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Seasonal abundance and habitat use by birds in Kano, Nigeria

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Abstract

Robust environmental data is a prerequisite to curtailing the current environmental degradation. Understanding species-habitat interactions and species' response to habitat and seasonal changes is necessary, considering the degradation in the quality and quantity of native habitats. Moreover, assessing the interaction between birds and their habitats is essential in regions like Kano, Nigeria that are subjected to extensive land degradation. During this study, the avian species composition and seasonal variation in abundance and richness in four habitats (farmland, shrubland, wetland, and suburban) were assessed. The line transect sampling method was used to count birds across the wet and dry seasons from 2018 to 2019. Species richness and abundance varied considerably across seasons and habitats. Species abundance was highest in the wetland, while the shrubland had the highest species richness. Environmental factors had significant effects on species abundance and richness. The results indicated that habitat is more important in predicting species composition than season, and there was significant interaction between habitat and season in explaining species abundance and richness. This study highlights the significance of the shrubland and wetland as hotspots for avian biodiversity. Therefore, there is need to prioritise these sites in the course of conservation action by the concerned authority.

Introduction

In recent times, there has been a rapid change in the environment (Blackburn *et al* 2024) and information portraying changes in avian communities over time is crucial (Tinoco *et al* 2021). Robust environmental data are a prerequisite to curtailing the present environmental degradation. Moreover, understanding species-habitat interactions and species response to habitat changes is necessary with the degradation in quality and quantity of native habitats (Cooper *et al* 2020). It is also important for the purpose of biodiversity conservation (Foysal and Panter 2024). Yet, lack of expertise, support and investment in biodiversity monitoring have resulted in the scarcity of such vital information in African nations like Nigeria (Wotton *et al* 2020).

Although numerous studies have assessed how species respond to environmental factors (Shochat *et al* 2010; Ndang'ang'a *et al* 2013; Girma *et al* 2017; Muhammad *et al* 2018; Lerm *et al* 2023; Adegbola *et al* 2024), species-habitat associations are not spatially consistent and variation exists at a regional scale (Bonthoux *et al* 2017) and even at landscape scale (Awoyemi *et al* 2024). Furthermore, land use intensification is on the rise in West African savannas (Leßmeister *et al* 2019) which threatens avian biodiversity (Afrifa *et al* 2023).

To this end, it is crucial to look into avian population dynamics and their habitat associations, especially in regions like Nigeria, where urbanisation (Awoyemi *et al* 2024) and agricultural intensification (Magaji and Rabiu 2024) are increasing rapidly. This is because recent studies reiterate that land cover change is the main cause of loss and extinction of biodiversity (e.g. Ali *et al* 2022; Griffith *et al* 2022; Garcia-R *et al* 2024). Knowledge of species population changes is a basic component of numerous conservation efforts (Schnelle *et al* 2024), likewise assessing the relationship between birds and their habitats (Lee and Marsden 2008). It is also essential in describing and predicting their response to environmental changes (Ivande and Cresswell 2016). Most importantly, knowledge of bird habitat use and seasonal abundance is key for monitoring species of conservation concern (Girma *et al* 2017).

Here, the composition, richness and abundance of avian species were investigated in different habitats in Kano, Nigeria, and also the seasonal variation in the abundance and richness of birds in these habitats. It is anticipated that species diversity will vary among the habitats as a result of habitat heterogeneity and seasonal changes.

Materials and methods

Study area and design

Kano is the largest city in Northern Nigeria (Barau *et al* 2015), located between 11.25°N – 12.47°N latitude and 8.22°E – 8.39°E longitude as shown in Figure 1. The vegetation of Kano is the semi-arid Sudan Savanna type (Mustapha *et al* 2014) with a tropical wet and dry climate. The long dry season starts from November to

March, while the wet season lasts from May to September with a peak in August, and a mean annual rainfall of 897.7mm (Mohammed *et al* 2015). The temperature usually ranges between a minimum of 15.8°C and a maximum of 33°C, although sometimes during the harmattan around December/January, temperature can be as low as 10°C (Bernadette *et al* 2014).

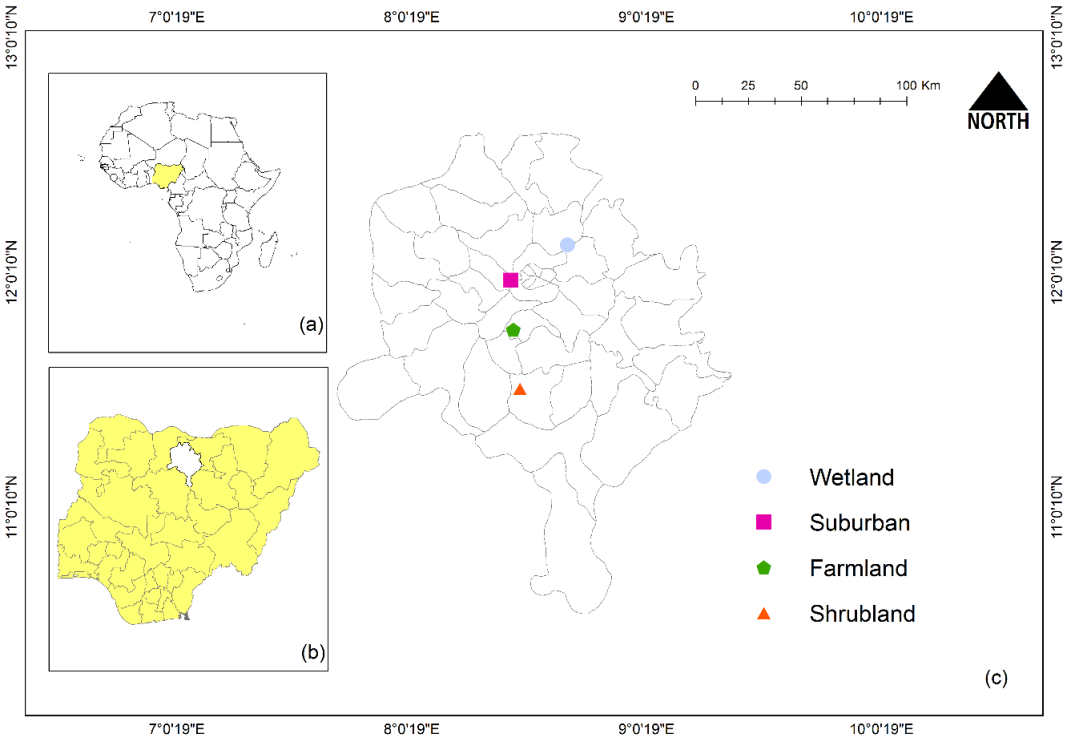

Figure 1. The study area showing the four study sites within Kano with insert of maps of (a) Africa and (b) Nigeria

Four study locations were selected with varying habitat features, and were named accordingly as wetland (Wasai 12.136°N, 8.692°E), suburban (Bayero University, Kano new Campus 11.972°N, 8.425°E), farmland (Kura 11.760°N, 8.438°E) and shrubland (Mariga 11.508°N, 8.473°E). The wetland is a reservoir built for irrigation and recreational uses. It is also utilized for fishing, thereby serving as a source of livelihood. Bayero University, new campus located within the metropolis is the suburban habitat. The tree species within the campus are mostly exotic, and the dominant ones are *Azadirachta indica* and *Eucalyptus camaldulensis*. The farmland comprises irrigated rice fields that are cultivated throughout the year. A mixed cropping system with vegetables and cereal crops is sometimes practiced. Lastly, the shrubland habitat is a mosaic of shrubs, trees, thickets, farmlands, as well as flowing water channels, but shrubs were the dominant habitat feature. Thirty five line transects (400-1000m in length) were randomly placed across the habitats as described by Manu *et al* (2010). A total length of 21km was covered across the habitats. Differences in transect length was due to variations in the terrain of the study sites. Transects were divided into 200m sections, the start and end points of these divisions were marked with a GPS.

Sampling protocol

The bird count was carried out using line transects (Lee and Marsden 2008). Surveys were carried out between 07:00 and 10:00 hours (Hulme and Cresswell 2012) and birds seen, heard, or in flight were recorded. A pair of binoculars was used for viewing distant birds and a field guide (Borrow and Demey 2014) was used for the identification of species. The percentage ground and grass cover were visually estimated to the nearest 5% (Manu *et al* 2010) and the number of shrubs, small trees, and large trees were counted by selecting four random plots of $20m^2$ in each 200m section of the transects (Hulme 2007).

A single observer (ASM) carried out all surveys throughout the period of data collection for consistency. Transects were conducted only on non-windy and dry (non-rainy) days. Sampling was carried out six times from February 2018 to January 2019, three times in the dry season period (November-April) and three times in the wet season period (May-October).

Data analyses

The IUCN red list of threatened species (IUCN 2022) was used to classify the species according to conservation status. All analyses were carried out in *R* statistical software (R Core Team 2024). Species abundance for each transect section was obtained by adding the total number of birds seen or heard per section, and species richness (i.e. number of individual species) was also determined for each section. The environmental variables were checked for possible multicollinearity using Spearman's correlation coefficient and Variance inflation factor (VIF) with the R package "car" (Fox *et al* 2024). The variables (ground

cover, grass cover, shrubs, small trees, and large trees) had VIF values less than 2, indicating very low multicollinearity (Zuur *et al* 2010), and thus were all included in our models. We also standardised our independent numerical variables using the "scale" function.

To determine the interactive effect of habitat and season on bird species abundance and richness, we used generalised linear mixed models (GLMMs) assuming Poisson distribution with the "glmer" function from the "lme4 package" (Bates *et al* 2024). Transect, section and repeated samplings were used as random effects in the models. The relative importance of the predictor variables was ascertained using the "glmm.hp" package (Lai *et al* 2022; Lai *et al* 2023).

Models with environmental variables used as predictors were also generated in order to investigate their potential effects on the interaction. Automatic stepwise backward selection was applied to select environmental variables that best explain the variation in the response variables with the function "regsubsets" from the "leaps" package (McGibney 2023; Lumley 2024). The selection was based on R^2 as an important statistical parameter for measuring model fitness (Nakagawa *et al* 2017). The potential models were compared using the "MuMIn" package (Bernat-Ponce *et al* 2022) to select the best based on the Lowest Second Order Akaike Information Criterion (AICc).

Results

Bird species composition, abundance and richness

A total of 168 species belonging to 64 families were recorded (Table 1), out of which 131 (78%) were resident species, eight (5%) were intra-African migrants, and 29 (17%) were Palaerctic migrants. Species abundance was highest in the wetland and lowest in the shrubland, while species richness was highest in the shrubland (73%), then wetland (61%), and lowest in the farmland (39%). In all the habitats, species richness was higher during the dry season (Table 2).

Seasonal variation in species abundance and richness within the habitat types

There was a significant seasonal variation in species abundance within the habitats (Figure 2a), likewise species richness (Figure 2b). Furthermore, the results revealed that habitat is more significant in accounting for the differences recorded in the interactive effect of habitat and season on species abundance and richness (Table 3)

Relationship between environmental variables and bird species abundance and richness

There were significant interactive effects, both positive (+) and negative (-) of habitat, season, and environmental variables on bird species abundance and richness (Table 4). All the environmental predictors were significantly associated with bird species abundance positively (Ground cover: Estimate ± SE=0.03±0.01, Z=3.10, p=0.002; Shrubs: Estimate ± SE = 0.09 ± 0.01, Z=13.78, p<0.001; Large trees: Estimate ± SE =0.03± 0.01, Z=3.30, p=0.001) or otherwise (Grass cover: Estimate ± SE=-0.15±0.01, Z=-12.59, p<0.001; Small trees: Estimate ± SE=-0.12±0.01, Z=-14.72, p < 0.001). On the other hand, bird species richness was only significantly influenced (positively) by shrubs (Estimate ± SE = 0.07 ± 0.02, Z=4.40, p<0.001).

Table 1: Checklist of birds recorded, indicating species that were common to the four habitats, and those that were unique to specific habitats

Family	Scientific Name	English Name	Habitat			
			Shrubland	Farmland	Wetland	Suburban
Accipitridae	*Accipiter badius*	Shikra	-	-	✓	✓
	Circus aeruginosus	Western Marsh Harrier	✓	✓	✓	-
	Circus macrourus	Pallid Harrier	✓	-	-	-
	Elanus caeruleus	Black-shouldered Kite	✓	✓	✓	✓
	Kaupifalco monogrammicus	Lizard Buzzard	-	-	-	✓
	Melierax metabates	Dark Chanting Goshawk	-	✓	✓	-
	Micronisus gabar	Gabar Goshawk	✓	-	-	✓
	Milvus migrans	Black Kite	-	-	✓	-
	Milvus aegyptius parasitus	Yellow-billed Kite	✓	✓	✓	✓
Falconidae	*Falco alopex*	Fox Kestrel	-	-	-	✓
	Falco ardosiaceus	Grey Kestrel	✓	✓	✓	✓
	Falco chicquera	Red-necked Falcon	✓	✓	✓	✓
	Falco naumanni	Lesser Kestrel	-	✓	✓	✓
	Falco tinnunculus	Common Kestrel	✓	✓	✓	✓
Charadriidae	*Charadrius dubius*	Little-ringed Plover	-	-	✓	-
	Charadrius pecuarius	Kittlitz's Plover	-	-	✓	-
	Vanellus spinosus	Spur-winged Lapwing	✓	✓	✓	✓
	Vanellus tectus	Black-headed Lapwing	✓	✓	✓	✓
Glareolidae	*Cursorius temminckii*	Temminck's Courser	-	✓	-	-
Laridae	*Chlidonias leucopterus*	White-winged Tern	-	-	✓	-
	Gelochelidon nilotica	Gull-billed Tern	-	-	✓	-
Rostratulidae	*Rostratula benghalensis*	Greater Painted-Snipe	-	✓	-	-

Family	Scientific Name	English Name	Habitat			
			Shrubland	Farmland	Wetland	Suburban
Scolopacidae	*Actitis hypoleucos*	Common Sandpiper	✓	-	✓	-
	Calidris pugnax	Ruff	-	-	✓	-
	Tringa glareola	Wood Sandpiper	-	✓	✓	-
	Tringa ochropus	Green Sandpiper	-	-	✓	✓
Strigidae	*Bubo cinerascens*	Greyish Eagle Owl	-	-	-	✓
	Glaucidium perlatum	Pearl-spotted Owlet	-	-	-	✓
Tytonidae	*Tyto alba*	Barn Owl	✓	-	-	✓
Anatidae	*Dendrocygna viduata*	White-faced Whistling Duck	✓	✓	✓	✓
	Plectropterus gambensis	Spur-winged Goose	-	-	✓	-
	Sarkidiornis melanotos	Knob-billed Duck	-	-	✓	-
Acrocephalidae	*Acrocephalus scirpaceus*	European Reed Warbler	✓	-	✓	✓
	Hippolais polyglotta	Melodious Warbler	-	-	✓	-
Alaudidae	*Eremopterix leucotis*	Chesnut-backed Sparrow Lark	✓	✓	-	-
	Galerida cristata	Crested Lark	✓	✓	✓	✓
Cisticolidae	*Camaroptera brachyura*	Grey-backed Camaroptera	✓	✓	✓	✓
	Cisticola brachypterus	Short-winged Cisticola	✓	-	-	-
	Cisticola cantans	Singing Cisticola	✓	-	✓	✓
	Cisticola galactotes	Winding Cisticola	✓	✓	✓	-
	Cisticola juncidis	Zitting Cisticola	✓	✓	✓	✓
	Prinia subflava	Tawny-flanked Prinia	✓	-	✓	✓
Dicruridae	*Dicrurus adsimilis*	Fork-tailed Drongo	✓	-	-	✓
Emberizidae	*Emberiza flaviventris*	Golden-breasted Bunting	✓	-	-	-
	Emberiza tahapisi	Cinnamon-breasted Rock Bunting	✓	-	✓	-
Estrildidae	*Amadina fasciata*	Cut-throat Finch	-	-	-	✓
	Amandava subflava	Zebra Waxbill	✓	-	-	-
	Estrilda caerulescens	Lavender Waxbill	✓	-	-	-
	Estrilda troglodytes	Black-rumped Waxbill	✓	-	✓	✓
	Euodice cantans	African Silverbill	✓	✓	✓	✓
	Lagonosticta senegala	Red-billed Firefinch	✓	✓	✓	✓
	Pytilia melba	Green-winged Pytilia	✓	-	-	-
	Spermestes cucullata	Bronze Mannikin	-	✓	-	-
	Uraeginthus bengalus	Red-cheeked Cordon-bleu	✓	✓	✓	✓
Fringillidae	*Crithagra leucopygia*	White-rumped Seedeater	✓	-	✓	✓
Hirundinidae	*Hirundo aethiopica*	Ethiopian Swallow	✓	✓	✓	✓
	Riparia riparia	Common Sand Martin	✓	-	-	-
Indicatoridae	*Indicator indicator*	Greater Honeyguide	✓	-	-	✓
Laniidae	*Corvinella corvina*	Yellow-billed Shrike	✓	✓	✓	✓
Locustellidae	*Acrocephalus arundinaceus*	Great Reed Warbler	✓	-	-	✓
	Acrocephalus schoenobaenus	Sedge Warbler	✓	-	✓	-
Macrosphenidae	*Sylvietta brachyura*	Northern Crombec	✓	-	-	-
Malaconotidae	*Laniarius barbarus*	Yellow-crowned Gonolek	✓	✓	✓	✓
	Malaconotus blanchoti	Grey-headed Bush-shrike	-	-	-	✓
	Tchagra senegalus	Black-crowned Tchagra	✓	-	-	✓
Monarchidae	*Terpsiphone viridis*	African Paradise Flycatcher	✓	-	-	-
Motacillidae	*Anthus campestris*	Tawny Pipit	✓	-	-	-
	Motacilla alba	White Wagtail	-	-	✓	-
	Motacilla flava	Yellow Wagtail	✓	✓	✓	✓
Muscicapinae	*Bradornis pallidus*	Pale Flycatcher	✓	-	✓	-
	Melaenornis edolioides	Northern Black Flycatcher	✓	-	-	-
Muscicapidae	*Cercotrichas galactotes*	Rufous Scrub Robin	✓	-	-	-
	Oenanthe oenanthe	Northern Wheatear	✓	✓	-	✓
	Phoenicurus phoenicurus	Common Redstart	-	-	-	✓
Musophagidae	*Crinifer piscator*	Western Grey Plantain-eater	✓	-	✓	✓
Oriolidae	*Oriolus auratus*	African Golden Oriole	✓	-	-	✓
Passeridae	*Passer griseus*	Northern Grey-headed Sparrow	✓	✓	✓	✓

Family	Scientific Name	English Name	Habitat			
			Shrubland	Farmland	Wetland	Suburban
Phylloscopidae	*Phylloscopus trochilus*	Willow Warbler	✓	✓	-	-
Ploceidae	*Bubalornis albirostris*	White-billed Buffalo Weaver	✓	✓	✓	✓
	Euplectes afer	Yellow-crowned Bishop	✓	✓	-	-
	Euplectes franciscanus	Northern Red Bishop	✓	✓	✓	✓
	Ploceus cucullatus	Village Weaver	✓	✓	✓	✓
	Ploceus luteolus	Little Weaver	✓	✓	✓	✓
	Ploceus vitellinus	Vitelline Masked Weaver	✓	-	✓	✓
	Quelea quelea	Red-billed Quelea	✓	✓	✓	✓
	Sporopipes frontalis	Speckle-fronted Weaver	✓	-	-	✓
Pycnonotidae	*Pycnonotus barbatus*	Common Bulbul	✓	✓	✓	✓
Ramphastidae	*Pogoniulus chrysoconus*	Yellow-fronted Tinkerbird	✓	-	-	✓
	Pogonornis dubius	Bearded Barbet	✓	-	-	✓
Recurvirostridae	*Himantopus himantopus*	Black-winged Stilt	-	✓	✓	-
Remizidae	*Anthoscopus parvulus*	Yellow Penduline Tit	✓	-	-	-
Sturnidae	*Lamprotornis caudatus*	Long-tailed Glossy Starling	✓	✓	✓	✓
	Lamprotornis chalybaeus	Greater Blue-eared Starling	-	-	✓	✓
	Lamprotornis chloropterus	Lesser Blue-eared Starling	-	-	-	✓
	Lamprotornis pulcher	Chesnut-bellied Starling	✓	✓	✓	✓
	Lamprotornis purpureus	Purple Glossy Starling	-	-	-	✓
Sylviidae	*Eremomela icteropygialis*	Yellow-billed Eremomela	-	-	-	✓
	Eremomela pusilla	Senegal Eremomela	✓	-	-	-
	Sylvia borin	Garden Warbler	-	-	-	✓
	Sylvia Communis	Common Whitethroat	✓	-	-	✓
Timaliidae	*Turdoides plebejus*	Brown Babbler	✓	✓	✓	✓
Turdidae	*Turdus pelios*	African Thrush	✓	-	✓	✓
Viduidae	*Anomalospiza imberbis*	Cuckoo Finch	✓	-	-	-
	Vidua chalybeata	Village Indigobird	✓	-	✓	✓
	Vidua macroura	Pin-tailed Whydah	✓	-	✓	✓
	Vidua orientalis	Sahel Paradise Whydah	✓	-	-	-
Buphagidae	*Buphagus africanus*	Yellow-billed Oxpecker	✓	-	✓	-
Columbidae	*Columba guinea*	Speckled Pigeon	✓	✓	✓	✓
	Oena capensis	Namaqua Dove	✓	-	-	✓
	Streptopelia decipiens	African Mourning Dove	✓	-	-	-
	Streptopelia senegalensis	Laughing Dove	✓	✓	✓	✓
	Streptopelia turtur	European Turtle Dove	✓	-	-	-
	Streptopelia vinacea	Vinaceous Dove	✓	-	✓	✓
	Treron waalia	Bruce's Green Pigeon	✓	-	-	-
	Turtur abyssinicus	Black-billed Wood Dove	✓	-	✓	✓
Alcedinidae	*Ceryle rudis*	Pied Kingfisher	✓	-	✓	-
	Corythornis cristatus	Malachite Kingfisher	✓	-	-	-
	Halcyon leucocephala	Grey-headed Kingfisher	✓	-	✓	✓
Bucerotidae	*Tockus erythrorhynchus*	Northern Red-billed Hornbill	✓	-	✓	✓
	Tockus nasutus	African Grey Hornbill	✓	✓	✓	✓
Coraciidae	*Coracias abyssinicus*	Abyssinian Roller	✓	✓	✓	✓
	Coracias naevius	Rufous-crowned Roller	✓	-	✓	✓
Meropidae	*Merops bulocki*	Red-throated Bee-eater	✓	-	-	-
	Merops pusillus	Little Bee-eater	✓	-	-	-
Phoeniculidae	*Phoeniculus purpureus*	Green Wood-hoopoe	✓	-	✓	✓
Upupidae	*Upupa epops*	Hoopoe	-	-	-	✓
Apodidae	*Apus affinis*	Little Swift	✓	✓	✓	✓
	Cypsiurus parvus	African Palm Swift	✓	✓	✓	✓
Nectariniidae	*Anthodiaeta platura*	Pygmy Sunbird	✓	-	✓	✓
	Chalcomitra senegalensis	Scarlet-chested Sunbird	✓	-	✓	✓
	Cinnyris cupreus	Copper Sunbird	-	-	✓	-
	Cinnyris pulchellus	Beautiful Sunbird	✓	-	✓	✓
	Cinnyris venustus	Variable Sunbird	✓	-	-	✓
Ardeidae	*Ardea cinerea*	Grey Heron	✓	✓	✓	✓

Family	Scientific Name	English Name	Habitat			
			Shrubland	Farmland	Wetland	Suburban
	Ardea intermedia	Intermediate Egret	✓	✓	✓	-
	Ardea melanocephala	Black-headed Heron	-	✓	✓	-
	Ardea purpurea	Purple Heron	✓	✓	✓	-
	Ardeola ralloides	Squacco Heron	✓	✓	✓	✓
	Bubulcus ibis	Cattle Egret	✓	✓	✓	✓
	Butorides striata	Green-backed Heron	✓	✓	✓	✓
	Egretta ardesiaca	Black Heron	-	-	✓	-
	Egretta garzetta	Little Egret	✓	✓	✓	✓
	Ixobrychus minutus	Little Bittern	-	✓	-	-
	Ixobrychus sturmii	Dwarf Bittern	✓	✓	-	-
	Nycticorax nycticorax	Black-crowned Night Heron	✓	-	-	-
Phalacrocoracidae	*Microcarbo africanus*	Long-tailed Cormorant	✓	✓	✓	✓
Scopidae	*Scopus umbretta*	Hamerkop	-	-	✓	-
Threskiornithidae	*Bostrychia hagedash*	Hadada Ibis	-	-	✓	-
	Plegadis falcinellus	Glossy Ibis	-	-	✓	-
Picidae	*Campethera punctuligera*	Fine-spotted Woodpecker	-	-	-	✓
	Mesopicos goertae	Grey Woodpecker	-	-	-	✓
Corvidae	*Corvus albus*	Pied Crow	✓	-	✓	✓
	Ptilostomus afer	Piapiac	-	✓	✓	✓
Cuculidae	*Centropus senegalensis*	Senegal Coucal	✓	✓	✓	✓
	Chrysococcyx klaas	Klaas's Cuckoo	✓	-	-	-
	Clamator jacobinus	Jacobin Cuckoo	✓	-	-	✓
	Cuculus clamosus	Black Cuckoo	✓	-	-	-
	Cuculus gularis	African Cuckoo	✓	-	-	✓
Psittacidae	*Poicephalus senegalus*	Senegal Parrot	-	-	✓	✓
Psittaculidae	*Psittacula krameri*	Rose-ringed Parakeet	✓	✓	✓	✓
Odontophoridae	*Ptilopachus petrosus*	Stone Partridge	✓	-	-	-
Phasianidae	*Pternistis bicalcaratus*	Double-spurred Francolin	-	-	-	✓
Jacanidae	*Actophilornis africanus*	African Jacana	✓	✓	✓	-
Rallidae	*Crex egregia*	African Crake	-	✓	✓	-
	Gallinula angulata	Lesser Moorhen	-	✓	-	-
	Gallinula chloropus	Common Moorhen	✓	✓	✓	-
	Porphyrio alleni	Allen's Gallinule	✓	-	✓	-
	Zapornia flavirostra	Black Crake	✓	✓	✓	-

✓ = recorded, - = not recorded

Table 2: Variation in bird species encounter rate and richness recorded across habitats and seasons in Kano-Nigeria, February 2018-January 2019

	Species encounter rate			Species richness		
Habitat	Overall	Dry season	Wet season	Overall	Dry season	Wet season
Farmland	13058	6606	6452	66	57	43
Shrubland	11241	5003	6238	122	100	92
Suburban	12755	5434	7321	99	82	75
Wetland	13528	8716	4812	102	83	76

Discussion

The high number of species (168) recorded in the study area implies that Kano, Nigeria, has appreciable species diversity. A study reported similar bird species diversity in the Dutse area of Jigawa, west of Kano (Muhammad *et al* 2018). It is important to note that the shrubland had the highest species richness, and many species were unique to this habitat. In addition, two migratory species recorded are of conservation concern. These are the European Turtle Dove (*Streptopelia turtur*) and Pallid Harrier (*Circus macrourus*), classified as vulnerable and near threatened, respectively (IUCN 2022). The European Turtle Dove (*Streptopelia turtur*) is strongly affected by nature and quality of habitat (Aitouakli and Bensaci 2021). Moreover, habitats with high tree density, shrubs and hedgerows are suitable for this species (Chiatante *et al* 2020).

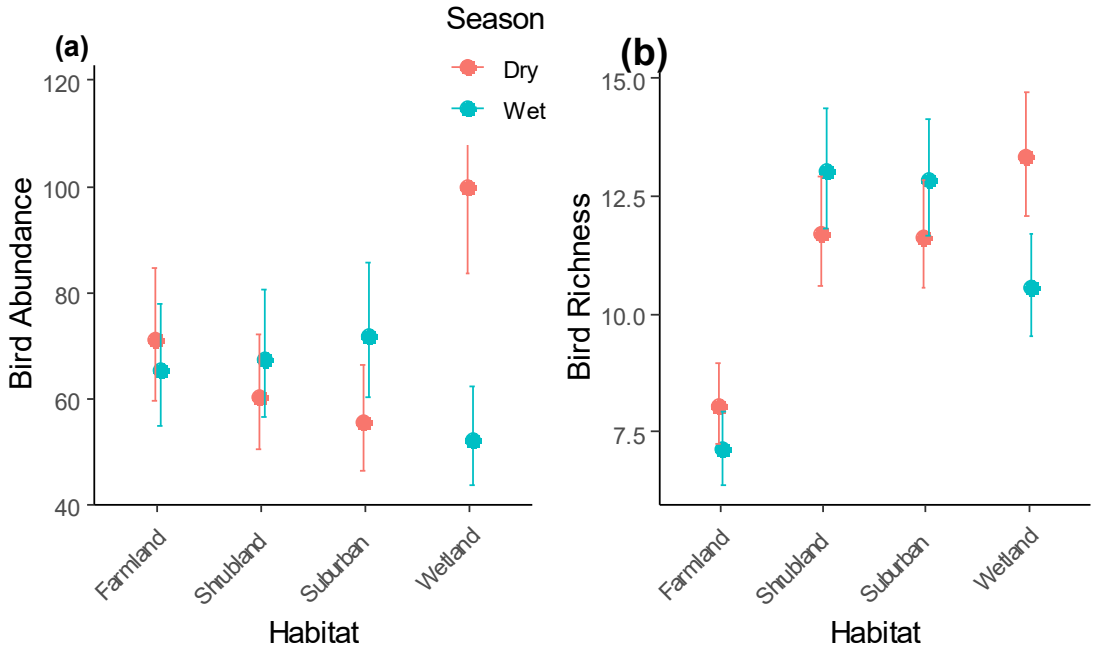

Figure 2. Interaction of habitat and season in predicting bird species abundance and richness in Kano, Nigeria

Table 3: Relative importance of individual variables in predicting bird species abundance and richness

Variable	Species Abundance				Species Richness			
	Unique	Average share	Individual	% contribution	Unique	Average share	Individual	(%) Contribution
Habitat	0.0103	0.0001	0.0104	60.82	0.2818	0.0004	0.2822	99.61
Season	0.0066	0.0001	0.0067	39.18	0.0007	0.0004	0.0011	0.39

Table 4: Associations between environmental variables and bird species abundance and richness across habitats and seasons in Kano, Nigeria

Variables	Abundance	Richness
Shrubland	NA	(+)
Suburban	(-)	(+)
Wetland	(+)	(+)
Wet season	(-)	NA
Grass cover	(-)	NA
Ground cover	(+)	(-)
Shrubs	(+)	(+)
Small trees	(-)	NA
Large trees	(+)	NA

(+) = significant positive association, (-) = significant negative association, NA = no significant association

Species richness in this site might be attributed to the availability of essential microhabitats that provide suitable conditions for species to flourish, and support the coexistence of diverse avifaunal species with different habitat requirements due to niche partitioning. This affords the habitats the ability to accommodate diverse species with reduced rate of competition and enhanced survival rate.

Cooper *et al* (2020) reported that microhabitat structure is a principal factor in ascertaining habitat quality, and the diverse niches within heterogeneous habitats render them greater species diversity than their homogeneous counterparts. Moreover, different natural and semi-natural components in heterogeneous habitats afford them additional resources to sustain a great diversity of species (Lee and Goodale 2018). On the other hand, farmland habitat had the lowest species richness. Farmlands are hotspots for diverse avian species. However, in this study, farmland habitat was the least in terms of bird species richness and abundance. The poor species diversity may be due to three factors.

The farmland site is largely devoid of standing plants, depriving birds nesting and foraging sites. Rice, which is the major crop on the farms, also limits the food variety of birds. Perhaps, the most important factor was disturbances by humans from farming activities. A recent study indicates that farmland diversification promotes greater species abundance and can be achieved with increasing vegetation complexity (Smith *et al* 2022). Certain structures like hedgerows and large trees

determine the occurrence of bird species on farmlands (Bonthoux *et al* 2017). They were shown to be desirable for Palearctic migrants on their wintering ground in northern Nigeria (Jones *et al* 1996).

Regarding species abundance, the wetland had the highest abundance and accommodates several Palearctic migrants, including the Glossy Ibis (*Plegadis falcinellus*), Common Whitethroat (*Sylvia communis*), and Yellow Wagtail (*Motacilla flava*). Studies on birds in the dryland zones of Nigeria's northeast of Gombe, Yobe, and the famous Hadejia-Nguru wetlands also reported remarkable waterbird species diversity (Adang *et al* 2015; Ringim and Muhammad 2017). On the contrary, species abundance was lowest in the shrubland despite being the site with the highest species richness.

Bird species richness and diversity decreased with increasing urbanisation (Vandewalle *et al* 2010) similar to recent studies. This emphasises the negative impact of urbanisation on avian diversity (e.g. Awoyemi *et al* 2024). The suburban habitat was relatively rich in avian species, as 99 bird species were identified, among which 11 were Palearctic migrants, and four were intra-African migrants. They comprised aquatic, terrestrial and farmland species. This might be attributed to the presence of small farms, dense vegetation, and proximity to a water body.

Furthermore, majority of the species recorded were human-commensal species, including Northern grey-headed sparrow (*Passer griseus*), Chestnut-bellied starling (*Lamprotornis pulcher*), and Common bulbul (*Pycnonotus barbatus*). The dominance of human-associated species is attributable to the exotic nature of the vegetation (Shochat *et al* 2010). There were exciting sightings of rare species in this habitat like the Hoopoe (*Upupa epops*), and nocturnal species such as Greyish eagle owl (*Bubo cinerascens*), Barn owl (*Tyto alba*), and Pearl- spotted owlet (*Glaucidium perlatum*). The Barn owl is very common in urban areas (Fergus *et al* 2013), according to Borrow and Demey (2014), it is often found in habitats associated with humans and the Pearl-spotted owlet may be diurnal to some extent. The Speckled pigeon (*Columba guinea*) is another interesting species recorded. Presently, urban habitats are experiencing a decline in the population of this species as a result of constructions and landscaping that caused them to shift to the city outskirts and nearby villages for better nesting and foraging habitats.

It is evident from this study that there is seasonal variation in avian species richness and abundance in Kano, which agrees with previous findings from Nigeria and elsewhere (Girma *et al* 2017; Muhammad *et al* 2018). Some species, like Yellow Wagtail (*Motacilla flava*) and Zebra Waxbill (*Amandava subflava*) were most abundant in the dry season, while others like African Grey Hornbill (*Tockus nasutus*) and Red-billed Quelea (*Quelea quelea*) were most abundant during the wet season. Furthermore, habitat was more influential than season in predicting species abundance and richness, accounting for 60.82% of the variance in the former and 99.61% in the later. Several factors may be responsible for the fluctuation in bird species abundance and richness; among them are migratory and breeding behaviours. Moreover, seasonal changes in the abundance and diversity of birds in the tropics might be as a result of local movements within and among habitats in response to food availability or could arise from long-distance migrants occurring at certain times of the year and absent in others (Mulwa *et al* 2012).

The most abundant species recorded in this study were mostly gregarious species such as Red-billed quelea (*Quelea quelea*), White-faced whistling duck (*Dendrocygna viduata*) and White-billed buffalo weaver (*Bubalornis albirostris*). Others include Palearctic migrants such as the European turtle dove (*Streptopelia turtur*), Gull-billed tern (*Gelochelidon nilotica*), and Ruff (*Calidris pugnax*). Species like the Red-billed quelea (*Quelea quelea*), and the White-faced whistling duck (*Dendrocygna viduata*) are resident species that showed seasonal movements. The former was not recorded during the late wet season while the latter was not recorded in the late dry season. The yellow-billed kite (*Milvus aegyptius parasitus*) also showed seasonal movement as they were not recorded in the middle of wet season.

Conclusion

It has been indicated herein that each habitat has its own distinct bird community. Habitat features have an effect on bird distribution, and habitat selection depends on various factors and also varies with species as well as season. Hopefully, these findings should initiate long-term monitoring of avian biodiversity in the shrubland and wetland, which are considered sites of conservation priority. This is critically needed, considering the fact that the paucity of avian population monitoring is a major hindrance to conservation action in western Africa.

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Conflict of interest

All authors declare no conflict of interest.

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