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ABUNDANCE AND DIVERSITY OF DRY SEASON AVIAN SPECIES IN KATSINA METROPOLIS, KATSINA STATE NIGERIA

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ABSTRACT

The study was conducted to assess avian abundance, distribution, and diversity in Katsina metropolis during the dry season. Point count was employed for the study. Data was collected in the morning and evening when birds were more active. Data was analyzed using the Shannon-Weiner diversity index, Simpson index of diversity, Evenness Index and Sorensens Similarity Index. A total of 2865 individual birds belonging to 35 species in23families were recorded during the study period. Laughing dove (Streptopelia senegalensis) 516(18.01%) was the most abundance species during the dry season. The Shannon Weiner index ranged between 0.996-2.553 with the highest being in golf course (2.553), biological preserve (2.306), and recreational (2.124) and the lowest being market (0.996), business district (1.096) and road (1.237). While species like the African silver bill and laughing dove were widely distributed across the study area, other species were restricted to three, two and even one habitat. Road and business district (0.750), residential and industrial areas (0.700), biological preserve and recreational area (0.640) recorded the highest similarity index while the least was recorded in farmland and market (0.182), farmland and business district (0.261). The result of the study found that bird abundance was influenced by the level of disturbance of the various land uses. Efforts should be geared towards creating a bird friendly urban environment and making urban dwellers realize the importance of avian species.

Keywords: Avian species, distribution, diversity, urbanization

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INTRODUCTION

Urbanization is an expanding process worldwide, causing major threats to biodiversity through both biotic homogenization and species extinction (Filloy *et al.*, 2018). There is no slowdown in sight as countries and cities modernize and continue to provide facilities attractive for human habitation and relocation (Angel *et al.*, 2011). Currently, 54 percent of humans live in urban areas; by 2050 it is estimated that 66 percent will dwell in urban areas (United Nations, 2015). Birds offer an ideal taxonomic group from which the effect of urbanization on biodiversity can be well understood (Aronson *et al.*, 2014). Birds are easily observable and important for the ecosystem services they provide, their occurrences have been helpful as ecosystem health indicators, plant pollinators, seed dispersal agents as well as plant pollinators (Ramchandra, 2013; Bideberi, 2013). As cities expand across the planet, urban ecosystems are becoming an increasingly important environmental setting for shaping ecological processes (Ramalho and Hobbs, 2012).

Urban areas and landscapes are different from non- urban habitats and green areas (Isaksson, 2018). Urban environment with its impervious structures, buildings and green spaces provides nesting and roosting habitats with additional food supplies provided by man (Jagruti *et al.*, 2017). Due to different species level of response to urbanization, once an area is urbanized, the species composition will change, with some species vanishing and others flourishing (Isaksson, 2018). Studies of urban birds are still scarce in tropical regions, despite the higher biodiversity and the increasing urbanization in the tropics (Chamberlin *et al*., 2018). For example, Fontana *et al.* (2011) investigated the community composition of birds in longitudinal gradient in Porto Alegre; they demonstrated that bird composition varied according to the level of urban occupation and that urban drivers such as noise and human density considerably affected species richness. In Nigeria, an urban avian survey by Efenakpo *et al.* (2019) in Choba community of Rivers State revealed that urban area possessed a limited number of species richness with higher number of individuals' abundance.

Katsina being an urban center accommodates people from different works of life, but the predominant ethnic groups are the Hausa and Fulani (Kabir and Maidawa, 2018). Like many urban centers in the country, Katsina has witnessed rapid expansion in its population size as (Ladan, 2014) observed that the population of the urban area has been increasing due to immigration of people from all over the country. The study on diversity, distribution and abundance of avifauna with respect to urban form is important in this area since it will provide an understanding of avian community response to human occupied habitat.

MATERIALS AND METHODS

Study area

The study was conducted in Katsina Metropolis in Katsina State. Katsina metropolis lies between latitude 12^0 57' 0" N to 13^0 1' 0" N and longitude 7^0 34'0" E to 7^0 40' 0''E. It is bounded by Kaita Local Government Area to the north, Jibia to the west, and Batagarawa to the south and east. It covers an area of about of about 3,370km^2 (Danjuma, 2012). The area receives an annual rainfall of 700mm (Abaje *et al.*, 2014) and high temperature in most part of the year, with maximum day temperature of about 38^0C or higher in the months of March (Ruma and Sheikh 2010). The area lies within the Sudan Savannah zone which combines the characteristics of both Sahel and Guinea savannah, the vegetation of the area is typically a grassland type. The area has various land use practices with different magnitude of anthropogenic disturbances.

Bird Survey Method

The study area was stratified into 10 land use gradients according to the varying anthropogenic disturbances (Jagruti *et al*., 2017), The selected land use gradients included roads, market areas, industrial area, residential area, recreational area, golf course, biological preserve, business districts, farmlands, and wetlands. Using a fixed 50m radius, birds were counted using the point count method (Bibby *et al.*, 2000), all birds seen or heard for 6-10 minutes were registered. Calls recorded were identified with the help of a specialist. Survey was conducted within 0700-0900hrs in the morning and 1700-1900hrs in the evening for a period of four months (two months for each season). Birds were identified and their taxonomic group properly categorized with the aid of a pair of binoculars and a field guidebook of Birds of West Africa (Borrow and Demey, 2008).

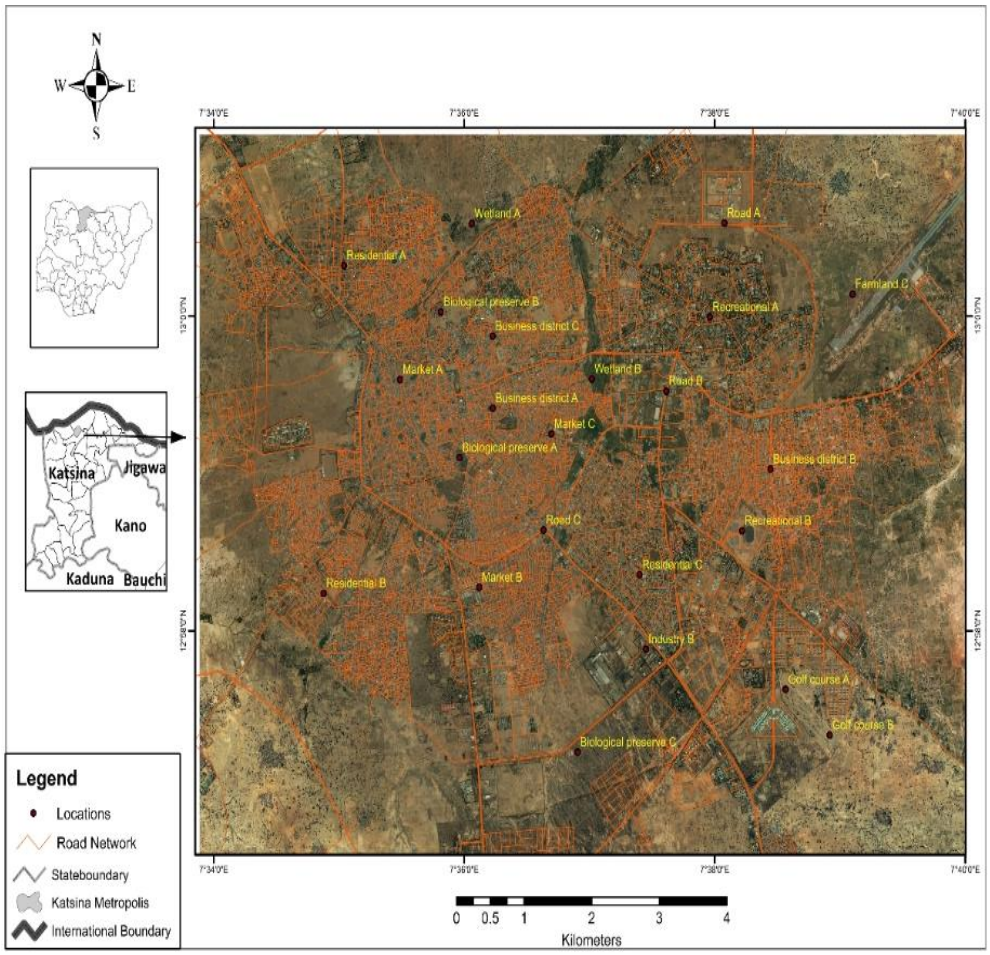

Fig 1. A Map Showing Sample Locations

Method of Data Analysis

A checklist of bird species was compiled in Microsoft office excel showing Families, species common and scientific names, and land use type in which the birds occur. Results were presented using simple descriptive statistic such as tables, bar charts and plates. Data on avian species in the ten land uses was calculated using the Shannon Weiner and Simpson Index. Similarity index of species between land uses was calculated using the Sorenson's Similarity Index. The Shannon diversity index, Simpson Index and Sorensons Similarity Index were calculated using the following formulas:

Relative Abundance (RA) % = $= \frac{\text{Freuency of a specie}}{\text{Total frequency of all species}} \times 100$ …….. (1)

Shannon Weiner Diversity Index: $H = -\sum_{i=1}^{S} Pi\ lnPi$ ..... (2)

Where, *H*= Diversity index; S= Total number of species, P_i= Proportion of each individual (i^{th}) species in the sample, ln P_i= Natural logarithm of the species proportion

The Simpson index is given by the formula: $D = \frac{\sum n(n-1)}{N(N-1)}$ ……. (3)

Where, n= total number of individuals of each species, N=the total number of organisms of all species, D= Simpson index.

D ranges between 0 and 1. With this index, 1 represents infinite diversity and 0, no diversity.

Sorenson's coefficient (CC) = $\frac{2c}{S1+S2}$ …….(4)

Where, C is the number of species the two communities have in common, S1 is the total number of species found in community 1, S2 is the total number of species found in community 2.

RESULTS

Checklist and Abundance of the species in the study area

Species checklist in the study area is presented in Table 1. The table shows that a total of 2865 individual birds belonging to 35 species and 23 Families were recorded. Laughing dove, Red-billed fire finch, Village weaver and African silver bill were the most frequently observed birds with a relative abundance of 18.01%, 15.64%, 13.23% and 10.37% respectively while the Black-shouldered kite, Forest swallow, Greater honey guide and bearded barbet were the least bird species recorded with relative abundance of 0.03% each. Table 2 shows Golf course, Biological preserver and residential area recorded the highest abundance with total number of individual birds 650, 554, and 443 respectively while road, business district and market recorded lowest abundance with 63, 82 and 103 birds, respectively.

Table 1. Bird species encountered in Katsina Metropolis

Family	Common name	Scientific name	Abundance	RA (%)
Accipitridae	African swallow-tailed kite	*Elanoides forficatus*	8	0.28
	Black -shouldered kite	*Elanus axillaris*	1	0.03
Acrocephalidae	Sedge warbler	*Acrocephalus schoenobaenus*	22	0.77
	Aquatic warbler	*Acrocephalus paludicola*	20	0.7
Alaudidae	Crested lark	*Galerida cristata*	21	0.73
Apodidae	Common swift	*Apus apus*	25	0.87
	Little swift	*Apus affinis*	100	3.5
Ardeidae	Cattle egret	*Bubulcus ibis*	39	1.36
Bucerotidae	Red-billed hornbill	*Tockus erythrorhynchus*	9	0.31
	African grey hornbill	*Lophoceros nasutus*	2	0.1
Charadriidae	Black-headed lapwing	*Vanellus tectus*	60	2.1
Columbidae	Laughing dove	*Streptopelia senegalensis*	516	18.01
	Speckled pigeon	*Columba guinea*	16	0.56
Corvidae	Piacpiac	*Ptilostomus afer*	10	0.35
Cuculidae	Senegal coucal	*Centropus senegalensis*	15	0.52
Estrildidae	Red-billed firefinch	*Lagonosticta senegala*	448	15.64
	African Silver bill	*Euodice cantans*	297	10.37
Hirundinidae	Forest swallow	*Atronanus fuliginosus*	1	0.03
Indicatoridae	Greater honeyguide	*Indicator indicator*	1	0.03
Laniidae	Yellow-billed shrike	*Corvinella corvina*	21	0.73
Lybiidae	Bearded barbet	*Lybius dubius*	1	0.03
Nectariniidae	Beautiful sunbird	*Cinnyris pulchella*	8	0.28
	Pigmy sunbird	*Hedydipna platura*	4	0.14
	Amethyst Sunbird	*Chalcomitra amethystina*	2	0.1
Phasianidae	Common quail	*Coturnix coturnix*	40	1.4
Phoeniculidae	Greenwood hoopoe	*Phoeniculus purpureus*	16	0.56
Ploceidae	Village weaver	*Ploceus cucullatus*	379	13.23
	White-billed buffalo weaver	*Bubalornis albirostris*	180	6.28
Pycnonotidae	Common Bulbul	*Pycnonotus barbatus*	86	3
Strigidae	Marsh owl	*Asio capensis*	1	0.03
	Southern white-faced owl	*Ptilopsis granti*	1	0.03
Sturnidae	Chestnut - bellied starling	*Lamprotornis pulcher*	279	9.74
	Long-tailed glossy starling	*Lamprotornis caudatus*	104	3.63
	Bronze-tailed starling	*Lamprotornis chalcurus*	130	4.53
Upupidae	Hoopoe	*Upupa africana*	2	0.1
			2865	

Distribution and Richness

In order of ranking, golf course had the highest species richness (22 species), followed by wetland (13 species) and biological preserve (13 species) while Market, business district and road had the lowest species richness, with market and business district having 3 species each and road having 5 species (Table 2). The recorded 2865 birds from 23 families and 35 species were distributed within different land uses. Of the 35

species observed, 5 occurred in almost all habitats, between 10 to 5 land uses. The study found that some species were restricted to two or just one land use (Fig.2)

Table 2. Abundance, Distribution and Richness of birds for dry season.

Land Use	Abundance	Richness	Percentage
Residential	443	9	15.5
Biological preserve	554	13	19.3
Farmland	174	8	6.1
Road	63	5	2.2
Market	103	3	3.6
Business district	82	3	2.9
Industry	183	11	6.4
Golf course	650	22	22.7
Recreational	317	11	11.1
Wetland	296	13	10.3
Grand total	2865		

Bird Diversity across land use in Katsina metropolis

Simpson diversity and Shannon-Weiner diversity index were higher in land uses with less human disturbance such as golf course (0.907, 2.553), biological preserve (0.882, 2.306), and recreational area (0.862, 2.124), except for farmland (0.774, 1.663) which had low diversity despite being less disturbed while market (0.614, 0.996), business district (0.673, 1.096), and road (0.666, 1.237) recorded low diversity (Table 3). The results indicated higher species evenness in business district, market, and recreational area. This shows higher evenness for disturbed areas (Table 3).

Table 3. Diversity Indices of bird species for the land uses

Land Use	Simpson Index	SID	Shannon-Weiner Index	Equitability Index
Residential	0.212	0.788	1.691	0.77
Biological preserve	0.118	0.882	2.306	0.874
Farmland	0.226	0.774	1.663	0.8
Road	0.334	0.666	1.237	0.768
Market	0.386	0.614	0.996	0.907
Business district	0.327	0.673	1.096	0.998
Wetland	0.169	0.831	2.101	0.819
Industry	0.222	0.778	1.695	0.707
Recreational	0.138	0.862	2.124	0.886
Golf course	0.093	0.907	2.553	0.826

Key: SID (Simpson Index of Diversity

Table 4. Sorensen similarity between land uses

Land uses	Res	BP	Fld	Rd	Mkt	BD	Ind	GC	Rec	Wtld
Res		0.435	0.235	0.429	0.500	0.500	0.700	0.387	0.600	0.455
BP			0.545	0.316	0.353	0.353	0.480	0.611	0.640	0.296
Fld				0.462	0.364	0.182	0.211	0.400	0.526	0.476
Rd					0.500	0.750	0.375	0.370	0.625	0.555
Mkt						0.666	0.429	0.240	0.429	0.375
BD							0.429	0.240	0.429	0.375
Ind								0.364	0.545	0.417
GC									0.606	0.457
Rec										0.666

Key: Res (residential), BP (biological Preserve), Fld (farmland), Rd (road), Mkt (market), BD (business district), Ind (industry), GC (golf course), Rec (recreational)

DISCUSSION

Abundance

There was difference in bird abundance between land use types during the sampling period. The distance between land uses and environmental features observed during birds' count could be the reason for the differences observed. However, there was higher bird abundance in areas with less human activities and low abundance in areas with highly induced human activities and noise. The result of this study concurs with the findings of Planillo *et al*., (2020) who disclosed that total bird abundance and species richness were higher in low disturbance areas and decrease towards more urbanized areas. The case of high bird abundance in areas with less human disturbance was not applicable to farmland, as it recorded low abundance compared to residential area and other areas with moderate level of anthropogenic activities. This could be because of absence of vegetation or lack of habitat heterogeneity. This is in line with the findings of Amano and Yamaura (2007); Koshida and Katayama (2018) who stated that farmland birds had experienced population decline mainly due to loss of habitat heterogeneity due to intensification of agricultural activities. The high abundance of avian species like the laughing dove (*Streptopelia senegalensis*), red-billed firefinch (*Lagonosticta senegala*) African silverbill (*Euodice cantans*) and other urban exploiters in residential areas suggests that human settlements harbor bird species. This agrees with the findings of Isaac *et al*. (2019) who discovered that areas with heavily induced human activities like human settlement areas indicated high avian abundance because they provide heterogeneous habitats which attract human tolerant avian species. Other studies elsewhere in human settlement (Pennington and Brail, 2011) also found similar result and concluded that high avian abundance in the settlement were triggered by habitat heterogeneity such as trees, buildings for roosting, and garden trees established by humans. The highest abundance recorded in golf course was associated with the presence of trees and grasses which provided food and cover for birds. This agrees with the results of Tanner and Gange(2005); Colding and Folke(2009) who concluded that golf courses enhance local biodiversity of an area by providing a greater variety of habitat than intensively managed agricultural areas. The high abundance of white-billed buffalo weaver (*Bubalornis albirostris)* in biological reserve could be attributed to the presence of Acacia tree, as it was observed during the study that the bird preferred the tree as its nesting support material.

Distribution and Richness

A total of 35 different species were recorded across the study area. Of the recorded species, some were generalists (occurring in few or most land uses) and others were specialists (occurring in one or two land uses). The nature of distribution of species was associated with the availability of resources and selection of habitat by the species. This agrees with Girma *et al.* (2017); Issa (2019) and Li *et al.* (2021), where the authors observed that species distribution was

dependent on habitat suitability, preference or specific habitat use such as food supply, nesting, and resting sites by some of the bird species.

Diversity and Evenness

Species diversity in areas with less human activity was higher than that of land uses highly disturbed. This pattern as described by Blair (1996) was related to shifts in habitat structure that occur along urban land use gradient. Among the ten studied land uses, the most diversified avian species were recorded in golf course, biological preserve, and wetland. Golf course was covered with vegetation compared to other areas. Other studies reported heterogenous vegetation community especially forest as habitats that provide several niches for birds, providing abundant food, nesting and roosting sites that attracts more birds (Wilxcoxen *et al.,* 2015; Tessfa *et al*., 2020). High diversity recorded in biological preserve and wetland area was clearly linked to the availability of crops, grasses and water in these land uses. All these features result to a heterogenous habitat which has an impact in the ecological processes of birds. This result is in line with Mohd-Azlan *et al.,* 2015 and Lorenzon *et al.,* 2016 who reported that increasing habitat heterogeneity accommodates more niches and has an impact on habitat resources, and ultimately determines species diversity in an area. Low avian diversity recorded in farmland during the dry season could be because of food resource scarcity for birds. Tessfa*et al.* (2020) noted similar case of low bird diversity in farmlands during the dry season due to food scarcity after the harvesting period, so birds use other habitats as their alternative.

The result of this study recorded Low diversity in road, market and business district which is evidently caused by the level of disturbance in these areas. The result conforms to that of Tanalgo *et al*. (2015) who recorded the lowest species diversity for roads and heavily disturbed habitats in South Central Mindanao in Philippines, the study envisioned the availability of food resources along roads and other disturbed land uses as an important factor that explained the low species diversity. Interestingly, moderate value of diversity was recorded in residential area, and recreational area. These are land uses with intermediate level of anthropogenic disturbance. Previous works have shown that moderately disturbed areas maintain high diversity, with some species especially urban exploiters preferring them to other habitats (Wang *et al.*,2022 and Jagruti, 2016). This agrees with the expectations of the intermediate disturbance hypothesis, which suggests that intermediate disturbances maintain high biodiversity by creating varied and conducive conditions for diverse species (Connell, 1978).

On the other hand, higher evenness was recorded in dry season, and business district had the highest species evenness. Low evenness could be due to dominance of some abundant species. This is in contrast with the findings of Bideberi (2013) who associated high evenness to continuation of vegetation which reduces the impact of predation to birds. Although business district here, lacks such vegetation, it recorded the highest evenness against land uses with vegetation.

CONCLUSION

The findings of this study revealed that bird species diversity, abundance and distribution vary between the studied land uses. Avian species abundance, richness and diversity was higher in less disturbed areas and lower in areas with high anthropogenic disturbance. Apparently, some species have adapted to the moderately disturbed land uses like the residential area. The study also proved that although anthropogenic disturbance, which is a product of urbanization affects avian species abundance and distribution, yet golf course and other land uses that harbor trees are important part of the urban ecosystem that harbour high number of birds. From the findings, the differences in availability of resources such as food, nesting and roosting sites and other necessities for bird's survival between land use types is the reason for the variation in distribution. This has caused some species to be restricted to certain habitat while others got widely distributed. Conclusively, the urban environment remains an important place for avian species, especially the urban exploiters and adapters.

REFERENCES

Abaje, B., Sawa, B. A. and Ati, O.F. (2014). Climate Variability and Change Impacts and Adaptation Strategies in Dutsin-Ma Local Government Area of Katsina State, Nigeria. *Journal of Geography and Geology,* 6 (2), 103-112.

Amano, T. and Yamaura, Y. (2007). Ecological and life history traits related to range. Contractions among breeding birds in Japan. *Biological Conservation,* 137(2), 271-282, https://doi.org/10.1016/j.biocon.2007.02.010

Angel, S., Parent, J., Civco, D. L., Blei, A. and Potere, D. (2011). The dimensions of global urban expansion: estimates and projections for all countries, 2000-2050. *Progress in planning* 75, 53-107.

Aronson, M. F. J., La Sorte, F. A., Nilon, C. H., Katti, M., Goddard, M. A., Lepczyk, C. A., Warren, P. S., Williams, N. S. G., Cilliers, S., Clarkson, B., Dobbs, C., Dolan, R., Hedblom, M., Klotz, S., Kooijmans, J. L., K€uhn, I., MacGregor-Fors, I., McDonnell, M., M€ortberg, U., Pysék, P., Sieber, T. S., Sushinsky, J., Werner, P. and Winter, M. (2014). A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. *Proceedings of Royal Society*, 281, 1-8. https://dx.doi.org/10.1098/rsp.1013.3330

Bibby, C. J., Burgess, N. D., Hill, D. A. and Mustoe, S. (2000). Bird Census Techniques. London: Academic Press. 137p

Bideberi, G. (2013). Diversity, Distribution, and Abundance of Avifauna in Respect to Habitat Types" a case study of Kilakala and Bigwa, Morogoro, Tanzania. Thesis for Master of Science, Sokoine University of Agriculture, Morogoro,Tanzania.

Blair, R. B. (1996). Land Use and Avian Species Diversity Along an Urban Gradient. *Ecological Applications*,6(2), 506-519. https://doi.org/10.2307/2269387

Borrow, N. and Demey, R. (2008). Helm Field Guides Birds of West Africa. *Christopher Helm, A and C Black Publisher Ltd, London WID 3HB.*

Chamberlin, D., Kibuule, M., Skeen, R. Q. and Pomeroy, D. (2018). Urban bird trends in a rapidly growing tropical city. *Ostrich-journal of African ornithology*, 89 (3), 275-280.

Colding, J. and Folke, C. (2009). The Role of Golf Courses in Biodiversity Conservation and Ecosystem Management. *Ecosystems,* 12, 191-206.

Connell, J. H. (1978). Diversity in tropical rain forest and coral reefs: high diversity of trees and coral is maintained only in a nonequilibrium state. *Science* 199(4335), 1302-1310. https://doi.org/10.1126/science.199.4335.1302

Danjuma, K. (2012). Urbanization and urban Agriculture. The case of Metropolitan Katsina and implications for sustainable Development in Nigeria. Journal for the Tropics, 9 (2), 56-58.

Efenakpo, O. D., Uwatt, A., Egbochie, C. and Akupue, I. C. (2019). Birds and urbanization: A case study of Choba Community River State, Nigeria. *In*: Adeyanju A.T., Orimaya, J.O., Coker, O. M., Alarape, A. A., Ayodele, I. A., Omonona, A. O., Ojo, S. O., Ajani, F., Ogunjinmi, A. A. (eds). Wildlife Management Contribution to the diversifying Economy. Proceeding of the 3rd Wildlife Society of Nigeria (WISON) Conference held in Ibadan, 16th-19th September 2019. Pp. 284-291

Filloy, J., Zurita, G. A. and Ballocq, M. I. (2018). Bird diversity in urban ecosystem: The role of the biome and land use along urbanization gradients. *Ecosystems*, 22, 213-227. https://doi.org/10.1007/s10021-018-0264-y

Fontana, S., Sattler, T., Bontadina, F. and Moretti, M. (2011). How to manage the urban green to improve bird diversity and community structure. *Landscape and Urban Planning,* 101(3), 278-285.

Girma, Z., Mamo, Y., Mengesha, G., Verma, A. and Asfaw, T. (2017). Seasonal abundance and habitat use of bird species

in and around Wondo Genet Forest, Southcentral Ethiopia. *Ecology and Evolution*, 7, 3397-3405. https://doi.org/10.1002/ece3.2926

Isaac, M. M., Muya, S. M., Kiiru, W. and Muchai, M. (2019). Avian Abundance, Diversity and Conservation status in Etago Sub-County Kisii County Kenya. *Open Journal of Ecology*, 9, 157-170. https://doi.org/10.4236/oje.2019.95013

Isaksson, C. (2018). Impact of Urbanization on Birds. In: Tietze, D. (eds) Bird Species Fascinating Life Sciences. Springer, Cham.

Issa, A. (2019). Diversity and abundance of wild birds' species in two different habitats at Sharkia Governorate, Egypt. *The Journal of Basic and Applied Zoology, 80 (34), 1-7.*https://doi.org/10.1186/s41936-019-0103-5

Jagruti, R., Sonal, D. and Geeta, P. (2017). Diversity of avifauna in urban city, Vadodara, Gujarat, India. *Biolife* 5(2), 224-231.

Kabir, A. and Maidawa, A.S. (2018). Spatial Dimension of Ginzo River Response to Urbanization in Katsna Metropolis, Nigeria. *International Journal of Scientific and Technology research* 7, 123-127.

Kwaga, B.T., Iliya, D., Ali, A. and Khobe D. (2017). Avifauna Abundance and Diversity in Jos Wildlife Park Nigeria. Agricultural science and technology 9(3), 234-239.

Koshida, C. and Katayama, T. (2018). Meta-analysis of the effects of rice field abandonment on biodiversity in Japan. *Conservation Biology*, 32, 1392-1402.

Ladan, S. I. (2014). Composting as a Sustainable Waste Management Method in Katsina Metropolis, Northern Nigeria. *International journal of Bioscience, Biochemistry and Bioinformatics* 4(1),11-13.

Li, Y., Chen, Z., Peng, C., Huang, G., Niu, H. and Zhang, H. (2021). Assessment of habitat change on bird diversity and bird-habitat network of a coral Island, South China Sea. *BMC Ecology and Evolution*, 21, 1-10. https://doi.org/10.1186/s12862-021-01865-y

Lorenzón, R. E., Beltzer, A. H., Olguin, P. F. and Ronchi-Virgolini, A. L. (2016). Habitat heterogeneity drives bird species richness, nestedness and habitat selection by individual species in fluvial wetlands of the paraná River, Argentina. *Austral Ecol*, 41(7), 829-841. https://doi.org/10.111/aec.12375

Mohd-Azlan, J., Noske, R. A. and Lawes, M. J. (2015). The Role of Habitat Heterogeneity in Structuring Mangrove Bird Assemblages. *Diversity*, 7(2), 118-136. https://doi.org/10.3390/d7020118

Pennington, D. N. and Blair, R. B. (2011). Habitat Selection of Breeding Riparian Birds in an Urban Environment: Untangling the Relative Importance of Biophysical Element and Spatial Scale. *Diversity and Distribution*, 17, 506-518.

Planillo, A., kramamer- Schadt, S., Buchhloz, S., Gras, P., Von der Lippe, M. and Radchuk, V. (2020). Arthropod abundance modulates bird community responses to urbanization. *Diversity and distribution*, 27, 34-39.

Ramchandra, A. M. (2013). Diversity and richness of bird species in newly formed habitats of Chandoli National Park in Western Ghats, Maharashtra State, India. *Biodiversity*, 4, 235-242.

Ruma, M. M. and Sheikh, A. U. (2010). Reuse of wastewater in urban farming and urban planning implications in Katsina Metropolis, Nigeria. *African journal of Environmental Science and Technology* 4(1), 28-3

Tanalgo, K. C., Pienda, J. A. F., Agravante, M. E. and Amerol, Z. M. (2015). Bird Diversity and Structure in Different Land-use Types in Lowland South-Central Mindano, Phillipines. *Tropical Life Sciences Research*, 26(2), 53-103

Tessfa, E., Ejigu, D, Degife, G., & Tassie, N. (2020). Diversity, relative abundance, and habitat selection of avian species in Tara Gedam Monastery forest and adjacent habitats, Northwestern Ethiopia. *Ethiopian. Journal of Science. & Technology*. 13(1), 65-80.

United Nations Department of Economic and Social Affairs, Population Division. (2015). *World Urbanization Prospects: The 2014 Revision, (ST/ESA/SERA.A/366)*

Wilcoxen, T.E., Horn, D. J., Hogan, B. M., Hubble, C. N., Huber, S. J., Flamm, J., Knott, M., Lundstrom, L., Salik, F., Wassenhove, S. J. and Wrobel E. R. (2015). Effects of bird feeding activities on the health of wild birds. *Conservation Physiology*, 3(1), 1-13.

Wang, X., Zhu, G., Ma, H., Wu, Y., Zhang, W., Zhang, Y., Li, C. and de Boer, W. F. (2022). Bird communities' responses to human-modified landscapes in southern Anhui Mountainous Area. *Avian Research*, 13, 1-8.