Avian Species Assemblage in Three Tertiary Campuses Mirrors Species Composition in a Semi-Protected Forest in Gombe State-Nigeria

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Abstract

Marginal habitat alteration can benefit some bird species, but extensive modification negatively impacts species diversity and abundance by altering vegetation structure and composition. We surveyed three tertiary institutions with varying land modifications in Gombe State to compare bird species composition and abundance with a semi-protected, degraded natural landscape. sing line transect census, we surveyed morning and evening transects, recording 9,624 individuals of 100 bird species from 42 families and 73 genera. Kanawa Forest Reserve had the highest species richness (76), followed by FCET (67), FUK (59), and GSU (50), with Kanawa Forest Reserve having 22 exclusive species. However, species composition did not significantly differ among sites. Bird species abundance varied across species and study sites, with the Laughing Dove (Streptopelia senegalensis) being the most abundant species (651 individuals at GSU). Other notable species included the Cattle Egret (Bubulcus ibis) at FCE (T) with 571 individuals, the Purple Glossy Starling (Lamprotornis purpureus) at FUK with 303 individuals, and the Northern Grey Headed Sparrow (Passer griseus) at KFR with 244 individuals. Each campus hosts a unique assemblage of bird species, contributing significantly to overall avian diversity in Gombe State. We recommend minimizing alterations, particularly in remaining woodlands, and establishing additional green areas to promote heterogeneity in modified landscapes. This approach will enhance campus capacity to support diverse bird species, especially those with specific habitat requirements.

Keywords: Urbanization, Avian Diversity, Species Assemblage, Habitat modification

INTRODUCTION

Biodiversity and cosmopolitan societies are synchronously going through rapid changes in Africa, with the full destructive impacts of urbanization gathering momentum in recent decades. The need to accommodate the growing human population in cities is driving the rate and scale of land conversion into cities at alarming proportions (Seto *et al*., 2012). This ugly trend has dire consequence for biodiversity and persistence of species in what is left of their extant natural habitats. Urbanization endangers species directly by replacing their natural habitats with irreversible developmental footprints typical of human occupied areas (Czech *et al*., 2000; Groffman *et al*., 2017). These often irreversibly modified habitats end up as mega-cities, with capacity to grow, taking more land, hence natural faunal habitats in its wake.

Cities are typically located near large water bodies, rivers and estuaries, or along coastlines (World Resources Institute, 1996). Thus, high proportions of urban areas are situated on the productive bottomland and riparian systems that traditionally support rich vertebrate communities (Knopf *et al*. 1988, Ohmart 1994). As a result, high species diversity may be supported by some large parks and reserves in urban areas because the protected green areas are habitat fragments and remnants of once contiguous and highly diverse ecosystems (Schaefer 1994; Nsor *et al*., 2018).

These small patches of forests or vegetation in most cities called Urban Green Spaces (UGS) are important for supporting the range of species adapted to and capable of exploiting human densely populated areas (McKinney 2002). Urban green spaces have been shown to play important roles in maintaining biodiversity within the urbanized landscapes of cities (Ijeomah *et al*., 2013; Ihuma *et al*, 2016; Nsor *et al*., 2018; Nsor *et al*., 2019; Odewumi *et al*., 2020; Lawal and Iwajumo 2020). However documented evidence of their value to species across sub-Saharan Africa is still scarce.

Tertiary campuses are amongst the few urban settlements with potential to support biodiversity on a remarkable scale (Aminu and Safianu 2018; Nsor *et al*., 2018; Odewumi *et al*., 2020). This is based on the fact that most campuses are typically engineered or landscaped to accommodate remnant natives' along-side exotic species; these green patches will undoubtedly serve as refuges and habitats for small vertebrates such as the ubiquitous avian taxa.

Birds are a group of highly mobile vertebrates, and are found in all habitats known to man (Ezealor, 2002); their mobility, cosmopolitan nature and sensitivity to ecosystem change makes them very vital part of biodiversity, and as such; birds are often used as bio-indicators of the state of health of the environment (Gregory *et al*., 2003; Krisanti *et al*., 2017).

Bird communities in urban settings are generally characterized by low species richness and high total density or biomass compared to adjacent natural areas (Chapman and Reich, 2007; Caula *et al*., 2008). Due to the presence of both urban-avoiding native species and urban-adapted exotic species, intermediate levels of suburban development are often associated with a peak in bird richness, (Blair and Johnson, 2008). Species common to urban settings, such as exotics, are thought to have plentiful food and experience low predation pressure, thus leading to high reproductive success and higher density (Shochat *et al*., 2004).

Studies of urban bird communities typically examine the influence of natural environmental factors, such as small-scale vegetation features (Daniels and Kirkpatrick, 2006a, b; Lawal and Iwajumo 2020) and the size and spatial arrangement of natural habitat patches (Melles *et al*., 2003; Campbell, 2009; Evans *et al*., 2009). Studies like these have contributed greatly to our understanding of the relationships between avian habitats and urban areas.

The aim of this study was to assess how well birds have adapted to human modified landscapes using bird diversity and abundance as determinants. The following objectives were considered: determine the composition and diversity of bird species in the study sites; identify species of birds that may have adapted to a human modified environment as opposed to their typical semi pristine environments; investigate the composition of bird species dietary guilds in the study areas as an indicator of habitat suitability and heterogeneity.

Study areas

Federal College of Education (Technical) Gombe is located within Latitude 10˚ 18'.30" N, and Longitude 11˚ 9'.30" E, along Ashaka road in Akko Local Government Area of Gombe State. Federal University Kashere is located within latitude 9^{o} 52' N and Longitude 11^{o} 0' E in Kashere, Akko Local Government Area of Gombe State, while Gombe State University is located within Latitude 10^{o} 30' N and Longitude 11^{o} 17' E, in Tudun Wada Quarters in Gombe metropolis, the capital city, under Akko Local Government Area of Gombe State, Nigeria. The campuses are structurally divided into the academic, administrative and residential areas. However, the vegetation of GSU is largely dominated by reintroduced plant species such as date palms, mahogany, and various orchards and plantations of fruit and shade trees. GSU campus has a zoo and a well-established botanical garden; designed to mimic the various vegetation zones in the country. Apart from this unique features highlighted above, the other two campuses are quite similar in remnant tree composition. However, FCET and FUK are relatively more adorn with remnants of less-disturbed areas, farmlands, and degraded land spaces largely dominated by *Azadirachta indica* and other introduced species.

Kanawa Forest Reserve Gombe was gazetted as a forest reserve in 1953 and is located in Yamaltu/Deba Local Government Area of Gombe State. It lies between Latitude 10^{o} 16 N and 10^{o} 18' 30" N Longitude 11^{o} 18'10" E and 11^{o} 22' 09"E. It is currently managed by Nigerian Erosion and Watershed Management Project (NEWMAP) Gombe.

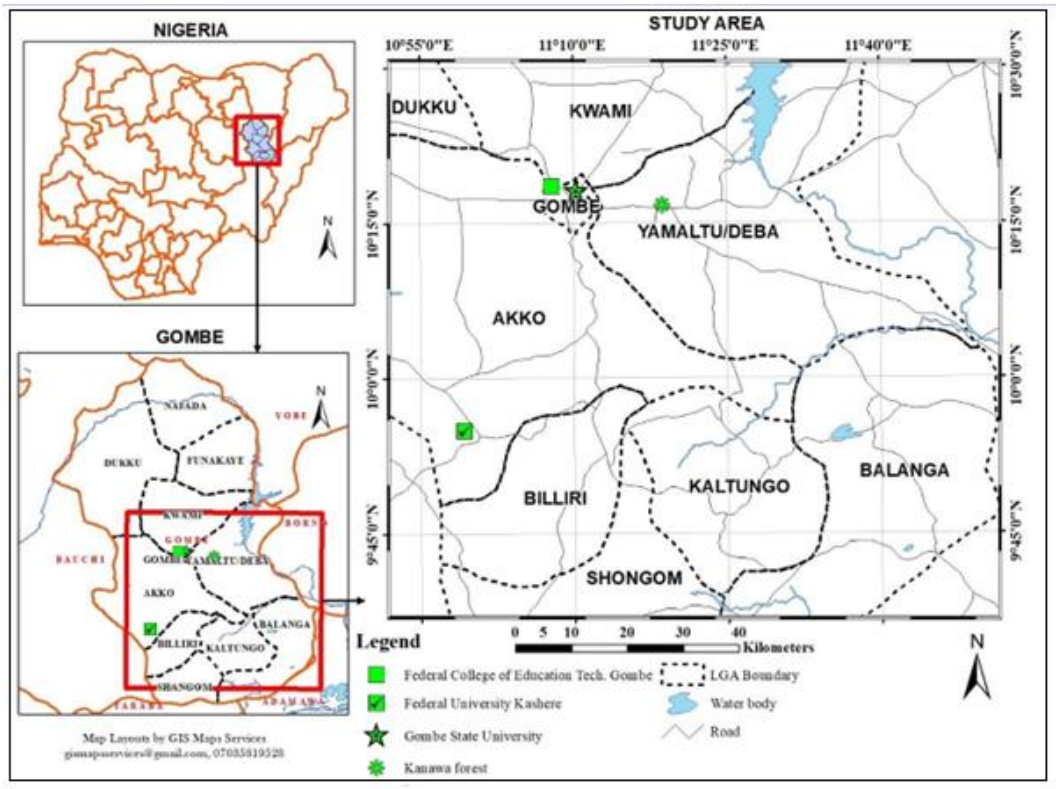

Figure 1: Map of Gombe State showing the study areas

All the study areas fall within the same vegetation zones in Gombe. In Gombe, there are two distinct seasons, the rainy and dry seasons with an annual rainfall which ranges from 850 to 1000

mm. The rainy season starts from May to October and dry season from November to April. Average daily temperatures are 34°C in April and 27°C in August. The relative humidity ranges from 70 to 80% in August and decreases to about 15 to 20 % in December. The natural vegetation is typically that of the Sudano-Sahelian Savannah, composed of shrubs, herbs, grasses and sparsely distributed trees.

Study design

Line transect method (Bibby *et al*, 2000) was adopted for the survey. Four transects of 1000m each were used in each of the study areas. Bird observations were carried out twice daily; morning session between 6:30 to 9:30 am and evening session between 3:30 to 6:30 pm. Transects were surveyed by walking slowly along the route, and all bird seen and heard were identified with the aid of a binocular (Drapter ® 12X50). Data was collected from June to November 2019. The number of times a particular bird species was seen performing the same activity gave clue about habitat utilization of the bird. Check list of all the bird species in all study sites was drawn from the total number of bird species recorded in all the sites.

Data Analysis

Data was analyzed using statistical package for social sciences (SPSS) version 25. Species richness was determined numerically as total number of species recorded in each study site. Shannon Weiner diversity index was used to determine the diversity in each of the study plots as follows;

$$H=-\sum[(p\text{i})\times\ln(p\text{i})]$$

Where H' = Shannon Wiener Index
Pi = the proportion of individuals of species "i" in relation to the total population of all species.
Loge = Natural logarithm of base e.

Sorenson's Similarity Index was used to compare the similarity of species among the various study sites following the equation below:

$$CC = 2C/S_1+S_2$$

Where CC = Sorenson's similarity index or Sorenson's coefficient of community
C = number of species present in both communities
S_1 = number of species present in community 1
S_2 = number of species present in community 2

RESULTS AND DISCUSSION

Results

Bird Species Composition in the three Campuses and KFR

A total of 9,624 bird individuals belonging to 100 bird species drawn from 42 families and 73 genera were recorded during the survey in all the study sites including Kanawa Forest Reserve which serves as control (semi-pristine environment) (Appendix 1). Results show that Kanawa Forest Reserve was the most species rich, with a total of 76 bird species belonging to 41 families

and 61 genera (Table 1). However, similarities and uniqueness in species did not differ significantly among and between the campuses (F_3=1.805, p<0.144).

Dissimilarities and Uniqueness

The Kanawa forest was the most unique in terms of species composition, with an exclusive composition of 22 species (i.e. 28.95%) contribution to the total species richness in this study. A total of 4 species each was exclusive to FCE (T) and FUK; while only two species were exclusive to GSU.

Bird species composition was most similar between FCE (T) Campus and FUK Campus (SI = 8.3, 83%) and least similar between FUK Campus and GSU Campus (SI = 7.5, 75%). Among the three Campuses**,** FUK Campus had the highest bird diversity (species richness), followed by FCET and GSU Campuses (Table 3).

Species Abundance

Species abundance differed between avian species and between study sites (F_{99} = 2.477, p<0.00). Ironically, the most abundant bird species in this study; Laughing Dove (*Streptopelia senegalensis*) with a total of 651 individuals was found in GSU - the least diverse study site. Accordingly, Cattle Egrets *Bulbus ibis* with 571, Purple Glossy Starling *Lamprotornis purpureus* with 303 and Northern Grey Headed Sparrow *Passer griseus* with 244 individuals were the most abundant species in FCET, FUK, and KFR respectively. The most species rich family was the Estrildidae family with 8, 7, and 6 species distributed across FUK, GSU and FCE (T) respectively. The three most dominant families in terms of species number were Estrildidae (Finches), Columbidae (Pigeons and Doves), and Ploceidae (Weavers) with 12, 7, and 7 species in total across the four study sites respectively (Table 2).

Table 1: Avian Species Composition in the Study Sites

Location	Habitat	Species	Family	Genera
FCET	Modified	67	33	52
FUK	Modified	59	31	48
GSU	Modified	50	28	44
KFR (Semi-Pristine)		76	41	61

Utilization of habitat by birds and feeding guilds

Avian species recorded in the various study sites were disproportionately engaged in various life sustaining activities (Figure 2). However for the most part, bird species were recorded perched, while feeding was the second most pre-dominant activity in the various study sites. Breeding, a major indicator of habitat suitability was recorded only in FUK (Figure 2).

Table 3: Diversity index within the study area

Shannon Index	FCET	FUK	GSU	KFR
Shannon DI(H)	3.08	3.19	2.83	3.29
Hmax	4.21	4.08	3.93	4.33
Equitability	0.73	0.78	0.72	0.76

Table 4: Matrix of Sorenson's coefficient of community for the three campuses and KFR

Study Sites	FCE	FUK	GSU
FUK	0.83 (83%)		
GSU	0.79 (79%)	0.75 (75%)	
KFR	0.69 (69%)	0.61 (61%)	0.63 (63%)

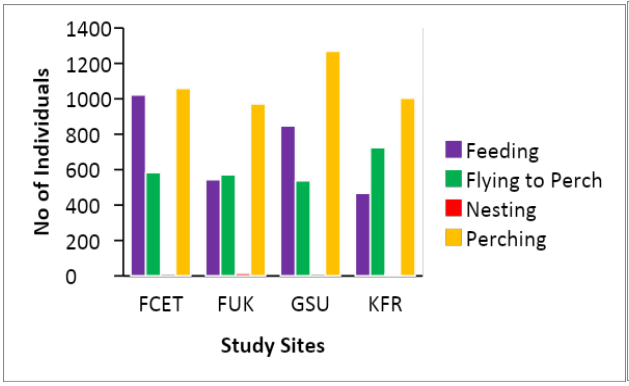

Figure 2: Distribution and abundance of avian species with regards to their activities in the three campuses and KFR

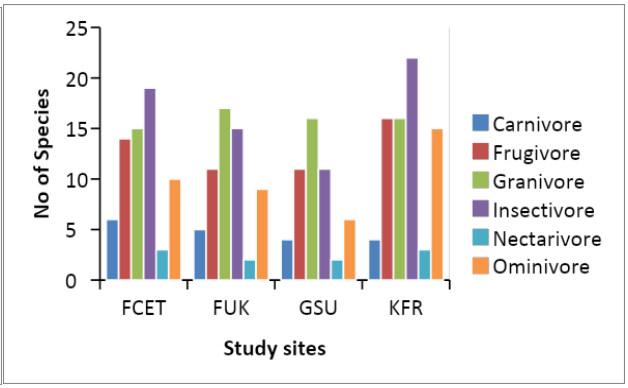

Figure 3: Distribution of avian species across different dietary guilds in the three campuses and Kanawa Forest Reserve.

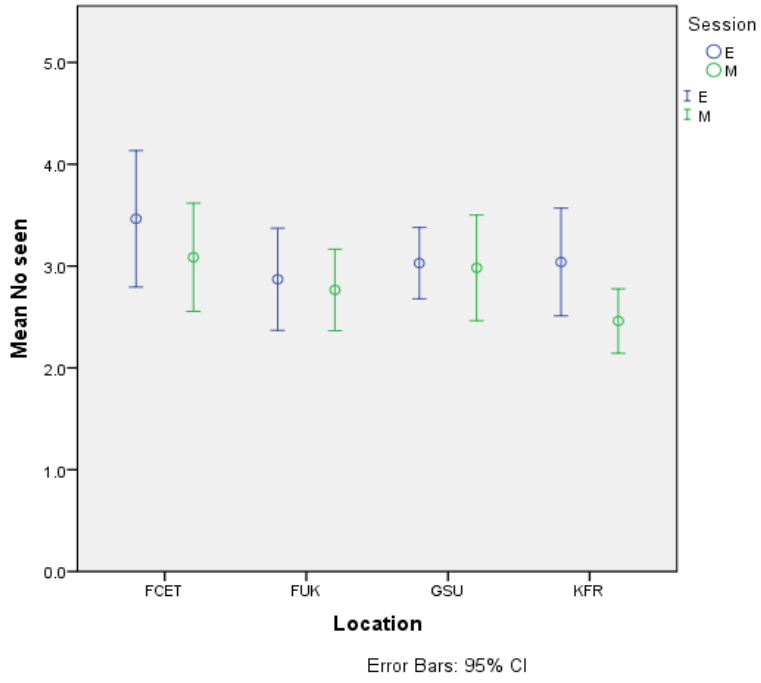

Figure 4: Variations in Mean Number of bird species across the various locations with time of day (E= Evening, M=Morning)

Discussion

The main goal of the study was to determine how well human modified habitats serve as refugia for bird species across a matrix of human dominated landscapes and remnant savanna woodlands. The idea is to evaluate the relative potential of each campus as refugium for avian diversity and to

identify the factors that may foster bird species persistence and survival in these remnants of once contiguous savannah landscapes.

Several factors are taken into consideration by birds in choosing a particular habitat; this varies from species to species based on inherent traits and ecological requirements. Territorial birds for instance will keep bigger territories in degraded landscapes and habitats, than in resource rich ones (Osinubi 2010). This dynamics interact with basic factors such as the vegetation structure to underpin avian diversity and distribution.

The fact that Kanawa forest was the most species-rich, despite not being the largest in area, suggest that species diversity is a function of several factors with vegetation structure and consistency being the foremost. The results suggest interplay between habitat size, quality and vegetation structure in predicting species richness and abundance; this assertion is based on the findings of this study where GSU with relatively smaller land area compared to the other sites had the highest record of laughing doves despite being the least in overall species richness. However, the result was neither numerically or statistically significant. Nonetheless, this perception was strengthened by the seeming correlation between size of study area and species richness, with FCET, the largest in land area ranking tops followed closely by FUK and GSU.

The importance of vegetation structure was emphasized in this study. For example, despite its smaller land area, GSU had a higher number of trees compared to FCET and FUK campuses. The dense tree cover and overall vegetation played a significant role in the relatively higher species richness compared to the other campuses with larger land areas but lower tree density. FCET campus, being the largest in terms of landmass, had a more spacious environment and lower tree density. Unfortunately, it also experienced more anthropogenic activities due to poor visitor entry regulations compared to FUK and GSU campuses. These factors reduced the predictive power of habitat size in relation to species richness and abundance.

In contrast to most avian surveys, where more birds are typically sighted in the morning, this study found more sightings in the evening than in the morning. This finding may be attributed to the presence of more people on the campuses during the early morning hours, while in the evenings, human activity decreases as people retire home. This leaves the birds with a better and less disturbed environment in terms of human presence, allowing them to move around more freely.

In total, 100 bird species from 42 bird families and 76 genera were recorded which is quite impressive compared to other similar landscapes elsewhere in the region. For instance, the combined result and in some cases for each campus is relatively higher than the 54 species in 31 families recorded in Zaria (Tanko & Ivande, 2006), 37 species in 25 families observed in Gombe State University Campus (Adang *et al*., 2015a), and the 60 species in 27 families recorded in Dadin-Kowa Dam (Adang *et al*., 2015b), the 69 species in 32 families at FCET, Gombe (Nsor *et al*., 2018). Conversely, the result is lower than the 108 species in 43 families recorded in Lokoja (Adang et a., 2018) and 136 species in 42 families recorded in Jos wild life Park (Khobe and Kwaga, 2017) and 138 in Pandam (Dami and Manu 2010).

The study primarily sought to understand how avian species utilize human modified habitat, and possible factors that could be responsible for species persistence in heavily modified landscapes. The result shows that even though there were bird species that were unique to all the study areas including KFR, certain species tended to prefer certain habitat features that were not common to

all the study sites and as such were excusive to only one or two sites. For instance FCET and FUK had 4 unique species, while GSU had only 2. As expected, 22 species were exclusively found in KFR (Appendix 2). Despite these differences, Sorenson Coefficient of Similarity suggests that some sites are compositionally similar to KFR a semi-pristine and partially degraded site (Table 4). This high level of similarity shows that human modified landscapes have capacity to support a wide range of species across different feeding guilds and families. On the other hand the results also suggest that some traditionally forest or patch dependent species are gradually adapting to a peri-urban lifestyle, as more natural habitats are progressively modified to meet the needs of man. Nonetheless, some bird species are naturally cosmopolitan and well adapted to a peri-urban and urban lifestyle (Borow and Demey, 2004), and as such may not be affected by anthropogenic disturbance. These group of species accounts for the similarity in composition of species in the three campuses and therefore represent a subset of those found in KFR with a range of 60 to 70% similarity.

However, although statistically insignificant, the difference in species composition amongst the study areas affirms the view that heterogeneous habitat (as seen in KFR) support more species than most homogeneous habitats (Abalaka and Manu, 2007; Dami *et al*., 2014), as seen in most parts of FCET, FUK and GSU; the homogeneous nature of the campuses is driven by the afforestation and greening program of the various tertiary institutions where the remnant natives, are interspersed and dominated by exotic plant species and expansive homogenous tree plantations of date palm, mahogany, and mango as seen in GSU. Renmant natives in these campuses include but not limited to *Parkia biblogosa*, *Tamarindus indica*, *Balanites aegyatiaca*, *Adansonia digitata* and *Phoenix dactilifera*. These remnant native tree species represent a subset of those found in Kanawa Forest Reserve, a semi protected landscape.

With regards to the presence of various feeding guilds, insectivores with 26 species was the most species rich generally, while nectarivores with 3 species were the least in terms of number of species across the study sites (Figure 3). The three campuses and Kanawa Forest reserve held all the 6 feeding guilds recorded in this survey, although the diversity and composition of species across these guilds differed amongst the study sites attesting to the relative differences in habitat structure, heterogeneity and size of total land area of each campus and KFR.

The high level of exclusive species recorded at Kanawa forest (Appendix 2) in contrast to the campuses could be attributed to the presence of a perennial stream which of course is a major habitat variable and driver of species richness. Ironically, species known to be traditionally forest dependent and non-peri-urban were recorded more in the campuses than in KFR (Appendix 3). This could be driven by a host of factors; the lack of protection in the forest reserve must have let to increase in poaching and persecution of small vertebrates such as birds compared to the other campuses that enjoy perimeter fences, security guards and a conscious drive for reforestation and vegetation restoration.

The size of the habitats might have contributed, for instance FCET had the most forest dependent species, followed by FUK and GSU, while KFR had the least, despite seemingly being larger than GSU. The interplay of the forces might be working synergistically to affect habitat use and overall avian preferences and trade-offs.

With regards to previous work in FCET 18 of the 69 species found by Nsor *et al*, (2018) were not observed in this study while 16 species observed in this study were not observed previously. This difference in composition between the two surveys could be attributed to a couple of factors,

prominent amongst them being seasonality and duration of assessment. The experimental design, primary goal of each study, scope of study or some unfolding development as a result of habitat modification could also be the reason for the compositional differences.

CONCLUSION

The study has shown that humans can actually meet their diverse needs while still coexisting side by side with nature and biodiversity. The similarities in species composition between the three campuses and the semi-pristine KFR suggest that bird species are gradually becoming more adapted to human occupied and/or modified habitats. In other words, the effects of habitat alteration can be less debilitating if a holistic approach in urban development is emphasized, such that environmental managers and architects begin to integrate urban development plans with the needs of other biotic components of the environment. This all-inclusive developmental approach will consolidate the "one health" goal of promoting a healthy environment for humans and biodiversity while providing livelihood support for the growing human population.

This study highlights the fact that most bird species are increasingly adapting to a peri-urban and human dominated landscape despite their traditional preferences for contiguous and densely forested habitats. The study shows that bird species habitat requirements is primarily driven by vegetation structure and each micro-habitat unit, degraded or semi-pristine maybe crucial to the overall abundance/diversity of an area. The campuses each hold a unique assemblage of avian species and therefore crucial to the overall avian diversity of the total surveyed area and Gombe state. We recommend minimal alterations especially of remnant woodlands and native flora on campuses and the establishment of more green areas in urbanized landscapes to foster heterogeneity. This will boost the capacity of campuses to accommodate more diversity especially bird species with unique habitat requirements.

References

Abalaka, J. I., & Manu, S. A. (2007). Factors affecting forest bird diversity and recent avifaunal changes in the degrading Kagoro-Nindam forest reserves, Kaduna, Nigeria. *Ostrich*, 78(2), 233-238.

Adang, K. L., Nsor, C. A. & Tela, M. (2015a). Survey of avifauna of Gombe State University, Gombe, Nigeria. *International Journal of Biology and Biological Sciences*, 4(2): 032-036.

Adang, K. L., Nsor, C. A. & Tela, M. (2015b). Checklist of bird species at the Dadin Kowa Dam, Gombe, Gombe State, Nigeria. *Global Advanced Research Journal of Agricultural Sciences*, 4(5):276-270.

Adang K. L., Tanko D., Kachi J., and Abdulwahab U. A (2018). Bird Species Richness and Diversity of Lokoja and Environs, Kogi State, Nigeria.

Aminu, A and Safianu, R (2018). Rainny Season Dietary Ecology of Avian Species in Semi-Refuge Habitats in Kano, Nigeria. *Bayero Journal of Pure and Applied Sciences*, 11(1):119

Bibby CJ, Burgess ND, Hill DA (2000). Bird census techniques. Academic Press London. pp.302.

Blair, R.B., Johnson, E.M., 2008. Suburban habitats and their role for birds in the urban-rural habitat network: points of local invasion and extinction? Landscape Ecol 23, 1157–1169.

Campbell, M.O., (2009). The impact of habitat characteristics on bird presence and the implications for wildlife management in the environs of Ottawa, Canada. *Urban Forestry & Urban Greening* 8, 87–95.

Caula, S., Marty, P., Martin, J.L., (2008). Seasonal variation in species composition of an urban bird community in Mediterranean France. *Landsc.Urb.Plan.* 87, 1–9.

Chapman, K.A., Reich, P.B., (2007). Land use and habitat gradients determine bird community diversity and abundance in suburban, rural and reserve landscapes of Minnesota, USA. *Biol. Conserv.* 135, 527–541.

Czech, B., Krausman, P.R. & Devers, P.K. (2000). Economic associations among causes of species endangerment in the United States. *BioScience*, 50, 593–601

Dami, F. D., Mwansat, G. S., & Shiiwua, A. M. (2014). The Effect of Fragmentation and Land Use Types on Bannerman's Weaver Ploceus bannermani (A Globally-Threatened Bird Species) on the Obudu Plateau, Southeast Nigeria. *Journal of Natural Sciences Research*, 4(19), 91-97.

Daniels, G.D., Kirkpatrick, J.B., (2006a). Does variation in garden characteristics influence the conservation of birds in suburbia? *Biol. Conserv.* 133, 326–335.

Evans, K.L., Newson, S.E., Gaston, K.J., (2009). Habitat influences on urban avian assemblages. Ibis 151, 19–39.

Ezealor, A.U. (2002). Critical Sites for Biodiversity Conservation in Nigeria. Nigerian Conservation Foundation, Lagos Nigeria 110p.

Gregory, R., Noble, D., Field, R., Marchant, J., Raven, M., & Gibbons, D. W. (2003). Using birds as indicators of biodiversity. *Ornis Hungarica*, 12(13), 11-24.

Groffman PM, Cadenasso ML, Cavender-Bares J, Childers DL, Grimm NB, Grove JM, Pataki DE. (2017). Moving towards a new urban systems science. *Ecosystems* 20: 38–43.

Ihuma, J.O; Tella, I. O; Madakan, S. P. and Akpan, M. (2016). Frugivorous Bird Species Diversity in Relation to The Diversity of Fruit Tree Species in Reserved and Designated Green Areas in The Federal Capital Territory, Nigeria. *Journal of Research in Forestry, Wildlife and Environment* 8,1. 80-94

Ijeomah, H.M., Chima, U.D., Okagnare, O.H (2013). Ecological survey of avifaunal resources in university of Port Harcourt, Nigeria. *Ethiopian Journal of Environmental Studies and Management*. Vol. 6 No.6

Khobe, D and Kwaga, B.T. (2017). Checklist of bird species of Jos Wildlife Park, Nigeria. International Journal of Agriculture, *Environment and Bioresearch* Vol. 2, No. 04.

Knopf, F. L., R. R. Johnson, T. Rich, F. B. Samson, and R. C. Szaro. (1988). Conservation of riparian ecosystems in the United States. Wilson Bulletin 100:272–284.

Krisanti, A.A., Choirunnafi, A., Septiana, N.O., Pratama, F.W., Amelia, F., Manjaswari, A., Septinigtyas, P.A., Wati, A.S., Satria, J.Y., Ani, I.L. Wibowo, T. and Sugiyarto (2017). The diversity of diurnal bird species on the Western Slope of Mount Lawu, Java, *Indonesia. Biodiveritas*, 18 (3): 1077-1083, DOI: 10.13057/biodiv/d180327.

Lawal, S.O., Iwajumo, S.B (2020). The Assessment of Avifaunal Potential of Lagos State Urban Green Spaces. *Journal of Reproduction and Development* 19(1):382-394

Marzluff, J. M., F. R. Gehlbach, and D. A. Manuwal. (1998). Urban environments: influences on avifauna and challenges for the avian conservationist. Pages 283–296 in J. M. Marzluff and R. Sallabanks, editors. Avian conservation: research and management. Island Press, Washington, D.C., USA.

Marzluff, J.M., (2001). Worldwide urbanization and its effects on birds. In: Marzluff, J.M., Bowman, R., Donnelly, R.E. (Eds.), Avian Ecology and Conservation in an Urbanizing World. Kluwer Academic, Norwell, Massachusetts, pp. 19–47.

Melles, S., Glenn, S., Martin, K., (2003). Urban bird diversity and landscape complexity: species-environment associations along a multi-scale habitat gradient. *Conservat. Ecol.* 7, 5.

Mckinney, M.L (2002) Urbanization, Biodiversity and Conservation. BioScience • October 2002 / Vol. 52 No. 10.

Nsor, C.A; Aliyu, B; Zhigla, D; Dauda, E and Cleophas, B. A (2018). Making the best of a Human modified Habitat; an Assessment of Avian Distribution and Diversity in Federal College of Education (Technical) Gombe State, Nigeria. *International Journal of Environment, Agriculture and Biotechnology* (IJEAB) Vol-3, Issue-4, Jul-Aug- 2018

Nsor, C.A., Tisseer, F., Maiguwa C. C. (2019). Maintaining Biodiversity in the face of Urbanization: an assessment of Plant Species Richness and Diversity in Four Public Parks in Abuja FCT. *Journal of Social and Environmental Sciences* (JOSES) 1(1) 9-17.

Odewumi, O.S., Adekola A.E., Aladesiun, O.A. (2020). Diversity and Abundance of birds of Prey in Akure Metropolis, Ondo State Nigeria. *J. For. Sci. Env.* Vol. 5 (2020): 1 – 10

Ohmart, R. D. (1994). The effects of human-induced changes on the avifauna of western riparian habitats. *Studies in Avian Biology* 15:273–285.

Osinubi S.T., Chapman H.M., Briskie J., Ottosson U., Brown J. (2010) Habitat does influence territorial and mate-guarding calls of the Yellow-breasted Boubou (Laniarius atroflavus). Presented at the 25th International Ornithological Congress, Campos doJordao.

Schaefer, V. (1994).Urban biodiversity. Pages 307–318 in L. E. Harding and E. McCullum, editors. *Biodiversity in British Columbia*. Environment Canada, Canadian Wildlife Service, Vancouver, British Columbia, Canada.

Seto, K.C., Guneralp. B., Hutyra R.L (2012). Global Forecasts of Urban expansion to 2030 and direct impacts on biodiversity and carbon Pools. PNAS (Proceedings of the National Academy of Science. 109(40)16083-16088.

Shochat, E., Lerman, S.B., Katti, M., Lewis, D.B., (2004). Linking optimal foraging behavior to bird community structure in an urban-desert landscape: Field experiments with artificial food patches. *Am. Nat.* 164, 232–243.

Tanko, D. & Ivande, S. T. (2006). A survey of the Avifauna of relatively undisturbed vegetation in Zaria, Nigeria. A paper presented at the 2nd Biennial Conference of the Ecological Society of Nigeria (EcSN) held at Calabar on 20th-24th October, 2009.

Tanko, D., Adang, K. L., & Kachi, J. B. (2017). Preliminary checklist of avifauna within Lokoja metropolis, Kogi State, Nigeria. *International Journal of Applied Biological Research.* In press.

United Nations, Department of Economic and Social Affairs, Population Division (2018). World urbanization prospects: The 2018 revision.

World Resources Institute. (1996). The urban environment. World resources Institute, Washington, D.C., USA.

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