Provided for Non-Commercial Research and Educational Use only Not for Reproduction, Distribution or Commercial Use

The attached copy of the article is provided by the publisher for the benefit of the author(s) for noncommercial research and educational use in instruction at their institution, or sending it to specific colleagues whom they know.

This article was originally published in the

International Journal of

Ecology and Environmental Sciences

CODEN: IJESDQ ISSN: 0377-015X (Print); 2320-5199 (Online)

Homepage: http://www.nieindia.org/Journal/index.php/ijees/

Editors **: Brij Gopal, A. Raman and P.S. Pathak**

Published by the

National Institute of Ecology

Jaipur and New Delhi

For details, contact: Email: ijees1@gmail.com OR nieindia@gmail.com

This OPEN ACCESS Journal accepts manuscripts from researchers in all areas of ecology and environmental science and from all countries. It considers original manuscripts for publication only after comprehensive peer review. Submissions can be made only online and must strictly adhere to the guidelines at the time of submission. Guidelines can be downloaded from volume 42 (no. 1). Detailed Instructions can be read at http://www.nieindia.org/Journal/index.php/ijees/announcement/view/1

International Journal of Ecology and Environmental Sciences 44 (2): 117-125, 2018
ISSN: 2320-5199 (Online)
© NATIONAL INSTITUTE OF ECOLOGY, NEW DELHI

Diversity and Density of Avifauna in Areas with Different Protection Status: A Case Study in Hadejia-Nguru Wetlands, North-eastern Nigeria

A. S. RINGIM [1]*, F.J. MAGIGE [2] AND J.R.M. JOHN [3]

[1] *Department of Biological Sciences, Federal University Dutse, P.M.B. 7156, Dutse, Jigawa State, Nigeria*
[2,3] *Department of Zoology and Wildlife Conservation, University of Dar es Salaam, P.O. Box 35064, Dar es Salaam, Tanzania*

Email: [1] abubakar.r@fud.edu.ng; asringiim@gmail.com; [2] magige.fm@gmail.com; [3] jasson76uk@yahoo.com
* Corresponding author

ABSTRACT

Diversity and density are critical variables in determining the functioning of an ecosystem. Wetlands are among the ecosystems that are rich in biodiversity. However, in many Ramsar wetlands, such information is lacking. Bird species were assessed in Protected Areas (PAs) and Unprotected Areas (UPAs) of the Hadejia-Nguru Ramsar site between October and December, 2015 using point count method. Ninety nine point count stations spaced 400 m apart with radius of 100 m were surveyed. A total of 42,255 individuals of birds belonging to 148 species, 50 families and 23 avian order were observed. Two globally threatened species, the European Turtle Dove *Streptopelia turtur* and Pallid Harrier *Circus macrourus* were observed. The former was categorized as Vulnerable while the latter as Near Threatened based on IUCN Red List categories version 3. There was higher species diversity in the UPAs than in the PAs ($t = -15.34$, $df = 40073$, $p < 0.001$). The two areas were similar in their species composition by 81% indicating that these areas share a number of species. A relatively higher bird density was recorded in the PAs (7 individuals ha^{-1}) than in the UPAs (5 individuals ha^{-1}).. Both habitats are rich in avifauna and therefore deserve equal conservation attention, , especially the Unprotected wetlands and the globally threatened species.
.
Key Words: Bird Diversity; Density; Hadejia-Nguru Wetlands; Protected and Unprotected Areas

INTRODUCTION

Protected Areas (PAs) are described as geographically defined areas which are designated or regulated and managed to achieve specific conservation objectives (CBD 1992). Such areas can provide a refuge for bird species, in particular, threatened and endemic species of global conservation concern, and an essential tool for long term conservation of biodiversity (Evans et al. 2006). Many studies pointed out that PAs serve to increase bird species diversity and density in contrast to Unprotected Areas (UPAs) (Franco et al. 2007). Thus, bird diversity and density are expected to increase with increase in the proportion of PAs by reducing habitat loss and other human pressures (Evans et al. 2006). The global protected area network has over 160 000 PAs in existence covering around 12.7% of the earth's terrestrial surface comprising the global PA network (Rayner et al. 2014).

Some PAs fall within Ramsar sites, a collective name given to a variety of wetland habitats including swamps, marshes, riverbanks, ponds, coral reefs, and floodplains, and are among the most productive eco-systems in the world (Barbier et al. 1997). In many countries, these areas qualify for different types of conservation statuses, such as Important Bird and Biodiversity Areas (IBAs), Endemic Bird Areas (EBAs) and Key Biodiversity Areas (KBAs). In the Hadejia-Nguru Wetlands (HNWs), a Ramsar site and an Important Bird Area (IBA) in Nigeria, four PAs: Adiani

Forest Reserve, Baturiya Game Reserve, Chad Basin National Park, and Nguru Lake and Marma Channel are found (Birdlife International 2015). Additionally, several unprotected wetland areas, not legally protected are also present in HNWs, which are regarded as Unprotected Areas (UPAs) in this study.

Ezealor et al. (1997) have demonstrated that Ruff *Philomachus pugnax* is not a pest of rice *Oryza* spp. in the HNWs, despite rice being its main diet (30.5–37.8%) in this wetland. Akinsola et al. (2000) highlighted that uncontrolled hunting, habitat loss and degradation are among the major challenges facing waterbird conservation in the HNWs. Oduntan et al. (2010) reported human – bird conflicts in this area. They further argued that fire arms and chemicals used by farmers in controlling waterbirds are unsustainable as they either kill or injure them. Lameed (2011) brought out to light the bird diversity and abundance of Dagona Waterfowl Sanctuary and the positive relationship between vegetation density and bird diversity. Sulaiman et al. (2015) reported that the size of wetland in this area does not have effect on bird abundance, but on bird diversity. Despite these important studies and increasing threats to the ecology of wetlands, our knowledge on avian species diversity and density in HNWs is scanty. The present study aimed to document and compare avian species diversity and density in PAs and UPAs of the HNWs. It was hypothesized that PAs will have higher bird diversity and density than UPAs.

THE STUDY AREA

The study was conducted during October – December, 2015 in HNWs located in the semi-arid region of North-eastern Nigeria. This wetland was formed where the Hadejia and Jama'are rivers meet and form the Yobe river, which drains into Lake Chad. The study area lies between Latitude 12º 10' N and 13º0' N and Longitudes 10º15' E and 11º 30' E (Figure 1), with an extent of 350, 000 hectares. It is situated between altitudinal range of 152–305 m above sea level. This wetland is the first and most important Ramsar wetland in Nigeria and among the most valued Ramsar wetlands in West Africa by serving as home to both resident and migratory birds especially waterbirds (Birdlife International 2013). The vegetation in this area is Sudan savanna consisting of sparse shrubs and isolated tall trees predominantly *Acacia* spp. Annual rainfall ranges between 500– 600 mm (Ogunkoya and Dami 2007).

METHODS

Fourteen (14) wetlands, 7 in each area, were selected. The PAs wetlands included Gwayo, Kwasabat, Kandamau, Maram, Marma Channel, Nguru Lake and Oxbow Lake were identified. Whereas Barrack, Dumbari, Hadejia Barrage, Kacallari, Kirikasamma, Muzza and Zemo were in the UPAs. A total of 48 and 51 census point stations were established in PAs and UPAs respectively. Field visits were made in the morning from 06:00 to 10:00 h and in the afternoon from 16:00 to 18:00 h when birds were more active. Point count method, as described by Bibby (2000), was used to sample birds. Birds seen and heard were recorded from a fixed point for 10 minutes within 100 m radius. Point count stations were spaced 400 m apart to avoid double counting. Observations were carried out using Braun Binoculars (16 x 50 m) and birds were identified using field guide to the birds of Western Africa by Borrow and Demey (2014).

Data Analyses

Paleontological Statistics (PAST version 2.17, Hammer et al. 2001) was used to compute species diversity using Shannon-Weiner diversity index. Special *t*- test was used to compare species diversity between PAs and UPAs. Jaccard's index was used to measure species similarity between PAs and UPAs according to Chao et al. (2005) following the formula given below:

$$J = \frac{Sc}{Sa + Sb}$$

Where, Sa and Sb are the numbers of species in the PAs and UPAs, respectively, and Sc is the number of species common to both areas. Population Density (PD) was determined following Sutherland (1996) as:

$$PD = \frac{\text{Number of individuals of a bird species}}{\text{Area of wetland (in hectares)}}$$

Comparison of bird diversity and density between PAs and UPAs was done using student *t*- test.

Avian species were categorized as resident, intra-African migrants or Palearctic winters according to Borrow and Demey (2014) and Dowsett et al. 2016). These birds were further categorized on the basis of their dependency on wetland environment, i.e. Wetland Generalist (WG) those that frequently visit wetlands for

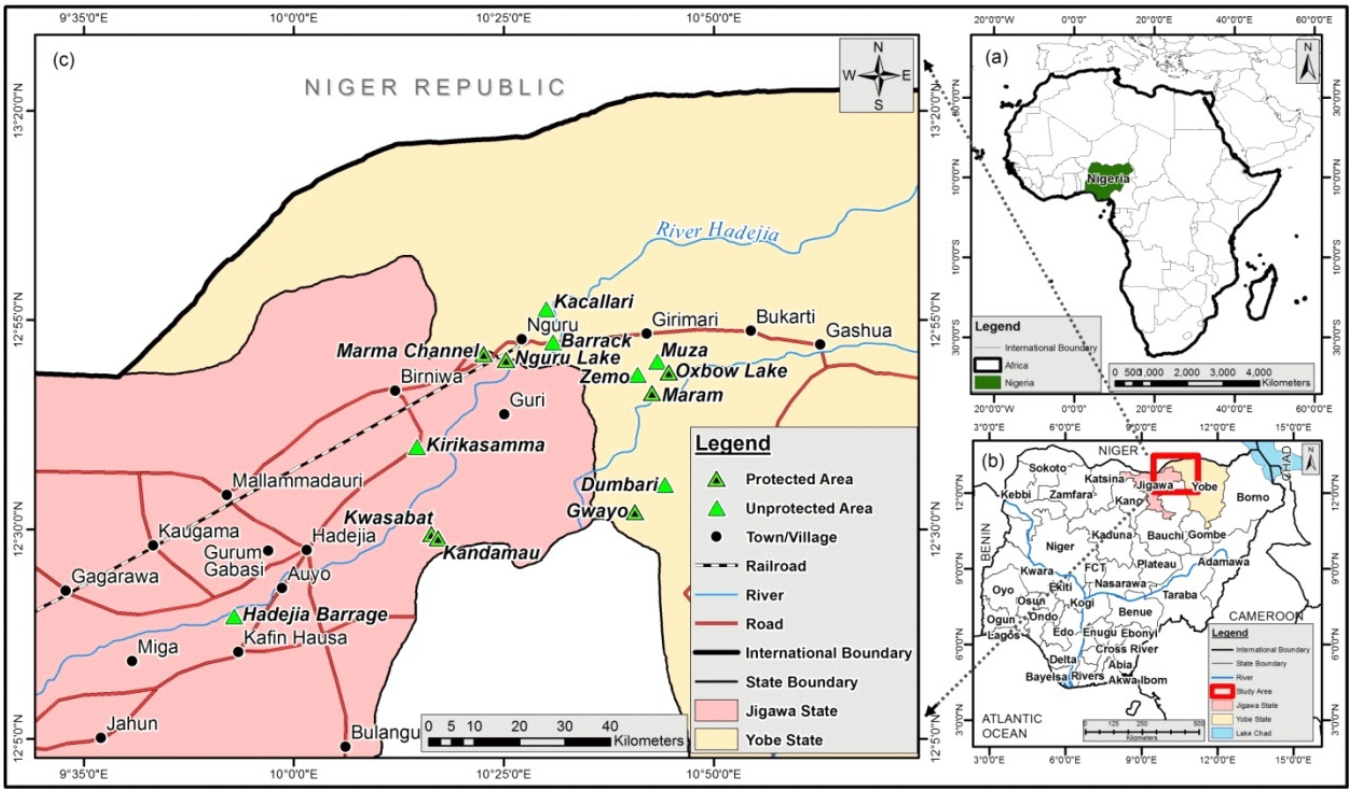


Figure 1. Sampling sites in PAs and UPAs of the Hadejia-Nguru Wetlands)

food or water, and Wetland Specialist those that adapt to wetland environment entirely for their life (Mutagwaba 2010).

RESULTS

A total of 42,255 individuals of birds belonging to 148 species, 50 families and 23 avian orders were recorded in the whole study area of the HNWs (Table 1). Unprotected areas had higher species diversity (H' = 1.98, evenness = 0.0456) than the PAs (H' = 1.70, evenness = 0.0556) (t = -15.34, df = 40073, p <0.001). These two areas were similar in terms of bird species composition by 81% indicating that the areas share a number of species. Bird abundance was higher in PAs than in the UPAs (see Table 1). Families with the highest species were Accipitridae (13 species), Ardeidae (11 species) and Columbidae (9 species). Two species of global conservation concern were also recorded: the Near Threatened Pallid Harrier *Circus macrourus* and Vulnerable European Turtle Dove *Streptopelia turtur;* the former was recorded in both areas i.e. PAs and UPAs whereas the latter was only recorded in PAs. Three individuals were recorded in PAs, whereas five individuals were recorded in UPAs. Twenty eight individuals of the Vulnerable European Turtle Dove, *Streptopelia turtur* were recorded in December in the PAs. Further, 14 species including *S. turtur* were recorded for the first time in HNWs (Table 2).

Table 2 shows the bird abundance in both PAs and UPAs as categorized by their status: resident species, Intra-African migrant or Palearctic winter, and their dependency on wetland environment.

A relatively higher bird density was recorded in the PAs (7 ha^{-1}), whereas only 5 ha^{-1} in the UPAs; but the difference was not statistically significant (t = 0.3813, df = 264, p = 0.7032). Overall density of birds in PAs ranged from 0.02 to 239.47 individuals ha^{-1}, and in the UPAs from 0.01 to 119.99 individuals ha^{-1} (see Table 1). The White-faced Whistling Duck *Dendrocygna viduata* (239.47 individuals ha^{-1}) had higher density in PAs whereas in UPAs, and Garganey *Spatula querquedula* had higher density (see Table 1).

Table 1. Checklist of bird species recorded in PAs and UPAs of the HNWs, new additions to existing studies (*)

Family	Species Name	Protected areas		Unprotected areas	
		No. of individuals	Density ha^{-1}	No. of individuals	Density ha^{-1}
Anatidae	African Pygmy Goose *Nettapus auritus*	22	0.03	12	0.19
	Fulvous Whistling Duck *Dendrocygna bicolor*	93	1.61	56	0.97
	Garganey *Spatula querquedula*	5210	90.45	6103	99.72
	Knob-billed Duck *Sarkidiornis melanotos*	198	3.43	106	1.73
	Spur-winged Goose *Plectropterus gambensis*	166	2.88	31	0.5
	White-faced Whistling Duck *Dendrocygna viduata*	13794	239.47	7344	120
Apodidae	African Palm Swift *Cypsiurus parvus*	78	1.35	11	0.17
	Common Swift *Apus apus*	2	0.03	-0	-
	Little Swift *Apus affinis*	1	0.01	19	0.31
Bucerotidae	African Grey Hornbill *Lophoceros nasutus*	10	0.17	11	0.17
	Northern Red-billed Hornbill *Tockus erythrorhynchus*	23	0.39	19	0.31
Accipitridae	African Harrier Hawk *Polyboroides typus*	1	0.01	1	0.01
	African Swallow-tailed Kite *Chelictinia riocourii**	-	-	2	0.03
	Black Shouldered Kite *Elanus axillaris*	-	-	6	0.09
	Black kite *Milvus migrans*	7	0.12	7	0.11
	Dark Chanting Goshawk *Melierax metabates*	-	-	2	0.03
	Gabar Goshawk *Micronisus gabar*	2	0.03	4	0.06
	Grasshopper Buzzard *Butastur rufipennis*	-	-	2	0.03
	Lizard Buzzard *Kaupifalco monogrammicus*	-	-	5	0.08
	Montagu's Harrier *Circus pygargus*	2	0.03	-	-
	Pallid Harrier *Circus macrourus*	3	0.05	5	0.08
	Shikra *Accipiter badius*	2	0.03	-	-
	Western Marsh Harrier *Circus aeruginosus*	8	0.13	13	0.21
	Yellow-billed Kite *Milvus migrans parasitus*	1	0.01	1	0.01
Ciconiidae	Abdim's Stork *Ciconia abdimii*	40	0.69	3	0.04
	African Openbill Stork *Anastomus lamelligerus*	6	0.1	10	0.16
	White Stork *Ciconia ciconia*	-	-	11	0.17
Cuculidae	Great Spotted Cuckoo *Clamator glandarius*	-	-	4	0.06
	Senegal Coucal *Centropus senegalensis*	5	0.08	28	0.45
Coliidae	Blue-naped Mousebird *Urocolius macrourus*	-	-	10	0.16
Alcedinidae	African Pygmy Kingfisher *Ispidina picta*	5	0.08	2	0.03
	Grey-headed Kingfisher *Halcyon leucocephala*	4	0.06	-	-
	Malachite Kingfisher *Corythornis cristatus*	9	0.15	3	0.04
	Pied Kingfisher *Ceryle rudis*	9	0.15	5	0.08
Columbidae	African Mourning Dove *Streptopelia decipiens*	359	6.23	163	2.66
	Black-billed Wood Dove *Turtur abyssinicus*	5	0.08	1	0.01
	Blue-spotted Wood Dove *Turtur afer*	-	-	1	0.01
	European Turtle Dove *Streptopelia turtur**	28	0.48	-	-
	Laughing Dove *Streptopelia senegalensis*	18	0.31	28	0.45
	Namaqua Dove *Oena capensis*	2	0.03	5	0.08
	Speckled Pigeon *Columba guinea*	7	0.12	19	0.31
	Tambourine Dove *Turtur tympanistria**	2	0.03	-	-
	Vinaceous Dove *Streptopelia vinacea*	5	0.08	6	0.09
Coraciidae	Abyssinian Roller *Coracias abyssinicus*	14	0.24	20	0.03
Charadriidae	Black-headed Lapwing *Vanellus tectus*	3	0.05	19	0.31
	Spur-winged Lapwing *Vanellus spinosus*	32	0.55	62	1.01
Jacanidae	African Jacana *Actophilornis africanus*	205	3.55	256	4.18
	Lesser Jacana *Microparra capensis*	13	0.22	9	0.14
Laridae	Gull-billed Tern *Gelochelidon nilotica**	20	0.34	2	0.03

Family	Species Name	Protected areas		Unprotected areas	
		No. of individuals	Density ha^{-1}	No. of individuals	Density ha^{-1}
	Grey-headed Gull *Larus cirrocephalus**	4	0.06	-	-
	Whiskered Tern *Chlidonias hybrida*	7	0.12	3	0.04
Scolopacidae	Common Sandpiper *Actitis hypoleucos*	4	0.06	2	0.03
	Common Snipe *Gallinago gallinago*	-	-	5	0.08
	Green Sandpiper *Tringa ochropus*	29	0.5	79	1.29
	Little Stint *Calidris minuta*	-	-	38	0.62
	Ruff *Calidris pugnax*	6	0.1	71	1.16
	Spotted Redshank *Tringa erythropus*	6	0.1	63	1.02
	Wood Sandpiper *Tringa glareola*	379	6.57	653	10.66
Recurvirostridae	Black-winged Stilt *Himantopus himantopus*	58	1	33	0.53
Falconidae	Grey Kestrel *Falco ardosiaceus*	-	-	2	0.03
	Lanner Falcon *Falco biarmicus*	4	0.06	3	0.04
	Red-necked Falcon *Falco ruficollis*	1	0.01	4	0.06
Numididae	Helmeted Guineafowl *Numida meleagris**	-	-	12	0.19
Odontophoridae	Stone Patridge *Ptilopachus petrosus*	-	-	6	0.09
Rallidae	Allen's Gallinule *Porphyrio alleni*	33	0.57	5	0.08
	Black Crake *Zapornia flavirostra*	43	0.74	11	0.17
	Common Moorhen *Gallinula chloropus*	26	0.45	18	0.29
	Lesser Moorhen *Gallinula angulata*	10	0.17	8	0.13
	Purple Swamphen *Porphyrio porphyrio*	33	0.57	12	0.19
Musophagidae	Western Grey Plantain-eater *Crinifer piscator*	3	0.05	6	0.09
Lybiidae	Bearded Barbet *Pogonornis dubius*	2	0.03	-	-
	Vieillot's Barbet *Lybius vieilloti*	1	0.01	2	0.03
	Yellow-fronted Tinkerbird *Pogoniulus chrysoconus*	1	0.01	-	-
Ardeidae	Black Heron *Egretta ardesiaca*	80	1.38	15	0.24
	Black-headed Heron *Ardea melanocephala*	11	0.19	3	0.04
	Cattle Egret *Bubulcus ibis*	19	0.32	39	0.63
	Great Egret *Ardea alba*	5	0.08	16	0.26
	Green-backed Heron *Butorides striata*	10	0.17	3	0.04
	Grey Heron *Ardea cinerea*	10	0.17	18	0.29
	Intermediate Egret *Ardea intermedia*	12	0.2	13	0.21
	Little Bittern *Ixobrychus minutus*	3	0.05	1	0.01
	Little Egret *Egretta garzetta*	16	0.27	21	0.34
	Purple Heron *Aredea purpurea*	42	0.72	23	0.37
	Squacco Heron *Ardeola rolloides*	149	2.58	63	1.02
Threskiornithidae	Glossy Ibis *Plegadis falcinellus*	31	0.53	39	0.63
Psittacidae	Red-headed Lovebird *Agapornis pullarius**	3	0.05	-	-
	Rose-ringed Parakeet *Psittacula krameri*	6	0.1	7	0.11
	Senegal Parrot *Poicephalus senegalus*	6	0.1	3	0.04
Pteroclidae	Four-banded Sandgrouse *Pterocles quadricinctus*	4	0.06	63	1.02
Caprimulgidae	Standard-winged Nightjar *Caprimulgus longipennis**	2	0.03	-	-
Upupidae	Hoopoe *Upupa epops*	1	0.01	1	0.01
Phaoeniculidae	Green Wood-hoopoe *Phoeniculus purpureus*	1	0.01	7	0.11
Alaudidae	Crested Lark *Galerida cristata*	3	0.05	13	0.21
Cisticolidae	Grey-backed Camaroptera *Camaroptera brachyura*	-	-	1	0.01
	Tawny-flanked Prinia *Prinia subflava*	5	0.65	5	0.07
	Zitting Cisticola *Cisticola juncidis*	-	-	4	0.06
	Winding Cisticola *Cisticola galactotes*	1	0.01	5	0.08
Corvidae	Piapiac *Ptilostomus afer*	-	-	23	0.37
	Pied Crow *Corvus albus*	1	0.01	15	0.24
Estrildidae	Cut-throat Finch *Amadina fasciata*	7	0.12	3	0.04
	Green-winged Pytilia *Pytilia melba**	1	0.01	2	0.03

Family	Species Name	Protected areas		Unprotected areas	
		No. of individuals	Density ha^{-1}	No. of individuals	Density ha^{-1}
	Red-billed Firefinch *Lagonosticta senegala*	33	0.57	17	0.27
	Red-cheeked Cordon-blue *Uraeginthus bengalus*	52	0.09	92	1.5
Fringillidae	Yellow-fronted Canary *Serinus mozambicus*	-	-	2	0.03
Hirundinidae	Common Sand Martin *Riparia riparia*	15	0.26	30	0.49
	Ethiopian Swallow *Hirundo aethiopica*	35	0.6	2	0.03
	Plain Martin *Riparia paludicola*	13	0.22	24	0.39
	West African Swallow *Cecropis domicella*	-	-	2	0.03
Laniidae	Southern-Grey Shrike *Lanius meridionalis*	-	-	2	0.03
	Woodchat Shrike *Lanius senator**	-	-	5	0.08
	Yellow-billed Shrike *Corvinella corvina*	-	-	1	0.01
Malaconotidae	Black-crowned Tchagra *Tchagra senegalus*	1	0.01	1	0.01
	Yellow-crowned Gonolek *Laniarius barbarus*	15	0.26	3	0.04
Meropidae	Little Bee-eater *Merops pusillus*	33	0.57	4	0.06
	Little Green Bee-eater *Merops orientalis*	-	-	5	0.08
Motacillidae	Yellow Wagtail *Motacilla flava*	289	5.01	333	5.44
Muscicapidae	Black Scrub Robin *Cercotrichas podobe*	1	0.01	2	0.03
	Northern Wheatear *Oenanthe oenanthe**	2	0.03	7	0.11
Nectariniidae	Beautiful Sunbird *Nectarinia pulchella*	43	0.74	9	0.14
Pandionidae	Osprey *Pandion haliaetus*	1	0.01	-	-
Passeridae	Northern Grey-headed Sparrow *Passer griseus*	123	2.13	48	0.78
	Sudan Golden Sparrow *Passer luteus*	42	0.72	21	0.34
	Speckle-fronted Weaver *Sporopipes frontalis*	23	0.39	34	0.55
Phalacrocoracidae	Long-tailed Cormorant *Microcarbo africanus*	323	4.02	150	2.45
Phasianidae	Double-spurred Francolin *Pternistis bicalcaratus*	2	0.03	-	-
Ploceidae	Black-headed Weaver *Ploceus melanocephalus*	8	0.13	1	0.01
	Little Weaver *Ploceus luteolus*	106	1.84	7	0.11
	Northern Red Bishop *Euplectes franciscanus*	26	0.45	14	0.22
	Red-billed Quelea *Quelea quelea*	595	10.32	759	12.4
	Village Weaver *Ploceus cucullatus*	94	1.63	48	0.78
	Vitellin Masked Weaver *Ploceus intermedius*	7	0.12	-	-
	White-billed Buffalo Weaver *Bubalornis albirostris*	141	2.44	227	3.7
	Yellow-crowned Bishop *Euplectes afer*	-	-	2	0.03
Pycnonotidae	Common Bulbul *Pycnonotus barbatus*	3	0.05	3	0.04
Sturnidae	Chestnut-bellied Starling *Lamprotornis pulcher*	20	0.34	40	0.65
	Great Blue-eared Starling *Lamprotornis chalybaeus*	36	0.62	14	0.22
	Long-tailed Glossy Starling *Lamprotornis caudatus*	16	0.27	26	0.42
	Yellow-billed Oxpecker *Buphagus africanus*	-	-	1	0.01
Sylviidae	African Reed Warbler *Acrocephalus baeticus**	6	0.1	6	0.09
	Common Whitethroat *Sylvia communis**	-	-	4	0.06
	European Reed Warbler *Acrocephalus scirpaceus**	6	0.1	8	0.13
	Greater Swamp Warbler *Acrocephalus rufescens*	16	0.27	9	0.14
	Lesser Swamp Warbler *Acrocephalus gracilirostris*	7	0.12	2	0.03
	Northern Crombec *Sylvietta brachyura*	3	0.05	-	-
	Sedge Warbler *Acrocephalus schoenobaenus*	48	0.83	14	0.22
Timalidae	Brown Babbler *Turdoides plebejus*	5	0.08	4	0.06
Viduidae	Sahel Paradise Whydah *Vidua orientalis*	-	-	2	0.03
	Village Indigobird *Vidua chalybeata*	5	0.08	2	0.03

Table 2. Avifauna of HNWs recorded in PAs and UPAs during the present study

Category	Protected areas (%)	Unprotected areas (%)
Resident	64.4	66.2
Intra-Africa migrant	14.1	12.0
Palearctic migrant	21.5	21.8
Total (%)	100	100
Wetland specialist	69.9	58.6
Wetland generalist	30.1	41.4
Total (%)	100	100

DISCUSSION

The findings have revealed that UPAs had higher bird diversity compared to PAs. However, there were high levels of similarity in the species composition between the two areas. This implies that the two areas shared a number of species common to both areas. The reason for the higher bird diversity in UPAs could be due to the higher vegetation diversity and composition as well as human modified habitats, such as farmlands where bird diversity can be increased (Devictor et al. 2007). Mutagwaba (2010) and Rayner et al. (2014) have also revealed similar findings. The study also recorded a higher number of bird species than previous studies in HNWs (Lameed 2011, Sulaiman et al. 2014). Lameed (2011) recorded only 135 bird species within three wetland sites in Dagona Waterfowl Sanctuary, while this study covered 14 wetland sites in the entire HNWs. However, the present study covered 14 wetland sites in the area. In a similar way, Sulaiman et al. (2014) reported 119 bird species within the HNWs 70 point count stations as compared to 99 point count stations in the present study. This agrees with Bibby (2000) and Somershoe et al. (2006), who have reported that increased sampling efforts and differences in the habitats can lead to high records of bird species.

Although UPAs supported the highest species diversity, there were more birds in PAs than in UPAs, with the exception of some migratory species whose abundances was higher in UPAs, such as *P. pugnax* and *T. glareola*. Gunnarsson et al. (2005) reported that migratory species can utilize a wide range of habitats on their wintering ground provided they are not severely degraded. This indicates that migratory birds in the HNWs are utilizing both PAs and UPAs on winter migration. *Spatula querquedula* was the most ubiquitous migratory species recorded in thousands in both areas. This supports studies of Madge and Burn (1988) and Cramp and Simmons (1977), who have observed several thousands of individuals of S. *querquedula* in African and Asiatic winter grounds.

Two globally threatened species were recorded in the study area. Pallid Harrier (NT) was recorded in both areas and European Turtle Dove (VU) was recorded only in PAs. Globally, these species are threatened from anthropogenic perturbations such as *Acacia* and scrub clearance, which adversely affects roosting and breeding sites, along with hunting, and climate change among others (Birdlife International 2016a). Although European turtle dove is listed in the checklist of the birds of Nigeria (Dowsett et al. 2016), this study was the first report of its presence in the HNWs. White-faced Whistling Duck was found to be the most common species recorded in both habitats, and they were mostly observed in areas covered with water lilies. According to Birdlife International (2016b), water lilies serve as an important feeding ground, and is a key factor determining the abundance and distribution of this species.

While bird species in the HNWs were observed to use both PAs and UPAs, specialist species showed a higher preference for PAs, than generalist species, which occupied both areas. Perhaps this is the reason for the higher total richness in UPAs, although not statistically significant. It is suggested that Northern Red Bishop *Euplectes franciscanus* and Little Bee-eater *Merops pusillus* perform seasonal migration further south or north. This observation is in accordance with that of Fry and Boesman (2016), who have described *M. pusillus* as nomadic, while *E. franciscanus* perform regular movements depending on breeding period and food availability (Borrow and Demey 2014, Craig 2016). On the other hand, PAs had a higher bird density than UPAs, which could be attributed to the low magnitude of anthropogenic disturbances in PAs, compared to UPAs. Other factors such as the wetland type, depth or size as reported by Weller (1999), Skinner and Clark (2008) and Sulaiman et al. (2015) could have contributed to the observed results.

CONCLUSIONS

It is concluded, compared to PAs, UPAs had higher bird density, probably due to high generalist species. Both PAs and UPAs of the HNWs can serve as refuge for both

resident and migratory birds. The findings of the present study bridge the gap in knowledge of bird diversity and density in PAs and UPAs of the wetlands, which serves as a baseline data for further studies. Wise and sustainable use of wetlands is strongly recommended in order to conserve the wetland bird community and their habitat as suggested by the Ramsar Convention and the Convention on the Conservation of Migratory Species (CMS) to which Nigeria is a signatory.

ACKNOWLEDGEMENTS

We profoundly thank the Nigerian Conservation Foundation, Chad Basin National Park (Dagona Waterfowl Sanctuary) and Jigawa State Ministry of Environment for their permission to conduct the present research. The expertise and help of Mr. Harry Hanson Jr., Mr. Ibrahim Dala and Mr. Musa Likori during the field study are gratefully acknowledged. Financial support for this study was made by Inuwa Sirajo and Muhammad Kabir.

REFERENCES

Akinsola, O.A.; Ezealor A.U. and Polet, G. 2000. Conservation of waterbirds in the Hadejia-Nguru Wetlands, Nigeria: current efforts and problems. Ostrich 71: 118-121.

Barbier, E.B.; Acreman, M. and Knowler, D. 1997. Economic Valuation of Wetlands: A Guide for Policy Makers and Planners. Ramsar Convention Bureau, Gland, Switzerland. 138 pages.

Bibby, C. J. 2000. Bird Census Techniques. Elsevier, New York. 278 pages.

BirdLife International. 2013. State of Africa's Birds: Indicators for Our Changing World, Cambridge, UK, BirdLife International. http://datazone.birdlife.org/userfiles/file/sowb/pubs/SOWB2013.pdf (Last assessed 02/02/2017).

BirdLife International. 2015. Important bird areas factsheet: Hadejia-Nguru wetlands. Cambridge, United Kingdom. http://datazone.birdlife.org/site/factsheet/hadejia-nguru-wetlands-iba-nigeria/map (Last assessed 14/07/2016).

BirdLife International. 2016a. IUCN redlist for birds. http://www.birdlife.org (accessed 19/02/2016). http://www.birdlife.org (Last accessed 19/02/2017).

BirdLife International. 2016b. Important Bird and Biodiversity Area factsheet: Hadejia-Nguru wetlands. http://www.birdlife.org (Last accessed 13/06/2016).

Borrow, N. and Demey, R. 2014. Field Guide to the Birds of Western Africa. Princeton University Press, Princeton, New Jersey, USA. 592 pages.

Convention on Biological Diversity. 1992. Programme of work on protected areas. Secretariat of the Convention on Biological Diversity, Montreal. https://www.cbd.int/doc/legal/cbd-en.pdf (Last accessed 15/12/2016). 34 pages.

Chao, A.; Chazdon, R.L.; Colwell, R.K. and Shen, T.J. 2005. A new statistical approach for assessing similarity of species composition with incidence and abundance data. Ecology Letters 8: 148-159.

Craig, A. 2016. Northern red bishop *Euplectes franciscanus* In: del Hoyo J, Elliott, A.; Sargatal, J.; Christie, D. A. and de Juana, E. (eds.). Handbook of the Birds of the World Alive. Lynx Edicions, Barcelona, Spain. (retrived https://www.hbw.com/node/55835 on 7 November 2017).

Cramp, S. and Simmons, K. E. L. 1977. handbook of the Birds of Europe, the Middle East and Africa. The Birds of the Western Palearctic, Vol. I: Ostriches to Ducks. Oxford University Press, Oxford, U.K. 722 pages.

Evans, K. L.; Rodrigues, A. S.; Chown, S. L. and Gaston, K. J. 2006. Protected areas and regional avian species richness in South Africa. Biological Letters 2: 184-188.

Ezealor, A. U. and Giles Jr, R. H. 1997. Wintering ruffs *Philomachus pugnax* are not pest of Rice *Oryza* spp. in Nigeria's Sahelian wetlands. Wildfowl 48: 202-209.

Devictor, V.; Godet, L.; Julliard, R.; Couvet, D. and Jiguet, F. 2007. Can common species benefit from protected areas? Biological Conservation 139: 29-36.

Dowsett, R. J.; Atkinson, P. W. and Caddick, J. A. 2016. Checklist of the birds of Nigeria. Downloaded from www.africanbirdclub.org (Last accessed 04/02//2016). 21 pages

Franco, P.; Saavedra-Rodriguez, C. A. and Kattan, G. H. 2007. Bird species diversity captured by protected areas in the Andes of Colombia: a gap analysis. Oryx 41: 57-63.

Fry, H. and Boesman, P. 2016. Little bee-eater *Merops pusillus* In: del Hoyo, J.; Elliott, A.; Sargatal, J.; Christie D.A. and de Juana, E. (Editors). Handbook of the Birds of the World Alive. Lynx Edicions, Barcelona, Spain. (retrieved https://www.hbw.com/node/55835 on 7 November 2017).

Gunnarsson, T.G.; Gill, J.A.; Newton, J.; Potts, P.M. and Sutherland, W.J. 2005. Seasonal matching of habitat quality and fitness in a migratory bird. Proceedings of the Royal Society of London B: Biological Sciences 272: 2319-2323.

Hammer, Ø.; Harper, D.A.T. and Ryan, P. D. 2001. Paleontological statistics software: package for education and data analysis. Palaeontologia Electronica 4:1-9.

Lameed, G.A. 2011. Species diversity and abundance of wild birds in Dagona-waterfowl sanctuary Borno State, Nigeria. African Journal of Environmental Science and Technology 5: 855-866.

Madge, S. and Burn, H. 1988. Wildfowl: An Identification Guide to the Ducks, Geese and Swans of the World. Christopher & Helm Publisheers (A&C Black), London. 298 pages.

Mutagwaba, S.J. 2010. diversity and Distribution of Avifauna Resource: A Case of Lake Burigi wetland, North Western Tanzania. Masters Dissertation, Sokoine University of Agriculture, Morogoro, Tanzania. 95 pages.

Oduntan, O. O.; Akinyemi, A. F.; Adetoro, A. O. and Osunsina, I. O. O. 2010. Seasonal availability of farmland and its contribution in wildbirds-landuse conflicts in Hadejia-Nguru wetlands, Nigeria. African Journal of General Agriculture 6: 131-137.

Ogunkoya, O. O. and Dami, A. 2007. Information Sheet on Ramsar Wetlands (RIS) 2006-2008 Version: Dagona Sanctuary Lake, Hadejia- Nguru Wetlands. Annual Report Submitted to Ramsar. Gland, Switzerland. 12 pages.

Rayner, L.; Lindenmayer, D. B.; Wood, J. T.; Gibbons, P. and Manning, A. D. (2014). Are protected areas maintaining bird diversity? Ecography 37: 43-53.

Skinner, S. P. and Clark, R. G. 2008. Relationships between duck and grassland bird relative abundance and species richness in southern Saskatchewan. Avian Conservation and Ecology 3: 1-16.

Sulaiman, I.M.; Cresswell, W. and Dami, F.D. 2014. Bird diversity and abundance in relation to Typha occurrence at the Hadejia-Nguru wetlands, Nigeria. Biotropic Research International Journal 6: 1-5.

Sulaiman, I.M.; Abubakar, M. M.; Ringim, A. S.; Apeverga, P. T. and Dikwa, M. A. 2015. Effects of wetlands type and size on bird diversity and abundance at the Hadejia-Nguru wetlands, Nigeria. International Journal of Research Studies in Zoology 1: 15-21.

Sutherland, W.J. 1996. Ecological Census Technique: A Handbook. Cambridge University Press, Cambridge, U.K. 172 pages.

Somershoe, S.G.; Twedt, D.J. and Reid, B. 2006. Combining breeding bird survey and distance sampling to estimate density of migrant and breeding birds. Condor 108: 691-699.

Weller, M.W. 1999. Wetland Birds: Habitat Resources and Conservation Implications. Cambridge University Press, Cambridge, U.K. 271 pages.

Received 29 July 2017
Accepted 18 December 2017