Research Article

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

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Introduction. Ethiopia is one of the most avifauna rich countries in Africa. Avifaunal surveys are required to inform conservation decisions and enhance land management for biodiversity. Avifaunal surveys from Ethiopia are lacking. This study examines species composition, relative abundance, and habitat association of avian fauna in Zegie Peninsula forest patches and associated wetlands from surveys carried out from August 2018 to March 2019, covering both the wet and dry seasons. *Data Collection*. Forest, shrub, lakeshore, and wetland habitats were identified as ecologically relevant habitats in the study area for data collection. Data were collected using point count and line transect methods, for 24 days in total for both seasons in the morning and afternoon. *Results*. A total of 96 species of birds were identified during the whole study period. Out of the total, 40 species were observed during the wet season, 13 during dry and 43 species in both seasons. There was significant variation of species distribution among habitats. During the wet season, the highest species diversity was recorded in the wetland habitat followed by forest habitat. During the dry season, avian diversity was the highest in the lakeshore followed by wetlands. The highest evenness was observed in the shrubland during both the wet and dry seasons. During the wet season, the highest species similarity was recorded between wetland and lakeshore habitats, and during the dry season, the highest species similarity was recorded between forest and shrub habitats. Based on encounter rate data, 64 (66.66%) of the avian species were uncommon. *Conclusions*. Compared to previous studies conducted in the study area, species diversity was lower. This might be due to various anthropogenic activities such as deforestation of trees for timber and cutting trees for firewood. Therefore, awareness creation should be given to the local community to reduce habitat destruction due to various human-induced factors.

1. Introduction

Ethiopia has diverse sets of ecosystems ranging from humid forests and extensive wetlands to deserts, supporting a wide variety of life forms [1, 2]. 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 an altitude of 4620 m a.s.l. [3]. Wide altitudinal variation and the extensive areas under Afro-alpine habitat, compared to the rest of Africa, have contributed to the diversity of flora and fauna of Ethiopia [4]. The country is rich in its faunal diversity, and as a result,

over 320 species of mammals, over 860 species of birds, 200 species of reptiles, 63 species of amphibians, and 145 species of fish are known [5]. In terms of the avian fauna, Ethiopia is one of the most diverse countries in Africa [6]. Forests, wetlands, and riverine systems are sites for wintering or passaging migrant birds in Ethiopia [1, 7]. 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 [8]. Lake Tana and the surrounding area (including Zegie Peninsula) qualify as an IBA because they possess 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*) [9]. Over 300 species of bird have been observed and recorded in the Lake Tana Basin, which has been defined as an international bird site by BirdLife International (BLI) [10].

Birds are not restricted to wetlands. They also occupy other habitats like forests, forest edges, grasslands, shrubs, and lakeshores [11]. Forests are important habitats for migrating birds in the major flyways [12]. As primary consumers, birds get nutrients from nectar, fruits, seeds, and vegetative tissues such as roots, shoots, and leaves [13]. The distribution and abundance of many bird species are determined by the composition of the vegetation that forms a major element of their habitats [9]. African forests are home to a particularly wide variety of species [14]. These especially include birds that are associated with vegetation, and the existence of trees is vital to their life cycle [15].

Ecological studies on birds are important to determine the biodiversity in the area and to understand the habitat requirements of the species and population dynamics [16]. In Ethiopia, a limited amount of research has been carried out on avian diversity, distribution, and abundance in different ecosystems, particularly in National Parks and protected areas [17]. The present study focusses on avian species composition, relative abundance, and habitat association in Zegie Peninsula forest patches and associated wetlands.

2. Methods

2.1. Description of the Study Area. Zegie is the largest peninsula along Lake Tana and is mostly covered with dense forest. The lake and its adjacent area are registered as UNESCO's Biosphere Reserve site for its rich biodiversity. It extends beyond the southwestern shore of the lake. It is located at coordinates of 11° 40' to 11° 43' N latitude and 37°19' to 37°21' E longitude, 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 from Bahir Dar city in a northwest direction. It can be accessed from and to Bahir Dar by both land and water. Zegie Peninsula includes a town called Zegie (Afaf) and two rural Kebeles, Ura and Yiganda, with an area of 1347 ha [18]. The total size of the study area is 1827 hectares, and an additional 480 ha of land from Wonjita Kebele is included in the wetland habitats. The size of habitats in the study area is 500, 460, 387, and 480 hectares for forest, shrub, lakeshore, and wetlands, respectively (Figure 1).

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

2.3. Sampling Design. Based on the preliminary survey, the habitats of the study area were identified and categorized into four different habitats depending on the vegetation composition. These are forest, shrubland, 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 shrubland is located at the boundaries of Ararat Mountain and covered by small to medium-sized woody plants 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 tomentosa, 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 [9]. The wetlands are lowland plains and are regularly inundated with water. The area is located toward the western side of Zegie Peninsula at the border of Wonjita Kebele. This area is the transition between a land-based and water-based ecosystem. Sampling units representing each habitat type were selected based on a stratified random sampling method. The technique involved dividing the study area into blocks by choosing the location of each habitat with random numbers [19]. Random blocks were selected for forest, shrubland, lakeshore, and wetland habitats [20]. We applied a grid to each habitat consisting of 0.5×1 km cells. Then, we randomly selected blocks from the grid resulting in 5 blocks in the forest, shrubland, and wetland and 4 blocks in the lakeshore (Table 1).

In each block, there were point counting stations. The point count stations in a sample block were 150–200 m apart to avoid under- or overestimation during the counting process. The point count method was used to count birds in forest, shrub, and lakeshore habitats [21]. In wetland habitats, we carried out line transects instead of point counts because the habitat is uniform and has less vegetation coverage. Therefore, birds are easily visible. In this habitat, a total of 20 transects were laid down. These transects were separated from each other by 150–200 m depending on the vegetation cover and accessibility of the area. Census of birds was carried out on foot within a radius of 25 m at both sides of the transect line following the methods of Aynalem and Bekele [8]. The sequence in which the transects and stations were visited was systematically alternating between sampling periods to partially compensate for the effects of hourly variation in bird activity [22]. Every effort was taken to avoid mistakes during the census period.

2.4. Data Collection. Based on the information gathered during the preliminary survey, fieldwork was 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 over six months, i.e., three months during the wet season and three months during the
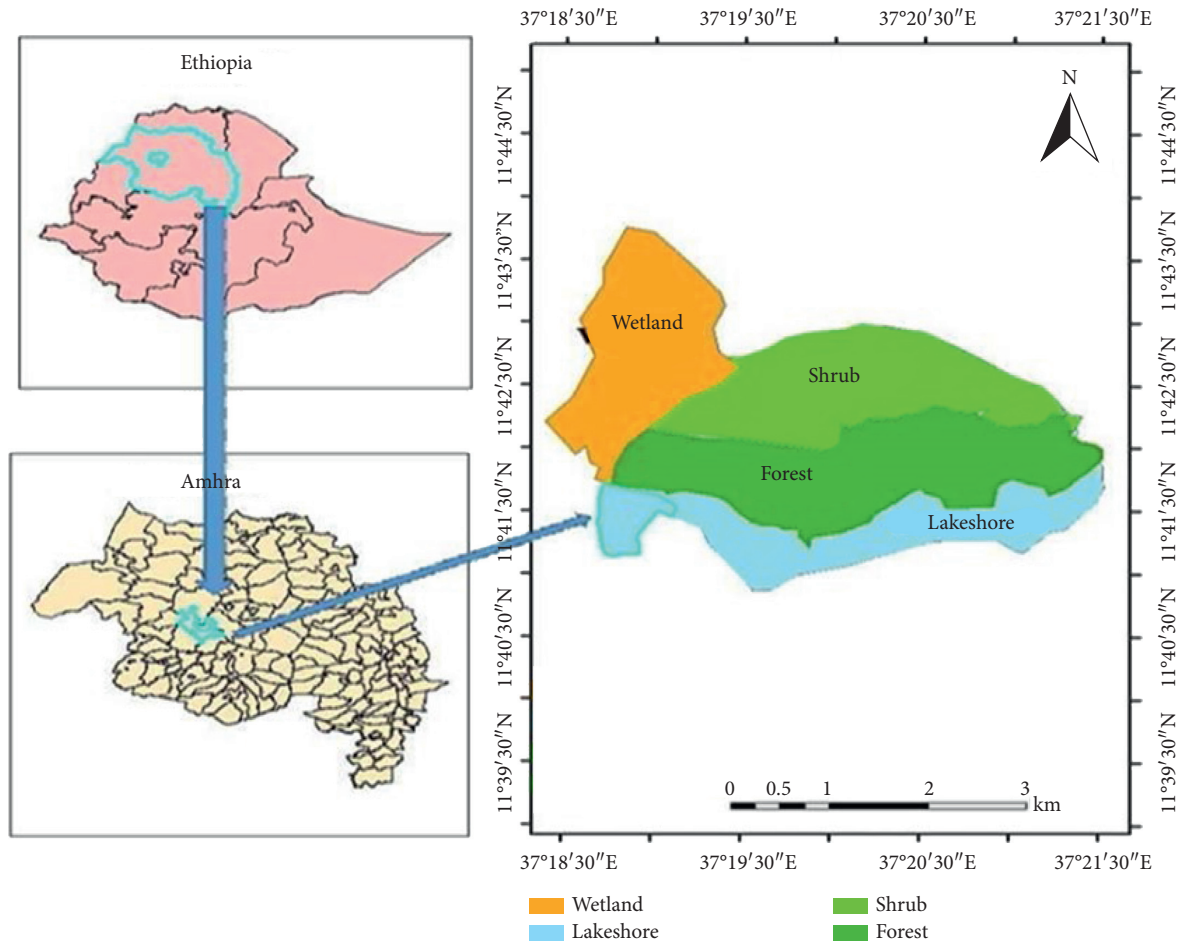
FIGURE 1: Location map of the study area.

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

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. and from 3:00 p.m. to 6:00 p.m. when the weather conditions were convenient and birds become active [23].

To minimize disturbance during the census, a waiting period of 3–5 minutes prior to counting individuals of avian species was maintained [24]. During data collection, the observer and assistants stood at a particular point for a fixed time (10 minutes), and all birds that could be seen within a fixed radius of 25 m were recorded.

Species observed during the survey were identified and taxonomically classified following Sinclari and Ryan [25].

Avian identification was based on different morphological features such as plumage pattern, color, body size, and shape [26]. We additionally used a field guide to the birds of East Africa [27]. Observations were assisted by binoculars, and photographs were also taken for further confirmation of the species.

2.5. Data Analysis. Data analysis methods for this study were performed using the 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 Weaver [28] as

$$H' = -\left(\sum_{1}^{96} Pi\text{Ln}Pi\right),\qquad(1)$$

where H' is the Shannon-Wiener index, Pi is the proportion of the ith species, and Ln is the Natural Logarithm.

Equitability or evenness index was calculated by using the ratio of observed diversity to the maximum diversity using

$$E = \frac{H'}{H\max},\qquad(2)$$

where E is the evenness index, H' is the Shannon-Wiener diversity index, and Hmax is the natural log of the total number of species.

Simpson's Index of Diversity (D) was used to evaluate the relative abundance of avian species in each habitat type. It is a measure of diversity that takes into account both richness and evenness. The index gives the probability of any two individuals drawn from a noticeably large community belonging to different species.

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right),\qquad(3)$$

where n is the total number of individuals of a particular species, and N is the total number of individuals of all species.

The relative abundance of each species was estimated from encounter rates. This value is used to give each species an ordinal rank of abundance using the ranking scale of Bibby et al. [29]. Encounter rate was calculated for each species by dividing the number of birds recorded by the number of hours spent searching, to get the number of individuals per hour for each species.

$$\text{Encounter rate} = \frac{\text{number of individual of a species}}{\text{number of observation hours}} \times 100.\qquad(4)$$

Following Bibby et al. [21], encounter rate values were used to categorize each species into the following five abundance categories: <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) (Simpson, 1949) was used to evaluate the similarity of species between four different habitats in both seasons by using the following formula:

$$\text{SI} = \frac{4C}{F} + LS + S + W,\qquad(5)$$

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

The Chi-square test was used to compare seasonal variations in diversity and evenness of birds at the 95% level of significance. ANOVA was 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 Alcedinidae (Kingfishers), which was followed by Anatidae and Columbidae (7 species for each). Two of the total species identified were endemic to Ethiopia (blue-winged goose (*Cyanochen cyanoptera*) and yellow-fronted parrot (*Poicephalus flavifrons*)). Among the total 96 species, 40 species were recorded only during the wet season, while 13 species were recorded 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 habitats compared to the dry season (Tables 3–5).

During the wet season, the highest diversity of avian species was recorded in the wetland habitat ($H' = 3.3$), followed by forest habitat ($H' = 2.9$), and then shrub habitat ($H' = 2.7$), and the lowest diversity was recorded in the 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 lowest diversity of birds was recorded in the shrubland habitat ($H' = 2.16$) (Table 4).

The highest evenness ($E = 0.87$ and $E = 0.84$) was recorded in the shrub habitat during the wet and dry seasons, respectively, and evenness was the lowest in the shrub habitat ($E = 0.68$) when considering both seasons together (Table 5).

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 ($\chi^2 = 17.2$, d$f = 2$, $p < 0.05$).

During the wet season, the highest species richness was recorded in the wetland (44) and the lowest in lakeshore (22). During the dry season, the highest species richness was in lakeshore (22) and the lowest in the shrub (13) (Figure 2).

3.4. Species Similarity.
Bird species similarity between different habitats showed variations between seasons (Tables 6–8). During the wet season, more species similarity was recorded between lakeshore and wetland habitats

TABLE 2: Bird species recorded in the study area during wet, dry, and both season surveys, representing the most common species.

| SN | Bird species | Family | Seasons | | |
			Wet	Dry	Both
1.	Abdim's stork (*Ciconia abdimii*)	Ciconiidae	Yes	—	—
2.	AbyssinianSlaty-flycatcher (*Melaenornis chocolatina*)	Muscicapidae	Yes	—	—
3.	Abyssinian thrush (*Turdus abyssinicus*)	Turdidae	—	—	Yes
4.	Abyssinian woodpecker (*Dendropicos abyssinicus*)	Picidae	—	—	Yes
5.	African sacred ibis (*Threskiornis aethiopicus*)	Threskiornithidae	—	—	Yes
6.	African black duck (*Anas sparsa*)	Anatidae	—	—	Yes
7.	African collared-dove (*Streptopelia roseogrisea*)	Columbidae	Yes	—	—
8.	African comb duck (*Sarkidiornis melanotos*)	Anatidae	Yes	—	—
9.	African darter (*Anhinga rufa*)	Anhingidae	—	—	Yes
10.	African fish-eagle (*Haliaeetus vocifer*)	Accipitridae	—	—	Yes
11.	African jacana (*Actophilornis africana*)	Jacanidae	—	—	Yes
12.	African paradise-flycatcher (*Terpsiphone viridis*)	Monarchidae	—	Yes	—
13.	African pied wagtail (*Motacilla aguimp*)	Motacillidae	Yes	—	—
14.	African pygmy-goose (*Nettapus auritus*)	Anatidae	—	—	Yes
15.	African pygmy kingfisher (*Ispidina picta*)	Alcedinidae	Yes	—	—
16.	African woolly-neck (*Ciconia microscelis*)	Ciconiidae	Yes	—	—
17.	Bare-faced go-away-bird (*Corythaixoides personata*)	Musophagidae	Yes	—	—
18.	Barred warbler (*Sylvia nisoria*)	Sylviidae	—	—	Yes
19.	Bearded woodpecker (*Dendropicos namaquus*)	Picidae	—	Yes	—
20.	Bimaculated lark (*Melanocorypha bimaculata*)	Alaudidae	Yes	—	—
21.	Black-billed barbet (*Lybius guifsobalito*)	Lybiidae	—	—	Yes
22	Black-crowned crane (*Balearica pavonina*)	Gruidae	Yes	—	—
23.	Black-headed weaver (*Ploceus melanocephalus*)	Ploceidae	Yes	—	—
24.	Black-billed wood-dove (*Turtur abyssinicus*)	Columbidae	Yes	—	—
25.	Black-headed lapwing (*Vanellus tectus*)	Charadriidae	Yes	—	—
26.	Black-winged lovebird (*Agapornis taranta*)-**EE**	Psittacidae	—	—	Yes
27.	Blue-breasted bee-eater (*Merops variegates*)	Meropidae	Yes	—	—
28.	Blue-breasted kingfisher(*Halcyon malimbica*)	Alcedinidae	—	—	Yes
29.	Blue-headed coucal (*Centropus monachus*)	Alcedinidae	—	—	Yes
30.	Blue-spotted wood –dove (*Turtur afer*)	Columbidae	Yes	—	—
31.	Blue-winged goose (*Cynochen cyanoptera*)-**E**	Anatidae	—	—	Yes
32.	Bronze sunbird (*Nectarinia kilimensis*)	Nectariniidae	—	Yes	—
33.	Bruce's green-pigeon (*Treron waalia*)	Columbidae	—	Yes	—
34.	Cattle egret (*Bubulcus ibis*)	Ardeidae	—	—	Yes
35.	Chestnut-backed sparrow-lark (*Eremopterix leucotis*)	Alaudidae	—	—	Yes
36.	Citrine wagtail (*Motacilla citreola*)	Motacillidae	Yes	—	
37.	Collared sunbird (*Anthreptes collaris*)	Nectariniidae	—	—	Yes
38.	Common bulbul (*Pycnonotus barbatus*)	Pycnonotidae	—	Yes	
39.	Common fiscal (*Lanius collaris*)	Laniidae	Yes	—	—
40.	Common sandpiper (*Actitis hypoleucos*)	Scolopacidae	—	—	Yes
41.	Common stonechat (*Saxicola torquata*)	Muscicapidae	—	Yes	—
42.	Coppery tailed coucal (*Centropus cupreicaudus*)	Cuculidae	Yes	—	—
43.	Dark chanting goshawk (*Melierax metabates*)	Accipitridae	Yes	—	—
44.	Double-toothed barbet (*Lybius bidentatus*)	Lybiidae	Yes	—	—
45.	Dusky crested flycatcher (*Elminia albiventris*)	Stenostiridae	Yes	—	—
46.	Eastern plantain-eater (*Crinifer zonurus*)	Musophagidae	—	Yes	—
47.	Egyptian goose (*Alopochen aegyptiacus*)	Anatidae	Yes	—	—
48.	Ethiopian bee-eater (*Merops lafresnayii*)	Meropidae	—	Yes	—
49.	Giant kingfisher (*Megaceryle maximus*)	Alcedinidae	—	—	Yes
50.	Glossy ibis (*Plegadis falcinellus*)	Threskiornithidae	—	—	Yes
51.	Goliath heron (*Ardea goliath*)	Ardeidae	Yes	—	—
52.	Gray-crowned crane (*Balearica regulorum*)	Gruidae	Yes	—	—
53.	Great reed-warbler (*Acrocephalus arundinaceus*)	Acrocephalidae	—	—	Yes
54.	Great-white egret (*Egretta alba*)	Ardeidae	—	—	Yes
55.	Green sandpiper (*Tringa ochropus*)	Scolopacidae	Yes	—	—
56.	Gray-headed wood pecker (*Dendropicos spodocephalus*)	Picidae	Yes	—	—
57.	Grey-backed fiscal (*Lanius excubitoroides*)	Laniidae	—	Yes	—
58.	Grey-headed kingfisher (*Halcyon leucocephala*)	Alcedinidae	—	Yes	—
59.	Hadada ibis (*Bostrychia hagedash*)	Threskiornithidae	—	—	Yes

TABLE 2: Continued.

SN	Bird species	Family	Wet	Dry	Both
			Seasons		
60.	Hammer kop (*Scopus umbretta*)	Scopidae	Yes	—	—
61.	Hooded vulture (*Necrosyrtes monachus*)	Accipitridae	—	—	Yes
62.	Isabelline wheatear (*Oenanthe isabellina*)	Turdidae	—	Yes	—
63.	Isabelline shrike (*lanius isabellinus*)	Laniidae	—	Yes	—
64.	Jameson's fire finch (*Lagonosticta rhodopareia*)	Estrildidae	Yes	—	—
65.	Lesser-swamp-warbler (*Acrocephalus gracilirostris*)	Acrocephalidae	—	—	Yes
66.	Little bee-eater (*Merops pusillus*)	Meropidae	—	—	Yes
67.	Little spotted woodpecker (*campethera cailliautii*)	Picidae	—	—	Yes
68.	Little weaver (*Ploceus luteolus*)	Ploceidae	Yes	—	—
69.	Long-crested eagle (*Lophaetus occipitalis*)	Accipitridae	—	—	Yes
70.	Malachite kingfisher (*Alcedo cristata*)	Alcedinidae	—	—	Yes
71.	Marsh sandpiper (*Tringa stagnatilis*)	Scolopacidae	—	—	Yes
72.	Marsh warbler (*Acrocephalus palustris*)	Acrocephalidae	Yes	—	—
73.	Namaqua dove (*Oena capensis*)	Columbidae	—	Yes	—
74.	Pied kingfisher (*Ceryle rudis*)	Alcedinidae	Yes	—	—
75.	Red -billed fire finch (*Lagonosticta senegala*)	Estrildidae	Yes	—	—
76.	Red-chested cuckoo (*Cuculus solitarius*)	Alcedinidae	Yes	—	—
77.	Red-eyed dove (*Streptopelia semitorquata*)	Columbidae	—	—	Yes
78.	Ruppell's robin-chat (*Cossypha semirufa*)	Muscicapidae	—	—	Yes
79.	Ruppell's weaver (*Ploceus galbula*)	Ploceidae	Yes	—	—
80.	Sacred ibis (*Threskiornis aethiopicus*)	Threskiornithidae	—	—	Yes
81.	Silvery-cheeked hornbill (*Ceratogymna brevis*)	Bucerotidae	—	—	Yes
82.	Speckled mousebird (*Colius striatus*)	Coliidae	Yes	—	—
83.	83. Speckled pigeon (*Columba guinea*)	Columbidae	—	—	Yes
84.	Spectacled weaver (*Ploceus ocularis*)	Ploceidae	—	—	Yes
85.	Spur-winged goose (*Plectropterus gambensis*)	Anatidae	—	—	Yes
86.	Spur-winged lapwing (*Vanellus spinosus*)	Charadriidae	—	—	Yes
87.	Squacco heron (*Ardeola ralloides*)	Ardeidae	Yes	—	—
88.	Striped kingfisher (*Halcyon chelicuti*)	Alcedinidae	—	—	Yes
89.	Tropical boubou (*Laniarius aethiopicus*)	Malaconotidae	—	—	Yes
90.	Wattled ibis (*Bostrychia carunculata*)-**EE**	Threskiornithidae	Yes	—	—
91.	White browed coucal (*Centropus superciliosus*)	Cuculidae	—	—	Yes
92.	White-faced whistling duck (*Dendrocygna viduata*)	Anatidae	Yes	—	—
93.	White-winged tern (*Chlidonias leucopterus*)	Laridae	Yes	—	—
94.	White-fronted black chat (*Oenanthe albifrons*)	Muscicapidae	Yes	—	—
95.	Yellow-billed stork (*Mycteria ibis*)	Ciconiidae	—	—	Yes
96.	Yellow-fronted parrot (*Poicephalus flavifrons*)-**E**	Psittacidae	—	—	Yes

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

TABLE 3: Species diversity of birds during the wet season.

Habitat	Species richness	Abundance	H'	Hmax	H'/Hmax	$D = 1 - \sum Pi^2$
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 the dry season.

Habitat	Species richness	Abundance	H'	Hmax	H'/Hmax	$D = 1 - \sum Pi^2$
Forest	20	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

TABLE 5: Species diversity of birds during both seasons.

Habitat	Species richness	Abundance	H'	Hmax	H'/Hmax	$D = 1 - \sum Pi^2$
Forest	17	126	2.2	2.8	0.79	0.833
Lakeshore	15	228	2.1	2.7	0.79	0.85
Shrub	9	72	1.5	2.2	0.68	0.64
Wetland	19	357	2.4	2.9	0.82	0.89

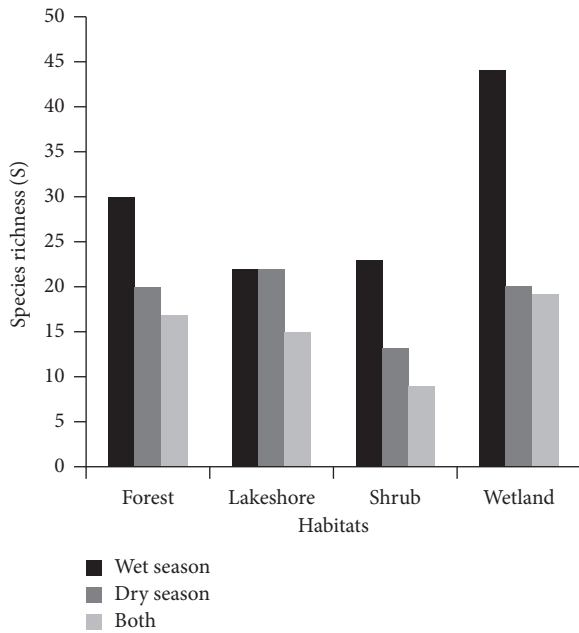Note: H' = Shannon-Wiener Index; H/H'max = Evenness; D = Diversity Index; H'max = ln(S).

FIGURE 2: Species richness of birds in the four different habitats.

TABLE 6: 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 7: 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 8: Simpson's similarity index (SI) during both seasons.

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

Note: Simpson's similarity index (SI) = 2C/A + B where A is the number of species in habitat A, B is the number of species in habitat B, and C is the number of common species for both habitats.

(SI = 0.39) (Table 6). The 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 7).

Species similarity was higher between bird species of forest and shrubs when considering both the wet and dry seasons together (SI = 0.58) (Table 8). 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 9).

3.5. Habitat Association. Chi-squared test showed that the distribution of bird species in different habitats was significantly different ($\chi^2 = 11.89$, d$f = 3$, $p < 0.05$) (Table 10).

Among the observed bird species, 34 (25.2%) of them were recorded from the forest, 32 (23.7%) of them were recorded from the lakeshore, 29 (21.5%) of them recorded from the shrub, and 40 (29.6%) of them were recorded from wetland habitats.

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

The mean number of individuals per habitat was statistically significant ($p < 0.05$, d$f = 3$). This indicates that habitat differences had a significant effect on the abundance of birds. However, there was not a statistically significant difference in the abundance of birds within the same habitat between seasons ($p > 0.05$, d$f = 2$).

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

4. Discussion

A total of 96 species of birds were recorded from the study area. Compared to the size of the study area, this result indicates that the area is moderately rich in avian diversity.

TABLE 9: 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

Note: Similarity Index (SI) = $2C/A + B$

TABLE 10: Multiple pairwise comparisons of mean difference in species abundance in different habitats using LSD.

(I) habitat	(J) habitat	Mean difference (I-J)	Std. error	Sig.(p)
Forest	Lakeshore	−7.04*	2.69	**.009**
	Shrub	1.91	2.90	.511
	Wetland	−9.43*	2.47	**.000**
Lakeshore	Forest	7.04*	2.69	**.009**
	Shrub	8.95*	2.98	**.003**
	Wetland	−2.38	2.56	.353
Shrub	Forest	−1.91	2.9	.511
	Lakeshore	−8.95*	2.98	**.003**
	Wetland	−11.34*	2.79	**.000**
Wetland	Forest	9.43*	2.47	**.000**
	Lakeshore	2.38	2.56	.353
	Shrub	1.13*	2.79	**.000**

*The mean difference is significant at the 0.05 level.
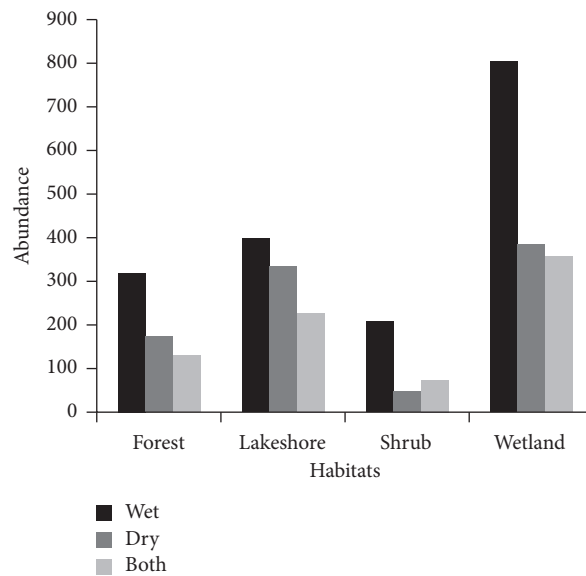
FIGURE 3: Abundance of the bird during wet, dry, and both seasons from all habitats.

From these recorded avian species, two species, namely, blue-winged goose (*Cyanochen cyanoptera*) and Yellow-fronted parrot (*Poicephalus flavifrons*), are endemic to only Ethiopia and black-winged lovebird (*Agapornis taranta*) and Wattled Ibis (*Bostrychia carunculata*) are endemic to Ethiopia and Eritrea.

A previous study in the same area by Aynalem and Bekele [8] showed that the area harbored 129 bird species. Currently, we have recorded fewer species than Shimelis

Aynalem. This could indicate that diversity is declining because of various anthropogenic activities such as deforestation of trees for timber and cutting trees for firewood. The forest coverage in the area is declining, which could also affect avian diversity [30, 31].

Even though bird species richness and relative abundance are influenced by local resource availability and vegetation composition, a study by Hansson [32] indicated that the number of plant species is not clearly correlated with the

number of bird species. However, according to Aynalem and Bekele [9], the distribution and abundance of many bird species are determined by the composition of the vegetation that forms a major element of their habitats. Differences in habitat characteristics and feeding habits of bird species in the study area are likely responsible for the variation in species diversity and the number of individuals of bird species among different habitats [33]. Wetlands, forests, lakeshore, and shrubs are the most dominant habitats in our study area.

Wetlands provide a home for a considerable diversity of wildlife including birds, mammals, fish, frogs, and various invertebrate species [34]. This is partly because wetland habitats contain different food sources for these organisms, including water plants and planktons [35]. Wetland birds are heterogeneous in their feeding habits [36]. In the study area, this habitat is enclosed with papyrus vegetation (*Cyperus papyrus*) and *Typha* plants. These are important for feeding, nesting, and breeding sites [9]; for instance, black-headed weaver (*Ploceus melanocephalus*), which was the most dominant bird species in the area, uses papyrus vegetation (*Cyperus papyrus*) and *Typha* for nesting. Also, the wetland habitat is close to forest habitat, which could provide an opportunity for lakeshore birds as a waiting area to detect their prey in the nearby Lake Tana.

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 [37] and they may also support abundant food resources for birds such as arthropods in bark and dead woody tissues [38].

During the dry season, the bird species of the lakeshore habitat were more diverse than other habitats. This might be due to the presence of diversified vegetation cover in the area that provides various functions for different avian species and the availability of food that attracts birds that feed on aquatic animals like fish and crustaceans at the edge of the lake. According to Baker and Baker [39], large numbers of species are expected to occur along the edges of different habitats. Most species of the family Alcedinidae including (African pygmy kingfisher (*Ispidina picta*), blue-breasted kingfisher (*Halcyon malimbica*), and giant kingfisher (*Megaceryle maximus*)) are concentrated in lakeshore habitats as they prey on fish that inhabit the lake. This idea is also supposed by Terborgh et al. [40]. Edge effects may have a great contribution to the increase in the number of species. The lowest avian diversity was recorded in the shrub habitat. This might be because birds move to the adjacent area that has an abundant supply of food and a stable source of food and cover [41].

In addition to this, the low number of species recorded at each habitat type might be due to different reasons including the less conspicuous nature of some avian species and the lower detectability of small cryptic birds in the area [42, 43]. This idea is supported by Tassie and Bekele [44]. Generally, it is difficult to list all species available in a natural community [45].

The study showed that lower avian species diversity was recorded during the wet season in the shrub habitat compared to the other habitat types. This might be because of anthropogenic activities. The local people clear the indigenous trees and they have changed the area to agricultural land for coffee plantation, and this could affect the bird's niche. This finding is in line with Rana [46], who reported that in natural habitats where the intervention of humans is lower, the diversity of species is higher than habitats where intensive farming is apparent.

As the number of vegetation layers increases, the number of available niches for birds also increases and so does the diversity of avian species [47]. The fluctuation of species diversity in different habitats and seasons might be due to the local migration of birds from one habitat to the other in search of food [48, 49]. Natural seasonal fluctuations and anthropogenic activities are driven in the shrub habitat; as a result, birds migrate to nearby habitats.

During the wet season, the highest species richness was recorded in the wetland, followed by the forest habitat. This might be due to the high availability of resources in the wetlands for wetland birds [50] and the high structural complexity of vegetation in the forest [51]. The difference in species richness between habitats might be due to variations such as topography and vertical and horizontal vegetation structure [52]. The highest evenness value was in shrub habitat, which also had the lowest species richness. This agrees with the idea of Krebs [48], which describes that evenness is independent of species richness.

The analysis of bird species similarity among the four habitat types showed the 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 the similarity in vegetation composition in the two habitats. This result coincides with the results of Karr [53], which state that faunas under similar ecological conditions are more 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 resources and breeding site requirements among the different bird species.

The distribution of birds within the four habitats varied. This variation might be due to the variation in the 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 [52, 54].

The highest number of individuals was 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 a food source for birds in wetlands. And also, there is higher vegetation complexity in the forest than in other habitats. As a result, the high number of individual species of birds was concentrated on specific trees. This might be the suitability and the availability of a high amount of fruits. For example, Bruce's Green-Pigeon (*Treron waalia*) was concentrated on *Ficus vasta* trees during the dry season.

The difference in the 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 resources result in seasonal changes in the species abundance of birds [52].

It is complicated to estimate the absolute density of species from count data in a multispecies study with dense vegetation. Instead, the encounter rate can be more appropriate. The data provided by the encounter rates do not provide an accurate indication of abundance and are not a substitute for the density estimate. In addition, the relative abundance of species may have little relation with IUCN species category criteria; rather, it is useful to know the abundance of the species in a particular area [8].

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 [55] suggested that the presence of large numbers of uncommon species in a certain area could be related to the breeding nature and the large home range of the species. In addition, degradation of the habitat might be a reason for the species to be uncommon. Aynalem and Bekele [8] suggested that cutting trees and clearing vegetation for coffee plantations and firewood production to sell to the nearest town were common in the area, and this affects the relative abundance of birds.

5. Conclusion

Zegie Peninsula forest patches and associated wetlands support diverse avian species including endemic species of birds in different habitats. During the survey, a total of 96 species of birds belonging to 38 families were identified from the study area. The highest number of bird species were recorded from the family Alcedinidae. Species diversity and richness were higher in both the wetland and forest habitats, and this might be associated with the presence of a sufficient amount of food, habitat conditions, and the breeding nature of species.

There was significant variation in species across habitats. The variation in the habitat depends on the types of vegetation in the area. During the wet season, the diversity of avian species was the highest in wetland habitat and the lowest in shrub habitat. During the dry season, the highest diversity of birds was observed in lakeshore habitats, perhaps because it is an intermediate between aquatic and terrestrial habitats. This habitat plays a great role for opportunistic birds, especially for kingfisher species.

The results of the present study showed that the majority of avian species in the area were known as uncommon and frequent. The forest is shrinking in size from all directions due to various anthropogenic activities including clear cutting of trees for firewood and construction materials (timber production). The wetland habitat is also exposed to overgrazing by livestock which has a negative impact on both birds' diversity and abundance. It seems likely that the bird species diversity in the area will decline.

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