Is the Bird Population in the Hadejia-Nguru Wetlands under Threat?

A. S. Ringim[1*] and H. Jr. Harry[2]

[1.] Department of Biological Sciences, Federal University Dutse, P. M. B. 7156, Dutse, Jigawa State, Nigeria

[2.] Nigerian Conservation Foundation/Hadejia-Nguru Wetlands Conservation Project, Nguru, Yobe State, Nigeria.

*Corresponding author: Email: abubakar.r@fud.edu.ng

Abstract

Anthropogenic disturbances have been found to be one of the key drivers of changes in bird populations as observed with dramatic consequences among the bird assemblages of Hadejia-Nguru Ramsar Wetland and elsewhere globally. We assessed the effects of farming, fishing, and grazing on bird species richness and density in Protected Areas (PAs) and Unprotected Areas (UPAs) of the Hadejia- Nguru Wetlands. Anthropogenic activities (grazing, fishing, and farming) at four different disturbance scales based on the level of anthropogenic activities: No, Low, Moderate and Intense were observed, assessed and recorded in PAs and UPAs of the Wetland. Results showed that farming, fishing and grazing had more negative influence on bird species richness, compared to bird densities and the species richness decreased significantly as intensity of these activities became more intensive ($p < 0.001$). The results also indicated that fishing had more negative influences on bird species richness than farming and grazing. This could lead to reduction of bird density in both areas if not checked. Management of both areas should ensure the long-term conservation of resident, intra-African and Palearctic migratory birds in the Hadejia-Nguru Wetlands. It is also recommended that anthropogenic activities within the wetland should be minimized in order to conserve the bird community and other wildlife.

Introduction

The Ramsar Convention defined wetlands "as areas of marsh, fen, peatland 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 metres" (Barbier *et al.*, 1997). Wetlands provide habitats for many wildlife species including amphibians, insects, fishes, and avifauna and are also rich in floral diversity. Protected Areas (henceforth PAs) are described "as geographically defined areas which are designated or regulated and managed to achieve specific conservation objectives (Convention on Biological Diversity, 2004). In recent years, increase in anthropogenic activities such as farming and grazing in and around PAs has been shown to influence bird diversity and density (Evans *et al.,* 2006; Cresswell, 2012). In the Senegal inner Niger Delta, for instance, extensive farming has resulted in about 12% decline of bird species diversity (Wymenga and Zwarts, 2010). Thiollay (2006) reported a decline of bird species diversity from PAs to Unprotected Areas (henceforth UPAs) where intense grazing is practised. Also,

Norris *et al.* (1998) observed a decline in the density of Common redshank (*Tringa tetanus)* following intense grazing in UPAs.

Long *et al.* (2007) reported that an increase in the area of farmland in North America, Europe, Asia and Africa could be associated with decreasing populations among the Anseriformes. In the European Union, extensive grazing has been shown to cause declines in bird densities compared to less grazed areas (Báldi *et al.*, 2005). Similarly, decrease in cover due to livestock grazing mostly leads to decrease in bird species diversity and density (Bock & Saab, 1993; Bideberi, 2013). In the United States, for instance, Greve *et al.* (2011) observed a decline in populations of insectivorous birds as a result of farming activities. Other studies indicated that intensive agricultural activities in UPAs may confine certain bird species within PAs (Sinclair *et al.,* 2002). On a continental scale, increasing demand for wetland resources due to increasing human populations, has led to reclamation of vast wetland areas and loss of bird habitats (Birdlife International, 2013). In the Senegal Inner Niger Delta, for example, rice cultivation dramatically increased from 163 km^2 in 1920 to 3, 400 km^2 in 1992 (Wymenga and Zwarts, 2010), and perhaps the increase currently after two decades will be staggering.

The Hadejia-Nguru Wetlands (henceforth HNWs) in North-eastern Nigeria is a Ramsar site and an Important Bird Area (IBA). It serves as an important refuge for resident and migratory birds as well as a stopover site for other migrant birds in the Sahel (Cresswell, 2012; Birdlife International, 2013). The HNWs are divided into four PAs within the three Nigerian states of Bauchi, Jigawa and Yobe. These are the Adiani Forest Reserve, Baturiya Game Reserve, Chad Basin National Park, and Nguru Lake and Marma Channel (Birdlife International, 2015). There are also several wetland areas that are not legally protected and are considered as UPAs in this study.

In Nigeria, some legal instruments that seek to preserve, manage and protect wildlife in PAs include the National Park Service Act (1999/2006), Environmental Protection Law (1988/1989), Wild Animal Law (1963), and Forestry Law (1938). However, lack of strong enforcement is threatening the biodiversity (particularly birds) of the wetland, due to increased anthropogenic activities (Akinsola *et al.,* 2000; Blench, 2013). The effectiveness of PAs in maintaining biodiversity and the bird community in particular, is well-documented (Brooks *et al.*, 2004; Rodrigues *et al.,* 2004; Franco *et al.,* 2007; Beresford *et al.*, 2010). However, despite the fact that HNWs is both a Ramsar site and IBA, information about the negative influence of anthropogenic activities at the site is inadequate. This study therefore aimed to investigate how anthropogenic activities like farming, fishing, and grazing could affect bird diversity and density in PAs and UPAs of the HNWs. We hypothesized that anthropogenic activities will affect bird diversity and density in both PAs and UPAs of the HNWs.

Materials and methods

Study area

The HNWs (12°15'-13°00' N; 10°00'-11°00' E) is an extensive area of floodplain in the Sudano-Sahelian zone of Nigeria

(Fig. 1). The wetland consists of a mosaic of habitats including swamp, ponds, lakes, and marshes covering 3,500 km^2. The wetland has two distinct seasons (i.e., wet season starting from May–September and dry season from October to April). Rainfall varies considerably, but usually between 500–600 mm, and temperature ranges between 12 °C in the cold season to about 40 °C in the hot season (Ogunkoya and Dami, 2007). The HNWs is a Ramsar site and an Important Bird Area (IBA) and is characterized by 16 globally-threatened bird species among the about 377 listed for the wetland (Birdlife International, 2017).

The wetland has undergone ecological changes, and most of the about 1.5 million human population directly or indirectly depend on its resources (e.g. wax, honey, and fuel wood) for their livelihoods. The wetland is now mainly used for farming, fishing and grazing. According to Birdlife International (2010), the fishery industry in the region supplies around 6% of Nigeria's inland fish catch with a market value of nearly US$ 300, 000 per annum. Every dry season, about 320, 000 cattle and 1, 000 sheep and goats graze in the wetland (Blench, 2013). However, even these disturbed habitats still have potential to harbour many wildlife species, especially migratory waterfowls.

Physiographically, the wetland is broadly divided into three areas:

- Scrub Savanna: Consisting of upland farmland areas and *Acacia* woodlands.
- Elevated Areas: Never inundated habitats of tree (*Acacia* spp, *Ziziphus* spp., *Balanites aegyptiaca*, *Tamarindus indica* and *Adansonia digitata*) and

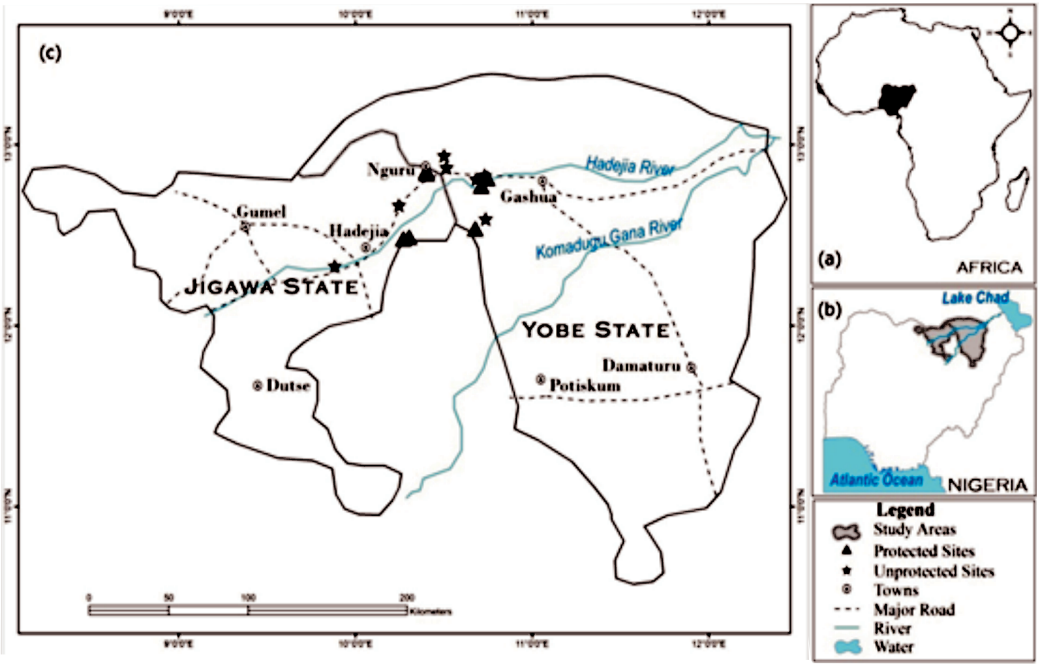

Fig. 1. Map of the HNWs showing the location of the 14 sampling sites in PAs and UPAs

grass (*Cenchrus biflorus*, *Andropogon* spp. and *Vetiveria nigritana*) species.
- Marshes: Seasonally-flooded areas with dominant trees like *Acacia nilotica* and Dum palms (*Hyphaene thebaica*) growing on small raised islands (Birdlife International, 2015).

Methods

Bird sampling

Fieldwork was conducted from October to December, 2015. Seven wetland sites each were surveyed in PAs and UPAs (Table 1). Totals of 48 and 51 point count stations were surveyed in the PAs and UPAs, respectively once per month from 6:00 to 10:00 hours GMT in the morning and from 16:00 to 18:00 hours GMT in the evening. Using the point count method (Bibby, 2000), each site was surveyed thrice during the study period and the average number of birds recorded were then taken for all the sites surveyed, i.e. sum of the total number of bird individuals recorded throughout the sampling period (3 months) divided by three for each species. We assumed this average number to be the actual number of individual bird species in the wetland, as well as to avoid being bias arising from double counting of individual bird species during the survey period. Birds seen or heard from a fixed point within a radius of 100 m were observed by three experienced ornithologists for 10 minutes in all point count stations throughout the study period. Point count stations were spaced 400 m apart to avoid double counting. Braun Binoculars (16 10 m) was used to observed birds, while birds were identified with the aid of Borrow and Demey (2014).

Anthropogenic Activities

Anthropogenic activities like grazing, fishing, and farming in PAs and UPAs

TABLE 1

Details of 14 study sites within five localities of the HNWs

S/No.	*Wetland name*	*Protection status*	*Location*	*Locality*
1	Gwayo	PA	Lat 12°32’18"N Long 10°40’37"E	Jakusko
2	Kandamau	PA	Lat 12°28’57"N Long 10°16’11"E	Kirikasamma
3	Kwasabat	PA	Lat 12°29’31"N Long 10°18’08"E	Kirikasamma
4	Maram	PA	Lat 12°46’30"N Long 10°42’38"E	Bade
5	Marma channel	PA	Lat 12°51’19"N Long 10°24’02"E	Nguru
6	Nguru Lake	PA	Lat 12°50’15"N Long 10°25’18"E	Nguru
7	Oxbow Lake	PA	Lat 12°48’59"N Long 10°44’40"E	Bade
8	Barrack	UPA	Lat 12°52’40"N Long 10°32’24"E	Nguru
9	Dumbari	UPA	Lat 12°35’33"N Long 10°43’57"E	Jakusko
10	Hadejia Barrage	UPA	Lat 12°19’52" Long 9°49’10"E	Hadejia
11	Kacallari	UPA	Lat 12°56’31"N Long 10°30’05"E	Nguru
12	Kirikasamma	UPA	Lat 12°40’04"N Long 10°14’41"E	Kirikasamma
13	Muza	UPA	Lat 12°50’00"N Long 10°43’50"E	Bade
14	Zemo	UPA	Lat 12°48’35" Long 10°40’09"E	Bade

(PA = Protected Area; UPA = Unprotected Area)

were observed, assessed and recorded at each point count station within 100 m radius during the sampling period. All the study sites were assigned to disturbance scales based on the level of anthropogenic activities as follows:

Grazing:
- No: No individual livestock recorded.
- Low-grazed: Up to 50 individuals of livestock recorded.
- Moderate: 51 to 99 individuals of livestock recorded.
- Intense: 100 and over individuals of livestock recorded.

Fishing:
- No: No fisherman recorded within point count station.
- Low-fished: Less than 20 fishermen recorded within a point count station.
- Moderate: Above 40 fishermen recorded within point count station.
- Intense: Above 70 fishermen recorded within point count station.

Farming:
- No: No farming within point count station.
- Low farming: Farming within 5 hectares within point count station.
- Moderate: Farming within 10 hectares within point count station.
- Intense: Farming within 15 hectares within point count station.

Statistical analyses

All the analyses were performed by using the Paleontological Statistical Package 2.17 (Hammer *et al.,* 2001) to compute species richness (S) or the number of bird species found in PAs and UPAs. The Special *t*- test was used to compare bird species richness between PAs and UPAs. A two-sample *t*- test was used to determine the differences in bird density between PAs and UPAs regarding the influence of anthropogenic activities (farming, fishing, and grazing). This is because these activities were simultaneously found in almost all the sites in both PAs and UPAs. Kruskal-Wallis's test was used to test the difference in bird densities between the different levels of anthropogenic activities in PAs and UPAs. Mean values are presented as Mean Standard deviation (± SD). Statuses of globally threatened species follows International Union for the Conservation of Nature Red List of Threatened Species, 2017 (Birdlife International, 2017).

Population density (PD) of bird species was determined as follows (Sutherland, 1996):

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

Results

Different disturbance levels (None, Low, Moderate and Intense) of anthropogenic activities (farming, fishing and grazing) were observed in both PAs and UPAs of the HNWs, but were more common in UPAs. However, in PAs, fishing activities were more frequent in Nguru Lake and Marma Channel compared to other sites in PAs and UPAs. Cultivated crops in both areas were mostly Rice (*Oryza sativa*), Tomato (*Solanum lycopersicum*), Onion (*Allium cepa*), Watermelon (*Citrullus lanatus*), Pearl millet (*Pennisetum glaucum*), Maize (*Zea mays*) and Cassava (*Manihot*

esculenta). The overall results showed that bird species richness decreased significantly as intensity of anthropogenic activities increased at different levels in PAs and UPAs (Table 2). Some bird species such as African mourning dove (*Streptopelia decipiens*), Crested lark (*Galerida cristata*), Northern grey-headed sparrow (*Passer griseus*), Red-billed firefinch (*Lagonosticta senegala)*, Sudan golden sparrow (*Passer luteus*), and Chestnut-bellied starling (*Lamprotornis pulcher*) were found in moderate to intense grazing areas in both PAs and UPAs.

In the PAs where there was no grazing, dominant bird species were White- faced whistling duck (*Dendrocygna viduata*), Garganey (*Spatula querquedula*), Little egret (*Egretta garzetta*) and Purple heron (*Aredea purpurea*). African Jacana (*Actophilornis africanus*) and Wood sandpiper (*Tringa glareola*) were the most common species observed in non-grazed areas in UPAs. In both PAs and UPAs, species mostly observed in farmed areas include Yellow wagtail (*Motacilla flava*), *S. decipiens*, White-billed buffalo weaver (*Bubalornis albirostris*), Piapiac (*Ptilostomus afer*) Black-headed lapwing (*Vanellus tectus*), Cattle egret (*Bubulcus ibis*) and Red-billed Quelea (*Quelea quelea*). Some species that were observed less often in farmed areas in both areas are Glossy ibis (*Plegadis falcinellus*) and Spur-winged goose (*Plectropterus gambensis*). It was observed that Allen's gallinule (*Porphyrio alleni*), Purple heron (*Ardea purpurea*, *A. africanus)*, and Squacco heron (*Ardea rolloides*), Black crake (*Zapornia flavirostra*), *E. garzetta*, Lesser jacana (*Microparra capensis*) and Lesser moorhen (*Gallinula angulata*) were more abundant in rice fields especially in UPAs. In UPAs where no fishing was observed, species such as *D. viduata*, Knob-billed duck (*Sarkidiornis melanotos*), *A africanus*, *S. spatula*, and *T. glareola* were more abundant, but

TABLE 2

Bird species richness across different levels of anthropogenic activities in PAs and UPAs of the HNWs

Activities	*No*	*Low*	*Moderate*	*Intense*	^{2}	*df*	*P*
Overall (HNWs)							
Grazing	110	99	92	64	12.65	3	<0.001
Farming	125	113	88	81	12.64	3	<0.001
Fishing	114	102	94	65	13.91	3	<0.001
			Protected areas				
Grazing	89	65	48	–	12.60	2	<0.001
Farming	110	58	65	–	20.50	2	<0.001
Fishing	85	82	65	63	5.12	3	0.0236
			Unprotected areas				
Grazing	94	75	74	66	5.47	3	<0.001
Farming	74	110	66	75	14.16	3	<0.001
Fishing	103	77	77	56	14.19	3	<0.001

abundance of Spotted redshank (*Tringa erythropus*), *A. africanus* and *T. glareola* tended to decrease with increase in fishing intensity in both PAs and UPAs. Some bird species found mainly along riverbanks in both PAs and UPAs included Spur-winged goose (*Vanellus spinosus*), Black-winged stilt (*Himantopus himantopus*), and Black heron (*Egretta ardesiaca*).

Overall bird density in relation to the influence of anthropogenic activities in HNWs was 2.8 ± 1.4/ha (± SD) and high bird density was recorded in No, Moderate and Intense grazed areas (Fig. 2). Furthermore, high bird density was recorded in the PAs (7.2 ± 3.2 individuals/ha) than UPAs (5.3 ± 2.2 individuals/ha) but the difference was not significant ($t = 0.3813$, $p = 0.7032$). Also, the difference in bird density between the different levels of anthropogenic activities in PAs and UPAs was not significant (KW^2, $p = 0.8245$).

High bird density was recorded in PAs in Low-fished areas compared to No, Moderate and Intense ones (Fig. 3). In the PAs, high bird densities were also recorded in Low fished areas, moderate in Moderate, and low in Intense fished areas which showed the strong influence of fishing activities on bird density. However, this high bird density in the low fished area, compared to No, Moderate and Intense was due to the influence of high density of few bird species *D. viduata* and *S. querquedula*, in particular. In both PAs and UPAs, the densities of African pygmy goose (*Nettapus auritus*), *S. melanotos*, *A. africanus*, *D. viduata*, Long-tailed cormorant (*M. africanus*), Black heron and *E. ardesiaca*) were recorded in No grazing and Low in Moderate and Intense grazed areas. The densities of Chestnut-bellied starling (*Lamprotornis pulcher*), Long-tailed glossy starling (*L. caudatus*), *V. tectus*, Speckled pigeon (*Columba guinea*), and *S. decipiens* were however found in Moderate and Intense grazed areas, showing a positive influence of grazing on them compared to other species.

Intense grazed areas might have positively influenced bird densities in UPAs compared to No, Moderate and Low grazing (Fig. 4), although generalist species were the majority recorded in this category, including species such as egret (*B. ibis*) (8.83 ± 3.2 individuals/ha) and *Quelea quelea* (12.4 ± 5.2 individual/ha). No, moderate, and intense farmed areas showed to positively influence bird density compared to low areas. Some dominant species recorded in No, Moderate and Intense farmed areas were mostly waterbirds, Allen's Gallinule (*Porphyrio alleni*, *A. purperea*, *A. africanus*) and *A. rolloides*, Black crake (*Zapornia flavirostra*), Lesser jacana (*Microparra capensis*), Lesser moorhen (*Gallinula angulata*), and *B. ibis*, Grey heron (*A. cinerea*), and *E. garzetta*. Raptor species (e.g. Pallid harrier- *Circus macrourus*, African Swallow-tailed kite- *Chelictinia riocourii*, and Black kite- *Milvus migrans*) were commonly recorded in moderately-farmed areas probably due to abundances of prey species. With respect to fishing, high bird density was recorded in No fished areas compared to Low, Moderate and Intense. This indicated that fishing activities had influence on bird density.

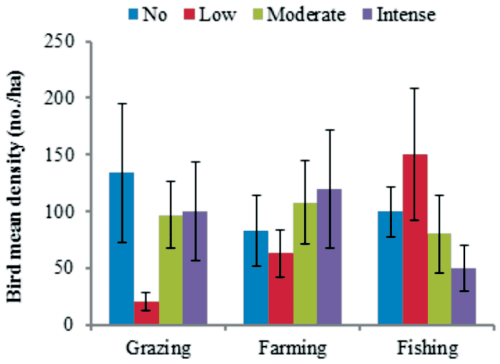

Fig. 2. Mean density (number of birds/ha) at different levels of Anthropogenic activities in HNWs

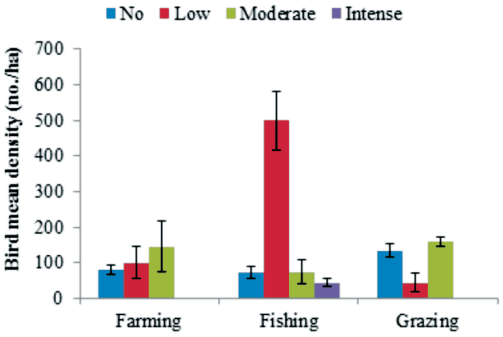

Fig. 3. Mean density (number of birds/ha) at different levels of Anthropogenic activities in PAs of the HNWs

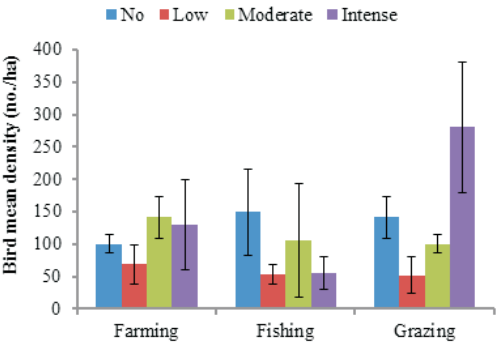

Fig. 4. Mean density (number of birds/ha) at different levels of Anthropogenic activities in UPAs of the HNWs

a

b

Plate: (a) Squacco heron *Ardeola ralloides* caught in fishing net in Kwasabat (PAs), (b) Damming of wetland area for fishing in Barrack wetland area (UPAs)

A summary of the density of individual number of bird species recorded in PAs and UPAs o the HNWs is presented below.

TABLE 3

Common name, number of individual and density of bird species recorded in PAs and UPAs of the HNWs arranged systematically from Non-passerines to passerines

Family	*Common name*	*Protected area*		*Unprotected area*	
		No. of individuals	*Density/ ha*	*No. of individuals*	*Density/ ha*
Anatidae	African Pygmy Goose *Nettapus auritus*	22.0	0.03	12.0	0.19
	Fulvous Whistling Duck*Dendrocygna bicolor*	93.0	1.61	56.0	0.97
	Garganey*Spatula querquedula*	5210.0	90.45	6103.0	99.72
	Knob-billed Duck*Sarkidiornis melanotos*	198.0	3.43	106.0	1.73
	Spur-winged Goose*Plectropterus gambensis*	166.0	2.88	31.0	0.5
	White-faced Whistling Duck*Dendrocygna viduata*	13794.0	239.47	7344.0	120
Apodidae	African Palm Swift*Cypsiurus parvus*	78.0	1.35	11.0	0.17
	Common Swift*Apus apus*	2.0	0.03	–	–
	Little Swift*Apus affinis*	1.0	0.01	19.0	0.31
Bucerotidae	African Grey Hornbill*Lophoceros nasutus*	10	0.17	11.0	0.17
	Northern Red-billed Hornbill*Tockus erythrorhynchus*	23	0.39	19.0	0.31
Accipitridae	African Harrier Hawk*Polyboroides typus*	1.0	0.01	1.0	0.01
	African Swallow-tailed Kite*Chelictinia riocourii**	0	0	2.0	0.03
	Black Shouldered Kite*Elanus axillaris*	–	–	6.0	0.09
	Black kite*Milvus migrans*	7.0	0.12	7.0	0.11
	Dark Chanting Goshawk*Melierax metabates*	–	–2.0	0.03	
	Gabar Goshawk*Micronisus gabar*	2.0	0.03	4.0	0.06
	Grasshopper Buzzard*Butastur rufipennis*	–	2.0	0.03	
	Lizard Buzzard*Kaupifalco monogrammicus*	–	–	5.0	0.08
	Montagu's Harrier*Circus pygargus*	2.0	0.03	–	–
	Pallid Harrier*Circus macrourus* NT	3.0	0.05	5.0	0.08
	Shikra*Accipiter badius*	2.0	0.03	–	–
	Western Marsh Harrier*Circus aeruginosus*	8.0	0.13	13.0	0.21
	Yellow-billed Kite*Milvus migrans parasitus*	1.0	0.01	1.0	0.01
Ciconiidae	Abdim's Stork*Ciconia abdimii*	40.0	0.69	3.0	0.04
	African Openbill Stork*Anastomus lamelligerus*	6.0	0.1	10.0	0.16
	White Stork*Ciconia ciconia*	–	–	11.0	0.17
Cuculidae	Great Spotted Cuckoo*Clamator glandarius*	–	–	4.0	0.06
	Senegal Coucal*Centropus senegalensis*	5	0.08	28.0	0.45
Coliidae	Blue-naped Mousebird*Urocolius macrourus*	–	–	10.0	0.16
Alcedinidae	African Pygmy Kingfisher*Ispidina picta*	5.0	0.08	2.0	0.03
	Grey-headed Kingfisher*Halcyon leucocephala*	4.0	0.06	–	–
	Malachite Kingfisher*Corythornis cristatus*	9.0	0.15	3.0	0.04
	Pied Kingfisher*Ceryle rudis*	9.0	0.15	5.0	0.08
Columbidae	African Mourning Dove*Streptopelia decipiens*	359.0	6.23	163.0	2.66
	Black-billed Wood Dove*Turtur abyssinicus*	5.0	0.08	1.0	0.01
	Blue-spotted Wood Dove*Turtur afer*	–	–	1.0	0.01

	European Turtle Dove*Streptopelia turtur** VU	28.0	0.48	–	–
	Laughing Dove*Streptopelia senegalensis*	18.0	0.31	28.0	0.45
	Namaqua Dove*Oena capensis*	2.0	0.03	5.0	0.08
	Speckled Pigeon*Columba guinea*	7.0	0.12	19.0	0.31
	Tambourine Dove*Turtur tympanistria**	2.0	0.03	–	–
	Vinaceous Dove*Streptopelia vinacea*	5.0	0.08	6.0	0.09
Coraciidae	Abyssinian Roller*Coracias abyssinicus*	14.0	0.24	20.0	0.03
Charadriidae	Black-headed Lapwing*Vanellus tectus*	3.0	0.05	19.0	0.31
	Spur-winged Lapwing*Vanellus spinosus*	32.0	0.55	62.0	1.01
Jacanidae	African Jacana*Actophilornis africanus*	205.0	3.55	256.0	4.18
	Lesser Jacana*Microparra capensis*	13.0	0.22	9.0	0.14
Laridae	Gull-billed Tern*Gelochelidon nilotica**	20.0	0.34	2.0	0.03
	Grey-headed Gull*Larus cirrocephalus**	4.0	0.06	–	–
	Whiskered Tern*Chlidonias hybrida*	7.0	0.12	3.0	0.04
Scolopacidae	Common Sandpiper*Actitis hypoleucos*	4.0	0.06	2.0	0.03
	Common Snipe*Gallinago gallinago*	–	–	5.0	0.08
	Green Sandpiper*Tringa ochropus*	29.0	0.5	79.0	1.29
	Little Stint*Calidris minuta*	–	–	38.0	0.62
	Ruff*Calidris pugnax*	6.0	0.1	71.0	1.16
	Spotted Redshank*Tringa erythropus*	6.0	0.1	63.0	1.02
	Wood Sandpiper*Tringa glareola*	379.0	6.57	653.0	10.66
Recurviro-stridae	Black-winged Stilt*Himantopus himantopus*	58.0	1.0	33.0	0.53
Falconidae	Grey Kestrel*Falco ardosiaceus*	–	–	2.0	0.03
	Lanner Falcon*Falco biarmicus*	4.0	0.06	3.0	0.04
	Red-necked Falcon*Falco ruficollis*	1.0	0.01	4.0	0.06
Numididae	Helmeted Guineafowl*Numida meleagris**	–	–	12.0	0.19
Odontopho-ridae	Stone Patridge*Ptilopachus petrosus*	–	–	6.0	0.09
Rallidae	Allen's Gallinule*Porphyrio alleni*	33.0	0.57	5.0	0.08
	Black Crake*Zapornia flavirostra*	43.0	0.74	11.0	0.17
	Common Moorhen*Gallinula chloropus*	26.0	0.45	18.0	0.29
	Lesser Moorhen*Gallinula angulata*	10.0	0.17	8.0	0.13
	Purple Swamphen*Porphyrio porphyrio*	33.0	0.57	12.0	0.19
Musopha-gidae	Western Grey Plantain-eater*Crinifer piscator*	3.0	0.05	6.0	0.09
Lybiidae	Bearded Barbet*Pogonornis dubius*	2.0	0.03	–	–
	Vieillot's Barbet*Lybius vieilloti*	1.0	0.01	2.0	0.03
	Yellow-fronted Tinkerbird*Pogoniulus chrysoconus*	1.0	0.01	–	–
Ardeidae	Black Heron*Egretta ardesiaca*	80.0	1.38	15.0	0.24
	Black-headed Heron*Ardea melanocephala*	11.0	0.19	3.0	0.04
	Cattle Egret*Bubulcus ibis*	19.0	0.32	39.0	0.63
	Great Egret*Ardea alba*	5.0	0.08	16.0	0.26
	Green-backed Heron*Butorides striata*	10.0	0.17	3.0	0.04
	Grey Heron*Ardea cinerea*	10.0	0.17	18.0	0.29
	Intermediate Egret*Ardea intermedia*	12.0	0.2	13.0	0.21
	Little Bittern*Ixobrychus minutus*	3.0	0.05	1.0	0.01
	Little Egret*Egretta garzetta*	16.0	0.27	21.0	0.34

	Purple Heron*Ardea purpurea*	42.0	0.72	23.0	0.37
	Squacco Heron*Ardeola rolloides*	149.0	2.58	63.0	1.02
Threskiornithidae	Glossy Ibis*Plegadis falcinellus*	31.0	0.53	39.0	0.63
Psittacidae	Red-headed Lovebird*Agapornis pullarius**	3.0	0.05	–	–
	Rose-ringed Parakeet*Psittacula krameri*	6.0	0.1	7.0	0.11
	Senegal Parrot*Poicephalus senegalus*	6.0	0.1	3.0	0.04
Pteroclidae	Four-banded Sandgrouse*Pterocles quadricinctus*	4.0	0.06	63.0	1.02
Caprimulgidae	Standard-winged Nightjar*Caprimulgus longipennis**	2.0	0.03	–	–
Upupidae	Hoopoe*Upupa epops*	1.0	0.01	1.0	0.01
Phaeniculidae	Green Wood-hoopoe*Phoeniculus purpureus*	1.0	0.01	7.0	0.11
Alaudidae	Crested Lark*Galerida cristata*	3.0	0.05	13.0	0.21
Cisticolidae	Grey-backed Camaroptera*Camaroptera brachyura*	–	–	1.0	0.01
	Tawny-flanked Prinia*Prinia subflava*	5.0	0.65	5.0	0.07
	Zitting Cisticola*Cisticola juncidis*	–	–	4.0	0.06
	Winding Cisticola*Cisticola galactotes*	1.0	0.01	5.0	0.08
Corvidae	Piapiac*Ptilostomus afer*	–	–	23.0	0.37
	Pied Crow*Corvus albus*	1.0	0.01	15.0	0.24
Estrildidae	Cut-throat Finch*Amadina fasciata*	7.0	0.12	3.0	0.04
	Green-winged Pytilia*Pytilia melba**	1.0	0.01	2.0	0.03
	Red-billed Firefinch*Lagonosticta senegala*	33.0	0.57	17.0	0.27
	Red-cheeked Cordon-blue*Uraeginthus bengalus*	52.0	0.09	92.0	1.5
Fringillidae	Yellow-fronted Canary*Serinus mozambicus*	–	–	2.0	0.03
Hirundinidae	Common Sand Martin*Riparia riparia*	15.0	0.26	30.0	0.49
	Ethiopian Swallow*Hirundo aethiopica*	35.0	0.6	2.0	0.03
	Plain Martin*Riparia paludicola*	13.0	0.22	24.0	0.39
	West African Swallow*Cecropis domicella*	–	–	2.0	0.03
Laniidae	Southern-Grey Shrike*Lanius meridionalis*	–	–	2.0	0.03
	Woodchat Shrike*Lanius senator**	–	–	5.0	0.08
	Yellow-billed Shrike*Corvinella corvina*	–	–	1.0	0.01
Malaconotidae	Black-crowned Tchagra*Tchagra senegalus*	1.0	0.01	1.0	0.01
	Yellow-crowned Gonolek*Laniarius barbarus*	15.0	0.26	3.0	0.04
Meropidae	Little Bee-eater*Merops pusillus*	33.0	0.57	4.0	0.06
	Little Green Bee-eater*Merops orientalis*	–	–	5.0	0.08
Motacillidae	Yellow Wagtail*Motacilla flava*	289.0	5.01	333.0	5.44
Muscicapidae	Black Scrub Robin*Cercotrichas podobe*	1.0	0.01	2.0	0.03
	Northern Wheatear*Oenanthe oenanthe**	2.0	0.03	7.0	0.11
Nectariniidae	Beautiful Sunbird*Nectarinia pulchella*	43.0	0.74	9.0	0.14
Pandionidae	Osprey*Pandion haliaetus*	1.0	0.01	–	–
Passeridae	Northern Grey-headed Sparrow*Passer griseus*	123.0	2.13	48.0	0.78
	Sudan Golden Sparrow*Passer luteus*	42.0	0.72	21.0	0.34
	Speckle-fronted Weaver*Sporopipes frontalis*	23.0	0.39	34.0	0.55
Phalacrocoracidae	Long-tailed Cormorant*Microcarbo africanus*	323.0	4.02	150.0	2.45
Phasianidae	Double-spurred Francolin*Pternistis bicalcaratus*	2.0	0.03	–	–

Ploceidae	Black-headed Weaver*Ploceus melanocephalus*	8.0	0.13	1.0	0.01
	Little Weaver*Ploceus luteolus*	106.0	1.84	7.0	0.11
	Northern Red Bishop*Euplectes franciscanus*	26.0	0.45	14.0	0.22
	Red-billed Quelea*Quelea quelea*	595.0	10.32	759.0	12.4
	Village Weaver*Ploceus cucullatus*	94.0	1.63	48.0	0.78
	Vitellin Masked Weaver*Ploceus intermedius*	7.0	0.12	–	–
	White-billed Buffalo Weaver*Bubalornis albirostris*	141.0	2.44	227.0	3.7
	Yellow-crowned Bishop*Euplectes afer*	–	–	2.0	0.03
Pycnono-tidae	Common Bulbul*Pycnonotus barbatus*	3.0	0.05	3.0	0.04
Sturnidae	Chestnut-bellied Starling*Lamprotornis pulcher*	20.0	0.34	40.0	0.65
	Great Blue-eared Starling*Lamprotornis chalybaeus*	36.0	0.62	14.0	0.22
	Long-tailed Glossy Starling*Lamprotornis caudatus*	16.0	0.27	26.0	0.42
	Yellow-billed Oxpecker*Buphagus africanus*	–	–	1.0	0.01
Sylviidae	African Reed Warbler*Acrocephalus baeticus* *	6.0	0.1	6.0	0.09
	Common Whitethroat*Sylvia communis* *	–	–	4.0	0.06
	European Reed Warbler*Acrocephalus scirpaceus* *	6.0	0.1	8.0	0.13
	Greater Swamp Warbler*Acrocephalus rufescens*	16.0	0.27	9.0	0.14
	Lesser Swamp Warbler*Acrocephalus gracilirostris*	7.0	0.12	2.0	0.03
	Northern Crombec*Sylvietta brachyura*	3.0	0.05	–	–
	Sedge Warbler*Acrocephalus schoenobaenus*	48.0	0.83	14.0	0.22
Timalidae	Brown Babbler*Turdoides plebejus*	5.0	0.08	4.0	0.06
Viduidae	Sahel Paradise Whydah *Vidua orientalis*	–	–	2.0	0.03
	Village Indigobird*Vidua chalybeata*	5.0	0.08	2.0	0.03

Key: VU (Vulnerable), NT (Near Threatened), new records added to the existing literature (*).

Discussion

Overall influence of anthropogenic activities on bird diversity and density in HNWs

It is evident that anthropogenic activities affect bird species richness and density of birds in both PAs and UPAs. The intensity of these activities and their influence on bird species richness and density differed across levels (i.e., from No to Low to Moderate to Intense). In general, fishing had more pronounced negative influence on the bird species richness than grazing and farming. This could largely be attributed to constant disturbance and habitat homogeneity as a result of extensive *Typha domingensis* vegetation especially in Nguru Lake and Marma Channel, where the numbers of many bird species, particularly waterbirds, were decreasing. Tews *et al.* (2004) reported that more structurally complex habitats provide more resources and niches, compared to homogenous habitat, thus increase species diversity (richness), as suggested by 'habitat heterogeneity hypothesis'. Other studies reported similar findings (Hockin *et al.* 1992; Rajpar & Zakaria, 2011).

Influence of grazing on bird diversity/density in PAs and UPAs

Grazing affected bird species richness and density in both PAs and UPAs. Most

bird generalists that preferred the bare wetland areas were affected by intense grazing in both areas. This may be because intense grazing led to the loss of floral diversity and decreased food availability, consequently decreasing bird diversity and density. Specialist bird species may however also be confined to certain sites (e.g. No and Low grazed areas). Bock and Saab (1993) also found that bird species that depended on herbaceous ground cover for foraging and nesting were negatively influenced by livestock grazing due to degradation of riparian vegetation and decrease vegetation cover. In Moderately to Intensely grazed areas in both areas, a higher bird density was recorded probably due to low vegetation which harbour many insects serving as food for many birds. This observation is in line with other studies (Evans *et al.,* 2006; Bideberi, 2013). However, in No and Low grazed areas, the recorded low bird density was largely attributed to low densities of specialist species in Oxbow Lake and Maram wetland (PAs). These wetland sites are characterized by dense vegetation of Hippo grass (*Vossia cuspidata)* which might not be suitable for foraging purposes for many waterbirds that preferred open space. According to Birdlife International (2017), specialist species like waterbirds are habitat-specific and prefer wetlands with emergent or floating vegetation such as Water Lily (*Nymphae lotus*), bulrush and *Typha* spp.

Influence of farming on bird diversity and density in PAs and UPAs

Farming activities affected bird species richness negatively in both PAs and UPAs. The low abundances of some waterbird species in Moderately to Intensely farmed areas could be due to intensive farming activities. This study found that agricultural activities negatively affected waterbird populations, which was consistent with results obtained by Duncan *et al.* (1999) and Long *et al.* (2007). Area-dependent species may be more affected by farming activities due to their reliance on specialized habitats for nesting and foraging. This observation supports Paracuellos (2006) who found that as wetland size diminished in size, specialist species may have more limited space for foraging and nesting owing to their habitat selection. Additionally, increasing farming activities and its attendant loss of wetland habitats in the HNWs may increase threats to the threatened species (Pallid harrier and European turtle dove) recorded in this study as well as other bird species. Studies by Browne and Aebischer (2005) and Cherry (1997) are consistent with this study. High bird density was however recorded in Moderately to Intensely farmed areas in both PAs and UPAs, compared to No and Low farmed areas, and this may be the result of the presence of crop residues, rice fields and weeds which serve as important food for many birds. Similar findings have been reported in other studies (e.g. Manley *et al*., 2004; O' Connor *et al.,* 1990). In future, however, encroachment on the wetland in the HNWs may restrict many birds in PAs, as noted elsewhere (Sinclair *et al.,* 2002; Wymenga & Zwarts, 2010; Greve *et al.*, 2011).

Influence of fishing on bird diversity/ density in PAs and UPAs

This study demonstrated that bird species, particularly waterbirds, were strongly influenced by fishing activities in both areas. In Nguru Lake and Marma Channel (PAs), for instance, the abundances of many waterbird species (e.g. ducks and geese), were severely reduced compared to other sites in both PAs and UPAs. This could be attributed to intense fishing activities which prevented the congregation of waterbirds. However, there was a high abundance of certain species like Purple swamphen, Quelea bird and Village weaver, probably because of the emergent vegetation of *T. domingensis*, which is known to provide a good nesting place for these species (Birdlife International, 2017). High bird density was recorded in Low fished areas in PAs and in non-fished areas in UPAs. This was probably due to the influence of some species such as White-faced whistling duck and Garganey in some wetland sites (Kandamau and Kwasabat, PAs) which influenced the densities recorded in No, Moderate and Intense areas.

Low bird density was recorded in the Intensely fished areas in both PAs and UPAs probably because of disturbances from fishing activities. This finding is consistent with the findings of Hockin *et al.* (1992) and Gill (2007) that high levels of human activities like fishing caused bird population decline as a result of site abandonment by birds. In addition, damming, diversion of water and use of nets for fishing, could have severely affected waterbirds and fish-eating birds through entanglement of birds in fishing nets. Kingsford and Johnson (1998) also found that water diversion upstream had significant impact on the breeding of colonial waterbirds in New South Whales. Generally, the results of the present study indicate that fishing severely affects bird diversity and density in both areas.

Conclusions and recommendations

This study has demonstrated that anthropogenic activities (i.e., farming, fishing and grazing) at different disturbance levels were carried out in both PAs and UPAs of the HNWs. Bird species richness responded negatively to the influence of these activities, and consistently decrease in number in both areas as these activities became more intensive (i.e. No to Low to Moderate to Intense). These activities would lead to loss reduction of bird density in both areas if not checked. Proper management of both PAs and UPAs would ensure long-term conservation of both Resident, Intra-African and Palearctic migratory birds and other wildlife. Wetland management authorities should also be encouraged to promote sustainable use of the resources in the wetland.

Acknowledgement

Special thanks go to the Chad Basin National Park (Dagona Waterfowl Sanctuary) and Jigawa State Ministry of Environment for their help and cooperation during the research period. We appreciate the field assistance of Baba Hamisu, Ibrahim Dala, Musa Likori, and Muhammad Bala. Financial support for the study was provided 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 evaluation of wetlands*: a guide for policy makers and planners. Gland: Ramsar Convention Bureau. pp 1.

Beresford A. E., Buchanan G. M., Donald P. F., Butchart S. H. M., Fishpool L. D. C. and **Rondinini C.** (2011). Poor overlap between the distribution of protected areas and globally threatened birds in Africa. *Anim. Conserv*. **14**: 99–107.

Bock C. E., Saab V. A., Rich T. D. and **Dobkin D. S.** (1993). Effects of livestock grazing on Neotropical migratory landbirds in western North America. General Technical Report, Department of Agriculture. United States. p. 296–209. Downloaded from *https://www.fs.fed.us/rm/pubs_rm/rm_gtr229/rm_gtr229_296_309.pdf o*n January 2017.

Báldi A., Batáry P. and **Erdõs S.** (2005). Effects of grazing intensity on bird assemblages and populations of Hungarian grasslands. *Agr. Ecosyst. Environ*. **108**: 251–263.

Bibby C. J. (2000). Bird census techniques. Elsevier, Netherlands. p 93–101.

Bideberi G. (2013). Diversity, distribution and abundance of avifauna in respect to habitat types: a case study of Kilakala and Bigwa, Morogoro, Tanzania. Masters Dissertation, Sokoine University of Agriculture, Tanzania.

BirdLife International (2010). In Nigeria, the BirdLife partner is assisting wetland restoration to safeguard ecosystem services. Cambridge, United Kingdom. Downloaded from *datazone.birdlife.org/sowb/casestudy/in-nigeria-the-birdlife-partner-is-assisting-wetland-restoration-to-safeguard-ecosystem-services* on 7 March 2016.

BirdLife International (2013). State of Africa's birds: Indicators for our changing world, Cambridge, UK, BirdLife International. Downloaded from *http://datazone.birdlife.org/userfiles/file/sowb/pubs/SOWB2013.pdf* on 2 June 2016.

BirdLife International (2015). Important Bird Areas factsheet: Hadejia-Nguru wetlands. Cambridge, United Kingdom. Downloaded from *http://datazone.birdlife.org/site/factsheet/hadejia-nguru-wetlands-iba-nigeria/map* on 14 July 2016.

BirdLife International (2017). The IUCN Red List of Threatened Species. Version 2017–1. Downloaded from *http://www.birdlife.org* on 25 August 2017 .

Blench R. (2013). An overview of the context of the Jewel project: Access rights and conflict over Common pool resources in the Hadejia-Nguru Wetlands, report of ITAD, Cambridge CB1 2AL, United Kingdom. Downloaded from *http://www.rogerblench.info/Pastoralism/PastAf/Nigeria/Hadejia-Nguru%20wetlands%202003.pdf* on 8 October 2016.

Borrow N. and **Demey R.** (2014). Field Guide to the Birds of Western Africa. Princeton University Press, USA. Pp 50-544.

Brooks T. M., Bakarr M. I., Boucher Da Fonseca T. G. A., Hilton-Taylor C., Hoekstra J. M. and **Rodrigues A. S.** (2004). Coverage provided by the global protected-area system: Is it enough?*BioScience* **54**: 1081–1091.

Browne S. J. and **Aebischer N. J.** (2005). Studies of West Palearctic birds: turtle dove. *Br. Birds* **98**: 58–72.

Convention on Biological Diversity (2004). *Programme of work on protected areas*. Secretariat of the Convention on Biological Diversity, Montreal.

Cherry M. (1997). The atlas of southern African birds (Vol. 1). Johannesburg, BirdLife South Africa.

Cresswell W. (2012). Living on the Edge: Wetlands and Birds in a Changing Sahel. *Condor* **114**: 430–432.

Duncan P., Hewison A. J. M., Houte S., Rosoux, R., Tournebize T., Dubs F. and **Bretagnolle V.** (1999). Longterm changes in agricultural practices and wildfowling in an internationally important wetland, and their effects on the guild of wintering ducks. *J. App. Ecol.* **36**: 11–23.

Evans D. M., Redpath S. M. Evans S. A., Elston D. A., Gardner C. J., Dennis P. and **Pakeman R. J.** (2006). Low intensity, mixed livestock

grazing improves the breeding abundance of a common insectivorous passerine. *Bio. Lett.* **2**: 636–638.

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.

Gill J. A. (2007). Approaches to measuring the effects of human disturbance on birds. *Ibis* **149**: 9–14.

Greve M., Chown S. L., Van Rensburg B. J., Dallimer M. and **Gaston K. J.** (2011). The ecological effectiveness of protected areas: a case study for South African birds. *Anim. Conserv*. **14**: 295–305.

Hammer Ø., Harper D. A. T. and **Ryan P. D.** (2001). PAST: Paleontological statistics software package for education and data analysis. Palaeontol. Electron. **1**: 9.

Hockin D., Ounsted M., Gorman M., Hill D., Keller V. and **Barker M. A.** (1992). Examination of the effects of disturbance on birds with reference to its importance in ecological assessments. *J. Environ. Manag.* **36**: 253–286.

Kingsford R. T. and **Johnson W.** (1998). Impact of water diversions on colonially-nesting waterbirds in the Macquarie Marshes of arid Australia. *Colonial Waterbirds* **21**: 159–170.

Long P. R., Székely T., Kershaw M. and **O'Connell M.** (2007). Ecological factors and human threats both drive wildfowl population declines. *Anim. Conserv*. **10**: 183–191.

Manley S. W., Kaminski R. M., Reinecke K. J. and **Gerard P. D.** (2004). Waterbird foods in winter-managed rice fields in Mississippi. *J. Wildlife. Manag.* **68**: 74–83.

Norris K., Brindley E., Cook T., Babbs S., Brown C. F., and **Yaxley R.** (1998). Is the density of redshank Tringa totanus nesting on salt marshes in Great Britain declining due to changes in grazing management?. *J. App. Ecol.* **35**: 621–634.

O'Connor R. J., Shrubb M. and **Watson D.** (1990). Farming and birds. CUP Archive.

Ogunkoya O. O. and **A. Dami A.** (2007). Information Sheet on Ramsar Wetlands (RIS) – 2006-2008 version: Dagona Sanctuary Lake, Hadejia- Nguru wetlands. Gland: Ramsar Convention Bureau.

Paracuellos M. (2006). How can habitat selection affect the use of a wetland complex by waterbirds?. *Biodiver. Conserv*. **15**: 4569–4582.

Rajpar M. N. and **Zakaria M.** (2011). Bird species abundance and their correlationship with microclimate and habitat variables at Natural Wetland Reserve, Peninsular Malaysia. *Int. J. Zool.* doi:10.1155/2011/758573

Rodrigues A. S., Andelman S. J., Bakarr M. I., Boitani L., Brooks T. M., Cowling R. M. and **Long J. S.** (2004). Effectiveness of the global protected area network in representing species diversity. *Nature*, **428**: 640–643.

Tews J., Brose U., Grimm V., Tielbörger K., Wichmann M. C., Schwager M. and **Jeltsch F.** (2004). Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. *J. Biogeography*, **31**: 79–92.

Thiollay J. M. (2006). Large bird declines with increasing human pressure in savanna woodlands (Burkina Faso). *Biodiver. Conserv*. **15**: 2085-2108.

Sinclair A. R., Mduma S. A. and **Arcese P.** (2002). Protected areas as biodiversity benchmarks for human impact: agriculture and the Serengeti avifauna. Proc. Roy. Soc. Lon. *B: Biol. Sci.* **269**: 2401-2405.

Sutherland W. J. (1996). Ecological census technique: A handbook. Cambridge University Press, United Kingdom. p. 128.

Wymenga, E. and **Zwarts, L.** (2010). Use of rice fields by birds in West Africa. *Waterbirds* **33**: 97–104.