Avian species diversity in the southern Gulf of Lake Tana and head of the Blue Nile River, Ethiopia

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Abstract

Avian study in the southern Gulf of Lake Tana and head of the Blue Nile River, Ethiopia was conducted from June 2016 to April 2017 during the wet and dry seasons to examine species composition, relative abundance, and habitat association of birds. The study area was classified based on its vegetation cover and composition and the point count method was used to gather information about the occurrence of avian species and their relative abundances. A total of 131 avian species belonging to 15 orders and 53 families were identified. The wet and dry seasons data indicated that 122 and 108 avian species, respectively, were recorded. Agapornis tranta and Oriolus monachal are endemic birds of Ethiopia and Eritrea that are occurring in the study area. Moreover, two Intra-African migrant, Threskiornis aethiopicus and Milves migrans, and two Palearctic migrant, Delichon urbicum and Motacilla flava were identified in the area. The highest avian diversity was recorded in the Debremariam wetland (H'=3.96), while the lowest was at the adjacent areas of Lake Tana (H'=3.22). The relative abundance score showed that 54.8% of the avian species were uncommon and there was a significant difference in the relative abundance of birds between the wet and dry seasons ($p<0.05$). Different anthropogenic activities and urbanization are the main threats to the conservation of birds in the southern Gulf of Lake Tana. Therefore, appropriate management actions should be designed and implemented to ensure the conservation of birds in the Lake and its adjacent habitats. Keywords: Blue Nile, endemic, Lake Tana, species diversity, point count

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Abstract

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1. INTRODUCTION

Ethiopia is known for its avifauna and the diverse avian species of the country is mainly due to its different habitat types. Over 863 species of birds are identified from Ethiopia representing approximately 9.5% of birds in the world and 39% in Africa. It is known that nineteen avian species are endemic to Ethiopia, three are rare or accidental to the country, while fourteen species are shared with Eritrea and thirty one are globally threatened (Lepage, 2021). According to Ethiopian Wildlife and Natural History Society (EWNHS) (1996) forests, wetlands, and riverine ecosystems are sites for wintering or migrant birds in Ethiopia. As a result, there are 214 Pale-arctic migrant avian species, and a large number of these birds have breeding populations in the country (Pol, 2006).

In Ethiopia, most avian species are found in Important Bird Areas (IBAs), but these areas cover only 5% of the country's total area and wetlands comprise 41% of the IBAs (Ayenalem & Bekele, 2008). Habitat variables of wetlands differ in water depth, water level fluctuation, salinity, topography, and vegetation (Colwell & Taft, 2000). Wetland birds are categorized into wetland specialist and wetland generalist (Airinatwe, 1999). Wetland specialists are completely dependent on aquatic habitats, while wetland generalists are frequently found in wetlands and they also use other habitats (Wondafrash, 2003). Wetland birds are placed into four categories as resident, sporadic, summer visitor, and vagrant (Clout & Hay, 1989).

The sizes of wetland habitats influence species richness and relative abundance of water birds (Froneman et al., 2001). Larger wetlands, which have high habitat heterogeneity can support a greater diversity of water birds than smaller ones (Colwell &Taft, 2000). Water birds foraging close to the shores persist in both large and small ponds and are considered as area-independent species, while those species foraging in open and deep-water habitats are considered as area-dependent species and are restricted to relatively large ponds (Paracuellos, 2006). The distribution of water bird species had a nested pattern among wetlands of different sizes (Paracuellos & Telleria, 2004). The kinds and amounts of resources available for breeding and foraging activities can also affect avian communities (Lee & Rotenberry, 2005). Thus, larger wetlands are of greater conservation value than smaller ones in supporting diverse water bird species (Paracuellos, 2006).

A number of environmental factors including food availability, temperature and the presence or absence of competitors and predators have been found to influence bird species diversity and their relative abundance. According to Robert & Kathleen (1992) habitat characteristics at different spatial scales, habitat modification or fragmentation, urbanization and the surrounding landscape composition can influence avian species diversity and abundance. Habitat loss and fragmentation are widely regarded as major factors contributing to the decline of avian populations (Raman, 2006). One in eight of the world's avian species face extinction in the next millennium because of habitat destruction (Delannoy, 2010). Therefore, the main objective of this study is to explore species composition, relative abundance, and habitat association of birds in the southern gulf of Lake Tana and head of the Blue Nile River to design appropriate conservation strategies and ensure conservation of birds in the Lake and its adjacent habitats.

2. MATERIALS AND METHODS

2.1. Description of the study area

Study on avian diversity and relative abundance was conducted in the southern gulf of Lake Tana and head

of the Blue Nile River, Ethiopia. Lake Tana has a total drainage area of approximately 15,000km^2 and the catchment of the lake is one of the global top 250 lake regions most important for biological diversity conservation (Barker, 2004). It has varied topography, and the altitude ranges from 1784m a.s.l. in the south of the lakeshore to 3712m a.s.l. in the northeast end. Lake Tana is the largest lake in Ethiopia with a total area of 3600 km^2 and is the source of the Blue Nile River.

Lake Tana is located at 12°00'N latitude and 37°15'E longitude and it is 565km far from the capital Addis Ababa. It has approximately 84km long and 66 km wide, with an average depth of about 9m (Dejen, 2003) and has more than 30 islands (EWNHS, 1996). It has more than 40 tributary rivers, but the major rivers feeding the Lake are Gilgel Abay from the South, Ribb and Gumara from the East, and Megetch from the North (Fig. 1).

Blue Nile River is the largest river in terms of volume of discharge and the second largest in terms of area in Ethiopia, which comprises of 176,000km^2 (17%) of the area of Ethiopia (Conway, 2000). There is a significant waterfall at Tis-Isat, roughly 25km from Lake Tana, where the river drops 50m into the Blue Nile gorge. Most of Lake Tana's catchment area is characterized by croplands, while only few limited areas of highlands are forest patches. Mean monthly maximum and minimum temperature recorded at Bahir Dar are 30.3°C and 7.82°C, respectively. The 10-year (2006 to 2016) rainfall data of the area shows unimodal distribution. Small rains occur sporadically during the months of April and May and heavy rainfall is recorded from June to August.

Figure 1: here

2.2. Methods

Field equipment and materials used during data collection period include binoculars, digital photo camera, GPS, and data sheet. Bird guidebooks (Stevenson & Fanashawe, 2002, Redman et al. , 2009; Ayanlem, 2013) were used for bird identification. Preliminary survey was conducted in May 2016 to gather relevant information about the study area. In this survey, an overall view of the study area was assessed. Global Positioning System readings were used to locate the positions and to identify the altitudinal ranges of the study area.

Based on the habitat type, the study area was classified into swampy, open-land, and forest patch. Sampling units representing each habitat type was 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 as adapted from Sutherland (1996).

Point count method was used to record the presence and abundance of bird species (Bibby et al., 2000). Data were taken on 30 sampling points of which 13 sampling points on swampy habitats, 9 on forest patches, and 8 on open habitats. In each point count station, a minimum distance of 150-200m was maintained using GPS to avoid double counting (Vielliard, 2000). Point count method was undertaken from a fixed location within the sample unit of radius of 25m at a fixed time interval consisting of 5-10 minutes depending up on the difficulties of the area and the type of bird species to be identified and enumerated (Vielliard, 2000; Buckland, 2006). To minimize disturbance during counts, a waiting period of 3–5minutes prior to counting were applied (Hostler & Martine, 2001). All birds seen were recorded, except birds flying over the canopy and not stopping within the 25m radius.

Data were recorded in the morning from 06:30–10:00 a.m. and late in the afternoon from 15:00–18.00 p.m. for five consecutive days per month for six months both during the wet and dry seasons. Wet season data were collected during June, July, and August 2016, while data for the dry season were collected during February, March, and April 2017. Identification of avian species was carried out using plumage pattern, size, shape, and color of birds (Aynalem & Bekele 2009). Photographs were taken to confirm identification of some of the avian species which were not easily identified in the field. The taxonomic groups of birds were categorized based on field guides (Stevenson & Fanashawe, 2002, Redman et al. , 2009; Ayanlem, 2013).

2.3. Data analysis

Data for the abundance of birds and the effect of habitat types and season on birds were analyzed using ANOVA, and avian diversity was analyzed using Shannon-Wiener Diversity Index (H'). Simpson's Index of Diversity (D) was used to evaluate the relative abundance of avian species in each habitat type. Species evenness was assessed using Shannon's equitability index (E). Relative abundance of avian species was determined using encounter rates (Bibby et al., 1998), and avian community similarity were assessed using Sorensen's coefficient as adopted from Jeffery et al. (2004). SAS (Version 9.2) software program was used to run the analysis and Tukey's HSD test at α=0.05 was used to test significant differences.

3. RESULTS

A total of 131 bird species belonging to 15 orders and 53 families were identified of which 122 and 108 species were recorded during the wet and dry seasons, respectively. Among the total avian species, 99 species were recorded both during the wet and dry seasons, 23 species were recorded only during the wet season, and 9 species only during the dry season (Table 1).

Table 1: here

The study area harbored black winged lovebird (*Agapornis tranta*), which is endemic to Ethiopia, Abyssinian black headed oriole(*Oriolus monacha*) is shared with Eritrea, sacred ibis (*Threskiornis aethiopicus)* and black kite (*Milves migrans)* are Inter-African migrants, and common house martine(*Delichon urbicum)* and yellow wagtail(*Motacilla flava)* are Pale-arctic migrants. Order Passeriformes contains the highest number of families which constitute of 25(47.1%) with 56 species (Fig.2).

Figure 2: here

3.1. Species diversity

The highest number (n=103) of avian species was recorded in Debremariam wetland and the lowest (n=59) was at the head of the Blue Nile River during the wet season (Table.2).

Table 2: here

During the dry season, the highest number of avian species was recorded at the head of the Blue Nile River and the lowest was at the adjacent areas of Lake Tana (Table.3).

Table 3: here

The highest number of avian species recorded both during the wet and dry seasons were at Debremariam wetland and the lowest was at the adjacent areas of Lake Tana (Table 4).

Table 4: here

3.2. Relative abundance

Relative abundance of avifauna in the study area indicated that 227 (54.8%) of the species were uncommon, 149(35.9%) were frequent, 34(8.2%) were common, and 4 (0.96%) were abundant. This indicated that over half of the avian species in the study area were uncommon species (Table 5).

Table 5: here

There was significant difference in relative abundance of birds among the difference species (F_{128}, 1836 =5.04, P<0.05). The most abundant bird species was village weaver (*Ploceus cucullatus*) with a mean relative abundance of 44.1 followed by red checked cordon-bleu (*Uraeginthus bengalus*) with a mean value relative abundance of 22.4, and the least abundant was African hoopoe (*Upupa africana*) with a relative mean abundance of 0.07.

During the wet season, Debremariam wetland had relatively high average number of birds (3.65) followed by head of the Blue Nile River (3.57) and the lowest was recorded at the adjacent areas of Lake Tana (2.35).

During the dry season, head of the Blue Nile River had relatively the highest number of birds (5.44) followed by Debremariam wetland (1.4), and the lowest was obtained from adjacent areas of Lake Tana (1.33). During both the wet and dry seasons, head of the Blue Nile River had the highest mean abundance of birds (8.15) followed by Debremariam wetland (4.97), and the lowest was at the adjacent areas of Lake Tana (3.6) (Table 6).

Table 6: here

3.3. Species similarity

During the wet season, the highest species similarity was recorded between Debremariam wetland and head of the Blue Nile River (CC=0.63), while the lowest was between adjacent areas of Lake Tana and head of the Blue Nile River (CC= 0.54). During the dry season, relatively the highest species similarity was recorded between adjacent areas of Lake Tana and head of the Blue Nile River (CC=0.74) and the lowest was obtained between adjacent areas of Lake Tana and Debremariam wetland (CC= 0.53) (Table 7).

Table 7: here

4. DISCUSSION

A total of 131 species of birds were recorded from the southern gulf of Lake Tana and its adjacent habitats, which indicates that the area is rich in its avian diversity. Majority of the avian species belong to the order Passeriformes. This result agrees with the findings of Esayas (2011) and Genet & Ejigu (2017) as they confirmed that order Passeriformes is also the most diversified species in other parts of the country. The distribution of birds in the different habitat types within the study site varied among each other. The highest number of avian species was recorded in the Debremariam wetland during the wet season. This might be due to the availability of high vegetation complexity and floristic composition of the wetland habitats as the swampy habitat holds papyrus (*Cyperus papyrus*) and Typha plants, which are important for feeding, nesting, and breeding sites for wetland birds. In addition to this the large size of Debremariam wetland as it compared to the other two sites might contribute to the highest avian species diversity. This is because of the availability of multiple and varieties of alternative food sources for different avian species. The lowest number of avian species recorded in the adjacent areas of Lake Tana might be due to food scarcity. Telleria & Santos, (1994) described that habitat structure affects the distribution of individual species. Moreover, habitat size (Willis, 1979), modes of foraging (Marone, 1991), and floristic composition (Wiens & Rotenberry, 1981) have significant influence on the abundance and distribution of species in an area.

Season is one important factor that determines avian species composition and abundance in the area. During the dry season, relatively a greater number of avian species is found at the head of the Blue Nile River. This is because many birds from Debremariam wetland locally migrate to this site as the wetland is dried out during the dry season. Debremariam wetland consists of more open land and swampy habitats compared to head of the Blue Nile River, and during the dry season over half of these areas are changed to dryland and most are used for cattle grazing ground. The distinct seasonality of rainfall and seasonal variation in the abundance of food resources result in seasonal changes in the species abundance of birds (Gaston et al*.,* 2000; Molla, Ejigu & Yitayih, 2021). The distribution and abundance of many avian species are determined by vegetation composition that forms a major element of their habitats. As vegetation changes along complex geographical and environmental gradients, a particular bird species may increase or decrease in number and disappear as the habitat changes (Lee & Rotenberry, 2005).

Wide areas of wetlands are being converted into farmlands and urban expansion that affect many bird species (Meyer & Turner, 1992). In addition to this, habitat fragmentation could affect distribution and abundance of birds by influencing habitat use, reproduction and survival. The removal of emergent vegetation could also affect birds that use the vegetation as food source (Rodewald & Yahner, 2001). People residing at the adjacent areas of Lake Tana and Debremariam wetland use the matured papyrus for local boat construction, and it is also used to spread at home during coffee ceremonies, which contribute for destruction of avian habitats and could affect their abundance and diversity in the area.

The distribution and abundance of birds could be affected in similar ways by the degree of specialization in their ecological requirements (Cofre et al., 2007). In the present study, egrets (*B. ibis),* Egyptian geese (*A. aegyptiaca*), hammerkops (*S. umbretta*), sacred ibis (*T. aethiopicus*), African jacanas (*A. africanus*), herons (*Ardeidae*), and darter *(A. rufa)* prefer wetlands and water bodies. Common bulbul (*P. barbatus*), eastern grey plantain eater (*C. zonurus*), and greater blue eared starling (*L. chalybaeus*) mainly prefer forest habitats, while wagtails (*Motacillidae)* and fiscals (*L. collaris*) prefer open land habitats. All habitats have certain particulars to attract birds of great ecological importance (Manhals & Ribeiro, 2005).

Herons, egrets, ibis, and jacana feed in shallow waters to catch diverse aquatic animals including fish, amphibians, and aquatic invertebrates. They prefer open and shallow areas as these habitats are rich in resources. They avoid the dense vegetation habitats that interferes with their movement and foraging efficiency (White, 2003; Lantz et al., 2011). When the water level increases, they moved to other areas as shallow water prey is easier to catch compared to deep water habitats (Liordos, 2010; Lantz et al., 2011). During the wet season, most birds were not found in adjacent areas of the Lake because water level was very high but after the wet season this area was very rich with different avian species. The highest water bird species richness occurs in the reed bed where water level is shallow (Holm & Clausen, 2006).

In the Debremariam wetland, there are many resident birds. In the back yard of the local people, there are many fruits such as mango, banana, lemon, coffee, and different types of vegetables that can attract many avian species. Habitats which are dominated by patches of shrubs and fruiting trees can attract a number of bird species (Knight et al., 2001). The relative abundance of avian species from the three different habitats showed that over half (58%) of the avian species identified are uncommon species. Ryan & Owino (2006) suggested that the presence of large number of uncommon species in a certain area could be related to the breeding nature, large home range, and niche of the species.

Some of the most common species from Debremariam wetland and head of the Blue Nile River are African jacana, laughing dove, red billed fire finch, red checked cordon bleu, speckled pigeon, village weaver and yellow billed egret. This might be due to the presence of suitable habitat and weather condition in the area. The Sorensen's coefficient of adjacent area of Lake Tana and head of the Blue Nile River showed that the overall community similarity of the two study sites is very high. Moreover, the overall community similarity of Debremariam wetland, adjacent areas of Lake Tan, and head of the Blue Nile River is relatively higher. This indicates that avian community composition of the three study habitats is similar. Tubelis & Cavaicanti (2001) showed that similarity of avian species composition between habitats indicates a tendency for similar habitats to have similar species composition (Genet & Ejigu, 2017). In contrast, the lowest avian species similarity was between adjacent area of Lake Tana and Debremariam wetland. This might be due to the differences in feeding adaptation of avian communities in each habitat types. Aich & Mukhobabadhyay (2008) described that canopy closure supports more of habitat specialist species, while areas under anthropogenic influence harbored more of opportunistic species.

The highest species diversity occurred in Debremariam wetland during the wet season compared to the other two habitat types. This could be due to the presence of better food availability in the wetland. Less mean species evenness is recorded at the head of the Blue Nile River during the dry season, which indicates that there is an unbalanced distribution of the number of individuals among different species. This uneven distribution in avian species richness can partly be attributed to differences in the habitat type and quality (Marie et al., 2008).

Most avian species are limited by availability of food. Seasonal fluctuations in the abundance of individual species are more extreme. During the dry season, some avian species totally left the area, decreasing both in number of species and their abundance. This is similar to the findings of Wiley et al. *(1996*), which confirm that different habitat features affect the habitat selection of birds. It is showed that the avian community structures in the marsh and water bodies are influenced by a number of environmental factors including water depth, vegetation structure and composition, food resource and foraging behavior (Chimney & Gawlik, 2007). The availability of food and human interference has great negative impact compared with the impact of weather conditions in affecting the activity of birds. However, avian species prefer sunny and

warm days than cold weather conditions.

5. CONCLUSION

The southern gulf of Lake Tana is a suitable habitat to support different avian species. The present study confirmed that wetlands, adjacent areas of the lake, and head of the Blue Nile River can support more avian species belonging to different orders and families. Family Ploceidae, Columbidae, Accipitridae, Ardeidea, Scolopacidae and Motacillidae are the most widely distributed families in the area. One endemic bird species of Ethiopia and one shared with Eritrea are identified in the study area. Diversity and abundance of avian species were relatively the highest at Debremariam wetland and it is followed by head of the Blue Nile River and adjacent areas of Lake Tana. However, wetlands are managed primarily for human land uses mainly for livestock grazing and farming rather than for biodiversity conservation. Thus, habitat disturbances due to various anthropogenic activities have significant negative impact on the conservation of avifauna. As a result, proper management strategies should be designed and implemented in order to maintain the Lake's ecosystem to ensure conservation of avian species in the area.

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CONFLICT OF INTEREST

The authors declare that there is no competing of interests.

AUTHOR CONTRIBUTIONS

Belaynesh Abebaw & Dessalegn Ejigu design the research proposal, and Belaynesh Abebaw & Tilahun Kefyalew directly involved in data collection. Dessalegn Ejigu & Ayalew Wondie participated in supervision activities during field data collection time. All of us contributed during data analysis mainly Belaynesh took the lead, and Dessalegn Ejigu prepared the manuscript in which all the authors edited and approved the final version before its submission.

DATA AVAILABILITY STATEMENT

All data used are included in the article.

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