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AVIFAUNA DIVERSITY AND STATUS OF SOME WET-LANDS IN ADAMAWA STATE, NIGERIA

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ABSTRACT

The Diversity and Status of the Avifauna of some Wetlands in Adamawa State, Nigeria, was Investigated to identify the major wetland sites within the Upper Benue River Basin. Following the identification of the four major wetland sites in the area, census of avifauna was conducted in each site over a period of six months (three months in the dry season and the other three months in wet season). Using point-count method, data were collected five times in a month, and two times a day, morning and evening per site. In each of the study sites, avifauna diversity and status as well as the relationship between avifauna species diversity and precipitation, relative humidity and temperature were assessed. Results obtained showed that 36 Avifauna species occurred in the study sites during the dry season, while 39 avifauna species were sighted at the study sites during the wet season. A total of 42 avifauna species were listed from the four wetland sites studied. Avifauna species diversity varied among months ($P < 0.05$) in the dry season but remained relatively constant in the months of wet season. There was no significant difference ($P > 0.05$) between dry and wet seasons diversity in each of the sites, and when the results were pooled, no significant difference ($P > 0.05$) existed between the bird diversity during the wet and dry seasons, for all the sites. When the four sites were compared for avian species diversity, no significant difference ($P > 0.05$) existed in the dry season among sites, while significant variability ($P = 0.05$) existed among sites in the wet season. The results also showed that *Egretta ardesiaca, Egretta garzetta, Scopus umbretta, Vanellus spinosus, Bubulcus ibis, Dendrocygna viduata*, *Actophilornis africanus, Casmerodius alba* and *Columba guinea* were common and abundant in the study sites, in both dry and wet seasons. An analysis of the relationship between avian species diversity and precipitation, temperature and relative humidity indicated that precipitation and relative humidity contributed more to avian species diversity at the study sites. In view of the importance of the study sites to the diversity of bird species, it is recommended that the sites should be given conservation status, so that the resources can be managed and perpetuated for the purpose of tourism and education in natural history.

Keywords: Avifauna, diversity, wetland.

INTRODUCTION

Avifauna are warm-blooded vertebrates. In the scheme of biological classification, birds belong to the phylum chordata, because of the presence of backbone and to the class – Aves for possessing feather on their bodies (Safra, 1998). The presence of feathers on their bodies is one major characteristic that distinguishes them from all other vertebrates. These occur in many different shapes and sizes, with adaptive functions such as thermal insulation and

flight.

The ability to fly has permitted an almost unlimited radiation of birds, so that they are now found virtually everywhere on earth, from occasional stragglers over the polar ice caps to complex communities in tropical forests (Safra, 1998). There are approximately 8,700 living species and more than 1,000 extinct species identified from fossil remains (Safra, 1998). Birds range from bee hummingbird of Cuba, which is 6.3 cm long and weigh less than 3gm to the largest ostrich location (e.g. Ostrich of Nigeria orchard), which may stand 2.5 m tall and weigh 135kg.

The Ramsar convention on wetlands define the term wetland as area of marsh, fen, peat-land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters. This definition of wetlands has been widely accepted. The definition encompasses coastal and shallow marine area (including coral reefs) as well as river course and temporary lakes or depressions in semi-arid zones (Smart, 1997).

Biodiversity encompasses all species of plants, animals and microorganisms and the ecosystems and ecological processes of which they are part (McNeely et al., 1990). It is the umbrella term for the degree of nature's variety including both the number and frequency of ecosystems, species or genes in a given assemblage. Organisms, which differ widely from each other in some respect, contribute more to overall diversity than those, which are very similar. (McNeely et al., 1990).

Arable crop production is widely practiced on both extensive and subsistence levels in all the four study sites. Besides, extensive grazing takes place within the catchment areas of the study sites. This could constitute a serious threat to the survival of some birds as a result of loss of habitat at the study sites. According to Neave et al. (1990), the physical structure of vegetation is considered an important habitat component through the provision of food, shelter and nesting resources and also in providing potential cues about the on set of conditions suitable for successful breeding. In addition birds are often at risk, either directly or indirectly from pesticides spray treatments. These primarily affect birds' populations by reducing the availability of their arthropod prey. For example, changes in feeding rate of pied kingfishers (Ceryle rudis) and little bee-eaters (Merops pusillus) that prey on small fish and day-flying insects respectively had been affected by spray treatments (Smart, 1997). Bird populations may be reduced by the consumption of contaminated insects with fenitrothions. This causes the death of insectivorous birds through acute poisoning or causes subtlethal effects which will affect their breeding success. Similarly, many insecticides are harmful to fish and thus piscivorous birds may also be at risk. Poisoning may occur when seeds dressed with insecticides are eaten, (Smart, 1997).

The International Water Birds Research Bureau – IWBRB (1990) recommended the necessity to organize coordinated counts of water birds in all tropical Africa, and to evolve a natural network as much as possible. Although some studies have been

carried out on wetlands of Adamawa State none was centered on the abundance and diversity of birds. This dearth of information on water birds of the wetland sites of the state makes the development of conservation and management strategies of the sites for bird species impossible. Therefore, the result of this study will contribute significantly to Africa water-birds checklist. It will also be used to create awareness on the multiple values, uses and monitoring for conservation of the ecosystems of the wetland areas of the state. Four wetland sites were selected for this study based on their size and utilization by water birds.

It is in view of the problems highlighted above that this study was proposed with the following objectives: to identify the bird species present in the four study sites at different seasons (wet and dry seasons); to measure the monthly and seasonal avifauna diversity of the four study sites; to determine the seasonal absolute population density of bird species in the four study sites and to evaluate the relationships, between bird species diversity and precipitation, temperature and relative humidity.

METHODOLOGY

Study Area

Adamawa State covers a land area of about 38,741km^2 (Adebayo, 1999). It lies between Latitude 7^0 and 11^1 North of the equator and between longitude 11^0 and $14^!$ E of the Greenwich meridian. It is bounded on South and West by Taraba State, Northeast by Gombe State and Borno state to the North. It shares international boundaries with the Cameroon Republic along its eastern border (Adebayo, 1999) as shown in Fig.1.

The Study Sites

Lake Gariyo

This lake is located in Yola North Local Government Area (LGA) of the state within River Benue valley. It is geographically located in latitude $9^0$18'N and longitude $12^0$15'E. It is about 260 hectares in size. The vegetation is open savannah with the following as the major woody plant species, Mitragina pigra, Vetivera mignitana, and Mitragina inermis (Figure 1).

Lake Tingno

The lake is located in Numan Local Government Area in Ngbakowo village. It is geographically located in latitude 9^0 25^1 N and longitude 11^0 32^1E. It is about 350 hectares in size. The vegetation is an open savanna and has been converted to farmland (Figure 1).

Njuwa Lake

Njuwa lake is located in Yola South Local Government Area; it is geographically located in latitude $9^0$$18^1$ N and longitude 12^0 28^1 E. It is about 750 hectares in size. The vegetation is open savannah. The lakeshore is dominated by Mimosa pigra and Vetivera nigritana (Figure 2).

Kiri Dam

This lake is located in Kiri town in Shelleng Local Government Area. It is geographically located within latitude 9^0 41^1 and longitude 12^0 00^1 E, about 11,500 hectares. Kiri Dam is an artificial lake with extensive draw down area. The draw down area is dominated by the following vegetation species *Echinochloa stagnina, Mimosa pigra,* and *Vetivera nigritana* (figure 1).

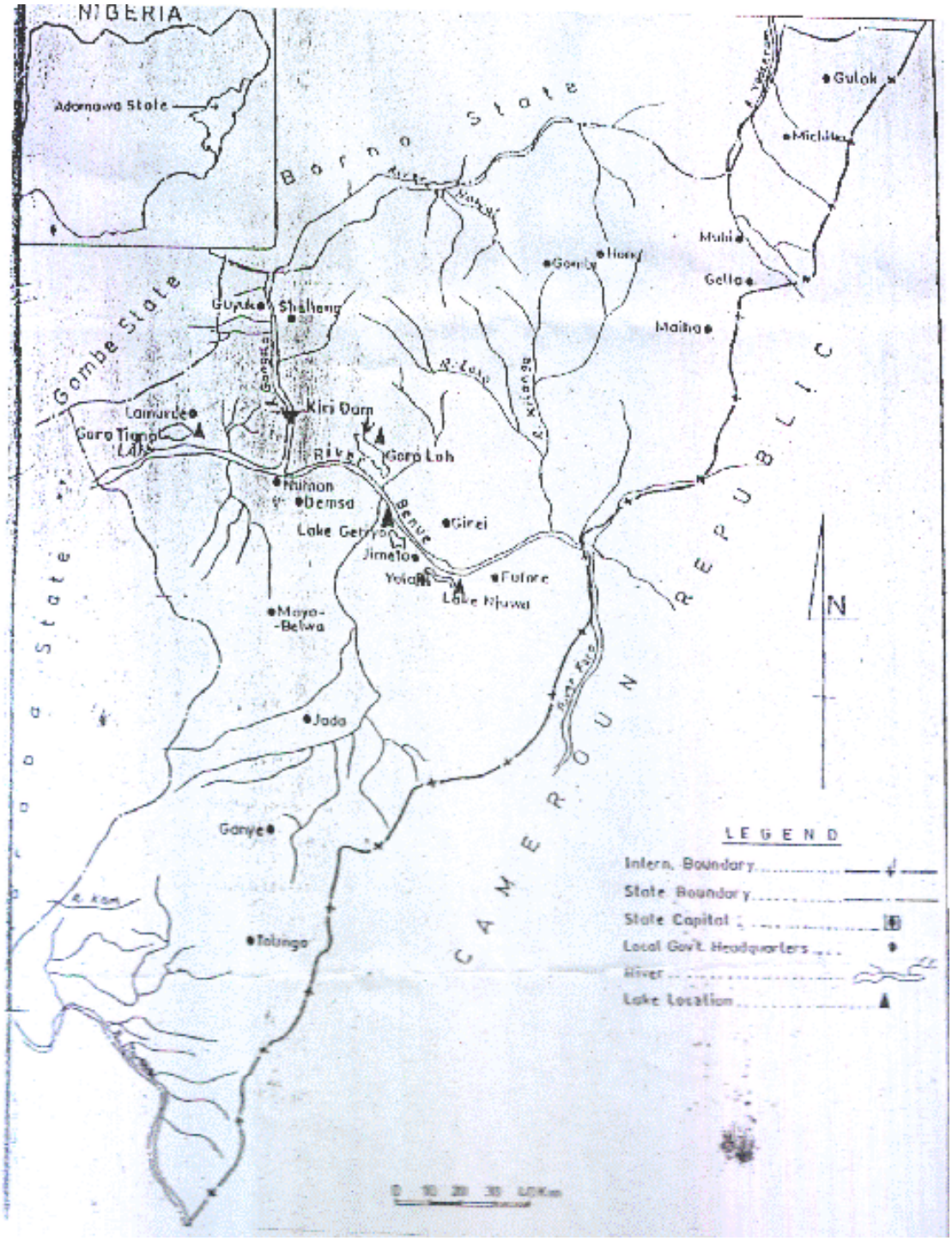

Figure 1: Some Wetlands of Adamawa State
Source: Adebayo (1990)

Study Design and Data Collection Techniques

The point count method as described by Sutherland (1999) was used for the census of birds at the study sites. This involved the establishment of counting stations at each study site. Counting bands of 50m radius was established in counting stations. The minimum distance between two counting stations was 200m. the number of counting stations was determined by the site size. Data on each site was collected for six months (3months in the wet seasons and 3 months in the dry season) on 5 days per month and twice a day from 07.00am – 12.00pm hours and 13.00pm – 18pm hours. The author waits for a few minutes after arrival at each station before beginning to count. This allowed the birds to settle down following the observer's arrival. Count was carried out for ten minutes. Each bird was counted once and all birds seen or heard within the bands were recorded.

Data Analysis

Avian Species Diversity

From the data collected, avian species diversity was calculated using Shannon diversity index, (Usher, 1991) which states:

Diversity (D) = $- \Sigma$ Pi In Pi

where: P_i = is the proportion of the i^{th} species in the sample

InP_i = is the natural logarithm of the species proportion.

Randomized complete block design and Fishers LSD were used to determine significant differences between months, seasons and sites.

Species Absolute Population Density

Species absolute population density of birds at various sites and seasons were determined as outlined by Bibby *et al.*, (1992) as follows:

$$D = \frac{n_1 + n_2}{\pi r^2 m} \quad \text{Log} \quad \frac{e[n_1 + n_{2-}]}{n_2}$$

where: D = density

r = radius of the first zone

n_1 = number of birds counted within zone

n_2 = number of birds counted beyond zone and

m = number of replicate count in such area.

Regression Analysis

Diversity of avian species (dependent variable) and precipitation, temperature and relative humidity (independent variables) were regressed to test the dependency of species diversity on the independent variables (Frank and Althoen, 1994).

where: $Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + e$

Y = *species diversity*

a = *intercept*

X_1 = *precipitation* (mm)

X_2 = *temperature*(^oC)

X_3 = *relative humidity (%)*

e = *error term*

b_1, b_2, b_3 = *coefficients*

RESULTS

In this study four major wetland sites were identified in the Northern Guinea Savannah Zone of Adamawa State. They include Lake Njuwa, Lake Geriyo, Lake Tingno

and Kiri Dam. The avian species that were present on these wetland sites both in the dry and wet seasons were observed and counted. The species list of the birds was made and their diversity and absolute population density estimate determined for both seasons. The influence of temperature, precipitation and relative humidity on the presence of birds on the wetland sites were also determined.

Species List of Avifauna of Four Wetland Sites in Adamawa State

Table 1 shows the species list of the avifauna of some wetland sites in Adamawa State and their seasons of occurrence. There were 42 species belonging to 25 families. Bird families with the highest number of species are the *Ardeidae* and the *Columbidae*. All the species listed were sighted directly at various times during the period of the study.

Table 1: Checklist of Avian Species in Four Wetland Sites in Adamawa State

SN	FAMILY/COMMON NAME	SCIENTIFIC NAME	LAKE GARIYO		LAKE TINGNO		LAKE NJUWA		KIRI DAM	
			DS	RS	DS	RS	DS	RS	DS	RS
	PHALACROCORACIDAE									
1	Long-tailed Cormorant	*Phalacrocorax africanus*	X	X	X	X	X	X	X	X
	ARDEIDAE									
2	Little Bittern	*Lxobrychus minutus*	X	X	X	X	X	X	X	X
3	Black crowned Night Heron	*Nycticorx nycticorx*	X	X	X	X	X	X	X	X
4	Madagascar Squacco Heron	*Ardeola idae*	X	X	X	X	X	X	X	X
5	Squacco Heron	*Ardeola ralloides*	X	X	X	X	X	X	X	X
6	Cattle Egret	*Bubulcus ibis*	X	X	X	X	X	X	X	X
7	Black Heron	*Egretta ardesiaca*	X	X	X	X	X	X	X	X
8	Little Egret	*Egretta garzetta*	X	X	X	X	X	X	X	X
9	Great White Egret	*Casmerodius alba*	X	X	X	X	X	X	X	X
10	Purple Heron	*Ardea purpurea*	X	-	X	-	X	-	X	X
11	Grey Heron	*Ardea cinerea*	X	X	X	X	X	X	X	X
12	Black-headed Heron	*Ardea melanocephala*	X	-	X	X	X	X	X	X
	SCOPIDAE									
13	Hammerkop	*Scopus umbretta*	X	X	X	X	X	X	X	X
	CICONIIDAE									
14	African Open-bill Stork	*Anastomus lamelligerus*	X	X	X	X	X	X	X	X
15	Abdim's Stock	*Ciconia abdimii*	-	X	-	X	-	X	-	X

	CICONIIDAE									
14	African Open-bill Stork	*Anastomus lamelligerus*	X	X	X	X	X	X	X	X
15	Abdim's Stock	*Ciconia abdimii*	-	X	-	X	-	X	-	X
	ANATIDAE									
16	White-faced Whistling Duck	*Dendrocygna viduata*	X	X	X	X	X	X	X	X
	ACCIPITRIDAE									
17	Black Kite	*Milvus migrans*	X	X	X	X	X	X	X	X
	RALLIDAE									
18	Allen's Gallinule	*Porphyrio allen*	-	-	-	-	-	X	-	-
	JACANIDAE									
19	Lily Trotter	*Actophilornis africanus*	X	X	X	X	X	X	X	X
20	Lesser Lily-Trotter	*Microparra capensis*	X	X	X	X	X	X	X	X
	RECURVIROSTRIDAE									
21	Black-winged Stilt	*Himantopus himantopus*	-	X	X	X	X	X	-	-
	BURHINIDAE									
22	Senegal Thick-knee	*Burhinus senegalensis*	X	X	X	X	X	X	X	X
	GLAREOLIDAE									
23	Egyptian Plover	*Pluvianus aegyptius*	X	X	X	X	X	X	X	X
	CHARADRIIDAE									
24	Spur-winged Plover	*Vanellus spinosus*	X	X	X	X	X	X	X	X
25	Ringed Plover	*Charadrius Hiaticula*	-	X	-	-	-	-	-	-
	COLUMBIDAE									
26	Speckled Pigeon	*Columba guinea*	X	X	X	X	X	X	X	X
27	African Mourning Dove	*Streptopelia decipiens*	X	X	X	X	X	X	X	X
28	Laughing Dove	*Streptopelis senegalensis*	X	X	X	X	X	X	X	X
	CUCULIDAE									
29	Senegal Coucal	*Centropus senegalensis*	X	X	X	X	X	X	X	X
	ALCEDINIDAE									
30	Pied Kingfisher	*Ceryle rudis*	X	X	X	X	X	X	X	X
	MEROPIDAE									
31	Carmine Bee-eater	*Merops nubicus*	-	X	-	-	-	-	-	-
	CORACIIDAE									
32	Rackettailed Roller	*Coracias sputulata*	X	X	X	X	X	X	X	X
	ALAUDIDAE									
33	Crested Lark	*Galerida cristata*	-	X	X	X	-	X	-	X
	TURDIDAE									
34	West African Thrush	*Turdius pelios*	X	X	X	X	X	X	X	X

	LANIIDAE									
35	Yellow-billed Shrike	*Corvinella corvine*	X	-	-	-	-	-	-	-
	MALACONOTIDAE									
36	Gonolek	*Laniarius barbarus*	X	-	-	-	-	-	-	-
	CORVIDAE									
37	Black Magpie	*Ptilostomus afer*	X	X	X	X	X	X	X	X
38	Pied Crow	*Corvus albus*	X	X	X	X	X	X	X	X
	PLOCEIDAE									
39	Red-billed Quelea	*Quelea quelea*	X	-	-	-	-	-	-	-
40	Yellow-crowned Bishop	*Euplectes afer*	-	X	-	X	-	X	-	X
	VIDUIDAE									
41	Pin-tailed Whydah	*Vidua macroura*	X	X	X	X	X	X	X	X
	FRINGILIDAE									
42	Streaky-headed Seed-eater	*Serinus gullaris*	-	-	-	X	-	-	-	-

KEY: DS = Dry Season RS = Rainy Season X=Present - = Absent

Sources: Field Study (2005)

Dry Season Monthly Diversity of avifauna in the study sites

The results of monthly diversity of avian species of the study sites in the dry season are shown in Table 2. The results indicate that species diversity varied among months on some of the sites. On Lake Njuwa, diversity was significantly ($P < 0.05$) higher in the months of February and April than in March. At Lake Gariyo, diversity was highest in March than in either February or April, While Lake Tingno experienced the lowest bird species presence in March. There was no significant difference ($P > 0.05$) in bird species diversity among months in dry season in Kiri Dam.

Wet Season Monthly Diversity of avifauna in the study sites

Table 3 shows the results of monthly diversity of avian species of the study sites in the wet season. The results show that there was no significant difference ($P>0.05$) in avian species diversity for three of the sites (Lake Geriyo, Lake Tingno and Kiri Dam). On Lake Njuwa, diversity was significantly higher ($P < 0.05$) in the month of September than in June and August.

Table 2: Monthly Diversity of Avian Species of Four Wetland Sites in Adamawa State (Dry Season Mean Values)

Wetland Sites	Months		
	February	March	April
Lake Njuwa	0.07876[ab]	0.05471[b]	0.13025[a]
Lake Geriyo	0.01530[b]	0.09406[a]	0.03404[b]
Lake Tingno	0.13757[a]	0.04861[b]	0.11568[a]
Kiri Dam	0.08104[a]	0.07976[a]	0.09027[a]

Means with different super-scripts differ significantly (P<0.05)

Table 3: Monthly Diversity of Avian Species of Four Wetland Sites in Adamawa State (Wet Season Mean Values)

Wetland Sites	Months		
	June	August	September
Lake Njuwa	0.05070[b]	0.04500[b]	0.12560[a]
Lake Geriyo	0.04078[a]	0.02544[a]	0.04105[a]
Lake Tingno	0.08577[a]	0.10050[a]	0.09809[a]
Kiri Dam	0.12200[a]	0.10684[a]	0.11263[a]

Means with different super-scripts differ significantly (P<0.05)

Seasonal Diversity of Avian Species on the Basis of Wetland Sites

Table 4 indicates diversity of avian species on the basis of sites and seasons. The results show that no significant difference [P > 0.05] occurred in bird species diversity between dry and rainy season on any of the wetland sites.

Table 4: Seasonal Diversity of Avian Species on the Basis of each site

Sites	Seasons	
	Dry season	Wet Season
Lake Njuwa	4.5766[a]	3.8669[a]
Lake Geriyo	2.7023[a]	2.4323[a]
Lake Tingno	5.4085[a]	6.1150[a]
Kiri Dam	4.9689[a]	6.3928[a]

Means with different super-scripts differ significantly (P < 0.05)

Comparison of Dry Season Avian Species* Diversity *Among* the Wetland *Sites

Table 5 shows the dry season avian species diversity for the four-wetland sites. The results show that there was no significant difference (P > 0.05) in bird species diversity among three of the four sites in the dry season. Only Lake Geriyo was significantly different (P < 0.05) from the other three.

Comparison of Wet Season Avian Species Diversity Among the Wetland Sites

The results of the wet season avian species diversity of the wetland sites are presented in Table 6. The results indicate that significant difference (P=0.05) occurred in avian species diversity among the sites. Kiri Dam (0.11418) and Lake Tingno (0.09466) had the highest bird diversity followed by Lake Njuwa (0.06893) While Lake Geriyo (0.03513) experienced the least.

Table 5: Diversity of Avian Species of Four Wetland Sites in Adamawa State (Dry Season Mean Values)

Wetland Sites	Mean
Lake Tigno	0.09361[a]
Lake Njuwa	0.08467[a]
Lake Geriyo	0.04386[b]
Kiri Dam	0.08290[a]

Means with different super-scripts differ significantly (P<0.05)

Table 6: Mean Values of Diversity of Avian Species of Four Wetland Sites in Adamawa State (Wet Season)

Wetland Sites	Mean
Lake Tigno	0.09466[ab]
Lake Njuwa	0.06893[a]
Lake Geriyo	0.03513[c]
Kiri Dam	0.11418[a]

Means with different super-scripts differ significantly (P<0.05)

Absolute Population Density Estimate of Bird Species in the Study Sites at Different Seasons

Dry Season Estimates (No/ha)

Results of absolute population density estimates of bird species in the study sites in the dry season are presented in Table 7. Birds with the highest and least absolute population density according to the study sites are as follows: -

Lake Geriyo

Bird species with the highest absolute population density include: *Ardeola ralloides (32005 ± 168630), Bubulcus ibis (17167*±52169),*Ardeolaidae* 5066±7090), *Egretta garzetta* (267±1147), *Pluvianus aegytius* (166 ± 142), *Ciconia abdmii* (163 ± 860), *Vanellus spinosus* (145 ± 106), *Egretta ardesiaca* (133 ±209), *Scopus umbretta* (90±369), *Columba guinea* (49±317) and *Actophilornis africanus* (41±73). The least include *Mesophyx intermedia* (3±37), *Ardea cinerea* (3±13), *Coracias sputulata* (3± 13) and *Himantopus himantopus* (3±13).

Lake Njuwa

Bird species with the highest absolute population density include: *Bubulcus ibis* (4752±16723), *Casmerodius alba*, 3768 ± 18852), *Pluvianus aegyptius*, (1633 ± 8087), *Ardeola ralloide* (1540 5124) *Columba guinea* (1159±5904), *Egretta ardesiaca* (572±2715), *Ptilostomus afer* (530±1474) and *Dendrocygna viduata* (426±2225). The least include *Ardea melanocephala* (3±14), *Ardeola idae* (2±8), *Ardea purpurea* (1±4)

Lake Tingno

The highest include *Bubulcus ibis* (3300±8338), *Pluvianus aegyptius* (1457±3459), *Vanellus spinosus* (1153±831), *Columba guinea* (393±758), *Actophilornis africanus* (320±624), *Dendrocygna viduata* (284±459), *Casmerodius alba* (150±188), *Streptopelia senegalensis* (112±377), *Scopus umbretta* (97"47), *Egretta garzetta* (81±261), *Ardeola ralloides* (76±33) and *Centropus senegalensis* (31±28). The least include *Mesophyx intermedia* (4±19), and *Ardea cinerea* (2.4±13).

Kiri Dam

Bird species with the highest absolute population density estimate include *Bubulcus ibis* (1366±3978), *Vanellus spinosus* (527±890), *Dendrocygna viduata* (276±1202), *Columbaguinea* (243±216), and *Streptopelia decipiens* (204±941). The least include *Ardea cinerea* (1.4±7), *Euplectes afer* [2±11], and *Cypsiurus parvus* (2±11).

Wet Season Absolute Population Density Estimate of Avian Species

Table 8 shows the result of absolute population density estimate of bird species in the study sites in wet season. Avian species with the highest and least absolute population density according to study sites are as follows: -

Lake Geriyo

Bird species with the highest absolute population density inclue: *Bubulcus ibis* (48000±82152), *Dendrocygna viduata* (703±3162), *Pluvianus aegyptius* (553±1708), *Vanellus spinosus* (479±2861), *Egretta ardesiaca* (181±709), *Ciconia abdimii* (170±579*), Casmerodes alba* (47±140), *Scopus umbretta* (41±135), and *Streptopelia decipiens* (22±27). The birds with the least absolute population density include *Ardeola idae* (3±13) and *Euplectes orix* (5±13).

Lake Njuwa

Avian species with the highest absolute population density estimate include *Bubulcus ibis* (23573±81400), *Egretta garzetta* (2063 ± 1388), *Vanellus spinosus* (1643±4433), *Pluvianus aegyptius* (1559±5671) *Dendrocygna viduata* (560±1257), *Columba guinea* (377±411), *Actophilornis africanus* (316±353), *Ptilostomus afer* (302±75), *Ardeola ralloides*

(167±420), and *Casmerodius alba* (158±190). The least include *Merops nubicus* (3±54), *Ardea purpurea* (3±16) and *Galerida cristata* (2±5).

Lake Tingno

Bubulcus ibis (1917±3006), *Pluvianus aegyptius* (830±1705), *Vanellus spinosus* (700±351), *Columba guinea* (583±643), *Dendrocygna viduata* (417±1091), *Ptilostomus afer* (390±528), *Casmerodius alba* (138±219), *Egretta ardesiaca* (95±138), *Scopus umbretta* (95±67), *Actphilornis africanus* (88±217), and *Ardeola ralloides* (79±93) had the highest absolute population density, while the least include *Coracias sputalata* (2±13], *Turdius pelios* (2±12), *Ardea melanocephala* (1±6).

Kiri Dam

Bird species with the highest absolute population density estimates include *Bubulcus ibis* (947±2634), *Dendrocygna viduata* (443 ± 2004), *Pluvianus aegyptius* (380±659), *Egretta arrdesiaca* (314 ± 1623), *Columba quinea* (137 ± 363), *Egretta garzetta* (121 ± 629), *Vanellus spinosus* (93±1479), *Actophilornis africanus* (88"226) while the least absolute population density estimate include *Streptopelia senegalensis* (2±11), *Galerida cristata* (2±11), *Ardeola idae* (1±7), *Burhinus senegalensis* (1±4).

The Relationship between Avian Species Diversity and Precipitation, Temperature and Relative Humidity

Results indicating the relationship between avian species diversity and precipitation, temperature and relative humidity are presented in Tables 9,10,11 and 12. The results show that while relative humidity was the major contributing factor to species diversity in Kiri Dam, rainfall was shown to be the determinant of species diversity in Lake Geriyo, Lake Njuwa and Lake Tingno.

Table 7: The Absolute Population Density Estimate of Bird Species for All the Sites (Dry season)

Species	Lake Geriyo	Lake Njuwa	Lake Tingno	Kiri Dam
Ardeola idae	5066±7090	2±8	24±25	---
Ardeola ralloide	32005±168630	1540±5124	76±33	16±66
Bubulcus ibis	17167±52169	4752±16723	3300±8338	1366±3978
Egretta ardesiaca	133±209	572±2715	290±1528	112±377
Egretta garzetta	267±1147	188±904	81±261	73±383
Casmerodius alba	4.2±2.8	3768±18852	150±188	101+103
Ardea purpura	11±37	0.8±4.4	7±37	-----
Ardea cinerea	2.5±13	6±19	2.4±13	1.4+7
Ardea melanocephala	12±24	3±14	31±67	4±40
Scopus umbretta	90±369	43±932	97±45	96±101
Ciconia abdimii	163±860	185±962	133±703	103±545
Dendrocygna iduata	73±42	426±2225	284±459	276±1202
Actophilornis fricanus	41±73	164±224	320±624	105±25
Micropara capensis	5±6	6±27	11±56	12±51
Pluvianus aegyptius	166±242	1633±8087	1457±3459	10±352
Vanellus spinosus	145±106	116±305	1153±831	527±890
Columba guinea	49±317	1159±5904	393±758	243±716
Centropus senegalensis	27±71	15±27	31±28	8±21
Ceryle rudis	6±16	±105	9±47	88±281
Turdius pelios	-----	9±27	-----	-----
Burhinus senegalensis	17±28	19±55	51±245	6±22
Cypsiurus parvus	10±13	10±53	------	2±11
Coracias abyssinica	3±13	9±35	------	3±15
Ptilostomus afer	-------	530±1474	54±143	12±65
Milvus migrans	8±11	-------	31±64	4±6
Himantopus himantopus	3±13	------	33±159	7±316
Streptopelia vinacea	-------	-------	-------	3±15
Streptopelia decipiens	10±36	-------	-------	204±941
Streptopelia senegalensis	--------	--------	112±377	27±44
Galerida cristata	--------	--------	7±37	--------
Coracias sputulata	3±13	--------	--------	--------
Quelea quelea	--------	--------	--------	--------
Merops nubicus	9±25	---------	---------	36±486
Corvinella corvine	-------	-------	-------	6±30
Euplectes orix	-------	-------	-------	2±11
Mesophyl intermedia	3 ± 37	--------	4 ± 19	

Table 8: The Absolute Population Density Estimate of Bird Species For All The Site (Wet Season)

Species	Lake Geriyo	Lake Njuwa	Lake Tingno	Kiri Dam
Ardeola idea	3±13	9±27	----------	1.4±7
Ardeola ralloides	10±30	167±420	79±93	36±19
Bulbulcus ibis	48000±82152	23573±81400	1917±3006	947±2634
Egretta ardesiaca	18±709	247±955	95±138	314±1623
Egretta garzetta	12±10	2063±1388	107±371	121±629
Casmerodius alba	47±140	158±190	138±219	62±55
Ardea cinerea	4±19	3±8	12±53	38±99
Scopus umbretta	41±135	150±398	95±67	57±338
Anastomus lamelligerus	15±53	16±55	5±26	--------
Ciconia abdimii	170±579	217±722	70±184	37±193
Dendrocygna viduata	703±3162	560±1257	417±1091	443±2004
Milvus migrans	3±7	7±20	7±19	41±126
Actophilornis africanus	21±37	316±353	88±217	88±226
Microparra capensis	9±15	---------	30±112	16±83
Himantopus himantopus	8±28	8±40	12±33	-------
Burhinus senegalensis	9±24	3±54	12±56	1±4
Pluvianus aegyptius	553±1708	1559±5671	830±1705	380±659
Vanellus spinosus	479±2861	1643±4433	700±351	93±1479
Streptopelia decipiens	22±27	6±32	18±75	-------
Centropus senegalensis	11±35	9±47	8±16	18±19
Ceryle rudis	9±6	6±32	3±19	10±51
Merops nubicus	32±86	3±54	8±44	22±116
Euplectes orix	5±13	7±20	11±19	77±62
Mesophyx intermedia	----------	----------	----------	----------
Columba guinea	253±989	377±411	583±643	137±363
Coracias sputulata	5±26	----------	2.4±	----------
Galerida cristata	29±155	2±5	14±67	2±11
Ptilostomus afer	245±1149	302±75	390±528	77±207
Corvus albus	10±50	----------	----------	----------
Turdius pelios	3±13	----------	2.4±12	1.4±7
Gallinula chloropus	----------	8±40	----------	----------
Ardea purpurea	----------	3±16	----------	----------
Ardea melanocephala	----------	----------	1±6	----------
Streptopelia senegalensis	----------	----------	30±98	2±11
Ardea melanocephala	----------	----------	1.2±6	8±26
Vidua macroura	----------	----------	----------	47±24
Elanus caeruleus	----------	----------	----------	7±37

Table 9: Regression Analysis for Avian Species Diversity for lake Geriyo

Variables	Parameter Estimate	Standard Error
Intercept	31.57849	±5.24604
Temperature	0.03465^{NS}	±0.26571
Rainfall	– 0.13499**	±0.04364
Relative Humidity	0.29219^{NS}	±0.17829

**Highly significant at 1% level
Coefficient of variability = 97.17402
R – Square = 0.0662

Table 10: Regression Analysis for Avian Species Diversity for Lake Njuwa

Variables	Parameter Estimate	Standard Error
Intercept	14.34628	1.70726
Temperature	0.08184^{NS}	0.08637
Rainfall	0.05351*	0.01453
Relative Humidity	0.07628^{NS}	0.05802

*This is significant at 5% level.
Coefficient of variability = 77.56
R – Square = 0.0845

Table 11: Regression Analysis for Avian Species Diversity for Kiri Dam

Variables	Parameter Estimate	Standard Error
Intercept	38.00528	3.49615
Temperature	0.18452^{NS}	0.10177
Rainfall	0.00551^{NS}	0.03952
Relative Humidity	0.16711*	0.08792

*This is significant at 5% level.
Coefficient of variability = 57.34843
R – Square = 0.0277

Table 12: Regression Analysis for Avian Species Diversity for Lake Tingno

Variables	Parameter Estimate	Standard Error
Intercept	31.57849	5.24604
Temperature	0.03465^{NS}	0.26571
Rainfall	0.13499*	0.04364
Relative Humidity	0.29219^{NS}	0.17829

*This is significant at 5% level.
Coefficient of variability = 97.17402
R – Square = 0.0662

DISCUSSION

Species List of Avifauna of the Study Sites

In all, forty two bird species in twenty five families were recorded during the survey. Of these, thirty two species were hydrophilous species. Earlier studies of biodiversity on fourteen wetland sites in Adamawa state showed that about forty-eight wetland bird species were sighted in them [DFID, 2000]. Therefore, the occurrence of forty two bird species or 87.5 percent of the total wetland bird species of the state on only four wetland sites is an indication of their rich avifauna diversity. The ornithological importance of the four wetland sites under study are derived partly as habitats for some uncommon birds of Nigeria such as lesser Lily-Trotter, (*Microparra capensis)* and Streaky-headed seed-eater, *(Serinus gullaris*). The study sites are also ideal breeding ground for Afrotropical Anatids and wintering ground for Palaearctic migrants [DFID, 2000].

Avifauna Diversity of the Study Sites (Monthly Diversity)

The results indicate that only Kiri Dam has stable diversity of avifauna species for three months (February, March and April) in the dry season. Bird species diversity in Njuwa, Geriyo and Tingno Lakes showed significant difference ($P<0.05$) between March and those of February and April. These variability in species richness of the sites might not be unconnected with human activities and the effects of microclimate. Jaensch (1997) and Neave et al. (1996) observed that species diversity is often affected by unsustainable subsistence and commercial fishing and arable farming within catchment areas of wetlands as well as environmental attributes such as temperature, precipitation and relative humidity. Usually the months of February, March and April are characterized by intense fishing activities in the Lakes and Land preparation at the shores or catchments areas for arable farming, a situation that generates competition between the birds and human beings. The results of monthly diversity of avifauna species in the wet season indicate that only

Lake Njuwa showed a significant difference in bird species diversity between April and the months of March and February. This result is indicative of stable bird species diversity among months on the wetland sites during the wet season. The results suggest a high level of stability in both environmental variables and human activities that affect bird species diversity.

Comparison of Avifauna Diversity Among Sites During the Dry Season and Wet Season

The results indicate that while no significant difference ($P > 0.05$) occurred in avifauna diversity among sites in dry season, wet season diversity showed some significant difference ($P < 0.05$). The results suggest that some of the birds that visit some lakes, for example Lake Geriyo in the dry season must have dispersed as a result of the availability of food and water elsewhere other than the Lakes during wet season. This observation is in agreement with the report of Neave *et al.* (1996).

Absolute Population Density Estimate of Bird Species in the Study Sites at Different Seasons

The results indicate that the most numerous *hydrophilous* birds in the study sites during the dry season were *Ardeola ralloides Egretta ardesiaca, Pluvianus aegyptius* and *Vanellus spinosus* in the order presented while that of the wet season were *Bubulcus ibis, Dendrocygna viduata, Pluvianus aegyptius*, and *Vanellus spinosus* also in the order presented. Despite the impressive numbers of these species, the absence of some expected water birds, for example, the Great pelican (*Pelicanus onocrotalus)*, Black crowned crane (*Balearica pavonina)*, Osprey (*Pandion haliactus)* and Gwiew (*Numenius arguata)*, suggests environmental disturbance within the catchments area of the wetlands under study. DFID (2000) reported that progressive reduction in bird population or outright disappearance from a given habitat is usually connected with environmental disturbance. The species compositions of the relatively abundant bird species in the four sites are closely similar, indicative of similar environmental conditions for all the study sites. These results also suggest that these species could be used in monitoring changes in the quality of the wetland sites.

The Relationship Between Avian Species Diversity and Precipitation, Temperature and Relative Humidity

Results indicate that avian species diversity in the study sites related more to precipitation followed by relative humidity. The result suggests that one of the major factors that accounts for avian species diversity in the study sites is water. This result is in agreement with Neave et al. (1996) finding that environmental attributes such as temperature, precipitation and flouristic structure determine the abundance, distribution and diversity of avifauna species across the regions. This finding therefore suggests that the availability of the avian species in the study sites depends on the preservation of the lakes. Therefore, to ensure that the bird species are available for recreation, education in natural history and for other purposes the Lakes must not be allowed to disappear.

CONCLUSION

From the available results it can be concluded that the study sites contain represen-

tative samples of hydrophilous birds that are found in some key wetland ecosystems in Nigeria. However, the absence of some water birds at the sites is an indication of environmental disturbances at the study sites.

RECOMMENDATIONS

Based on the findings of this study the following recommendations are made to ensure a continuous production of the resources in these wetlands. In view of the value of the sites as avifauna species habitat, it is recommended that the study sites should be converted to conservation sites and managed as bird sanctuaries. This will help bring both the site factors and the avifauna under adequate protection against poachers, livestock grazer, wildfire and other forms of trespass, so that, the receding of the water bodies will stop and the avifauna species can increase both in number and composition.

A detailed investigation should be carried out to uncover those environmental factors that may explain the absence or disappearance of some species. Research and monitoring of the dynamics of the avifauna status should be on continuous bases.

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