

Avian Diversity in Audu Bako Zoological Garden, Kano State, Nigeria

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Abstract

Zoological gardens play crucial role in maintaining avian diversity, emphasizing their value in urban biodiversity conservation amidst growing urbanization. The study assessed avian species abundance, distribution and diversity in Audu Bako Zoological Garden, using the line transect method. A total of six transects were laid and visited four times each for a period of four weeks. A total of 2300 individuals belonging to 23 species and classified into 19 families were recorded. Laughing dove (27.26%) and Long-tailed glossy starling (17.09%) were the highest occurring birds. Columbidae (2), Sturnidae (2) and Lybiidae (2) had the highest numbers of species represented. The Majority of bird species were recorded in the wetland habitat (50%), followed by the plain area (28%) and forest habitat (22%). Highest diversity and evenness were recorded in the forest habitat (2.82, 0.90) followed by wetland habitat (2.60, 0.83) and plain area (2.26, 0.72). These findings highlight the importance of the zoological garden in serving as a safe haven for bird species, emphasizing its significance in conserving birds' species. Survey of nocturnal avian species and implementation of appropriate conservation measures are recommended.

Keywords: Avian Diversity, Zoological Garden, Species Abundance, Urbanization, Urban Ecology.

Introduction

Birds are one of the most common faunas in all ecological habitats. Owing to their responsiveness to ecological changes, avifauna diversity and distribution are considered as important indicators to evaluate ecological trends of an area (Mistry et al., 2008). Among the wildlife resources, about 690 species of birds occupy a vital position for their contribution to ecological, economic and cultural sectors of the ecosystem (Gatesire et al., 2014). Forest is the most significant habitat for maintaining the most complex bird community structure. However, this natural habitat of birds has been threatened by human interferences, such as wanton deforestation for urbanization (Shah et al., 2022). Urbanization is an expanding process worldwide, causing major threats to biodiversity through both biotic homogenization and species extinction (Filloy et al., 2018). As global human population continues to increase, current trends and projections indicate that the population of people living in urban areas will nearly double to around 6.5 Billion by 2050 (CBD, 2012). In an increasingly urbanizing world, green spaces such as zoological and

botanical gardens within cities provide conditions suitable to support varying levels of biodiversity (Lepczyk et al., 2017). Zoos play important role in urban ecological networks, bridging gaps between conservation, education and real-world biodiversity protection (Wang et al., 2024).

Audu Bako zoological garden, a conservation spot for captive mammals and birds, located in urban Kano may serve as a safe haven for free ranging avian species. However, despite its ecological importance, there is currently no updated information on the composition, abundance and diversity of free ranging avifauna within the zoo, especially in relation to the dominant habitat types. The only available data is nearly a decade old (Ishaq & Rabia, 2017). The paucity of up-to-date information on bird diversity in Audu Bako zoological garden makes it difficult to assess changes that may have occurred over time, thereby posing a challenge to effective biodiversity monitoring and conservation. The aim of this study was to assess avifaunal abundance, distribution and diversity in relation to the different habitat types in the zoo. The findings of this study will provide updated information on avian diversity in the zoological garden, as well as inform decision making regarding conservation of avifauna, for potential avitourism development.

Methodology

Study Area

The study was conducted at the Audu Bako Zoological garden Kano, Kano State, Nigeria. It is located in Gandun Albasa, Kano Municipal Local Government, covering an area of about 46 hectares. The Zoological garden lies between Latitude 11° 57' 30"N to 11° 58' 00"N and Longitudes 8° 31' 15"E to 8° 32' 00"E. The study area experiences moderately high relative humidity year-round, with temperatures ranging from 19°C to 33°C and an annual rainfall of 690 mm. The soil in the area belongs to the sandy loam textural class and combines a characteristic feature of Guinea and Sudan Savanna vegetation zones of Northern Nigeria (Haruna *et al.*, 2018).

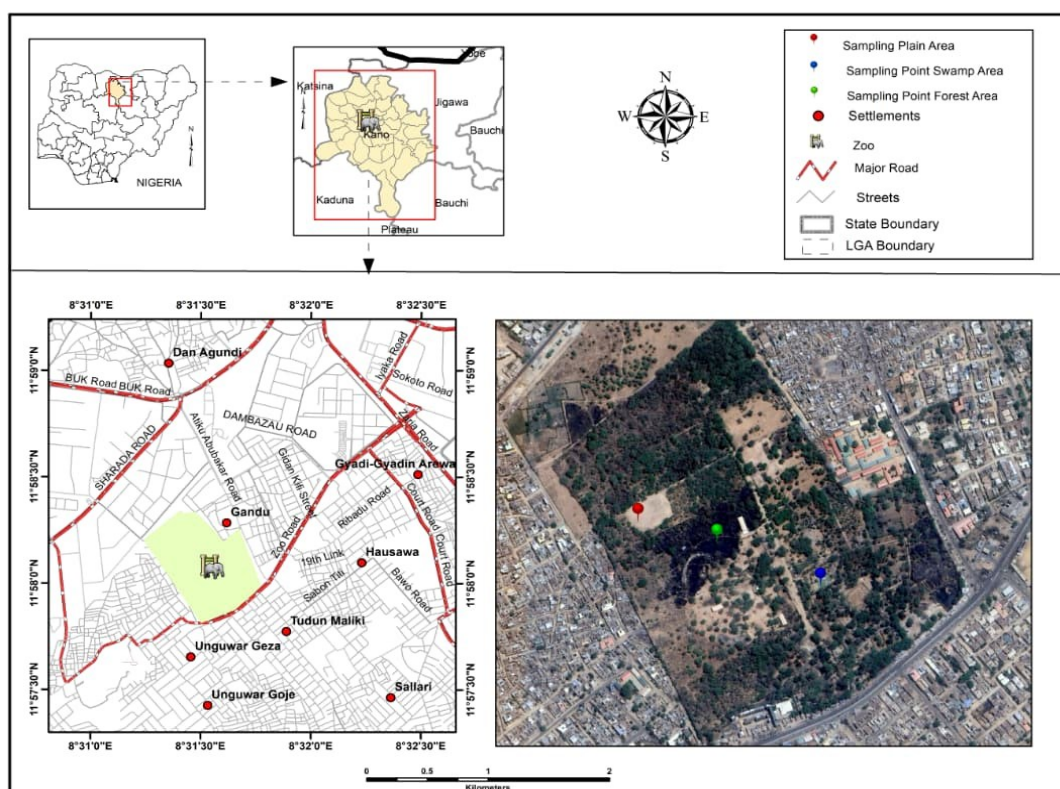


Figure 1: Map of the study area showing Kano Zoological Garden

Site Selection and Bird Census Method

The stratified sampling technique was employed for the survey. The study area was stratified into three different strata based on habitat types namely; wetland area, plain area and forest area. Bird count was conducted using the line transect method. In each habitat type, two transects of 200 m long were laid. Transects were visited twice, once in the morning (06300-0830hrs) and evening (1600- 1800hrs). This period was considered most appropriate, because birds' activities tend to be high during morning and late afternoon. Adjacent transects were not visited on same day to avoid overlapping observations of birds. A pair of binoculars and Helm's field guide to birds of Western Africa (Borrow and Demey, 2008) were used to view and identify birds to species level.

Data Analysis

Descriptive statistics such as (mean, frequencies, and percentages) were used in compiling data for checklist and abundance of birds. The Kruskal-Wallis H test and Friedman test were used to test for significance in bird abundance in the three habitats. Species richness (S) were counts of species number.

Relative Frequency (RF) for individual species in the study area was calculated using the formula below:

$$\text{Relative Abundance (RA) \%} = \frac{\text{Frequency of a specie}}{\text{Total frequency of all species}} \times 100 \dots\dots\dots(i)$$

The Sorenson's Similarity Index was used to evaluate species similarities across habitat types. It gives a value between 0 and 1, with 1 indicating complete similarity and 0 if species of two habitat types are dissimilar.

$$\text{Sorenson's coefficient (CC)} = \frac{2c}{S_1 + S_2} \dots\dots\dots (ii)$$

Where C is the number of species the two communities have in common

S₁ is the total number of species found in community 1

S₂ is the total number of species found in community 2

Bird species diversity indices such as Shannon-Weiner diversity, Simpson Index of Diversity and Pielou's species evenness index (E) were estimated using the PAST Program. The formulas are generally given by:

$$H = - \sum_{i=1}^S P_i \ln P_i \dots\dots\dots (iii)$$

Where,

H= Shannon Diversity index;

S= Total number of species

$$P_i = \frac{\text{Number of individuals of } i\text{th species}}{\text{Total abundance of all species}}$$

ln P_i= Natural logarithm of the species proportion

The Simpson index is given by the formula:

$$D = \frac{\sum n(n-1)}{N(N-1)} \dots\dots\dots (iv)$$

Where n= total number of individuals of each species

N=the total number of organisms of all species

D= Simpson index.

$$\text{Pielou's Evenness index (J')} = \frac{H'}{\ln(S)} \dots\dots\dots (v)$$

Where:

J' = Pielou's Evenness Index

H' = Shannon-Wiener Diversity Index

S = Total number of species (species richness)

ln = Natural logarithm

$$\text{Kruskal Wallis index } H = \frac{12}{N(N+1)} \sum_{i=1}^K \frac{R_i^2}{n_i} - 3(N+1) \dots\dots\dots (vi)$$

Where (N)= Total number of observations across the habitats

(n_i) = sum of observations in groups (i)

(R_i) = sum of Ranks assigned to the observations in group (i) after ranking all (N) values

$$\text{Friedman test } X^2_F = \frac{12}{bk(k+1)} \sum_{j=1}^K R_j^2 - 3b(k+1) \dots\dots\dots (vii)$$

Where b= number of blocks (subjects or matched sets)

(k) = number of treatments or conditions

R_j = sum of ranks for treatments (j) across all blocks (each blocks ranks the (k observation from 1 to k))

Results and Discussion

Results

Checklist and Abundance of Avian Species in Audu Bako Zoological Garden

The bird species, their families, abundance and relative abundance is presented in Table 1. In total, 2300 birds belonging to 23 bird species and 19 families were recorded. The most abundant bird species were Laughing dove and the Long-tailed glossing starling with a relative abundance of 27.26% and 17.09% respectively. The Rose ringed parakeet, African grey woodpecker and Grey-backed camaroptera with relative abundance of 0.83%, 1.13% and 1.17% respectively, were identified as the least abundant species. The families' columbidae, Lybididae and sturnidae had 02 species representative each, while other families recorded 01 species only. Columbidae had the highest relative abundance of species (29.83%), followed by Sturnidae (19.05%) and Lybiidae (5.52%).

Table 1. Checklist and Relative abundance of bird species in the study area

Family	Common name	Scientific name	Abundance	R.A (%)
<u>Accipitridae</u>	Yellow-billed kite	<i>Milvus aegyptius</i>	131	5.7
Apodidae	African palm swift	<i>Cypsiurus parvus</i>	77	3.35
<i>Ardeidae</i>	Cattle egret	<i>Bubulcus ibis</i>	72	3.13
Bucerotidae	Northern red-billed hornbill	<i>Tockus erythrorhynchus</i>	90	3.91
Buphagidae	Yellow-billed oxpecker	<i>Buphagus africanus</i>	30	1.30
Cisticolidae	Grey-backed camaroptera	<i>Camaroptera brevicaudata</i>	27	1.17
Cuculidae	Senegal coucal	<i>Centropus senegalensis</i>	58	2.52
Columbidae	Mourning collared dove	<i>Streptopelia decipiens</i>	59	2.57
Columbidae	Laughing dove	<i>Spilopelia senegalensis</i>	627	27.26
Estrildidae	Red-billed firefinch	<i>Lagonosticta senegala</i>	68	2.96
Falconidae	Common kestrel	<i>Falco tinnunculus</i>	74	3.22
Laniidae	Yellow-billed shrike	<i>Lanius corvinus</i>	50	2.17
Leiiothrichidae	Brown babbler	<i>Turdoides plebejus</i>	61	2.65
Lybiidae	Bearded barbet	<i>Lybius dubius</i>	50	2.17
Lybiidae	Yellow-fronted thinker bird	<i>Pogoniulus chrysoconus</i>	77	3.35
Malaconotidae	Yellow-crown gonolek	<i>Laniarius barbarus</i>	38	1.65
Picidae	Grey-headed wood pecker	<i>Picus canus</i>	70	3.04
Picidae	African grey wood pecker	<i>Dendropicos goertae</i>	26	1.13
Ploceidae	White-billed Buffalo weaver	<i>Bubalornis albirostris</i>	74	3.22
Psittaculidae	Rose-ringed parakeet	<i>Psittacula krameria</i>	19	0.83
Sturnidae	Chestnut-bellied starling	<i>Lamprotoris pulcher</i>	45	1.96

Sturnidae	Long-tailed glossy starling	<i>Lamprotornis caudatus</i>	393	17.09
Turdidae	African thrush	<i>Turdus pelios</i>	84	3.65

Distribution and similarity of bird species across habitat types in the study area

Table 2 shows the distribution of bird species across the study area. All species observed were generalists, distributed across all the habitat types. No specie was found to be restricted to a specific habitat type. Though some of the species had higher abundance in a certain habitat type, and low abundance in another habitat. Results showed significant difference in abundance between habitat types (One- way ANOVA). Highest abundance by percentage was recorded in the wetland area (50.09%), followed by plain area (28.26%). The forest area was found to have the least abundance (21.65%) (Figure 2). The value for Sorenson coefficient between habitat types was 1 (Table 3), indicating complete similarity in species between habitats.

Table 2. Distribution of bird species across the selected habitat types

Common Name	Scientific Name	Wetland	Plain area	Forest
Yellow-billed kite	<i>Milvus aegyptius</i>	53	53	25
African palm swift	<i>Cypsiurus parvus</i>	45	20	12
Cattle egret	<i>Bubulcus ibis</i>	41	9	22
Northern red-billed hornbill	<i>Tockus erythrorhynchus</i>	62	10	18
Yellow-billed oxpecker	<i>Buphagus africanus</i>	15	8	7
Grey-backed camaroptera	<i>Camaroptera brevicaudata</i>	10	7	10
Senegal coucal	<i>Centropus senegalensis</i>	35	8	15
Mourning collared dove	<i>Streptopelia decipiens</i>	25	19	15
Laughing dove	<i>Spilopelia senegalensis</i>	379	185	63
Red-billed firefinch	<i>Lagonosticta senegala</i>	25	10	33
Common kestrel	<i>Falco tinnunculus</i>	52	6	14
Yellow-billed shrike	<i>Lanius corvinus</i>	35	11	4
Brown babbler	<i>Turdoides plebejus</i>	33	18	10
Bearded barbet	<i>Lybius dubius</i>	25	11	14
Yellow-fronted thinker bird	<i>Pogoniulus chrysoconus</i>	42	7	28
Yellow-crowned gonolek	<i>Laniarius barbarus</i>	15	10	13
Grey-headed wood pecker	<i>Picus canus</i>	47	8	15
African grey wood pecker	<i>Dendropicos goertae</i>	15	5	6
White-billed Buffalo weaver	<i>Bubalornis albirostris</i>	24	15	35
Rose-ringed parakeet	<i>Psittacula krameria</i>	3	11	5
Chestnut starling	<i>Lamprotornis pulcher</i>	25	9	11
Long tailed glossy starling	<i>Lamprotornis caudatus</i>	102	198	93
African thrush	<i>Turdus pelios</i>	44	10	30
Total		1152	650	498

Source: Field survey, 2024

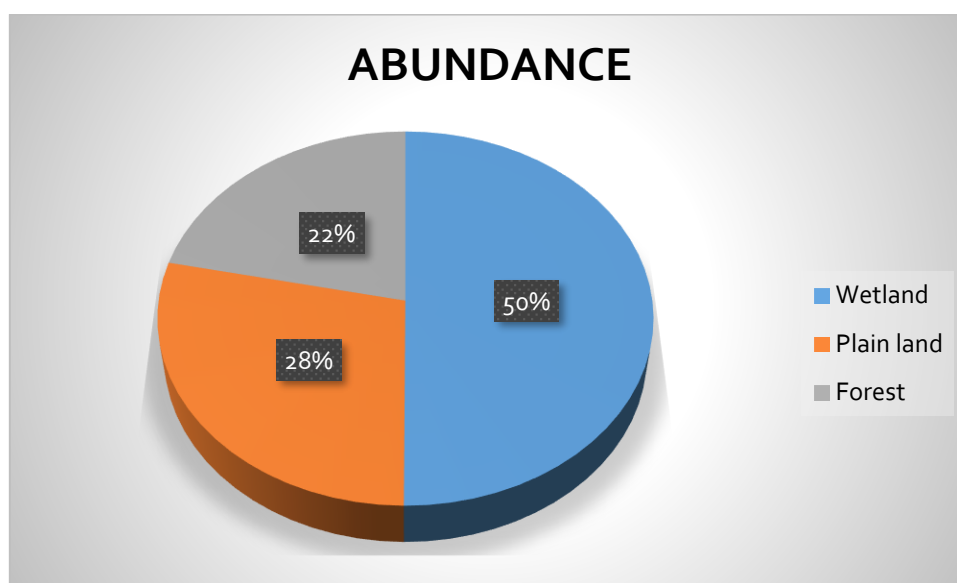


Figure 2. Distribution of birds by percentage across habitat types

Table 3. Sorensen similarity between habitat types

Habitat types	Wetland	Plain area	Forest
Wetland		1	1
Plain area			1
Forest			

Diversity of Avian species in the study area

Species richness recorded across all habitat types during the survey was 23. The forest area had the highest diversity index (2.82), followed by wetland area (2.60), while the plain area had the least diversity (2.26). Forest area had the highest equitability index of 0.9 while plain area had the lowest of 0.72 (Table 4)

Table 4. Diversity Indices of bird species in the study area

Habitat type	Abundance	Richness	Percentage (%)	Shannon-Weiner Index	Equitability Index
Entire Zoo	2300	23	100	2.63	0.84
Wetland	1152	23	50.09	2.60	0.83
Plain area	650	23	28.26	2.26	0.72
Forest	498	23	21.65	2.82	0.90

Table 5. Kruskal wallis H test of Significance between habitat types

Statistical Test	Null Hypothesis	Test Statistics	Degrees of Freedom	P value
Kruskal-Wallis H	Medians are equal across groups	15.749	2	< 0.001

Discussion

Bird Species Richness and Abundance

The findings of this study indicate that zoos serve as important refuges for birds in urban areas. This study recorded 23 bird species, fewer than the 30 species reported by Ishak and Rabi (2017) in the same environment. Several species recorded in the earlier survey were absent in this study, while others appeared only in the present study, with some species shared between both surveys. The variation in both studies could be attributed to changes in resources (food, nesting) availability, seasonal variations, climate-driven changes or habitat alteration, all of which can lead to species turnover. This aligns with several studies that have shown temporal fluctuations of bird assemblages (Loiselle and Blake, 1991), and suggest that both changes in climatic factors such as precipitation and temperature (Boyle, 2011), as well as changes in resources availability (Mulwa et al., 2013) can cause local fluctuations of bird assemblages. Bibi and Ali (2013) also noted that changes in favorable conditions such as rainfall and food availability, likely contribute to seasonal variation in species composition. The study also agrees with Márquez-Luna (2024) who revealed the persistence of certain species in an urban protected area in Mexico, indicating that even when species turnover occurs, some species will remain in the same ecosystem overtime. Laughing dove and long tailed glossy starling identified as the most abundant species could be due to the birds' ability to exploit urban resources and thrive even with the presence of humans. This finding corroborates the submissions of Yapici and Erdogan (2023), that the Laughing dove can easily adapt to urban ecosystem, people and also reproduce in all seasons of the year. Similarly, Kwaga et al. (2017) also reported that starlings are known to inhabit a wide variety of habitats, such as park land and bushes, owing to their behavioural plasticity and close association with humans.

The dominance of Columbidae in this study was similar to the findings of Turshak and Abdullahi 2024, who recorded columbidae as the dominant family in Jos Wildlife Park, Plateau state, Nigeria. This is in line with the submission of Crome 1991, that columbidae which includes Pigeons and doves, have a wide range of geographic distribution.

Species Distribution across Habitat Types

Similar distribution of species observed at the time of this study, along with high similarity index between habitat types indicates that species are habitat generalists. This could be attributed to availability of similar resources across the study site. This disagrees with the findings of Musa et al. (2024), who reported that certain species were restricted to certain habitat types while others were generalist in Urban Katsina. The findings of this study however corroborate with Frickie et al. (2009) who revealed that similarity in species distribution between habitats is common, particularly for generalist species. Wetland habitat had the highest species abundance, with 50% of the total abundance of bird species found in the habitat. This could be as a result of the heterogeneous nature of the habitat; having trees, water, and grasses which translates to provision of better feeding and other survival resources for bird species. Although most bird species found were not those known

to be associated with wetlands. This result is consistent with other studies (Mckinny et al., 2011) where it was reported that wetlands in urban landscapes provided resources to birds, including those not normally associated with wetlands, but take advantage of enhanced resources associated with these mesic habitats.

A large Kruskal-Wallis H value (Table 5) indicates that the median ranks of bird abundance differ substantially among the three habitats. Because the associated p-value is far below the conventional $\alpha = 0.05$ threshold ($p < 0.001$), the test rejects the null hypothesis of equal medians. Consequently, we can conclude that bird abundance is not uniformly distributed across plain, wet, and forest land-use types, implying that some habitats support higher or lower bird numbers than others (Mundry and Niemann, 2011). The Kruskal-Wallis (independent medians) tests yielded highly significant results ($p < 0.001$), providing convergent evidence that land uses or different habitats are key drivers of bird abundance in the study area. The high significance implies that the observed variation in bird counts among Plain, Wet, and Forest habitats is real and ecologically meaningful rather than random. Habitat specialization is implied: the Wet habitat may supply critical resources (water, food) that attract many individuals of certain species, whereas the Forest may host fewer, more specialized birds (Jansson and Angelstam, 2002; Aliyu et al, 2023).

Species Diversity and Evenness

The high bird species diversity and evenness recorded in the Audu Bako zoological garden indicated its role in maintaining avian diversity, emphasizing its value in urban biodiversity conservation amidst growing urbanization. According Greenwell et al. (2023) and Wang et al. (2024), zoos play important role in urban ecological networks, bridging gaps between conservation, education and real-world biodiversity protection. Despite low abundance of species in the forest habitat, the habitat had the highest diversity and evenness. This pattern could be attributed to the presence of several species represented by only few individuals, which reflect the importance of both habitat type, structural complexity and heterogeneity. This finding aligns with the reports of Basile et al., (2021), that the presence of forest alone does not inherently result in higher bird abundance. The authors emphasized that landscape context, diameter of living and dead trees and dead wood significantly influence forest bird abundance. Therefore, the presence of trees alone does not inherently result in higher abundance of birds, rather it is the structural complexity of the forest that plays a critical role.

Conclusion and Recommendation

The findings of this study affirmed that the Audu Bako zoological garden plays an important role in maintaining avian species conservation, as it harbors various species of birds that are of ecological importance. Species abundance and diversity varied between the studied habitats types, indicating variation in favourable condition of these habitats. The study proved that although anthropogenic disturbance, which is a product of urbanization affects

avian species abundance and distribution, zoological garden in urban environment are important part of the urban ecosystem that harbour high number of birds. From the findings, it is evident that all bird species encountered were habitat generalists. The similarity in availability of resources such as food, nesting and roosting sites and other necessities for bird's survival between habitat types is the reason for the similar distribution of species.

It is important that survey on nocturnal avian species in the zoological garden be conducted as there is limited information available on this species. Furthermore, avitourism should be encouraged, that way, visitors can appreciate birds' species and be aware of their importance in the ecosystem and the need to preserve them. Furthermore, appropriate conservation measures such as maintaining and improving the different habitats should be implemented to safeguard the nesting, breeding and roosting sites of bird species. By so doing, the zoos role in maintaining avian biodiversity will be enhanced. The forest habitat should be managed to enhance to its structural complexity thereby improving its capacity to support higher bird abundance and diversity.

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