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ORIGINAL ARTICLE

Aquatic bird assemblages of a tropical African man-made lake

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Aquatic birds are important biotic components of Lake Ecosystem serving as indicator of pollution, sources of protein, fishing agent, income, recreation, tourism, sport and pest control. The aim of this study was to provide a baseline data and checklist of the bird assemblages in Asa Lake, Ilorin, Nigeria. Bird sampling was conducted weekly for 24 weeks, by walking 10 mS^{-1} along a line transect on the bank of the lake. The populations were classified as rare, frequently seen and common based on the number of sightings, and abundance. Diversity indices such as dominance, evenness, Simpson diversity, Shanon-Weiner diversity, Marglef's richness were estimated. 13682 birds consisting of 17 species in 9 families were recorded in the lake. Species were found in highest number during the rains. Water fowl was the most abundant species 42.21%. African jacana was the least abundant constituting 0.67%. Family Ardeidae was the most abundant in terms of species diversity. Three species were commonly seen, four frequently seen, while nine were rare. Diversity indices of the bird species were; (D) 0.045, (1-D) 0.95; (e^H/S) 0.96, Margalef richness 3.67 and (H) 2.99. The assemblage of bird species in the lake was high due to the availability of food, submerged aquatic macrophytes seeds and foliage, large volume of water, surface area and depth of the lake and absence of large predators. Morphological characteristics and behavioural tactics of the birds were attributed to the high occurrence of some of the birds. For continued residency of the birds in the lake, lake best management practices (LBMP) should be implemented. Continuous monitoring of the birds (bio monitor) in the lake should also be done to give an insight into the ecological conditions of the lake and at the same time serving as aesthetic organisms in the lake.

Keywords: Birds; assemblages; lake; foraging; diversity; macrophytes; waterfowl

Introduction

According to Hoyer (2013), aquatic birds are birds that live at least part of their lives in or around water. Lakes serve as excellent resting/wintering, breeding/nesting, and feeding habitat for birds. Aquatic birds are very significant to any aquatic environment, their presence or absence may indicate the ecological conditions of such environment (Rajpar and Zakaria, 2011). Their presence plays a crucial role in the limnology, aesthetic value and food chain of lakes, while their absence or low assemblage could indicate limnological imbalance, pollution, habitat loss and degradation, thus serving as lakes and reservoirs biological indicators.

Species composition, abundance and diversity of aquatic birds in a lake depend on availability of food, foraging behaviour, surface area, trophic status, productivity, aquatic macrophytes richness and limnological characteristics, morphometrics of the lake. Bird assemblage in a lake could be used in water quality assessment, index of pollution, avifauna biodiversity conservation and lake management. Apart from these, aquatic birds of lakes could serve as sources of protein (meat), fishing agent (cormorant fishing), income, recreation, tourism, sport, and pest control.

There are numerous lakes and reservoirs in Africa created for different purposes (Mustapha, 2011). But, very few studies have been done on their avifauna composition, diversity, distribution and abundance. The aim of this study was to document the species composition, diversity and abundance of aquatic birds of an important tropical African lake (Asa Lake) in Nigeria. This is with a view to providing a checklist of the bird assemblages and baseline data and information on the bird's species in the lake for their subsequent monitoring, utilization, sustainable exploitation, conservation and management.

Materials and methods

Study site description

Asa Lake was constructed in 1977 primarily for domestic water supply to Ilorin town by the Kwara State Government of Nigeria. The lake is located at about 5 km south of Ilorin the Kwara State capital across river Asa at a latitude 08°26' north and a longitude 04°29'. The dam is 597 m in length and 27 m height with a crest width of 6 m (Table 1). Surface area of the reservoir is 302 hectares, and the reservoir is fed by four river tributaries with river Asa being the major river. The sampling sites extended from the dam site to Odore, Laduba and Afon basins. The periods of maximum water levels associated with

floods around the lake usually commenced as from June to middle of October corresponding with the rainy season starting from May to the early October (Araoye, 2009).

Table 1. Morphometrics charcteristics of Asa Lake.

Features	Measurements
Overall length	596 m
Storage capacity	43 million cm^3
Extent of lake	18 km
Earth Embankments:	
Length	402 m
Crest width	6 m
Maximum height	27 m
Upstream slope	0.04375
Downstream slope	0.00072338
Earth fills	250,000 cm^3
Non-overflow concrete gravity section:	
Length	130 m
Crest width	6 m
Maximum height	11 m
Spill way:	
Length	65 m
Height	14 m
Maximum discharge	79,000 cm^3s^{-1}
Total volume of concrete:	49,000 cm^3

Source: Kwara State Utility Board, Ilorin.

Bird sampling/survey

The sampling was conducted weekly for 24 weeks between January and June 2016. Bird sampling was made by walking at a slow pace (about 10 m S^{-1}) along the line transect made on the bank of the lake (Gaston 1975; Bibby et al., 2000). Birds were counted at their point of first detection and care was taken to ensure that same birds were not counted twice. Birds that were seen in or on the lake were the only ones censured. The number of aquatic birds of various species was recorded on each census day. The birds were identified to species level using field guide of Grimmet et al., (1999), Ali (1996), Grimmett & Inskipp (2007), Serle et al., (1977), Evans (1994), Shirihai & Christie (1996) and Harris et al., (1991). Call notes of the birds were sometimes used for identification after confirmation from the locals. Counting of the birds was made in the mornings between 07.00 and 10:00 am and/or in the evenings between 4:00 and 6:00 pm.

Classification and occurrence of bird in population analysis

The bird populations were classified as rare (R), frequently seen (Fs) and common (C) based on the number of sightings, and abundance. Similarly, based on the percentage frequency of occurrence of the bird species, the scores were classified as 0.00-3.00% rare (Re), 3.01-9.99% less common (Lc) and 10.00-100% common (Co).

Data analysis

Dominance indices (D), Evenness (e^H/S), Simpson diversity index (1-D), Shanon-Weiner diversity (H), Marglef's richness indices and two-way ANOVA at $P<0.05$ were estimated using the computer program PAST version 3.20 software (Hammer et al., 2011). The percent abundance and percent frequency of bird species were also calculated. The diversity indices measured were according to Magurran (1988).

Results and discussion

Bird assemblages

A total of 17 species of aquatic birds in 9 families were recorded in the lake spanning 24 weeks of survey, covering both dry and rainy seasons (Table 2). All the species were found in the two seasons. A total number of 136832 birds were sighted in the lake in the two seasons with the rainy season having the highest number of 8928 (65%) of the total abundance of birds. All the species were also found in their highest number during the rainy season. There was significant difference at $P<0.05$ in the abundance of the species between the seasons, with rainy season abundance significantly higher ($P<0.05$) than the dry season. Water fowl of/and the family Anatide was the most abundant species and family in the lake in both dry and rainy seasons. It constituted 42.21% of the total number of birds found in the lake. African jacana of/and the family Jacanidae was the least abundant species constituting 0.67% of the total bird population in the lake. The family Ardeidae was the most abundant family in terms of species diversity with four species, while five families were represented by a single species (Table 2). Based on sighting and percentage frequency of occurrence, three species were commonly seen and recorded in

population sampling and survey; four species were less common and frequently seen, while nine species were rare in terms of percentage occurrence and sighting on the lake (Table 3).

Table 2. Bird species composition and abundance of Asa Lake, Ilorin, Nigeria.

Season	Week	GH	BH	PH	WF	FH	AJ	BL	SL	WL	BK	PK	PyK	CE	WD	SP	LD	S	Total
Dry	1	18	10	12	212	5	2	15	12	9	18	6	4	26	30	2	6	3	391
	2	12	7	9	202	4		10	8	6	12	4	3	28	32	1	9	2	351
	3	9	12	10	186	6	1	8	10	7	14	9	5	30	41	3	12	4	370
	4	21	14	18	172	8	1	10	12	9	19	12	6	36	45	5	18	6	416
	5	18	10	14	150	5	2	6	7	5	10	8	5	30	36	3	12	4	330
	6	15	8	10	162	4		5	10	7	9	12	7	36	42	5	16	7	361
	7	20	10	14	164	3	1	8	12	9	12	14	6	32	40	2	14	5	373
	8	16	12	16	180	6	1	6	10	7	10	8	5	35	48	1	18	3	390
	9	22	8	12	192	5	2	7	10	5	6	10	2	40	52	4	20	2	408
	10	25	6	8	204	3	1	6	8	3	8	12	2	45	56	6	20	4	427
	11	20	10	14	220	2	1	5	6	4	7	7	4	48	58	8	24	6	455
	12	24	12	15	228	4		8	5	5	5	5	5	54	60	10	22	8	482
Total		220	119	152	2272	55	12	94	110	76	130	107	54	440	540	50	191	54	4754
Rain	13	26	14	18	240	6	1	10	8	6	9	8	8	50	60	10	30	10	527
	14	24	10	12	245	7	2	12	10	7	12	12	6	56	62	12	30	10	543
	15	28	18	16	250	10	4	18	10	5	14	16	10	60	65	14	36	12	601
	16	31	26	24	266	12	3	22	18	5	16	10	10	62	70	13	38	15	657
	17	30	32	20	275	12	5	20	15	4	24	10	12	65	66	15	40	18	680
	18	26	30	25	300	15	5	25	20	10	22	8	14	68	72	18	41	20	737
	19	22	28	32	312	18	7	28	22	12	25	14	10	76	75	22	45	22	789
	20	24	34	34	315	21	9	30	25	15	32	12	8	78	78	25	48	25	833
	21	25	36	40	320	25	10	22	18	18	36	16	14	84	82	30	50	28	875
	22	20	26	46	300	28	12	18	15	14	40	22	18	90	80	30	50	30	861
	23	21	24	54	330	20	10	15	10	8	42	20	20	92	84	26	52	30	881
	24	25	29	60	350	36	12	10	8	5	45	24	22	96	88	25	55	30	944
Total		302	307	381	3503	210	80	230	179	109	317	172	152	877	882	240	515	250	8928
Overall Total		522	426	533	5775	265	92	324	289	185	447	279	206	1317	1422	290	706	304	13682

Key: GH=Grey Heron; BH=Black Heron; PH=Purple Heron; WF=Waterfowl; FH=Fish Hawk; AJ=African Jacana; BL=Blackhead Lapwing; SL=Spur winged Lapwing; WP=Wattled Lapwing; BL=Blue breasted Kingfisher; PK=Pied Kingfisher; PyK=Pygmy Kingfisher; CE=Cattle Egret; WD=Whistling Duck; SP=SandPiper; LD=Laughing Dove; S=Shikra.

Table 3. Name, Family and Percentage Abundance, Sightings, Percentage Frequency of Bird Species in Asa Lake, Ilorin, Nigeria.

Common name	Scientific name	Family	% abundance	Sighting and % frequency
Grey Heron	*Ardea cinerea*	Ardeidae	3.81	Fs; Lc
Black Heron	*Egretta ardesiaca*	Ardeidae	3.11	Fs; Lc
Purple Heron	*Ardea purpurea*	Ardeidae	3.89	Fs; Lc
Cattle Egret	*Bubulcus ibis*	Ardeidae	10.63	C; Co
Water Fowl	*Anas acuta*	Anatidae	42.21	C; Co
Whistling Duck	*Dendrocygna bicolour*	Anatidae	10.39	C; Co
Blackhead Lapwing	*Vanellus tectus*	Charadriidae	2.37	R; Re
Spur winged Lapwing	*Vanellus spinosus*	Charadriidae	2.11	R; Re
Wattled Lapwing	*Vanellus senegalus*	Charadriidae	1.35	R; Re
Blue breasted Kingfisher	*Halcyon malimbica*	Alcedinidae	3.27	Fs; Lc
Pied Kingfisher	*Ceryle rudis*	Alcedinidae	2.04	R; Re

Pygmy kingfisher	*Ispidina picta*	Alcedinidae	1.51	R; Re
Sand Piper	*Actitis hypoleucos*	Scolopacidae	2.12	R; Re
Laughing Dove	*Streptopelia senegalensis*	Columbidae	5.16	Fs; Lc
Shikra	*Accipiter badius*	Accipitridae	2.22	R; Re
Fish Hawk	*Pandion haliaetus*	Pandionidae	1.94	R; Re
African Jacana	*Actophilornis africanus*	Jacanidae	0.67	R; Re

Key: R=rare; Fs=frequently seen; C=common; Re=0.00-3.00%; Lc=3.01-9.99%; Co=10.00-100%.

Diversity indices

The diversity indices of the bird species in the lake were as follows; Dominance (D) 0.045, Simpson (1-D) 0.95; Evenness (e^H/S) 0.96, Margalef richness 3.67 and Shanon-Weiner (H) 2.99.

Discussion

This is the first study of water bird assemblages of Asa Lake, Ilorin, Nigeria, an important lake for the supply of domestic and industrial water for a population of about 500,000 people. The abundance, composition and diversity of the bird species in the lake was due to the good limnological heterogeneity of the lake which provided quality habitat for the assemblages of the birds species throughout the sampling period. Suter (1994) showed that trophic status of Lake Ecosystem to be positively correlated with bird abundance.

The assemblages of the birds' species varied significantly with seasons. The high abundance of species in the rainy season could be due to the availability of food resources such as fish and their eggs for the piscivorous species, submerged aquatic macrophytes seeds and foliage which provided food for herbivorous birds and nests/roosts for laying of most aquatic birds eggs, large volume of water and surface area of the lake for movement and gliding by the birds, the depth of the lake which provided fish, and macrobenthic invertebrates as food for the birds, absence of large predators that could prey on the birds in the lake, as well as the season being the reproductive period for most aquatic birds. Malizia (2001) reported an increase of diversity of aquatic birds during the rainy season, while Oliveira (2006) observed migrations of aquatic birds in response to significant variation in water level and resource availability. Donatelli et al., (2013) have also noted large aggregations of birds in the wet season, which he called the ebb period.

Waterfowl and the family Anatidae which were the most abundant species and family in the lake has also been reported in other lakes to be in high abundance (Garay et al., 1991). The reasons for their high abundance could be linked to the reasons advanced above. The diversity of the family Ardeidae was due to the presence of species in the family with different foraging habits, using various behavioural and morphological adaptations to wade in the water and seek different food resources which were available in the lake as well as the morphometric characteristics of the lake which favour their presence and abundance.

The low numbers of African Jacana found in the lake could be due to their feeding preference for insects which were not so abundant in the lake and absence of floating vegetation on the lake on which to lay their eggs. Submerged and emergent aquatic macrophytes are known as habitats and foods for many species of aquatic birds (Knapton & Petrie, 1999), thus influencing their assemblages.

The species commonly seen were primarily aquatic which poses morphological characteristics such as long bill and behavioural tactics such as ability to eat different food sources which are available in the lake. They are mostly seen because most of them are not migratory, been resident in the lake all the time, using the lake as home and nesting place. The rare species are occasionally visitors to the lake, though during the 24 weeks of sampling, they were encountered in every week, only their numbers were low as compared to common and less common species. Their low abundance and rarity could be attributed to their feeding habit (carnivorous) and food preference which include molluscs and crustaceans which were not so abundant in the lake as well as the depth of the lake. Lake depth has been shown to be an important factor influencing distribution and abundance of aquatic birds in lakes and wetland systems (Colwell & Taft, 2000).

Diversity indices of the bird species in the lake is high, this could be due to a high foraging resources available and the good morphometrics of the lake. Hoyer and Canfield (1994), Paszkowski & Tonn (2006) have reported a positive relationship between lake area and its mophometrics as contributing to aquatic bird species richness and assemblages.

Conclusion

The bird species assemblage in Asa Lake, Ilorin, Nigeria shows a high a species diversity and abundance attributed to the to the good water quality and limnological heterogeneity of the lake which provided food resources and submerged aquatic macrophytes for the survival of the birds. For the continued residency and visit of the birds to the lake, lake best management practices (LBMP) should be implemented to prevent water quality deterioration, sedimentation, and anthropogenic materials inflow.

Similarly, continuous monitoring of the birds (bio monitor) in the lake should be done to give an insight into the ecological conditions of the lake and at the same time serving as aesthetic organisms in the lake.

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