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Avian community dynamics around a man-made reservoir: Implication for conservation

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Abstract

Reservoirs are characterised by open surface water, surrounding vegetation, and diverse microhabitats that support rich bird communities. However, increasing anthropogenic activities and population growth have led to habitat fragmentation and loss, forcing many bird species to rely on man-made reservoirs. This study assessed bird species richness and abundance around the Ahmadu Bello University (ABU) Reservoir during the dry and wet seasons using point transect surveys. A total of 4,673 individual birds representing 16 orders, 41 families, and 80 species were recorded. Compared with an unpublished 2004 inventory around the ABU Reservoir, both species' richness and abundance increased. Shannon diversity was higher in the dry season (2.36 ± 0.10) than rainy season (2.15 ± 0.08), although the difference was not statistically significant ($p = 0.10$). Total bird abundance was significantly higher in the dry season (78%) than rainy season (22%) ($p < 0.01$). Evening surveys recorded higher encounter rates (55%) than morning surveys (45%), though this difference was not significant ($p = 0.08$). Migratory species, like the Sandpipers, contributed substantially to increased dry-season abundance. These findings highlight reservoirs' role in sustaining bird populations. Improved management is recommended to conserve the ABU Reservoir and its wetlands.

Introduction

Waterbirds help maintain the diversity of other organisms, regulate pest populations, serve as effective bioindicators of ecological conditions, and act as sentinels of potential disease outbreaks (Green *et al* 2014). Bird ecology in reservoirs involves studying avian species and their interactions within the unique habitat provided by these man-made water bodies. Typically created by impounding rivers or streams, reservoirs serve purposes such as water supply, irrigation, and flood control (Mulligans *et al* 2021).

Reservoirs are characterised by open water, surrounding vegetation, and diverse microhabitats that provide resources supporting rich bird communities. The Ahmadu Bello University (ABU) Reservoir and its associated wetlands (Avar-tsue 2004) serve as important habitats for numerous bird species. Many globally threatened birds rely on water bodies (Paracuellos 2006), and reservoirs also function as resting and refueling sites for some migratory species (Singh and Laura 2012).

Therefore, this study was undertaken to evaluate the seasonal dynamics of bird species richness and abundance around the ABU Reservoir and its associated wetlands.

Materials and methods

Study Area

This study was conducted around Kubanni Lake, also known as the ABU Dam, located in Samaru, Zaria, Kaduna State, Nigeria (11°11′ N, 7°38′ E). The Kubanni River was impounded in 1973 to create the reservoir, which measures approximately 800 m in length and includes a concrete section rising 10.38 m above the riverbed (Ologe 1973). The reservoir's catchment area spans 57 km², with a depth of 6 m; during the wet season, the average water level is 644.81 m, while the crest level reaches 646.34 m (Adakole and Abolude 2012). Recent water-quality monitoring using a Reservoir Water Quality Index highlights the environmental status of Kubanni Reservoir, showing that its water quality is influenced by both natural processes and anthropogenic activities in the catchment area (Eneogwe *et al* 2021).

The dominant vegetation of the reservoir area consists of *Polygonium* and *Echinochloa* species. *Typha australis* and *Phragmites* species dominate the shallow parts of the reservoir. Other common trees around the reservoir are *Khaya senegalensis*, *Mangifera indica*, *Albizia lebbeck* and *Azadirachta indica*. Shrubs in the area include *Guiera senegalensis*, *Cassia tora* and *Isoberlina doka* (Avar-tsue 2004).

Survey Method

The point transect method (Lee *et al* 2008) was used to sample birds at 13 points around the reservoir, with each point spaced at least 200 m apart. At every point, observers allowed a 3-minute settling period before conducting a 10-minute stationary observation. These observations were carried out twice daily, once in the morning (06:30–08:30) and once in the evening (16:30–18:30). Surveys were conducted twice weekly over a six-month period in 2018, from March to September, covering the dry season (March–May) and the rainy season (July–September).

During each survey, several variables were recorded, including the date and time of the survey, bird abundance (number of individuals seen), species identified, season, primary foraging site, and the activity of each bird at the time of observation. Actual numbers of each species detected during each sampling period were also documented. For birds that could not be identified immediately, observable physical characteristics were noted and later confirmed using Burrow and Demey (2014).

Birds were categorised into two foraging groups based on their established primary feeding habitats rather than on their temporary behaviour at the reservoir. Aquatic or wetland birds were defined as species that obtain most of their food from aquatic environments (e.g., Common Sandpiper, *Actitis hypoleucos*), while terrestrial birds were those that primarily forage away from water bodies (e.g. Laughing Dove, *Spilopelia senegalensis*). Occasional visits by terrestrial birds to the reservoir for drinking or other minor activities did not alter their classification.

Data analysis

Statistical analysis was carried out using the R statistical software, version 4.1.3. All response variables were subjected to normality test before fitting into any model. Models with few variables which are said to be parsimonious (Daganzo *et al* 2012) were used for analysis.

Species richness and Shannon diversity index were calculated using the BiodiversityR package in R (Roeland and Kindt, 2019).

Generalised Linear Models (GLMs) with a quasi-Poisson error distribution were used to examine the relationship between bird abundance and season and time of day.

In the first model, bird diversity was used as the response variable, with season (rainy/dry) included as the predictor variable. In the second model, bird abundance served as the response variable, while season and time of day were included as predictor variables. For the third and final model, which focused on a subset of birds that primarily foraged in or around the reservoir, bird abundance was the response variable, and season was the predictor variable. All plots were generated from the models built.

Results

A total of 4,673 individual birds were recorded during the study period, comprising 80 species from 41 families and 16 orders (Table 1). Of these, 3,661 individuals were recorded in the dry season and 1,012 in the rainy season, indicating that bird abundance was substantially higher in the dry season (season effect = -0.79, SE=0.16, t = -4.84, $p<0.001$). The three most frequently observed species were the White-faced Whistling Duck, *Dendrocygna viduata* (942 individuals), Long-tailed Glossy Starling, *Lamprotornis caudatus* (423), and Green Sandpiper, *Tringa ochropus* (321), whereas the Zitting Cisticola, *Cisticola juncidis* (5) and Allen's Gallinule, *Porphyrio alleni* (1) were the least abundant.

Species richness was slightly higher in the dry season (68 species) than rainy season (60 species). Shannon diversity was also higher in the dry season (2.36 ± 0.10) compared to the rainy season (2.15 ± 0.08), although this difference was not statistically significant (season effect = -0.21, SE=0.13, t = -1.67, p=0.10).

A total of 1,809 wetland birds were recorded, with 1,646 individuals in the dry season (2.60 ± 0.15) and 163 in the rainy season (1.22±0.47). This difference was statistically significant ($p<0.01$; Figure 2).Time of day did not significantly influence overall bird abundance (Morning vs Evening; t = -1.49, p = 0.14), although more birds were observed in the evenings (2,548 individuals, mean = 1.86 ± 0.10) than in the mornings (2,125 individuals, mean = 1.60±0.11). Migratory species documented included the Black-winged Stilt, *Himantopus himantopus*, White-faced Whistling Duck, *Dendrocygna viduata*, and several sandpipers (Family: Scolopacidae).

Discussion

This study shows that the ABU reservoir and its associated wetlands function as important avifaunal refuges, particularly during the dry season when water becomes scarce. We recorded more bird species (80) and a higher abundance (4,673 individuals) in 2018 compared to the 46 species and 587 individuals reported in the 2004 unpublished study by Aver-Tsue. This difference is unlikely to be due to increases in campus residents, as rising human activity generally drives sensitive species away and favours only a few opportunistic birds. Instead, a plausible explanation is that the reservoir is the only water body within the area that retains water throughout the year, especially during the dry season, thereby attracting and concentrating birds seeking reliable water sources. Although agricultural activities around the reservoir may exert pressure on birds, the reservoir itself experiences comparatively low human disturbance, serving as a haven where birds can forage, drink, and rest. This pattern is consistent with findings by Tanko and Ivande (2009), who reported increased bird species richness and abundance at the ABU Botanical Garden following improved fencing and reduced human interference, further highlighting the importance of low-disturbance habitats in sustaining avian diversity.

Differences in the methodologies employed between the two studies may be the second reason for the variation in species richness and abundance. Variations in survey design, sampling effort, timing, and equipment can significantly influence the detectability of bird

species, thereby affecting the results. For example, changes in observation periods or the number of survey points can lead to differences in the number and diversity of species recorded, even within the same location.

Table 1: Bird species recorded during the study at the Ahmadu Bello University (ABU) Reservoir and surrounding areas

S/No.	Order	Family	Species	Commonm Name
1	Passeriformes	Oriolidae	*Oriolus auratus*	African Golden Oriole
2		Turdidae	*Turdus pelios*	African Thrush
3		Estrildidae	*Spermestes cucullatus*	Bronze Mannikin
4		Leiothrichidae	*Turdoides plebejus*	Brown Babbler
5		Sturnidae	*Lamprotornis caudatus*	Long Tailed Glossy Starling
6			*Lamprotornis purpureus*	Purple Glossy Starling
7			*Lamprotornis pulcher*	Chestnut- Bellied Starling
8		Pycnonotidae	*Chlorocichla flavicollis*	Yellow-Throated Leaflove
9			*Pycnonotus barbatus*	Common Bulbul
10		Dicruridae	*Dicrurus adsimilis*	Forked-Tailed Drongo
11		Cisticolidae	*Camaroptera brevicaudata*	Grey-Backed Camaropteran
12		Monarchidae	*Terpsiphone viridis*	African Paradise Flycatcher
13		Hirundinidae	*Cecropis abyssinica*	Lesser Striped Swallow
14		Passeridae	*Passer griseus*	Northern Grey-Headed Sparrow
15		Malaconotidae	*Dryoscopus gambensis*	Northern Puffback
16		Corvidae	*Ispidina picta*	Piapiac
17		Estrildidae	*Lagonosticta senegala*	Red Billed Firefinch
18		Buphagidae	*Buphagus africanus*	Yellow Billed Oxpecker
19		Estrildidae	*Uraeginthus bengalus*	Red Cheeked Cordon Bleu
20		Nectariniidae	*Chalcomitra senegalensis*	Scarlet Chested Sunbird
21		Ploceidae	*Bubalornis albirostris*	White-Billed Buffalo Weaver
22			*Ploceus luteolus*	Little Weaver
23			*Ploceus cucullatus*	Village Weaver
24			*Euplectes hordeaceus*	Black- winged Red Bishop
25			*Euplectes franciscanus*	Northern Red Bishop
26		Malaconotidae	*Laniarius barbarus*	Yellow-Crowned Gonolek
27		Motacillidae	*Motacilla flava*	Yellow Wagtail
28			*Macronyx croceus*	Yellow-Throated Longclaw
29		Cisticolidae	*Cisticola juncidis*	Zitting Cisticola
30		Viduidae	*Vidua chalybeata*	Village Indigo Bird
31		Corvidae	*Corvus albus*	Pied Crow
32		Muscicapidae	*Melaenornis edolioides*	Northern Black Flycatcher
33	Charadriiformes	Charadriidae	*Vanellus spinosus*	Spur Winged Lapwing
34		Recurvirostridae	*Himantopus himantopus*	Black-Winged Stilt
35		Scolopacidae	*Actitis hyploleucos*	Common Sandpiper
36			*Tringa ochropus*	Green Sandpiper
37		Jacanidae	*Actophilornis africanus*	African Jacana
38	Columbiformes	Columbidae	*Treron waalia*	Bruce's Green pigeon
39			*Turtur abyssinicus*	Black Billed Wood Dove
40			*Spilopelia senegalensis*	Laughing Dove
41			*Columba guinea*	Speckled Pigeon
42			*Streptopelia semitorquata*	Red Eyed Dove
43			*Streptopelia vinacea*	Vinaceous Dove
44	Musophagiformes	Musophagidae	*Crinifer piscator*	Western Grey Plantain-Eater
45	Laniidae	Laniidae	*Corvinella corvina*	Yellow-Billed Shrike
46	Falconiformes	Falconidae	*Falco tinnunculus*	Common kestrel
47			*Falco chicquera*	Red Necked Falcon
48	Cuculiformes	Cuculidae	*Cuculus clamosus*	Black Cuckoo
49	Cuculiformes		*Centropus senegalensis*	Senegal Coucal
50	Psittaciformes	Psittacidae	*Poicephalus senegalus*	Senegal Parrot
51			*Psittacula krameri*	Rose Ringed Parakeet
52	Anseriformes	Anatidae	*Dendrocygna viduata*	White-Faced Whistling Duck
53			*Plectropterus gambiensis*	Spur winged Goose

S/No.	Order	Family	Species	Commonm Name
54	Coraciiformes	Coraciidae	*Eurystomus glaucurus*	Broad Billed Roller
55			*Coracias naevius*	Rufus Crowned Roller
56		Alcedinidae	*Megaceryle maxima*	Giant kingfisher
57			*Ispidina picta*	African Pigmy Kingfisher
58			*Corythornis cristatus*	Malachite Kingfisher
59			*Ceryl rudis*	Pied Kingfisher
60	Pelecaniformes	Ardeidae	*Bubulcus ibis*	Cattle Egret
61			*Ardea purpurea*	Purple Heron
62			*Nycticorax nycticorax*	Black Crowned Night Heron
63			*Egretta garzetta*	Little Egret
64			*Ardea cinerea*	Grey Heron
65			*Ardeola ralloides*	Squacco Heron
66			*Butorides striata*	Green-Backed Heron
67			*Egretta intermedia*	Intermediate Egret
68	Gruiformes	Rallidae	*Porphyrio alleni*	Allen's Gallinule
69	Piciformes	Picidae	*Dendropicos fuscescens*	Cardinal Woodpecker
70		Lybiidae	*Lybius dubius*	Bearded Barbet
71	Accipitriformes	Accipitridae	*Milvus migrans*	Black Kite
72			*Micronisus gabar*	Gabar Goshawk
73			*Accipiter badius*	Shikra
74			*Elanus axillaris*	Black- Shouldered Kite
75	Galliformes	Phasianidae	*Francolinus bicalcaratus*	Double- Spurred Francolin
76	Bucerotiformes	Bucerotidae	*Tockus erythrorhynchus*	Red Billed Hornbill
77			*Lophoceros nasutus*	African Grey Hornbill
78		Phoeniculidae	*Phoeniculus purpureus*	Green Wood-Hoopoe
79	Apodiformes	Apodidae	*Cypsiurus parvus*	African Palm Swift
80			*Apus affinis*	Little Swift

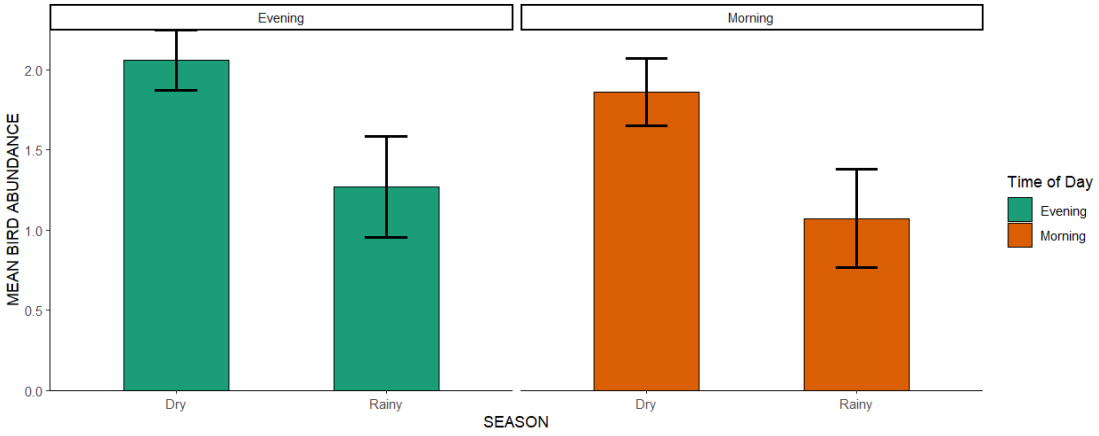

Figure 1. Model-estimated mean abundance by season and time of day, with 95% confidence intervals.

A third probable reason for the difference in the avian community between this study and that conducted by Aver-Tsue (2004, unpublished) may be linked to the higher frequency at which waste is deposited around the reservoir by students and residents visiting the area for picnics, social gatherings, and other recreational activities (Yunusa *et al* 2010). Fewer birds may have frequented the reservoir in 2004 compared to fourteen years later when this study was conducted. Visitors to the reservoir appear to have turned the area into a dumpsite during their recreational visits. Tesfahunegny and Assefa (2023) reported that waste materials around dumpsites may attract various animals, such as rodents and insects, which could serve as potential food sources for birds, thereby influencing the composition of avian communities in the area.

Recording more birds during the dry season underscores the importance of water sources in the life of birds and other wildlife (Nystrom and Bennett 2019). Water is essential for drinking and bathing, both of which are vital for survival and for maintaining feather condition (Brilot and Bateson, 2012). Because birds have a high metabolic rate, access to water is critical for effective thermoregulation, especially under the hot and dry weather conditions typical of Zaria, which resemble those of more arid habitats where water demand is even greater (Smit *et al* 2019). Similarly, Tanko *et al* (2014) observed higher bird species richness during the dry months in Dumbi Inselberg and adjacent woodland in northern Nigeria, attributing this to water reservoirs that served as reliable drinking sources. These reservoirs acted as strong attractants, concentrating birds in the area

during periods when natural water sources were scarce. In the same way, the ABU Reservoir provides a consistent, year-round water supply that draws birds throughout the year, and likely plays an even more critical role during the dry season when water availability is otherwise limited.

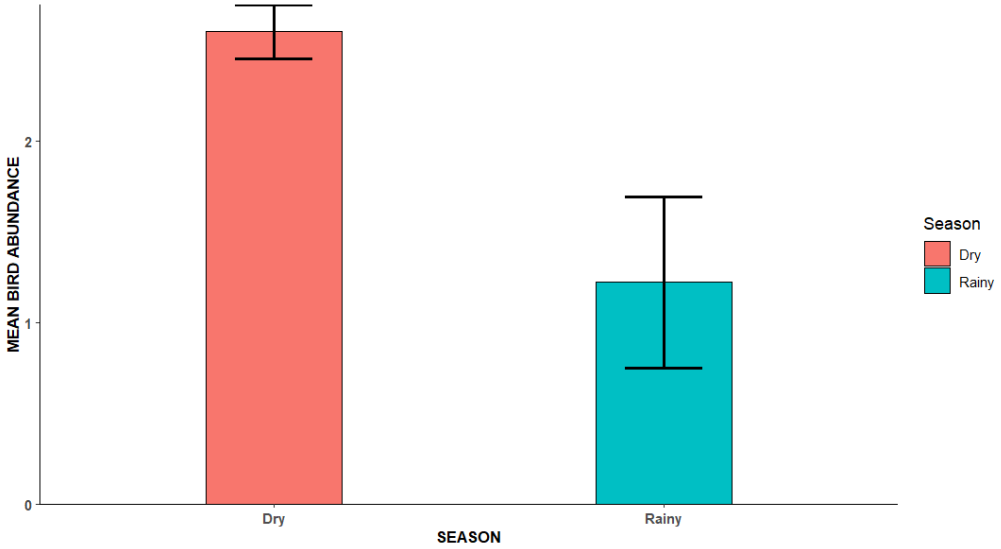

Figure 2. Model-estimated mean abundance of wetland birds by season, with 95% confidence intervals.

More wetland birds were encountered around the reservoir in the dry season. The congregation of water birds at larger permanent water bodies when smaller water bodies dry up faster during the dry season, may be a reason for the significantly higher numbers of waterbirds seen during the dry season (Mundava *et al* 2012). More so, the ABU Reservoir has diverse surrounding habitats like the open water, marshes and shorelines that might have attracted a wide range of birds with differing habitat preferences which in turn increased the overall avifaunal abundance.

Sandpipers, ducks, egrets, herons, and shoreline passerines recorded around the ABU Reservoir are consistent with the findings of Aver-Tsue (2004, unpublished) and Weller (2009). In the study area, the dry season caused a significant drop in the reservoir's water level, creating a low-water zone that supported numerous invertebrates.

As the water level declined throughout the dry season, a greater number of sandpipers were encountered at the location, which could be explained by the concentration of fish fingerlings, tadpoles and aquatic invertebrates in the shrinking body of water. The easy accessibility of preys to predators in these water bodies as they become shallow (Mundava *et al* 2012) may be another reason why the abundance of waterbirds in the dry season was significantly higher than in the rainy season.

The year-round availability of water at the ABU Reservoir, particularly during the dry season, makes it a crucial potential 'wintering' area for migratory birds. Notably, species such as the White-faced Whistling Duck, Common and Green Sandpiper, and Black-winged Stilt were significant contributors to the high bird abundance observed during the dry season.

Conclusion

The ABU Reservoir and associated wetlands are important avifauna sites as shown by the results of this study. The recording of many wetland birds and other shoreline passerines in this study may have been made possible by the creation of the reservoir that provides year-round water supply. Palearctic migrants such as the Green Sandpiper were sighted on numerous occasions during the study, especially in the dry season. This study advocates the intensification of management practices aimed at sustaining the reservoir and associated wetlands so that it may continuously offer the University community health services and by extension a haven for avifauna and other biological taxa. Tourists intending to visit the study area for recreational purposes could plan their trips during the dry season to maximise their chances of experiencing increased avifauna activity. Additionally, they should minimise littering around the reservoir's surroundings. Conducting studies of this nature across the country is highly encouraged, as they help track the abundance and diversity of avifauna, which serve as important indicators of the overall health and stability of the environment.

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Conflict of Interest

The authors declare no conflict of interest.

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