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ASSESSMENT OF BIRD DIVERSITY IN HADEJIA-NGURU WETLANDS, YOBE STATE, NIGERIA

A. Ali, C. Akosim and B.T. Kwaga

Department of Forestry and Wildlife Management, Federal University of Technology, Yola, Adamawa State, Nigeria.

ABSTRACT

The aim of this study was to assess the avian diversity in Hadejia-Nguru Wetlands. Point count method for bird census was used in the study. The number of birds found in the wetlands in the five years of study (1995-1999 census periods) were 254,964; 191,055; 194,280; 266,034; and 160,387, respectively. Also, the number of species of birds encountered were 57; 63; 63; 64; and 63. Calculated Simpson indices for bird species were 0.2661, 0.2753, 0.2666, 0.3628 and 0.2406 for 1995, 1996, 1997, 1998 and 1999 respectively. This indicates high diversity and heterogeneity of bird species in the wetlands. The information generated from this study can be used to develop appropriate conservation strategy for avifauna of Hadejia-Nguru wetlands.

Keywords: Biodiversity; Wild bird species; heterogeneity; palearctic migrants

INTRODUCTIION

Hadejia-Nguru wetland is part of the 8 wetland areas, internationally recognised as wetland sites in Nigeria (Okali, 1998). Its importance (ecologically, economically, socially and politically) demands that the site be conserved. However, effective conservation of the site requires adequate baseline data on the renewable resources of the site (Ali *et al., 2008*). At the United Nations Millennium Summit in 2000, governments adopted the Millennium Development Goals (MDGs). Convention on Biological Diversity (2006) observed that the conservation of biodiversity is fundamental for achieving these goals. At the 2002 World Summit on Sustainable Development, the MDGs were reaffirmed and governments agreed to pursue more effective implementation of the Convention on Biological Diversity, and specifically to achieve, by 2010, a significant reduction in the rate of loss of biodiversity (Convention on Biological Diversity, 2006).

Throughout the ages, traditional African societies have maintained complex religious and cultural beliefs that guided the conservation of biodiversity using traditional norms such as taboos, totems and myths. Such traditional practices enabled the protection of biological resources from human disturbances and wanton over-exploitation. The establishment of sacred groves, (Kingdom, 1989; Campbell, 2004; William and Keith 1985), ensured the protection of forests surrounding environmentally-sensitive areas, and ranged in size from hundreds of hectares of forest to small areas of about 0.5 ha containing single trees or a few stones (Gordon, 1992). Biological diversity is the variety of living things and its processes in a given area, which constantly changes (Van Dyke, 2008). These changes have occurred since

live began and they will continue, with or without the presence of humans. Major factors that cause the decline of forest biodiversity in Nigeria include fragmentation of habitats and populations, human over exploitation of renewable natural resources, introduction of toxic substances and pollutants, introduction of exotic species, conversion of wild areas to agricultural lands and other intensive human use and alterations in the structure and function of ecosystems (Ali *et al.*, 2008). Indiscriminate destruction of natural forests coupled with profound modification of our landscapes have resulted to decrease in plants and wild animal populations, many of which are on the verge of extinction (CBD, 2008). Nigerian has an estimated 274 mammal species belonging to 13 orders, 42 families and 133 genera; over 20,000 species of insects, 839 species of birds, and 109 species of snakes (Ramsar 2000). Also, Nigeria has 935 tree species representing 86 families and 417 genera (Ramsar 2000). The implication of wetland conservation has been recognized internationally for the last 29 years, essentially since the ratification of the Ramser Convention on the 2nd of February, 1971 sponsored by UNESCO in Iran (Finlayson and Moser, 1991). The Hadejia-Nguru wetlands are on the List of Ramsar wetlands of international importance. Nguru Lake and the Marma Channel complex (58,100 ha) are designated as Ramsar Sites. The wetlands are important for waterbirds, both for breeding species and for wintering and passage of palearctic waterbirds. In spite of its international recognition, no baseline data have been established for the articulation of management plan necessary for the conservation of entire wetlands ecosystem and the avifauna diversity in particular. This dearth of information prompted this study.

METERIAL AND METHODS

Study Area

The Hadejia-Nguru wetlands (HNW) lie on the southern edge of the Sahel savannah in North-Eastern Nigeria. The area is a flood-plain complex, comprising of a mixture of seasonally flooded lands and dry uplands. Prior to the droughts of the 1970s, the wetlands covered an area of about 4,125 km², but are now reduced to 3, 500 km². The wetland is supplied by the Hadejia and Jama'are rivers. The Jama'are rises in the Jos Plateau while the Hadejia rises in the hills around Kano. They join within the HNW to form the Yobe River, which discharges into Lake Chad. Annual rainfall ranges between 200-600 mm, confined between the months of May-September (North-East Arid Zone Development Project [NEAZDP], 1994).

Sampling Technique

The method described by Bibby *et al*. (1992) and Sutherland (1999) were used for bird censuses. At each zone, counting points were established depending on the total area of the site. The area was divided into three (Baturiya, Dagona and Nguru) and each of the three areas was sub-divided. At Baturiya, 12 points were made; three in each zone. At Nguru, twelve points were made; three in each zone, and at Dagona, six points were also made; two in each zone. Each point has a radius of 50 metres.

Data Collection

Data on avian species population for the study area were obtained from two sources. The first consist of primary data which covered a period of five years (1995-1999) while the secondary data were obtained from Hadejia-Nguru Wetland office at Nguru. The counting stations were adequately spaced to ensure that birds were not counted twice or more. Bird census took place from 06.00 to 11.00 hours and 15.00 to 18.00 hours. On arrival at the counting station, the observers waited for one minute before beginning to count. This is to allow the birds to settle down following expected disturbance by the arrival of the observers. The observers positioned themselves at the counting station and recorded all the birds identified by sight or calls within a specified distance (50 m radius) and beyond the zone. Each bird was counted once.

Data Analysis

Both the secondary and the primary data were analysed using Simpson's diversity index (Colinvaux, 1973). The formula is as follows:

$$D = \sum_{i=1}^{S} p_i^2.$$

Where p_i is the fraction of all organisms which belong to the i-th species, s is the number of species and D is the calculated diversity. Note that $0 \leq D \leq 1$, with values near zero corresponding to highly diverse or heterogeneous ecosystems and values near one corresponding to more homogeneous ecosystems (Colinvaux, 1973).

RESULTS

The result presented in Tables 1 – 6 indicated that 57 species of birds having a total population of 254, 964 were detected in Hadejia – Nguru wetland sites in 1995, in 1996, 63 species containing 191, 055 birds were censured in the study area while in 1997 a total of 194, 280 birds represented in 63 bird species were found in the same area. In 1998 however, 64 species of birds having a population of 266, 034 were observed in the study area. The results also show that 63 species of birds having a total population of 160, 387 were censured in the study area in 1999 (Table 1). The above results further indicate that *Dendrocyna viduatea, Anas acuta, Anas querquedula*, and *Philomachrus puqnax* consistently maintained the highest population abundance from 1995 to 1998 except in 1999 when *Plectopterus qanibiencs* and *Sarkidiornis melanotus* showed higher populations than *Dendrocydna viduata* and *Anas acuta*. All the species recorded over 10,000 birds throughout the period of the study.

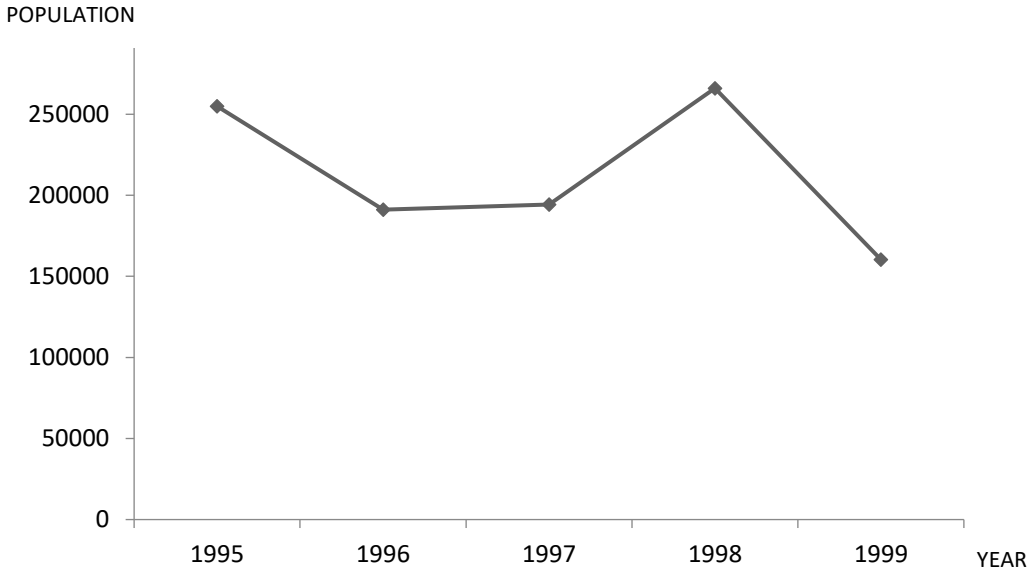

Figure 1: Trend in the population of avifauna species in Hadejia-Nguru wetlands, Yobe State, Nigeria

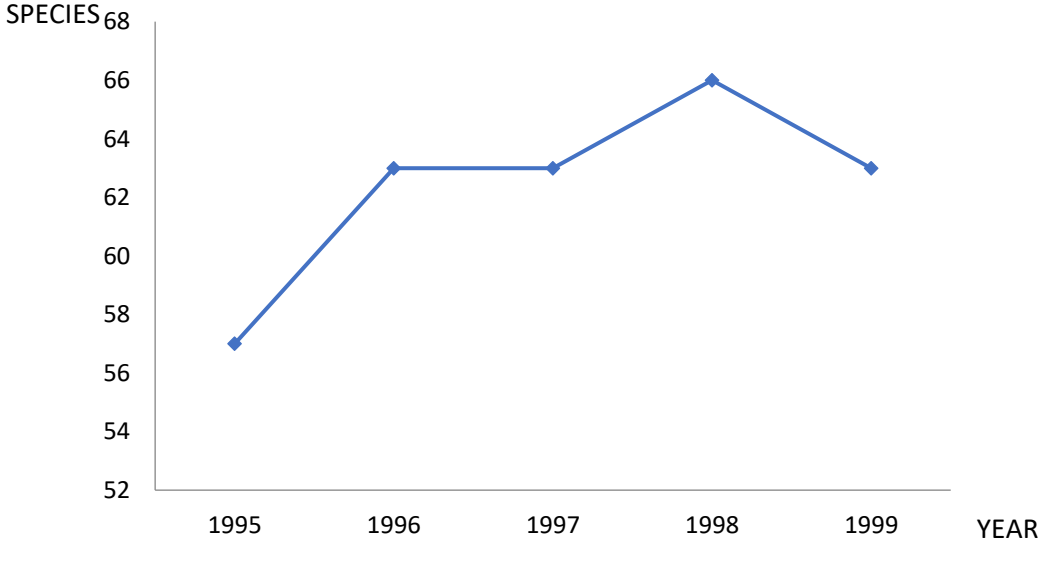

Figure 2: Trend in the Species number of birds in Hadejia-Nguru wetlands, Yobe State, Nigeria

Table 1: Summary of avian diversity indices of Hadejia-Nguru wetlands, Yobe State, Nigeria

Year	No. of species	Population	Simpson's index
1995	57	254,964	0.2661
1996	63	191,055	0.2753
1997	63	194,280	0.2666
1998	64	266,034	0.3628
1999	63	160,387	0.2406

Table 2: Diversity of birds encountered for the year 1995 at the Hadejia-Nguru wetlands, Yobe State, Nigeria

Name of species	Population	Proportion	Simpson's index
Phalacrocorax africanus	519	2.04×10^{-3}	4.14×10^{-6}
Ardea cineria	678	$2{,}66\times10^{-3}$	7.07×10^{-6}
Ardea malanocephala	26	1.02×10^{-4}	1.04×10^{-8}
Ardea pupurea	316	1.24×10^{-3}	1.54×10^{-6}
Casmerodius albus	84	3.29×10^{-4}	1.09×10^{-7}
Mesophyx intermedia	549	2.15×10^{-3}	4.64×10^{-6}
Egretta gularies	15	5.88×10^{-5}	3.46×10^{-9}
Egretta garzeta	845	3.31×10^{-3}	1.10×10^{-5}
Bubulcus ibis	4135	1.62×10^{-2}	2.63×10^{-4}
Ardeola ralvidis	870	3.41×10^{-3}	1.16×10^{-5}
Butorides striatus	3	1.18×10^{-5}	1.38×10^{-10}
Nycticorax nycticorax	8	3.14×10^{-5}	9.85×10^{-10}
Mycteria ibis	30	1.18×10^{-4}	1.38×10^{-8}
Anastomus lamelligerus	326	1.28×10^{-3}	1.63×10^{-6}
Cicolia cicolia	119	4.67×10^{-4}	2.18×10^{-7}
Thriskionis aethopicus	42	1.65×10^{-4}	2.71×10^{-8}
Plagades falcinellus	435	1.71×10^{-3}	2.91×10^{-6}
Platalia lincorodia	4	1.57×10^{-5}	2.46×10^{-10}
Microcabra capensis	144	5.65×10^{-4}	3.19×10^{-7}
Actophilonis africana	897	3.52×10^{-5}	1.24×10^{-5}
Dendrocydna bicolor	3551	1.39×10^{-3}	1.95×10^{-4}
Dendrocydna viduata	47879	1.88×10^{-1}	3.53×10^{-2}
Plectopterus gambensis	2320	9.10×10^{-3}	8.28×10^{-5}
Sarkidiornis melanotus	2196	8.61×10^{-3}	7.41×10^{-8}
Nettapus auritus	31	1.22×10^{-4}	1.48×10^{-8}
Anas acuta	13520	5.30×10^{-2}	2.81×10^{-3}
Anas querquedula	98689	3.87×10^{-1}	1.50×10^{-3}
Anas clypeata	5	1.96×10^{-5}	3.85×10^{-10}
Aythya nyroca	17	6.67×10^{-5}	4.45×10^{-9}
Amaurornis flavirosta	83	3.26×10^{-4}	1.06×10^{-7}
Gallinule chloropus	214	8.39×10^{-4}	7.04×10^{-7}
Porphirio porphirio	68	2.67×10^{-4}	7.11×10^{-8}
Himantopus himantopus	814	3.19×10^{-3}	1.02×10^{-5}

Recurvirosta avosetta	32	1.26×10^{-4}	1.58×10^{-8}
Glacorla pratincola	80	3.14×10^{-4}	9.85×10^{-8}
Vannellus spinosus	456	1.79×10^{-3}	3.220×10^{-6}
Charamdrius alexandrines	9	3.53×10^{-5}	1.25×10^{-9}
Charamdrius dublus	5	1.96×10^{-5}	3.85×10^{-10}
Charamdrius pecuarius	3	1.18×10^{-5}	1.38×10^{-10}
Limosa limosa	8	3.14×10^{-5}	9.85×10^{-10}
Tringa erythropus	1075	4.22×10^{-3}	1.78×10^{-5}
Tringa tetanus	1081	4.24×10^{-3}	1.80×10^{-5}
Tringa stagnatilis	66	2.59×10^{-4}	6.70×10^{-8}
Tringa nebularia	214	8.39×10^{-4}	7.04×10^{-7}
Tringa glareola	35	1.37×10^{-4}	1.88×10^{-8}
Tringa hypoleocus	26	1.02×10^{-4}	1.04×10^{-8}
Calidris alba	40	1.57×10^{-4}	2.46×10^{-8}
Philomachus pugna	70845	2.78×10^{-1}	7.72×10^{-2}
Larus cirocephalus	5	1.96×10^{-5}	3.85×10^{-10}
Chlidonia hybridus	53	2.08×10^{-4}	4.32×10^{-8}
Gellochenidon niloticus	108	4.24×10^{-4}	1.79×10^{-7}
Sterna albifrons	430	1.69×10^{-3}	2.84×10^{-6}
Pandion haiactus	7	2.75×10^{-5}	7.54×10^{-6}
Circus aeruginisus	99	3.88×10^{-4}	1.51×10^{-7}
Cirycle rudis	6	2.35×10^{-5}	5.54×10^{-10}
Venelius tectus	11	4.31×10^{-5}	1.86×10^{-9}
Total 57	254,964	1	0.2661

Table 3: Diversity of Birds encountered for the year 1996 at the Hadejia-Nguru wetlands, Yobe State, Nigeria

Name of species	Population	Proportion	Simpson's index
Phalacrocorax africanus	463	2.42×10^{-3}	5.87×10^{-6}
Ardea cineria	211	1.10×10^{-3}	1.22×10^{-6}
Ardea malanocephala	79	4.13×10^{-4}	1.71×10^{-7}
Ardea purpurea	232	1.21×10^{-3}	1.47×10^{-6}
Casmerodius albus	58	3.04×10^{-4}	9.20×10^{-8}
Mesophyx intermedia	331	1.73×10^{-3}	3.00×10^{-6}
Egretta ardesiaca	51	2.67×10^{-4}	7.13×10^{-8}
Egretta garzeta	154	8.06×10^{4}	6.50×10^{-7}
Bubulcus ibis	3225	1.69×10^{-2}	2.85×10^{-4}
Ardeola ralvidis	139	7.28×10^{-4}	5.29×10^{-7}
Anas crecca	70	3.66×10^{-4}	1.34×10^{-7}
Microparra capensis	47	2.46×10^{-4}	6.05×10^{-8}
Mycteria ibis	11	5.76×10^{-5}	3.31×10^{-9}
Anastomus lamelligerus	172`	9.00×10^{-4}	8.10×10^{-7}
Cicolia cicolia	147	7.69×10^{-4}	5.92×10^{-7}
Thriskionis aethopicus	116	6.07×10^{-4}	3.69×10^{-7}
Plagades falcinellus	553	2.89×10^{-3}	8.38×10^{-6}

Platalia lincorodia	6	3.14×10^{-5}	9.86×10^{-10}
Platalia alba	6	3.14×10^{-5}	$9{,}86\times10^{-10}$
Actophilonis africana	882	4.62×10^{-3}	2.13×10^{-5}
Dendrocydna bicolor	965	5.05×10^{-3}	2.55×10^{-5}
Dendrocydna viduata	28430	1.49×10^{-1}	2.21×10^{-2}
Plectopterus gambensis	1479	7.74×10^{-3}	6.00×10^{-5}
Sarkidiornis melanotus	1287	6.74×10^{-3}	4.54×10^{-5}
Nettapus auritus	6	3.14×10^{-5}	9.86×10^{-10}
Anas acuta	12905	6.75×10^{-2}	4.56×10^{-3}
Anas querquedula	74570	3.90×10^{-1}	1.52×10^{-1}
Anas clypeata	82	4.29×10^{-4}	1.84×10^{-7}
Porphirio alleni	35	1.83×10^{-4}	3.36×10^{-8}
Amaurornis flavirosta	4	2.09×10^{-5}	4.38×10^{-10}
Gallinula chloropus	229	1.20×10^{-3}	1.44×10^{-6}
Porphirio porphirio	39	2.04×10^{-4}	4.17×10^{-8}
Himantopus himantopus	449	2.35×10^{-3}	5.52×10^{-6}
Recurvirosta avosetta	12	6.28×10^{-4}	3.94×10^{-9}
Tringa ocropus	6	3.14×10^{-5}	9.86×10^{-10}
Vannellus spinosus	397	2.08×10^{-3}	4.32×10^{-6}
Galliago galliago	5	2.62×10^{-5}	6.85×10^{-10}
Charamdrius dublus	34	1.78×10^{-4}	3.17×10^{-8}
Charamdrius pecuarius	1	5.23×10^{-6}	2.74×10^{-11}
Limosa limosa	2576	1.35×10^{-2}	1.82×10^{-4}
Tringa erythropus	301	1.58×10^{-3}	2.48×10^{-6}
Tringa tetanus	121	6.33×10^{-4}	$4{,}01\times10^{-7}$
Tringa stagnatilis	47	2.46×10^{-4}	6.05×10^{-8}
Tringa nebularia	13	6.80×10^{-5}	4.63×10^{-9}
Tringa glareola	79	4.13×10^{-4}	1.71×10^{-7}
Tringa hypoleocus	14	7.33×10^{-5}	5.37×10^{-9}
Calidris alba	163	8.53×10^{-4}	7.27×10^{-7}
Philomachus pugnax	59317	3.11×10^{-1}	9.60×10^{-2}
Larus cirocephalus	14	7.33×10^{-5}	5.37×10^{-9}
Chlidonia hybridus	209	1.09×10^{-3}	1.20×10^{-6}
Gellochenidon niloticus	2	1.05×10^{-5}	1.10×10^{-10}
Sterna cospia	1	5.23×10^{-6}	2.74×10^{-11}
Circus microurus	4	2.09×10^{-5}	4.38×10^{-10}
Circus aeruginisus	92	4.82×10^{-4}	2.31×10^{-7}
Cirycle rudis	19	9.94×10^{-5}	9.89×10^{-9}
Venelius tectus	2	1.05×10^{-5}	1.10×10^{-10}
Fulica atra	49	2.56×10^{-4}	6.58×10^{-8}
Pelacanus rufescens	2	1.05×10^{-5}	1.20×10^{-10}
Calidris temmunkii	38	1.99×10^{-4}	3.96×10^{-8}
Calidris ferruginea	1	5.24×10^{-6}	2.74×10^{-11}
Larus ridibundus	1	5.23×10^{-6}	2.74×10^{-4}
Corythernis cristata	2	1.05×10^{-5}	1.01×10^{-5}
Motocilla flava	100	5.23×10^{-4}	2.73×10^{-7}

Total	63	191,055	1.00	0.2753

Table 4: Diversity of Birds encountered for the year 1997 at the Hadejia-Nguru wetlands, Yobe State, Nigeria

Name of species	Population	Proportion	Simpson's index
Phalacrocorax africanus	1511	7.78×10^{-3}	6.05×10^{-5}
Ardea cineria	535	$2{,}75\times10^{-3}$	7.58×10^{-6}
Ardea malanocephala	9	4.63×10^{-5}	2.15×10^{-9}
Ardea pupurea	355	1.83×10^{-3}	3.34×10^{-6}
Casmerodius albus	373	1.92×10^{-3}	3.67×10^{-6}
Mesophyx intermedia	320	1.65×10^{-3}	2.71×10^{-6}
Egretta ardesiaca	32	1.65×10^{-4}	2.71×10^{-8}
Egretta garzeta	154	7.93×10^{-6}	6.28×10^{-7}
Bubulcus ibis	3225	1.66×10^{-2}	2.76×10^{-4}
Ardeola ralloides	139	7.16×10^{-4}	5.12×10^{-7}
Microcabra capensis	47	2.42×10^{-4}	5.85×10^{-8}
Anas crecca	70	3.60×10^{-4}	1.30×10^{-7}
Mycteria ibis	11	5.66×10^{-5}	3.21×10^{-9}
Anastomus lamelligerus	172	8.85×10^{-4}	7.84×10^{-7}
Cicolia cicolia	147	7.57×10^{-4}	5.73×10^{-7}
Thriskionis aethopicus	116	5.97×10^{-4}	3.57×10^{-7}
Plagades falcinellus	553	2.85×10^{-3}	8.10×10^{-6}
Platalia leuncorodia	6	3.09×10^{-5}	9.54×10^{-10}
Platalia alba	6	3.09×10^{-5}	9.54×10^{-10}
Actophilonis africana	882	4.54×10^{-3}	2.06×10^{-5}
Dendrocydna bicolor	965	4.97×10^{-3}	2.47×10^{-5}
Dendrocydna viduata	28430	1.46×10^{-1}	2.14×10^{-2}
Plectopterus gambensis	1479	7.61×10^{-3}	5.80×10^{-5}
Sarkidiornis melanotus	1287	6.63×10^{-3}	4.39×10^{-5}
Nettapus auritus	6	3.09×10^{-5}	9.54×10^{-10}
Anas acuta	12905	6.64×10^{-2}	4.41×10^{-3}
Anas querquedula	74570	3.84×10^{-1}	1.47×10^{-1}
Anas clypeata	82	4.22×10^{-4}	1.78×10^{-7}
Amaurornis flavirosta	4	2.06×10^{-5}	4.24×10^{-10}
Gallinule chloropus	229	1.18×10^{-3}	1.39×10^{-6}
Porphirio alleni	35	1.80×10^{-4}	3.25×10^{-8}
Porphirio porphirio	39	2.01×10^{-4}	4.01×10^{-8}
Himantopus himantopus	449	2.31×10^{-3}	5.34×10^{-6}
Recurvirosta avosetta	12	6.18×10^{-5}	3.82×10^{-9}
Fulica atra	49	2.52×10^{-4}	6.36×10^{-8}
Vannellus spinosus	397	2.04×10^{-3}	4.18×10^{-6}
Tringa acropus	6	3.09×10^{-5}	9.54×10^{-10}
Charamdrius dublus	34	1.75×10^{-4}	3.06×10^{-8}
Charamdrius pecuarius	1	5.15×10^{-6}	$2{,}65\times10^{-11}$
Limosa limosa	257	1.32×10^{-3}	1.75×10^{-6}

Tringa erythropus	301	1.55×10^{-3}	2.40×10^{-6}
Tringa tetanus	121	6.23×10^{-4}	1.51×10^{-7}
Tringa stagnatilis	47	2.42×10^{-4}	5.85×10^{-8}
Tringa nebularia	13	6.70×10^{-5}	4.48×10^{-9}
Tringa glareola	79	4.07×10^{-4}	1.65×10^{-7}
Tringa hypoleocus	14	7.21×10^{-5}	5.19×10^{-9}
Calidris alba	163	8.39×10^{-4}	7.04×10^{-7}
Philomachus pugnax	59317	3.05×10^{-1}	9.32×10^{-2}
Larus cirocephalus	14	7.21×10^{-5}	5.19×10^{-9}
Calidris ferruginea	1	5.15×10^{-6}	2.65×10^{11}
Gellochenidon niloticus	2	1.03×10^{-5}	1.06×10^{-10}
Sterna cospia	1	5.15×10^{-6}	2.65×10^{-11}
Galligo galliago	5	2.57×10^{-5}	6.62×10^{-10}
Circus aeruginisus	92	4.74×10^{-4}	2.24×10^{-7}
Cirycle rudis	19	9.78×10^{-5}	9.56×10^{-9}
Venelius tectus	2	1.03×10^{-5}	1.06×10^{-10}
Tachybtus ruficolus	1517	7.81×10^{-3}	6.10×10^{-5}
Calidris temmunkii	38	1.96×10^{-4}	3.83×10^{-8}
Larus ridubundus	1	5.15×10^{-6}	2.65×10^{-11}
Circus macrourus	4	2.06×10^{-5}	4.24×10^{-10}
Corythernis cristata	2	1.03×10^{-5}	1.06×10^{-10}
Motocilla flava	100	5.15×10^{-4}	2.65×10^{-7}
Clidonia hybridus	209	1.08×10^{-3}	1.16×10^{-6}
Total 63	194,280	1	0.2666

Table 5: Diversity of Birds encountered for the year 1998 at Hadejia-Nguru wetlands, Yobe State, Nigeria

Name of species	Population	Proportion	Simpson's index
Phalacrocorax africanus	881	3.31×10^{-3}	1.10×10^{-5}
Ardea cineria	383	$1,44\times10^{-3}$	2.07×10^{-6}
Ardea malanocephala	35	1.32×10^{-4}	1.73×10^{-8}
Ardea purpurea	192	7.22×10^{-4}	5.21×10^{-7}
Casmerodius albus	518	1.95×10^{-3}	3.79×10^{-6}
Mesophyx intermedia	414	11.56×10^{-3}	2.42×10^{-6}
Egretta ardesica	102	3.83×10^{-4}	1.47×10^{-7}
Egretta garzeta	1421	5.34×10^{-3}	2.85×10^{-5}
Bubulcus ibis	1900	7.14×10^{-3}	5.10×10^{-4}
Ardeola ralloides	206	7.74×10^{-4}	6.00×10^{-7}
Ciconia nigra	66	2.48×10^{-4}	6.16×10^{-8}
Platalia alba	100	3.76×10^{-4}	1.41×10^{-7}
Mycteria ibis	30	1.18×10^{-4}	1.38×10^{-8}
Anastomus lamelligerus	64	2.41×10^{-4}	5.79×10^{-8}
Cicolia cicolia	1	3.79×10^{-5}	1.41×10^{-11}
Thriskionis aethopicus	164	6.17×10^{-4}	3.80×10^{-7}
Plagades falcinellus	567	2.13×10^{-3}	4.54×10^{-6}
Platalia lincorodia	52	1.96×10^{-4}	3.82×10^{-8}

Microcabra capensis	144	5.65×10^{-4}	3.19×10^{-7}
Actophilonis africana	1604	6.03×10^{-3}	3.64×10^{-5}
Dendrocydna bicolor	237	8.91×10^{-4}	7.94×10^{-7}
Dendrocydna viduata	20053	7.52×10^{-2}	5.68×10^{-3}
Plectopterus gambensis	1386	5.21×10^{-3}	2.71×10^{-5}
Sarkidiornis melanotus	563	2.17×10^{-3}	4.48×10^{-6}
Nettapus auritus	8	3.01×10^{-5}	9.04×10^{-10}
Anas acuta	34566	1.30×10^{-1}	1.69×10^{-2}
Anas querquedula	147563	5.55×10^{-1}	3.08×10^{-1}
Anas clypeata	57	2.14×10^{-4}	4.59×10^{-8}
Aythya nyroca	20	7.52×10^{-5}	5.65×10^{-9}
Amaurornis flavirosta	20	7.52×10^{-5}	5.65×10^{-9}
Gallinula angulata	54	2.03×10^{-4}	4.12×10^{-8}
Porphirio porphirio	132	4.96×10^{-4}	2.46×10^{-7}
Himantopus himantopus	537	2.02×10^{-3}	4.08×10^{-6}
Tachybtus ruficolis	2	7.52×10^{-6}	5.65×10^{-11}
Pelicanus anocrotanus	6	2.26×10^{-5}	5.09×10^{-11}
Vannellus spinosus	352	1.32×10^{-3}	1.75×10^{-6}
Charamdrius alexandrines	12	4.51×10^{-5}	2.04×10^{-9}
Charamdrius dublus	8	3.01×10^{-5}	9.04×10^{-10}
Charamdrius pecuarius	31	1.17×10^{-4}	1.36×10^{-8}
Limosa limosa	357	1.43×10^{-3}	1.80×10^{-6}
Tringa erythropus	1	3.76×10^{-5}	1.41×10^{-11}
Tringa tetanus	349	1.31×10^{-3}	1.72×10^{-6}
Tringa stagnatilis	52	1.96×10^{-4}	3.82×10^{-8}
Tringa nebularia	46	1.73×10^{-4}	2.99×10^{-8}
Tringa glareola	151	5.68×10^{-4}	3.22×10^{-7}
Tringa hypoleocus	48	1.80×10^{-4}	3.25×10^{-8}
Calidris alba	1231	4.63×10^{-3}	2.14×10^{-5}
Philomachus pugnax	47618	1.79×10^{-1}	3.20×10^{-2}
Larus cirocephalus	20	7.52×10^{-5}	5.65×10^{-9}
Chlidonia hybridus	53	1.99×10^{-4}	3.97×10^{-8}
Gellochenidon niloticus	174	6.54×10^{-4}	4.28×10^{-7}
Sterna cospia	3	1.13×10^{-5}	1.27×10^{-10}
Pandion haiactus	8	3.01×10^{-5}	9.04×10^{-10}
Circus aeruginisus	90	3.38×10^{-4}	1.14×10^{-7}
Cirycle rudis	12	4.51×10^{-5}	1.34×10^{-8}
Venelius tectus	47	1.77×10^{-4}	3.12×10^{-8}
Microcabra capensis	241	9.06×10^{-4}	8.21×10^{-7}
Anas crecca	6	2.26×10^{-5}	5.05×10^{-10}
Tringa ocropus	4	1.50×10^{-5}	2.26×10^{-10}
Galliago galliago	2	7.52×10^{-6}	5.65×10^{-11}
Galliago media	2	7.52×10^{-6}	5.65×10^{-11}
Sterna hirundo	270	1.05×10^{-3}	1.03×10^{-6}
Corythermis cristata	3	1.13×10^{-5}	1.27×10^{-10}

Motocilla flava	929	3.49×10^{-3}	1.22×10^{-5}
Motocilla alba	1	3.76×10^{-5}	1.41×10^{-11}
Total 64	266034	1	0.3628

Table 6: Diversity of Birds encountered for the year 1999 at the Hadejia-Nguru wetlands, Yobe State, Nigeria

Name of species	Population	Proportion	Simpson's index
Phalacrocorax africanus	1190	7.42×10^{-3}	5.51×10^{-5}
Ardea cineria	604	3.77×10^{-3}	1.42×10^{-5}
Ardea malanocephala	9	5.61×10^{-5}	3.14×10^{-9}
Ardea purpurea	247	1.54×10^{-3}	2.40×10^{-6}
Casmerodius albus	301	1.88×10^{-3}	3.53×10^{-6}
Mesophyx intermedia	91	5.67×10^{-4}	3.22×10^{-7}
Egretta ardesiaca	2	1.25×10^{-5}	1.56×10^{-10}
Egretta garzeta	654	4.08×10^{-3}	1.67×10^{-5}
Bubulcus ibis	3861	2.41×10^{-2}	5.81×10^{-4}
Ardeola raloides	1199	7.48×10^{-3}	5.60×10^{-5}
Ixobricus minitus	34	2.12×10^{-4}	4.49×10^{-8}
Nycticorax nycticorax	2831	1.77×10^{-2}	3.13×10^{-4}
Anas hotteniota	3	1.87×10^{-5}	3.50×10^{-10}
Anastomus lamelligerus	2	1.25×10^{-5}	1.6×10^{-6}
Ciconia ciconia	7	4.36×10^{-5}	1.90×10^{-9}
Thriskionis aethopicus	601	3.75×10^{-3}	1.40×10^{-5}
Plagades falcinellus	14	8.73×10^{-5}	7.62×10^{-9}
Platalia alba	220	1.37×10^{-3}	1.88×10^{-6}
Microcabra capensis	4601	2.87×10^{-2}	8.24×10^{-4}
Actophilonis Africana	12	7.48×10^{-5}	5.60×10^{-9}
Dendrocydna bicolour	49	3.06×10^{-4}	9.30×10^{-8}
Dendrocydna viduata	1536	9.58×10^{-3}	9.17×10^{-5}
Plectopterus gambensis	64938	4.05×10^{-1}	1.64×10^{-1}
Sarkidiornis melanotus	10563	6.59×10^{-2}	4.34×10^{-3}
Nettapus auritus	11889	1.18×10^{-2}	1.39×10^{-4}
Anas acuta	8	4.99×10^{-5}	2.49×10^{-9}
Anas querquedula	40292	2.51×10^{-1}	6.31×10^{-2}
Numenlus aquata	1	6.24×10^{-6}	3.89×10^{-11}
Galliago galliago	2	1.25×10^{-5}	1.56×10^{-10}
Amaurornis flavirosta	65	3.99×10^{-4}	1.59×10^{-7}
Gallinula chloropus	474	2.96×10^{-3}	8.73×10^{-7}
Porphirio porphirio	96	5.99×10^{-4}	3.58×10^{-7}
Himantopus himantopus	398	2.48×10^{-3}	6.16×10^{-6}
Recurvirosta avosetta	2	1.25×10^{-5}	1.56×10^{-10}
Sterna cospia	36	2.24×10^{-4}	5.04×10^{-8}
Vannellus spinosus	1233	1.69×10^{-3}	5.91×10^{-5}
Charamdrius alexandrines	8	4.99×10^{-5}	2.49×10^{-9}

Charamdrius dublus		23	1.43×10^{-4}	2.06×10^{-8}
Circus macrourus		7	4.34×10^{-5}	1.91×10^{-9}
Limosa limosa		7	4.34×10^{-5}	1.91×10^{-9}
Tringa erythropus		4065	2.54×10^{-2}	6.42×10^{-5}
Tringa tetanus		201	1.25×10^{-3}	1.57×10^{-6}
Tringa stagnatilis		83	5.18×10^{-4}	2.68×10^{-7}
Tringa orcropus		73	1.55×10^{-4}	2.07×10^{-7}
Tringa glareola		205	1.28×10^{-3}	1.63×10^{-6}
Tringa hypoleocus		169	1.05×10^{-3}	1.11×10^{-6}
Calidris alba		187	1.17×10^{-3}	1.36×10^{-6}
Philomachus pugnax		12301	7.67×10^{-2}	5.88×10^{-3}
Larus cirocephalus		5	3.12×10^{-5}	9.72×10^{-10}
Chlidonia leucopterus		3288	2.05×10^{-2}	4.20×10^{-4}
Gellochenidon niloticus		20	1.25×10^{-4}	1.56×10^{-8}
Sterna albifrons		14	8.73×10^{-5}	7.62×10^{-9}
Pandion haliactus		7	4.34×10^{-5}	1.91×10^{-9}
Circus aeruginisus		40	2.49×10^{-4}	6.22×10^{-8}
Cirycle rudis		24	1.50×10^{-4}	2.24×10^{-8}
Motocilla flava		1550	9.66×10^{-3}	9.34×10^{-5}
Corythermis cristata		5	3.12×10^{-5}	9.72×10^{-10}
Glareola cineria		1	6.24×10^{-6}	3.89×10^{-11}
Tachybtus ruficolis		2	11.25×10^{-5}	1.56×10^{-10}
Anas crecca		6	3.74×10^{-5}	1.40×10^{-9}
Rostratula bengalensis		1	6.24×10^{-6}	3.89×10^{-11}
Chlidonius hybridus		1	6.24×10^{-6}	3.89×10^{-11}
Larus spp		23	$11{,}43\times10^{-4}$	2.06×10^{-8}
Total	63	160,387	1	0.2406

DISCUSSION

Analysis of trend for both species number and population abundance indicate that the number of species fluctuated minimally between 1995 and 1997 while an irruptive population pattern was observed between 1998 and 1999 in population abundance.

The results of bird species diversity in the study area did not show any consistency over the period of the study. Calculated Simpson's diversity index for each year, however, indicated high diversity of bird species in Hadejia – Nguru wetlands. Bird species diversity indices were 0.2661, 0.2753, 0.2666, 0.3628 and 0.2406 for 1995, 1996, 1997, 1998 and 1999 respectively (Table 1).

The consistency or minimal variation in the number of bird species observed in the study area and the high species diversity indices are indicative of high stability and good ecological health of Hadejia – Nguru wetlands throughout the period of the study. These results agree with the observations of Usher (1992) that the ecological health of a conservation area or an ecosystem is determined by the number of species that it contains especially birds, mammals or plant species.

The irruptive pattern observed in the abundance of bird populations particularly in 1998 and 1999 may not be unconnected with the inconsistency in the periods of censuses for both years in relation to migrant birds in the study area. These include the winter migrants,

residents and summer visitors. The winter migrants included; *Anas querquedula, Circus aerugenisus, Phalocrocorax africanus, Triga glareola, Himantopus himantopus, Egretta intermia, Ardeolaibis, Platalea leucrodia, Sarkidionis melanotus, Nettapus auritus, Dendrocydna bicolor,* while the summer visitors include; *Egretta ardesiaca, Pelicanus sp.* These Palearctic migrant birds were found in the wetlands mostly between January and March. They winter in the wetlands and return to Europe to breed.

The results of this study clearly suggest that the Hadejia – Nguru wetland sites should be accorded the status of biodiversity hot – spot, essentially for bird species conservation. The information provided by this study can also be used to develop a sound management plan for bird species in the study area.

CONCLUSION

The wetlands contain high diversity of bird species. The number and density of bird species obtained in this study indicated the existence of healthy populations of birds in the study area. The distribution pattern of bird species in the study area is an indication that the area provides the ecological requirements of the bird species. All the above information made the Wetlands area among the Wetlands of international importance in the world.

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