



## AVIFAUNA SPECIES ABUNDANCE AND DIVERSITY IN GIREI LOCAL GOVERNMENT, ADAMAWA STATE, NIGERIA

KWAGA BT <sup>a\*</sup> • IBRAHIM D <sup>a</sup> • ALI A <sup>b</sup> • KHOBE D <sup>b</sup>

<sup>a</sup> Department of Forestry and Wildlife Management, MAUTECH, Yola

<sup>b</sup> Department of Crop Science, Adamawa State University, Mubi.

\*Correspondence Author's email: [divinetizhe@yahoo.com](mailto:divinetizhe@yahoo.com) and [zifadi007@gmail.com](mailto:zifadi007@gmail.com)

**ABSTRACT:** The study assessed the avifauna species list, abundance and diversity in Girei Local Government of Adamawa State, Nigeria. Three distinct habitats (grassland, mountainous and riparian/Riverine) were used for data collection. Two transects of 2km in length were established in each of the habitats for the purpose of data collection on bird's species. Data collected were subjected to descriptive statistics (frequencies tables and percentages), one way ANOVA as well as Shannon Weiner's diversity index. The result on the checklist of birds obtained showed that there was a total of 3,838 individual species. Speckled pigeon was dominant (8.49%), followed by village weaver (8.08%) while copper sunbird, little egret and lesser krestrel were the least (0.05%) among others. Results of the relative abundance of bird's species showed that riparian/Riverine had  $\pm 5.537$ , grassland had  $\pm 3.620$  and mountainous area had  $\pm 2.782$ . The result of Shannon Weiner's diversity index revealed 2.2123, 2.232 and 2.320 for riparian/Riverine, grassland and mountainous area. Conservation education campaigns and formation of ornithological and ecological societal clubs in the study area is highly recommended.

Key words: avifauna species, habitats, abundance, diversity

Received: April 24, 2020 • Returned in Revised form: August 21, 2020 • Accepted: August 27, 2020

### 1. INTRODUCTION

Birds are visible and integral part of the ecosystem. Their occurrences have been helpful as environmental health indicators, crop plants pollinators and seed dispersal as well as pest control (Bideberi, 2013). They have been able to adapt themselves to living in climates varying from the ice snow of the Antarctic to the fringes of the hottest deserts, they are often perceived as being more attractive than other animal species. In general, birds are more easily observed than other animal groups with the possible exception of the larger mammals (Kwaga *et al*, 2017). For these reasons, the distribution of birds, their abundance and diversity has been of interest to many

people (naturalists, citizen scientists and professionals, organizations and societies) throughout the world.

Quantifying the birds' species abundance and diversity in related communities had gained increasing importance in environmental impact assessment, especially in conservation planning and ecological research (Mohammed and Mohammed, 2011). Therefore, data from bird-habitat survey have been shown to be a straight-forward and efficient means for estimating biodiversity, monitoring ecological change, measuring the baseline pattern of diversity, and gauging the effectiveness of management practices in protected areas (Anne and Brian, 2011).

Diversity has been referred to as the quantitative measure that reflects how many different species are in existence in a data set. A variety of objective measures have been created in order to measure diversity. The basic idea is to obtain a quantitative estimate of biological variability that can be used to compare biological entities, composed of direct components, in space or time (Albert, 2012).

Species diversity is often measured as an index that incorporates the interplay between species richness and abundance (Ramchandra, 2013). Quantifying the avifauna species abundance and diversity in communities has gained increasing importance in environmental impact assessment especially in conservation planning and ecological research (Ali *et al.*, 2019). Species inventories not only help in understanding species losses but also help determine the characteristics of species that are vulnerable to habitat perturbations (Kwaga *et al.*, 2019). Assessment of avifauna species is essential for sustainable development. The lack of it, results in weak monitoring of bio-data, vegetation degradation and loss of ecosystem resources. Wrong attitude towards achieving its goal has led to reduced variety of ecosystem potentials which could have negative impact on socio-economic development of varieties of goods and services derived from the ecosystem (Ali *et al.*, 2019).

Diversity is the biological assemblage of species in its entity, which is the complete representation of all possible measures of biological diversity across space and time (Kwaga *et al.* 2017). Species diversity is often measured as an index that incorporates the interplay between species richness and abundance (Ramchandra, 2013). Quantifying the avifauna species abundance and diversity in communities has gained increasing importance in environmental impact assessment especially in conservation planning and ecological research. Species inventories not only help in understanding species losses but also help determine the characteristics of species that are vulnerable to habitat perturbations (Khobe and Kwaga, 2017). Evaluation of avifauna species is essential for sustainable development. The lack of it, results in weak monitoring of bio-data, vegetation degradation and loss of ecosystem resources (Ali *et al.*, 2019). Wrong attitude towards achieving its goal has led to reduced variety of ecosystem potentials which could have negative impact on socio-economic development of varieties of goods and services derived from the ecosystem.

Birds have been used as source of income and key model for measuring the quality of the altered biodiversity, where diversity of birds is influence by habitat stability (Ngongolo and Mtoka, 2013b). Some bird species depend on the disturbed habitat for food and shelter such as homegarden. Reduction in their habitats therefore forces the species to migrate to other areas permanently.

Differences in requirement among bird species have caused specificity on habitat requirement (Buckley and Freckleton, 2010).

Habitat destruction, fragmentation and loss have been observed due to increase of human population (Mohammed and Mohammed, 2011). Forests have been converted to urban settlement, agricultural field and pasture land, sometimes to open land. These human activities have an impact on bird species abundance, distribution and diversity due to isolation and fragmentation (Kwaga *et al.*, 2017). Decline in abundance and loss of species due to human interference have been observed in the tropics. This concurs with the studies of Doggart *et al.* (2005) on Uluguru Mountains. The results indicate that diversity and distribution of birds are affected by human activities in the Uluguru forest reserve. The research done in Morogoro region by Buckley and Freckleton (2010) and Doggart *et al.* (2005) had given attention to the protected area (Uluguru Nature Reserve) without considering other habitat types outside the protected area system such as farmlands, settlement area and open shrubland which occur at the foot of the mountain. Basing on the idea that birds are widely distributed, these habitats may become important for avifauna survival.

Thus Study on abundance and diversity of birds with respect to different habitat types is important since it will provide an understanding on the avifauna abundance and diversity within natural and human occupied habitats. Also assessment of birds' species abundance and diversity of an area makes it possible for any organization to plan for future conservation and sustainable utilization of avifauna resources (Anne and Brian, 2011; Khobe and Kwaga, 2017). Hence, the need for this study which is aimed at assessment of avifauna species abundance and diversity in Girei Local Government Area Adamawa State, Nigeria.

## 2. METHODOLOGY

### 2.1 Location of the study area

The research was conducted in Girei Local Government Area of Adamawa State, Nigeria. The area is located at the central part of the state and lies between latitudes  $9^{\circ} 11'$  to  $9^{\circ} 39'$  North of the equator and longitudes  $12^{\circ} 11'$  to  $12^{\circ} 49'$  East of the Greenwich Meridian with a land mass of about 2,186 km<sup>2</sup>(Adebayo, 1999). The local government is boarded by Song Local Government Area in the North, Furore Local Government Area in the east, while River Benue acts as a physical boundary between the local government area, and Yola North and Demsa Local Government Area. (Adebayo, 1999) (Figure 1). The study area experiences distinct dry and wet seasons

with temperature and relative humidity varying with seasons. The wet or rainy season fall between April and November, which is characterized by single maxima in August. During this season, the moisture laden south west trade wind from the Atlantic Ocean blow over the area. Seventy percent of the total rainfall in the area happens to fall within four months of May – August. The area has an average of 62 rainy days, while average amount of rainfall recorded in the area is 972mm. The dry season which is the harmattan period is between Decembers to March. The period is characterized by dry, dusty and hazy Northern trade wind that blows over the area from Sahara deserts. Temperature within the area varies with season. Although the temperatures are

relatively high almost all the year round, temperature of the area ranges from 27°C - 40°C. December and January is the coldest months with an average temperature of 34°C. (Adebayo, 1999). The vegetation of the area is Sudan Savannah type which is characterized by thick vegetation around hills and mountain ranges. The vegetation has a wide variety of Savannah woodland plant species among which are; *Acacia* spp, *Combretun* spp, *Adansonia* spp, *Anogeissus* spp, *Prosopis africana*, *Terminalia glaucescens*, *Daniela oliverii*, *Citrus aurantium*, *Philiostigma thonningii*, *Anona senegalensis*, *Parkia biglobosa*, *Lannea acida* among others (Kwaga *et al.*, 2017).

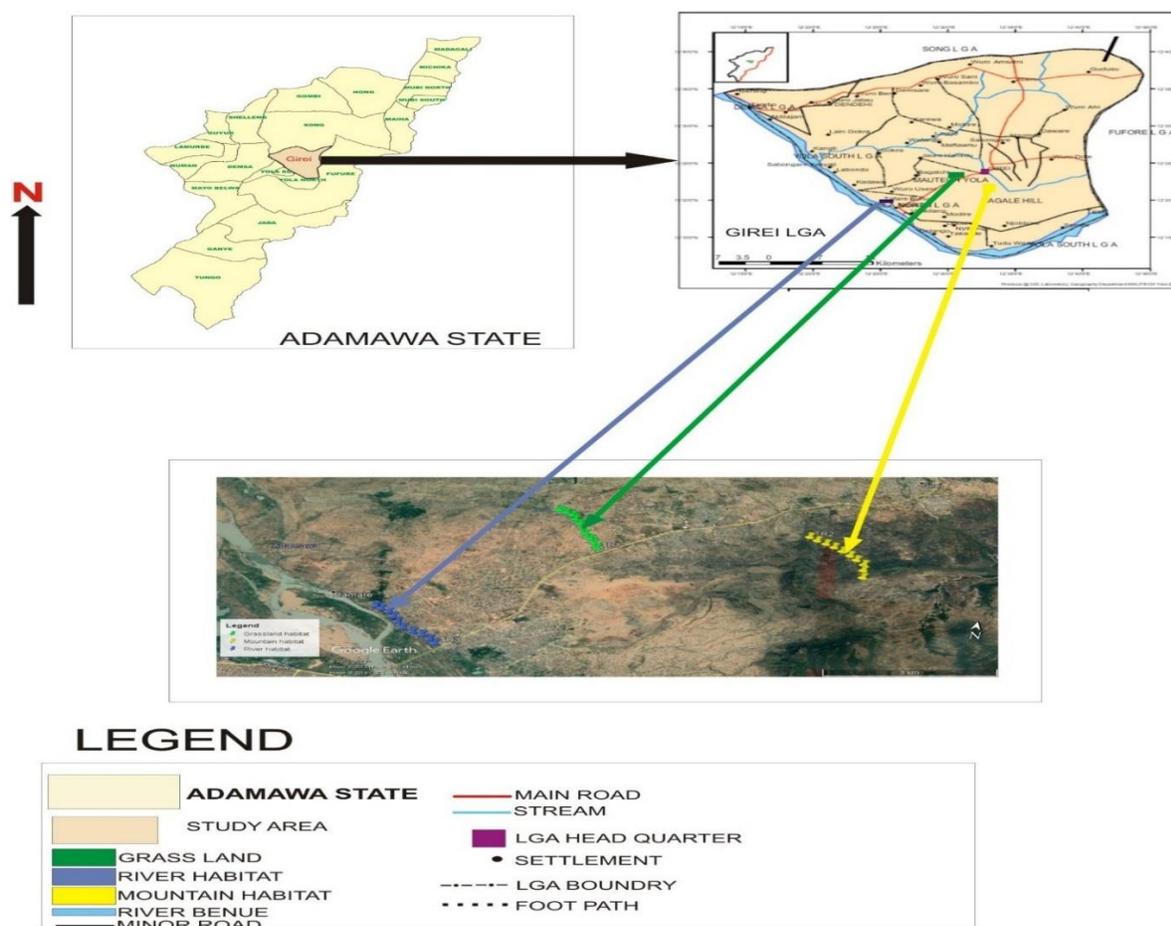


FIG 1. MAP OF ADAMAWA STATE SHOWING THE STUDY AREA AND THE DIFFERENT SELECTED HABITAT TYPES  
 Figure 1: Map of Adamawa State showing the study area (Source: G.I.S. Unit MAUTECH, 2019)

## 2.2 Study design

The study design followed the method described by Sutherland (1999) and adopted by Kwaga *et al.*, (2019). Reconnaissance survey was carried out in order to ascertain the existing habitats, possible transects for bird identification in the study area. This, was followed by the division of the entire area in to three (3) basic habitats as follows; A: Grassland habitat (located at Mararaba Daware), B: Mountainous habitat (located at Wuro-dole of Bagale Hills) and C: Riparian habitat/Riverine area (along the bank of river Benue) respectively.

## 2.3 Data Collection Techniques

### 2.3.1 Check-list of avifauna species in the study area

Line transects of 2km length and 50m radius at intervals of 100m following (Ali *et al.* 2019) was used to assess avifauna species list in the study area as well as the use of related literatures. Any bird species noted (in group/single or flight) were identified and recorded in a data sheet in the study area.

### 2.3.2 Avifauna abundance and Diversity in the study area based on habitats

Line transects were used for obtaining information on avifauna species abundance in the study area. A length of 2km transect was walked at interval of 100m during early mornings, between 07:00am and 10:00am hours, and in the evening between 2:30pm and 5:30pm hours (in each habitat) were laid and assessed following Khobe and Kwaga (2017) and Bideberi (2013). The researcher visited each transect twice (morning and evening) for a period of three months (August to October). During each visit, the researcher and his assistants walked slowly along the established transects, waited for five minutes for birds to settle, and recording of birds sighted was done. All birds observed or heard, including those in flight within 50m radius were recorded as adopted by Khobe and Kwaga (2017) and Kwaga *et al.*, (2019). Bird species, number, habitat type were also recorded. A pair of binocular with magnification of 10\*42 was used for the identification of birds sighted. The study was limited to diurnal birds only due to lack of special equipment to detect nocturnal birds. Also assessment was limited to avifauna species lists abundance and diversity in each of the selected habitats as adopted by Kwaga *et al.*, (2017).

## 2.4 Statistical Analysis of Data

### 2.4.1 Species checklist, bird abundance and diversity

- i. a checklist of avifauna species was compiled in microsoft excel showing common species names and habitat type in form of Tables as well as the frequencies of each species of birds and their occurrences following Adesoye (2004).
- ii. Data on the avifauna species abundance in each of the habitat in the study area was analysed following Pennington and Brail (2011) as illustrated below.

#### Estimates of Avifauna Species Abundance Across Habitats

Habitat	Mean $\pm$ std	Frequency
Grassland		
Mountainous		
Riparian		

- iii. Avifauna species diversity was determined using Shannon-Wiener diversity index as well as Kruskal-Wallis one-way ANOVA in the study area. This is illustrated below

$$H = - \sum_{i=1}^S P_i \ln P_i$$

Where  $P_i$  = number of individual species over the total number of species.

- iv. Kruskal-Wallis One-Way ANOVA (CRD) was used to test for significant difference in avifauna abundance and diversity across the habitats in the study area.

## 3. RESULTS AND DISCUSSIONS

### 3.1 Checklist of Avifauna Species in the Study Area

The results of checklist of avifauna species for the three habitat types in the study area are presented in Table 1. The result shows a checklist of 80 different avifauna species distributed in the study area. A total number of 3,838 individuals of avifauna species were identified in the study area. In grassland 1124 individuals were identified, 1054 individuals in the mountainous habitat and 1660 individuals were identified in the riparian habitat.

### 3.2 Avifauna species Abundance in the study area

The results of avifauna species abundance is shown in Table 2. The riparian habitat had the highest abundance of birds per point ( $20.75 \pm 5.5366$ ), followed by the grassland ( $14.05 \pm 3.6205$ ) habitat, and mountain had the least ( $13.175 \pm 2.7826$ ). The results of ANOVA carried out shows that the abundance of avifauna species differs significantly ( $P > 0.05$ ) across habitats. The birds species of the grassland and mountain habitats was not significantly ( $P \geq 0.05$ ) different, however the abundance of birds in Riverine/riparian habitat was significantly different ( $P \leq 0.05$ ) from the grassland and mountain habitats.

Higher abundance of avifauna species in the riparian habitat may be as a result of the wide varieties of foraging opportunities available, and as a result of the habitat heterogeneity induced by human activities of farming and fishing along the river banks at the time of this study. The findings of this study concur with that of Pennington and Brail (2011); Shochat *et al.*, (2010) Khobe and Kwaga (2017), who observed that higher abundance of birds in habitats were triggered by habitat heterogeneity such as farmlands, gardens, irrigated areas, and buildings created by men.

Also, higher abundance of birds in grassland than the mountain habitat may have been contributed by few species that can coexist with humans such as yellow-billed shrike laughing dove, Bronze Mannikin, Common Bulbul and African palm swift while the mountain habitat with highest elevation in this study maintained the least abundance of birds, this may be due to absences of ecological requirements as well as and risk of predation in the elevated areas could be ascribed to the reasons for the

decline in abundance of birds compared to the heterogeneity of habitat close to human settlement. Ali *et al.* (2019) Pennington and Brail (2011) and Shochat *et al.*, (2010) made similar observations during their various studies.

### 3.3 Diversity of Avifauna Species in the study area

Result of avifauna species diversity in the study area is shown in Table 3. The result indicated that avifauna species diversity was not normally distributed across habitats ( $D = 0.95366$ ,  $p\text{-value} < 0.001$ ). Mountain habitat had the highest Shannon diversity index of avifauna species ( $H = 2.320$ ), followed by grassland ( $H = 2.232$ ) and riverine habitat had the least. The findings from this study also indicated that the diversity of avifauna species varies significantly across the habitat types. With Shannon diversity index of the bird's ranging from 2.123 to 2.320, this shows that the habitats are quite diverse for biological communities.

The mountain habitat had the highest diversity of birds; this may be due to wide altitudinal variation and a complex array of vegetation types which has created transition areas in the mountain habitat for many bird species. This finding is in agreement with that of Khobe and Kwaga (2017) who also observed that Climatic variation, competitive exclusion, predation and habitat discontinuities (ecotones) may be the basis of transitions along gradients. Ali *et al.* (2019) and Kwaga *et al.*, (2019) made a similar observation during their study. The river habitat tends to have the least diversity which is as a result of the human intense activities of farming and along the river edges. Gloria (2013) reported that avifauna species diversity tends to decline in areas with human induced disturbances and less foraging resource except for some specialist and human intolerant species.

Table 1: Check-list of avian species in the study area

s/n Species	Grassland	Mountain	river	percentages	Total
1.Abdims stork	12	0	0	0.31	12
2.Abyssinian roller	54	12	0	1.72	66
3.African darter	0	0	6	0.16	6
4.African grey hornbill	38	10	0	1.25	48
5.African jacana	0	0	4	0.10	4
6.African palm swift	91	46	75	5.52	212
7.African silver bill	0	0	162	4.22	162
8.African thrush	61	90	108	6.75	259
9.African wattle lapwing	5	0	0	0.13	5
10.Bearded barbet	0	10	0	0.26	10
11.Beautiful sunbird	10	0	12	0.57	22
12.Black billed wood dove	0	4	0	0.10	4
13.Black crane	0	0	48	1.25	48
14.Black crowned tchagra	0	4	0	0.10	4
15.Black headed heron	4	6	6	0.42	16
16.Black shouldered kite	2	4	10	0.42	16
17.Bronze manikin	0	12	0	0.31	12
18.Brown babbler	7	0	0	0.18	7
19.Bruces green pigeon	0	6	0	0.16	6
20.Bush petronia	7	0	0	0.18	7
21.Cattle egret	94	38	127	6.75	259
22.Cinnamon breasted bunting	0	6	0	0.16	6
23.Cliff chat	0	14	0	0.36	14
24.Common bulbul	17	82	0	2.58	99
25.Common kestrel	11	8	0	0.50	19
26.Copper sunbird	2	0	0	0.05	2
27.Dark chanting goshawk	2	0	2	0.10	4
28.Double spurred francolin	0	4	0	0.10	4
29.Ethiopian swallow	0	0	4	0.10	4
30.Fork tailed drongo	28	8	0	0.94	36
31.Fox kestrel	12	10	0	0.57	22
32.Green wood hoopoe	6	6	0	0.31	12
33.Grey back camaroptera	2	0	2	0.10	4
34.Hammer kop	0	0	7	0.18	7
35.Helmeted guinea fowl	0	126	0	3.28	126
36.Lanner falcon	0	2	0	0.05	2
37.Laughing dove	54	93	100	6.44	247
38.lesser kestrel	2	0	0	0.05	2
39.Little egret	0	0	2	0.05	2
40.little green bee eater	0	34	0	0.89	34

Table 1 Cont'd: Check-list of avian species in the study area

s/n Species	Grassland	Mountain	river	percentages	Total
41.Little swift	40	0	42	2.14	82
42..Little weaver	0	0	22	0.57	22
43.Lizard buzzard	6	0	12	0.47	18
44.Long tailed camorot	0	0	2	0.05	2
45.Malachite kingfisher	0	0	2	0.05	2
46.Mottled spine tail	0	2	0	0.05	2
47.Mourning dove	12	2	23	0.96	37
48.Northern black fly catcher	0	4	0	0.10	4
49.Northern brubru	0	11	0	0.29	11
50.Northern grey headed sparrow	25	4	0	0.76	29
51.Northern red billed hornbill	20	2	0	0.57	22
52.Northern red bishop	0	0	24	0.63	24
53.Pallid swift	0	0	39	1.02	39
54.Piac piac	0	22	0	0.57	22
55.Pie crop	2	0	0	0.05	2
56.Purple glossy starling	41	22	34	2.53	97
57.Red billed firefinch	0	20	149	4.40	169
58.Red cheeked cordon bleu	10	24	14	1.25	48
59.Red northern bishop	0	0	2	0.05	2
60.Rock loving cisticola	0	6	0	0.16	6
61.Scarlet chested sunbird	19	14	0	0.86	33
62.Senegal coucal	13	0	13	0.68	26
63.Senegal eremomela	0	10	0	0.26	10
64.Senegal parrot	5	6	14	0.65	25
65.Shikra	2	0	4	0.16	6
66.Speckled pigeon	135	22	169	8.49	326
67.Spur winged lapwing	0	0	30	0.78	30
68.Stone partridge	0	88	0	2.29	88
69.Tawny flaked prinia	0	18	0	0.47	18
70.Variable sunbird	12	44	9	1.69	65
71.Village weaver	0	0	310	8.08	310
72.Vinaceous Dove	44	66	23	3.47	133
73.Violet back starling	0	6	0	0.16	6
74.Western grey plantain eater	3	0	7	0.26	10
75.White face whistling duck	0	0	10	0.26	10
76.Yellow billed kite	2	8	4	0.36	14
77.Yellow billed shrike	208	4	22	6.10	234
78.Yellow crowned gonolek	0	0	5	0.13	5
79.Yellow fronted canary	4	0	0	0.10	4
80.yellow fronted thinker bird	0	14	0	0.36	14

Grand Total	1,124	1,054	1,660	100	3,838
-------------	-------	-------	-------	-----	-------

Table 2: Estimates of Avifauna Species Abundance Across Habitats in the study area

Habitat	Mean $\pm$ stde	Frequency
Grassland	14.05 $\pm$ 3.620	1124
Mountainous	13.175 $\pm$ 2.782	1054
Riparian	20.75 $\pm$ 5.5366	1660

Source: *Field work, 2019.*

Table 3. Shannon Diversity of Avifauna Species in the study area across the habitats

Habitat type	Species Richness	Shannon Species Diversity	Shannon species evenness
Grassland	41	2.232	0.0544
Mountain	47	2.320	0.0494
River	41	2.123	0.0518

Source: *Field work, 2019.*

#### 4. CONCLUSION

From the findings of this study, the following conclusions are made:

1. The habitat in the study area is heterogeneous. The different habitat types indicated habitat usage by some of the species in common and species specific to certain habitat in response to ecological factors such as altitude, precipitation, vegetation and climate across landscape in the area.
2. The study also provides evidence that though human induced disturbance may cause low diversity, yet riparian and grassland are important part of the ecosystem that attract large number of avifauna compared to mountainous habitat.
3. Bird species diversity was higher in area with less human activities than in areas with much human activities. The higher diversity suggests higher ecological stability compared to human disturbed habitats where few species occur.
4. More conservation efforts should be put in place to improve upon bird diversity in human occupied environment, and creation of garden and Fruit tree planting should be encouraged. This will enhance bird species diversity around human settlement and farmland.

#### REFERENCES

Adebayo A. A. & Tukur A. L. (1999). Climate 1 (Sunshine, temperature, evaporation and relative humidity), *Adamawa State in Maps*. Adebayo, A. A. and Tukur, A. L. (eds.). Pp. 20-26.

Adesoye, P.O. (2004). *Practical guide to statistical analysis for scientists*. Premier edition, Ibadan-Nigeria. Pp. 1- 189.

Albert, O.H. (2012). Measurement of Species Diversity in Developing Nations. *Journal of Applied Ecology*. B lackwell Publishing. Oxford, U.K. Pp 22-29.

Ali, A, Akosim, C. And Kwaga, B.T. (2019). Evaluation of Avian and Flora Diversity in Relation to Some Ecology and Water Quality Parametetrs in Hadija-Nguru Wetlands, Nigeria. Unpublished PhD Thesis, Department of Forestry and Wildlife Management, MAUTECH, Yola. Pp1-199

Anne, E.M.and Brian, J.M. (2011). Biological Diversity: Frontiers in Measurement and Assessment Oxford University Press, U.K

Bideberi, G. (2013). Diversity, Distribution and Abundance of Avifauna in Respect to Habitat types. A case study of Kilakala and Bigwa- Morogoro, Tanzania; M.Sc. Thesis, University of Agriculture, Morogoro. Tanzania.p 2.

Buckley, H.L and. Freckleton R. P. (2010). Understanding the role of species dynamics inabundance–occupancy relationships. *Journal of Ecology*98: 645–658. 35

Dogart, N; Lovett, J; Mhoro, B; Kiure, J and Burgess, N. (2005). Biodiversity surveys in the Forest Reserves of the Uluguru Mountains. Technical paper for The Wildlife Conservation Society of Tanzania and Tanzanian Forest Conservation Group. DSM, Tanzania. 8 – 18 pp.

Gloria b., (2013). Diversity, distribution and abundance of avifauna in respect to habitat types: a case study of kilakala and bigwa, morogoro, Tanzania.

Khobe, D. and Kwaga, B. T. (2017). Check-list of Birds Species of Jos Wildlife Park, Nigeria. *International Journal of Agriculture, Environment and Bioresearch*. Vol. 2, issue 4. ISSN: 2456-8643. Pp 216-229.

Kwaga, B.T., Gawaisa, S.G., Ali, A. and Khobe, D. (2019). Avifauna Abundance and Diversity in Modibbo Adama University of Technology, Yola, Adamawa State-Nigeria. *Glogal Journal of Science Frontier Research: D. Agriculture and Veterinary: Vol.19, Issue 2*. Global Journal Headquarters, Concord Street, Framingham Massachusetts Pin: 01701, U.S.A. Pp25-34

Mohammed, N.R. and Mohammed,Z. (2011). Birds species Abundance and their relationship with micro-climate and Habitat Variables at Natural Wetland Reserve, Pennisula-Malaysia. *International Journal of Zoology, Vol. 11, Pp2-11*

- Ngongolo, K. and Mtoka, S. (2013b). Biodiversity conservation in inhabited area; What are helmeted guinea fowl (*Numidameleagris*: Numididae) domestication offer in socio-economic development and wildlife conservation. *African Journal of Poultry Farming* 2 (5).
- Pennington, D.N and Brail, 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. 40
- 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 Journal* 4 (1): 235-242.
- Shochat, E; Lerman, S and Fernández-Juricic, E. (2010). Birds in Urban Ecosystems: Population Dynamics, Community Structure, Biodiversity, and Conservation. *Urban Ecosystem Ecology* 55:75-86.
- Sutherland, W.J. (1996). *Ecological Census Techniques: A Hand book*. Cambridge University Press, Cambridge, 336 pp.
- Tworek, S. (2002). Different bird strategies and their responses to habitat changes in an agricultural landscape. *Ecological Research* 17: 339-359.