Comparison of avian species diversity and abundance in relation to habitat structure: toward using birds as indicators of ecosystem health at zone 8, Lokoja, Kogi State, Nigeria

Tanko, D[1]*., Okwu, N. S[2]., Kachi, J. B[1]. and Adejoh, B[1].
[1]Department of Biological Sciences, Federal University Lokoja, PMB 1154, Lokoja, Kogi State, Nigeria.
[2]AP Leventis Ornithological Research Institute, University of Jos, Nigeria
*Correspondence author's email: tyankwa2007@yahoo.com

Abstract

Avian species in relation to plant community can be used to determine the health status of the ecosystem. Habitat destruction can lead to extinction of many bird species as well as other plant communities. The study was conducted for three (3) months to determine the variation in avian species diversity and abundance in four different adjacent habitat structures: Farmland, Gallery Forest, Rocky Outcrops and Uncultivated Grassland, all located at Zone 8 area of Lokoja, Kogi State. The Line Transect method was used to collect data from the entire study area where 2000 m transect was marked and further divided into short sections of 100m with 50m distance apart. Each marked section was sampled ten (10) times from 6:30 am to 10:00 am. Birds' species encountered were identified using the field guide and songs. Species diversity was determined using the Shannon-Weiner diversity index (H). The study recorded a total number of 4,490 individuals of 110 species belonging to 32 families. Farmland had the highest number of individuals with a total of 1,228 individuals belonging to 92 species, followed by the Gallery Forest with a total of 652 belonging to 95 species, followed by uncultivated grassland with a total of 339 individuals belonging to 65 species and the Rocky outcrop with a total of 122 individuals belonging to 55 species. Bird species abundance between the habitat types differ significantly ($p<0.05$). The Gallery Forest was the most diverse in bird species with a mean diversity index ($H=3.55$), though diversity between the habitat was not statistically different ($p>0.05$). The findings from this study indicate that Zone 8 is rich in avian species diversity. Therefore, there is need to conserve this area from activities that might contribute to habitat loss, which can lead to extinction of some bird species and possibly plants community in the nearest future.

Keywords: Avian diversity, abundance, habitat structure

Received: 20 June, 2022 **Revised:** 11 October, 2022 **Accepted:** 16 October, 2022

Introduction

Birds are a group of unique vertebrates with very fascinating and distinguishing characteristics, which have been considered only next to mammals (Campbell *et al* 2008). According to Kress (2000), the presence of diverse bird populations that are capable of sustainable reproduction is an indication of a healthy environment. It has been reported that high species diverse and rich sites within the ecosystem can be indicated using birds (Mikusinski *et al* 2001; Sauberer *et al* 2004; Thomson *et al* 2007; Tanko *et al* 2018; Adang *et al* 2018 and Lin *et al* 2019) and for the purpose of evaluating the effectiveness of management practices, this method is being widely used as a strategy to measure baseline patterns of diversity and abundance as cited by Tanko *et al* (2018).

Owing to the complexities involved in measuring ecological systems, the use of indicator organisms become necessary as cited by Mekonen (2017). This makes birds "excellent barometer for the health of the environment" (Carignan and Villard 2002) as they occur in many habitats, reflect changes in plants and other animal's communities and interact greatly with the public (IUCN 2010). For example, birds have been studied as bio-indicators of the condition of ecosystems such as forests, rainforests, grasslands, rangelands, riparian ecosystems, terrestrial wetlands, marine ecosystems, and urban areas (Chambers 2008), and also in response to ecosystem disturbances and processes which includes urban expansion, logging regimes, hydrological regimes, eutrophication, replacement of endemic ecosystems with plantations, grazing, hunting and habitat restoration programs (Chambers 2008).

Bibby *et al* (2000) posits that different habitats, environments, vegetation, biotypes and ecosystems have certain Birds species that characterize them and these species are said to have restricted habitat requirements. These requirements make them more sensitive to changes in the environment causing them to easily disappear or get disturbed when the habitat is destroyed or degraded (Bird life International 2000). Habitat selection and use by birds has been long established as functional field of study in bird ecology Nsor *et al* (2018). Studies on habitat selection have revealed that several factors such as land scape structure, nest predation, competition, intraspecific attraction, food availability, variable climate, diseases

http://dx.doi.org/10.4314/tzool.v20i1.16

and human activities can influence animals' freedom while traversing a landscape in search of suitable habitats (Nsor *et al* 2018).

According to Gabbe *et al* (2002) and Earnst and Holmes (2012), the vegetation structure of any given ecosystem plays an important role in structuring the avian communities as well, and that makes their relative abundance to be often associated with vegetation community. Facts abound that the vegetative structure is often frequently assumed to be the fundamental factor determining the where and how of species resources use. For example, Sage Grouse (*Centrocercus urophasianus*) is strongly associated with sagebrush (*Artemesia tridentata*), Chukar (*Alectoris chukar*) is associated with cheatgrass (*Bromus tectorum*) (Nsor *et al* 2018).

The Lokoja area is well known for its biodiversity and support for rich wildlife communities including birds (Tanko and Wada 2020). However, many of the habitats have been extensively exploited and cleared for timber, urban settlement and other forms of land uses over the last century, which actually calls for genuine concern. The loss of biodiversity especially at the ecosystem level is of great concern among scientists. An ecosystem such as the savanna is considered degraded or lost when the distinct habitats, species assemblages and natural processes are disrupted or diminished in quality and quantity (Tanko 2008). In the case of birds that are highly dependent on the habitat condition, the habitat loss and degradation as a result of anthropogenic activities would be a serious threat to their survival. As human population continue to explode leading to increased demand for land, timber and non-timber forest products (the preferred habitat of these birds) become smaller and/or modified. Consequently, the long-term survival of many birds and other wildlife will depend largely upon their ability to persist in human altered habitats (Zakaria *et al* 2005).

The patterns of species diversity and abundance have always intrigued ecologists. Studies of birds in their natural environment are useful for conservation of biological diversity and monitoring the effects of environmental changes and habitat alteration. Many factors influence bird diversity and abundance as it relates to their habitat (Bakam *et al* 2016). Birds found in a particular habitat will selectively utilize vegetation rather than randomly (Bakam *et al* 2016). Species will also coexist through resource partitioning including partitioning of habitat, food and habitat utilization time. The variations of habitat utilization and foraging behaviour of coexisting species have been considered evolutionary strategies to partition limited resources and to minimize potential interspecific competition (Ishtiaq *et al* 2010).

Zone 8 of Lokoja is located along Kabba road and it is made up of different vegetation structure such as Savannah, Rocky and Gallery forest. There are different anthropogenic activities going on in this area such as; intensive farming, grazing, illegal mining, deforestation and wood logging. These areas sometimes referred to as "countryside habitats (Daily *et al* 2001) may support a considerable fraction of the original avifauna. In the face of expected global climate change, areas at interface of biome boundaries such as the Lokoja region, are of particular importance because, they are likely the first to show possible shift of floral and faunal zones. In such regions, landscape features such as inselbergs may provide a retreat for species and thus are of conservation importance.

Although a comprehensive account of the avifauna species diversity and abundance in Lokoja and Kogi State as a whole may not readily be in place. However, few recent researches such as a checklist of avifauna species within Lokoja metropolis by Tanko *et al* (2018) and bird species richness and diversity of Lokoja environs by Adang *et al* (2018) provide preliminary information on the birds of Lokoja. These previous studies did not sufficiently cover the zone 8 area in Lokoja, which has uniquely different habitat structures in term of vegetation and anthropogenic interferences. The sole aim of this research was to identify, determine bird species abundance and richness with respect to the different habitat types in the zone 8 area and to also provide additional information on the use of birds as bio-indicators of ecosystem degradation.

Materials and methods

Study area

The area under study is popularly known as Zone 8 within Lokoja metropolis, the capital of Kogi State. Lokoja situates between latitudes 7º 45′ N – 7º 51′ N and longitude of 6º 41′ E - 6º 45′ E (Figure 1). It lies at an altitude of between 45 to 125m above sea level. It covers a total land area of 63.82 km^2 and is characterized by tropical climate that comprises of wet and dry season which falls within the Savanna vegetation belt. It has an annual rainfall of about 1150mm and a mean annual temperature of about 27.7ºC.

The Zone 8 area is located along Kabba road and consists of two villages (Oworo and Crusher). Its vegetation outlay is characterized by structures that can be categorized as; Savanna, Rocky Outcrop and Gallery Forest. Settlers around this area are also involved in intensive farming activities, grazing and other anthropogenic activities such as illegal mining, wood logging, and deforestation. Notable plant species in the area include; *Parkia biglobossa*, *Lophira alata*, *Gmelina arborea*, *Tectona grandis* etc. Four (4) habitat types were identified and used as the sampling plots to compare the bird species that utilizes each of the habitats. The four habitats are Farmland (FL), Gallery Forest (GF), Rocky Outcrops (RO) and Uncultivated Grassland (UG).

Sampling method

This study was carried out in 2019 for a period of three (3) months (January-March). The site was visited twice weekly. The Line transect method was used for sampling as described by Bibby *et al* (2000). A transect of 2000m was marked out, which was further divided into twenty sub-transects of 100m that are at least 50m distance apart from each other were randomly selected on either side of the road cutting across the four habitat types. A preliminary study was carried out before the commencement of the study. All transects were flagged with colored ribbon to ensure easy location.

Figure 1: Map of the study site indicating the sampling stations (KG1-KG4).

Sampling was carried out in the morning between the hours of 6:00 to 10:00 am. A settling time of about 3 minutes was given on arrival to each transect to enable the birds settle and felt free in carrying out their activities. Walking across the selected transects and stopping at each distance of 50m, birds sighted or heard were identified and counted. Birds sighted or heard behind the researchers were not recorded on assumption that the birds have already been recorded to avoid double recordings. The 50m stopping points for counting was determine with the use of Global Positioning System (GPS). Each transect was visited/sampled 10 times during the fieldwork. All the visits to the different transect were alternated accordingly and an average of 5-7 minutes was spent in each session.

Identification of bird species

During the sampling period, all birds encountered and observed were identified with the aid of field guide of Birds of Western Africa (Borrow and Demey 2013). A pair of binoculars was used for sighting distant birds and birds that were not visibly seen were identified by listening to the sounds made by them in comparison with the collection of recorded birds' songs on an android phone.

Statistical analysis

Microsoft excel 2007 version 3.3.0 was used to input and arrange all data collected in the field. Histogram was used to test for normality of data of which the data was normally distributed. One-way Analysis of variance (ANOVA) was used to compare species abundance and diversity between the habitat types using R Studio version 1.1.4. The mean abundance of species if significant at $p<0.05$ was followed by post hoc test to separate the means. Shannon-Wiener diversity index was used to calculate species diversity. Species effort curve was plotted to show the amount of effort put in species recovery and to ascertain if all the species at the sampling sites have all been identified.

Results

A total number of 4,490 individuals of 110 species belonging to 43 families were identified and recorded during this study (Table 1). The highest number of birds with a total of 1,228 belonging to 95 species in 37 families was recorded on the Farmlands, followed by the Gallery Forest habitat, which had a total of 652 birds belonging to 92 species in 35 families, then the uncultivated- grassland habitat which had a total of 339 birds belonging to 64 species in 38 families. The Rocky outcrop habitat had the least number of birds in comparison with the other three habitats with a total number of 122 birds belonging to 59 species in 31 families. The study revealed that 38 out of the 110 encountered species utilizes the four habitat types. Nine (9) families; These include Meropidae, Oriolidae, Psittacidae, Apopdiade, Motacilidae, Campephagidae, Certhridae Zostheropidae and Passeridae were represented by a single species each.

Bird species abundance among different habitat types

Habitat types had a significant effect on bird species abundance ($F_{3,\ 16}=4.52$, $p=0.02$). The significant difference was between the gallery forest and the farmland ($p=0.02$) and between uncultivated grassland and gallery forest ($p=0.02$) as shown in Table 2. Mean species abundance was however significantly higher ($p<0.05$) on farmland compared to other habitat types (Figure 2).

Bird species diversity among different habitat types

The habitat types did not show any statistically significant effect on bird species diversity on the whole ($p=0.13$). Although the gallery habitat showed higher mean diversity of bird species in comparison with other habitat types.

Table 1: A Checklist of bird species recorded at Zone 8 Lokoja

S/N	Group/Family	English Name	Scientific name	FL	GF	RO	UG
1	Ardeidae	Black-headed Heron	*Ardea melanocephala*	+	-	-	-
2	Scopidae	Hammerkop	*Scopus umbretta*	+	+	+	-
3	Scpoidae	Yellow-billed Kite	*Milvus migrans*	+	+	+	+
4	Accipitridae	Black-shouldered Kite	*Elanus axillaris*	+	-	+	-
5	Accipitridae	Shikra	*Accipiter badius*	+	-	+	-
6	Accipitridae	Gabar Goshawk	*Micronisus gabar*	+	-	-	-
7	Accipitridae	Dark chanting goshawk	*Melierax metabates*	+	+	+	+
8	Accipitridae	Lizard Buzzard	*Kaupifalco monogrammicus*	-	+	-	-
9	Accipitridae	Wahlberg's Eagle	*Aquila wahlbergi*	+	-	-	-
10	Accipitridae	Tawny Eagle	*Aquila rapex*	+	+	-	-
11	Accipitridae	Crowned Eagle	*Stephanoaetus coronatus*	+	-	-	-
12	Accipitridae	Long Crested Eagle	*Lophaetus occipitalis*	+	+	-	-
13	Falconidae	Common Kestrel		+	+	+	+
14	Falconidae	Lanner Falcon	*Falco biarmicus*	+	+	+	-
15	Falconidae	Grey Kestrel	*Falco ardosiaceus*	+	+	+	+
16	Phasianidae	Double-spurred Francolin	*Pternisitis bicalcaratus*	+	+	+	+
17	Phasianidae	Stone Partridge	*Ptilopachus petrosus*	+	+	+	+
18	Columbidae	African green pigeon		-	+	-	+
19	Columbidae	Bruce's Green Pigeon	*Treron waalia*	+	+	-	-
20	Columbidae	Red-eyed Dove	*Streptopelia semitorquata*	+	+	+	+
21	Columbidae	Vinaceous Dove	*Streptopelia vinacea*	+	+	+	+
22	Columbidae	Laughing Dove	*Streptopelia senegalensis*	+	+	+	+
23	Columbidae	Black-billed Wood Dove	*Turtur abyssinicus*	+	+	+	+
24	Psittacidae	Senegal Parrot	*Poicephalus senegalensis*	+	+	-	-
25	Musophagidae	Violet Turaco	*Musophaga violacea*	+	+	-	-
26	Musophagidae	Western Grey Plantain-eater	*Crinifer piscator*	+	+	+	+
27	Cuculidae	Didric cuckoo	*Chrysococcyx capricus*	+	+	+	+
28	Cuculidae	Klaas's Cuckoo	*Chysococcyx klaas*	+	+	+	+
29	Cuculidae	Red-chested Cuckoo	*Cuculus solitaries*	+	+	+	-
30	Cuculidae	Senegal Coucal	*Centropus senegalensis*	+	+	+	+
31	Caprimulgidae	Long-tailed Nightjar	*Caprimulgus climacurus*	+	-	-	-
32	Caprimulgidae	Plain Nightjar	*Caprimulgus inornatus*	+	+	-	+
33	Apodidae	Little Swift	*Apus affinis*	+	+	+	-
34	Alcedinidae	African Pygmy Kingfisher	*Ispidina picta*	+	+	-	-
35	Alcedinidae	Pied kingfisher	*Ceryle rudis*	+	+	-	-
36	Meropidae	Red-throated Bee-eater	*Merops bulocki*	+	+	-	-
37	Coraciidae	Blue-bellied Roller	*Coracias cyanogaster*	+	+	-	-
38	Coraciidae	Broad-billed Roller	*Eurystomus glaucurus*	+	-	-	-
39	Bucerotidae	Piping Hornbill	*Bycanistes fistulator*	+	-	-	-
40	Bucerotidae	African Grey Hornbill	*Tockus nasutus*	+	+	+	+
41	Bucerotidae	Bearded Barbet	*Lybius dubius*	+	+	-	-
42	Bucerotidae	Viellot Barbet	*Lybius vielloti*	+	+	-	-
43	Picidae	Cardinal Woodpecker	*Dendropicos lafresnayi*	+	-	-	-
44	Picidae	Fine-Spotted Woodpecker	*Campethera punctuligera*	+	-	-	-
45	Hirundinidae	Ethiopian Swallow	*Hirundo aethiopica*	+	+	+	-
46	Hirundinidae	Saw-wings	*Psalidoprocne obscura*	+	+	+	-
47	Hirundinidae	Rock Martin	*Ptyonoprogne fuligula*	-	-	+	-
48	Hirundinidae	Red-rumped Swallow	*Cecropis daurica*	+	+	+	+
49	Motacilidae	Yellow-throated Longclaw	*Macronyx croceus*	+	+	-	+
50	Campephagidae	Red-shouldered cuckoo-shrike	*Campephaga phoenicea*	+	+	-	+
51	Pycnonotidae	Common Bulbul	*Pycnonotus barbatus*	+	+	+	+
52	Pycnonotidae	Yellow-throated Leaflove	*Atimastillas flavicollis*	+	+	+	+
53	Turdidae	African Thrush	*Turdus pelios*	+	+	+	+
54	Turdidae	Snowy-crowned Robin-chat	*Cossypha niveicapilla*	+	+	+	+
55	Turdidae	White-crowned Robin-chat	*Cossypha albicapilla*	-	+	+	-
56	Muscicapidae	Familiar Chat	*Oenanthe familiaris*	-	+	+	+
57	Sylviidae	African Moustached Warbler	*Melocichla mentalis*	+	+	-	+
58	Sylviidae	Black Cap	*Sylvia atricapilla*	+	+	-	-
59	Sylviidae	Northern Crombec	*Sylvieeta branchyura*	+	+	-	+
60	Sylviidae	Garden warbler	*Sylvia borin*	+	+	+	-

S/N	Group/Family	English Name	Scientific name	FL	GF	RO	UG
61	Sylviidae	Oriole Warbler	*Hypergerus atricep*	+	+	-	+
62	Sylviidae	Red-winged Warbler	*Prinia erythroptera*	+	+	+	+
63	Sylviidae	Senegal Eremomela	*Eremomela pusilla*	+	+	-	+
64	Sylviidae	Grey-backed Camaroptera	*Camaroptera brevicaudata*	+	+	+	+
65	Sylviidae	Tawny-flanked Prinia	*Prinia subflava*	-	+	-	+
66	Cisticolidae	Dorst's Cisticola	*Cisticola dorsti*	+	+	+	+
67	Cisticolidae	Winding Cisticola	*Cisticola galactotes*	+	+	-	+
68	Cisticolidae	Rock-loving Cisticola	*Cisticola emini*	-	-	+	-
69	Cisticolidae	Short-winged Cisticola	*Cisticola brachypterus*	+	+	+	+
70	Cisticolidae	Singing Cisticola	*Cisticola cantans*	+	+	+	+
71	Muscicapidae	African Blue Flycatcher	*Elminia longicauda*	+	-	-	-
72	Muscicapidae	African Paradise Flycatcher	*Terpsiphone viridis*	+	-	-	-
73	Muscicapidae	Northern Black Flycatcher	*Melaenornis edolioides*	+	+	-	+
74	Muscicapidae	Senegal Batis	*Batis senegalensis*	+	+	+	-
75	Platysteiridae	Common Wattle-eye	*Platysteira cyanea*	+	+	-	+
76		Brown Babbler	*Turdoides plebejus*	+	+	-	-
77	Certhiidae	African Spotted Creeper	*Salpornis salvadori*	+	-	-	+
78	Zosteropidae	Yellow white-eye	*Zosterops anderssoni*	-	+	-	
79	Nectariniidae	Green-headed Sunbird	*Cyanomitra verticalis*	+	+	-	+
80	Nectariniidae	Scarlet-chested Sunbird	*Chalcomitra senegalensis*	+	+	+	+
81	Nectariniidae	Splendid Sunbird	*Cinnyris coccinigastrus*	+	+	-	+
82	Nectariniidae	Variable Sunbird	*Cinnyris venustus*	+	+	+	+
83	Nectriniidae	Copper Sunbird	*Cinnyris cupreus*	+	+	-	+
84	Liniidae	Yellow-billed Shrike	*Corvinella corvine*	+	+	-	+
85	Malaconotidae	Tropical Boubou	*Laniarius major*	+	+	-	-
86	Malaconotidae	Northern Puffback	*Dryoscopus gambensis*	+	+	-	-
87	Malaconotidae	Black-crowned Tchagra	*Tchagra senegalus*	+	+	+	+
88	Oriolidae	African Golden Oriole	*Oriolus auratus*	+	+	-	-
89	Corvidae	Piapiac	*Ptilostomus afer*	+	+	-	-
90	Corvidae	Pied Crow	*Corvus albus*	+	+	+	+
91	Sturnidae	Purple Glossy Starling	*Lamprotornis purpureus*	-	+	+	+
92	Sturnidae	Long-tailed Starling	*Lamprotornis caudatus*	+	+	-	-
93	Passeridae	Northern Grey-headed Sparrow	*Passer griseus*	+	+	+	+
94	Ploceidae	Black-necked Weaver	*Ploceus nigricollis*	+	+	-	+
95	Ploicedae	Black-headed Weaver	*Ploceus melanocephalus*	+	+	-	+
96	Ploicedae	Village Weaver	*Ploceus cucullatus*	+	+	+	+
97	Ploicedae	Black-winged Red Bishop	*Euplectes hordeaceus*	-	+	+	-
98	Ploceidae	Yellow-mantled Widowbird	*Euplectes macroura*	+	+	+	+
99	Ploicedae	Northern Red Bishop	*Euplectes franciscanus*	+	+	+	+
100	Viduidae	Pin-tailed Whydah	*Vidua macroura*	+	+	+	+
101	Estrildidae	Black-bellied Firefinch	*Lagonosticta rara*	-	+	-	+
102	Estrildidae	Black-rumped Waxbill	*Estrilda troglodytes*	+	+	+	+
103	Estrildidae	Black and White Mannikin	*Spermestes bicolor*	-	+	+	+
104	Estrildidae	Bronze Mannikin	*Lonchura cucullata*	+	+	+	+
105	Estrildidae	Orange-cheeked Waxbill	*Estrilda melpoda*	+	+	-	+
106	Estrildidae	Red-billed Firefinch	*Lagonosticta senegala*	-	-	+	+
107	Estrildidae	Red-cheeked Cordon-bleu	*Uraeginthus bengalus*	+	+	+	+
108	Emberizidae	Cinnamon-breasted Bunting	*Emberiza tahapisi*	-	-	+	-
109	Viduidae	Village Indigobird	*Vidua chalybeate*	+	+	+	+
110	Bucerotidae	Yellow-fronted Tinkerbird	*Pogniulus chrysoconus*	+	+	+	+

FL= Farmland, GF= Gallery forest, RO= Rocky outcrop, UG= Uncultivated grassland

Table 2: Comparison of bird species abundance among different habitat types

Habitat Types	Difference	Lower Value	Upper Value	p value
Farmland-Gallery Forest	60.70	7.72	113.69	0.02*
Farmland-Rocky Outcrop	11.45	-83.33	106.24	0.99
Farmland-Uncultivated Grassland	-13.80	-66.78	39.19	0.88
Gallery Forest-Rocky Outcrop	-49.25	-150.71	52.21	0.52
Gallery Forest - Uncultivated Grassland	-74.50	-138.67	-10.33	0.02*
Uncultivated Grassland-Rocky Outcrop	-25.25	-126.71	76.21	0.89

* = statistically significant

Table 3: Comparison of bird species diversity among different habitat types

Habitat	Difference	Lower value	Upper value	p- value
Farmland-Gallery Forest	0.09	-0.11	0.29	0.58
Farmland-Rocky Outcrop	0.18	-0.18	0.54	0.49
Farmland-Uncultivated Grassland	-0.01	-0.21	0.19	0.10
Gallery Forest-Rocky Outcrop	0.09	-0.30	0.48	0.91
Gallery Forest-Uncultivated Grassland	-0.10	-0.35	0.14	0.64
Uncultivated Grassland-Rocky Outcrop	-0.19	-0.58	0.19	0.50

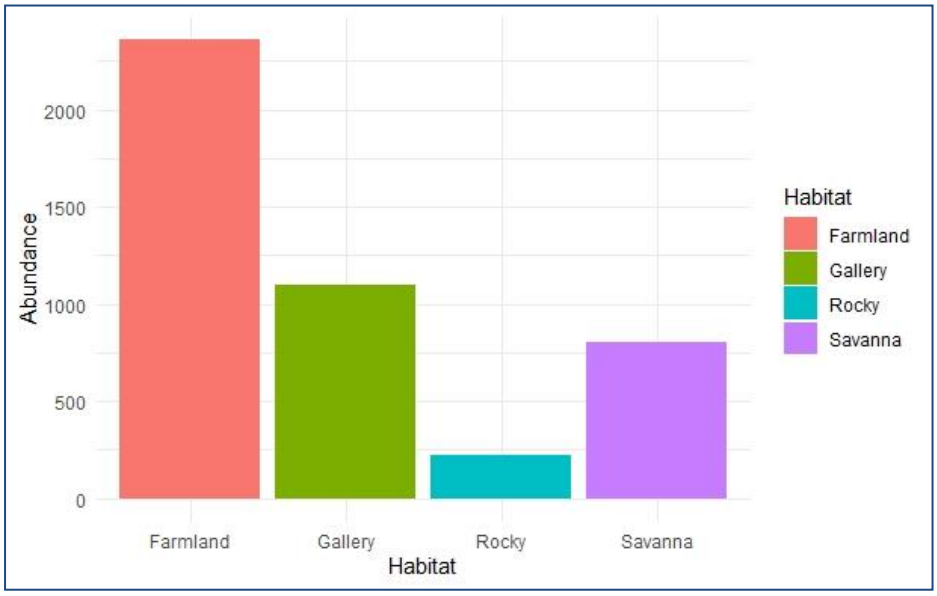

Figure 2. Abundance of bird species across different habitat type (df=3, p=0.02)

Bird species abundance and diversity in comparison with vegetation variables

The vegetation variables had no significant (p>0.05) effect on avian species diversity (Figure 3) on the whole. However, vegetation variables such as small trees, number of dead trees, number of fruiting trees, percentage canopy cover and liter cover showed a significant (p<0.05) change in the bird species abundance. The Shannon-Wiener diversity index was highest in the rocky habitat (H=3.64) followed by gallery habitat with diversity index of 3.55 while uncultivated woodland and the cultivated farmlands had diversities of 3.45 and 3.46 respectively.

Bird species diversity in comparison with anthropogenic activities

The anthropogenic activities observed during the study include farming (F), grazing (G), mining (M), logging (L) and deforestation (D). All of these anthropogenic activities did not show any significant ($F_{5,14}$ 1.453, P=0.27) effect on the bird species diversity in the study site.

Species effort curve

The Species effort Curve (Figure 4) shows the amount of effort put in during the study with respect to the total number of species at the study site. The curve reached asymptote, which implies that much effort was inputted during the study thus; most of the species in the study site were identified and recorded during the survey. (Effort is an ornithological language meaning enough number of visits were made to record 99% of the species at the site. If the Curve did not flatten at the peak it signifies not all species at the site were identified because less effort was put in).

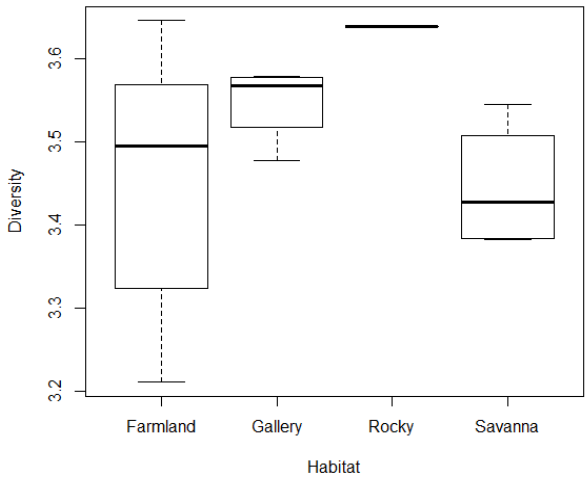

Figure 3. Mean bird species diversity across different habitat types.

Legend: ----- = The whisker from the bottom shows the lowest value that is not an outlier while the whisker at the top shows the highest value that is not an outlier.

▭ = The bottom box represents the first quartile while the top box represents the 3rd quartile.

___ the thick middle line represents the median while the width of the box shows the inter quartile range.

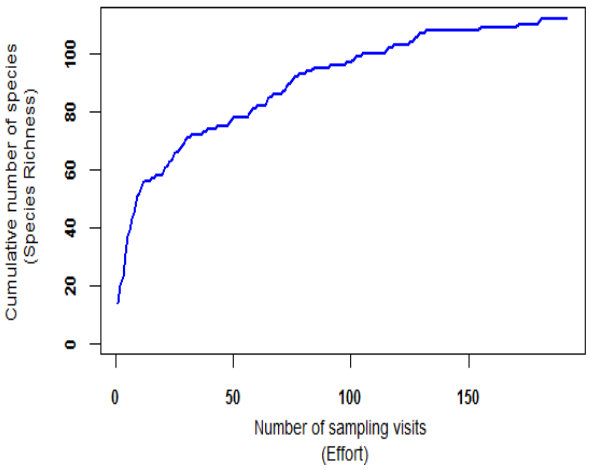

Figure 4. Species effort curve during sampling at the study site.

Discussion

The large number of species (110) recorded during the study including restricted range species is an indication of ornithological importance of the study site. Studies have shown that the more complex a habitat is the more species it is likely to contain (Aubrey *et al* 2005, Imong and Manu 2011). The zone 8 area of Lokoja having four habitat types (gallery forest, cultivated farmland, uncultivated grassland and rocky outcrops) adjacent to one another demonstrated this attribute of high bird diversity. Although both bird species abundance and diversity are known to vary with habitat type, but in the present study habitat type affected bird species abundance only. Imong and Manu (2011) observed that habitat types affected both bird species diversity and abundance in Sankwala Mountains in Southern Nigeria. In this study, bird species diversity was not significantly different between the four habitat types. A possible reason for the observed similarity in species diversity could be differences in detectability among the habitats. A habitat may contain more species and more individuals, if the probability of detecting is low, it may compare to hold similar number with the other habitats with higher detection probability. Also, the habitat structure and the species behavior will determine the bird's detectability. Shy bird species have low detectability while gregarious species have high probability of been detected. Also, the close proximity of these habitats to one another could make the birds to utilize the other habitats as their home-range (Tanko 2008; Tanko and Ivande 2011).

The habitats differ significantly in terms of species abundance. Farmland and uncultivated grassland differed significantly from the gallery forest. This is in line with the findings of Ajagbe (2004) and Nsor *et al* (2018) that reported that avian community structure is a function of habitat types as well as other factors. The availability of crops and type of crops grown on farmlands could also have a marked effect on bird's abundance. The results obtained in this study corroborates the very recent study of Tu *et al* (2020) who asserted from their findings that different habitat types affect bird richness and evenness. In a study by Imong and Manu (2011), a montane grassland was reported to contained higher bird's density than other habitat types. In a similar study (Igl and Ballard 1999), birds density was higher in woody vegetation than the grassland habitat. In advancing reason for their observation, they attributed the variation as due to the presence of several conspicuous relatively less shy and flocking species. These less shy and conspicuous species were the common species encountered in this study. The results may also be explained by the presence of several visiting or forest edge species recorded in these habitats and demonstrate the importance of other habitat types to savanna birds in a heterogeneous landscape like Lokoja. In this study, the farmland had more number of individuals than other habitats; this is probably due to temporal abundance of food supply on farmland as this survey was done during rainy season. Abundance of food could have attracted several birds as they could feed easily and quickly, and thus reducing predation risk. Also, the availability of different types of crops on the farmlands could also have a marked effect on abundance as different crops may attract other visitors that seve as birds' food. The birds encountered during the study include granivorous and insectivorous feeders, examples of such species are doves, bishops, bronze manikin common bulbuls etc. Also, most of the species encountered move in flocks, which is in line with the findings of Bradbury *et al* (2004).

Higher density estimates for cultivated farmland compared to other undisturbed habitat types illustrate that habitat disturbance might be an important factor in the distribution of birds in the Lokoja area. Increase in bird numbers has been reported to follow habitat disturbance because of invasion by generalist, opportunistic and habitat edge species (Fjeldsa 1999; Tanko and Ivande 2011). When ecosystems are modified, traditional habitats for some species are lost while some are created for other species.

Habitat type had no significant effect on bird species diversity. This could be attributed to the fact that the habitats are close to each other or overlapping, making it possible for different species to utilize almost all the habitat types. The findings comply with many other studies (Chace and Walsh 2006; Sandstrom *et al* 2005 and Nsor *et al* 2018) that higher vegetation cover support higher diversity of birds.

The species composition in the different habitat types however indicates that each habitat is important in supporting certain species than others. For example, even though cultivated farmland had more species (95) than other habitats, there were some species that restricted their activities to one or two of the other habitat types. The loss of these habitats may therefore mean the loss of these species. From the species accumulation curve, it can be inferred that a considerable amount of effort was put in place during the study period and a good number of the species in the study site were encountered, but the point of asymptote on the graph clearly depicts that it was not a steady straight line but fluctuated from time to time. If the study time was a bit extended a steady point would have been reached, and we can conclude all species in the study area have been identified and recorded.

Conclusion

Zone 8 is made up of different habitat such as, uncultivated grassland, farmland, rocky and gallery habitat (riparian forest inclusive). In view of the study, irrespective of different anthropogenic activities on-going in this area, Zone 8 was observed to be rich in avian species diversity and abundance with different species occupying different favorable habitat. These activities however can disrupt the natural ecosystem and affect the abundance and diversity of both avian species and plant community. Of all these activities, farming, which is the dominating disturbance should be monitored to avoid serious negative impact on avifauna in the nearest future. Further studies are recommended at the site to examine the habitat in terms of quality and quantity that could be managed and conserved in order to maintain the ecosystem.

References

Adang, K.L, Tanko, D., Kachi, J and Abdulwahab, U.A. 2018. Bird Species Richness and Diversity of Lokoja and Environs, Kogi State, Nigeria. Proceedings of 6th NSCB Biodiversity Conference; Uniuyo 2018, 117-124.

Ajagbe, A.A. 2004. A comparison of Bird diversity between Amurum Forest Reserves, Jos East L.G.A., Plateau State and surrounding farmlands. *Unpublished M.Sc. Project*, University of Jos.

Aubry, S., Magnin, F., Bonnet, V. and Preece, R. 2005. Multi-scale altitudinal patterns in species richness of land snail communities in Southe Eastern France. J. Biogeogr. *32*(*6*): 985- 998.

Bakam, H., Nura, F. Agbo, B. O. and Tanko, D. 2016. Study on Avian Utilization of *Gmelina arborea* in General Hassan Usman Katsina Park, Kaduna, Nigeria. *J. Nat. Sci. Res. 6*(*12*): 65-73.

Bibby, C.J., Bugress, N. D., Hill, D.A. and Mustoe, S.H. 2000. *Birds Census Techniques*, Acdemic press Lodon.257pp

Bird Life International, 2000. *Threatened birds of the world*. Lynx Editions, 852pp.

Borrow, N. and Demey, R. 2013. *Birds of Western Africa*. Christopher Helm, London, 511pp.

Bradbury, R.B., Browne, S.J., Stevens, D.K. and Aebischer, N.J. 2004. Five-year evaluation of the impact of the Arable Stewardship Pilot Scheme on birds. *Ibis 146*: 171–180.

Campbell, N.A., Reece, L.A., Cain, M.L. Wasserman, S. A., Minorsky, P. V. and Jackson, R. B. 2008. *Biology* (8th ed.) Pearson International Edition, Benjamin Cummings, San Francisco, Canada. 1393pp.

Carignan, V. and Villard, M.A. 2002. Selecting indicator species to monitor ecological integrity: a review. *Environ. Monit. Assess. 78*: 45-61.

Chace, J.F., and Walsh, J.J. 2006. Urban effects on native avifauna: A review. *Landsc. Urban Plan 74*:46–69.

Chambers, S.A. 2008. *Birds as Environmental Indicators*: Review of Literature. Parks Victoria Technical Series No. 55. Parks Victoria, Melbourne

Daily, G.C. Ehrlich, P. R. and Snchez-Azofeifa, G. A. 2001. Countryside Biogeography: use of human dominated habitats by the avifauna of South Costa Rica. *Ecol. Appl. 11*: 1-13.

Earnst, S.L. and Holmes, A.L. 2012. "Bird-habitat relationships in interior Columbia Basin shrubsteppe," *Condor. 114* (*1*): 15–29.

Fjeldsa, J. 1999. The impact of forest disturbance on the endemic avifauna of the Udzungwa Mountains, Tanzania, *Bird Conserv. Int. 9*: 47-62

Gabbe, A.P., Robinson, S.K. and Brawn, J.D. 2002. "Tree-species preferences of foraging insectivorous birds: Implications for food plain forest restoration," *Conserv. Biol. 16*(*2*): 462–470.

International Union for the Conservation of Nature-IUCN, 2010. Abundance and distribution of selected species: Common Bird Index, Armenia, Azerbaijan and Georgia. Tanzania. *Bird Conserv. Int. 9*:46-62.

Ishtiaq, F., Javed, S. Coulter, M.C. and Rahmani, A.R. 2010. Resources partitioning in three sympatric species of storks in Keoadea National Park, India, *Waterbirds*, *33*(*1*): 41-49.

Igl, L.D. and Ballard, B.M. 1999. Habitat associations of migrating and overwintering grassland birds in Southern Texas. *Condor 101*: 771-782

Imong S.I. and Manu, S.A.2011. Effects of habitat type and anthropogenic disturbance on the density and distributrion of birds in the Sankwala Mountains, Cross -river state, Nigeria, *Roans 5*(*1*): 50-62.

Kress, S.W. 2000. *Birder's Handbook*. Dorling Kindersley Publishing, Inc., New York, 176pp.

Lin, D. L. Fu, S.W. Yuan, H.W. and Ding, T.S. 2019. Bird species richness in relation to land-use patch structure and vegetation structure in a forest-agriculture mosaic. *Ornithol. Sci. 18*: 1-13.

Mekonen, S. 2017. Birds as Biodiversity and Environmental Indicator. *J. Nat. Sci. Res. 7*(*21*): 28-34.

Mikusinski, G., Gromadzki, M. and Chylarecki, P. 2001. Woodpeckers as indicators of forest bird diversity. *Conserv. Biol. 15*(*1*): 208-217.

Nsor, C. A., Acquah, E, Mensah, G. Kusi-Kyei, V. and Boadi, S. 2018. Avian Community Structure as a Function of Season, Habitat Type, and Disturbance, in Mole National Park, Northern Region (Ghana). *Int. J. Ecol.* 1-15. https://doi.org/10.1155/2018/2045629

Sandstrom, U.G; Angelstam, P. and Mikusinski, G. 2005. Ecological diversity of birds in relation to the structure of urban green space. *Landsc. Urban Plan. 77*: 39-53.

Sauberer, N., Zulka, K.P., AbenspergTraun, M., Berg, H.M., Bieringer, G., Milasowszky, N., Moser, D., Plutzar, C., Pollheimer, M., Storch, C., Trostl, R., Zechmeister, H. and Grabherr, G. 2004. Surrogate taxa for biodiversity in agricultural landscapes of eastern Austria. *Biol. Conserv. 117*(*2*): 181-190.

Tanko, D. 2008. Quantitative and Qualitative description of the preferred habitat of the White crowned Robin-chat *Cossypha albicapilla*, in Zaria, Nigeria. *Biol. Environ. Sci. J. Trop. 5*(*20*): 23-26.

Tanko, D. and Ivande S.T. 2011 A Survey of the avifauna of relatively undisturbed vegetation in Zaria, Nigeria, *Roan 5*(*1*): 131-140.

Tanko, D., Adang K.L. and Kachi, J.B. 2018. Preliminary Checklist Avifauna within Lokoja Area *Int. J. Appl. Biol. Res. 8*(*2*): 222-231.

Tanko, D. and Wada, F.E. 2020. Assessment of Ecological and Conservation Impacts of wildlife Exploitations as Bushmeat in Lokoja Forest Area, Kogi State, Nigeria. *Int. J. Zool. Res. 16*(*1*): 26-32.

Thomson, J.R., Fleishman, E., Mac Nally, R. and Dobkin, D.S. 2007. Comparison of predictor sets for species richness and the number of rare species of butterflies and birds. *J. Biogeogr. 34*(*1*): 90-101.

Tu, H.M., Fan, M.W. and Ko, C.J. 2020. Different Habitat Types Affect Bird Richness and Evenness. Sci Rep 10, 1221. https://doi.org/10.1038/s41598-020-58202-4. Access 7th October, 2019.

Zakaria, M.L., Leong P.C. and Yusuf, M.E. 2005. Comparison of Species Composition in Three Forest Types: Towards using Birds as indicators of Forest Ecosystem Health. *J. Biol. Sci. 5*(*6*): 734- 737.

Citation: Tanko, D., Okwu, N. S., Kachi, J. B. and Adejoh, B. 2022. Comparison of avian species diversity and abundance in relation to habitat structure: toward using birds as indicators of ecosystem health at zone 8, Lokoja, Kogi State, Nigeria. http://dx.doi.org/10.4314/tzool.v20i1.16.

The Zoologist, 20. 124-132 October, 2022, ISSN 1596 972X.
Zoological Society of Nigeria