



A SURVEY OF AVIFAUNA AND VEGETATION COMMUNITIES IN HADEJIA-NGURU WETLANDS, NIGERIA

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ABSTRACT

*An understanding of the ecological relationship between birds and vegetation is important for management and conservation of any wetland ecosystem. Despite the significant importance of the Hadejia-Nguru Ramsar site and an Important Bird Area, little is known about the ecological relationship between bird and vegetation communities. Bird diversity and density were examined and compared between Protected Areas (PAs) and Unprotected Areas (UPAs) with attention to vegetation diversity and density. Data were collected from October to December, 2015. A total of 14 wetland sites were surveyed (seven in PAs and seven in UPAs), and point count method was employed. In total, 42, 255 bird individuals, 148 species, 23 orders, and 50 families were identified. Two globally threatened species namely, European Turtle Dove (*Streptopelia turtur*) and Pallid harrier (*Circus macrourus*) were also recorded. Results showed that neither vegetation diversity nor density correlated with bird diversity nor density in both PAs and UPAs ($p > 0.05$), suggesting that there could be other factors that influence the bird diversity and density in both areas. PAs and UPAs of the Hadejia-Nguru Wetlands are rich in avifaunal species, thus management of these areas will preserve large species diversity. Increase public awareness in the wetland on the importance of conserving birds and vegetation, as they play a vital role in the ecosystem is strongly recommended. The results presented here provide an overview of the relationship between bird and vegetation communities of the Hadejia-Nguru Wetlands, an important input for better understanding of its conservation.*

Key words: Bird diversity, Density, Hadejia- Nguru Wetlands, Protected and unprotected areas, Vegetation

INTRODUCTION

The Ramsar convention defined wetlands as "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters" (Barbier *et al.*, 1997). Wetlands are distributed all over the world except Antarctica and represent about 4-6% of the earth's surface (7-9 million km²), and ranked among the earth's most productive ecosystems (Mironga, 2006). Ecological values of wetlands to humans consists of flood control, nutrient absorption and cycling which improve water quality, as well as protection of coastal communities from erosion and wave energy (Barbier *et al.*, 1997). Economic values of wetlands include agriculture, provision of timber, fuel wood, and non-timber products, such as cotton, silk and potash (Barbier *et al.*, 1997). On the other hand, it has been shown that vegetation community is an essential component influencing bird species (Bideberi, 2013). This is due to the vegetation that serves as a great determinant for bird species diversity and density by providing foraging and nesting ground (Riffel *et al.*, 2001) and cover from predation (Hurlbert, 2004).

Due to this, studies on the relationship between birds and vegetation have been conducted in various parts of

the world including Australia (Neave *et al.*, 2006), South America (Beese and Bryant, 1999), Asia (Hawkins *et al.*, 2007) and Africa (Sulaiman *et al.*, 2014). Some of them (e.g. Neave *et al.*, 2006, Beese and Bryant, 1999) explained the relationship between plant species composition and bird diversity. A study by Kumar and Gupta (2009) found many birds to exploit a variety of wetland habitats likely due to high foraging ground and/or shelter for nesting and roosting. It has also been shown that different bird species select a variety of wetland habitats based on their choice and preferences (Bideberi, 2013). For instance, Cattle egret *Bubulcus ibis* that feed primarily on insects such as crickets, grasshoppers and ants prefer wetland areas with short grasses for foraging. In contrast, species like ducks, geese and waders which feed on invertebrates (e.g. molluscs, crustaceans, etc.) and fish prefer lakes and ponds (Bideberi, 2013).

In the Hadejia-Nguru Wetlands (HNWs), the wetlands consist of mosaic wetland areas including marshes, swamps, ponds, rivers and floodplains. The wetland comprises of four Protected Areas (PAs) as well as several wetland areas that have no legal protection which in this study are considered as Unprotected Areas (UPAs).

Important studies on birds of the HNWs exist. Ezealor and Giles (1997) demonstrated that Ruff *Philomachus pugnax* are not pest of Rice *Oryza spp.*, despite rice being its main constituent diet in the wetland. Lameed (2011) brought out to light the bird diversity and abundance of Dagona Waterfowl Sanctuary and the positive relationship between vegetation densities and bird diversity. Sulaiman *et al.* (2015) reported that wetland sizes do not have effect on bird abundance, but had effect on bird diversity. Nevertheless, our knowledge in understanding the relationship between birds and vegetation in the HNWs is inadequate. The aim of this paper is to provide an overview of the relationship between bird diversity/density versus vegetation diversity/density in PAs and UPAs of the HNWs.

MATERIAL AND METHODS

Description of the study area

The HNWs (12°15'N 13°00'N; 10°00' E 11°00'E, Figure 1) is form by the Hadejia and Jama'are rivers, to form

the Yobe river, which drained into Lake Chad. The wetland cover about 3500 000 ha situated on altitudinal range between 152-305 m a.s.l. Three main vegetation types are recognized, namely: (i) Scrub savannah which consists of upland farmland areas and *Acacia* woodlands, (ii) Raised areas locally known as *tudu* which become inundated during the wet season and predominated by tree species such as *Acacia spp*, *Ziziphus spp*, and Desert date *Balanites aegyptiaca*, and (iii) Seasonally flooded areas of marsh with trees of *Acacia spp* and Doum palm *Hyphaene thebaica*, common grasses includes Egyptian crowfoot grass *Dactyloctenium aegyptium* and Giant sensitive tree *Mimosa pigra* along the Lakes (Birdlife International, 2016a). There are four PAs in the HNWs (Table 1). The wetland is a Ramsar site and an Important Bird Area, which has been recognized as one of the most important wintering site for migratory birds in the Sahel (Birdlife International, 2013).

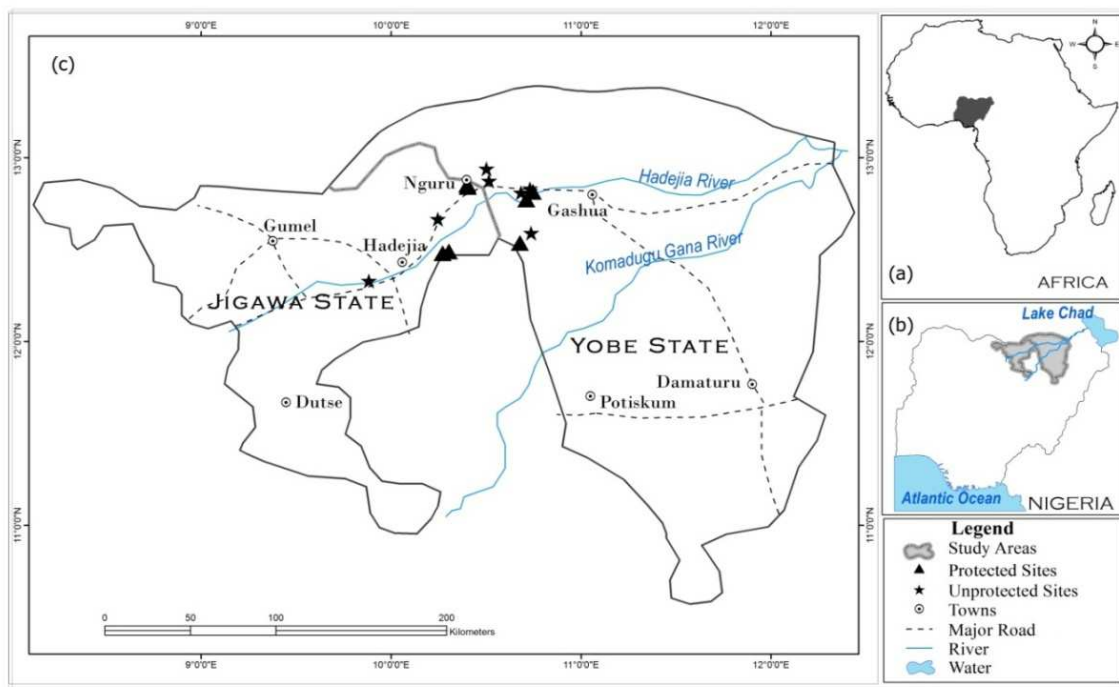


Fig. 1: Location of sampling sites in PAs and UPAs in the HNWs

Table 1: Protected areas in the HNWs

Protected areas	Designation	Area (ha)	Overlap with IBA (ha)
Adiani	Forest Reserve	132	132
Baturiya Wetlands	Game Reserve	29 700	29 700
Chad Basin	National Park	230 000	0
Nguru Lake and Marma Channel	Ramsar site	58 100	58 100

Bird sampling

Bird surveys were conducted from October to December, 2015. Seven wetland sites were surveyed in PAs namely Gwayo, Kwasabat, Kandamau, Maram, Marma Channel, Nguru Lake, and Oxbow Lake. Whereas seven wetland sites in the UPAs comprised of Barrack, Dumbari, Hadejia Barrage, Kacallari, Kirikasamma, Muzza, and Zemo. A total of 48 point count stations were surveyed in PAs and 51 in UPAs once per month. Visits were made in the morning from 6:00 to 10:00 h and in the evening from 16:00 to 18:00 h when birds were more active. Each site was surveyed thrice during the study period and the average number of birds counted was taken for all the sites. Point count method described by Bibby (2000) was used to survey bird species. In this technique, during arrival at the point count station, a period of five minutes was observed to allow birds settle down due to any disturbance caused by the observer. Birds seen or heard from a fixed point within a radius of 100 m using Braun Binoculars 16 x 10 m were observed for 10 minutes in all point counts stations and throughout the study period. Point count stations were spaced 400 m apart to avoid double counting. Birds were identified using field guide to the birds of Western Africa by Borrow and Demey (2014).

Vegetation sampling

Vegetation data was collected according to Modified-Whittaker method by Campbell *et al.* (2002). This involved three different plot sizes used to sample vegetation. Bigger plots of the size 20 x 50 m were established for assessment of trees, within the bigger plot, nested plots of the size 2 x 5 m were established for assessing shrubs and herbs and 1 x 1 m for grasses, respectively. Name and number of individual trees, herbs and shrubs found within each plot were recorded. Graminae species were recorded on presence-absence basis. Plant species were identified according to Gbile (1984) and Burkill (1995).

Data analysis

Microsoft Office Software (Excel version 2007) was used to compute the relationship between vegetation diversity/density and bird diversity/density in PAs and UPAs. However, correlation was determined by using scatted plot, while linear correlation in Paleontological Statistical software by Hammer *et al.* (2001, version 2.17) was used to test if there was significant difference between vegetation diversity/density and bird species diversity/density in PAs and UPAs.

RESULTS

Bird diversity and density in PAs and UPAs

A total of 42, 255 bird individuals, 148 species, 23 orders and 50 families were recorded from both PAs and UPAs of the HNWs (Appendix I). Families with the highest species were Accipitridae (13 species), Ardeidae (11 species) and Columbidae (9 species), while families with lowest species include Bucerotidae and Jacanidae (2 species each), Coliidae, Coraciidae and Pandionidae (1 species each). Two species in the IUCN Redlist (2015) global conservation concern were also recorded (Birdlife International, 2016b), the Vulnerable European

turtle dove *Streptopelia turtur* and the Near Threatened Pallid harrier *Circus macrourus*. The former and other 13 species was the first recording in HNWs (Appendix I).

Vegetation composition in PAs and UPAs

A total of 77 plant species belonging to 34 families were recorded in PAs and UPAs of the HNWs (Appendix II). Forty two species in the PAs and 73 species were recorded in the UPAs, respectively. The following tree species were the most abundant in both areas: Doum Palm *Hyphaene thebaica*, Egyptian mimosa *Acacia nilotica* and Paperbark acacia *A. sieberiana*. Dominant shrubs include Camel's foot *Piliostigma reticulatum*, Large jujube *Ziziphus abyssinica*, and Kharroub *Bauhinia rufescens*. Dominant herb species in both areas were Marsh barbel *Hygrophilus auriculata* and Woodrose *Ipomoea eriocarpa*. Whereas common grasses includes Bermuda grass *Cynodon dactylon*, Sickle senna *Cassia tora* and Coffee senna *Senna occidentalis*. In terms of density, *A. nilotica* and *H. thebaica* registered the highest density in PAs (119.5/ha and 29/ha) while Tamarind *Tamarindus indica* and Black Plum *Vitex doniana* registered the lowest density (0.21/ha and 0.1/ha). Similarly in UPAs, *H. thebaica* registered the highest density followed by *A. nilotica* (147.5/ha and 63.38/ha). Krobo christmas tree *Hildegardia barteri* and Forssk *Cadaba farinosa* registered the lowest density, 0.12/ha and 0.1/ha (Appendix II).

Relationship between birds and vegetation in PAs and UPAs

Results showed that neither vegetation diversity nor density correlated with bird diversity nor density in the PAs and UPAs of the HNWs respectively (PAs; $r = 0.0370$, $p > 0.05$, UPAs; $r = -0.1720$, $p > 0.05$). However, despite this, positive associations were observed between certain bird species and plant species. For instance, most dove species including African mourning dove *Streptopelia decipiens*, Namaqua dove *Oena capensis*, Vinaceous dove *Streptopelia vinacea*, and other bird species like Chestnut-bellied starling *Lamprotornis pulcher*, Crested lark *Galerida cristata* showed a strong association with bare grassy areas. Some species such as Spur-winged goose, White-faced whistling duck *Dendrocygna viduata*, Garganey *Spatula querquedula*, African Jacana *Actophilornis africanus*, Yellow wagtail *Motacilla flava*, and Squacco heron *Ardea rolloides* and Knob-billed duck *Sarkidiornis melanotos* indicated a close relationship with floating and emergent vegetation of Water lilies *Nymphae lotus* and Hippo grass *Vossia cuspidata* vegetation. African reed warbler *Acrocephalus baeticus*, Lesser swamp warbler *Acrocephalus gracilirostris*, Village weaver *Ploceus cucullatus* and Quelea *Quelea quelea* showed a strong association with emergent vegetation of Southern cattail *Typha domingensis* especially along the shores in Nguru Lake and Marma channel. Species such as Beautiful sunbird *Nectarinia pulchella*, Sudan golden sparrow *Passer luteus*, Red-cheeked cordon-blue *Uraeginthus bengalus*, and Sedge warbler *Acrocephalus schoenobaenus* showed a strong positive relation with shrub and tree species especially *Acacia* spp.

DISCUSSION

Bird diversity and density was neither influenced by vegetation diversity nor by vegetation density in both PAs and UPAs. However, other studies (e.g. Henderson and Harper, 1992; Riffel *et al.*, 2001) reported a positive relationship between birds and vegetation. The present study could largely be attributed to low vegetation diversity and density, especially in PAs. A number of studies (e.g. Bideberi, 2013; Connor *et al.*, 2000) related bird diversity and density to complex vegetation structures and wetland factors, such as water levels, wetland size and food. In this case, bird diversity and density in PAs and UPAs of the HNWs possibly depends on other factors, apart from vegetation. Nevertheless, the relationship between birds and certain plant species was observed in both areas. For example, Senegal coucal *Centropus senegalensis* and African mourning dove showed a strong association with Doum palm vegetation anticipating that it may serve as a nesting and roosting site. In addition, Purple swamphen *Porphyrio porphyrio*, Common Gallinula *chloropus* and Lesser moorhen *Gallinula angulata* as well as Black crane *Zapornia flavirostra* also showed a positive association with the emergent vegetation of Southern cattail which might serve as foraging ground and shelter. This observation is similar to that of Rajpar and Zakaria (2011) who found bird species such as Common moorhen and Purple swamphen to have strong positive association with emergent vegetation of *Typha* spp. in Peninsula Malaysia.

The ornithological significance of the HNWs is high and the mosaic habitats are critical for the survival of resident, intra-African and Palearctic migrants and other wildlife as well. The exceptional vegetation of the wetland also benefits the local communities through recharge of drinking water, food crops, protection against erosion and fodder for animals. Thus, should generally be conserved. However, human population is on the increase which may increase demand for the wetland resources, e.g. fuel wood, and farmland areas.

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Therefore, a good management plan and strict law enforcement especially in PAs will limit exploitation of the wetland resources, minimize conflicts between the different ethnic groups in the wetland and wildlife alike. The possibility of an extension of PAs to include high bird diversity areas (e.g. Dumbari wetland) should be considered. Further studies for birds are recommended in HNWs in the Adiani Forest Reserve and other unexplored wetland areas. This is because many bird species are cryptic and shy which are very hard to detect and in several cases has been recorded only once during month-long surveys (Dinesen, 1998).

Moreover, there is need to increase public awareness (especially the awareness of the indigenous communities in the wetland) on the importance of conserving birds and vegetation, as they play a vital role in the ecosystem. The management of the wetland needs to step up efforts to protect certain vegetation types (e.g. *Acacia* spp.) against overexploitation. This is because they are important roosting sites for the vulnerable European turtle dove. Finally, the study has demonstrated that both PAs and UPAs of the HNWs are important for bird conservation. Thus, legal attention will be of uttermost importance for the long-term conservation of the wetland rich bird species, which from conservation point of view is very important.

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Contribution of authors

A. S. Ringim collected the field data, analyzed the data and wrote the manuscript, while M. M. Dogara proofread and reviewed the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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Appendix I: Checklist of bird species in PAs and UPAs of the HNWs recorded during the study period (October to December, 2015). New records added to the existing literature (*).

Family	Common names	Species name	
Anatidae	African Pygmy Goose	<i>Nettapus auritus</i>	
	Fulvous Whistling Duck	<i>Dendrocygna bicolor</i>	
	Garganey	<i>Spatula querquedula</i>	
	Knob-billed Duck	<i>Sarkidiornis melanotos</i>	
	Spur-winged Goose	<i>Plectropterus gambensis</i>	
	White-faced Whistling Duck	<i>Dendrocygna viduata</i>	
Apodidae	African Palm Swift	<i>Cypsiurus parvus</i>	
	Common Swift	<i>Apus apus</i>	
	Little Swift	<i>Apus affinis</i>	
Bucerotidae	African Grey Hornbill	<i>Lopoceros nasutus</i>	
	Northern Red-billed Hornbill	<i>Tockus erythrorhynchus</i>	
Accipitridae	African Harrier Hawk	<i>Polyboroides typus</i>	
	African Swallow-tailed Kite	<i>Chelictinia riocourii*</i>	
	Black Shouldered Kite	<i>Elanus axillaris</i>	
	Black kite	<i>Milvus migrans</i>	
	Dark Chanting Goshawk	<i>Melierax metabates</i>	
	Gabar Goshawk	<i>Micronisus gabar</i>	
	Grasshopper Buzzard	<i>Butastur rufipennis</i>	
	Lizard Buzzard	<i>Kaupifalco monogrammicus</i>	
	Montagu's Harrier	<i>Circus pygargus</i>	
	Pallid Harrier	<i>Circus macrourus</i>	
	Shikra	<i>Accipiter badius</i>	
	Western Marsh Harrier	<i>Circus aeruginosus</i>	
	Yellow-billed Kite	<i>Milvus migrans parasitus</i>	
Ciconiidae	Abdim's Stork	<i>Ciconia abdimii</i>	
	African Openbill Stork	<i>Anastomus lamelligerus</i>	
	White Stork	<i>Ciconia ciconia</i>	
Cuculidae	Great Spotted Cuckoo	<i>Clamator glandarius</i>	
	Senegal Coucal	<i>Centropus senegalensis</i>	
Coliidae	Blue-naped Mousebird	<i>Urocolius macrourus</i>	
Alcedinidae	African Pygmy Kingfisher	<i>Ispidina picta</i>	
	Grey-headed Kingfisher	<i>Halcyon leucocephala</i>	
	Malachite Kingfisher	<i>Corythornis cristatus</i>	
	Pied Kingfisher	<i>Ceryle rudis</i>	
Columbidae	African Mourning Dove	<i>Streptopelia decipiens</i>	
	Black-billed Wood Dove	<i>Turtur abyssinicus</i>	
	Blue-spotted Wood Dove	<i>Turtur afer</i>	
	European Turtle Dove	<i>Streptopelia turtur*</i>	
	Laughing Dove	<i>Streptopelia senegalensis</i>	
	Namaqua Dove	<i>Oena capensis</i>	
	Speckled Pigeon	<i>Columba guinea</i>	
	Tambourine Dove	<i>Turtur tympanistris*</i>	
	Vinaceous Dove	<i>Streptopelia vinacea</i>	
	Coraciidae	Abyssinian Roller	<i>Coracias abyssinicus</i>
		Charadriidae	Black-headed Lapwing
Spur-winged Lapwing	<i>Vanellus spinosus</i>		
Jacanidae	African Jacana	<i>Actophilornis africanus</i>	
Laridae	Lesser Jacana	<i>Microparra capensis</i>	
	Gull-billed Tern	<i>Gelochelidon nilotica*</i>	
Scolopacidae	Grey-headed Gull	<i>Larus cirrocephalus*</i>	
	Whiskered Tern	<i>Chilidonias hybrida</i>	
	Common Sandpiper	<i>Actitis hypoleucos</i>	
	Common Snipe	<i>Gallinago gallinago</i>	
	Green Sandpiper	<i>Tringa ochropus</i>	
	Little Stint	<i>Calidris minuta</i>	
	Ruff	<i>Calidris pugnax</i>	
Spotted Redshank	<i>Tringa erythropus</i>		

	Wood Sandpiper	<i>Tringa glareola</i>
Recurvirostridae	Black-winged Stilt	<i>Himantopus himantopus</i>
Falconidae	Grey Kestrel	<i>Falco ardosiaceus</i>
	Lanner Falcon	<i>Falco biarmicus</i>
	Red-necked Falcon	<i>Falco ruficollis</i>
Numididae	Helmeted Guineafowl	<i>Numida meleagris*</i>
Odontophoridae	Stone Partridge	<i>Ptilopachus petrosus</i>
Rallidae	Allen's Gallinule	<i>Porphyrio alleni</i>
	Black Crake	<i>Zapornia flavirostra</i>
	Common Moorhen	<i>Gallinula chloropus</i>
	Lesser Moorhen	<i>Gallinula angulata</i>
	Purple Swampphen	<i>Porphyrio porphyrio</i>
Musophagidae	Western Grey Plantain-eater	<i>Crinifer piscator</i>
Lybiidae	Bearded Barbet	<i>Pogoniulus dubius</i>
	Vieillot's Barbet	<i>Lybius vieilloti</i>
	Yellow-fronted Tinkerbird	<i>Pogoniulus chrysoconus</i>
Ardeidae	Black Heron	<i>Egretta ardesiaca</i>
	Black-headed Heron	<i>Ardea melanocephala</i>
	Cattle Egret	<i>Bubulcus ibis</i>
	Great Egret	<i>Ardea alba</i>
	Green-backed Heron	<i>Butorides striata</i>
	Grey Heron	<i>Ardea cinerea</i>
	Intermediate Egret	<i>Ardea intermedia</i>
	Little Bittern	<i>Ixobrychus minutus</i>
	Little Egret	<i>Egretta garzetta</i>
	Purple Heron	<i>Ardea purpurea</i>
	Squacco Heron	<i>Ardea rolloides</i>
Threskiornithidae	Glossy Ibis	<i>Plegadis falcinellus</i>
Psittacidae	Red-headed Lovebird	<i>Agapornis pullarius*</i>
	Rose-ringed Parakeet	<i>Psittacula krameri</i>
	Senegal Parrot	<i>Poicephalus senegalus</i>
Pteroclididae	Four-banded Sandgrouse	<i>Pterocles quadricinctus</i>
Caprimulgidae	Standard-winged Nightjar	<i>Caprimulgus longipennis*</i>
Upupidae	Hoopoe	<i>Upupa epops</i>
Phoeniculidae	Green Wood-hoopoe	<i>Phoeniculus purpureus</i>
Alaudidae	Crested Lark	<i>Galerida cristata</i>
Cisticolidae	Grey-backed Camaroptera	<i>Camaroptera brachyura</i>
	Tawny-flanked Prinia	<i>Prinia subflava</i>
	Winding Cisticola	<i>Cisticola juncidis</i>
	Zitting Cisticola	<i>Cisticola fasciata</i>
Corvidae	Piapiac	<i>Ptilostomus afer</i>
	Pied Crow	<i>Corvus albus</i>
Estrildidae	Cut-throat Finch	<i>Amadina fasciata</i>
	Green-winged Pytilia	<i>Pytilia melba*</i>
	Red-billed Firefinch	<i>Lagonosticta senegala</i>
	Red-cheeked Cordon Blue	<i>Uraeginthus bengalus</i>
Fringillidae	Yellow-fronted Canary	<i>Serinus mozambicus</i>
Hirundinidae	Common Sand Martin	<i>Riparia riparia</i>
	Ethiopian Swallow	<i>Hirundo aethiopica</i>
	Plain Martin	<i>Riparia paludicola</i>
	West African Swallow	<i>Ceropsis domicella</i>
Laniidae	Southern Grey Shrike	<i>Lanius meridionalis</i>
	Woodchat Shrike	<i>Lanius senator*</i>
	Yellow-billed Shrike	<i>Corvinella corvina</i>
Malaconotidae	Black-crowned Tchagra	<i>Tchagra senegalus</i>
	Yellow-crowned Gonolek	<i>Laniarius barbarus</i>
Meropidae	Little Bee-eater	<i>Merops pusillus</i>
	Little Green Bee-eater	<i>Merops orientalis</i>
Motacillidae	Yellow Wagtail	<i>Motacilla flava</i>
Muscicapidae	Black Scrub Robin	<i>Cercotrichas podobe</i>
	Northern Wheatear	<i>Oenanthe oenanthe*</i>

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Nectariniidae	Beautiful Sunbird	<i>Nectarinia pulchella</i>	
Pandionidae	Osprey	<i>Pandion halieatus</i>	
Passeridae	Northern Grey-headed Sparrow	<i>Passer griseus</i>	
	Sudan Golden Sparrow	<i>Passer luteus</i>	
Phalacrocoracidae	Speckle-fronted Weaver	<i>Sporopipes frontalis</i>	
	Long-tailed Cormorant	<i>Microcarbus africanus</i>	
Phasianidae	Double-spurred Francolin	<i>Pternistis petrosus</i>	
Ploceidae	Black-headed Weaver	<i>Ploceus melanocephalus</i>	
	Little Weaver	<i>Ploceus luteolus</i>	
	Northern Red Bishop	<i>Euplectes franciscanus</i>	
	Red-billed Quelea	<i>Quelea quelea</i>	
	Village Weaver	<i>Ploceus cucullatus</i>	
	Vitellin Masked Weaver	<i>Ploceus intermedius</i>	
	White-billed Buffalo Weaver	<i>Bubalornis albirostris</i>	
	Yellow-crowned Bishop	<i>Euplectes afer</i>	
	Pycnonotidae	Common Bulbul	<i>Pycnonotus barbatus</i>
	Sturnidae	Chestnut-bellied Starling	<i>Lamprotornis pulcher</i>
Great Blue-eared Starling		<i>Lamprotornis chalybaeus</i>	
Long-tailed Glossy Starling		<i>Lamprotornis caudatus</i>	
Sylviidae	Yellow-billed Oxpecker	<i>Buphagus africanus</i>	
	African Reed Warbler	<i>Acrocephalus baeticus*</i>	
	Common Whitethroat	<i>Sylvia communis*</i>	
	European Reed Warbler	<i>Acrocephalus scirpaceus*</i>	
	Greater Swamp Warbler	<i>Acrocephalus rufescens</i>	
	Lesser Swamp Warbler	<i>Acrocephalus gracilirostris</i>	
	Northern Crombec	<i>Sylvietta brachyura</i>	
	Sedge Warbler	<i>Acrocephalus schoenobaenus</i>	
Timalidae	Brown Babbler	<i>Turdoides plebejus</i>	
Viduidae	Sahel Paradise Whydah	<i>Vidua orientalis</i>	
	Village Indigobird	<i>Vidua chalybaeta</i>	

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Appendix II: Vegetation composition in PAs and UPAs of the HNWs recorded during the study period (October to December, 2015). Key: Presence (+), Absence (-), D/ha (Density/ha)

Family	Species name	Common names	Habit	PAs		UPAs	
				Individual	D/ha	Individual	D/ha
Amaranthaceae	<i>Achyranthes aspera</i> L.	Chaff flower	Graminae	+	+	-	-
Araceae	<i>Pistia stratiotes</i> L.	Water lettuce	Graminae	+	+	-	-
Asclepiadaceae	<i>Leptadenia hastata</i> (Pers.) Decne.	Leptadenia	Graminae	+	+	+	-
Asteraceae	<i>Ambrosia maritima</i> L.	Wild indigo	Graminae	+	+	+	+
Asteraceae	<i>Acanthospermum hispidum</i> DC.	Bristly starbur	Graminae	-	-	+	+
Convolvulaceae	<i>Evolvulus decumbens</i> R. Br.	Dwarf morning glory	Graminae	-	-	+	+
Cucurbitaceae	<i>Ipomoea asarifolia</i> Roem. & Schult	Morning glory	Graminae	+	+	+	+
Cucurbitaceae	<i>Lagenaria siceraria</i> (Molina) Standl.	Bottle gourd	Graminae	-	-	+	+
Cyperaceae	<i>Cyperus esculentus</i> L.	Nut grass	Graminae	-	-	+	+
Cyperaceae	<i>Cyperus rotundus</i> L.	Coco grass	Graminae	+	+	+	+
Leguminosae	<i>Cassia singueana</i> Delile	Cassia	Graminae	-	-	+	+
Leguminosae	<i>Diadilium guineense</i> Willd.	Velvet tamarind	Graminae	-	-	+	+
Leguminosae	<i>Senna italica</i> Mill.	Italian senna	Graminae	+	+	+	+
Leguminosae	<i>Senna occidentalis</i> (L.) Link	Coffee senna	Graminae	-	-	+	+
Leguminosae	<i>Sesbania dalzielli</i> E. Phillips & Hutch.	Riverhemp	Graminae	-	-	+	+
Malvaceae	<i>Gossypium hirsutum</i> L.	Mexican cotton	Graminae	-	-	+	+
Nyctaginaceae	<i>Boerhavia diffusa</i> L.	Hogweed	Graminae	-	-	+	+
Nymphaeaceae	<i>Nymphae lotus</i> L.	Water lily	Graminae	+	+	+	+
Poaceae	<i>Acroceras amplexens</i> Stapf.	Acroceras	Graminae	-	-	+	+
Poaceae	<i>Andropogon gayanus</i> Kunth	Gamba grass	Graminae	+	+	+	+
Poaceae	<i>Cenchrus biflorus</i> Roxb.	Indian sandbur	Graminae	-	-	+	+
Poaceae	<i>Cynodon dactylon</i> (L.) Pers.	Bermuda grass	Graminae	+	+	+	+
Poaceae	<i>Digitaria debilis</i> Willd.	Finger grass	Graminae	+	+	+	+
Poaceae	<i>Eragrostis tremula</i> Hochst. ex Steud.	Canegrass	Graminae	-	-	+	+
Poaceae	<i>Heteropogon contortus</i> (L.) Beauv. ex Roemer & J.A. Schultes	Steakgras	Graminae	-	-	+	+
Poaceae	<i>Pennisetum pedicellatum</i> Trin.	Annual Kyasuwa grass	Graminae	+	+	+	+
Poaceae	<i>Phragmites australis</i> (Cav.) Steud.	Common reed	Graminae	+	+	+	+
Poaceae	<i>Schizachyrium exile</i> (Hochst.) Pilg.	Bluestems/Pilger	Graminae	-	-	+	+
Poaceae	<i>Urelytrum giganteum</i> Pilg.	Pilger	Graminae	-	-	+	+
Poaceae	<i>Vossia cuspidata</i> Griff.	Hippo grass	Graminae	+	+	+	+
Tiliaceae	<i>Corchorus tridens</i> L.	Wild jute	Graminae	-	-	+	+
Typhaceae	<i>Typha domingensis</i> Pers.	Southern cattail	Graminae	+	+	+	+
Lamiaceae	<i>Clerodendrum capitatum</i> Hook.	Cleredenron	Graminae	-	-	+	+
Acanthaceae	<i>Calophanes perrottetii</i> Nees.	Snake herb	Herb	+	+	-	-
Acanthaceae	<i>Hygrophila auriculata</i> (Schumach.)	Marsh barbel	Herb	7	0.97	2	0.28
Commelinaceae	<i>Commelina erecta</i> Chapm.	Slender dayflower	Herb	-	-	6	0.62
Convolvulaceae	<i>Ipomoea eriocarpa</i> R. Br.	Woodrose	Herb	-	-	7	0.73
Cucurbitaceae	<i>Momordica balsamina</i> L.	African pumpkin	Herb	2	0.28	3	0.31
Euphorbiaceae	<i>Ricinus communis</i> L.	Castorbean	Herb	-	-	7	0.73
Leguminosae	<i>Crotalaria mucronata</i> Desv.	Rattlepod	Herb	-	-	16	1.6

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Lamiaceae	<i>Leonotis nepetifolia</i> Schimp. ex Benth.	Wild tea bush	Herb	-	-	4	0.42
Malvaceae	<i>Hibiscus sabdariffa</i> L.	Roselle	Herb	-	-	2	0.28
Annonaceae	<i>Annona senegalensis</i> Pers.	African custard-apple	Shrub	-	-	12	0.2
Asclepiadaceae	<i>Calotropis procera</i> (Aiton) W.T.Aiton	Kapok	Shrub	27	3.03	171	17.85
Capparaceae	<i>Cadaba farinosa</i> Fossk.	Forssk	Shrub	-	-	1	0.1
Combretaceae	<i>Guiera senegalensis</i> J.F.Gmel.	Moshi medicine	Shrub	3	0.31	5	0.58
Leguminosae	<i>Bauhinia rufescens</i> Lam	Kharroub	Shrub	52	5.9	107	25.25
Leguminosae	<i>Piliostigma thonningii</i> (Schumach.) Milne-Redh.	Camel's foot	Shrub	133	15	192	21.88
Rhamnaceae	<i>Ziziphus abyssinica</i> Hochst. ex A. Rich.	Large jujube	Shrub	32	4.12	75	8.12
Rubiaceae	<i>Mitragyna inermis</i> (Willd.) & Kuntze	Abura	Shrub	13	0.56	7	0.82
Salvadoraceae	<i>Salvadora persica</i> L.	Mustard bush	Shrub	-	-	2	0.21
Lamiaceae	<i>Vitex doniana</i> Sweet	African oak	Tree	1	0.1	1	0.1
Anacardiaceae	<i>Mangifera indica</i> L.	Mango	Tree	2	0.24	13	1.39
Arecaceae	<i>Cocos nucifera</i> L.	Palm tree	Tree	8	0.88	-	-
Arecaceae	<i>Hyphaene thebaica</i> (L.) Mart	Doum palm	Tree	267	29	1282	147.5
Arecaceae	<i>Phoenix dactylifera</i> L.	Date palm	Tree	6	0.73	6	0.62
Ebenaceae	<i>Diospyros sabiensis</i> Hiern	African Ebony	Tree	8	1.01	5	0.64
Leguminosae	<i>Acacia nilotica</i> (L.) Delile	Egyptian mimosa	Tree	901	119.5	505	63.38
Leguminosae	<i>Acacia Senegal</i> Willd.	Gum Arabic	Tree	7	0.97	20	2.37
Leguminosae	<i>Acacia seyal</i> Delile	Shittah tree	Tree	3	0.42	109	14.48
Leguminosae	<i>Acacia sieberiana</i> (DC.) Kyal. & Boatwr	Paperbark acacia	Tree	173	23.6	176	21.4
Leguminosae	<i>Faidherbia albida</i> (Delile) A. Chev.	Apple ring-acacia	Tree	44	4.9	45	4.89
Leguminosae	<i>Mimosa asperata</i> L.	Giant sensitive tree	Tree	43	5.97	3	0.31
Leguminosae	<i>Tamarindus indica</i> L.	Tamarind	Tree	2	0.2	7	0.9
Bombacaceae	<i>Adansonia digitata</i> L.	African Baobab	Tree	-	-	13	1.25
Sterculiaceae	<i>Hildegardia barteri</i> (Mast.) Kosterm.	Krobo Christmas tree	Tree	3	0.31	1	0.12
Meliaceae	<i>Azadirachta indica</i> A. Juss	Neem tree	Tree	60	6.5	275	29.16
Moraceae	<i>Ficus thonningii</i> Blume	Wild fig	Tree	3	0.31	5	0.5
Moringaceae	<i>Moringa oleifera</i> Lam	Moringa	Tree	-	-	2	0.21
Rhamnaceae	<i>Ziziphus mucronata</i> Willd.	Buffalo thorn	Tree	3	0.42	29	3.32
Balanitaceae	<i>Balanites aegyptiaca</i> Delile	Desert date	Tree	28	2.92	42	5.56

Key: PAs (Protected Areas), UPAs (Unprotected Areas)