Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.12, No.11, 2022

Species Composition, Relative Abundance and Habitat Association of Avifauna in Zegie Peninsula Forest Patches and Associated Wetlands, Bahir Dar, Ethiopia

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Abstract
The study about species composition, relative abundance and habitat association of avian fauna in Zegie Peninsula forest patches and associated wetlands was carried out from August 2018 to March 2019, covering both the wet and dry seasons. Forest, shrub, lakeshore and wetland were habitats. Data were collected using point count and line transect methods, for 24 days. A total of 96 species of birds were identified. Out of the total, 40 species were observed during the wet season; 13 during dry and 43 species in both seasons. There was statistically significance variation of species distribution among habitats ($\chi 2$=11.89, df=3, p=0.008). During the wet season, the highest species diversity was recorded in the wetland habitat (H'=3.3) followed by forest habitat (H'= 2.9). During the dry season, avian diversity was highest in lakeshore (H'=2.58) followed by wetland (H'=2.51). Highest evenness was observed in the shrub land (E=0.87) and (E=0.84) during the wet and dry seasons, respectively .During the wet season, the highest species similarity was recorded between wetland and lakeshore habitat (SI=0.39) and during the dry season the highest species similarity was recorded between forest and shrub habitats (SI= 0.6). 64(66.66%) of the avian species were uncommon. Currently, however, the species diversity in the area decreases. This might be due to various anthropogenic activities such as deforestation of trees for timber and cutting tree for fire wood. Therefore, awareness creation should be given to the local community to reduce habitat destruction.
Keywords/Phrases: Bird diversity, relative abundance, wetlands, Zegie Peninsula,
DOI: 10.7176/JBAH/12-11-01
Publication date: June 30th 2022

1. INTRODUCTION

Ethiopia has diverse sets of ecosystems ranging from humid forest and extensive wetlands to deserts supporting a wide variety of life forms (EWNHS, 1996; Viveropol, 2001). Its topography varies from vast plains to high mountains having an altitudinal range of 110 m below sea level (Kobar sink) in the Afar depression to the highest peak at Ras Dejen with the altitude of 4620 m a.s.l. (Tedla, 1995). Wide altitudinal variation and extensive area under afro alpine habitat, as compared to the rest of Africa, have contributed to the diversity of flora and fauna of Ethiopia (Yalden, 1983). The country is rich in its faunal diversity and as a result, over 320 species of mammals, above 860 species of birds, 200 species of reptiles, 63 species of amphibians and 145 species of fish are known (Afework Bekele and Yalden, 2013).

In terms of the avian fauna, Ethiopia is one of the most diverse countries in Africa (WCMC, 1995). Forests, wetlands and riverine systems are sites for wintering or passage migrant birds in Ethiopia (EWNHS, 1996). To promote the conservation of these birds and their habitats, 73 Important Bird Areas (IBAs) have been identified in Ethiopia, 30 of these sites (41% of total IBAs) comprise wetlands, while the rest are representatives of other ecosystems (Shimelis Ayenalem and Afework Bekele, 2009).Of these sites Lake Tana qualifies as an IBA because it possesses globally threatened species such as Wattled Crane (Bugeranus carunculatus), Lesser Flamingo (Phoeniconaias minor), Rouget's Rail (Rougetius rougetti), Pallid Harrier (Circus macrourus), and Greater Spotted Eagle (Aquila clanga) (Shimelis Ayenalem and Afework Bekele, 2009). Over 300 species of birds have been observed and recorded in the Lake Tana basin, which has been defined as an international bird site by BirdLife International (BLI) (Shimelis Aynalem, 2013).

Birds are not restricted on wetlands. They also occupy other habitats like forests, forest edges, grasslands, shrubs, lakeshores (Berg, 1997). Forests are important habitats for migrating birds in all the major flyways (Kirby *et al*., 2008). As primary consumers, birds get nutrients from nectar, fruits, seeds and vegetative tissues such as roots, shoots and leaves. The distribution and abundance of many bird species are determined by the composition of the vegetation that forms a major element of their habitats (Shimelis Ayenalem and Afework Bekele, 2008). Forests attract a large number of avifauna because of the habitat suitability for most birds (Hosetti and Harisha, 2009). These especially include the birds that are associated with the vegetation, and the existence of trees is vital to their life cycle (Yenew Genet and Dessalegn Ejigu, 2017).

Ecological studies on birds are important to determine the importance of biodiversity in the area, habitat

requirements of the species and to understand the population dynamics (Gibbons *et al*.,1996). In Ethiopia, many researchers have carried out different studies on avian diversity, distribution and abundance in different ecosystems particularly on National Parks and protected areas. An ecological study of avifauna community of a particular area has a great importance in many aspects. Therefore, the present study focus on avian species composition, relative abundance, and habitat association in Zegie Peninsula forest patches and associated wetlands.

2. MATERIAL AND METHODS

2.1 Description of the study area

Zegie is the largest Peninsula along Lake Tana and is mostly covered with dense forest. It extends beyond the south-western shore of the lake. It is located at coordinates of 11° 40' to 11° 43' N latitudes and 37 °19' to 37 °21' E longitudes, 600 km northwest of Addis Ababa, at an altitude ranging from 1770 m a.s.l. along the banks of the lake to 1975 m a.s.l. at its summit called Ararat. Zegie is part of Bahir Dar city administration and is 32 km far away from Bahir Dar city to northwest direction. It can be accessed from and to Bahir Dar both by land and water. Zegie Peninsula includes a town called Zegie (Afaf) and two rural Kebeles, Ura and Yiganda with an area of 1347 ha (Getachew Gebeyehu and Afework Bekele, 2009). The total size of the study area is 1827 hectare, an additional 480 ha of land from Wonjita kebele is included to the wetland habitats. The size of habitats in the study area are 500, 460, 387, and 480 hectares for the forest, shrub, lakeshore and wetland, respectively. Thus, the study area totally covers about 1827 hectares (Fig 1).

2.2 Methods

2.2.1 Preliminary survey

Preliminary survey was carried out in August, 2018 to collect information about vegetation types, human settlement, land use and topography of the study area. Additional information about the area was gathered from the local people. Global Positioning System (GPS) readings were used to record the locations and to identify the altitudinal ranges of the study habitats.

2.2.2 Sampling design

Based on the preliminary survey the habitats of the study area were identified and categorized into four different habitats depending on vegetation compositions. These are forest, shrub land, lakeshore, and wetland habitats. The forest is a large area dominated by trees and representative of typical dense vegetation. Locally, this site is designated as a conservation area. This site has a closed, dense canopy. The shrub land is located at boundaries of Ararat Mountain and covered by small to medium sized woody plant and dwarf trees. This habitat is clearly different from dense forests by its vegetation type and size. This area is dominated by *Vernonia schimperi, Capparis tomantosa, Acacia oerfota* and *Carissa edulis*. The lakeshore represents a transitional area between undisturbed (dense) forest and Lake Tana. The vegetation of this habitat predominantly comprises species of Typha and Papyrus (Shimelis Aynalem and Afework Bekele, 2008).This site harbors both forest and wetland birds. The wetlands are lowland plains and are regularly inundated with water. The area is located towards the western side of Zegie peninsula at the border of Wonjita kebele. An area is the transition between a land-based and water-based ecosystem. Seasonal flood is more frequent in the wetland habitats. Sampling units representing in each habitat type were selected based on stratified random sampling method. The technique involved dividing the study area into blocks by choosing the location of each habitat with random numbers (Sutherland, 1996). Random blocks were selected for the forest, shrubland, lakeshore and wetland habitats (Krebs, 1999). In the forest, lakeshore, shrub and wetland habitats blocks of 0.5 x1 km were taken and making 5km^2, 3.87 km^2 , 4.6km^2 , 4.8 km^2 blocks, respectively each separated by 250-300m.

A total of 19 sample blocks were selected at random which were generally representative of the whole study area. Thus five blocks for forest habitat, four blocks for lakeshore habitat, five blocks for shrub habitat, and five blocks for wetland habitat were taken (Table 1). In each blocks there were point counting stations. The point count stations in a sample block were 150-200 m apart to avoid under or over estimation during the counting process. Point count method was used to count birds in the forest, shrub and lakeshore habitats (Bibby et al., 1992).

Line transect was laid down in wetland habitats. Line transects sampling method were used for a large and relatively uniform area of wetland habitat and less vegetation density (Bibby et al., 1992). In this habitat, a total of 20 transects were laid down. These transects were separated each other by 150-200m depending on vegetation cover and accessibility of the area. Census of birds was carried out on foot within a radius of 25m at both sides of the transect line. The sequence, in which the transect and stations visited were in systematic alternative way among sampling periods to partially compensate for effects of hourly variation in bird activity (Rodriguez-Ferraro and Blake, 2008). Every effort was taken to avoid mistakes during the census period.

2.2.3 Data collection

Based on the information gathered during the preliminary survey, field works were carried out from August to

October, 2018 to collect the wet season data. Dry season data collection was carried out from January to March, 2019. Data were collected for about six months, i.e. three months during the wet season and three months during the dry season for a total of 24 days i.e. four days per month in both seasons. Data were collected from 6:30 a.m. to 10:00 a.m. in the morning, and from 3:00 p.m. to 6:00 p.m. in the afternoon when the weather condition was convenient and birds become active (Centerbury *et al.,*2000).

To minimize disturbance during census, waiting period of 3-5 minutes prior to counting individuals of avian species was maintained (Hosteler and Martin, 2001). During data collection, the observer and assistants stand at a particular point for a fixed time (10 minutes) and all birds that can been seen are recorded with a fixed radius or arbitrary range of 25m (Pomeroy, 1992; Sutherland , 1996; Bibby *et al.,* 1998). In addition to birds, the vegetation type/coverage was also recorded while the count was carried out to see the dominant vegetation types, and to study the association of birds in the type of vegetation they were inhabited.

Species observed during the survey were identified and taxonomically classified following Sinclair and Ryan (2003).Avian identification was based on different morphological features such as plumage pattern color,body size and shape (Redman et al., 2009), using Field guide to the birds of East Africa. Observations were assisted by binoculars, and photographs were also taken for further confirmation of the species.

2.2.4 Data analysis

Data analysis methods for this study were performed using Shannon-Wiener diversity index (H′), Simpson′s Index of Diversity (D), and quantitative and qualitatively by using ANOVA and chi square.

The species diversity was calculated using the formula provided by Shannon and Wiener (Shannon and Weaver, 1949)

Simpson′s Index of Diversity (D) was used to evaluate the relative abundance of avian species in each habitat type.

The relative abundance of each species was estimated from encounter rates. This value used to give each species an ordinal rank of abundance using the ranking scale of Bibby and Jones (1999). Encounter rate was calculated for each species by dividing the number of birds recorded by the number of hours spent searching, in order to get number of individuals per hour for each species.

$$\text{Relative Abundance} = \frac{\text{Number of individual of a specie}}{\text{Number of individual of all species}} \text{ X } 100$$

Following Bibby *et al.,* (1992) encounter rate values were used to categorize each species under the following five abundance categories (Table 2). : < 0.1, 0.1-2.0, 2.1- 10.0, 10.1-40.0 and >40. For each category, the following abundance score was given: 1 (Rare), 2 (Uncommon), 3 (Frequent), 4 (Common) and 5 (Abundant), respectively.

Simpson's similarity index (SI) used to evaluate the similarity of species between four different habitats in both seasons by using the formula:

SI = 4C/F+LS+S+W

Where, SI = Simpson's similarity index; F=Number of species that occur in forest habitat ; LS=Number of species that occur in lakeshore habitat ; S = Number of species that occur in shrubland habitat; W=number of species that occur in wetland habitat and C= number of common species that occur in all habitat types.

Chi-square test was used to compare seasonal variations in diversity and evenness of birds at the 95 % level of significance. ANOVA was also used to analyze the effect of season and habitat .SPSS (version 20.0) statistical program was used to run the analysis.

3. RESULTS

3.1 Species composition

In the present study, a total of 96 avian species belonging to 38 families were identified from all study sites during both the wet and dry seasons. Of these the majority (9 species) of the species are in the family Alcidinidae which was followed by Anatidae, and Culmbidae (7 species for each). Two of the total species identified were endemic to Ethiopia.

Among the total 96 species, 40 species were recorded only during the wet season, while 13 species were recording only during the dry season and 43 species were recorded during both seasons (Table 2).

3.2 Species diversity

Variations in species diversity among the different habitats during the wet and dry seasons were recorded. Thus, species diversity was higher during the wet season in all the habitats compared to the dry season (Table 3, 4,).

During wet season, the highest diversity of avian species was recorded in the wetland habitat (H'=3.3),which was followed by forest habitat (H'=2.9) and the lowest diversity of species was found in the shrub habitat (H'=2.7), and the least was recorded in lakeshore (H'=2.6) (Table 3).

During the dry season, the lakeshore habitat (H'=2.58) supported the highest diversity of avian species, which was followed by wetland habitat (H'=2.51). The least diversity of birds was recorded in the shrubland

habitat (H'=2.14) (Table 4)

3.3 Species richness

Variation in the number of species was observed among the four different habitats, and between seasons in the same habitat. The species composition of birds between the wet and dry seasons showed significant differences ((χ^2=17.2, df=2,p<0.05)).

The highest species richness recorded during the wet season in the wetland habitat was 44 and 22 in the lakeshore during the dry season. The least species richness was recorded in the lakeshore habitat (22) during the wet season, and in the shrub (13) during the dry season. During both seasons, the highest number of bird species was recorded from wetland habitat(19), which was followed by forests(17) (Fig 2).

3.4 Species similarity

Bird species similarity between different habitats showed variations between seasons (Tables 5,6, 7,). During the wet season more species similarity was recorded between Lakeshore and wetland habitats (SI=0.39) (Table 5). Least similarity of species was observed between shrub and wetland habitats (SI=0.08).

During the dry season the highest similarity was recorded between forest and shrub (SI=0.6), and the least species similarity was recorded between lakeshore and shrub habitats (SI=0.057) (Table 6). Species similarity was higher between bird species of forest and shrub during both the wet and dry seasons (SI=0.58) (Table 7). The lowest species similarity was seen between shrub and wetland habitats (SI=0.07).

Within the same habitat, the percentage comparison of species similarity during the wet and dry seasons showed the highest species similarity in the lakeshore habitat (68.2%). The least similarity was obtained in the shrub habitat (50%) (Table 8)

3.5 Habitat association

During the present study, bird species were distributed differently through the habitats. Chi square test showed that the distribution of bird species with in different habitat is statistically significant (χ^2=11.89,df=3,p<0.05).Among the observed bird species 34(25.2%) of them were recorded from the forest,32(23.7%) of them were recorded from lakeshore, 29 (21.5%) of them recorded from shrub, and 40(29.6%) of them were recorded from wetland habitats.

3.6 Abundance

Bird species abundance varied among the habitats. During the wet season, the numbers of individuals of species recorded were 802, 396, 318, 209 in the wetland, lakeshore, forest and shrub habitats respectively. During the dry season, there were 386, 333, 172, 46 individuals in the wetland, lakeshore, forest and shrub habitats respectively(Fig 3).

The mean number of individuals observed varied between habitats, and the difference was statistically significant (p<0.05, df=3). This indicates that habitat difference had significant effect on the abundance of birds. But there was not statistically significant difference in abundance of birds within the same habitat between seasons (p>0.05 ,df=2).

The relative abundance score and rank of each avian species in different habitats and seasons was determined by using encounter rate data. Encounter rate showed that, relative abundance of avian fauna in the study area during the wet and dry seasons indicated that 32(33.33%) of the species were frequent and 64(66.67%) of the species were uncommon.

4. DISCUSSION

4.1 Diversity

A total of 96 species of birds were recorded from the study area, this indicates that the area is rich in avian diversity. From these recorded, avian species two species namely blue winged goose (*Cynochen cyanoptera*) and yellow fronted parrot (*Poicephalus flaviforns*) are endemic to only Ethiopia and black-winged lovebird (*Agapornis taranta*) and Wattled Ibis (*Bostrychia carunculata*) are endemic to Ethiopia and Eritrea.

Previous study in the same area by Shimelis Aynalem (2008) showed that the area harboured 129 bird species. Currently, however, the species diversity decreases. This might be due to various anthropogenic activities such as deforestation of trees for timber and cutting tree for fire wood. As a result, the forest coverage in the area declines which directly affects avian diversity in the area.

Even though bird species richness and relative abundance are influenced by local resources availability and vegetation composition, Studies by Hansson (1997) indicated that the number of plant species is not clearly correlated with the number of bird species. However, According to Shimelis Aynalem and Afework Bekele (2008) the distribution and abundance of many bird species are determined by the composition of the vegetation that forms a major element of their habitats. Due to this there is difference in the diversity of birds. Differences

in habitat characteristics and feeding habits of bird species in the study area are responsible for variation in species diversity and number of individuals of bird species among different habitats as proposed by Smith, (1992).

The floristic composition of the four habitats is different. Majority of the study area is surrounded by Lake Tana and wetlands that harbor large numbers of birds. Papyrus vegetation (*Cyperus papyrus*) and Typha plants, which are accessible along the shores of the Lake Tana are important feeding, nesting and breeding sites for wetland birds (Shimelis Aynalem and Afework Bekele, 2008).During the study period, black headed weaver (*Ploceus melanocephalus*) was the most dominant bird species in this area. The other side of the study area is covered by forests that harbours forest birds and this is a great opportunity for lakeshore birds as a waiting area to detect their prey in the nearby Lake Tana.

During the wet season, the highest diversity of bird species was recorded in the wetland habitat. It is clearly known that wetlands provide home for a huge diversity of wildlife including birds, mammals, fish, frogs, and various invertebrate species (Buckton, 2007). The reason for high diversity of bird species in wetland habitat during the wet season could be the availability of variety of food sources.

Wetland habitats support different food sources for fish, crustaceans, and invertebrates. Water plants and planktons further add to the diversity of wetland birds (Basavarajappa, 2004). During the wet season, the productivity and yield of habitat increases as many of the invertebrates breed and the vegetation becomes more productive on which the birds depend which increases their diversity. The wetland birds are in general heterogeneous in their feeding habits (Ali and Ripley, 1987). Gebrecherkos Woldegeorgis and Tilaye Wube (2012) also found that the Yayu forest food resources become plenty and attractive during the wet season resulting in higher avian species during the wet seasons than the dry season. The reason for such high diversity of bird species in the wetland habitat during the wet season might be due to the availability of different food sources .Martin and Possingham (2005) have also described that habitat structure and food resources are the major determinant of bird species diversity.

Most bird species, particularly large tree users like woodpecker species occur in forest habitats. This is because trees provide nest sites for cavity nesting birds. This is supported by Newton (1994), and this may also support abundant food resources for birds such as arthropods in bark and dead woody tissues (Sillett, 1994). During the dry season, the bird species of lakeshore habitat is most diversified than other types. This might be due to the presence of diversified vegetation cover in the area that provide various function for different avian species and availability of food attract birds that feed on aquatic animals like fish and crustaceans at the edge of the lake. According to Baker *et al.,* (2002) large number of species would occur along the edges of different habitats. Most species of family Alcedinidae including (African pygmy-Kingfisher (*Ispidina picta*), blue breasted kingfisher (*Halcyon malimbica*), and giant Kingfisher (*Megaceryle maximus)*) are concentrated at lakeshore habitat as they prey fishes that inhabit in the lake. This idea is also supposed by Terborgh *et al*., (1990). Edge effect have great contribution to increase in the number of species.

During the dry season the lowest avian diversity is recorded in the shrub habitat. This might be birds move to the adjacent area that has an abundant supply of food and stable source of food and cover. In addition to this the low number of species recorded at each habitat type might be due to different reasons including less conspicuous nature of some avian species, and lack of experience of the researcher to observe small and cryptic birds in the area. This idea is also supposed by Nega Tassie and Afework Bekele (2007). Generally it is often difficult to list all of the species available in a natural community (Krebs, 1999).

The study showed that less avian species diversity is recorded during the wet season in the shrub habitat compared to the other habitats types. This might be because of anthropogenic activities. The local people clear indigenous tree and they have changed the area to agricultural land for coffee plantation and this have an effect on bird's niche. This finding is in line with Rana (2005), who reported that in natural habitats where the intervention of humans is less and minimum, the diversity of species is higher than habitats where intensive farming is apparent.

As the number of vegetation layer increases, the number of available niches for birds also increases and so does the diversity of avian species. Structural change in the vegetation of shrubs as a result of removal of plants might have forced birds to migrate to nearby habitats. The fluctuation of species diversity at different habitats and seasons might be due to local migration of birds from one habitat to the other in search of food (Adeyemo and Ayodele, 2005).

During the wet season, the highest species richness is recorded in the wetland followed by the forest habitat . This might be due to high availability of resource in the wetlands for wetland birds (Basavarajappa, 2004) and high structural complexity of vegetation structure for forest birds (Oindo *et al*., 2001). The difference in species richness might be due to variation such as topography, vertical and horizontal vegetation structure (Oindo *et al*., 2001). The highest evenness value in the shrub habitat had the smallest species richness. This agrees with the idea of Krebs (1999), which describes that evenness is independent of species richness.

The analysis of bird species similarity among the four habitat types showed highest similarity of bird

species was observed between the wetland and lakeshore habitats during the wet season and between forest and shrub habitats during the dry season. This similarity might be due to the presence of stable bird niches and similarity in vegetation composition in the two habitats. This result coincides with the result of Karr (1980), which states that faunas under similar ecological conditions are more or less similar to each other in species richness and topographic structure than faunas under different ecological conditions. In contrast, the least avian species similarity was observed between shrub and wetland habitats (SI=0.08). This might be due to the difference in the resources and breeding site requirement among the different bird species.

4.2 Habitat Association

The distribution of birds within the four habitats was varied. This variation might due to variation in foraging strategy of birds. Some groups of birds feed on insects, some on flowers, some on seeds and others feed on aquatic animals. The distribution and abundance of many bird species are determined by the composition of the vegetation that comprises a major element of their habitats (Lee and Rotenberry, 2005).

The highest numbers were observed in the wetland habitat (40) followed by forest habitat (34). This might be due to the availability of aquatic animals that are used as food source for birds in wetland rather than season and higher vegetation complexity in the forest than other habitats. As a result, high number of individual species of birds was concentrated on specific tree. This might be the suitability and the availability of high amount of fruits. For example Bruce's Green-Pigeon (*Treron waalia*) was concentrated on *Ficus vasta* tree during the dry season.

4.3 Relative Abundance

The difference in relative abundance of birds recorded at the present study areas might be due to the availability of food, habitat condition and breeding nature of the species. The distinct seasonality of rainfall and seasonal variation in the abundance of food resource result in seasonal changes in species abundance of birds (Karr and Roth, 1980).

It is impossible to apply absolute density to estimate the relative abundance of each species of birds in a multi-species study and a dense vegetation, rather encounter rate is more appropriate .The data provided by the encounter rates do not provide an accurate indication of abundance and are not a substitute for density estimate. In addition, the relative abundance of species has no relation with IUCN species category criteria rather it is useful to know the abundance of the species in a particular area (Shimelis Aynalem and Afework Bekele,2009).

Based on encounter rate data, relative abundance of bird species in the study areas is grouped as rare, uncommon, common, frequent, and abundant. The presence of more uncommon species of birds in the present study area might be due to the relatively large home range and large niche requirement of the species. Ryan and Owino (2006) suggested that the presence of large number of uncommon species in a certain area could be related to the breeding nature and large home range of the species. In addition, degradation of the habitat might be a reason for the species to be uncommon. Shimelis Aynalem and Afework Bekele (2009) suggested that cutting trees and clearing vegetation for coffee plantation and fire wood production to sell to the nearest town were common in the area and this affects the relative abundance birds.

Conflict of interest

On the behalf of all authors there is no conflict of interest.

ACKNOWLEDGMENTS

The authors are thankful to Bahir Dar university science college and the local community of Zegie Peninsula for their hospitality and kind response for sharing their accumulative indigenous knowledge to our inquire data.

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Figures

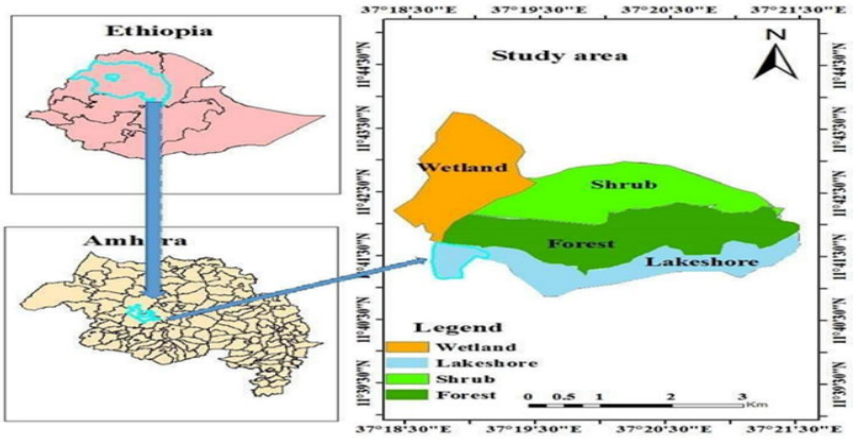

Figure 1. Location map of the study area

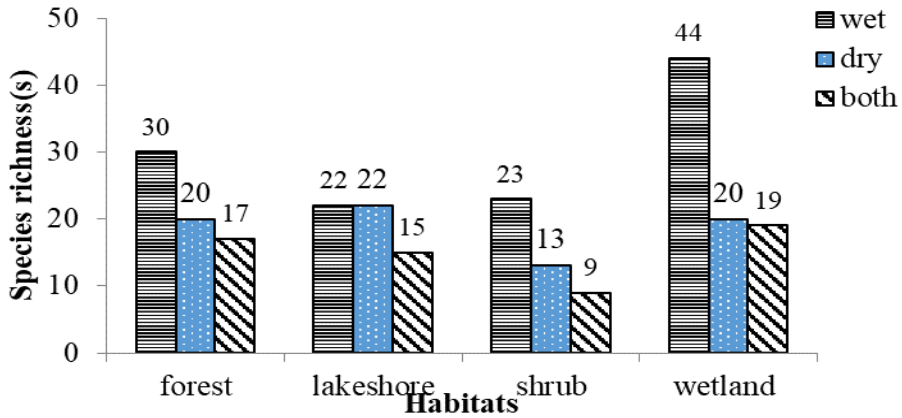

Figure 2. Species richness of birds in the four different habitats

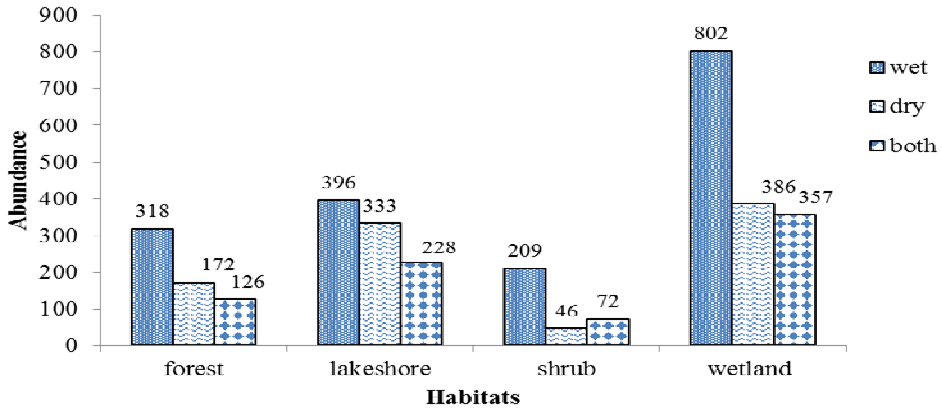

Figure 3. Abundance of bird during wet, dry and both seasons from all habitats

Tables

Table 1: stations for the point count and transect count methods

Habitat type	Total area (Km^2)	Total blocks (0.5×1 Km	Sample blocks (0.5×1 Km	Number of Point stations	Number of line transects
Forest	5 (500 ha)	10	5	13	-
Shrubland	4.6(460 ha)	9	5	12	-
Lakeshore	3.87(387 ha)	8	4	10	-
Wetland	4.8 (480 ha)	10	5	-	20
Total	18.27(1827 ha)	37	19	35	20

Table 2. Bird species recorded in the study area during the wet and dry seasons

SN	bird species	Family	Seasons		
			Wet	Dry	Both
1.	Abdim's Stork (*Ciconia abdimii*)	Ciconiidae	✓		
2.	AbyssinianSlaty-Flycatcher(*Melaenornis chocolatina)*	Muscicapidae	✓		
3.	Abyssinian trush(*Turdus abyssinicu)*	Turdidae			✓
4.	Abyssinian woodpecker(*Dendropicos abyssicus*)	Picidae			✓
5.	Afrcan Sacred Ibis(*Threskiornis aethiopicus)*	Threskiornithidae			✓
6.	African Black Duck (*Anas sparsa*)	Anatidae			✓
7.	African Collared-Dove (*Streptopelia roseogrisea*	Columbidae	✓		
8.	African comb Duck(*Sarkidiornis melanotos*)	Anatidae	✓		
9.	African darter(*Anhinga rufa)*	Anhingidae			✓
10.	African Fish-Eagle (*Haliaeetus vocifer*)	Accipitridae			✓
11.	African Jacana (*Actophilornis africana*)	Jacanidae			✓
12.	African Paradise-flycatcher (*Terpsiphone viridis*)	Monarchidae		✓	
13.	African peid wagtail (*Motacilla aguimp*)	Motacillidae	✓		
14.	African pygmy-goose (*Nettapus auritus*)	Anatidae			✓
15.	African pygmy-Kingfisher (*Ispidina picta*)	Alcedinidae	✓		
16.	African woollyneck(*ciconia microscelis*)	Ciconiidae	✓		
17.	Bare-faced Go-away-bird (*Corythaixoides personata)*	Musophagidae	✓		
18.	Barred Warbler(*Sylvia nisoria*)	Sylviidae			✓
19.	BeardedWoodpecker(*Dendropicos namaquus*)	Picidae		✓	
20.	Bimaculated lark (*Melanocorypha bimaculata*)	Alaudidae	✓		
21.	Black billed barbet (*Lybius guifsobalito*)	Lybiidae			✓
22.	Black crowned crane(*Balearica pavonina)*	Gruidae	✓		
23.	Black headed weaver (*Ploceus melanocephalus*)	Ploieidae	✓		
24.	Black-billed Wood-dove (*Turtur abyssinicus*)	Columbidae	✓		
25.	Black-headed Lapwing (*Vanellus tectus)*	Charadriidae	✓		
26.	Black-winged Lovebird (*Agapornis taranta*) **EE**	Pasittacidae			✓
27.	Blue –breasted Bee-eater *(Merops variegates*)	Meropidae	✓		
28.	Blue breasted kingfisher(*Halcyon malimbica*)	Alcedinidae			✓
29.	Blue headed Coucal(*Centropus monachus*)	Alcedinidae			✓
30.	Blue spotted wood –dove(*Turtur afer)*	Columbidae	✓		

SN	bird species	Family	Seasons		
			Wet	Dry	Both
31.	Blue winged Goose(*Cynochen cyanoptera*) **E**	Anatidae			✓
32.	Bronze Sunbird (*Nectarinia kilimensis*)	Nectariniidae		✓	
33.	Bruce's Green-Pigeon (*Treron waalia*)	Columbidae		✓	
34.	Cattle Egret (*Bubulcus ibis*)	Ardeidae			✓
35.	Chestnut-backedSparrow-Lark(*Eremopterix leucotis)*	Alaudidae			✓
36.	Citrine Wagtail (*Motacilla citreola*)	Motacillidae	✓		
37.	Collared Sunbird (*Anthreptes collaris*)	Nectariniidae			✓
38.	Common Bulbul (*Pycnonotus barbatus*)	Pycnonotidae		✓	
39.	Common Fiscal (*Lanius collaris*)	Laniidae	✓		
40.	Common Sandpiper (*Actitis hypoleucos*)	Scolopacidae			✓
41.	Common Stonechat (*Saxicola torquata*)	Muscicapidae		✓	
42.	Coppery tailed coucal (*Centropus cupreicaudus)*	Cuculidae	✓		
43.	Dark chanting goshawk (*melierax metabates)*	Accipitridae	✓		
44.	Double toothed Barbet (*Lybius bidentatus)*	Lybiidae	✓		
45.	Dusky crested fly catcher (*Elminia albiventris*)	Stenostiridae	✓		
46.	Eastern plantain-eater(*Crinifer zonurus*)	Musophagidae		✓	
47.	Egyptian goose (*Alopochen aegyptiacus*)	Anatidae	✓		
48.	Ethiopian Bee-eater(*Merops lafresnayii*)	Meropidae		✓	
49.	Giant Kingfisher (*Megaceryle maximus)*	Alcedinidae			✓
50.	Glossy Ibis (*Plegadis falcinellus*)	Threskiornithidae			✓
51.	Goliath Heron (*Ardea goliath*)	Ardeidae	✓		
52.	Gray crowned crane (*Balearica regulorum*)	Gruidae	✓		
53.	Great Reed-Warbler (*Acrocephalus arundinaceus*)	Acrocephalidae			✓
54.	Great-white Egret (*Egretta alba*)	Ardeidae			✓
55.	Green Sandpiper (Tringa ochropus)	Scolopacidae	✓		
56.	Grey headed wood pecker (*Dendropicos spodocephalus)*	Picidae	✓		
57.	Grey-backed Fiscal (*Lanius excubitoroides*)	Laniidae		✓	
58.	Grey-headed Kingfisher (*Halcyon leucephala*)	Alcedinidae		✓	
59.	Hadada ibis(*Bostrychia hagedash*)	Threskiornithidae			✓
60.	Hammer kop (*Scopus umbretta*)	Scopidae	✓		
61.	Hooded volture (*Necrosyrtes monachus*)	Accipitridae			✓
62.	Isabelline Wheatear (*Oenanthe isabellina*)	Turdidae		✓	
63.	Isbeline Shrike (Lanius isabellinus)	Laniidae		✓	
64.	Jameson's Firefinch (*Lagonosticta rhodopareia*)	Estrildidae	✓		
65.	Lesserswamp-warbler(*Acrocephalus gracilirostris)*	Acrocephalidae			✓
66.	Little Bee-eater (*Merops pusillus*)	Meropidae			✓
67.	Little spotted woodpecker (C*ampethera cailliautii*)	Picidae			✓
68.	Little Weaver(*ploceus Luteolus*)	Ploceidae	✓		
69.	Long-crested Eagle (*Lophaetus occipitalis*)	Accipitridae			✓
70.	Malachite Kingfisher (*Alcedo cristata*)	Alcedinidae			✓
71.	Marsh Sandpiper (*Tringa stagnatilis*)	Scolopacidae			✓

SN	bird species	Family	Seasons		
			Wet	Dry	Both
72.	Marsh warbler(*Acrocephalus palustris*)	Acrocephalidae	✓		
73.	Namaqua Dove (*Oena capensis*)	Columbidae		✓	
74.	Pied Kingfisher *(Ceryle rudis)*	Alcedinidae	✓		
75.	Red billed fire finch (*Lagonosticta senegala*)	Estrildidae	✓		
76.	Red-chested Cuckoo *(Cuculus solitarius*)	Alcedinidae	✓		
77.	Red-eyed Dove (*Streptopelia semitorquata*)	Columbidae			✓
78.	Ruppell's Robin-chat(*Cossypha semirufa)*	Muscicapidae			✓
79.	RupellsWeaver*(Ploceus galbula)*	Ploceidae	✓		
80.	Sacred Ibis (*Threskiornis aethiopicus)*	Threskiornithidae			✓
81.	Silvery-cheeked Hornbill (*Ceratogymna brevis*)	Bucerotidae			✓
82.	Speckled mouse bird (*Colius striatus*)	Coliidae	✓		
83.	Speckled Pigeon (*Columba guinea*)	Columbidae			✓
84.	Spectacled Weaver (*Ploceus ocularis*)	Ploceidae			✓
85.	Spur-winged goose (*Plectropterus gambensis*)	Anatidae			✓
86.	Spur-winged Lapwing (*Vanellus spinosus*)	Charadriidae			✓
87.	Squacco Heron (*Ardeola ralloides*)	Ardeidae	✓		
88.	Striped Kingfisher (*Halcyon chelicuti*)	Alcedinidae			✓
89.	Tropical Boubou (*Laniarius aethiopicus*)	Malaconotidae			✓
90.	Wattled Ibis (*Bostrychia carunculata*) **EE**	Threskiornithidae	✓		
91.	White browed coucal(*Centropus superciliosus*)	Cuculidae			✓
92.	White –faced whistling duck (*Dendrocygna viduata)*	Anatidae	✓		
93.	White –winged tern (*Chliodonias leucopterus*)	Laridae	✓		
94.	White-Fronted Black Chat(*myremecocichela albifrons)*	Muscicapidae	✓		
95.	Yellow-billed Stork (*Mycteria ibis*)	Ciconiidae			✓
96.	Yellow-fronted Parrot (*Poicephalus flavifrons*) **E**	Psittacidae			✓

E=Endemic to only Ethiopia, **EE**=Endemic to Ethiopia and Eritrea

Table 3: Species diversity of birds during wet season

Habitat	Species Richness	Abundance	H'	Hmax	H'/Hmax	D=1-∑pi2
Forest	30	318	2.9	3.4	0.85	0.926
Lakeshore	22	396	2.6	3.1	0.84	0.910
Shrub	23	209	2.7	3.1	0.87	0.914
Wetland	44	802	3.3	3.8	0.86	0.954

Table 4 : Species diversity of birds during dry season

Habitat	Species Richness	Abundance	H'	Hmax	H'/Hmax	D=1-∑pi2
Forest		172	2.44	2.99	0.81	0.874
Lakeshore	22	333	2.58	3.09	0.83	0.904
Shrub	13	46	2.16	2.56	0.84	0.86
Wetland	20	386	2.51	2.99	0.84	0.903

Note:H'= Shannon Weiner Index ; H/H'max = Evenness ;D=Diversity Index; H'max=ln(S)

Table 5. Simpson's similarity Index (SI) during the wet season

Habitat	Forest	Lakeshore	Shrub	Wetland
Forest	-	8 (0.31)	10 (0.37)	5 (0.13)
Lakeshore	-	-	6(0.26)	13(0.39)
Shrub	-	-	-	3 (0.09)
Wetland	-	-	-	-

Table 6.Simpson's similarity Index (SI) during the Dry season

Habitat	Forest	Lakeshore	Shrub	Wetland
Forest	-	4 (0.10)	10 (0.60)	2 (0.10)
Lakeshore	-	-	1 (0.06)	6 (0.28)
Shrub	-	-	-	1(0.06)
Wetland	-	-	-	-

Table 7. Simpson's similarity Index (SI) during both season

Habitat	Forest	Lakeshore	Shrub	Wetland
Forest	-	3(0.18)	7 (0.58)	0
Lakeshore	-	-	0	6(0.35)
Shrub	-	-	-	1(0.07)
Wetland	-	-	-	-

Table 8. Seasonal species similarity within the same habitats

Habitats	Wet season	Dry season	Common species	Similarity index (SI)	Species similarity between seasons (%)
Forest	30	20	17	0.68	68 %
Lakeshore	22	22	15	0.682	68.2 %
Shrub	23	13	9	0.5	50 %
Wetland	44	20	19	0.594	59.3 %