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Diversity of avifauna in relation to habitat types in selected areas of Guinea savanna zone of Nigeria

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Abstract Human disturbances have degraded Nigeria's dense vegetation and this is leading to a continuous habitat destruction of avian species in the Guinea Savanna zone of Nigeria. This study investigated the diversity of avifauna in relation to habitat types in selected areas of Guinea Savanna zone of Nigeria. The point count method was used to record bird species richness and abundance in four stratified habitats – forest, woodland, grassland, and riverside. A total of 2,545 individuals from 50 families of 136 species were recorded across 64 sampling points in the four habitats, in 2023 and 2024. The forest habitat had the highest species richness (86), followed by woodland (85) and grassland (54). The difference was only significant through pairwise comparisons that is between forest and grassland as well as between woodland and grassland. Riverside habitat had the highest abundance (54.5.0±38.7) while grassland had the least (28.1±8.93). The difference in abundance significantly varied across habitat types. Meanwhile, the woodland habitat recorded the highest bird species diversity (2.59). Common Bulbul *(Pycnonotus barbatus)* – a generalist – had the highest relative abundance while White-faced Whistling Duck *(Dendrocygna viduata)* had the highest abundance in a single habitat, the riverside habitat, recognized as a specialist. In conclusion, the diversity index of bird species was high in all the habitats with no significant difference, and therefore, the results highlighted the importance of habitat diversity in the Guinea Savanna zone. Conservation efforts should focus on protecting and restoring habitats, particularly forests and woodlands, to maintain the rich avifaunal diversity of the region.

Keywords: avifauna, abundance, habitat type, species richness, diversity, Guinea savanna

Összefoglalás Nigéria sűrű vegetációját az emberi zavarás jelentősen degradálta, ami folyamatos élőhelypusztulást eredményez a madárfajok számára Nigéria guineai szavanna-övezetében. A jelen tanulmány a madárfauna sokféleségét vizsgálta az élőhelytípusokkal összefüggésben, a guineai szavanna-övezet néhány kiválasztott területén. A pontszámlálásos módszert alkalmazva négy rétegzett élőhelytípusban – erdő, nyílt erdő (woodland), gyep és vízpart – rögzítettük a madárfajok gazdagságát és egyedszámát. 2023 és 2024 során összesen 2545 egyedet regisztráltunk, 136 fajból, 50 család képviseletében, 64 mintavételi ponton. Az erdei élőhelyen volt a legnagyobb fajgazdagság (86 faj), ezt követte a nyílt erdő (85 faj), majd a gyep (54 faj). A különbség csak páronkénti összehasonlításban bizonyult statisztikailag szignifikánsnak: az erdő és a gyep, valamint a nyílt erdő és a gyep között. A legnagyobb egyedszámot a vízparti élőhelyen figyeltük meg (átlagosan 54,5±38,7), míg a legalacsonyabbat a gyepen (átlagosan 28,1±8,93). Az egyedszám jelentősen eltért az egyes élőhelytípusok között. Ezzel szemben a madárfajok diverzitása a nyílt erdőben volt a legmagasabb (Shannon-index: 2,59). A legnagyobb relatív abundanciával a közönséges bülbül *(Pycnonotus barbatus)* – egy generalista faj – rendelkezett, míg az apáca-fütyülőlúd *(Dendrocygna viduata)* egyetlen élőhelyen, a vízparton mutatott kiemelkedően magas egyedszámot, így specialistának tekinthető. Összességében a madárfauna diverzitási indexe minden élőhelyen magas volt, szignifikáns különbség nélkül, ami kiemeli az élőhelyi sokféleség fontosságát a guineai szavanna övezetben. A természetvédelmi erőfeszítéseknek az élőhelyek – különösen az erdők és nyílt erdők – megóvására és helyreállítására kell összpontosítaniuk, hogy fenntartható maradjon a térség gazdag madárvilága.

Kulcsszavak: madárfauna, abundancia, élőhelytípus, fajgazdagság, diverzitás, guineai szavanna

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Introduction

The Guinea Savanna zone of Nigeria is a vital component of the West African savanna ecosystem, covering approximately 30% of the country's land area (Adebayo *et al*. 2015). This region is characterized by diverse habitats, including woodlands, grasslands, and farmlands, which support a wide range of plant and animal species (Ibrahim *et al*. 2024). Among these, birds are an important component of the ecosystem, playing crucial roles in pollination, seed dispersal, and pest control (Whelan *et al*. 2008). They are also bio-indicators of healthy ecosystems, birds of prey (raptors) eat up carcasses, thereby cleaning the environment (Egwumah *et al*. 2017).

About 2,300 species of birds are identified in Africa of which 975 species occurred in Nigeria (Avibase 2023, Clements *et al*. 2023). Avian species constitute the most common fauna of all habitat types and they are responsive to changes in Nigerian environment (Birdlife International 2018).

Avifaunal diversity is closely linked to habitat diversity, and changes in habitat structure and composition can have significant impacts on bird populations (Fahrig 2003). The Guinea Savanna zone is facing numerous environmental challenges, including habitat fragmentation, deforestation, and climate change, which threaten the long-term survival of many bird species (IPPC 2013).

Despite the importance of the Guinea Savanna zone for avifaunal diversity, there is a paucity of information on the relationship between habitat types and bird species diversity in this region (Afolayan *et al*. 2015). The aim of this study was to investigate the diversity of avifauna in relation to habitat types in selected areas of the Guinea Savanna zone of Nigeria, to provide insights into the conservation of bird species and their habitats in this critical ecosystem.

Materials and Methods

Description of the study area

The study area covered selected parts of the Guinea Savanna zone of Nigeria on latitude 7°42′55.29″N – 11°5′55.62″N and longitude 4°0′44.05″E – 8°43′53.40″E. Almost half of the territory of Nigeria is occupied by Guinea Savanna. The annual precipitation is 1000–1400 mm on the average. The plots of these savannas border the banks of the rivers with gallery forests. The grass reaches above 2 m height. Among the savanna vegetation in Nigeria,

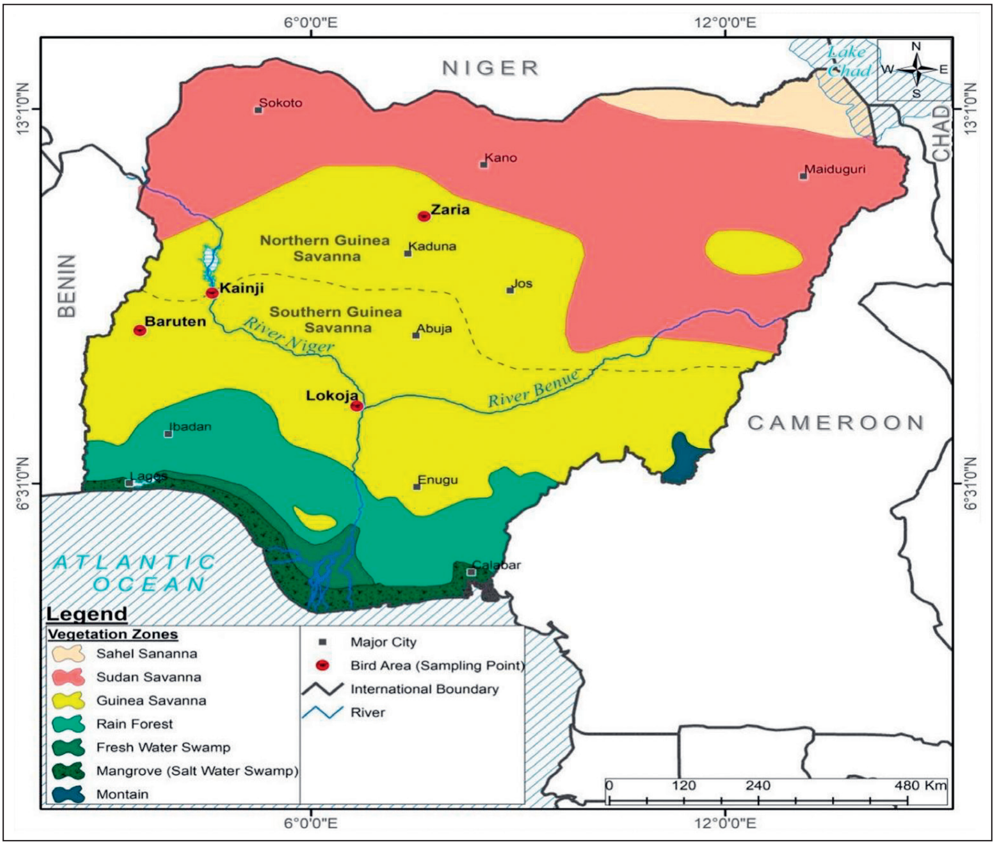

Figure 1a Vegetation map of Nigeria showing sampling locations (Source: Modified from Moberg & Esu 1991)
1a ábra Nigéria növényzeti térképe a vizsgálati pontokkal (Moberg és Esu 1991 módosítva)

various types of so-called elephant grass predominate. The ecological zone is known with two seasons; dry season (November–February) and wet season (March–October). The Guinea Savanna is composed of the northern Guinea Savanna and southern Guinea Savanna *(Figure 1a)*. The northern part is covered with grasses, with scattered trees and shrubs dominate the vegetation. Trees are shorter and thorny and are fewer in numbers than in the southern Guinea Savanna (Kupika *et al*. 2017, Makinwa 2017).

Study design

The study was conducted in purposively selected areas of the Guinea Savanna vegetation, considering especially forests, woodlands, and rivers/lakes around Important Bird Areas (IBAs), including protected reserves within the region as shown in *Figure 1*. The specific areas selected by authoritative sampling are: ABU Phase II forests, ABU dam (Zaria, Kaduna State); Federal University, Lokoja forests, River Lokoja (Lokoja, Kogi State); Western Borgu forests, River Moshi (Baruten, Kwara State), Kainji Lake National Park and Kainji dam (Kainji, Niger State). These sampling sites are listed in *Table 1*.

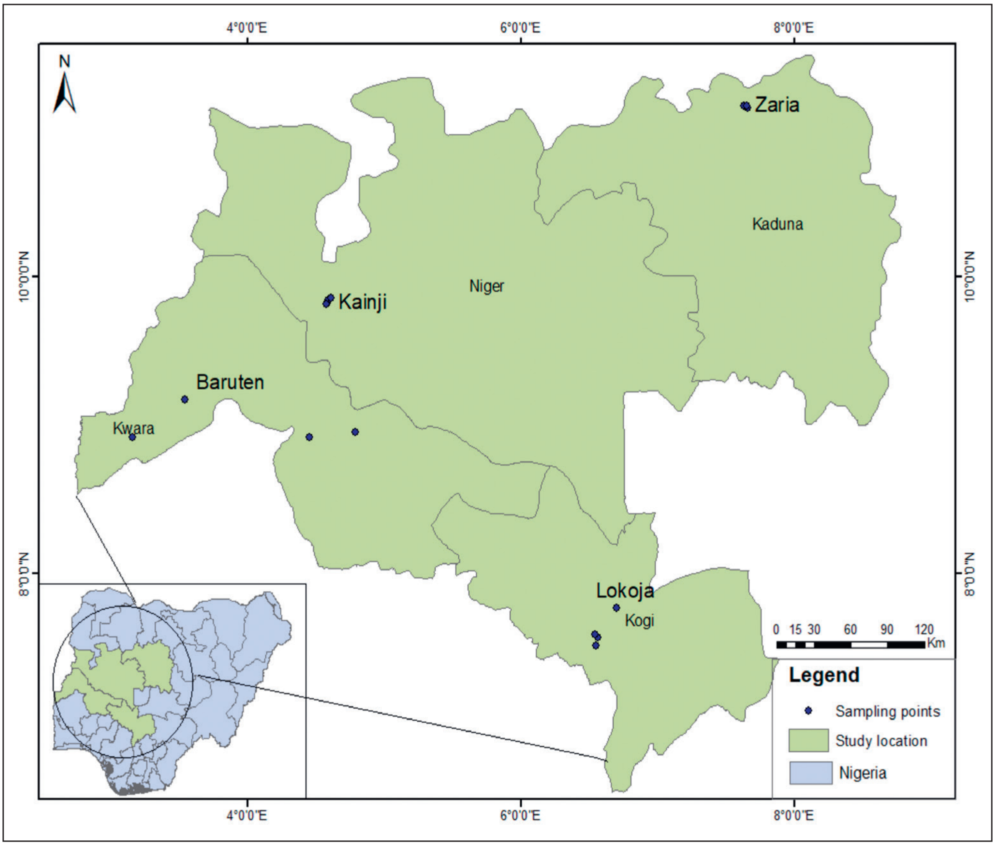

Figure 1b Sampling sites and points in Guinea Savanna zone of Nigeria (Source: ArcGIS 10.8 Version)
1b ábra Mintavételi helyek és pontok Nigéria guinea szavanna zónájában (ArcGIS 10.8 verzió)

The area was stratified into natural habitats (Forest, Woodland, Grassland and Riverside). Then, the position of each habitat was Geo-referenced by coordinates taken using a hand-held GPS, Model N9 GARMIN eTrexLegend personal navigator.

Random sampling method was employed to select four permanent counting points of 30 m radius with a distance of at least 100 m apart (Jankowski *et al*. 2009) using Geographical Information System (GIS). Each of the four habitat types had four points in four sites of the study area, making a total of 64 sampling points. The Point Count Method was adopted, and the most suitable for the uneven terrain and dense undergrowth in which detection of birds using other techniques may be difficult (Fiala *et al*. 2006).

Determination of bird species composition and abundance

Birds were counted in each sampling point. Here, upon reaching a point, birds were immediately counted on sight or hearing of their sounds/calls (Bryan *et al*. 1984). Ten minutes was used to count and record all birds observed or heard within 30 m radius (Terborgh *et al*. 1990, Robinson *et al*. 2000)

Table 1. Sampling locations within Guinea Savanna Zone with their coordinates in the study area
1. táblázat A mintavételi helyek a Guinea Szavanna Zónán belül a területek koordinátáival

S/N	Sampling locations	Central coordinates	Habitat type
1	Ahmadu Bello University Phase II	11°11′60″N – 7°41′59.9″E	Forest
2	Ahmadu Bello University Dam	11°7′60″N – 7°39′59.8″E	Riverine
3	Area BZ, ABU- Zaria	11°09′28″N – 07°37′56″E	Woodland/Grassland
4	Kainji Lake National Park	10°21′59″N – 4°32′59.9″E	Forest/Woodland/ Grassland
5	Kainji Dam	9°8′25″N – 4°59′33″E	Riverine
6	Borgu Game Reserve, Baruten	10°02′27″N – 4°03′36″E	Forest/Woodland/Grassland
7	River Moshi, Baruten	9°9′22″N – 4°25′36″E	Riverine
8	Federal University, Lokoja	6°31′0″N – 3°23′10″E	Forest/Woodland/Grassland
9	River Niger, Lokoja	7°45′51″N – 6°41′45″E	Riverine

The recording of birds was conducted from 6:30–10:30 in the morning and from 16:00–18:00 in the evening of the same day, as this is the period when most birds are active (Bryan *et al*. 1984). Observation of birds were done with naked eyes, sound/calls and binoculars 12 × 32 m (Model: 1080P), where they were far away or similar with one another. The date, bird species, number, habitat type, were recorded and coordinates were taken using a hand-held GPS (Model N9 GARMIN eTrexLegend) personal navigator. Based on field guides of Borrow and Demey (2013), birds were identified to the species level. The abundance of each species of bird was recorded and the mean abundance was determined for each.

$$\text{Relative abundance} = (ni / N) \times 100$$

where ni = number of individuals of bird species in an area, and N = total number of individuals in that community.

Data analyses

Bird species diversities and richness were determined using Shannon–Wiener Diversity Index using R Core Team (2022). One-way ANOVA was used to compare mean abundance of birds, as well as diversities across habitats and locations of study. Tukey HSD test was used as a *post-hoc* for pairwise comparisons where a significance difference was shown. Generalized Linear Model (GLM) with family Poisson was used to compare bird richness across habitats.

'Vegan and Biodiversity R' were used to plot rank abundance and species accumulation curves while Bray–Curtis distance was used to compare similarity of bird species across habitats.

A P-value threshold of ≤ 0.05 was considered statistically significant using R-Statistics package for Windows version 4.1.2 (R Core Team 2022).

Result

Bird species composition and abundance in habitat types of the study area

A total of 2,545 birds were recorded across the 64 sampling points in four habitats, four sites and in two years of study. The recorded species were from 50 families of 136 species, and the distribution of the first 20 species across habitat types and relative abundance in the study area is presented in *Table 2*.

Table 2. Bird species composition based on their relative abundance in the study area
2. táblázat A fajösszetétel a relatív abundanciáik alapján

S/N	Habitat	Common name	Scientific name	Family	Abundance	Rel. Abundance
1	Riverside	White-faced Whistling Duck	*Dendrocygna viduata*	Anatidae	172	19.725
2	Riverside	Spur-wing Lapwing	*Vanellus spinosus*	Charadriidae	62	7.110
3	Forest	Common Bulbul	*Pycnonotus barbatus*	Pycnonotidae	51	7.634
4	Riverside	Ethiopean Swallow	*Hirundo aethiopica*	Hirudinidae	49	5.619
5	Riverside	Common Bulbul	*Pycnonotus barbatus*	Pycnonotidae	48	5.505
6	Grassland	Bronze Mannikin	*Spermestes cucullatus*	Estrildidae	46	10.222
7	Forest	Piapiac	*Ptilostomus afer*	Corvidae	43	6.437
8	Forest	Bronze Mannikin	*Spermestes cucullatus*	Estrildidae	42	6.287
9	Forest	Long-tailed Starling	*Lamprotormis caudatus*	Sturnidae	39	5.838
10	Grassland	Common Bulbul	*Pycnonotus barbatus*	Pycnonotidae	38	8.444
11	Woodland	Common Bulbul	*Pycnonotus barbatus*	Pycnonotidae	37	6.666
12	Riverside	Cattle Egret	*Bubulcus ibis*	Ardeidae	31	3.555
13	Riverside	Brown Barbler	*Turdoides plebejus*	Timaliidae	29	3.325
14	Woodland	Piapiac	*Ptilostomus afer*	Corvidae	29	5.225
15	Woodland	Long-tailed Glossy Starling	*Lamprotormis caudatus*	Sturnidae	28	5.045
16	Forest	Village Weaver	*Ploceus cucullatus*	Ploceidae	27	4.041
17	Riverside	Long-tailed Glossy Starling	*Lamprotormis caudatus*	Sturnidae	26	2.981
18	Woodland	Vinacious Dove	*Turtur abyssinicus*	Columbidae	26	4.684
19	Forest	Brown Barbler	*Turdoides plebejus*	Timaliidae	25	3.742
20	Riverside	Yellow-crowned Gonolek	*Laniarius barbarous*	Malaconotidae	25	2.866

ANOVA results indicated that mean bird species abundance varied significantly across habitat types (F(3) = 5.2651, P = 0.006), ranging from 28.1 ± 8.93 in grassland to 54.5 ± 38.7 at riverside *(Figure 2)*. Post-hoc Tukey HSD tests revealed no significant pairwise differences among most habitats, except between riverside and woodland, and riverside and grassland, where significant differences were detected (P < 0.05) *(Table 3)* .

Species richness ranged from 54 on grassland to 86 in forest. The difference between any two habitats was statistically significant (GLM: Chi^2 = 10.182, df = 3, P = 0.017). However, the difference was only through a pairwise comparison, between forest and grassland (P = 0.03); and grassland and woodland (P = 0.04) *(Figure 3)*. Bird species diversity (SWI) did not differ significantly across habitat types (P = 0.148). It ranged from 2.32 on grassland to 2.59 on woodland *(Figure 4)*. The similarity indices showed the distance apart between one habitat and the other. Since it is a distance matrix, the higher the values the father apart are the habitats *(Table 4)*.

The closest value to zero (0) under forest is 0.456311 in woodland which clearly showed the most similar bird species recorded while 0.622727 in riverside was the farthest to forest which revealed that there was little or no similarity of bird species recorded among those habitats *(Table 4)*.

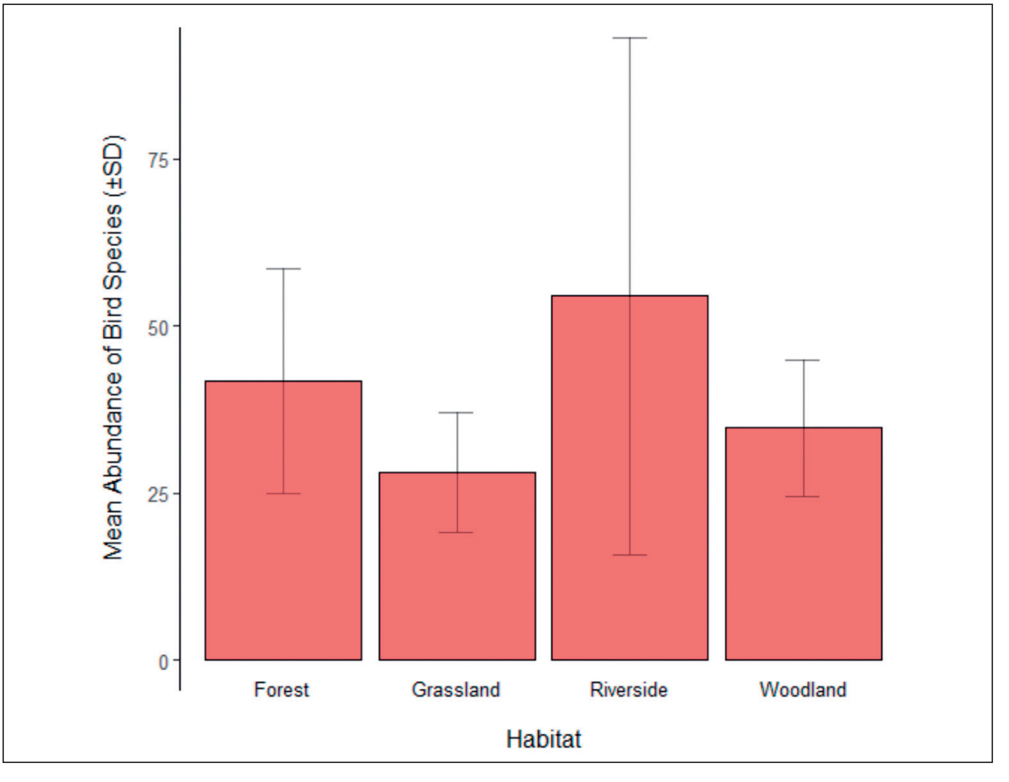

Figure 2. Mean abundance of bird species across habitat types in the study area (ANOVA: F(3) = 5.2651, P = 0.006)

2. ábra A madárfajok átlagos abundanciája a különböző élőhelyek között (ANOVA: F(3) = 5.2651, P = 0.006)

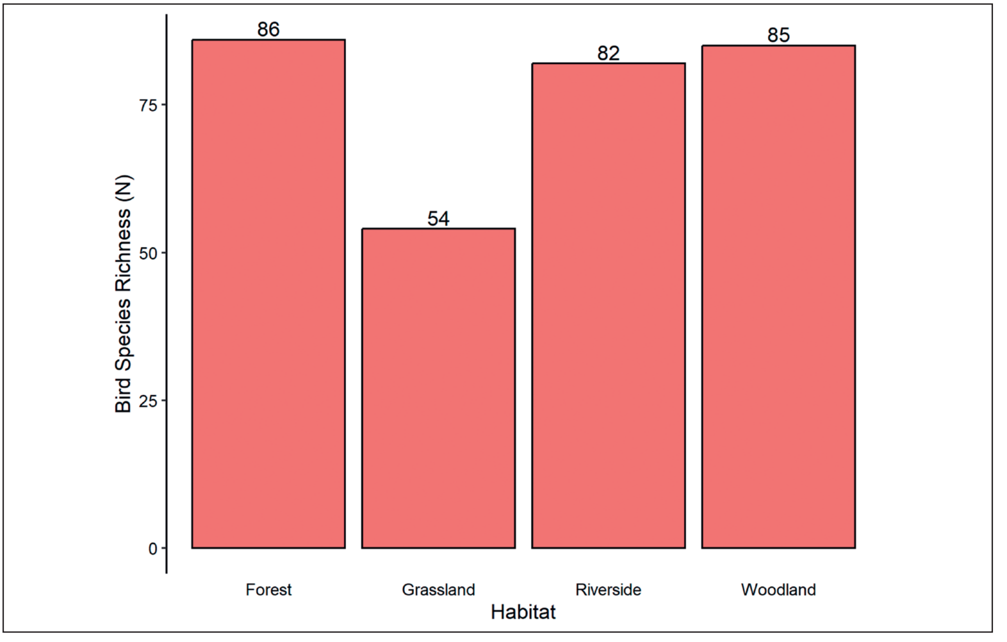

Figure 3. Species richness of birds across habitats in the study area (GLM: $Chi^2 = 10.182$, df = 3, P = 0.017)

3. ábra Fajgazdagság a különböző élőhelyek között (GLM: $Chi^2 = 10.182$, df = 3, P = 0.017)

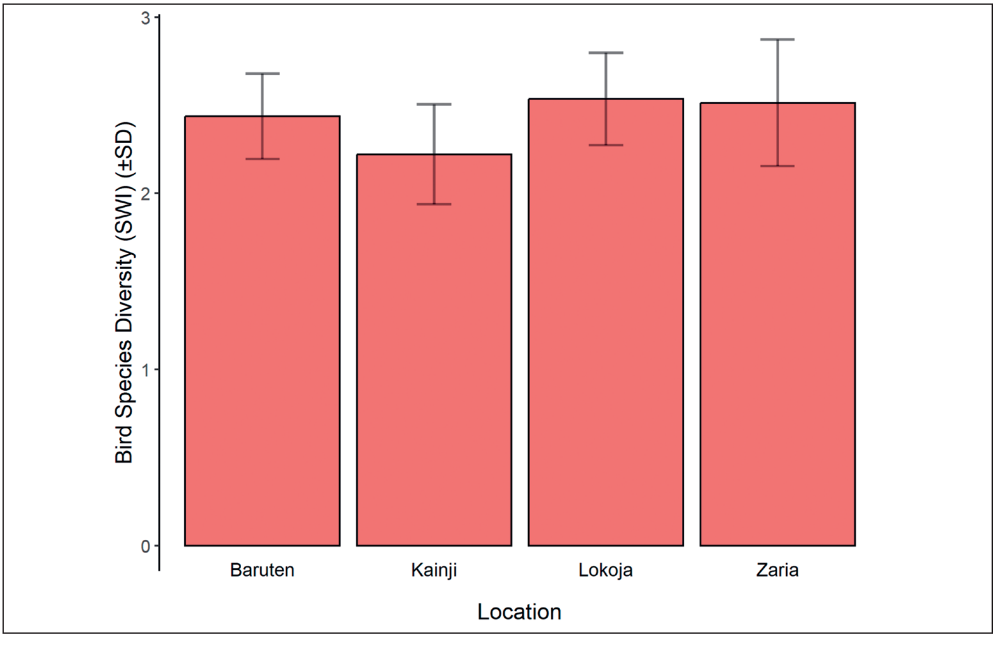

Figure 4. Bird species diversity across all habitats in the study area (ANOVA: F3 = 2.1461, df = 3, P = 0.148)

4. ábra A madárfajok diverzitása az élőhelyek között (ANOVA: F3 = 2.1461, df = 3, P = 0.148)

Table 3. *Post-hoc* test of mean abundance of bird species across habitats in the study area
3. táblázat A fajok élőhelyek közötti átlagos abundanciájának *post-hoc* tesztje

Habitat	Difference	Lower bound	Upper bound	P-value
Grassland-Forest	-13.625	-32.0464	4.796391	0.179542
Riverside-Forest	12.750	-5.6714	31.17139	0.222397
Woodland-Forest	-7.062	-25.4839	11.35889	0.674234
Riverside-Grassland	26.375	7.9536	44.79639	0.005357
Woodland-Grassland	6.562	-11.8589	24.98389	0.720293
Woodland-Riverside	-19.812	-38.2339	-1.39111	0.033875

s = significant; ns = not significant at P = 0.05

Table 4. Similarity Distance (Bray–Curtis Distance) across habitats in respect to bird species in the study area
4. táblázat Az élőhelyek közötti Similarity Distance (Bray–Curtis távolság) a vizsgálati területen található madárfajok tekintetében

	Forest	Grassland	Riverside	Woodland
Forest	0	0.568238	0.589286	0.456311
Grassland	0.568238	0.000000	0.611675	0.572539
Riverside	0.589286	0.611675	0.000000	0.622727
Woodland	0.456311	0.572539	0.622727	0.000000

Note: Bray–Curtis's distance estimates the dissimilarity of habitats based on presence/absence and number of bird species in each habitat. The value ranges from 0 (which means perfect similarity and no difference in bird species composition) to 1 (which means any two habitats do not share any bird species in common). Therefore, the higher the values the farther apart the habitats.

The overall ranking among all bird species recorded across the habitat types was the Common Bulbul *(Pycnonotus barbatus)* as the first *(Figure 5)*. The cumulative number of bird species across the 64 sampling points showed that newer species were recorded as we counted from the first sampling point to the last. The curve reveals that more newer species will be recorded if the study period was extended *(Figure 6)*.

Discussion

There are factors which influence the high number of bird species in the Guinea Savanna zone of Nigeria, in the habitats studied. The highest bird species abundance observed in the riverside habitat was largely a result of the water bodies around the habitat where many species in high numbers converge for feeding and breeding since such habitats have water, food and nesting materials. This record of high abundance could also be attributed to the fact that most bird species use river channels as corridors of migration to other landscapes for their wellbeing. This agrees with the report of Sinha *et al*. (2019) that birds use riverine environments and wetlands for breeding, nesting and habituating young, as a source of drinking water, feeding, resting, shelter and for social interaction. The habitat is also unique because of the large number of White-faced Whisling Duck *(Dendrocygna viduata)* which

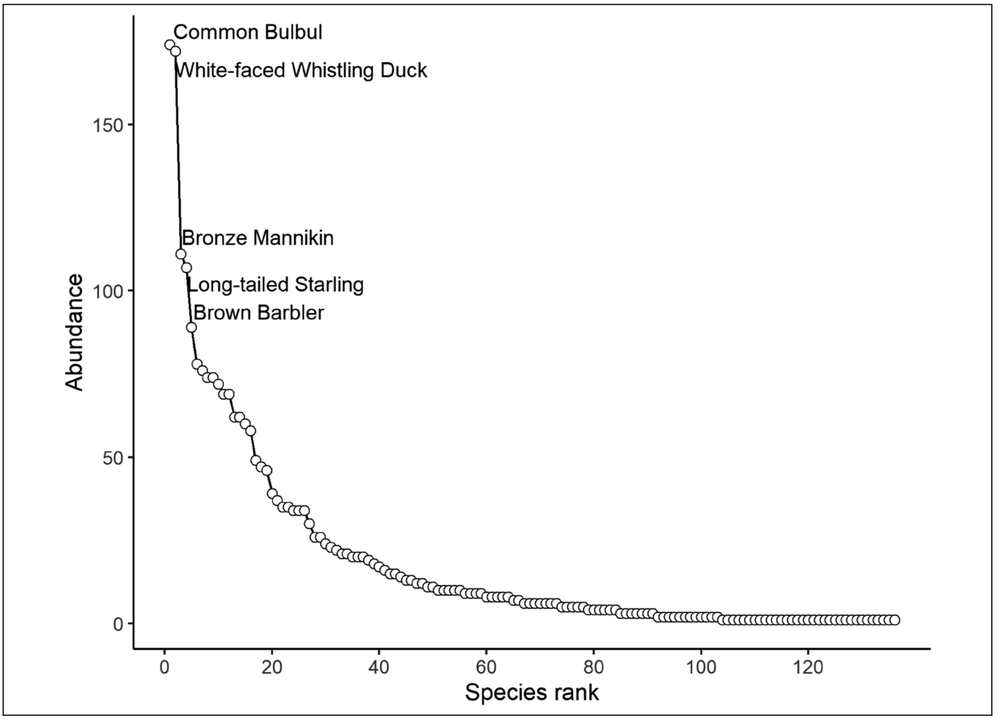

Figure 5. Overall bird species ranking by abundance across all habitats and sites in the study area
5. ábra A madárfajok összesített rangsora a vizsgált terület összes élőhelyén és helyszínén a madárfajok gyakorisága alapján

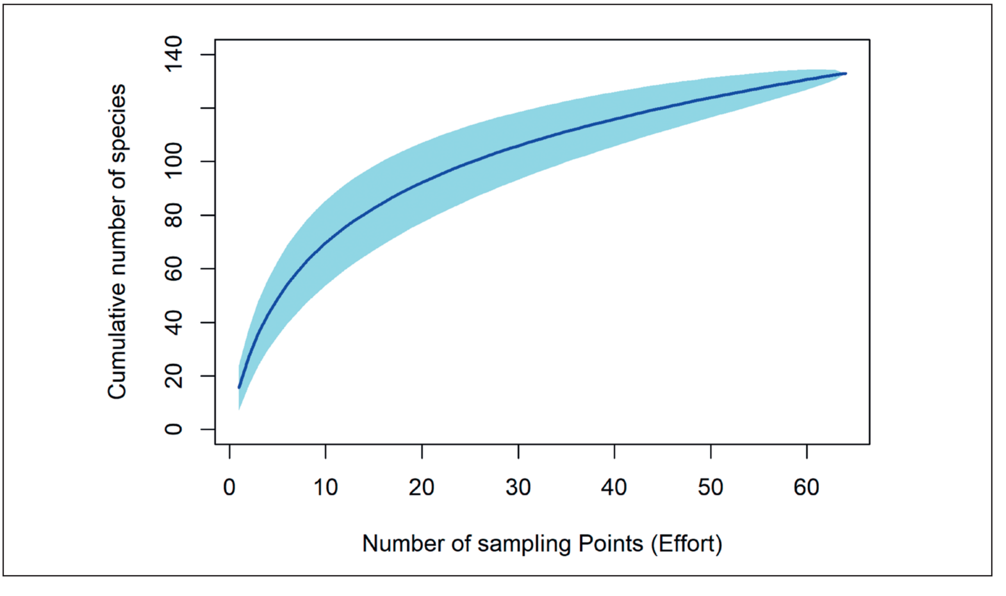

Figure 6. Cumulative number of bird species by sampling points in the study area
6. ábra A madárfajok összesített száma a vizsgált terület mintavételi pontjai szerint

are gregarious in nature. Ringim *et al.* (2019) also recorded this species with the highest abundance across some IBAs in Nigeria and attributed it to the protection of the areas.

Meanwhile, the forest habitat recorded the highest species richness, and it is next to riverside in terms of abundance due to its complexity of more trees with close canopy. The presence of trees with understory vegetation in this area provided food resources, breeding habitat and cover for the birds. Again, this habitat has a suitable nesting environment for several bird species. Okosodo and Okosodo (2020) reported a high number of bird species in a study in Okomu National Park, Nigeria. Meanwhile, Askins *et al*. (2012) reported that the more complex the structure or composition of the vegetation, the more likely that habitat will contain more bird species.

The high species richness and abundance in the woodland habitat is not unrelated to the habitat's proximity with the forest, since there were similar species recorded in both habitats. The open vegetation of the habitat is also an added advantage for several species that enjoy flight between trees at short distances like the Northern Red-billed Hornbill *(Tockus erythrorhynchus),* Green Wood Hoopoe *(Phoeniculus purpureus)* and the starlings. The high number of species and their abundance here could be attributed to the fact that woodland serves as the boundary between forest and grassland habitats, and birds that are both specialists and generalists were recorded. This is in compliance with many other studies like Clergeau *et al*. (1998), Chace and Walsh (2006) and Sandstrom *et al*. (2005) that high vegetation of woodland support higher diversity of birds.

Furthermore, the grassland habitat recorded the least species richness and abundance possibly due to the lowest number of tree population and probably it is too open for some species of birds to hide from predators. It may also largely be related with non-availability of certain food items but mainly grasses and seeds. This was evidenced by the sights of granivores like Laughing Dove *(Spilopelia senegalensis)*, Red-eyed Dove *(Streptopelia semitorquata)* and the finches. The findings of this research agree with the report of Chace and Walsh (2006) who concluded that human-disturbed grassland areas provide heterogeneous habitats which attract human tolerant bird species. Higher abundance per species counts and density near settlements could have contributed by few species that can coexist with humans such as Bronze Mannikin *(Spermestes cucullatus)* and Common Bulbul.

The highest similarity of bird species that was found between forest and woodland habitats is attributed to the fact that the habitats are closely related in terms of tree population, with woodland having open canopy while forest has closed canopy. This is similar to the study of Johnsingh and Joshua (1994) who found 52% similarity in bird species between secondary vegetation and dry deciduous forest. Bideberi (2013) also had high similarity between forest and woodland habitats in a study on bird species diversity in relation to habitat types. Both generalists and specialists' bird species were found in these habitats. This is explained by the availability of ecological requirements for the species offered by a mixture of an environment with garden patches (Shochat *et al*. 2010). This highlights the fact that, while species may be similar between habitats, there is still a difference in requirement hence it is important to conserve a mosaic of natural habitats.

The overall abundance showed a distribution pattern of bird species according to the spatial structure of the environment and habitat requirement. This explains habitat specificity and generalization that was observed. For example, Common Bulbuls ranked first in all habitat types except in riverside, but it ranked the overall highest abundance because they are generalists. Meanwhile, the cumulative species curve revealed high diversity of bird species since newer species were encountered from one sampling point to the other. This corresponds with Tanko *et al*. (2022) who reported a similar curve of recording new species within sampling points in different habitats.

Climate change is also likely to impact avifaunal diversity in the Guinea Savanna zone of Nigeria. Changes in temperature and rainfall patterns may alter the distribution and abundance of bird species, as well as the availability of food resources (IPCC 2013). Therefore, conservation efforts should focus on protecting and restoring habitats, as well as promoting sustainable land-use practices that can help to mitigate the impacts of climate change.

In conclusion, this study revealed that forest, woodland and riverside habitats are most suitable for bird species diversity. The findings also underscore the importance of habitat heterogeneity in maintaining avifaunal diversity. It is recommended that sustainable land-use practices such as agroforestry and permaculture should be promoted to reduce habitat fragmentation and degradation.

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