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THE DIVERSITY AND RELATIVE ABUNDANCE OF WATERBIRDS IN BOYE, KITO AND KOFFE WETLANDS, AT THE PERIPHERY OF JIMMA TOWN, SOUTHWEST ETHIOPIA

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LIST OF ACRONYMS

ANOVA: Analysis Of Variance

CBD: Convention on Biological Diversity

CSA: Central Statistical Authority

EWNHS: Ethiopian Wildlife and Natural History Society

GIS: Geographical Information System

GPS: Global Positioning System

IBAs: Important Bird Areas

IUCN: International Union for Conservation of Nature and Natural resources

SPSS: Statistical Package for Social Sciences

NMA: National Meteorological Agency

NYZS: New York Zoological Park

WWF: World Wildlife Fund

UNEP: United Nation Environmental Program

Abstract

Bird species diversity and relative abundance survey at Boye, Kito and Koffe wetlands were conducted from late September to early November, 2014 for wet and from December, 2014 to February, 2015 for dry season. Based on the area size and habitat heterogeneity Boye and Koffe were divided into two blocks, and Kito in one block. Consequently, two representative line-transects that ranges 1.5 to 1.8 km long at 500m space between were established on each blocks. A total of 3321 individual birds from 107 belonging to 42 families and 12 orders were recorded. Of the total 107 overall bird species recorded 50 were wetland specialist and 57 wetland generalist birds. Maximum numbers of wetland specialist waterbird species in wet season were recorded from Boye wetland (40) and during dry seasons from Kito wetland (35). Minimum numbers of wetland specialist waterbird species in both wet and dry seasons were recorded from Koffe wetland (24) and (21). During wet season, the highest (H`: 2.727) wetland specialist waterbird diversity were recorded from Boye wetland and least (H`: 2.383) from Koffe, although in dry season the highest (H`: 2.935) were at Boye wetland and smallest (H`: 2.397) in Kito. Significant difference in wetland specialist waterbird diversity between wet and dry seasons were recorded at Boye and Koffe wetlands (Pair Independent T-test: t= -2.201, n=43 and t=2.309, n= 28 where P<0.05). Maximum numbers of wetland generalist bird species during wet season were recorded from kito wetland (39) and minimum was recorded from Boye wetland (32). During dry season maximum numbers of wetland generalist bird species were recorded from Koffe wetland (34) and minimum numbers was from Boye and Kito wetlands (28). Highest (H'=3.236) wetland generalist bird species diversity during wet season was recorded from koffe wetland and smallest (H'=3.026) from Boye; while, during dry season highest (H'=3.015) was recorded from Koffe and smallest (H'=2.456) from Boye wetland.

Key Words: Wetland specialist waterbird; wetland generalist bird; Diversity; Richness

1. INTRODUCTION

1.1. Background of the study

Wetlands shelter countless species of fauna and flora, of which the most widely explored are birds (Carp, 1980). Waterbirds are a diverse group of birds that utilize natural and artificial wetlands both saline and fresh water habitats including rivers, estuaries, embayment and open shores (Kingsford and Norman, 2002). Wetland birds are extremely diverse, reflecting early anatomical and physiological adaptations to this unique but rich habitat (Milton, 2003). In comparison to other avian species, waterbirds are characterised by their frequent utilisation of multiple habitats over varying spatial scales to moult, roost, breed and forage (Haig et al., 1998, Kingsford and Norman 2002). Wetland water regimes strongly influence waterbird populations. Floods trigger breeding in many species, and wetland systems that are flooded after a dry period support large numbers of waterbirds compared to permanently flooded sites (Kingsford and Norman 2002, Kingsford and Auld, 2005). There are two categories of waterbirds; wetland specialists and generalists (Ayenalem and Bekele, 2008). Wetland specialists are wholly dependent on aquatic habitats, and cannot survive in other habitats (Airinatwe 1999); and includes 871 species grouped into 32 families (Wetland International, 2012). Generalists are those birds that frequently visit and partially depend on wetland habitat for food, shelter and perch.

According to Hillman (1993), there are 77 wetlands in Ethiopia and Eritrea with a total coverage of 13,699 km2 or 1.14 % of the total land area of the two countries. Wetlands are widely distributed in all climatic regions of Ethiopia and support a wealth of flora and fauna, including many endemic plant species and several of Ethiopia's endemic or near-endemic birds. Consequently, the country has a diverse number of both terrestrial and aquatic bird species and one of the most significant in Africa and divers habitat type definitely contribute for the immensely diverse avifauna (Welegerima *et al*., 2014).

In Ethiopia, a total of 73 hotspots have been identified as important bird areas (IBAs), of which 30(41%) comprised wetlands (Wondafrash, 2003). The Ethiopian IBA sites have been grouped into three conservation categories: critical (19), urgent (23) and high (31) (Wondafrash, 2003). Lepage (2013) described there are 857 bird species in

the country. Hence, about 204 (25%) bird species in Ethiopia are considered wetland dependent (Mengistu, 2003).

According to the Food and Agriculture Organization (FAO, 1984), swamps and marshes are the two dominant wetland types, especially in southwestern part of the country. These resources have immense ecological importance and important endemic plant and animal species (Yimer and Mengistou, 2009). Boye, Kito and Koffe are the wetlands found in this region specifically near Jimma town. Mekonnen and Aticho (2011) recorded a total of 36 bird species from Boye wetland and EWNHS survey team has recorded 78 bird species from Koffe wetland in 1995. Among these, two species; *Poicephalus flavifrons* and *Macronyx flavicollis* are endemic to Ethiopia. Bird species including Wattled ibis (*Bostrychia carunculata),* Abyssinian Slaty Flycatcher *(Dioptrornis chocolatinus)* and Thick-billed raven (*Corvus crassirostris)* which occur in Ethiopia & Eritrea were also recorded in these wetlands (Mekonnen and Aticho, 2011). In addition to the Wattled Crane (*Bugeranus carunculatus*), endangered bird species are reported to breed in Koffe area (EWNHS, 1999). Therefore, the aim of this study is to assess the present diversity and abundance of bird species that exploit Boye, Kito and Koffe wetland habitats of wet and dry seasons.

1.2. Statement of the problem

Wetlands typically occur in discrete patches in a matrix of upland habitat, such that most local populations of wetland bird species are small and isolated and thus vulnerable to extinction (Moller & Rordam 1985: Dodd, 1990). On the other hand birds are potentially detect the health of wetland conditions that are not detected by other groups and hence serve as indicators (USEPA, 2002). They may be ordered into functional groups representing a combination of diet and habitat use that allow assessment of changes to wetland habitats (Balpure *et al*., 2013). The preparation of a list of species is basic to the study of avifauna of a site, because a list indicates species diversity in a general sense (Bibby *et al*., 1992).

Boye, Koffe and kito wetlands are found in Oromia regional state, periphery to the Jimma town. Previous studies during 1995 by EWNHS survey team 78 bird species from Koffe and in 2011 by Mekonnen and Aticho 36 bird species from Boye wetland were recorded but more species were expected. Bird species diversity in Kito wetland was not recorded before. Hence, the conditions of these wetlands are deteriorating that the study was important to see the difference since then of Boye and Koffe wetlands and also the diversity of bird species in kito wetland. In addition to these, this study addressed the major land-use activities to the three wetland habitats. Therefore, the finding of this research will answer the following research questions.

- What is the present species diversity, richness and similarity in distribution of overall bird species and water bird species specifically (resident and migratory) at Boye, Kito and Koffe wetland habitats?
- Are there any seasonal variations in species diversity and abundance of the birds /water birds/?
- What are the major land-uses pattern at Boye, Kito and Koffe wetland habitats and that could be potential threats to wetland dependent bird species?

1.3. Objectives

1.3.1. General objective

The general objective of this study was to determine the diversity and relative abundance of water bird species of Boye, Kito and Koffe wetlands, around Jimma town, southwest Ethiopia.

1.3.2. Specific objectives

The specific objectives of this study were;

- To determine the diversity of resident and migratory birds inhabiting the wetlands
- To determine their relative abundance
- To evaluate the significance of the three wetlands as important if it support species & ecological communities
- To assess potential threats affecting the wetlands, and hence the characteristic avifauna

1.4. Significance of the study

Understanding community structure and species composition are critical to explain local and regional biodiversity and prioritization of the areas of conservation (Ricklefs and Schluter 1993; Willig *et al.* 2003; Franco *et al.,* 2009). Because of their association with wetland ecosystems, the abundance and variations in avian species diversity, in a specific habitat could serve as a useful barometer of the ecological status and management tools of that habitat (Podoces, 2009; Harebotte, 2012; Bibi and Ali, 2013). Kito, Koffe and Boye wetlands are considered important habitats for bird species (EWNHS, 1996; Hayal and Seyoum, 2009; Mekonnen and Aticho, 2011). Although bird species in some wetland of Jimma periphery have been recorded (EWNHS, 1996, Mekonnen and Aticho, 2011), their diversity, relative abundance and the variation among the three wetlands have not been scientifically explored. Therefore, the present study will fill the information gap regarding the diversity of the avian fauna (resident and migratory) of the three wetlands, variation in the stated variables among the wetlands and to determine the significance of the areas as bird habitat. The study also assesses any anthropogenic effects that threaten the survival of the habitat and hence the avian fauna.

2. Literature Review

2.1 Wetlands and Bird Species Diversity

Wetlands are 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 6m (Ramsar Convention, 2010). The Ramsar Convention has adopted classification of wetland types which includes 42 types, grouped into three categories; Marine and Coastal wetlands, Inland wetlands and Human-made wetlands (www.ramsar.rgis.ch/cda/en/ramsar/. The area extent of wetlands at a global scale, estimated for wetlands coverage by UNEP-World Conservation Monitoring Center stated on Ramsar Convention review of 2009, about 570 million hectares (5.7 million Km^2)-roughly 6% of the earth`s land surface. Of which 2 % are lakes, 30 % bogs, 26 % fens, 20 % swamps, and 15% floodplains.

Wetlands are among the most productive ecosystems in the world, rich in biodiversity and harbored many globally threatened species (WWF/IUCN, 1988; Green, 1996; Petrie, 1998; Getzner, 2002). They are cradles of biological diversity, providing important functions that are essential to the functioning of biotic communities and maintaining quality of the environment and these form important habitats for birds (Mitsch and Gosselink, 1986; Guadagnin, *et al.,* 2005). They also provide suitable breeding sites for resident as well as a wintering ground for short and long distance migratory water birds (Patra *A., et.al.,* 2010).

Birds are the most conspicuous and significant components of different wetland habitats, i.e. their presence or absence may indicate the ecological conditions of the particular area (Rajpar & Zakaria 2011). Habitat selection in birds may greatly vary from species to species, depending upon the morphology of the bill (i.e. straight, elongated, slender, curved bills), prey availability (i.e. richness and vulnerability to capture) and foraging behavior such as visual vs. tactile foragers (Gawlik 2002; White & Main 2005).

Wetland birds differ widely in their species composition and relative abundance within a community (Milton 2004). Consequently, a wide variety of birds use wetland habitats for all or part of their life (*Patra et.al.,* 2010). Determining the species

diversity, richness and evenness are major aspects of bird diversity research, as it indicates the variation, richness and distribution of different bird species in a particular habitat (Rajpar and Zakaria, 2013).

2.2. Seasonal Abundance and Diversity in the Waterbird Community

Wetland habitats are used by bird species for nesting, breeding, feeding, sheltering, migration stopovers, and wintering in the different parts of their annual life cycle and are especially important habitats for long-distance migratory bird species (Weller, 1999; Getzner, 2002). Natural dynamics and presence of waterbird populations in specific wetlands are mainly driven by certain conditions such as habitat types, climatic conditions and water availability, which influence the physical structure of habitats and determine resource stability/or availability and accessibility (Paillisson *et al*., 2002; Saygili, F. *et al*., 2011). Other drivers of waterbird community composition and abundance include bird biology (migration, breeding and moulting) and anthropogenic influences, such as hunting, water extraction for industrial and domestic purposes, and agricultural practices (Caziani *et al*. 2001, van Niekerk 2010).

Generally wetlands are used by a host of different species which either exploits them throughout the year (resident species) or for only part of the year (migrant and nomadic species) (Harebottle, 2012). Thus, wetland sites whether at a local scale or at a global or flyway scale form important habitat chains for waterbirds which are mobile and able to use a variety of different sites through the year (Harebottle, 2012). The ecological requirements vary between species so that habitats or sites become important or valuable the factors that affect the abundance of aquatic birds in a given wetland, an abundance that may differ depending on the time of day, season or year in which the bird surveys are conducted (Weller 1988; Tucker and Evans 1997; Miller 2003). Knowing the functions and status of organisms in ecosystems places value on sites and habitats have significance in determining the importance of the availability and distribution of habitats and sites for species (Ando *et al*., 1998). Nevertheless, dry seasons usually result in reduced exploitable water surfaces and birds tend to congregate in the few remaining waterbodies, whereas in the wet season they tend to disperse as temporary waterbodies form (Dodman and Diagana 2007). Furthermore,

the attractiveness of a group of small wetlands to a single bird species compared with that of solitary wetlands of the same number and size will differ only if the home range of the species incorporates these several wetlands, thereby enhancing dependability and quantity of resources.

2.3. Wetland changes and impacts on waterbirds

It has been widely recognized that human civilization now has a much more significant impact on earth surface changes than natural disturbances (Herold *et al*., 2005). Due to a tremendous expansion of human population and economic development, almost half the world's wetlands have disappeared in the last century (Shine and Klemm, 1999; Barter, 2002; Xie, 2004). One of most important human activities in coastal areas is wetland reclamation, which serves a variety of purposes, changes in the natural flood regime, pollution, and over-utilization of natural water resources as a result of industry development, and human resettlement are primary factors on the loss of natural wetlands (Suchaneck, 1994; Czech and Parson, 2002; Junk *et al*., 2006; Battisti *et al*., 2008).

This pattern is a consequence of habitat loss and strong habitat fragmentation, and affects the movement of individuals through the landscape, and appears to select the species better adapted to the small, isolated wetlands (Brown and Dinsmore, 1986; Fahrig and Merriam, 1994; Fairbairn and Dinsmore, 2001; Whited *et al.* 2000). Thus, cause threats in reducing the local richness of wetland habitats dependent bird species and changes in community structure that alter the population trends include loss of shore habitat, reduced food availability and disturbances (Diamond 1976; Czech and Parson, 2002; Gomes and Magalhães Júnior 2004; IUCN, 2004; Niu, J. Y. *et al*., 2013).

A summary Report of Wetlands International in 2012 stated that overall, 3% of the known waterbird populations are considered to have become extinct since the seventeenth century; a large majority of these were resident populations and restricted to one or a small number of islands (Wetlands International, 2012). Of all populations, 38% are declining, 39% are stable and, 3% are fluctuating and only 20% are increasing.

Under the IUCN Red List criteria, 79% of all waterbird species considered to be Extinct, Extinct in the Wild, Critically Endangered, Endangered or Vulnerable, belong to six families (IUCN Red List www.redlist.org). Of these, 28% of them are Rallidae, followed by Anatidae (19%), Scolopacidae (8%), Ardeidae (7%), and Laridae, Phalacrocoracidae and Gruidae each contribute 6% to the total number of Globally Threatened waterbird species (IUCN Red List www.redlist.org).Nonetheless a review of BirdLife International in 2006 identified that the threat status of globally threatened waterbird species have a higher threat status by 23 waterbird than in 2002 (Wetlands International, 2012).

3. The Study area and methods

3.1. Description of the Study areas

The study was conducted in three wetlands; Boye, Kito and Koffe bordering Jimma town. Boye is located in Southeast at coordinate points between latitudinal parallels 07°38'- 07°40' N and longitudinal parallels 36°50' - 36°54' E; Kito wetland bordered Jimma town towards the southwest of the town between 07°39' - 07°41' N and 36°48' - 36°50' E; while Koffe borders towards the southern portion of the town lies between 07°38' - 07°39' N and 36°48' - 36°50' E. The elevation of the study areas ranges from 1,700 to 1,950 m a.s.l.

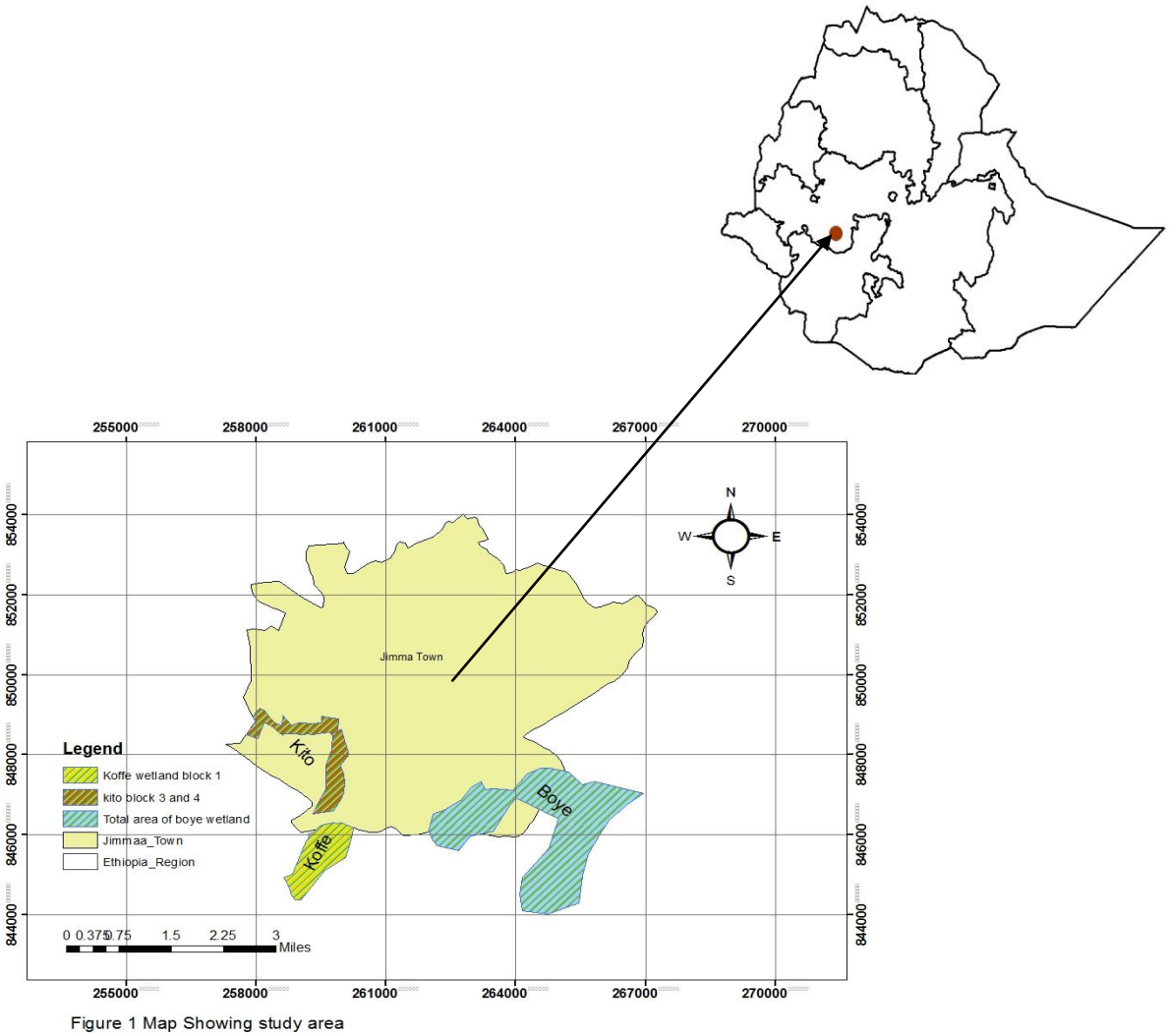

Figure 1 Map Showing study area

The study area major rainfall season ranges May to November (i.e. Wet season) and the dry season prevail from December to April with unconditional rain. The annual rainfall of the last five ranges from 1406 to 1,642 mm (NMA, 2015) (Fig. 2).

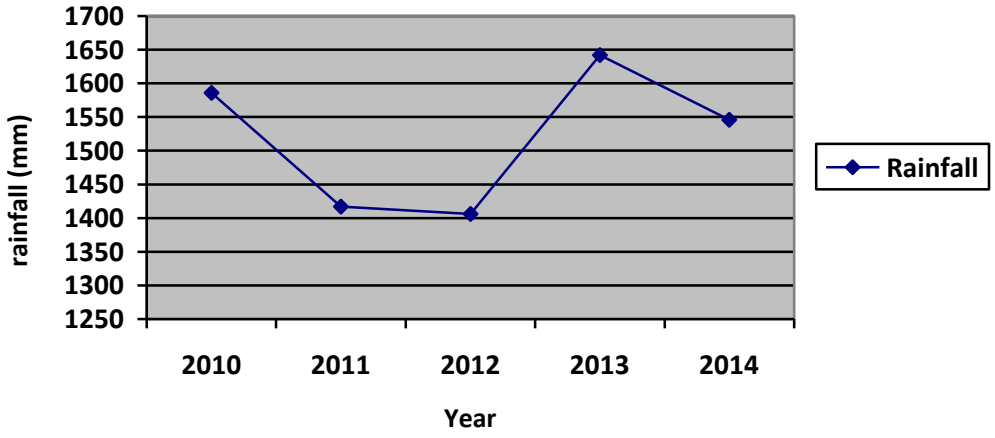

Figure 2. Five years Annual rainfall of study area (NMA, Jimma Branch)

The area characterized by warm climate with a mean annual minimum and maximum temperature of 14^{o}C and 30^{o}C respectively (NMA, 2015) (Fig.3).

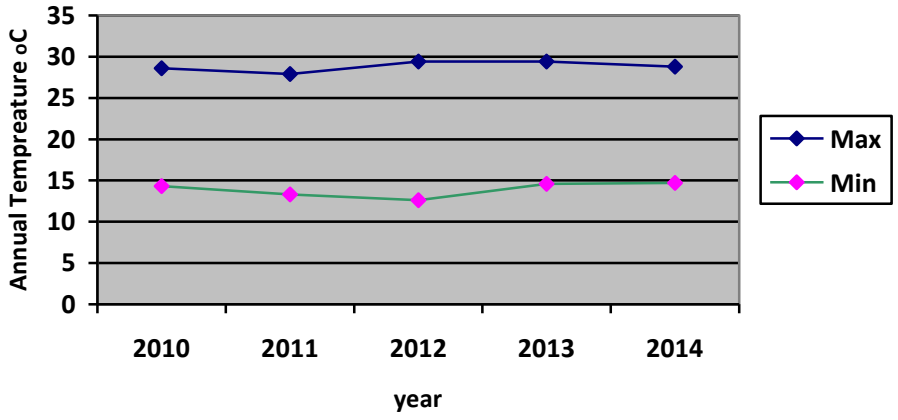

Figure 3. Annual temperature of the study area (NMA, Jimma Branch)

The water source of Boye wetland is from Boye River, whereas the source for kito and koffe wetlands is Kito River. The three wetlands are dominated by marshes and swamps with variable water level at different seasons. Boye is the largest (341.64 ha) of the three wetlands, followed by Koffe (284.4 ha) and Kito is the smallest (258.32

ha). Topographically, the three wetlands are situated on a flat land surrounded by small hills. The flat swampy grassland of the three wetlands is dominated by grass species including *Typhaceaeceae, Sporobolus pyramidus* and *Hyparrhenia rufa*. The surrounding land and small hills are covered by Eucalyptus plantation (*Eucalyptus grandis*); fruiting species and flowering trees. Likewise, Boye, Kito and koffe wetlands support greater number of bird species. Among these two endemic bird species to Ethiopia; Yellow-fronted Parrot (*Poicephalus flavifrons)* and Abyssinian Longclaw (*Macronyx flavicollis)* and two vulnerable species; Black Crowned-crane (*Balearica pavonina)* and Wattled Crane (*Bugeranus carunculatus)* were reported by Hayal (2006); Mekonnen and Aticho (2011) from Boye Wetland. Also Wattled Crane (*Bugeranus carunculatus*) is reported to breed in Koffe area (EWNHS, 1996).

3.2. Methods

3.2.1. Preliminary survey

Preliminary survey was conducted for six days between September13 to 18, 2014. During this period the map showing physical boundary of the three study sites was produced from GPS coordinate points recorded. This involves dividing up the study site with a grid, and then positioning walking transects line using stratified random sampling technique. Also familiarizing observers with the bird fauna and the habitats, obtaining local knowledge on distribution of key species and habitat types, major local uses of the wetlands, and practice on distance estimation was done during the survey.

3.2.2. Bird species diversity, distribution and abundance

In the study area, wet season extends from May to November and the dry season from December to April with unconditional rain between the seasons (NMA, 2014). To assess the diversity of water birds in the three wetlands and the variation with seasons, surveys were conducted from late September to early November, 2014 for wet and from December, 2014 to February, 2015 for dry season. Based on the size of their area, and habitat heterogeneity Boye and Koffe were divided into two blocks, but a block for Kito wetland. Consequently, two line transects (ranging between 1.5 and

1.8 km long at 500m space between) was established on each blocks for the avifaunal diversity survey.

Surveys were carried out for two days at each transect in both seasons. Depending on the species and habitat types bird species in 50-150 m sighting distance range from vantage points on either sides along the transect were recorded (Bibby et al., 1998) and the speed of walking on the route was 2km per hour (Bibby et al., 1992). Bird counting and species identification were carried out by recording groups assigned for each counting block. Survey result of the line transects of the block was summarized in a data sheet. Species were identified and counted by means of direct observation using binoculars (8×50). For the bird species identification, field guide (Redman *et al*., 2009) was used. Pictures were taken for further confirmation. The surveys (Data collection) were performed twice a day, from 06:30 to 10:00 hrs in the morning and between 16:00 and 18:00 hrs in the afternoon.

3.2.3. Habitat and environmental characteristics

The major land use patterns and the physiographic variability of wetlands of Boye, Kito and Koffe wetlands were examined from direct field observation. Purposive measurements were taken from the three wetlands to examine surface water area coverage change from wet to dry seasons.

3.24. Data Analysis

Shannon-Weiner **(H' = - Σ Pi ln Pi**) diversity index was used to evaluate the bird species diversity in each habitat (Rajashekara and Venkatesha, 2014).

Where, H' = Diversity Index; Pi = is the proportion of each species in the sample;

lnPi = natural logarithm of this proportion.

Species evenness among habitats in both wet and dry seasons was evaluated using Pielou evenness index (J) expressed as: **J = H'/ln S**

Where H´ is the diversity index, S is species number and ln is natural logarithm (Pielou, 1969).

Species richness was quantified using Margalef's index (D) for species richness expressed as: **RI= (S-1)/ln N** (Margalef, 1968). Where, S= Total number of species; N= Total number of individuals; ln = Natural logarithm

The similarity of the three study sites in terms of bird species composition was analyzed using Similarity index (**SI) = 2C/ A + B**) (Sorensen, 1948).
Where, SI = Similarity index
A = Number of species that occur in site A; B= Number of species that occur in site B
C = Number of common species that occur in site A and B

Variation in diversity of bird species among the wetlands and between seasons were tested by the paired independent t-test (Arthur, 2010). Also the occurrence of bird species at three wetland habitats were statistically tested by One way Anova f-test.

For describing frequency of occurrence and comparative abundance, the terms described by Bull (1974) were followed. The bird species found between 51 to 200 individuals were termed as very common, whereas those found between 21 to 50 individuals were considered as common species. Bird species, were termed as fairly common having population between seven and 20 individuals per day. Whereas those observed between one and six individuals were named as uncommon. Correspondingly, birds with one to six individuals per season were described as rare.

To evaluate the significance of the three wetlands in supporting species & ecological communities, the criteria (Criterion 2 & 3) for identifying wetlands of international importance by Ramsar convention (1971) were used.

4. Results

4.1. Species Composition

A total of 3321 individual birds of 107 species belonging to 42 families and 12 orders were recorded from the three wetland habitats. From 42 families documented Accipitridae, Ardeidae and Turdidae family contained the highest number of bird species recorded (8) , whereas 17 families (Anhingidae, Jacanidae, Recurvirostridae, Cuculidae, Meropidae, Coliidae, Bucerotidae, Bucorvidae, Capitonidae, Hirundinidae, Sturnidae, Pycnonotidae, Timaliidae, Malaconotidae, Zosteropidae, Fringillidae, and Numididae) represented by a single bird species (Table 1).

Table 1. Bird species composition of the three wetland habitats

Order	**Families**	**Total no of spp. recorded in the family**	**Number of spp recorded in each wetland habitats**		
			Boye	**Kito**	**Koffe**
Acciptriformes	Accipitridae * (1 spp.)	8	7	6	7
Anseriformes	Anatidae *	6	4	6	2
Charadriiformes	Charadriidae *	3	3	2	2
	Recurvirostridae *	1	1	1	0
	Scolopacidae *	4	4	4	4
Ciconiiformes	Ardeidae *	8	8	5	5
	Ciconiidae *	5	4	5	4
	Scopidae *	1	1	1	1
	Threskiornithidae *	5	5	5	3
Columbiformes	Columbidae	2	2	1	2
Coraciiformes	Alcedinidae*	5	4	5	3
	Bucerotidae	1	0	1	1
	Bucorvidae	1	0	1	1
	Coliidae	1	1	1	1
	Meropidae	1	1	1	1
Cuculiformes	Cuculidae	1	1	1	1

Galliformes	Numididae	1	0	1	1
Gruiformes	Gruidae *	2	1	2	1
	Jacanidae *	1	1	1	1
	Rallidae *	3	3	2	0
Passeriformes	Corvidae	3	3	3	3
	Estrildidae	2	2	1	1
	Fringillidae	1	1	1	0
	Hirundinidae	1	1	1	1
	Laniidae	2	2	2	2
	Malaconotidae	1	0	1	0
	Motacillidae	3	2	2	3
	Muscicapidae	4	2	4	3
	Nectariniidae	2	1	2	1
	Platysteiridae	2	1	2	1
	Ploceidae	3	3	3	3
	Pycnonotidae	1	1	1	1
	Sturnidae	1	0	0	1
	Timaliidae	1	0	1	1
	Turdidae	8	5	4	5
	Viduidae	2	1	2	1
	Zosteropidae	1	0	1	1
Pelecaniformes	Anhingidae *	1	1	1	1
	Pelicanidae *	2	1	2	0
	Phalacrocoracidae*	2	2	1	1
Piciformes	Capitonidae	1	0	1	0
	Picidae	3	0	3	1
Total		**107**	**80**	**91**	**72**

Note: * families contained wetland specialist birds

During wet season a total of 92 overall species were recorded from the three wetland habitats. Among them 44 were waterbird species and 48 were wetland generalist bird species. Where from Boye 65 overall bird species (33 wetland specialist & 32 generalist); 74 bird species (35 specialists & 39 generalist) from Kito and 60 bird species (24 wetland specialist & 36 generalist) were recorded from Koffe wetland. Likewise, during dry season a total of 92 bird species were recorded from the three wetland habitats. of which 42 were wetland specialist birds and the remaining were wetland generalist bird species . Where from Boye 68 bird species (40 wetland specialists & 28 generalist); 60 bird species (32 wetland specialists & 28 generalist) from Kito and 55 bird species (i.e. 21 wetland specialists & 34 generalist) from Koffe wetland were recorded. Seventy seven (77) bird species were common for both seasons (Fig. 2).

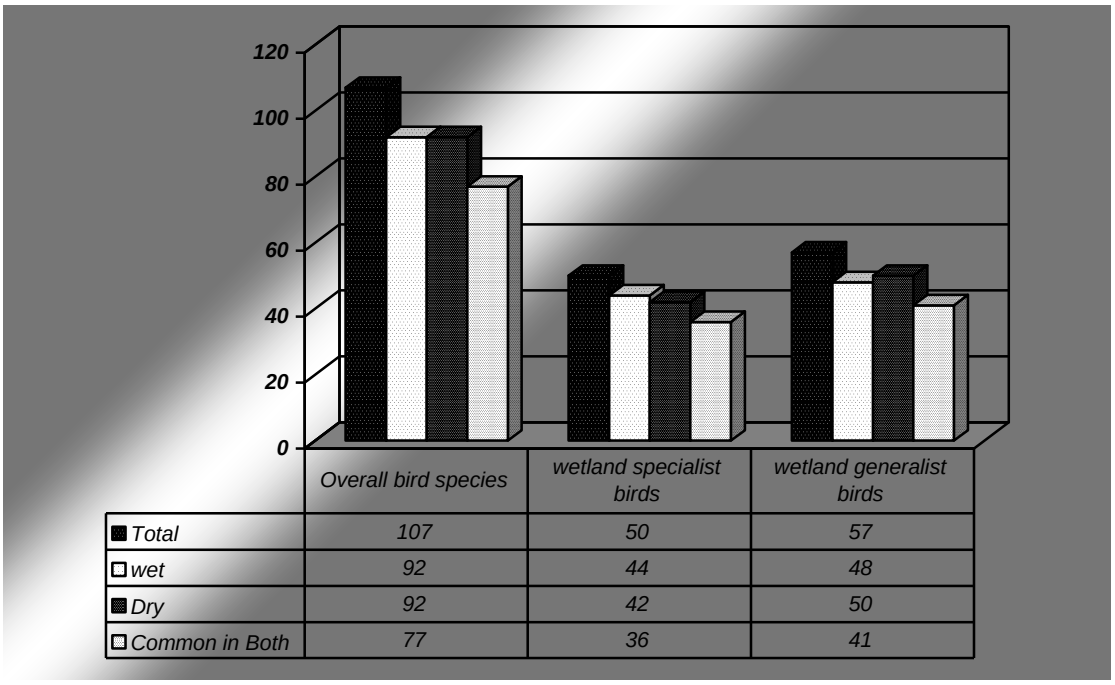

Figure 4. Seasonal occurrences of overall bird species

4.2. Bird species diversity and richness

4.2.1. Overall bird diversity

The highest overall bird species (diversity (H': 3.537) was recorded from Koffe wetland and least (H': 3.427) from Boye during the wet season. Whereas in the dry season the highest (H`: 3.422) was at Boye wetland and least (H`: 3.121) in Kito

wetland. Further, the diversity indices of overall bird species between wet and dry season were significantly different in Koffe wetland (t= 2.669, P<0.05). While the highest overall bird species richness (RI=11.1) was recorded from Kito wetland and least (RI= 9.4) from Koffe during the wet season. However, during the dry season the highest (RI= 10.4) richness were recorded on Boye wetland and least (RI=9.2) on Koffe. The richness indices of overall bird species between wet and dry season were significantly different only in Kito wetland (t= 2.056, P<0.05, n=90). Likewise, the highest (J= 0.864) evenness of overall bird species was recorded from Koffe wetland and least (J=0.811) from Kito during wet season. During dry season, the highest (J= 0.811) was at Boye wetland and least (J= 0.762) in Kito (Table 2).

Table 2. Diversity estimates of overall bird species among the three wetland habitats of wet and dry season.

Habt. name	**S**		**N**		**RI**		**H`**		**lnS**		**J**	
	W	D	W	D	W	D	W	D	W	D	W	D
Boye	65	68	504	625	10.3	10.4	3.427	3.422	4.174	4.219	0.821	0.811
Kito	74	60	719	585	11.1	9.3	3.493	3.121	4.304	4.094	0.811	0.762
Koffe	60	55	527	361	9.4	9.2	3.537	3.313	4.094	4.007	0.864	0.809

4.2.2. Wetland specialist bird species diversity

During wet season, the highest (H`: 2.727) wetland specialist bird species diversity were recorded from Boye wetland and smallest (H`: 2.383) from Koffe, although in dry season the highest (H`: 2.935) were at Boye wetland and smallest (H`: 2.397) in Kito. The diversity indices of various wetland specialist bird populations between wet and dry season were significantly different at Boye and Koffe wetlands (at t= -2.201, n=43 and t=2.309, n= 28 where P<0.05). Consequently, Wetland specialist bird species richness index showed that, during wet season the highest (RI=5.6) wetland specialist bird richness were at Kito wetland and least (RI= 4.2) at Koffe. Whereas, during dry season the highest (RI= 6.5) were recorded from Boye and smallest (RI= 4.1) from Koffe. The richness indices of various wetland specialist bird populations at

the three wetlands between wet and dry seasons were not significantly different (at t= -1.857, n= 43; t= 0.65, n= 43 and t= 1.154, n= 28 where P>0.05). Meanwhile; Pielou evenness index showed that, during wet season the highest (J= 0.78) wetland specialist bird evenness were at Boye wetland and smallest (J= 0.725) in Kito; while, during dry season the highest were (J= 0.81) in Koffe wetland and smallest (J= 0.692) were at Kito (Table 3).

Table 3. Diversity estimates of wetland specialist bird species among three study sites in wet and dry season

Habt.	S		N		RI		H`		lnS		J	
name	W	D	W	D	W	D	W	D	W	D	W	D
Boye	33	40	349	410	5.5	6.5	2.727	2.935	3.496	3.688	0.78	0.80
Kito	35	32	413	376	5.6	5.2	2.577	2.397	3.555	3.465	0.725	0.692
Koffe	24	21	239	123	4.2	4.1	2.383	2.455	3.178	3.044	0.75	0.866

4.2.3. Wetland generalist bird species diversity

Highest (H'=3.236) wetland generalist species diversity during wet season was recorded from koffe wetland and smallest (H'=3.026) from Boye; while, during dry season highest (H'=3.015) was recorded from Koffe and smallest (H'=2.456) from Boye. The diversity indices of various wetland generalist bird species at the three wetlands between wet and dry seasons were not significantly different (at t=1.160, n=35; t=2.202, n=46 and t=0.496, n=42; where; P>0.05). Likewise, during wet season the highest (RI= 6.6) wetland generalist bird species richness were recorded at Kito wetland and smallest (RI=6.1) at Boye. During dry season, the highest (RI=6.2) terrestrial bird richness were on Koffe, while smallest (RI= 5.0) were in Boye and Kito. The richness indices of wetland generalist species between wet and dry season were significantly different only in Kito wetland (t= 2.202, n=46 where; P<0.05). Thus, the highest (J=0.903) evenness was on Koffe wetland and smallest (J=0.828) in kito during wet season; whereas, during dry season the highest (J=0.855) evenness were in Koffe and smallest (J=0.737) in Boye wetland (Table 4).

Table 4: Diversity estimates of wetland generalist birds among the three wetland habitats of wet and dry season

Habt.name	**S**		**N**		**RI**		**H`**		**lnS**		**J**	
	W	D	W	D	W	D	W	D	W	D	W	D
Boye	32	28	155	215	6.1	5.0	3.026	2.456	3.466	3.332	0.873	0.737
Kito	39	28	306	209	6.6	5.0	3.036	2.594	3.663	3.332	0.828	0.778
Koffe	36	34	288	238	6.2	6.2	3.236	3.015	3.583	3.526	0.903	0.855

4.3. Similarity Index

4.3.1. Seasonal species similarity

The highest (SI= 0.79 or = 79%) similarity of overall bird species between wet and dry season was observed at Boye and less similarity (SI=0.64 or= 64 %) were at Kito wetland (Table 5).

Table 5. Overall bird species similarity (SI) within habitats during the wet and dry seasons.

Habitat	Wet	Dry	Common species	SI	% SI
Boye	65	68	53	0.79	79
Kito	74	60	43	0.64	64
Koffee	60	55	43	0.75	75

High similarity (SI= 0.79 = 79%) of wetland specialist bird species within habitat between wet and dry seasons was observed at Boye wetland; while, less similarity (SI= 0.68 or= 68%) were at Kito wetland (Table 6).

Table 6. Wetland specialists bird species similarity (SI) within habitat during wet and dry seasons.

Habitat	Wet	Dry	Common species	SI	% SI
Boye	33	40	29	0.79	79%
Kito	35	32	23	0.68	68%
Koffee	24	21	16	0.71	71%

While, wetland generalist birds species similarity between wet and dry season was high (SI=0.8) at Koffe and less (SI=0.59) at Kito wetland (Table 7).

Table 7. Wetland generalist birds species similarity within habitat during wet and dry seasons.

Habitat	Wet	Dry	Common species	SI	% SI
Boye	32	28	23	0.76	76%
Kito	36	28	20	0.59	59%
Koffee	36	34	27	0.8	80%

4.3.2. Species Similarity between habitats

During wet season, overall bird species similarity was high (SI= 0.79) between Kito and Koffe wetlands. Besides in dry season high similarity (SI= 0.70) was recorded between Boye and Kito wetland habitats (Table 7).

Table 8. **.** Overall bird species similarity between habitats in wet and dry seasons

Habitat	Boye		Kito		Koffe	
	wet	dry	Wet	Dry	wet	Dry
Boye	-	-	54(0.78) (78%)	45(0.70) (70 %)	47(0.75) (75%)	40(0.65) (65%)
Kito			-	-	53(0.79) (79%)	39(0.68) (68%)
Koffe					-	-

The highest wetland specialist bird species similarity (SI= 0.79 and 0.77) in both wet and dry seasons was recorded between Boye and Kito wetlands (Table 8). The occurrence of water bird species at three habitats was significantly different (One way Anova, F= 9.696, P<0.05).

Table 9. Wetland specialist bird species similarity between habitats in wet and dry seasons

Habitat	Boye		Kito		Koffe	
	Wet	Dry	Wet	dry	wet	Dry
Boye	-	-	27(0.79) (79%)	28(0.77) (77%)	22((0.77) (77%)	20(0.66) (66%)
Kito					23(0.78) (78%)	19(0.72) (72%)
Koffe					-	-

Although, during wet season similarity of wetland generalist birds species was high (SI= 0.79) between Boye and Kito wetlands. However, dry season high similarity (SI= 0.64) was recorded between Boye and Koffe as well between Kito and Koffe wetland habitats (Table 10).

Table 10. Wetland generalist birds species similarity between habitats in wet and dry seasons

Habitat	**Boye**		**Kito**		**Koffe**	
	Wet	Dry	Wet	Dry	Wet	Dry
Boye			27(0.78) (78%)	17(0.6) (60%)	25(0.73) (73%)	20(0.64) (64%)
Kito					30(0.66) (66%)	20(0.64) (64%)
Koffe						

4.4. Abundance

4.4.1. Overall bird abundance

A total of 1129, 1306 and 888 individual of wetland specialist and generalist birds were recorded from Boye, Kito and Koffe wetlands in both wet and dry seasons. Highest number (N=719) of overall individual birds were recorded from Kito wetland and least (N=504) from Boye during wet season. During dry season, the highest (N=625) number of individual were recorded from Boye wetland and least (N=361) from Koffe (Fig. 3).

Abundance of overall bird increased from 504 to 625 in Boye wetland, respectively from wet to dry seasons. While, the abundance of overall birds decreased 719 to 585 and 527 to 361 at Kito and Koffe wetlands respectively wet to dry seasons (Fig 3).

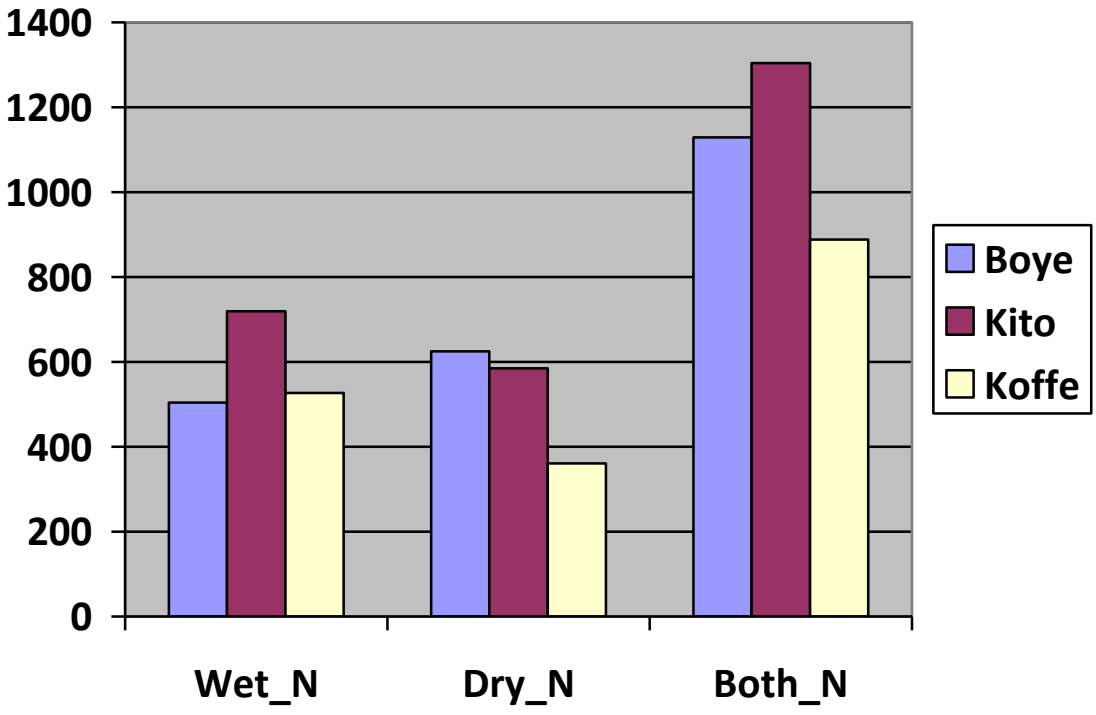

Figure 5. Abundance of individuals (N) overall birds species in the three wetlands

During the wet season, the status of local occurrence was very common for 10, common for 10, uncommon for 39 and rare for 30 overall bird species. Among overall bird species recorded during dry season, 7 species scored very common, 9 species common, 47 species uncommon and 29 species were observed rarely (Table 9).

Table 11. Overall bird species local occurrence status during wet and dry season at three habitats

No	Order	No. of Families		No. of species		Occurrence							
						VC		C		Un		R	
		W	D	W	D	W	D	W	D	W	D	W	D
1	Acciptriformes	1	1	7	7	1	-	2	4	1	-	3	3
2	Anseriformes	1	1	6	4	2	2	1	-	2	1	1	1
3	Charadriiformes	3	3	5	8	-	-	-	-	2	6	3	2
4	Ciconiiformes	4	4	16	19	3	3	1	2	6	4	6	10
5	Columbiformes	1	1	2	2	-	-	1	-	1	2	-	-
6	Coraciiformes	1	4	7	7	-	1	1	-	1	1	5	5
7	Cuculiformes	1	1	1	1	-	-	-	-	1	-	-	1
8	Galliformes	1	1	1	1	-	-	-	-	1	1	-	-
9	Gruiformes	3	3	6	4	-	-	2	1	-	1	4	2
10	Passeriformes	15	14	33	33	4	1	2	3	13	9	14	19
11	Pelecaniformes	3	3	5	3	-	-	-	-	3	2	2	1
12	Piciformes	2	1	3	3	-	-	-	-	-	-	3	3

Note: W= Wet season; D= Dry season VC= Very Common; C= Common; Un= Uncommon; R= Rare

4.4.2. Wetland specialist waterbirds abundance

A total of 759, 789 and 362 wetland specialist birds individuals were recorded from Boye, Kito and Koffe wetlands in wet and dry season. During wet season, the highest (N=413) abundance of wetland specialist birds was recorded from kito wetland and least (N=239) from Koffe wetland; whereas during dry season the highest (N=410) abundance were at Boye wetland and least (N=123) in Koffe (Fig 4).

Thus, wetland specialist birds abundance increased from 349 to 410 at Boye wetlands from wet to dry seasons. While, waterbirds decreased from 413 to 376 and 239 to 123 at Kito and Koffe wetlands, respectively from wet to dry seasons (Fig 4).

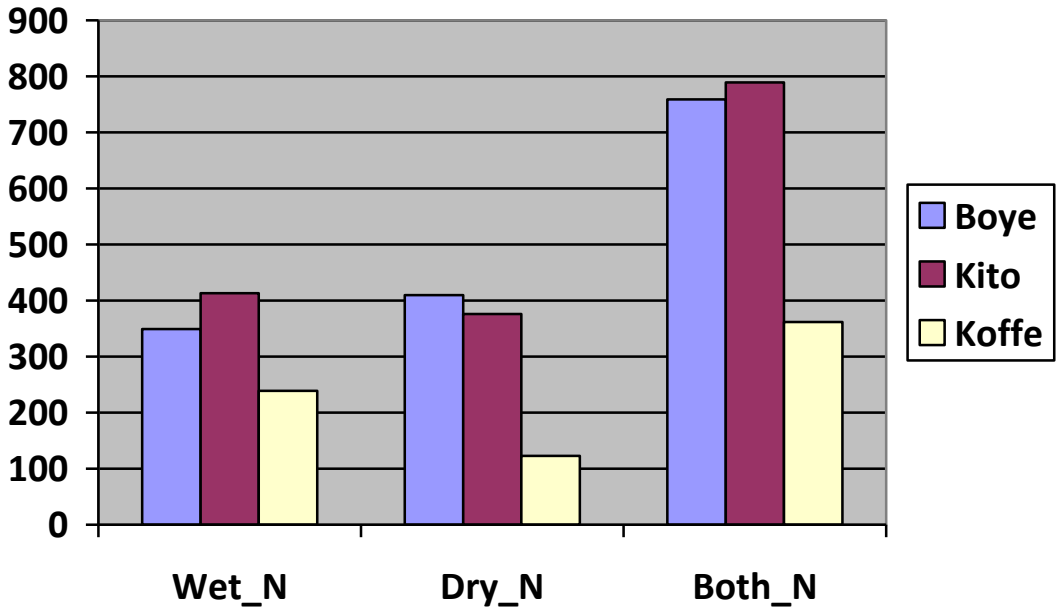

Figure 6. Abundance of wetland specialist birds individuals in the three wetlands

4.5. Habitat land-use

The socio-economic activities and the major land-use system in these three wetland habitats were recorded. Table 10 shows the major land-use practices in the three wetlands. Encroachment for farming, bricks production and grazing were commonly observed practices in Kito and Boye wetlands. Whereas, Municipal waste disposal, Eucalyptus plantation and grazing were the main activities in Koffe wetland.

Table 10. Major land-use of Boye, Kito and koffe wetland Habitats

Habitat	Main land-uses	High	Medium	Low
Boye	Encroachments	✓		
	Cropland	✓		
	Bricks production		✓	
	Grazing			✓
Kito	Cropland	✓		
	Encroachments		✓	
	Grazing		✓	
	Bricks production			✓
Koffe	Eucalyptus plantation	✓		
	Municipal waste dispose		✓	
	Grazing		✓	

4.6. Habitat characteristics

During field observation of study year, habitat variables included surface area coverage of water, vegetation coverage and wetland connectivity was reduced in dry season than that has been at wet season. Result of purposive measurement taken from three wetlands at dry season shows that (Table 11.), the water coverage (wetland size/Marshes & swampy) was reduced up to 35 m (in Boye), 43 m (in Kito) and 61 m (in Koffe) on average from the edge that has been of wet season.

Table 11. Wetland habitats size reduction of three study sites in dry season

Wetland	**Wetland total area (he.)**	**Average water coverage reduced (M)**
Boye	341.64	35
Kito	258.32	43
Koffe	284.4	61

5. Discussion

5.1. Bird species composition and diversity of three wetlands

The present study revealed seasonal variability of avifaunal composition in Boye, Kito and koffe wetlands. There were 107 (i.e. 22 migrants, 4 threatened and 5 endemic/near-endemic) species of wetland specialist and generalist bird species recorded in the three wetland habitats with wet and dry seasons of the year. Family Accipitridae, Ardeidae and Turdidae had the highest number of bird species. Family Anhingidae, Jacanidae, Recurvirostridae, Cuculidae, Meropidae, Coliidae, Bucerotidae, Bucorvidae, Capitonidae, Hirundinidae, Sturnidae, Pycnonotidae, Timaliidae, Malaconotidae, Zosteropidae, Fringillidae, and Numididae had only one species each. While, Kantrud and Stewart (1984) reported that Seasonal and semi-permanent wetlands provided habitat for the largest proportion of the population of all species, the current study however, found that the overall bird species (both wetland specialist and generalist birds) diversity indices across the three wetlands were high in both wet ($H' = 3.427 – 3.537$) and dry ($H` = 3.121 – 3.422$) seasons. The diversity and community composition of bird species indicated that these three wetland habitats are extensively utilized by water birds and land birds to acquire their daily requirements such as food, shelter and water and considered internationally important maintaining species and ecological communities. A wetland should be considered internationally important if it support vulnerable, endangered, critically endangered species or threatened ecological communities (Ramsar, 1971).

Of the total 107 overall bird species recorded 50 species were wetland specialist waterbird species (i.e. 34 residents, 16 migrant, 2 threatened and 1 near-endemic). This indicates, the three wetlands are ideal habitat for resident wetland specialist waterbird species and stopover for migrant wetland specialist waterbird species in order to forage, loaf, rest and refuel their energy. The divergent habitats (land use patterns), seasonality of rainfall and seasonal variation result changes in wetland size and richness of food resources, are factors determining the habitat selection of wetland birds (Gaston *et al*., 2000; Bolwig *et al*., 2006; Guadagnin et at., 2009).

Correspondingly, recording higher wetland specialist waterbird species richness and diversity at Boye wetland in wet and dry seasons may in part explain that presence of differing habitat conditions including water surface area and vegetation coverage for roosting/nesting/ and the availability of food sources in the habitat, whereas Koffe was least waterbird diversity and richness in wet and dry seasons because of less surface water and vegetation coverage and greater human interference. Kushland (1987) explained that wetland dependent birds used the availability of water in the whole of spring, as proximate cues to assist in their broad scale selection of habitat preference. Thus, wetland specialist waterbird community structures (i.e. species richness, distribution, and diversity) is influenced by different factors such as availability and richness of food resources, water depth, size of the effective foraging area (Burkert et al. 2004; Gillis et al. 2008; Lentz-Cipollini & Dunson 2006) and the abiotic changes in the wetlands (Jaksic 2004; Lagos et al. 2008; Wrona et al. 2006).

Plate 1. Some of wetland specialist waterbird species on Boye wetland habitat during the dry season (Photo by Tamirat Megersa)

Plate 2. Yellow-billed Egret from Kito wetlands (Photo by Tamirat Megersa)

Plate 3. Black-headed Heron From Koffe (Photo by Tamirat Megersa)

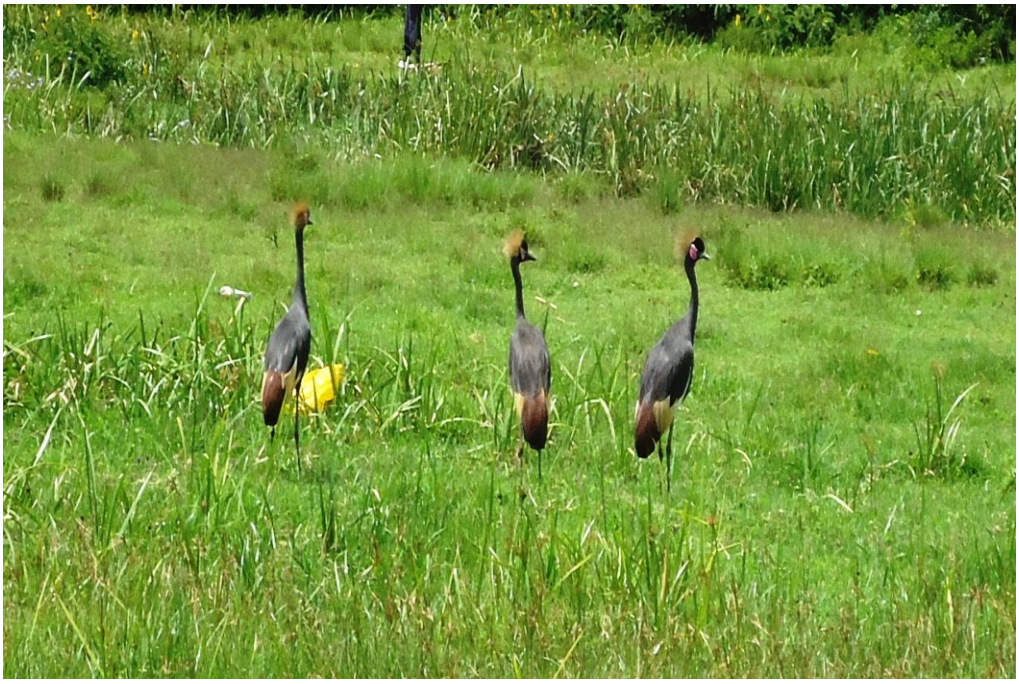

Plate 4. Black Crowned Crane From Koffe wetland during dry season (Photo by Tamirat Megersa)

Likewise, the recording of 57 wetland generalist bird species (i.e. 51 residents, 6 migrant, 2 threatened and 4 endemic/near-endemic) indicated that this habitats is not only preferred by water birds but are also utilized by land bird species for food and shelter. The occurring of higher number of wetland generalist bird species could also be due to the diversity of vegetations (grass species such as *Typhaceaeceae*,

Hyparrhenia rufa; plant species including *Carissa edulis, Lantana trifolia*, *Psidium guajava*; Eucalypts plantation (*Eucalyptus grandis*); fruiting species (i.e. ficus trees) and flowering trees) had attracted different fruit eating birds and nectarivore bird species to nip the nectar and prey on insects.

The result of species diversity and richness analysis revealed that wetland generalist birds had highest diversity than wetland specialist waterbird species in all habitats at both seasons. Among the three habitats the highest wetland generalist bird species diversity (H'=3.236 & H'=3.015) were recorded at Koffe wetland for both seasons. This was due to, presence of more diversity vegetation and coverage of tree species adjacent to koffe wetland gives more choice for food preference as well as nesting ground for wetland generalist birds. Petersen and Westmark (2013) point out that bird species richness and diversity within wetlands were positively correlated with percent cover of tree.

Plate 5. Some of wetland generalist bird species recorded (Photo by Tamirat Megersa)

5.2. Seasonal occurrence of water bird species between habitats

Species composition differed among areas and months because of habitat differences, seasonal movement patterns, local and regional habitat changes, large-scale population changes and climatic conditions (Ericia et al. 2005). The present study revealed seasonal occurrence of waterbird species of three wetlands was different. Although surface water and vegetation coverage of Boye wetland had decreased in the dry season, wetland specialist wetland specialist waterbird diversity and abundance

was fairly high than wet season, thus may be associated with immigration (Berthold, 1993). Whereas, occurrence of wetland specialist waterbird species in Kito and Koffe wetlands was decreased in dry season than wet season and may be because of habitat change, grazing intensity and bushfires in dry season occurred in these two wetland habitats.

5.3. Threats to avifauna in the habitats

During field observation of this study, different type of land use and socio-economic activities in relation to three wetlands such as agriculture, illegal human settlements, grazing, brick making, Municipal waste dispose, and presence of large area coverage of Eucalyptus plantation has been observed. This study did not sample correlation analysis of bird species community with habitat quality, But Mekonnen and Aticho (2011) found that drainage for agricultural and other land use types has altered Boye wetland ecosystem that had effect on bird species.

There have been reported declines in the global diversity of habitat-specific birds and shorebird populations, between 1980 – 2007 (Butchart, S. H.,. et.al., 2010). This decline has been linked to a number of anthropogenic factors, including pollution (Gordon C. et.al., 1998), water fluctuations (Riffell, S. K., 2001, Timmermans, S. et.al., 2008), cutting of mangrove vegetation (ttuqueyefio, D. K. and F. Gbogbo, **2001**), habitat and landscape configuration (Caziani et al. 2001, Stickney et al. 2002) and the influence of the surrounding physiographic matrix (Czech and Parsons 2002). All these factors are probably involved in the species gradients found at Boye, Kito and koffe wetlands; and therefore deserve further attention.

Plante 6. Encroachments at Boye and Kito wetlands (Photo by Tamirat Megersa)

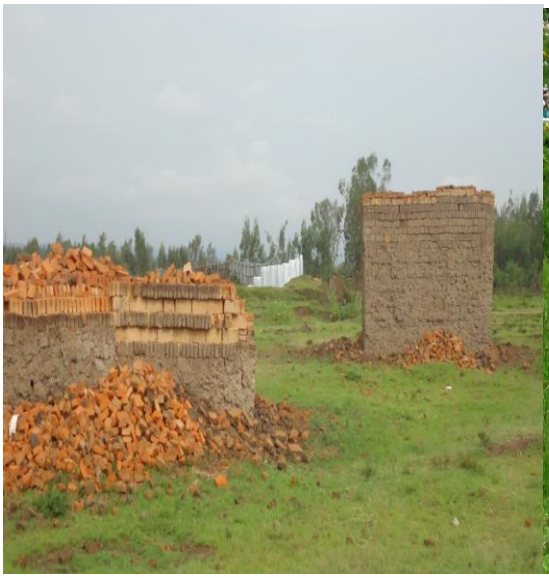

Plate 7. Bricks production from Boye

Plate 8. Municipal waste from Koffe

(Photo by Tamirat Megersa)

6. Conclusions and Recommendations

6.1. Conclusion

The results of this study indicated that Boye, Kito and Koffe wetlands are potential habitats for a wide array of water birds that include migratory, endemic and globally threatened species of conservation concern. The presence of good surface water and vegetation coverage in Boye and Kito wetlands which favored food preference and nesting ground has resulted high wetland specialist waterbird species richness, diversity and evenness than Koffe wetland. The turnover between wet and dry resulted were small seasonal variations in the number of water bird species. Thus, the higher diversity of terrestrial birds was found in Koffe wetland. This was due to, presence of more diversity vegetation and coverage of tree adjacent to koffe wetland gives more choice for food preference as well as nesting ground for terrestrial birds.

The presented study also observed the surge of wetland specialist waterbird abundance was decreased in Kito and koffe wetlands respectively from wet seasons to dry seasons. This may be due to less surface water and vegetation coverage and occurrence of bushfire were during dry season in two wetland habitats. Unlikely the increase of wetland specialist waterbird abundance at Boye wetland may be because of winter/or local/ migration.

This study also revealed that presence of different types of land use and socio-economic activities in relation to three wetlands such as agriculture, illegal human settlements, grazing, brick making, Municipal waste disposal, and large area coverage of Eucalyptus plantation pose major threats to these wetlands.

6.2. Recommendations

Although the three wetlands supported several water and terrestrial birds, they had no conservation attentions from concerned bodies. The variety of land-use patterns and anthropogenic alterations observed to the three wetland habitats are major threats facing water birds. Further follow up studies for a longer period will help to determine species-specific conservation measures for wetland dependent birds. As a precautionary measure a specific awareness programme should be initiated to educate the peoples and resource users to protect water birds. For conserving the three wetland habitats and biodiversity, a management plan should be prepared emphasizing an avenue for the sustainable utilization of resources of the wetland without jeopardizing its continued ecological values and functions.

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Appendix 1. Bird species composition, residential and conservation status in the three habitats

No	Common name	*Scientific name*	Status
Order:	**Ciconiiformes**		
Family:	**Ardeidae**		
1	Grey Heron↑↓	*Area cinerea*	RE/B
2	Black-headed Heron↑↓	*Ardea melanocephala*	RE/B
3	Purple Heron↓	*Ardea purpurea*	WM
4	Cattle Egret↑↓	*Bubulcus ibis*	RE/B
5	Yellow-billed Egret↑↓	*Egretta intermedia*	RE/B
6	Indian Pond heron↓	*Ardeola idea*	WM
7	Great White-egret↑↓	*Egretta alba*	RE/B
8	Yellow Bittern↓	*Ixobrychus sinensis*	WM
Family:	**Ciconiidae**		
9	African Openbill↑↓	*Anastomus lamelligerus*	M
10	Yellow-billed Stork↑↓	*Mycteria ibis*	RE
11	Saddle-billed Stork↑↓	*Ephippiiorhynchus senegalensis*	RE
12	Abdim`s Stork↑↓	*Ciconia abdimii*	WM
13	Woolly-necked Stork↑↓	*Ciconia episcopus*	RE
Family:	**Scopidae**		
14	Hamerkop↑↓	*Scopus umbretta*	RE/B
Family:	**Threskiornithidae**		
15	Hadada Ibis↑↓	*Bostrychia caruculata*	RE/B
16	Glossy Ibis↑↓	*Plegadis falcinellus*	WM
17	Africa Sacred Ibis↑↓	*Threskiornis aethiopicus*	RE/B
18	Wattled Ibis↑↓	*Bostrychia carunculata*	RE/B, NE

19	African Spoonbill↑↓	*Platalla alba*	LM
Order:	**Pelecaniformes**		
Family:	**Pelicanidae**		
20	Great White-pelican↑↓	*Pelecanus onocrotalus*	RE
21	Pink-backed Pelican↑	*Pelecanus rufescens*	RE
Family:	**Phalacrocoracidae**		
22	Long-tailed Cormorant↑↓	*Phalacrocorax lucidus*	RE/B
23	Great Cormorant↑	*Phalacrocrorax carbo*	LM
Family:	**Anhingidae**		
24	African Darter↑↓	*Anhinga rufa*	RE
Order:	**Anseriformes**		
Family:	**Anatidae**		
25	Egyptian Goose↑↓	*Alopochen aegyptiaca*	RE/B
26	Knob-billed Duck↑↓	*Sarkidiornis melanotos*	NBM
27	Yellow-billed Duck↑↓	*Anas undulate*	RE/B
28	White-faced Whistling Duck↑	*Dendrocygna viduata*	LM
29	Spur-winged Goose↑	*Plectroptrerus gambensis*	LM
30	Hottentots Teal↑↓	*Anas hottentola*	RE/B
Order:	**Acciptriformes**		
Family:	**Accipitridae**		
31	African Fish-eagle↑↓	*Haliaeetus vocifer*	RE/B
32	Augur Buzzard↑	*Buteo augur*	RE/B
33	Hooded Vulture↑↓	*Necrosyrtes monachus*	RE/B
34	White-headed Vulture↓	*Trigonoceps occipitalis*	RE/B
35	African White-backed Vulture↑↓	*Gyps africanus*	RE/B
36	Black Kite↑↓	*Milvus migrans*	RE/B
37	Tawny Eagle↑↓	*Aquila rapax*	RE/B

38	Long- crested Eagle↑↓	*Lophaetus occipitalis*	RE/B
Order:	**Gruiformes**		
Family:	**Rallidae**		
39	Black Crake↑↓	*Amaurornis flavirostra*	RE/B
40	Lesser Moorhen↑	*Gallinula angulata*	B/M
41	Common Moorhen↑↓	*Gallinula chloropus*	RE/B
Family:	**Gruidae**		
42	Black-crowned Crane↑↓	*Balearica pavonina*	RE/NT
43	Wattled Crane↑	*Grus carunculatus*	RE/VU
Family:	**Jacanidae**		
44	African Jacana↑↓	*Actophilorins africanus*	RE/B
Order:	**Charadriiformes**		
Family:	**Recurvirostridae**		
45	Black-winged Stilt↑↓	*Himantopus himantopus*	RE/B
Family:	**Charadriidae**		
46	African wattled Plover↑↓	*Vanellus senegallus*	RE/B
47	Three-banded Plover↓	*Charadrius tricollaries*	RE/B
48	Spur-winged Plover↑↓	*Vanellus spinosus*	RE/B
Family:	**Scolopacidae**		
49	Common Sandpiper↑↓	*Common Sandpiper*	WM
50	Marsh Sandpiper↑↓	*Marsh Sandpiper*	RE
51	Wood Sandpiper↓	*Wood Sandpiper*	WM
52	Little Stint↓	*Calidris minuta*	WM
Order:	**Columbiformes**		
Family:	**Columbidae**		
53	Speckled Pigeon↑↓	*Columbia guinea*	RE/B
54	Red-eyed Dove↑↓	*Streptopelia semitorquata*	RE/B
Order:	**Cuculiformes**		

Family:	**Cuculidae**		
55	Blue-headed Coucal↑↓	*Centropus monachus*	RE/B
Order:	**Coraciiformes**		
Family:	**Alcedinidae**		
56	Malachite Kingfisher↑↓	*Alcedo cristata*	RE/B
57	Woodland Kingfisher↑↓	*Halcyon senegalensis*	RE/B
58	Giant Kingfisher↑	*Megaceryle maxima*	RE/B
59	Pied Kingfisher↑↓	*Ceryle rudis*	RE/B
60	Grey-headed Kingfisher↑	*Halcyon leucocephala*	RE/B
Family:	**Meropidae**		
61	Little Bee-eater↑↓	*Merops pusillus*	RE/B
Family:	**Coliidae**		
62	Speckled Mousebird↑↓	*Colius striatus*	RE/B
Family:	**Bucerotidae**		
63	Silvery-cheeked Hornbill↓	*Bycanistes brevis*	RE/B
Family:	**Bucorvidae**		
64	Abyssinian Ground-hornbill↓	*Bucorvus abyssinicus*	RE/B/NE
Order:	**Piciformes**		
Family:	**Capitonidae**		
65	Double-toothed Barbet↑	*Lybius bidentatus*	RE
Family:	**Picidae**		
66	Nubian Woodpecker↑↓	*Campethera nubica*	RE
67	Cardinal Woodpecker↑↓	*Dendropicos fuscescens*	RE
68	Eurasian Wryneck↓	*Jynx torquilla*	M
Order:	**Passeriformes**		
Family:	**Hirundinidae**		
69	Wire-tailed Swallow↑↓	*Hirundo smithii*	RE/B
Family:	**Laniidae**		
70	Grey-backed Fiscal↑↓	*Lanius excubitoroides*	RE/B

71	Common Fiscal↑↓	*Lanius collaris*	RE/B
Family:	**Sturnidae**		
72	Greater Blue-eared Starling↑↓	*Lamprotornis chalybaeus*	RE/B
Family:	**Corvidae**		
73	Cape Crow↑↓	*Corvus capensis*	RE/B
74	Pied Crow↑	*Corvus albus*	RE/B
75	Thick-billed Raven↑↓	*Corvus crassirostris*	RE/B/NE
Family:	**Pycnonotidae**		
76	Common Bulbul↑↓	*Pycnonotus barbatus*	RE/B
Family:	**Timaliidae**		
77	White-rumped Babbler↑↓	*Turdoides leucopygia*	RE/B
Family:	**Muscicapidae**		
78	African Paradise Flycatcher↑↓	*Terpsiphone viridus*	RE/B
79	Northern Black Flycatcher↑↓	*Melaenornis edolioides*	RE/B
80	Abyssinian Dusky Flycacther↑↓	*Muscicapa adusta*	RE/B/NE
81	Eastern Grey Plantain-eater↑↓	*Crinifer zonurus*	RE/B
Family:	**Nectariniidae**		
82	Scarlet-chested Sunbird↑↓	*Chalcomitra senegalensis*	RE/B
83	Variable Sunbird↑↓	*Cinnyris venustus*	RE/B
Family:	**Ploceidae**		
84	Little Weaver↑↓	*Ploceus luteolus*	RE/B
85	Village Weaver↑↓	*Ploceus cucullatus*	RE/B
86	Fan-tailed Widowbird↑↓	*Euplectes axillatis*	RE/B
Family:	**Malaconotidae**		
87	Ethiopian Boubou↑	*Laniarius aethiopicus*	RE/NE
Family:	**Zosteropidae**		

88	Abyssinien White-Eye↑↓	*Zosterops abyssinicus*	RE/B
Family:	**Platysteiridae**		
89	Brown-throated Wattle-eye↑	*Platysteira cyanea*	RE/B
90	Black-headed Batis↑	*Batis minor*	RE/B
Family:	**Motacillidae**		
91	Yellow Wagtail↑↓	*Motacilla flava*	RE/B
92	Abyssinian Longclaw↑↓	*Morconyx Flavicollis*	RE/B/E/ NT
93	Plain-backed Pipit↓	*Anthus leucophrys*	RE/B
Family:	**Turdidae**		
94	Northern Wheatear↑↓	*Oenanthe oenanthe*	WM
95	Pied Wheatear↓	*Oenanthe pleschanka*	WM
96	Cyprus Wheatear↓	*Oenanthe cypriaca*	WM
97	Common Rock Thrush	*Monticola Saxatilis*	WM
98	Ruppell`s Robin-Chat↑↓	*Cossypha semirufa*	RE/B
99	African Thrush↑↓	*Turdus pelios*	RE/B
100	Little Rock Thrush↑↓	*Monticola rufocinereus*	RE/B
101	Whinchat↑↓	*Saxicola rubetra*	WM
Family:	**Viduidae**		
102	Village Indigobird↑↓	*Vidua chalybeata*	RE/B
103	Pin-tailed Whydah↑↓	*Vidua macroura*	RE/B
Family:	**Fringillidae**		
104	African Citril ↓	*Serinus citrinelloides*	RE/B
Family:	**Estrildidae**		
105	African Firefinch↑	*Lagonosticta rubricata*	RE
106	Bronze Mannikin↑↓	*Spemestes cucullata*	RE/B
Order:	**Galliformes**		
Family:	**Numididae**		
107	Helmeted Guineafowl↑↓	*Numida meleagris*	RE/B

Note: ↑= Species occurred at wet Season; ↓= Species occurred during the dry season: RE = Resident, B = Breeding, WM = Winter Migrant and LM = Local Migrant; E= Endemic; NE= Near-endemic: V= Vulnerable: Near-threatened

Appendix 2. Statistical analysis of bird species distribution in the Boye, Kito and Koffe wetlands of wet and dry

Scientific name	**Species common name**	**Boye_wet**	**Boye dry**	**Kito wet**	**Kito dry**	**Koffe wet**	**Koffe dry**
Actitis hypoleucos	Common Sandpiper	1	1	1	1	1	.0
Actophilornis africanus	African Jacana	1	1	1	1	1	1
Alcedo cristata	Malachite Kingfisher	1	1	1	.0	1	1
Alopochen aegyptiaca	Egyptian Goose	1	1	1	1	1	.0
Amaurornis flavirostra	Black Crake	1	.0	.0	1	.0	.0
Anas hottentota	Hottentot Teal	1	1	1	.0	.0	.0
Anas undulate	Yellow-billed Duck	1	1	1	1	1	1
Anastomus lamelligrus	African Openbill	.0	.0	1	1	1	1
Anhinga rufa	African Darter	1	1	.0	1	1	1
Anthus leucophrys	Plain-backed Pipit	.0	.0	.0	.0	.0	1
Aquila rapax	Tawny Eagle	1	1	1	1	1	1
Ardea alba	Great White Egret	1	1	1	1	1	1
Ardea cinerea	Grey Heron	1	1	1	1	1	1
Ardea melanocephala	Black-headed Heron	1	1	1	1	1	1
Ardea puprpurea	Purple Heron	.0	1	.0	.0	.0	.0
Ardeola idea	Indian Pond heron	.0	1	.0	.0	.0	.0
Balearica pavonina	Black Crowned Crane	1	1	1	1	1	1

Batis minor	Black-headed Batis	1	.0	1	.0	1	.0
Bostrychia carunculata	Wattled Ibis	1	1	1	1	1	1
Bostrychia hagedash	Hadada Ibis	1	1	1	1	1	1
Bubulcus ibis	Cattle Egret	1	1	1	1	1	1
Bucorvus abyssinicus	Abyssinian Ground-hornbill	.0	.0	.0	1	.0	1
Bugeranus carunculatus	Wattled Crane	.0	.0	1	.0	.0	.0
Buteo augur	Augur Buzzard	1	.0	1	.0	1	.0
Bycanistes brevis	Silvery-cheeked Hornbill	.0	.0	.0	1	.0	1
Calidris minuta	Little Stint	.0	1	.0	1	.0	1
Campethera nubica	Nubian Woodpecker	.0	.0	.0	1	1	.0
Centropus monachus	Blue-headed Coucal	1	1	1	1	1	1
Ceryle rudis	Pied Kingfisher	1	1	1	1	1	.0
Chalcomitra senegalensis	Scarlet-chested Sunbird	.0	.0	1	1	.0	.0
Charadrius tricollaris	Three-banded Plover	.0	1	.0	1	.0	1
Ciconia abdimii	Abdim`s Stork	.0	1	.0	1	.0	1
Ciconia episcopus	Woolly-necked Stork	.0	1	1	.0	1	1
Cinnyris venustus	Variable Sunbird	1	.0	1	1	1	1
Colius striatus	Speckled Mousebird	1	1	1	1	1	1
Columba guinea	Speckled Pigeon	1	1	.0	.0	1	.0
Corvus albus	Pied Crow	1	.0	1	.0	1	.0

Corvus capensis	Black Crow	1	1	1	.0	1	1
Corvus crassirostris	Thick-billed reaven	1	1	1	1	1	1
Cossypha semirufa	Ruppell`s Robin-Chat	.0	1	1	1	1	1
Crinifer zonurus	Eastern Grey Plantain-eater	1	1	1	1	1	1
Dendrocygna viduata	White-faced Whistling Duck	.0	.0	1	.0	.0	.0
Dendropicos fuscescens	Cardinal Woodpecker	.0	.0	1	.0	.0	.0
Egretta intermedia	Yellow-billed Egret	1	1	1	1	1	.0
Ephippiiorhynchus senegalensis	Saddle-billed Stork	.0	1	1	1	.0	.0
Euplectes axillaris	Fan-tailed Widowbird	1	1	1	1	1	1
Gallinula angulata	Lesser Moorhen	1	.0	.0	.0	.0	.0
Gallinula chloropus	Common Moorhen	1	1	1	.0	.0	.0
Gyps africanus	African White-backed Vulture	1	1	1	1	1	1
Halcyon leucocephala	Grey-headed Kingfisher	.0	.0	1	.0	.0	.0
Halcyon senegalensis	Woodland Kingfisher	1	1	1	1	1	1
Haliaeetus vocifer	African Fish-Eagle	1	1	1	.0	1	.0
Himantopus himantopus	Black-winged Stilt	1	.0	1	1	.0	.0
Hirundo smithii	Wire-tailed Swallow	1	1	1	1	1	.0
Ixobrychus sinensis	Yellow Bittern	.0	1	.0	.0	.0	.0
Jynx torquilla	Eurasian Wryneck	.0	.0	.0	1	.0	.0

Lagonosticta rubricate	African Firefinch	1	.0	.0	.0	.0	.0
Lamprotornis chalybaeus	Greater Blue-eared Starling	.0	.0	.0	.0	1	1
Laniarius aethiopicus	Ethiopian Boubou	.0	.0	1	.0	.0	.0
Lanius collaris	Common Fiscal	1	1	1	.0	1	1
Lanius excubtorius	Grey-backed Fiscal	1		1	1	1	1
Lophaetus occipitalis	Long-crested Eagle	1	.0	.0	.0	.0	.0
Lybius bidentatus	Double-toothed Barbet	.0	.0	1	.0	.0	.0
Megaceryle maxima	Giant Kingfisher	1	.0	1	.0	.0	.0
Melaenornis edolioides	Northern Black Flycatcher	.0	.0	1	1	.0	.0
Merops pusillus	Little Bee-eater	1	1	1	.0	1	1
Milvus migrans	Black Kite	1	1	1	1	1	1
Monticola rufocinereus	Little Rock Thrush	1	1	.0	.0	.0	.0
Monticola Saxatilis	Common Rock Thrush	.0	1	.0	.0	.0	.0
Morconyx Flavicollis	Abyssinian Longclaw	1	1	1	.0	1	
Motacilla flava	Yellow Wagtail	1	1	1	1	1	1
Muscicapa adusta	Abyssinian Dusky Flycacther	.0	.0	.0	1	1	.0
Mycteria ibis	Yellow-billed Stork	1	1	1	1	1	.0
Necrosyrtes monachus	Hooded Vulture	.0	1	1	1	1	1
Numida meleagris	Helmeted Guineafowl	.0	.0	1	.0	1	1
Oenanthe cypriaca	Cyprus Wheatear	.0	.0	.0	.0	.0	1

Oenanthe oenanthe	Northern Wheatear	1	1	1	.0	.0	1
Oenanthe pleschanka	Pied Wheatear	.0	1	.0	1	.0	.0
Pelecanus onocrotalus	Great White Pelican	1	1	1	.0	.0	.0
Pelecanus rufescens	Pink-backed Pelican	.0	.0	.0	1	.0	.0
Phalacrocrorax africanus	Long-tailed Cormorant	1	1	1	1	1	.0
Phalacrocrorax carbo	Great Cormorant	.0	1	.0	.0	.0	.0
Platalea alba	African Spoonbill	1	1	.0	1	.0	.0
Platysteira cyanea	Brown-throated Wattle-eye	.0	.0	1	.0	.0	.0
Plectropterus gambensis	Spur-winged Goose	.0	.0	1	.0	.0	.0
Plegadis falcinellus	Glossy Ibis	1	1	1	.0	.0	.0
Ploceus cucullatus	Village Weaver	1	1	1	1	1	1
Ploceus luteolus	Little Weaver	1	1	1	.0	1	1
Pycnonotus barbatus	Common Bulbul	1	1	1	1	.0	1
Sarkidiornis melanotos	Knob-billed Duck	.0	1	1	1	.0	.0
Saxicola rubetra	Whinchat	.0	.0	.0	.0	1	1
Scopus umbretta	Hamerkop	1	1	1	1	1	1
Serinus citrinelloides	African Citril	1	.0	.0	1	.0	.0
Spermestes cucullata	Bronze Mannikin	1	1	1	.0	1	.0
Streptopelia capicola	Ring-necked Dove	1	1	1	1	1	1
Terpsiphone viridis	African Paradise Flycatcher	1	1	1	1	1	1

Threskionis aethiopicus	African Sacred Ibis	1	1	1	1	1	1
Trigonoceps occipitalis	White-headed Vulture	.0	.0	.0	.0	.0	1
Tringa glareola	Wood Sandpiper	.0	1	.0	1	.0	1
Tringa stagnatilis	Marsh Sandpiper	1	1	.0	1	.0	1
Turdoides leucopygia	White-rumped Babbler	.0	.0	1	.0	1	1
Turdus pelios	African Thrush	.0	.0	1	.0	1	1
Vanellus senegallus	African Wattled Plover	1	1	1	1	1	.0
Vanellus spinosus	Spur-winged Plover	1	1	.0	.0	.0	.0
Vidua chalybeate	Village Indigobird	.0	.0	.0	1	1	1
Vidua macroura	Pin-tailed Whydah	1	1	1	.0	.0	.0
Zosterops abyssinicus	Abyssinien White-Eye	.0	.0	1	.0	1	1
Total number of overall bird species		65	68	74	60	60	55

Note: 0= absence 1= presence