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RESEARCH ARTICLE

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Predictors of West African urban bird species richness and composition

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Abstract

Urbanisation and its associated habitat loss and fragmentation are considered a major threat to wildlife. In this study, we assessed the predictors of bird species abundance, richness and composition within 70 cells of 500 m by 500 m spread across the five urban areas constituting Ibadan metropolis. A total of 4167 individuals of 55 species belonging to 30 families were recorded. We report that Laughing dove *Streptopelia senegalensis*, Speckled pigeon *Columba guinea* and Yellow-billed kite *Milvus aegyptius* contributed to a greater proportion of bird abundance across sites and Columbidae was the most abundant bird family. Bird species richness increased significantly with tree abundance but decreased significantly with the number of pedestrians. Similarly, foraging guild richness declined significantly with the number of pedestrians. Granivores and scavengers constituted the most abundant foraging guilds. Areas with high pedestrians' traffic were associated with fewer trees and were dominated by fewer numbers of species belonging to a few foraging guilds. This is likely because such areas offer limited foraging opportunities or cover from potential predators. We conclude that improving urban landscape characteristics through revegetation, establishment of green spaces and buffering from human disturbance will improve the composition and richness of avian species in the Ibadan metropolis.

KEYWORDS
avian composition, avifauna, conservation, functional richness, species richness, urbanisation

Résumé

L'urbanisation ainsi que la perte et la fragmentation de l'habitat qui en découlent sont considérées comme une menace majeure pour la faune et la flore. Dans cette étude, nous avons évalué les indicateurs de l'abondance, de la richesse et de la composition des espèces d'oiseaux dans 70 cellules de 500 m sur 500 m, réparties dans les cinq zones urbaines constituant la métropole d'Ibadan. Au total, 4 167 individus de 55 espèces appartenant à 30 familles ont été recensés. Nous rapportons que la tourterelle rieuse *Streptopelia senegalensis*, le pigeon biset *Columba guinea*, et le milan à bec jaune *Milvus aegyptius* ont contribué à une plus grande proportion de l'abondance des oiseaux à travers les sites et que les Columbidae étaient la famille d'oiseaux la plus abondante. La richesse en espèces d'oiseaux a augmenté de manière considérable avec l'abondance des arbres, mais a diminué de manière remarquable avec le nombre de piétons. De même, la richesse des guildes de recherche de nourriture a diminué de manière considérable avec le nombre de piétons. Les granivores et les charognards constituaient les guildes de recherche de nourriture les plus abondantes. Les zones à forte fréquentation piétonne étaient associées à moins d'arbres et étaient dominées par moins d'espèces appartenant à quelques guildes de recherche de nourriture. Cela s'explique probablement par le fait que ces zones n'offrent que peu de possibilités de se nourrir ou de se protéger des prédateurs potentiels. Nous concluons que l'amélioration des caractéristiques du paysage urbain par la revégétalisation, l'établissement d'espaces verts et la protection contre les perturbations humaines, améliorera la composition et la richesse des espèces aviaires dans la métropole d'Ibadan.

1 | INTRODUCTION

Urban expansion and densification are occurring at an alarming rate globally (Georgi & Dimitriou, 2010), and currently, about 50% of the human population reside in cities, and by 2050, this proportion is projected to reach 70% (Loss et al., 2009). The implication is that the remaining natural and seminatural habitats will come under intense pressure from anthropogenic activities, and consequently, many more species and ecosystems are likely to become threatened. Generally, urbanisation is associated with the fragmentation or loss of natural and seminatural habitats as well as the transformation of natural landscapes into built-up areas with impervious surfaces (McKinney, 2006; Seto et al., 2012). Urbanisation is regarded as one of the major threats to avifauna due to its impact on habitat and landscape characteristics such as vegetation structure and diversity (reviewed in Evans et al., 2009). Birds are incredibly responsive to ecosystem changes, and from an ecological perspective, the presence of suitable habitats is crucial for the survival of the fauna residing within them (Yisau et al., 2023). Also, many urban areas have relatively few trees and natural vegetation; even where such exist, they are usually confined to small areas. The consequence of this transformation is a change in species richness and composition in many areas (Marzluff, 2001; McKinney, 2008), owing to the loss or modification of vital ecological requirements for sustaining diverse bird populations.

Landscape and habitat attributes of urban areas influence the patterns of bird abundance and richness. For example, synanthropic species typically show a positive response to anthropogenic food sources (Chace & Walsh, 2006; Fuller et al., 2008) and the breeding opportunities available on artificial structures such as cavities, eaves and ledges of buildings, bridges and telephone towers (Kumar et al., 2014; Mainwaring, 2015). These species maintain high populations and can therefore inflate bird abundance data in urban areas. Bird species richness, on the contrary, responds positively to habitat variables such as patch area, vegetation structure and tree cover (Beninde et al., 2015). Hence, the spatial distribution of these attributes can result in a disproportionate occurrence of bird communities across the urban area. This is further amplified by the fact that increasing density of buildings and other artificial structures results in increasing distances between vegetation patches. Furthermore, bird composition in urban areas is often dominated by omnivores, granivores and scavengers (Chace & Walsh, 2006; Lee et al., 2021). These dominant guilds are more likely to be associated with the open habitats of the urban landscape as compared to frugivores and nectarivores that may be associated with more closed green spaces or densely vegetated areas.

Africa is urbanising faster than any other continent, and its population is projected to double by 2050, with its cities housing an additional 950 million people (OECD/SWAC, 2020), and this expansion is expected to occur in susceptible ecological zones. Relatedly, urbanisation has been listed as one of the drivers of biodiversity loss in Africa (Curtis et al., 2018). A number of African studies also show that the increment in altered areas through urbanisation affects the community ecology of bird species in such areas (Blankespoor, 1991; Halassi et al., 2022; Sanderson et al., 2022; Yilangai et al., 2023). In Nigeria, 50% of the country's population now live in urban areas since 2018 (UN, 2018), and about 1% of total forest area is lost annually (FAO, 2020). Given a current population estimated to be 200 million and an annual increase of 2.6%, much of the country's natural landscapes will be subject to pressures from anthropogenic activities in the coming years. Furthermore, a few studies have investigated the impact of urbanisation on bird richness and composition in Nigeria (Kumdet et al., 2021; Lawal & Iwajomo, 2020; Lee et al., 2021). This study, therefore, seeks to contribute to the growing knowledge of how bird populations are impacted by urbanisation, with the expectation that the results would contribute to inform the conservation of bird populations in urban areas. The goal of this study was to investigate how bird species richness and composition are predicted by habitat attributes representing three components of urban landscape: vegetation cover, represented by tree abundance and the percentage of canopy and ground cover; urban infrastructures, represented by number of buildings and telecommunication masts;

and human traffic, represented by number of pedestrians. The study focussed on five urban local governments with similar levels of urbanisation, within the ancient city of Ibadan, the biggest city in West Africa. We predict that: (1) bird composition will be dominated by species and foraging guilds capable of exploiting human-dominated habitats; (2) bird abundance and richness will be positively related to increasing vegetation cover but negatively related to an increase in urban infrastructures and human traffic.

2 | METHODS

2.1 | Study area

This study was conducted within Ibadan metropolis, Oyo State, located in South-Western Nigeria, 128 km inland northeast of Lagos and 530 km southwest of Abuja, the federal capital. Ibadan (Figure 1) is located between latitude 3°3′ N and 4°10′ N and longitude 7°2′ E and 7°40′ E. Ibadan with a total area of 3123 km^2, as reported by (Adelekan et al., 2014), has eleven local governments, of which five are urban, which constitute the 'Ibadan Metropolitan Region', and six are semiurban areas. The Ibadan Metropolis, Nigeria, is an urban study area with diverse habitat types and a mix of activities such as residential and commercial. This study was conducted in the five urban local government areas called Ibadan Metropolis, which are Ibadan South East, Ibadan North East, Ibadan North West, Ibadan South and Ibadan North Local Government Areas.

2.2 | Bird and habitat variable assessment

To map Ibadan Metropolis' urban area, the ArcGIS software's fishnet tool was employed, creating a grid of 499 rectangular cells measuring 500 by 500 metres. Four hundred and ninety-nine cells of 500 m by 500 m are needed to completely cover the five urban local governments of the Ibadan metropolis. Following this, 100 cells (Figure 1) were selected at random for data collection and their coordinates were uploaded onto the MAPINR mobile application, allowing for easy navigation and site visits. Inside each cell, five point counts were established randomly, spaced 200 metres apart. Each point count was surveyed by documenting birds seen or heard within a 50-metre radius for 5 minutes, and laser range finder was utilised to accurately measure the 50-metre radius around each survey point. During each visit, birds were identified based on features described

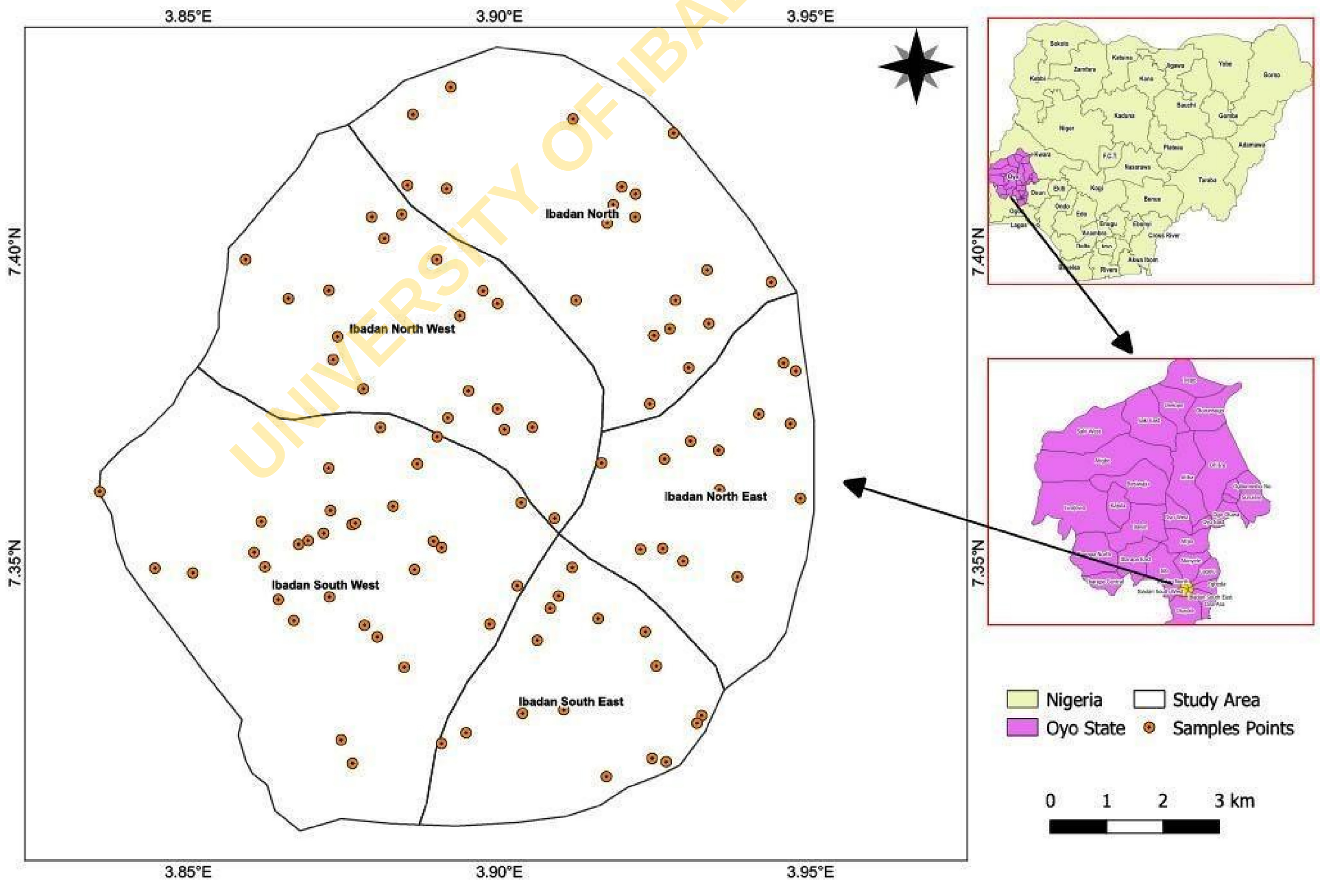

FIGURE 1 Map of Ibadan Metropolis displaying the surveyed local government areas, with dots representing the 100 randomly selected cells within the broader grid of 499 cells covering the entire metropolis. Inset A: Map of Nigeria, highlighting the location of Oyo State. Inset B: Detailed map of Oyo State, highlighting the city of Ibadan within its boundaries.

in the Helms field guide to the birds of western Africa (Borrow & Demey, 2001). Observations were done in the morning and evening to account for possible differences in bird species encountered due to variation in time of day, avoiding days with strong winds or rain. We predicted that urban bird composition would be similar due to the comparable degree of human disturbance and vegetation structure across the Ibadan urban areas, so we characterised each point count by recording a set of variables considered to be relevant characteristics of urban habitat. The following habitat variables representing attributes of the urban landscape were recorded within the 50 m radius of each point station: the number of buildings, number of trees, number of communication masts, percentage of ground cover, percentage of canopy cover and number of pedestrians. No specific permissions were required to conduct this work. All bird surveys were conducted in areas that are open to the public; therefore, there was no need to ask land managers for approval.

2.3 | Data analysis

Out of the 100 cells that were randomly selected for the bird survey, data were available for only 70 cells. This was mainly because some of the cell locations were inaccessible due to various factors such as the presence of rivers, industrial sites and restricted areas, as well as security challenges. In this study, we estimated species richness using the package vegan (Oksanen et al., 2013) while also grouping the bird species into foraging guilds based on their primary diets in 'The Birds of Africa' Volumes 1–7 (Brown et al., 1982; Fry et al., 1988-2004; Keith et al., 1992; Urban et al., 1986–1997). Foraging guild classifications used in this study consist of scavengers (species feeding on carcasses); carnivores (species feeding on vertebrate prey); insectivores (species whose primary diet is arthropods); nectarivores (species whose primary diet is nectar); granivores (species feeding mainly on seeds); piscivores (species whose main diet consist of fish); and frugivores (species feeding mainly on fruits). For each foraging guild, we estimated the number of individual birds recorded and the number of species making up the guild, hereafter referred to as foraging guild abundance and richness, respectively. To verify our assumption that the habitat structures and urbanisation levels of the five local government areas were similar, we conducted a preliminary analysis. Specifically, we tested using Kruskal–Wallis ANOVA whether the habitat variables differed significantly between the five areas and also whether the differences will translate to significant difference in bird richness, abundance, foraging guild richness across the local government areas.

General linear models were used to test the relationships between bird species richness, foraging guild richness and habitat variables. To improve the normality of abundance, species and foraging group richness, we applied a log transformation, that is log10. For each of these linear models, species richness and foraging guild richness were entered as dependent variables. In contrast, numbers of trees, buildings, telecom masts, pedestrians and percentage ground and canopy cover were entered as independent variables. We tested for collinearity between independent variables using variance inflation factor (VIF). All VIF values were less than the suggested thresholds (>10; Gareth et al., 2013). Using the stepwise backward elimination method (Crawley, 2005), variables with the highest *p*-values were removed, starting with the nonsignificant interactions. The procedure was repeated until the best model was attained. Differences in the number of individual birds represented in the foraging guilds were assessed using Kruskal–Wallis test. All statistical analyses were conducted using R statistical language version 4.1.2 (2021-11-01; R Core Team, 2021), and the significance of all tests was determined at $p < 0.05$.

3 | RESULTS

3.1 | Bird abundance and species richness

Our preliminary analysis revealed that most of the habitat variables differed significantly between the areas: tree abundance (Kruskal–Wallis: $\chi^2 = 20.96$, df = 4, $p < 0.001$), number of buildings ($\chi^2 = 14.12$, df = 4, $p = 0.007$), number of telecom mast ($\chi^2 = 18.51$, df = 4, $p = 0.001$) and ground cover (%) ($\chi^2 = 14.42$, df = 4, $p = 0.006$), whereas the number of pedestrians and percentage canopy cover did not differ significantly between the areas (pedestrians: $\chi^2 = 5.70$, df = 4, $p = 0.223$; canopy cover: $\chi^2 = 6.15$, df = 4, $p = 0.188$). Relatedly, we found no significant difference in species richness ($\chi^2 = 8.5$, df = 4, $p = 0.075$), bird abundance ($\chi^2 = 6.97$, df = 4, $p = 0.137$) and foraging guild richness ($\chi^2 = 4.24$, df = 4, $p = 0.375$) between the local government areas. Hence, we aggregated the bird abundance, richness and foraging guild richness data across the areas in subsequent analysis. A total of 4167 individual birds of 55 species belonging to 30 families were recorded across all the 70 cells surveyed within the study area. The three most abundant species recorded were Laughing dove *Streptopelia senegalensis* ($n = 196$), Speckled pigeon *Columba guinea* ($n = 155$) and Yellow-billed Kite *Milvus aegyptius* ($n = 190$; Table 1). Overall, the family Columbidae represented by Laughing dove, Speckled pigeon, Red-eyed dove *Streptopelia semitorquata* and Blue-spotted wood dove *Turtur afer* was the most abundant and accounted for 38% of the bird abundance. Similarly, Columbidae accounted for the highest proportion of bird families recorded across the study area (range: 35%–45%). Thirty-four species (62%) occurred in all the five urban local governments of the Ibadan Metropolis, while 21 species (38%) occurred only in one urban local government of the Ibadan Metropolis (Table S1). Total bird abundance and richness within each surveyed cell ranged from 18 to 220 and 4 to 24, respectively. None of the habitat variables significantly predicted bird abundance. Hence, we report only the analysis for species and foraging guild richness. The best model predicting bird species richness retained tree abundance, and the number of pedestrians as significant predictors (Table 2). Species richness was positively related to the number of trees but negatively related to the number of pedestrians present in the study area (Table 2, Figures 2 and 3).

TABLE 1 Bird species recorded across all the 70 cells surveyed in Ibadan metropolis, Nigeria.

Family	Species	Common name	Abundance
Apodidae	*Cypsiurus parvus*	African palm swift	11
Motacillidae	*Motacilla aguimp*	African pied wagtail	3
Turdidae	*Turdus pelios*	African thrush	11
Estrildidae	*Lagonosticta rufopicta*	Bar-breasted Firefinch	1
Alcedinidae	*Halcyon malimbica*	Blue-breasted kingfisher	17
Cuculidae	*Centropus monachus*	Blue-headed coucal	1
Columbidae	*Turtur afer*	Blue-spotted wood dove	3
Coracidae	*Eurystomus glaucurus*	Broad billed roller	6
Estrildidae	*Lonchura cucullatta*	Bronze mannikin	33
Ardeidae	*Bulbucus ibis*	Cattle egret	3
Nectarinidae	*Hedydipna collaris*	Collared sunbird	15
Pycnonotidae	*Pycnonotus barbatus*	Common bulbul	94
Falconidae	*Falco tinnunculus*	Common kestrel	101
Platisteiridae	*Platysteira cyanea*	Brown-throated Wattle-eye	1
Phasianidae	*Pternistis bicalcaratus*	Double-spurred francolin	2
Hirundinidae	*Hirundo aethiopica*	Ethiopian swallow	42
Sturnidae	*Sturnia malabarica*	Forest chestnut starlin	1
Dicruridae	*Dicrurus adsimilis*	Forked-tailed drongo	2
Phoeniculidae	*Phoeniculus purpureus*	Green wood-hoopoe	1
Cisticolidae	*Camaroptera brevicaudata*	Grey-backed camaroptera	1
Bucerotidae	*Lophoceros nasutus*	Grey hornbill	3
Falconidae	*Falco ardosiaceus*	Grey kestrel	8
Musophagidae	*Crinifer piscator*	Grey plantain-eater	42
Columbidae	*Streptopelia senegalensis*	Laughing dove	196
Apodidae	*Apus affinis*	Little swift	7
Alcedinidae	*Corythornis cristatus*	Malachite kingfisher	1
Hirundinidae	*Cercropis senegalensis*	Mosque swallow	1
Apodidae	*Telacanthura ussheri*	Mottled spine tail	8
Passeridae	*Passer griseus*	Northern grey-headed sparrow	74
Nectarinidae	*Cinnyris chloropygius*	Olive-bellied sunbird	27
Nectarinidae	*Cinnyris jugularis*	Olive sunbird	2
Estrildidae	*Estrilda melpoda*	Orange-cheeked waxbill	2
Corvidae	*Ptilostomus afer*	Piac piac	2
Corvidae	*Corvus albus*	Pied crow	79
Bucerotidae	*Lophoceros fasciatus*	Pied hornbill	1
Motacillidae	*Anthus leucophrys*	Plain-backed pipit	2
Sturnidae	*Lamprotornis purpureus*	Purple Glossy starling	2
Ardeidae	*Ardea purpurea*	Purple heron	1
Alcedinidae	*Ispidina picta*	Pygmy kingfisher	1
Columbidae	*Streptopelia semitorquata*	Red-eyed dove	14
Cisticolidae	*Cisticola erythrops*	Red-faced cisticola	3
Ploceidae	*Malimbus rubricollis*	Red-headed malimbe	1
Hirundinidae	*Ptyonoprogne fuligula*	Rock martin	1
Cuculidae	*Centropus senegalensis*	Senegal coucal	3
Psittacidae	*Poicephalus senegalus*	Senegal parrot	2

(Continues)

TABLE 1 (Continued)

Family	Species	Common name	Abundance
Columbidae	*Columba*	Speckled pigeon	155
Nectarinidae	*Cinnyris coccinigastrus*	Splendid sunbird	5
Charadriidae	*Vanellus spinosus*	Spur-winged lapwing	2
Nectarinidae	*Cinnyris superbus*	Superb sunbird	1
Cisticolidae	*Prinia subflava*	Tawny-flanked prinia	1
Ploceidae	*Ploceus cucullatus*	Village weaver	18
Meropidae	*Merops albicollis*	White-throated bee-eater	2
Alcedinidae	*Halcyon senegalensis*	Woodland kingfisher	10
Accipitridae	*Milvus aegyptius*	Yellow-billed kite	190
Laniidae	*Corvinella corvina*	Yellow-billed shrike	6

TABLE 2 Relationship between bird species richness, foraging guild richness and habitat variables based on general linear models. The full starting models and final models are shown.

	Bird species richness (log10 transformed)					
	Full model			Final model		
	(R^2 adjusted = 0.17)			(R^2 adjusted = 0.18)		
Coefficient	Estimates	Conf. Int (95%)	*p*-Value	Estimates	Conf. Int (95%)	*p*-Value
Intercept	0.89	0.79 – 0.99	<0.001	0.94	0.87–1.01	<0.001
Number of buildings	0.00	−0.00 – 0.01	0.389			
Number of trees	0.02	−0.00 – 0.04	0.053	0.02	0.01–0.03	0.007
Number of telecom mast	0.02	−0.08 – 0.11	0.728			
Ground cover (%)	0.00	−0.00 – 0.00	0.144			
Canopy cover (%)	−0.00	−0.00 – 0.00	0.735			
Number of pedestrians	−0.01	−0.01 – −0.00	0.030	−0.01	−0.01 to −0.00	0.019
	Foraging guild richness					
	Full model			**Final model**		
	(R^2 adjusted = 0.09)			**(R^2 adjusted = 0.15)**		
Coefficient	**Estimates**	**Conf. Int (95%)**	***p*-Value**	**Estimates**	**Conf. Int (95%)**	***p*-Value**
Intercept	0.68	0.62 – 0.75	<0.001	0.70	0.67–0.73	<0.001
Number of buildings	0.00	−0.00 – 0.01	0.807			
Number of trees	0.00	−0.01 – 0.01	0.940			
Number of telecom mast	0.02	−0.04 – 0.08	0.532			
Ground cover (%)	0.00	−0.00 – 0.00	0.736			
Canopy cover (%)	0.00	−0.00 – 0.00	0.713			
Number of pedestrians	−0.01	−0.01 – −0.00	0.003	−0.01	−0.01 to −0.00	0.001

3.2 | Foraging guilds

The number of individual birds within the different foraging guilds differed significantly (Kruskal–Wallis: $\chi^2 = 185.3$, df = 6, $p < 0.001$, Figure 4, Table 3). On average, granivores and scavengers were the two most abundant guilds (mean = 30.6 and 14.5, respectively). The insectivore guild was however the most species rich (27 species) followed by granivore (9 species) and frugivore (7 species), whereas scavenger was the least (2 species). Across the areas, foraging guild richness ranged from 2 to 6 in the grids surveyed. Foraging guild richness declined significantly with an increase in the number of pedestrians ($p < 0.001$, Figure 5).

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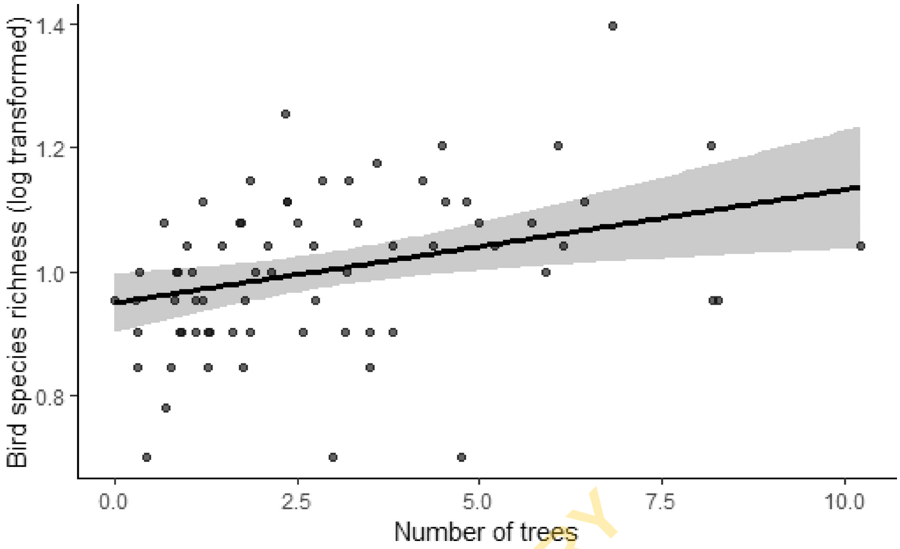

FIGURE 2 Predicted relationship between bird species richness and number of trees based on the best model (Table 2) which retained numbers of trees and pedestrians as significant predictors of bird richness.

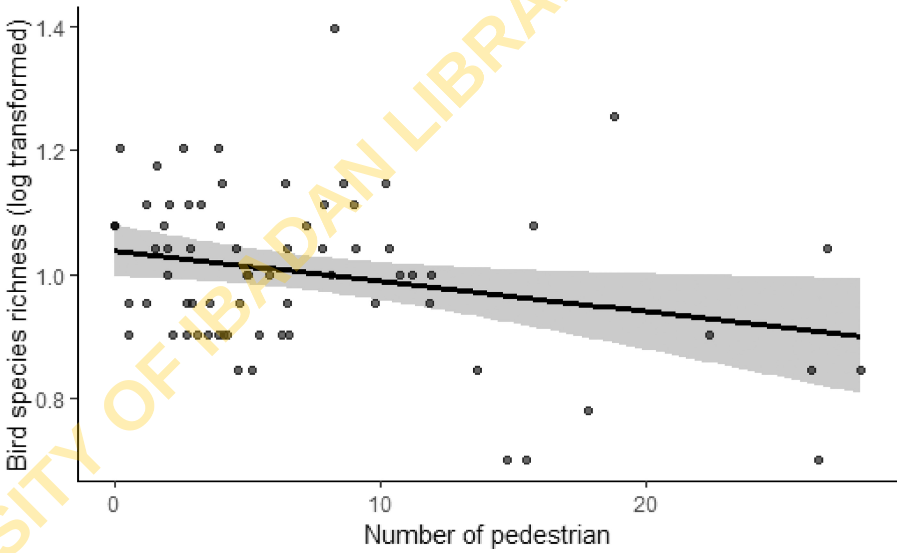

FIGURE 3 Predicted relationship between bird species richness and number of pedestrians based on the best model (Table 2) which retained numbers of trees and pedestrians as significant predictors of bird richness.

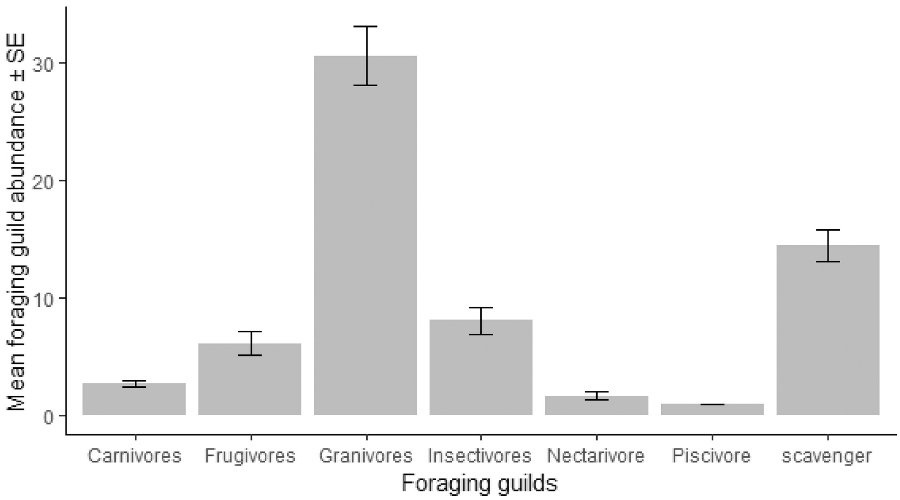

FIGURE 4 Mean abundance of foraging guilds of birds recorded across Ibadan metropolis.

4 | DISCUSSION

This study examined the bird composition and richness in a West African city, and expectedly, bird composition consisted of a high abundance of a relatively few species, mostly the laughing dove, speckled pigeon and Yellow-billed kite. This pattern of dominance of a few species has been well documented in urban settings (Lepczyk et al., 2017). These dominant species have become

TABLE 3 Output of analysis of variance test of foraging guild richness, species richness and bird abundance between the five urban areas.

Response variable		df	Sum Sq	Mean Sq	F value	Pr (>F)
Foraging guild richness	Area	4	3.02	0.75	1.11	0.358
	Residuals	65	44.07	0.68		
Species richness	Area	4	74.44	18.61	1.79	0.142
	Residuals	65	677.05	10.42		
Bird abundance	Area	4	4774.00	1193.38	1.23	0.307
	Residuals	65	63066.00	970.24		

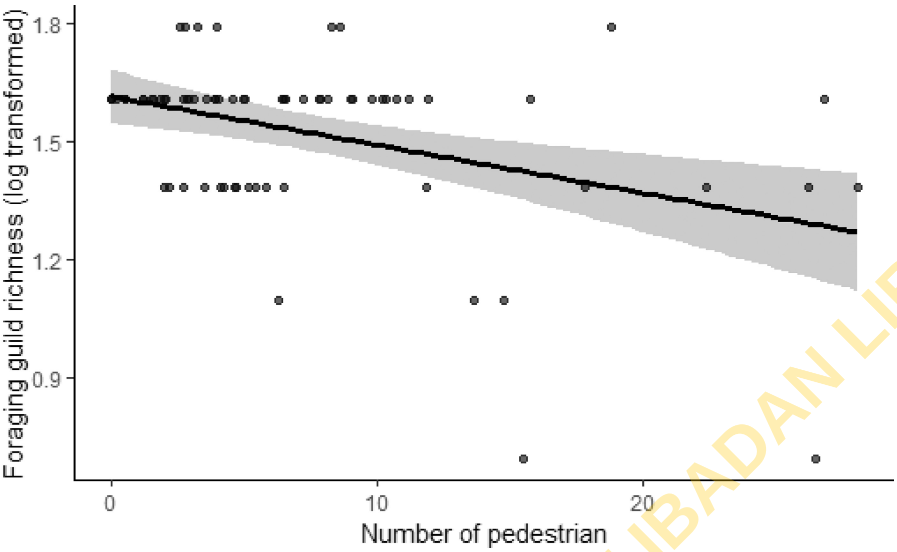

FIGURE 5 Predicted relationship between foraging guild richness and number of pedestrians based on the best mode (Table 2).

well adapted to towns and cities due to their broad dietary niche and habitat generalism, being capable of feeding on a wide range of food resources (generalist) and exploiting different habitats and artificial structures in the urban landscape (Baptista et al., 2022; Callaghan et al., 2019; David et al., 2021; Moura et al., 2023; Neate-Clegg et al., 2023). Similarly, the family Columbidae was the most abundant of all bird families recorded in the study area. Their dominance may be attributed to their generalist feeding habits, capacity to utilise ledges of buildings and telecommunication towers as nesting sites (Savard et al., 2000) and tolerance to human presence (Suárez-Rodríguez et al., 2023) all of which have contributed to their success in urban settings. Many Columbidae species are granivores (seed eaters) and so can exploit anthropogenic food sources like discarded food scraps (Mckinney, 2006), ornamental plants and even agricultural crops found in urban areas. This dietary flexibility allows them to find sustenance and maintain a high population in a variety of urban habitats.

Bird species richness in the study area increased with tree abundance in line with our hypothesis. Generally, tree abundance and vegetation complexity have been shown to positively influence bird richness via the provision of food, perching, nesting and roosting resources required for supporting a diverse group of species (Evans et al., 2009; Mayorga et al., 2020; Ortega-Álvarez & MacGregor-Fors, 2009). Urban greening through tree planting and the establishment of green spaces are a common practice in many urban centres, and these landscape features contribute to urban avian diversity by serving as wildlife refuges (MacGregor-Fors et al., 2016). Furthermore, birds living in urban areas are subjected to a wide range of anthropogenic disturbances, ranging from physical disturbances from vehicular and pedestrian traffic to auditory disturbances from noise generated by machinery and vehicular traffic. Urban-adapted species often show increased tolerance for human and vehicular traffic, an adaptive trait for thriving in the urban environment (e.g. Gravolin et al., 2014) although this may be limited to species that have become habituated (Lowry et al., 2013). We report that bird richness was negatively related to pedestrian traffic as have been reported in previous studies (Iwajomo et al., 2018; Kumdet et al., 2021), possibly reflecting the sensitivity of some of the bird species to human disturbances. High pedestrian movement can elicit antipredator behaviours such as fleeing in bird species, resulting in the loss of foraging or breeding opportunities (Tryjanowski et al., 2020; Ydenberg & Dill, 1986). Areas with high pedestrian traffic were associated with fewer trees and so were more likely to support fewer species because they offer limited foraging opportunities or cover from potential predators. This likely explains why foraging guild richness was negatively related to the number of pedestrians, thus suggesting that areas with high human activities and consequently pedestrian movement were dominated by fewer species belonging to few foraging guilds and which have become habituated to human presence or are capable of exploiting areas with fewer vegetation cover. The responses of bird species and foraging guild richness to pedestrian abundance are thus not surprising given the estimated population density of 2889 people per square kilometre documented for Ibadan: one of the highest in Nigeria (NPC, 2006).

5 | CONCLUSIONS

The results of this study offer valuable insights into the interplay between habitat variables and bird populations within urban environments. It underscores the need for thoughtful urban planning that balances development with the preservation of essential habitat elements, such as trees, while vegetated areas are buffered from the effect of human disturbance. Although Ibadan metropolis supports a rich diversity of bird species, the increasing pressure on the remaining natural vegetation by human-related development will create conditions that lead to a reduction in diversity but favouring only a few widespread, adaptable species.

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CONFLICT OF INTEREST STATEMENT

The author declares no potential conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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