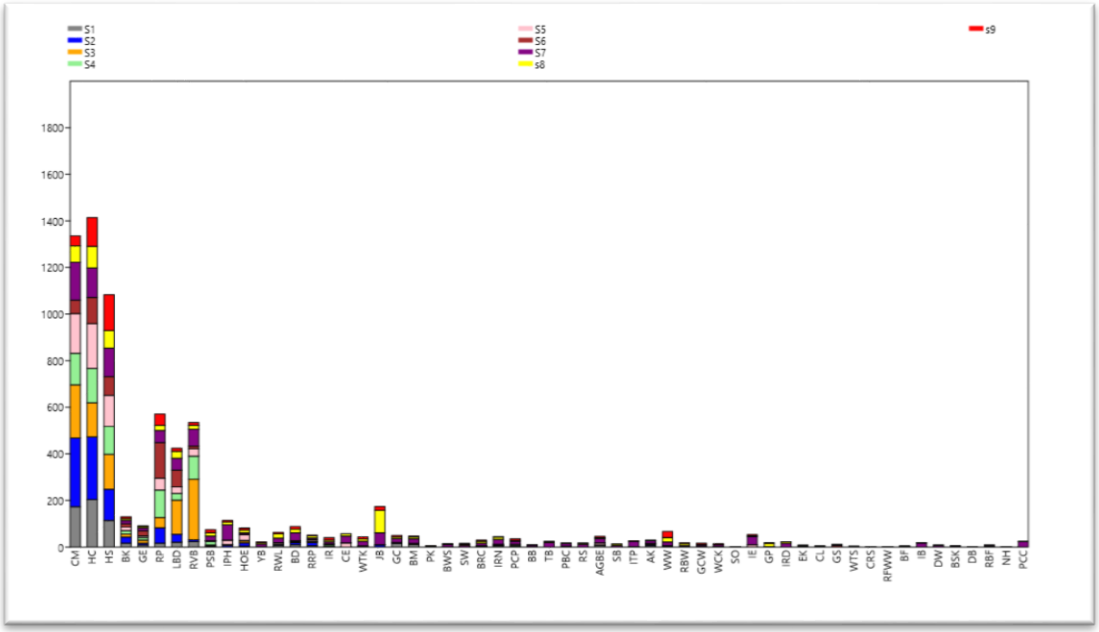

Figure 6: Yearly site wise diversity of birds.

Variables

The table also includes information about how the original variables (e.g., Vegetation %, Birds species, Cats and Dogs %, Trees species(n), Water Resources %) relate to the principal components. The values in the PC1 and PC2 columns represent the weights or loadings of these variables in each principal component. For instance, the variables "Vegetation%" and "Birds spp" in PC1 have loadings of 426.68 and 1932.4, respectively. The degree and direction of the correlation between the variables and PC1 are shown by these loadings. Strong influences on that component are indicated by high positive or negative loadings.

While "Birds spp." has a very tiny negative loading (-2.3288) in PC2, "Vegetation%" has a large positive loading (76.876). These loadings show how the variables are weighted in PC2 and imply that the correlations between the original variables are changed in PC2.

As a whole, this graph offers important details regarding the primary components' ability to capture data variation and their relationships to the original variables. The high Eigenvalue and high percentage of variance described by PC1 imply that it is a major contributor to explaining the variability of the data, with PC2 making a considerably smaller contribution. Researchers may better comprehend the underlying structure of the data and spot important patterns and linkages with the help of this knowledge (Figure 7).

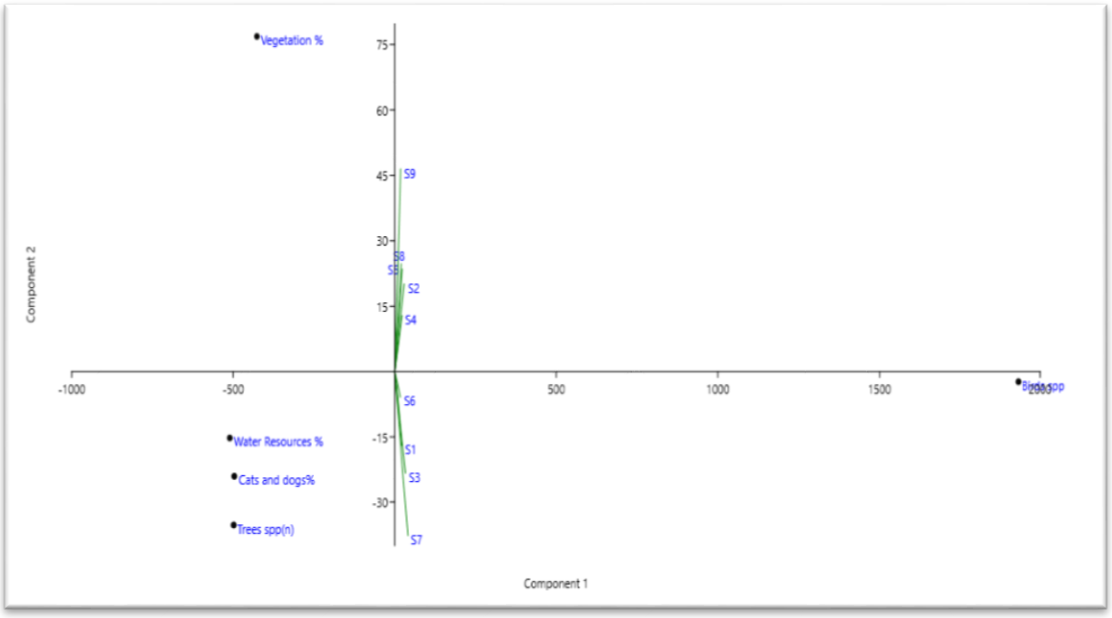

Figure 7: Principal component analysis of birds.

EFFECTS ON BIRDS' DIVERSITY DUE TO SEASONS

I observed a wider variety of birds in this area. I was researching throughout the year.

Summer season

Large varieties of food supplies are readily available, which is one factor contributing to the increased bird diversity in the summer. Various bird species have enough of food during this season because a wide variety of insects, fruits, and plants bloom. These plentiful food sources draw a variety of species with various nutritional demands. The summer is the best season for breeding and rearing young birds. Temperatures are more moderate and there are more daylight hours, which favors reproduction. This results in the presence of migratory and resident birds, each of which has a unique breeding strategy. Some bird species travel from their wintering areas to our region throughout the summer. This seasonal migration helps to improve avian variety at this time of year. The distinct traits and behaviours of these migrants add to the overall variety of birds. The summer season frequently results in the establishment of particular habitats, such as wetlands, for birds to thrive. These transient habitats draw a varied variety of avian species that are uniquely adapted to these surroundings.

Birds find favourable weather conditions, such as moderate temperatures and lots of natural light, to be very appealing. As a result, more species are enticed to travel to or stay in the region throughout summer time. The ecology is impacted by changes in environmental factors, such as flowering and tree blooming, which in turn affects bird diversity. Certain floral plants may attract birds for their nectar, while trees may draw them for shelter and nesting.

Spring season

When compared to the summer season, we saw less bird species in our research region during the spring. We must examine a number of environmental and biological elements that affect bird diversity and the seasonal fluctuations in order to fully understand this variance. The availability of food is the main factor impacting the diversity of birds. Food supplies frequently gradually grow in the spring, albeit they might not be as plentiful as in the summer. Since many bird species depend on specific food sources, their spring time presence may be constrained. Compared to the autumn season, we saw a wider diversity of birds in our research region during the winter.

Winter season

In the winter, a variety of bird species move from their breeding sites to warmer regions, which includes the area where we conduct our study. Due to their need to flee the severe conditions of their breeding sites, more different species of birds are attracted to our region during this migration. Only during the winter can you observe some of these species. Some birds spend the winter in our area and settle there permanently. These local birds frequently interact with migratory species, increasing the variety overall. Since food options in other locations may be limited throughout the winter, birds may be drawn to our area. Because there is so much food available, a variety of species are attracted, which boosts diversity. A variety of birds can survive over the winter in our area because to its unique ecosystem characteristics, including the abundance of food and shelter. Changes in the climate have an impact on birds. The warmer winters in our area compared to their breeding regions can make a number of animals more comfortable.

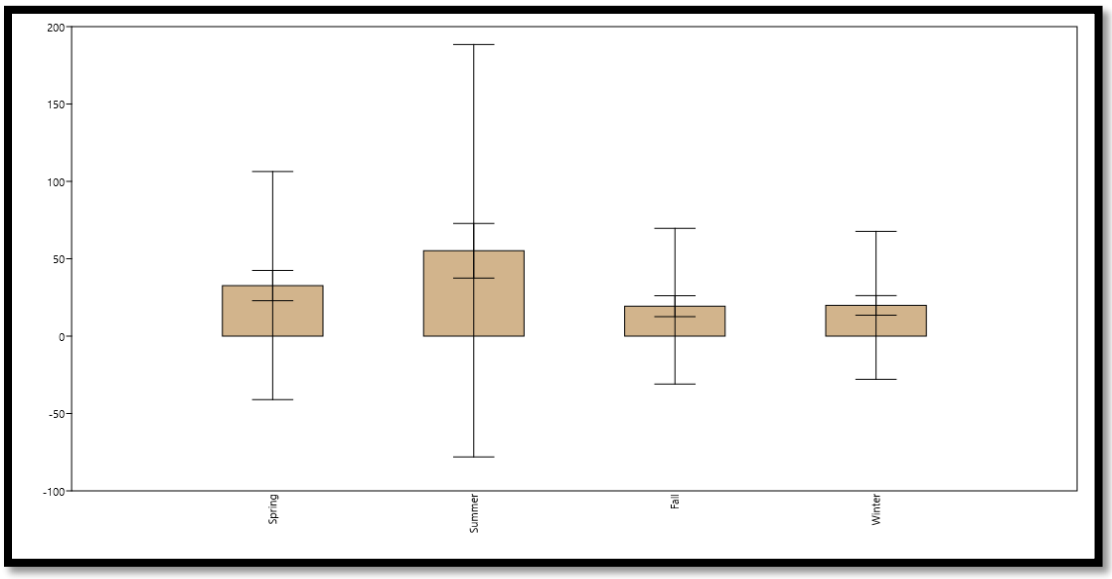

Figure 8: Yearly seasonal effects on birds.

Fall Season

Fall is when certain bird species start their migrations from breeding grounds to wintering habitats. Because some migratory species have not yet got there, diversity

during this time may be reduced. Perhaps some have already moved on. Birds that are getting ready for migration in the fall may not stay in the area for extended periods. This can result in a temporary decrease in diversity. Changes in food supply and vegetation during the autumn season may prompt certain species to migrate to areas with better environmental circumstances. For many bird species, their reproductive season concludes in the fall. These birds may go in certain cases, while others may stay but not actively engage in activities connected to nesting (Figure 8). In ornithological and ecological study, these seasonal variations in bird diversity are significant. It enables us to better understand how dynamically bird populations are affected by yearly migration patterns and environmental changes.

DISCUSSION

While urban public gardens are primarily created for people to enjoy, adding different bird species to these gardens can make them even more enjoyable for humans. It can also offer a chance for people to learn about wildlife. Moreover, recent studies have shown that green spaces in cities are increasingly recognized as important habitats for urban birds (MacGregor-Fors et al., 2010). City gardens can be good homes for various types of birds, not just the ones that are used to living in cities or are not originally from there, as mentioned before (Ml, 1999). Just like in my research, where more than half of the birds I counted were species that thrive in urban environments and are not local to the area. So, if we want to design gardens that attract a variety of bird species, landscape designers should think about how the features of urban gardens affect the number of bird species, their variety, and how they interact. This study highlights some important factors to think about in this regard.

VARIETY AND RICHNESS OF BIRD SPECIES

It is well known that species richness rises with habitat diversity (Hortal et al., 2009) and urban birds are no exception (Pino et al., 2000; Evans et al., 2009). However, we discovered that few of the environmental factors we examined had an impact on the diversity of bird species. We discovered that the richness of shrub species is strongly correlated with bird species diversity. As it considers both the number of species present and their relative abundance, we think this assessment of the composition of birds is more accurate than one that entirely considers species richness. This second discovery is also compatible with studies that indicated the importance of bushes for many forest birds in urban gardens (Daniels and Kirkpatrick, 2006; Bino et al., 2008). Plants offer birds food in the form of insects, seed mixture, and fruits as well as partial protection from predators and harsh weather (heavy rain and searing sunshine). So, in order to create varied landscaping with a high bird species variety, we advise planting a variety of shrub species.

SPATIAL GARDEN DESIGN

Our findings demonstrate the significance of garden composition in determining the composition of bird communities in urban locations. The largest number of bird species were found in gardens with a great diversity of trees and shrubs, and a low to medium amount of lawn and trees. In the same direction, only a small number of bird species, some of which were urban scavengers and foreign species, were attracted to

high lawn or tree coverage. According to our findings, a separate city area's study on the relationship between tree coverage and the diversity of bird species found no such relationship (Bino et al., 2008). The number of trees has a favourable correlation with the diversity of bird species. Due to the fact that these features support only a small number of bird species mostly alien species like the Common Myna (*Acridotheres tristis*) or urban scavengers like the Rock Pigeon (*Columba livia*) I suggest towards using them. Rather, we advise planting a variety of trees and shrubs while maintaining a balance between open grass area and nearby shrubberies or tiny thickets. As is clear from, greater numbers of bird species are supported by such different gardens, which can enhance the enjoyment that locals can have from visiting gardens. People can also benefit from the seasonal variation in bird species variety brought on by migratory seasons.

This allows the observation of numerous species at various periods of the year. Additionally, the distinct seasonal pattern shown in (Figure 3). Demonstrates how important urban gardens are to local birds. The fact that 68% of the bird species recorded in the examined gardens were residents. We meticulously studied a variety of bird species that frequented our research sites all year long for our academic study. Based on when they arrive, we divided these birds into four major groups:

Residents (68%)

These are birds that spend the full year in our research regions. They are regarded as permanent residents since they do not emigrate. These birds may be observed all year round since they have adapted to the environment.

Summer Breeders (14% of all breeding birds)

These birds come to our study locations during the warm summer months to build their nests and maintain their young. When mating and raising their young, they like positive weather.

Winter Visitors (9%)

Birds that visit our study locations in the wintertime are known as winter visitors. They move here from other locations since it is too cold for them to remain there. During the winter, they seek shelter in our areas.

Passage Migrants (9%)

Passage migrants are migratory birds who pause at our research locations to rest. During their brief stops on the way between their breeding and wintering areas, they don't stay here for very long.

According to our research's findings, 68% of the birds at the study locations are residents, making up the biggest group of birds. Then, in lower numbers, we have summer breeders, winter visitors, and passage migrants. This knowledge is essential to our academic work because it enables us to monitor and protect the many bird species that live all year long in our study locations.

PRESENCE OF PEOPLE, CATS AND DOGS

Prior research has demonstrated that birds suffer when people are around (Boyle and Samson, 1985), and it also reveals that fewer bird species were discovered in gardens with a large dog population. We discovered no significant link between dog availability and grass covering, making it unlikely that this result is due to the fact that dogs and humans prefer gardens with more open space and lawns gardens that are unattractive to birds. Same results, and it also reveals that fewer bird species were discovered in gardens with a large dog population. We discovered no significant link between dog availability and grass covering, making it unlikely that this result is due to the fact that dogs and humans prefer gardens with more open space and lawns gardens that are unattractive to birds. We did not detect a substantial negative impact of cats on bird species richness, but a recent research indicated that cats are probably the main cause of bird and animal death, killing 1.4–3.7 billion birds yearly in the US (Loss et al., 2013).

We assumed that the presence of cats would have a detrimental effect on the diversity of bird species. Our investigation revealed that, with the exception of three species the House crow (*Corvus splendens*), Little brown dove (*Spilopelia senegalensis*), and the white wagtail (*Motacilla alba)* the number of all observed bird species decreased in response to the presence of cats, although this association was not statistically significant. This finding, according to our analysis, can be attributed to the substantial percentage (13.91%) of birds from the three species that were unaffected by the presence of cats (Mirmovitch, 1995). Thus, we advise removing possible food and water sources available to cats in gardens and forbidding feeding cats in gardens in order to reduce the number of cats and prevent future dangers to the bird community in urban gardens.

IMPLICATIONS FOR DESIGNING URBAN LANDSCAPES

It indicates local variables (such as building density and vegetation structure) have a greater impact on the species richness of urban bird assemblages than regional ones (such as temperature and latitude) do, highlighting the need of managing urban settings for preservation. as in the case of reviews by (Evans et al., 2009). We would want to emphasize the necessity of multidisciplinary research projects carried out by zoologists and landscape architects. These investigations can provide a better knowledge of the structure and content needed in a garden to increase the variety of animal species that can live there. In the current study, for instance, zoological information (categorizations of birds and plants to native and alien ones) allowed us to comprehend the enchantment of native birds to native plants and alien birds to alien trees. This information may be shared with cooperating landscape designers, who can subsequently put it to use when designing gardens in cities. In addition to the significance of green spaces in cities for the preservation of species (Fuller et al., 2009). Recently, there has been a rise in understanding of their impact on people's welfare (Pretty et al., 2007; Berman et al., 2008). Example, discovered that the diversity of animals in greenery in cities increases a number of psychological advantages. Additionally, it study shown that people can detect variations in plant species richness in urban green areas, but less so in bird species diversity. Green areas can detect changes in plant species diversity and, to a lesser extent, in bird species

diversity. These results highlight the significant potential impact that urban gardens may have in giving urban residents a taste of nature. Therefore, we are confident that research like the one at hand will offer crucial information and tools for use in making decisions about the design of urban landscapes. The goal of landscape architects is to create urban environments that meet both human requirements and those of other animals. Consequently, this work's broad perspective is what gives it its significance.

CONCLUSION

As a result, our research has illuminated the ecological complexity and great variety of the bird population in our study region. It is clear that this area is an important habitat for numerous avian populations given the observation of 57 distinct bird species and a total count of 7,226 individuals as shown in (Table 3). Our study's dominant observation of resident birds, which make up 68% of the observed population, is an important discovery. These local birds rely greatly on the local flora, highlighting the need of protecting and preserving the area's natural greenery. The relationship between the richness of bird species and the amount of greenery further highlights how the environment influences the local avian ecology. The pattern of behaviour of the bird populations in the area likewise heavily depend on seasonal fluctuations. According to our observations, the summer season was when we saw the most birds, followed by the spring and autumn, with the number of birds declining in the winter. This trend highlights the crucial importance of seasonal variations in maintaining birdlife. It can be assigned to the increased diversity and accessibility of food supplies throughout the summer. Our study revealed the effects of numerous additional environmental parameters, in addition to vegetation and seasonality, on bird diversity. Bird populations were found to be significantly impacted by human activity in some regions and the presence of domestic animals like cats and dogs. These findings highlight the complex interactions between wildlife and human activity.

ACKNOWLEDGEMENT

The authors are thankful to Institute of Forest Sciences for providing research facilities.

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Table 2: Birds species and individual diversity observed at the sites during the study period.

Common name	Code	Scientific Name	Order	Family	Status	Feeding Behavior	Authority	Distribution	Total
Common Myna	CM	*Acredotheras tristis*	Passeriformes	Sturnidae	LC	Omnivore	Linnaeus 1766	R	1337
House Crow	HC	*Corvus splendens*	Passeriformes	Corvidae	LC	Omnivore	Vieillot 1817	R	1429
House Sparrow	HS	*Passer domesticus*	Passeriformes	Passeridae	LC	Omnivore	Linnaeus 1758	R	1106
Black Kite/Pariah Kite	BK	*Milvus migrans*	Accipitariformes	Accipitaridae	LC	Omnivore	Boddaert 1783	R	130
Golden Eagle	GE	*Aquila chrysaetos*	Accipitariformes	Accipitaridae	LC	Carnivore	Linnaeus 1758	R	78
Rock Pigeon	RP	*Columba livia*	Columbiformes	Columbidae	LC	Granivore	Gmelin 1789	R	583
Little Brown Dove	LBD	*Spilopelia senegalensis*	Columbiformes	Columbidae	LC	Granivore	Linnaeus 1766	R	424
Red Vented Bulbul	RVB	*Pycnonotus cafer*	Passeriformes	Pycnontidae	LC	Omnivore	Linnaeus 1766	R	540
Purple Sun Bird	PSB	*Nectarinia asiatica*	Passeriformes	Nectariniidae	LC	Omnivore	Latham 1790	SB	73
Indian Pond Heron	IPH	*Ardeola grayii*	Pelecaniformes	Ardeidae	LC	Omnivore	Sykes 1832	R	119
Hoopoe	HOE	*Upupa epops*	Bucerotiformes	Upupidae	LC	Carnivore	Linnaeus 1758	R	81
Yellow Bittern	YB	*lxobrychus sinesnis*	Pelecaniformes	Ardeidae	LC	Carnivore	Gmelin 1789	PM	22
Red Wattled Lapwing	RWL	*Hoplopterus indicus*	Charadriiformes	Charadriidae	LC	Insectivore	Boddaert 1783	R	63
Black Drongo	BD	*Dicrurus macrocercus*	Passeriformes	Dicruridae	LC	Insectivore	Viellot 1817	R	88
Rose Ring Parakeet	RRP	*Alexandrinus krameri*	Psittaciformes	Psittaculidae	LC	Omnivore	Scopoli 1769	R	52
Indian Roller	IR	*Coracias benghalensis*	Coraciiformes	Coraciidae	LC	Carnivore	Linnaeus 1758	R	41
Cattle Egret	CE	*Bubulcus ibis*	Pelecaniformes	Ardeidae	LC	Pisivore	Linnaeus 1758	R	59
White Throated Kingfisher	WTK	*Halcyon smyrnensis*	Coraciiformes	Alcedinidae	LC	Carnivore	Linnaeus 1758	R	45
Jungle Babbler	JB	*Turdoides striatus*	Passeriformes	Leiothrichidae	LC	Insectivore	Dumont 1823	R	184
Greater Coucal	GC	*Centropus sinensis*	Cuculiformes	Cuculidae	LC	Carnivore	Stephens 1815	R	48
Bank Myna	BM	*Acridotheras ginginianus*	Passeriformes	Sturnidae	LC	Omnivore	Latham 1790	R	51
Pied Kingfisher	PK	*Ceryle rudis*	Coraciiformes	Alcedinidae	LC	Pisivore	Linnaeus 1758	R	6
Black Winged Stilt	BWS	*Himantopus himantopus*	Charadriiformes	Recurvirostridae	LC	Carnivore	Linnaeus 1758	SB	15
Streaked Weaver	SW	*Ploceus manyar*	Passeriformes	Ploceidae	LC	Herbivore	Horsfield 1821	R	14
Brown Rock Chat	BRC	*Cercomela fusca*	Passeriformes	Muscicapidae	LC	Carnivore	Blyth 1851	SB	30
Indian Robin	IRN	*Saxicoloides fulicatus*	Passeriformes	Muscicapidae	LC	Omnivore	Linnaeus 1766	R	46
Plain Coloured Prinia/Tawny	PCP	*Prinia inornata*	Passeriformes	Cisticolidae	LC	Insectivore	Sykes 1832	R	36
Black Bittern	BB	*Ixobrychus flavicollis*	Pelecaniformes	Ardeidae	LC	Insectivore	Latham 1790	SB	9
Tailor Bird	TB	*Orthotomus sutorius*	Passeriformes	Cisticolidae	LC	Insectivore	Pennant 1789	R	25

Pied Bush Chat	PBC	*Saxicola caprata*	Passeriformes	Muscicapidae	LC	Insectivore	Linnaeus 1766	SB	19
Rosy Pastor	RS	Sturnus roseus	Passeriformes	Sturnidae	LC	Insectivore	Linnaeus 1758	WV	20
Asian Green Bee Eater	AGBE	*Merops orientalis*	Coraciiformes	Meropidae	LC	Insectivore	Latham 1802	R	49
Striated Babblers	SB	*Turdoides earlei*	Passeriformes	Leiothrichidae	LC	Insectivore	Blyth 1844	R	13
Indian Tree Pie	ITP	*Dendrocitta vagabunda*	Passeriformes	Corvidae	LC	Omnivore	Latham 1790	R	26
Asian Koel Male	AK	*Eudynamys scolopaceus*	Cuculiformes	Cuculidae	LC	Omnivore	Linnaeus 1758	R	46
White Wagtail	WW	*Motacilla alba*	Passeriformes	Motacillidae	LC	Insectivore	Linnaeus 1758	R	67
Rufous Backed Shrike	RBW	*Lanius schach*	Passeriformes	Laniidae	LC	Carnivore	Linnaeus 1758	R	16
Golden Backed Woodpecker	GCW	*Dinopium benghalense*	Piciformes	Picidae	LC	Omnivore	Valenciennes 1826	R	25
Eurasian Common Kingfisher	WCK	*Alcedo atthis*	Coraciiformes	Alcedinidae	LC	Pisivore	Linnaeus 1758	R	13
Spotted Owlet	SO	*Anthene brama*	Strigiformes	Strigidae	NT	Omnivore	Xantus de vesey 1860	R	4
Intermediate Egret	IE	*Egretta intermedia*	Pelecaniformes	Ardeidae	LC	Omnivore	Linnaeus 1758	PM	54
Grey Partridge	GP	*Francolinus pondicerianus*	Galliformes	Phasianidae	LC	Omnivore	Gmelin 1789	R	17
Indian Ring Dove	IRD	*Streptopelia decaocto*	Columbiformes	Columbidae	LC	Herbivore	Frivaldszky 1838	R	34
Eurasian Kestrel	EK	*Falco tinnunculus*	Falconiformes	Falconidae	LC	Carnivore	Linnaeus 1758	WV	7
Crested Lark	CL	*Galerida cristata*	Passeriformes	Alaudidae	LC	Omnivore	Linnaeus 1758	R	2
Green Sandpipper	GS	*Tringa ochropus*	Charadriiformes	Scolopacidae	LC	Carnivore	Linnaeus 1758	WV	4
Wire Tailed Swallow	WTS	*Hirundo smithii*	Passeriformes	Hirundinidae	LC	Insectivore	Leach 1818	SB	3
Common Redstart	CRS	*Phoenicurus phoenicurus*	Passeriformes	Muscicapidae	LC	Insectivore	Linnaeus 1758	PM	2
Rufous Fronted Wren Warbler	RFWW	*Prinia buchanani*	Passeriformes	Cisticolidae	LC	Insectivore	Blyth 1844	R	2
Brown Flycatcher	BF	*Muscicapa latirostris*	Passeriformes	Muscicapidae	LC	Insectivore	Pallas 1811	PM	4
Indian Baya	IB	*Ploceus philippinus*	Passeriformes	Ploceidae	LC	Granivore	Linnaeus 1766	R	22
Desert Wheatear	DW	*Oenanthe deserti*	Passeriformes	Muscicapidae	LC	Insectivore	Temminck 1829	WV	2
Black Shoulder Kite	BSK	*Elanus caeruleus*	Accipitariformes	Accipitaridae	LC	Carnivore	Latham 1801	R	4
Desert Buzzard	DB	*Buteo buteo*	Accipitariformes	Accipitaridae	LC	Carnivore	Linnaeus 1758	PM	8
Red Brested Flycatcher	RBF	*Ficedula parva*	Passeriformes	Mscicapidae	LC	Insectivore	Bechstein 1792	WV	3
Night Heron	NH	*Nycticorax nycticorax*	Pelecaniformes	Ardeidae	LC	Carnivore	Linnaeus 1758	SB	2

Pied Crested Cuckoo	PCC	*Clamator jacobinus*	Cuculiformes	Cuculidae	LC	Omnivore	Linnaeus 1783	SB	24 7226

Table 3: Diversity indices of study area.

Diversity Indices	Total
Species	57
Individuals	7226
Dominance	0.1148
Simpson	0.8852
Shannon	2.698
Evenness	0.2605

Competing interests: Authors have declared that no competing interests exist.
Funding: Authors have no source of funding for this work.
Authors' contributions: Laraib and Altaf have designed this project, collected data and written this article; while all authors have critically analyzed this article and approved as final.