



EFFECTS OF ENVIRONMENTAL VARIABLES ON THE DISTRIBUTION AND DIVERSITY OF AVIAN SPECIES IN THREE SELECTED LOCATIONS IN THE UNIVERSITY OF IBADAN, IBADAN, NIGERIA

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ABSTRACT

*The effects of environmental variables on the distribution and abundance of avian species in the University of Ibadan was carried out. Three sites were selected within UI [Fallow/Urban Land (FUL), Conserved Forest (CF), and Oil Palm Plantation (OPP)]. Birds were sampled between November 2023 and March 2024 using the Point Count method with a 50m radius. Binoculars were used for visible species and a voice recorder for audible but out-of-sight birds. Avian species composition and abundance were determined using standard methods. Diversity was determined using Shannon-Weiner index. Monthly temperature and rainfall data were collected from Nigerian Meteorological Agency (NiMet). Data were analysed using descriptive statistics, Canonical Correspondence analysis, and Bray-Curtis Cluster analysis in Paleontological Statistics (PAST). A total of 1,642 individual avian species were encountered belonging to 17 families. The families Corvidae and Columbidae were the most dominant families in the study area. The highest and lowest diversity indices were: FUL (2.271) and OPP (1.935) respectively. Temperature and rainfall ranges were 28.6°-32°C and 0-96mm respectively. Temperature influenced the abundance of *Spilopelia senegalensis*, *Crinifer piscator*, *Milvus migrans*, and *Columba* sp. While rainfall influenced the abundance of *Bubulcus ibis*. Both CF and FUL were similar in terms of avian diversity. Avian species were encountered in the University of Ibadan at low diversity. Hence, conservation efforts should focus on preserving diverse habitats and minimizing human impacts to maintain healthy bird populations.*

Keywords: Avian diversity, Land use systems, Habitat fragmentation, Conservation Implications, Management strategies, University of Ibadan.

Correct Citation of this Publication

xxxx (2024) effects of environmental variables on the distribution and diversity of avian species in three selected locations in the university of Ibadan, Ibadan, Nigeria. *Journal of Research in Forestry, Wildlife & Environment* Vol. 16(3): 20 - 31

INTRODUCTION

The class Aves refers to a diverse group of organisms collectively known as birds. Birds are of high economic importance in Agriculture. It is thus, very important to identify and understand factors that can influence the abundance and distribution of the avian species. There are 23 current different orders under this class. With reclassification of some other members of the

class, new orders which are yet to be universally accepted are being created (Gill, 2007). Birds are renowned for their unique adaptation of feathers, which serve many purposes such as flight, insulation, waterproofing, and display. Feathers mainly contain a protein called keratin, which is arranged in a complex structure. This complex structure of keratin allows for both flexibility and strength in birds (Wu *et al.*, 2015). Example of

these birds includes; ducks, rooster, eagle, black kite, barn owl, etc.

Avian species exhibit a remarkable diversity of beak shapes and sizes, which represent the wide range of ecological niches they occupy and the diverse feeding strategies, put in place to ensure their survival. This variation in their beak morphology has been observed and studied to be as a result of evolutionary adaptation to specific environmental challenges and resource availability (Grant and Grant, 2006).

Some birds exhibit a very strong and powerful beak which is highly useful during hunting. Birds of prey (eagles and hawks) have very powerful, hooked beaks which are well adapted for tearing flesh, while little birds such as the hummingbirds (Trochilidae family) possess long but slender beaks perfectly suited for sipping nectar from flowers (Jung *et al.*, 2018). Water-loving birds such as ducks and geese have broad, flat beaks which engineered to enhance filter-feeding on aquatic vegetation. On the other hand, shorebirds like sandpipers have slender, probing beaks which are ideal for burrowing and searching for invertebrates in mudflats (Höfling and Abourachid, 2020). The variation in avian beaks projects the importance of niche specialization and resource partitioning in ecosystems sustainability, management and in maintaining biodiversity (Höfling and Abourachid, 2020). Birds are oviparous organisms. Unlike mammals, they reproduce by laying eggs rather than giving birth to live young ones. This reproduction strategy offers many advantages which include efficient utilization of resources and the ability to disperse offspring widely. This process of bird's reproduction begins with the formation of eggs within the female's reproductive tract and stored right in the tract, after which they are fertilized by sperm from the male during copulation (Gilbert, 2014).

As oviparous organisms, birds have a key adaptation that enables their success. A key factor to this success as oviparous organisms observed in birds is the development of complex nesting behaviours and parental care strategies. Many bird species construct intricate nests to provide a secure environment for their eggs and young (e.g. Village Weaver *Ploceus cucullatus*), while others

rely on cryptic egg coloration or nesting in inaccessible locations (e.g Peregrine Falcon *Falco peregrinus*) to avoid predation (Arslan and Martin, 2024). Despite these advantages of oviparity in aves, avian reproduction also poses challenges, most especially in terms of incubation and thermoregulation.

Generally, birds have evolved over time different strategic mechanisms for adaptations to their oviparous reproductive mode. This accounts for their ability to successfully reproduce and thrive in diverse environments (Martin and Mouton, 2020). Some social behaviour such as cooperative breeding and flocking, have also been extensively studied. Cooperative breeding is a situation where individual birds other than the parents help raise offspring. It has been documented in various bird species and is believed to confer reproductive and survival benefits (Koenig and Dickinson, 2016).

Migration behaviour in birds is another fascinating aspect of avian behaviour. Studies on avian foraging behaviour have revealed core feeding strategies and adaptations to resource availability. Birds have a wide range of foraging techniques, from probing and pecking to diving and aerial hawking. Each foraging technique is tailored to meet their specific dietary preferences and ecological niches (Morales *et al.*, 2020).

In addition to individual behaviours, birds have interesting social interactions and networks in shaping avian communities and ecosystems. Birds engage in complex social behaviours, such as cooperative breeding, cooperative foraging, and coalition formation, which influence group dynamics and resource distribution (Farine *et al.*, 2021). With respect to the increase in the rate of climate change, research on the effects of climate change on avian distributions in Africa has become increasingly of high ecological importance. Shift in the elevation ranges of montane bird species in East Africa indicates the potential vulnerability of highland avifauna to warm temperatures. Land disturbance is another major factor in the distribution of avian species in the world. Hence, the need to understand how environmental variables and disturbance of land affect avian species distribution and diversity. This study was aimed at determining the avian

species distribution and abundance in three selected locations within the University of Ibadan, Ibadan, Oyo state, Nigeria.

MATERIALS AND METHODS

Description of Study Area

This study was carried out inside University of Ibadan, Ibadan, Oyo State, Nigeria. University of Ibadan is one of the metropolitan areas in the Ibadan North West Local Government Area,

located between Latitude: 7.3912 and Longitude: 3.9167. The sample sites picked within the University of Ibadan for this survey were selected based on the land use system employed over these sites. The sites were selected to study the abundance and richness of the avian species based on the three different land use system; Conserved, Cultivated and Fallow system (Fig. 1).

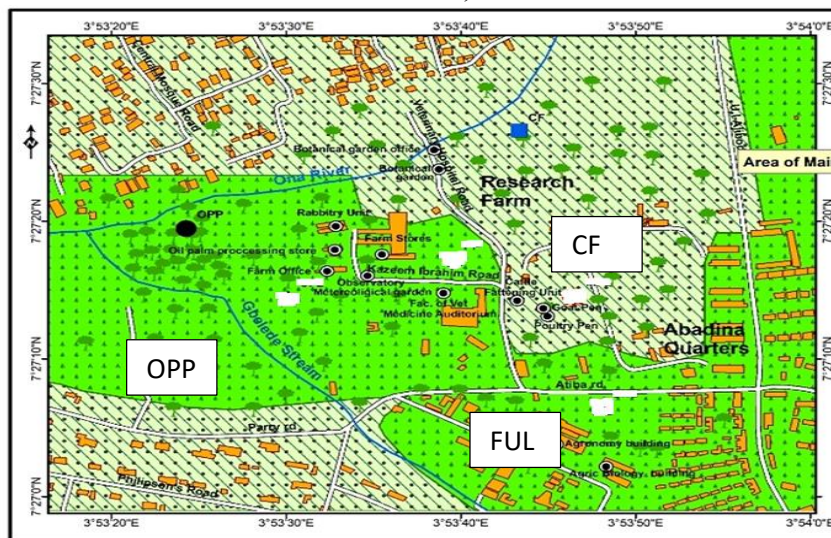


Fig 3.1: A schematic map showing the three selected locations in the University of Ibadan Fallow/Urban Land (FUL), Conserved Forest (CF), Oil Palm Plantation (OPP)

Methods of Data Collection

Point Count Method was employed to collect data. Data were collected at specified points at the sample sites over the period of 5 months (November 2023-March 2024). Specified points were selected across the three locations for this study. Each specified points had a circumference of 50m radius around it. Binoculars was used for the visible bird species and a voice recorder for the birds that are out of sight but audible (Zeleeuw and Bekele, 2008). Data on the avian species abundance were collected within this circumference. These specified points remained the same throughout the study. Data collected include avian species composition and abundance. Temperature and rainfall data were collected from Nigerian Meteorological Agency (NiMet).

Identification of the avian species encountered

Sighted bird species were confirmed through bird identification app. Merlin Bird ID and Birds of Africa were used in this task. Sounds of audible yet out-of-sight birds were examined with recorded birds from the same region to confirm the perfect match. Birds that are out of reach fast and are not audible are examined by their feather pattern on Merlin Bird ID for the best match. After identifying possible bird species, more attention is paid to their distinctive activities to pinpoint the exact bird species. This survey put into consideration the time of the day, the bird species, and the most preferred tree (that is, if they are resident birds). This survey was carried out between 7.00 – 9.00 hrs and 17.00 – 19.00 hrs twice in a month across the three selected sites.

Data Analysis

Data collected were analysed using descriptive statistics and percentages. Diversity and similarities were analysed using Shannon-Weiner index and Bray-Curtis Cluster analysis respectively in Paleontological STatistics (PAST). Canonical Correspondence Analysis (CCA) was done on PAST to determine the influence of environmental variables on the abundance of the avian species encountered in the study area

RESULTS

Species Composition and Abundance of Avian Species

The result of the study showed that a total of 1,642 individual avian species were encountered belonging to 17 families the study area between November 2023 and March 2024 (Table 1). These families which include: Corvidae, Columbidae, Accipitridae, Ploceidae, Turdidae, Ardeidae, Musophagidae, Bucerotidae, Alcedinidae, Phoeniculidae, Falconidae, Muscicapidae, Hirundinidae, Frangillidae, Phasianidae, Esterillidae and Cuculidae (Table 1). Of all these families, family Corvidae and Columbidae appeared to be most dominant families in the study area which account for three (3) species each. In addition, certain avian species were observed to not exist at all in a selected region. For example, Munia Bird Tricolor (*Lonchura malacca*) was never sighted in any location except the OPP.

Monthly Relative Abundance Across the Three Sites in the University of Ibadan (November, 2023 – March, 2024)

The result of the present study revealed the comparison or relative abundance of the avian species across the three selected locations for all the five months of survey. Highest relative abundance of avian species was recorded in the months of November 2023 (33.4) and December 2023 (26.0) in CF (Table 2). In January, 2024, highest relative abundance was recorded in OPP (25.9). Meanwhile, highest relative abundance was recorded in the month of February 2024 (38.8) and March 2024 (38.6) in FUL (Table 2).

Some Tree Species in the selected locations in the University of Ibadan (November 2023-March 2024)

Avian species need trees to feed and to roost. As such, their abundance in a particular location is greatly influenced by the trees available. This result of the present study showed some of the trees species across the three locations that were used by the avian species to nest or roost. These trees species include: *Elaeis guineensis*, *Azadirachta indica*, *Terminalia, mentaly/superba*, *Polyathlia longifolia*, *Plumeria rubra*, *Roystonea regia*. (Plate 1)

The Diversity Indices of the avian species in the three selected locations in the University of Ibadan (Nov 2023-Mar 2024)

The result of this study showed the diversity of the avian species encountered in the three selected locations in the University of Ibadan between November 2023 and March 2024 (Table 3). OPP had the highest Taxa i.e. Species richness. However, despite having a richer species composition, OPP showed the lowest Shannon Weiner diversity (1.935). FUL despite having the lowest amount of species composition showed the highest Shannon Weiner diversity (2.271) (Table 3). Highest individual species was recorded in OPP (620) while the lowest was recorded in FUL (481). On the contrary, the highest evenness was recorded in FUL (0.61) while the lowest evenness was recorded in OPP (0.39).

Influence of Environmental variables on the avian species abundance in the University of Ibadan (November, 2023 – March, 2024)

The effect of environmental variables (rainfall and temperature) on the distribution of avian species were examined in this study (Fig. 2). The result showed that abundance of *Ploceous cucullatus*, *Milvus migrans* and *Crinifer piscator* were highly influenced by change in temperature. In addition, some avian species like *Bulbuscus ibis* and *Hirundo rustica*, were greatly influenced by rainfall (Fig. 2). However, abundance of avian species such as *Corvus albus*, *Lophoceros spp*, *Falco tinninculus*, etc was not affected by rainfall and temperature (Fig. 2).

Similarities among the three selected locations based on avian species diversity in the University of Ibadan (November, 2023 – March, 2024)

The result of the present study showed the similarities among and differences between the

three selected locations in terms of the avian species diversity in the study area (Fig. 3). From the result, out of the three selected locations, FUL and CF shared high similarities compared to the OPP.

Table 1: Species Composition and Abundance of the Avian Species Encountered in the University of Ibadan (November, 2023- March, 2024)

Species	Common Name	Family	Relative Abundance (%) In Each Location					
			FUL		CF		OPP	
			7:00-9:00	17:00-19:00	7:00-9:00	17:00-19:00	7:00-9:00	17:00-19:00
<i>Corvus albus</i>	African Pied Crow	Corvidae	45	32	07	22	18	28
<i>Milvus migrans</i>	Black Kite	Accipitridae	21	27	27	18	42	27
<i>Columba spp</i>	Pigeon	Columbidae	48	53	02	08	05	02
<i>Spilopelia senegalensis</i>	Dove	Columbidae	32	24	08	09	05	03
<i>Turdus merula</i>	Common Blackbird	Turdidae	01	00	03	00	00	00
<i>Bubulcus ibis</i>	Cattle egret	Ardeidae	11	20	12	12	28	02
<i>Crinifer piscator</i>	Western Plantain Eater	Musophagidae	05	05	02	03	06	05
<i>Lophoceros spp</i>	African Hornbill	Bucerotidae	16	12	19	07	21	02
<i>Alcedo athis</i>	Woodland Kingfisher	Alcedinidae	01	00	03	04	01	01
<i>Falco tuninulus</i>	Common Kestrel	Falconidae	03	02	03	00	06	01
<i>Turtur afer</i>	Wood Dove	Columbidae	00	00	10	12	16	13
<i>Malimbe ibadanensis</i>	ÌbàdànMalimbe	Ploceidae	00	01	00	00	04	00
<i>Luscinia megarhynchos</i>	Common Nightingale	Muscicapidae	08	18	27	21	20	04
<i>Hirundo rustica</i>	Barn Swallows	Hirundinidae	25	20	150	110	186	115
<i>Crithegera spp</i>	Seed Eaters	Fringillidae	29	16	05	09	20	15
<i>Gallus gallus domestica</i>	Domestic Fowl	Phasianidae	00	01	15	13	01	00
<i>Ploceus cucullatus</i>	Weaver Bird	Ploceidae	05	00	00	00	09	00
<i>Lonchura Malacca</i>	Munia Tricolour	Estrillidae	00	00	00	00	02	00
<i>Dicrurus macrocercus</i>	Black Drongo	Corvidae	00	00	00	00	08	04
<i>Centropus sinensis</i>	Greater coucal	Cuculidae	02	00	01	04	00	00
<i>Ptilostomus afer</i>	Pipiac	Corvidae	01	00	00	00	00	04
<i>Phoeniculus spp</i>	Wood Hoopoe	Phoeniculidae	00	00	00	00	00	05

FUL= Fallow/Urban Land; CF= Conserved Forest; OPP= Oil Palm Plantation

Table 2: Monthly Relative Abundance of Avian Species across the three selected locations

MONTHS	% Relative Abundance		
	FUL	CF	OPP
NOV. 2023	21.5	33.4	16.8
DEC. 2023	22.8	26.0	24.1
JAN. 2024	16.9	11.3	25.9
FEB. 2024	38.8	29.3	33.2
MAR. 2024	38.6	32.6	28.8

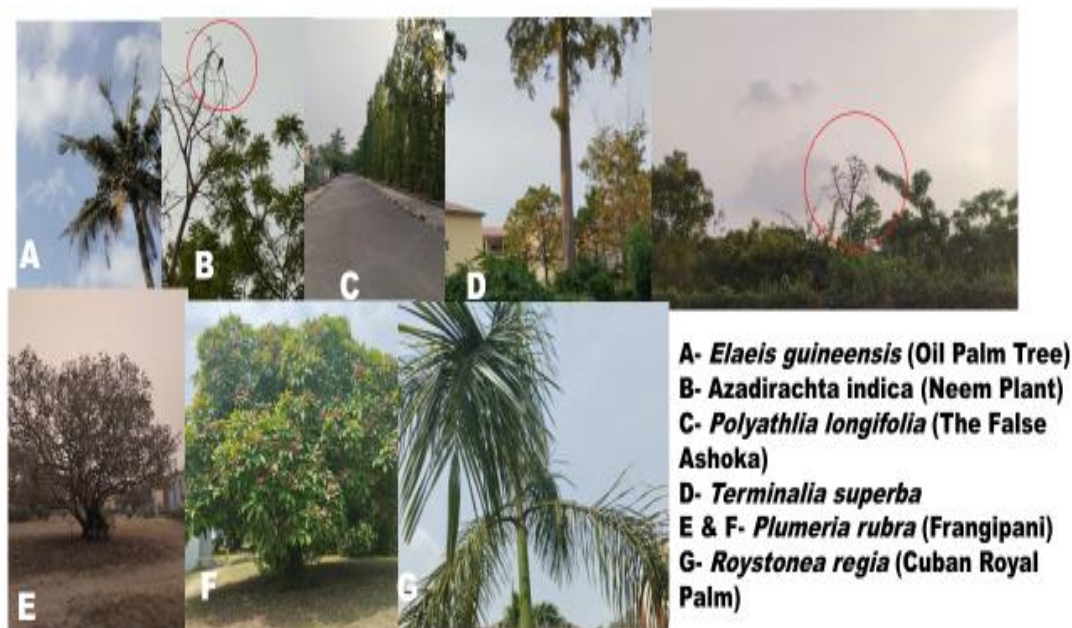


Plate 1: Some tree species used for roosting and nesting across the selected locations in the University of Ibadan

Table 3: Diversity indices of the avian species in the three (3) selected locations in the University of Ibadan (November 2023- March 2024)

	Three selected locations in the study area		
	FUL	CF	OPP
Taxa_S	17	17	20
Individual	481	541	620
Dominance_D	0.1219	0.2596	0.2656
Simpson_1-D	0.8781	0.7404	0.7344
Shannon_H	2.271	1.946	1.935
Evenness_eH/S	0.6058	0.4605	0.3846
Brillouin	2.207	1.875	1.877
Menhinick	0.7295	0.6449	0.7229
Margalef	2.429	2.225	2.644
Equitability_J	0.8193	0.7136	0.6694

Table 4: Classification (based on whether migratory or resident) of encountered Avian Species in the University of Ibadan (Nov 2023-Mar 2024)

Residential Birds	Migratory Birds
• Common Kingfisher	• Hornbill
• Black Kite	• Crow
• Pigeon	• Nightingale
• Wood Dove	• Cattle Egret
• Swallow	• Common Kestrel
• Rooster	• Seed eater
• Ibadan Malimbe	

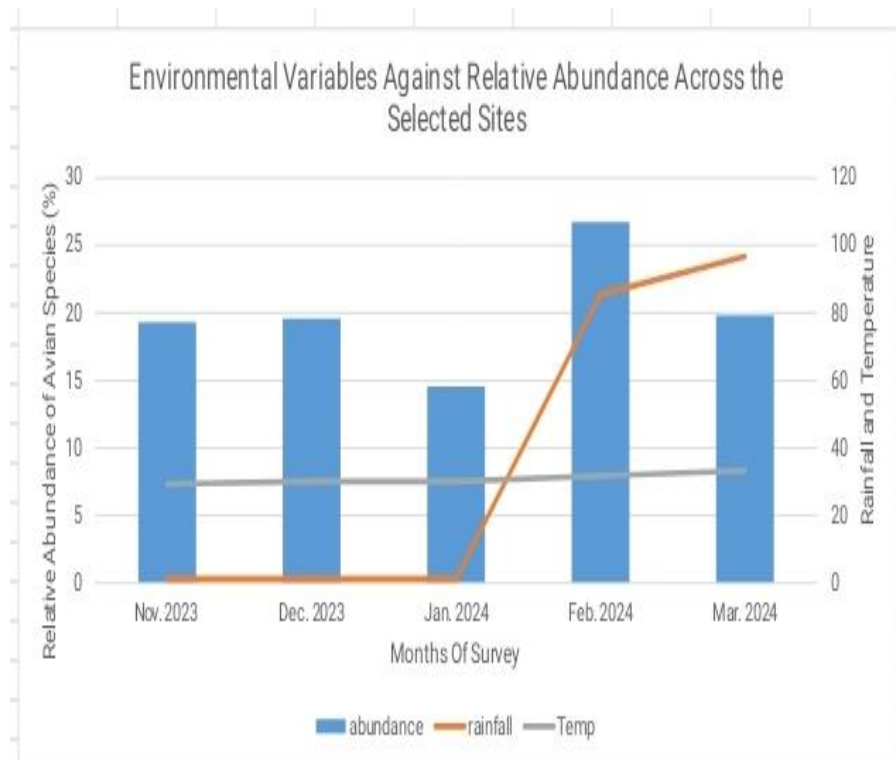


Figure. 4: Effect of Rainfall and Temperature on the monthly abundance of the avian species

DISCUSSION

Avian species distribution and diversity are influenced by various factors, including food, water, and shelter availability, which vary across different study sites. Urbanization has been shown to impact biodiversity, with native species declining and urban-adapted species becoming more prevalent in urban environments (McKinney, 2008). In this study, a total of 1,642 birds were encountered from November 2023 – March 2024. The species composition described in Table 4.1 revealed that a total of 22 avian species belonging to 17 different families were recorded within the University of Ibadan from November 2023 to March 2024. While a total of 22 avian species was encountered during the course of this study, the result revealed that some certain avian species were observed to not exist at all in a selected region. For example, Munia Bird Tricolor (*Lonchura malacca*) was never sighted in any location except the OPP. This could be that

the landscape and agricultural activities influence its presence. As rightly described by Amit *et al.* (2014), Munia birds are top candidate avian species commonly found around oil palm plantations.

In addition, Wood Dove (*Turtur afer*) was never seen in FUL but seen across CF and OPP. This could be that the avian species prefers a less disturbed area or regions with thick cover. This agrees with previous studies by Mikula *et al.* (2023) that every bird has a range of human disturbance that they can tolerate before they are triggered to flight. As such, *Turtur afer* was never sighted in FUL which had a very high human disturbance. When the monthly relative abundance of the three selected regions were analysed, there was variation in the relative abundance of the three selected locations during the course of this study. The high relative abundance observed in FUL and CF could be as a result of the availability of high tree diversity

which influences more avian species to nest or roost on. Compared to OPP with a major tree (Oil Palm), the CF and FUL showed high tree diversity, hence, influencing high relative abundance across the period of survey. This falls in agreement with previous work by Beason *et al.* (2023) that mixed tree forests and locations have more potential to support more bird species compared to a monoculture tree (as seen in OPP).

This study has revealed that avian species have different behaviour patterns, hence, are different from each other. One of such differences observed in this study is the nature of this avian species as whether migratory (Moving about) or resident (preferring a particular tree or a particular location). In this study, avian species were classified as resident species depending on whether they have a high preference for a particular tree and the frequency of sighting the avian species on the same tree. For example, *Milvus migrans* was sighted to have a nest on the *Terminalia superb* tree. In addition, *Columba guinae* were observed around the same building over many times of survey. However, certain avian species such as *Corvus albus* and *Lophoceros* spp were found to have no preference for any tree. Contrary to resident birds, they travel over a long distance and often do not build nests (Phillips *et al.*, 2018).

The study revealed a generally low diversity across the three selected locations in the University of Ibadan. However, FUL exhibited the highest relative avifaunal diversity (2.271), while OPP had the lowest (1.935). OPP had the highest Taxa i.e. Species richness (20). However, despite having a richer species composition, OPP showed the lowest Shannon Weiner diversity (1.935). FUL despite having a lower amount of species composition showed the highest Shannon Weiner diversity (2.271). This is because diversity is a measure of the ratio between total number of species and the total abundance in the community. Hence, the reason for the low species diversity in OPP despite having the highest abundance.

This study also revealed that OPP had the highest individual species (620) while FUL was recorded to have the lowest (481). On the contrary, highest evenness was recorded in FUL (0.61) while

lowest evenness was recorded in OPP (0.39). The high abundance and low evenness recorded in OPP could be as a result of the presence of few dominant species influencing the abundance of the community. This is seen in OPP having a high abundance of *Milvus migrans* and *Hirundo rustica*. This shows that the high species abundance is influenced more by the same set of species with few rare species adding to the species richness from time to time (Hillebrand *et al.*, 2008).

This study further revealed that environmental variables play a huge role in the distribution and diversity of avian species across seasons. This study revealed that some bird species are affected by temperature. Examples of these bird species include: *Ploceus cucullatus*, *Milvus migrans* and *Crinifer piscator*. In addition, some avian species like *Bulbuscus ibis* and *Hirundo rustica* are greatly influenced by rainfall. However, some birds, such as *Corvus albus* and *Lophoceros* spp., appear to be indifferent with variation to rainfall and temperature. This could be attributed to their high adaptability to different environments (DeVault *et al.*, 2016). This accounts for the availability and distribution of these avian species across a wide range of location and season. It also accounts for their ability to feed on different feed materials as reported by DeVault *et al.* (2016).

Fallow/Urban Land (FUL) having the highest avifaunal diversity and OPP having the lowest posits that there's a significant relationship between level of disturbance and avifaunal diversity. This finding resonates with previous study by Perfecto *et al.* (2014), which suggests that fallow lands can support high bird diversity by providing nesting sites, food resources, and shelter from predators. The FUL aligned with the description of Perfecto *et al.* (2014) as the trees and nesting areas of these birds are rarely disturbed when compared with the plantation site (OPP) which are constantly being disturbed by predators and chemicals used on the farm.

Ideally, studies have shown that CF should have relatively the highest avifaunal diversity among the three selected locations (Lees *et al.*, 2018). However, deforestation and other human-related activities in CF may have contributed to the low

avian diversity recorded in that area. Conserved forests, characterized by minimal human disturbance and intact natural habitats, are crucial for maintaining high levels of bird biodiversity (Lees *et al.*, 2018). The Conserved Forest of the Botanical Garden, University of Ibadan, experiences high level of disturbances such as heavy logging (as evident by the trees lying) and its use for parties. This must have contributed to the low avifaunal diversity observed in CF as against what was discovered by Lees *et al.* (2018). This agrees with previous study and fact that avian species are strongly repelled by anthropogenic noise (Francis and Barber, 2013).

Furthermore, this study revealed that there was spike in the total abundance of avian species during the first month of rainfall. This was evident in the increase of many avian species such as *Hirundo rustica*. This shows that rainfall greatly affects avian species abundance. It is also possible to state that this increase in the total abundance could have been an increase in the abundance of a single species or a few.

Agricultural activities have been known to contribute to the major decline in fauna diversity globally. Large scale agricultural practices and use of chemicals have continued to play a huge role in ecosystem declination in terms of biodiversity. These agricultural activities often result into habitat loss and fragmentation, which limits the availability of suitable habitats for all living organisms including birds (Sodhi *et al.*, 2009). OPP being densely involved in agricultural activities can account for its low avifaunal diversity and its relatively lowest avifaunal diversity when compared to FUL and CF.

Comparing the similarities between the three selected locations, the result revealed that FUL and CF shared high similarities compared to the OPP. This could be as a result of high tree diversity of the two locations compared to OPP (Beason *et al.*, 2023). This could also be as a result of low level of human intervention of the avian community observed in the two communities compared to the OPP (Bayne *et al.*, 2008). In summary, the analysis classified FUL and CF as the same structure in terms of avifauna abundance and community.

Furthermore, monoculture system (planting only one crop) farming practices also contributed to the reduction of bird species diversity by limiting the variety of food sources available. This could explain the low avifaunal diversity observed in OPP. As there was limited food range available in OPP, less avian species were attracted to it compared to the total abundance of the birds seen on it. Although OPP showed highest species composition, its diversity was low as the ratio total abundance to species was relatively higher than other sites.

Birds have been observed to be less abundant in regions with high anthropogenic noises. According to a report by Francis and Barber (2013), avian species are generally drawn away from very noisy environment. This can also account for the low diversity recorded in CF as against what was expected. This is because the open grounds in CF were sometimes utilised by the management for events that generate a very high level of noise. These activities involve the use of highly noisy speakers altered the expected diversity and distribution of the avian species in CF as against what Lees *et al.* (2018) reported.

This study has revealed the distribution and diversity of avian species in three selected locations. This study shed light on the crucial relationship between land use and avian populations. While this study revealed a low avian diversity across the three selected locations, it was revealed, alongside previous studies, that land use change, particularly habitat fragmentation and urbanization, poses significant threats to avian biodiversity. With a huge and vital role played by avian species in the environment, threats to the avian species remain a threat to the ecosystem sustenance.

Many studies have shown that deforestation, agricultural expansion, and urban development lead to declines in avian species richness and abundance, highlighting the urgent need for conservation efforts and sustainable land management practices. In addition, many studies have also agreed that urbanisation result into development of avian species better adapted to urban area.

Furthermore, this study emphasizes the importance of considering different land use types in shaping avian diversity within human-dominated landscapes. Agricultural landscapes can support a mix of generalist and specialist species, while urban areas may harbour unique avian communities adapted to anthropogenic environments. By understanding the impacts of land use on avian populations, conservationists and policymakers can develop effective strategies to mitigate these effects and promote avian

biodiversity in the face of changing environmental conditions.

CONCLUSION

Avian species were encountered in the University of Ibadan at low diversity. Hence, conservation efforts should focus on preserving diverse habitats and minimizing human impacts to maintain healthy bird populations.

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