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Thriving Wings: A Comprehensive Study of the Avifaunal Community's Health in Jiwaji University Campus, Gwalior.

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Abstract

This research provides a thorough assessmentof biodiversity in four distinct habitats: Tree, Bushy, Grassland, and Artificial Feeding Zone.It utilizes essential ecological indices, including Simpson's 1-D index, Shannon's diversity index, Evenness (E^H/S), and estimates species richness using the Chao-1 index.These indicesare utilized to examine thehealth and stability of ecosystems,providing insights into thediversity and composition of species within the study area.Furthermore,the study investigates the dietaryassociations and similarities among a diverse set of bird species by using the Bray-Curtis clustering method.By analyzing data on the relative abundance of various food sources in their diets, the study aims to disclose underlying patterns in feeding behavior and identify potential ecological relationships.The findings of the research provide valuable understanding of the ecological dynamics and interrelationships among species in various environments.In general, this study highlights the importance of assessing biodiversity in ecological research as it yields vital information necessary for conservationefforts and sustainable ecosystem management. The utilization of both ecological indices and clustering methods is a highly effective approach for revealing ecological patterns and interrelationships among species within the study area.

Keywords: Birds, diversity, human modified land

1. Introduction

Investigating and analyzing the variety of bird species is essential in comprehending and tackling the conservation requirements of bird populations globally. For centuries, humans have been fascinated by birds due to their distinctive characteristics like feathers, wings, and specially developed traits that enable them to thrive in the sky. Scientific research and efforts for conservation find them captivating due to their mesmerizing qualities, distinctive behaviors, and diverse characteristics (Araneda *et al.*, 2022). By examining the variety of birds, scientists obtain a deeper understanding of the complex functioning of ecosystems; detect risks to bird populations, and devise tactics to safeguard these fascinating creatures. Birds, with their charming existence and mesmerizing songs, have an essential role in preserving the intricate equilibrium of the natural world. They do not just observe the symphony of life as spectators, but rather, actively engage and influence ecosystems, serving as significant indicators of biodiversity. For a considerable period of time, ecologists have acknowledged that the richness, abundance and community composition of bird species serve as essential instruments in comprehending the variety of organisms found in natural environments (Singh *et al.*, 2018). Understanding the correlation between natural plants and animals and urban environments is crucial due to the swift growth of urban development. In contrast to natural and protected ecosystems, conservation biologists have paid scant attention to the biodiversity in urban areas. The rapid urbanization in India has led to a significant decline in biodiversity, despite the fact that many cities in the country are known for their abundant variety of plants and animals (Dapke *et al.*, 2015). India exhibits a notable diversity of avian species inside its borders, , with over 1200 species documented (Manakadan& Khan, 2020). Out of these, there are 26 species classified as Endangered, 17 species as Critically Endangered, 77 species as Vulnerable, and 92 species as Near Threatened, making a total of 212 species facing some degree of risk (Manakadan& Khan, 2020).Birds play a crucial function in the ecosystem by contributing to the maintenance of food chain equilibrium. The term "bioindicators" was used to describe organisms that play an important role in maintaining the health of an ecosystem by, among other things, acting as pollinators and decomposers. The rapid growth of activities and industries has led to the exploitation and even destruction of natural ecosystems. The primary goal of the MEA (2005) was to assess the possible impacts of ecosystem alteration from the standpoint of human well-being, focusing on ecosystem services. It determined that there are four distinct types of ecosystem services, namely those that are associated with resources, those that are associated with culture, those that are associated with regulation, and those that are associated with support. There is evidence that birds contribute to the provision of each of these four categories of ecosystem services(Sekercioglu 2006; Whelan *et al.*, 2008). It should be noted that provisioning services can be provided by both domesticated (poultry) and wild species.In the course of human history, birds have been an essential component in the maintenance of human diets, performing the function of a source of food for the purposes of survival, sustenance, and leisure pursuits (Moss & Bowers, 2007). Bird feathers serve as versatile assets, offering not only cozy bedding and effective insulation but also stunning adornments (Green & Elmberg, 2014). The hunting and gathering habits of numerous bird species provide a wide range of crucial benefits that help regulate and sustain ecosystems. Birds demonstrate their immense ecological importance by engaging in a variety of foraging activities, such as scavenging carcasses, promoting the recycling of nutrients, spreading seeds, assisting in flower pollination, and regulating pest populations (Sekercioglu 2006; Whelan *et al.*, 2008). The rapidly escalating activities and industries have sadly exploited and, in some cases, even destroyed natural ecosystems. As a result, the consequential environmental changes have surpassed the tolerance limits of many species, leading to habitat alterations that have become the primary catalyst for long-term shifts in bird distribution. This sobering reality highlights the urgent need for conservation and sustainable practices to safeguard our precious natural environments and ensure the continued thriving of avian populations.The interaction and bond between humans and birds are richly diverse, spanning across cultures and evolving over time. Recognizing the significance of positive interactions between these two entities is vital for maintaining ecological balance. Extensive research conducted in recent decades has shed light on the profound effects of urbanization on species distribution and ecological dynamics. These impacts often arise from drastic transformations in landscape structure and configuration. Engaging with nature, such as through the act of feeding birds, can yield favorable outcomes for human well-being and foster harmonious connections between humans and the natural world.

The main areas of interest of this research revolve around three objectives centered on the variety of bird species found on the Jiwaiji University Campus. To begin, the objective of the research is to develop a list of the different species of birds that may be found in the area immediately surrounding the university. Furthermore, it aims to examine and evaluate the tendencies of these bird species when it comes to visiting and inhabiting particular locations within the campus premises. Finally, the research seeks to examine the present condition of specific regions near the university campus through the utilization of birds as biological indicators. By attaining these goals, the research will bring about a better understanding of the varied bird species and their ecological functions within the campus setting. This will offer significant knowledge for the purposes of conservation and the management of biodiversity.

2. Materials and Methods

Study area

The study was conducted at Jiwaji University Campus, from 26°11.976' to 26°12.319' North latitude to 78° 11.363' to 78° 11.845' East longitude **(Fig. 1).** The selection of study areas for this research was based on the availability of these locations and the observed visiting habits of birds in and around the campus. Four specific sites as the focal points for investigation were chosen inside the university campus according to their flora pattern; those are large tree dominated patch, thick Bush and hedge covered patch, unused field as grassy patch and a modified concrete structure with presence of sparse vegetation where bird feeding activities by human were observed often, known in this study as AFZ (Artificial Feeding Zone).Each study site or patch has at least one km distance from the next one. Birds were counted in by opportunistic sighting and standard point count method regarding 200-meter radius in 5-minuteintervals. The study was conducted in early monsoon months (May - June) in this campus area. Birds were identified using standard guide books and pictorials (Grimmett *et al.*, 2015). Necessary photographs were taken for further identification with the help of digital camera (Canon IXUS115 HS). Survey was done in every 2 days in late morning hours (7-9 am) excluding any rainy day. In this study, four indices were employed to assess diversity: the Shannon-Wiener index (H'), Simpson's index (D), Chao-1 and species evenness. The Shannon-Wiener index is a commonly employed metric in ecological research for the analysis of uncommon species' occurrence and abundance. On the other hand, Simpson's index is more suitable for studying the diversity of abundant or common species (Peet, 1974). Chao is used to estimate the species richness whereasspecies evenness quantifies the proportionate distribution of various species that contribute to the overall diversity of a particular area (Bibi & Ali, 2013). Furthermore, we have used Bray-Curtis clustering to compare the groups between the different feeding habits of birds. Bray-Curtis clustering is a method used in data analysis and bioinformatics to group or cluster similar items based on their abundance or occurrence across different variables. It is particularly useful when dealing with ecological and environmental data, where the presence or absence of species or features is important. The Bray-Curtis clustering method is a modified version of the Bray-Curtis dissimilarity index, which quantifies the dissimilarity of two samples by considering the relative abundance of shared and non-shared species or traits. The software used to calculate these diversity indexes is Past 4.03.

Fig. 1. Map showing the area of study conducted

3. Results

This study reports 57species of birds belonging to 33 families under 14 orders from the Jiwaji University, Gwalior, Madhya Pradesh. Among these, 25 speciesbelongs to Passeriformes, followed by 6 species of Columbiformes and 5 species of Cuculiformes. Then, Piciformes, Galliformes and Coraciiformes orders contain 3 species of birdseach, and Charadriiformes, Bucerotiformes, Gruiformes and Accipitriformes order with 2 species each, and Pelecaniformes, Apodiformes, Psittaciformes and Strigiformes follow single species each.The tree habitat is the best visited place by the bird species as it contains the most no. of species. Among these 57 species, there were different types of food preference, some were frugivores, some insectivores, and few were only granivores, whereas some species prefer multiple types of foods. **(Table 1).**

Table – 1: List of Bird Species and their Visitation Pattern Observed from the Study Area along with their Food Habits.

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Sl. No.	Common Name	Scientific Name	Habitat				Food			
			T	B	Gl	AFZ	F	I	C	Gv
Order: **Passeriformes** Linnaeus, 1758 Family: **Sturnidae** Rafinesque, 1815										
1.	Asian Pied Starling	*Gracupica contra* (Linnaeus, 1758)	-	-	-	+	+	+	-	-
2.	Bank Myna	*Acridotheres ginginianus* (Latham, 1790)	+	+	+	+	+	+	-	-
3.	Brahminy Starling	*Sturniapagodarum* (Gmelin, 1789)	+	+	+	+	+	+	+	-
4.	Common Myna	*Acridotheres tristis* (Linnaeus, 1766)	-	+	-	+	+	+	+	+
		Family: **Hirundinidae** Rafinesque, 1815								
5.	Barn Swallow	*Hirundo rustica* Linnaeus, 1758	+	+	+	+	-	+	+	-
6.	Red-rumped Swallow	*Cecropisdaurica* Linnaeus, 1771	+	-	+	+	-	+	-	-
		Family: **Laniidae**Rafinesque, 1815								
7.	Bay-backed Shrike	*Lanius vittatus* Valenciennes, 1826	+	-	-	+	-	+	+	-
		Family: **Dicruridae**Vigors, 1825								
8.	Black Drongo	*Dicrurusmacrocercus* Vieillot, 1817	+	+	+	+	-	+	+	-
		Family: **Leiothrichidae**Swainson, 1832								
9.	Common Babbler	*Turdoidescaudata* (Dumont, 1823)	+	+	-	-	+	+	-	+
10.	Jungle Babbler	*Turdoides striata* (Dumont, 1823)	+	+	+	+	+	+	+	+
Family: **Cisticolidae**Sundevall, 1872										
11	Common Tailor bird	*Orthotomussutorius* (Pennant, 1769)	-	-	-	+	-	+	+	-

		Family: **Oriolidae**Vigors, 1825								
12.	Golden Oriole	*Orioluskundoo* Sykes, 1832	+	-	+	-	+	+	+	+
		Family: **Motacillidae**Horsfield, 1821								
13.	Grey Wagtail	*Motacilla cinerea* Tunstall, 1771	+	+	+	+	+	+	-	-
14.	Tree Pipit	*Anthustrivialis* (Linnaeus, 1758)	-	-	-	+	-	+	-	-
Family: **Passeridae**Rafinesque, 1815										
15.	House sparrow	*Passer domesticus* (Linnaeus, 1758)	+	+	+	+	+	+	+	+
Family: **Monarchidae**Bonaparte, 1854										
16.	Indian paradise flycatcher	*Terpsiphone paradisi* (Linnaeus, 1758)	+	-	-	-	+	+	-	-
Family: **Muscicapidae**Fleming J., 1822										
17.	Indian Robin	*Saxicoloidesfulicatus* (Linnaeus, 1766)	+	+	+	+	+	+	+	-
18.	Oriental Magpie Robin	*Copsychussaularis*(Linnaeus, 1758)	+	+	+	+	-	+	+	-
19.	Rufous-backed Redstart	*Phoenicuruserythronotus* (Eversmann, 1841)	+	+	+	+	+	+	+	-
		Family: **Corvidae**Leach, 1820								
20.	Jungle Crow	*Corvus culmintus* Sykes, 1832	+	+	+	-	+	+	+	+
21.	Rufous Tree pie	*Dendrocittavagabunda* (Lath am, 1790)	+	+	+	+	+	+	+	-
Family: **Campephagidae**Vigors, 1825										
22.	Large Cuckoo Shrike	*Coracinamacei* (Lesson, 1831)	-	-	+	-	-	+	+	-
		Family: **Nectariniidae**Vigors, 1825								
23.	Purple sunbird	*Cinnyris asiaticus* (Latham, 1790)	+	-	+	+	+	+	-	-
		Family: **Pycnonotidae**Gray, GR, 1840								
24.	Red-vented Bulbul	*Pycnonotuscafer* (Linnaeus, 1766)	+	+	-	+	+	+	+	-
		Family: **Estrildidae**Bonaparte, 1850								
25.	Scaly breasted Munia	*Lonchurapunctulata* (Linnaeu s, 1758)	+	-	+	-	+	-	-	+

Order: **Columbiformes**Latham, 1790 Family: **Columbidae**Leach, 1820										
26.	Collared Dove	*Streptopeliadecaocto*Frivaldszky, 1838	+	+	+	+	+	-	-	+
27.	Laughing Dove	*Spilopelia senegalensis* (Linnaeus, 1766)	+	+	+	+	-	+	-	+
28.	Red Turtle Dove	*Streptopeliatranquebarica* (Hermann, 1804)	+	-	+	+	+	-	-	+
29.	Rock Pigeon	*Columba livia*Gmelin, 1789	+	+	+	+	+	-	-	+
30.	Spotted Dove	*Spilopelia chinensis* (Scopoli, 1786)	+	-	-	+	-	-	-	+
31.	Yellow footed Green Pigeon	*Treron phoenicopterus* (Latham, 1790)	+	-	+	+	+	-	-	-
Order: **Cuculiformes**Wagler, 1830 Family:**Cuculidae**Leach, 1820										
32.	Asian Koel	*Eudynamysscolopaceus* (Linnaeus, 1758)	+	+	-	-	+	+	+	-
33.	Common Hawk Cuckoo	*Hierococcyxvarius* (Vahl, 1797)	+	-	-	-	-	+	+	-
34.	Greater Coucal	*Centropus sinensis* (Stephens, 1815)	+	+	-	+	+	+	+	+
35.	Indian Cuckoo	*Cuculusmicropterus*(Gould, 1837)	-	-	-	+	+	+	+	+
36	Southern Coucal	*Centropus(sinensis) parroti* Stresemann, 1913	+	-	+	-	+	+	+	+
Order: **Piciformes**Meyer & Wolf, 1810 Family: **Megalaimidae**Blyth, 1852										
37.	Brown-headed Barbet	*Psilopogonzeylanicus* (Gmelin, 1788)	+	-	-	+	+	+	-	-
38.	Coppersmith Barbet	*Psilopogonhaemacephalus* (Müller, 1776)	+	-	-	-	+	-	-	+
		Family: **Picidae**Leach, 1820								
39.	Lesser Flameback Woodpecker	*Dinopiumbenghalense* (Linnaeus, 1758)	+	-	-	-	-	+	+	-
Order: **Galliformes**Temminck, 1820 Family: **Phasianidae**Horsfield, 1821										
40.	Grey Francolin	*Francolinuspondicerianus* (Gmelin, 1789)	+	+	+	+	+	+	+	+
41.	Indian Peafowl	*Pavo cristatus*Linnaeus, 1758	+	+	+	-	+	+	+	+
42.	Jungle Bush Quail	*Perdiculaasiatica* (Latham, 1790)	+	+	-	-	+	+	+	+
Order: **Coraciiformes**Forbes, 1884 Family:**Coraciidae**Rafinesque, 1815										
43.	Indian Roller	*Coracias*	-	+	-	+	-	+	+	-

		benghalensis (Linnaeus, 1758)								
Family: **Meropidae**Rafinesque, 1815										
44.	Little Green Bee-eater	*Meropsorientalis* Latham, 1802	+	-	-	+	-	+	-	-
Family: **Alcedinidae**Rafinesque, 1815										
45.	White-breasted Kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)	-	+	+	-	-	+	+	-
Order: **Charadriiformes**Huxley, 1867 Family: **Charadriidae**Leach, 1820										
46.	Red-wattled Lapwing	*Vanellus indicus* (Boddaert, 1783)	-	-	+	+	-	+	+	-
47.	Yellow-wattled lapwing	*Vanellusmalabaricus* (Boddaert, 1783)	-	-	+	-	-	+	+	-
Order:**Bucerotiformes**Fürbringer, 1888 Family: **Upupidae**Leach, 1820										
48.	Eurasian Hoopoe	*Upupa epops*Linnaeus, 1758	+	-	+	-	+	-	-	+
Family: **Bucerotidae**Rafinesque, 1815										
49.	Grey hornbill	*Ocycerosbirostris* (Scopoli, 1786)	-	-	+	-	+	-	-	-
Order: **Gruiformes**Bonaparte, 1854 Family: **Rallidae**Rafinesque, 1815										
50.	Common moorhen	*Gallinula chloropus* (Linnaeus, 1758)	-	-	+	-	+	+	+	-
51.	White-breasted Waterhen	*Amaurornisphoenicurus*Pennant, 1769	-	+	-	+	-	+	+	-
Order: **Accipitriformes**Vieillot, 1816 Family: **Accipitridae**Vieillot, 1816										
52.	Pariah Kite	*Milvus migrans* (Boddaert, 1783)	+	+	+	+	-	+	+	-
53.	Shikra	*Accipiter badius* (Gmelin, 1788)	+	+	-	-	-	+	+	-
Order: **Pelecaniformes**Sharpe, 1891 Family: **Ardeidae**Leach, 1820										
54.	Cattle Egret	*Bubulcus ibis* (Linnaeus, 1758)	-	+	+	+	+	+	+	-
Order: **Apodiformes**Peters, 1940 Family: **Apodidae**Hartert, 1897										
55.	Little Swift	*Apus affinis*(JE Gray, 1830)	-	+	+	-	-	+	+	-
Order: **Psittaciformes**Wagler, 1830 Family: **Psittacidae**Rafinesque, 1815										
56.	Rose-ringed Parakeet	*Psittaculakrameri* (Scopoli, 1769)	+	+	+	+	+	-	-	-
Order: **Strigiformes**Wagler, 1830 Family: **Strigidae**Leach, 1820										

57.	Spotted Owlet	*Athene brama* (Temminck, 1821)	+	+	-	-	-	+	+	-

Abbreviation used: **T:** Tree; **B:** Bushy; **Gl:** Grassland; **AFZ:** Artificial Feeding Zone; **F:** Frugivore; **I:** Insectivore; **C:** Carnivore; **Gv:** Granivore

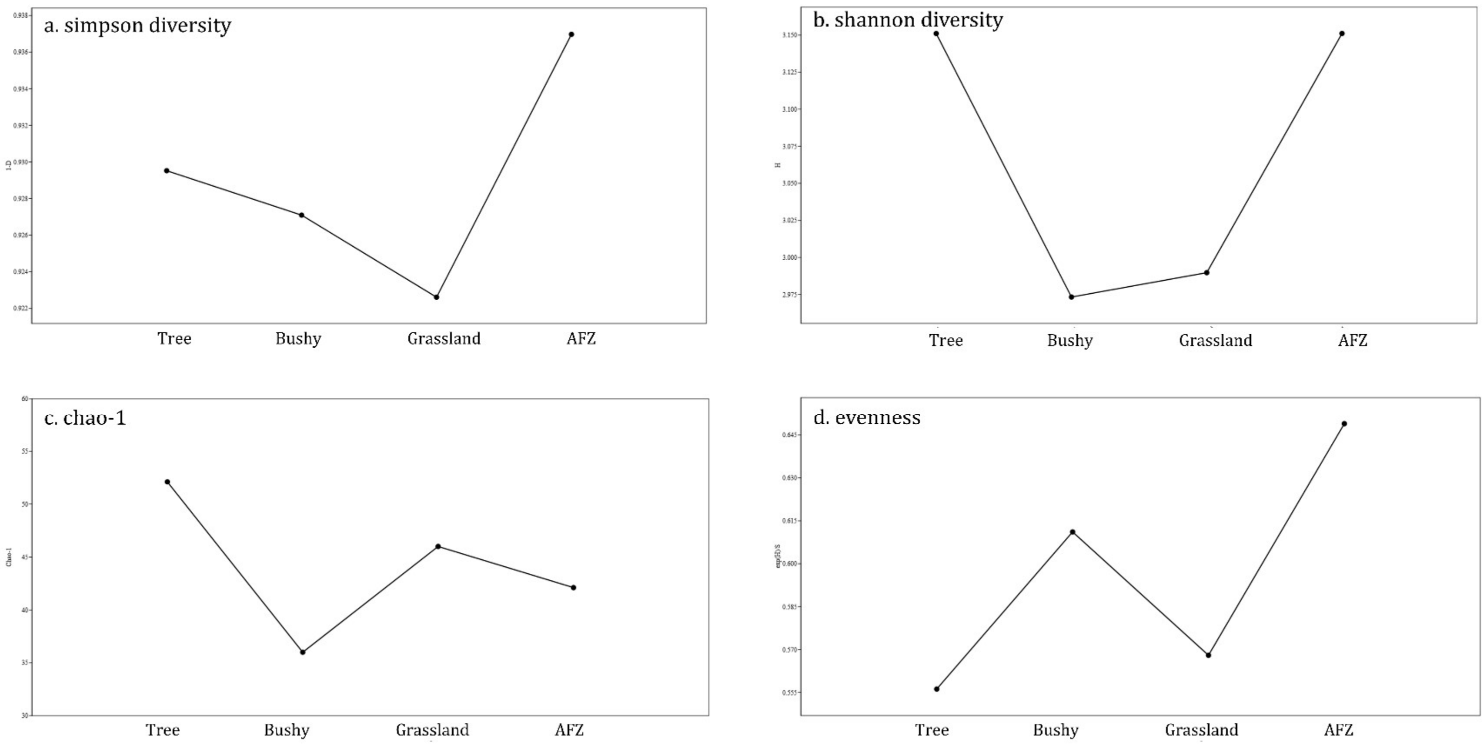

Fig. 2. Graph showing the (a)simpson diversity, (b)shannon diversity, (c)chao-1, (d)evenness analysis from the study sites.

The Simpson's 1-D values for Tree, Bushy, Grassland, and AFZ were calculated to be 0.9295, 0.9271, 0.9226, and 0.937, respectively. In every environment, high levels of diversity are observed, with the AFZ exhibiting the greatest diversity and the Grassland revealing the lowest. The findings also emphasize the fairly equal distribution of species in every habitat, indicating ecological stability and the absence of one particular species having control or dominance (Fig. 2a). The values acquired indicate the abundance and vitality of each habitat's ecological diversity. The AFZ area displays a greater Simpson's index, indicating a well-rounded and varied ecosystem. This can be attributed to the implementation of agroforestry techniques, which promote diverse habitats and create specialized environments for different species. Conversely, the slightly decreased Simpson's index observed in the Grassland could suggest the existence of particular environmental conditions and restricted resources, which ultimately lead to a community with lower diversity.The Tree and Bushy habitats are considered significant in sustaining diverse ecological communities due to their relatively high Simpson's diversity index values. Despite human disruptions, Bushy urban environments can uphold ecological diversity because of the adaptability and availability of resources in trees, which are recognized for hosting a vast array of species.

The calculated Shannon's diversity index values for Tree, Bushy, Grassland, and AFZ were 3.151, 2.973, 2.990, and 3.151, respectively. These values provide insights into the ecological diversity of each habitat. The highest diversity was observed in Tree and AFZ habitats, while Bushy and Grassland habitats exhibited slightly lower diversity but remained ecologically significant (Fig. 2b).The obtained Shannon's diversity index values reveal the varying degrees of ecological diversity in the studied habitats. The higher diversity observed in Tree and AFZ habitats reflects the presence of multiple species with relatively even abundances. Trees, being complex ecosystems, often provide various niches and resources, supporting diverse communities. Similarly, the AFZ, managed for feeding wildlife, creates favourable conditions for multiple species to thrive.The slightly lower Shannon's diversity index in Bushy and Grassland habitats may be attributed to human impacts and specific environmental conditions. Bushy urban environments might experience habitat fragmentation and alterations, affecting certain species' presence and abundance. Grassland habitats may have a limited range of resources, resulting in fewer species adapted to these specific conditions.

The calculated Chao-1 values for Tree, Bushy, Grassland, and AFZ were 52.11, 36, 46, and 42.11, respectively. These estimates provide valuable information on the total species richness in each habitat, considering the potential presence of unobserved or rare species (Fig. 2c).The Chao-1 estimator values shed light on the ecological complexity and biodiversity of the studied habitats. The higher Chao-1 estimate in Tree habitat (52.11) suggests the existence of a considerable quantity of unobserved or infrequent species, suggesting the presence of a remarkably diverse and abundant environment. Trees, as keystone species, often provide a variety of niches and habitats that support a wide range of flora and fauna.In contrast, the relatively lower Chao-1 estimate in Bushy habitat (36) may imply that the observed species in this habitat represent a significant proportion of the total species richness. Urban environments, characterized by human activities and modifications, might experience reduced species diversity compared to natural habitats.The Chao-1 values for Grassland (46) and AFZ (42.11) indicate moderate levels of species richness in these habitats. Grasslands provide essential habitats for various species, but their biodiversity might be influenced by specific environmental conditions and land management practices. AFZ, characterized by artificial feeding practices for wildlife, offers supplementary resources, attracting diverse species, but it may be subject to certain limitations regarding habitat heterogeneity.

The calculatedEvenness_e^H/S values for Tree, Bushy, Grassland, and AFZ were 0.5562, 0.6111, 0.568, and 0.649, respectively. These values offer insights into the evenness of species distribution in each habitat, complementing the understanding gained from the analysis of Shannon's diversity index. Each habitat exhibited varying levels of species evenness, providing essential information about the ecological balance and potential resilience of these ecosystems (Fig. 2d).The obtained Evenness_e^H/S ratio values reveal the diverse patterns of species evenness across the studied habitats. The higher ratio observed in AFZ indicates a more equitable distribution of species, suggesting that multiple species coexist with comparable abundances. This is likely due to the deliberate management practices in AFZ, which create favourable conditions for diverse wildlife.The slightly lower evenness ratio in Tree, Bushy, and Grassland habitats might be attributed to specific ecological factors and anthropogenic influences. In Tree habitats, certain species may dominate the community, reducing evenness. Similarly, Bushy urban environments may experience alterations in natural habitats, leading to changes in species distribution and abundance. In Grassland habitats, the limited range of resources may favour certain species over others, resulting in a less even distribution.

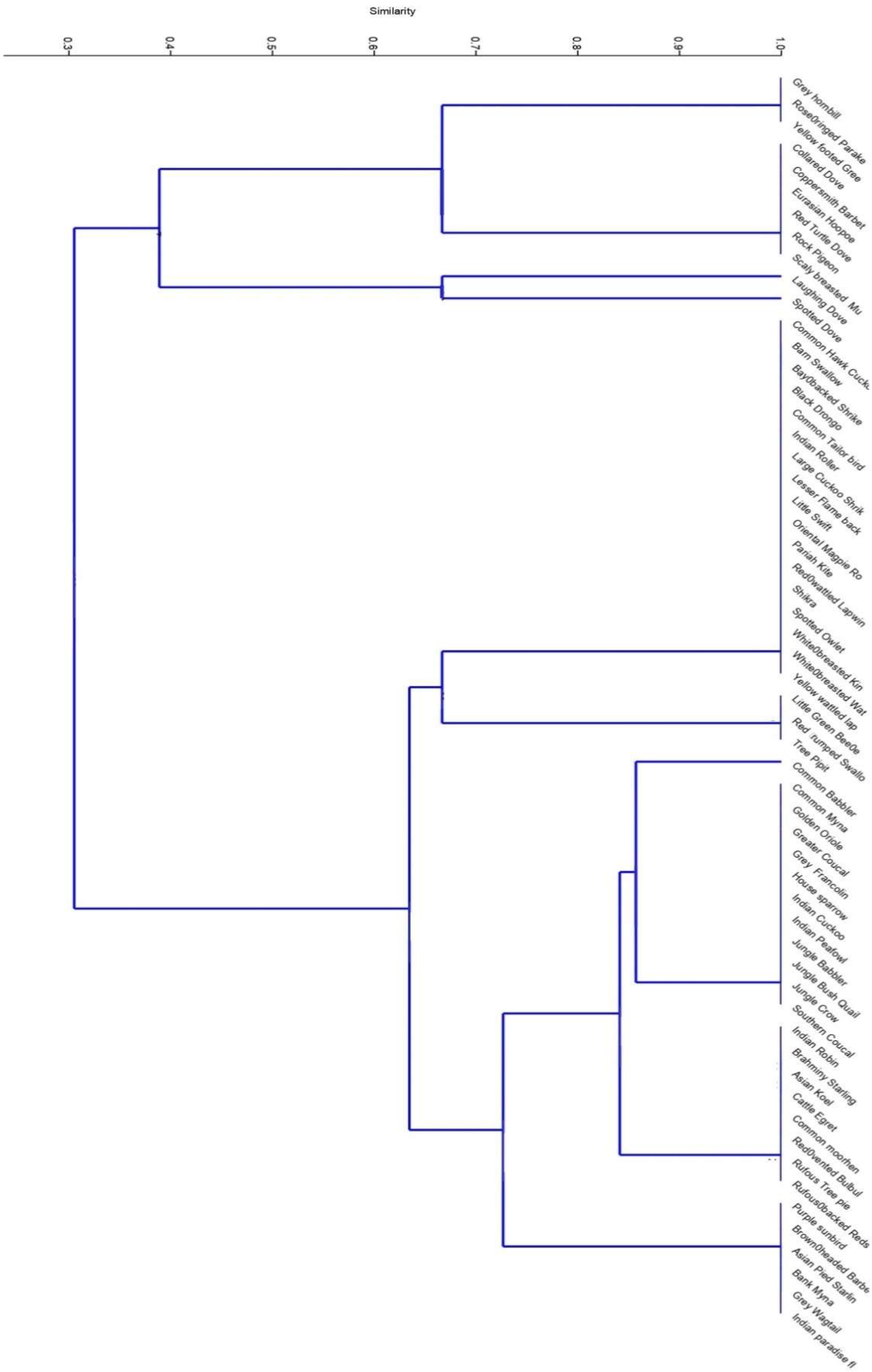

Fig. 3. Bray-Curtis clusteringshowing the clusteringof birds based on different feeding habits.

The Bray-Curtis clustering analysis produced a dendrogram which demonstrated significant groupings of bird species determined by their feeding behaviours (Fig. 3). Various groups were noticed, each indicating a unique feedinghabit among bird species.However Laughing dove and spotted dove do not form cluster, so these two birds having specific feeding habits then rest of the avifaunal species. Species belonging to the same cluster displayed comparable tendencies for selecting specific food sources, indicating potential similarities in their ecological behaviour and strategies for utilizing resources.

4. Discussion

The findings emphasize significant variations in biodiversity among the four habitats that were examined. The dominance index indicates that there is a greater abundance of particular species in the Artificial Feeding Zone, which could be due to human activities and the availability of resources. Both the Shannon's diversity index and Chao-1 estimator demonstrate that the Artificial Feeding Zone harbours a higher variety of species and greater diversity in comparison to other habitats. Moreover, the Tree habitat also displays significant species richness.The varying evenness values indicate differences in species distribution and habitat complexity among the studied areas. Such differences may be attributed to habitat structure, resource availability, and species interactions. The Bray-Curtis clustering analysis provides valuable insights in identifying dietary relationships among bird species. The clusters that have been identified provide a clearer understanding of distinct patterns of feeding habits, offering insights into how different bird species share resources and compete with each other in their communities. The clustering of data also provides valuable information on how certain food sources contribute to the formation and functioning of bird communities and ecosystems.Identifying bird species with similar dietary preferences and grouping them together can provide valuable insights for conservation efforts. This information can be helpful for creating specific conservation tactics, plans for managing habitats, and safeguarding crucial resources necessary for the survival of different bird species.

5. Conclusion

The comprehensive assessment of ecological diversity in four distinct habitats, namely Tree, Bushy, Grassland, and Artificial Feeding Zone (AFZ), using multiple diversity indices has provided valuable insights into the complexity and resilience of these ecosystems. The research findings highlight the importance of considering various aspects of biodiversity to better understand the ecological health and conservation needs of each habitat.The significant levels of diversity and evenness seen in the AFZ highlight the beneficial effects of conservation initiatives and habitat management in promoting the existence of varied wildlife populations.. Tree and Bushy habitats demonstrate considerable ecological importance, contributing to overall ecosystem health in urban environments. While Grassland exhibits slightly lower diversity, it still plays a crucial role in supporting unique species adapted to its specific environmental conditions.These findings have critical implications for habitat-specific conservation strategies. The application of Bray-Curtis clustering to analyse avian feeding habits has provided valuable insights into dietary associations and clustering among bird species.In summary, this study contributes to our understanding of biodiversity patterns in different habitats and establishes a basis for making knowledgeable choices regarding conservation and sustainable management practices to safeguard the invaluable ecological diversity. It is crucial to continuously monitor and conduct research in order to protect these habitats and guarantee a stronger and more enduring planet for future generations.This study also contributes to the growing body of ecological research on avian communities and their functional roles within ecosystems. By elucidating dietary patterns, the findings can aid in advancing conservation efforts and promoting sustainable management of avian populations and their habitats.

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