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Research Article

Diversity and Relative Abundance of Avian Species in the Wetland Area Northwest of Lake Abaya, Southern Ethiopia

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Studies on the diversity and relative abundance of birds are crucial for improving wetland bird conservation in Ethiopia. The current study aimed at investigating the diversity and relative abundance of avian species in the wetland area around Lake Abaya's northwest tip in southern Ethiopia due to the lack of previous studies that were conducted in the area. A line transect method was applied to determine the avian species in the area. A total of eight line transects were established along the banks. Using encounter rates, which provide crude ordinal scales of abundance, the relative abundance of avian species was calculated. In the intended habitat, Shannon-Wiener diversity indices (H') were employed to analyze the diversity of avian species. During the study period, a total of 34 bird species belonging to 18 families and 12 orders were recorded. Ardeidae and Threskiornithidae were the two most dominant families. In this study, 13 bird species were frequent, four were common, four were rare, one was uncommon, and 10 had abundant records. The highest species diversity ($H' = 3.40$), species evenness (0.093), and Margalef's richness index ($N = 30$) were recorded during the months of June, July, and May, respectively. The lowest species diversity ($H' = 3.13$), evenness (0.088), and Margalef's richness index ($N = 23$) were all recorded during the month of February. The present findings will provide relevant information to the concerned bodies and policymakers to take appropriate conservation measures for wetland birds.

1. Introduction

Birds are a well-known class of species because they are the most noticeable animals in most environments [1]. They serve as models and indicators for the study of nutrition and habitat use to examine how wetland environments have changed [2, 3]. They provide major contributions to the socioeconomic system and ecosystem health [4]. They provide ample services, such as pollinating the plants, dispersing the seed, and controlling the pest [5–7]. Avian abundance and species richness reflect comprehensive ecological consequences with diverse societal impacts [8].

Due to the highest levels of richness and production, the wetland bird community profited considerably from the wetlands [9]. Any wetland has a variety of geographical and temporal distributions of birds [10]. Food availability, habitat suitability, geophysiological structure, and wetland size affect the diversity and dispersion patterns of birds [11]. Wetland birds, which are relatively large species and frequently congregate in extremely high numbers, serve as important herbivores or predators in many aquatic ecosystems [12, 7]. The dynamics of wetland bird communities are intricate and impacted by both natural (bird life cycles and water availability) and manmade (hunting, water extraction, and agriculture) phenomena [13].

According to Yasin and Wondimagegnehu [14], wetlands are mosaic habitats that wetland birds use as breeding grounds and access locations for foraging. However, these habitats are disappearing globally [15]. Wetland disturbance,

degradation, and loss reduce the ecological and socioeconomic benefits of wetlands and have a detrimental effect on the plant and animal species that depend on them [16, 17].

In terms of avifauna, Ethiopia is one of the most notable countries in Africa. Due to the diverse habitat types of Ethiopia, ranging from moist rain forests to deserts, over 926 species of birds have been recorded in the country, of which 19 are endemic to the country, 14 are endemic to both Ethiopia and Eretria, and 39 are threatened globally [18, 19]. In Ethiopia, wetlands, rivers, and woods serve as wintering grounds or transit points for migratory birds [19, 20]. Studies on the diversity and quantity of bird species focus on national parks and other types of protected areas in Ethiopia [2, 21, 22]. There was no sufficient evidence of the diversity and number of bird species outside the wetlands and protected areas in the country.

Understanding the diversity and relative abundance of birds will help manage ecosystems and their services. In order to provide fundamental knowledge on the abundance and diversity of bird species, the current study was carried out in the northwest of Lake Abaya, at the boundary of the Wolayta zone. This study attempted to find answers to the following research questions due to the lack of sufficient scientific evidence on the aforementioned topic within the present study area: (i) What types of avian species exist in the wetland of the study area? (ii) What is the relative abundance of the water-dependent avian species at the northwest part of Lake Abaya in different months of the year? (iii) What is the seasonal difference between the species at the northwest end of Lake Abaya?

Due to time and financial constraints, the present study only focused on the diversity and relative abundance of wetland bird populations in the northwest end of Lake Abaya rather than other ecological studies that could be conducted on wetland bird populations, such as feeding ecology, reproductive behavior, activity pattern, social behavior, and conservation challenges.

2. Materials and Methods

2.1. The Study Area. The study area is located to the northwest of Lake Abaya in the Wolayta zone, Abala Abaya District, between 6° 26′0″ and 6° 50′0″N latitude and 37° 45′0″ to 38° 3′30″E longitude. The district contains sixteen kebeles (the smallest administrative unit in Ethiopia). From these, the three kebeles were intentionally selected, which are neighbors to Lake Abaya (Abaya Gurucho, Abaya Bilate, and Abaya Chokare). The area has a total of 136.52 km^2 of coverage. The study area is 30 km and 430 km away from Wolaita Sodo town and the capital city of the country, Addis Ababa, respectively (Figure 1).

With regard to economic activities, agriculture (mainly crop and livestock production) is the most important economic sector in the Abala Abaya District. The mean annual temperature of the area is 22°C, and the mean annual rainfall is 1123.15 mm. The dry season in the area is from January to March, and the wet season is from May to July. The type of rainfall in the area is biannual (short and long rainy seasons). The area with the lowest elevation, less than 1100 meters above sea level, lies in the southeast and has the largest Rift Valley Lake, Lake Abaya.

2.2. Methods. A preliminary survey was carried out in December 2019 to assess the existence and identification of wetland birds for the purpose of checking the reliability of the data. In this period, the vegetation, fauna, topography, and infrastructure of the study area were investigated.

A line transect method was used to determine the avian species of the area following the work of Lloyd et al. [23] and Sutherland [24]. A total of eight transects were established along the banks. Each of the determined transects had a length of 400 m and a width of 100 m. Following the work of Aynalem and Afework [25], each transect line was 100 m away from the roadside to avoid the edge effect, with a minimum of 300 m between the consecutive line transects to avoid double counting of the same bird species. The observer periodically walked at a speed of 0.5 km per hour on the transect line to detect wetland bird records, as recommended by Bibby et al. [26]. To minimize disturbance during the count, observers moved silently [24, 26, 27].

Data collection was carried out for three days in each month of the dry (January–March, 2020) and wet (May–July, 2020) seasons, i.e., for about thirty-six days during the whole study period. The data were collected from 6:30 a.m. to 10:00 a.m. in the morning and 3:00 p.m. to 6:00 p.m. in the afternoon when the birds were active in performing multiple activities [28]. Through direct sightings, an observer used binoculars to record bird species and numbers in the wetland area and along the lake's edge. Birds were identified using different morphological features (e.g., plumage pattern, size, shape, and color). For those species that were tough to recognize, their photographs and videos were taken using a digital camera [29]. At each sampling transect line, a species heard without being seen was recorded once to avoid overestimation of the population due to repeated singing by the same birds. The field guidebooks of Sinclair and Ryan [30] and Redman et al. [31] were used for the identification and categorization of birds into their respective taxonomic groups.

2.3. Data Analysis. The species diversity of the area was analyzed using the Shannon diversity index as follows:

$$H' = -\sum\{(Pi) * (\ln\ Pi)\}, i = 1, \quad (1)$$

where H' denotes the Shannon diversity index, Pi denotes the proportion of the total population made up of species I, S denotes the number of species encountered, Σ denotes the sum of species 1 to species S, and ln denotes the natural logarithm. Species richness (S) was calculated by

$$S = \sum n, \quad (2)$$

where n is the number of species in a community. Species evenness was evaluated using the Shannon–Wiener evenness index (E) as follows:

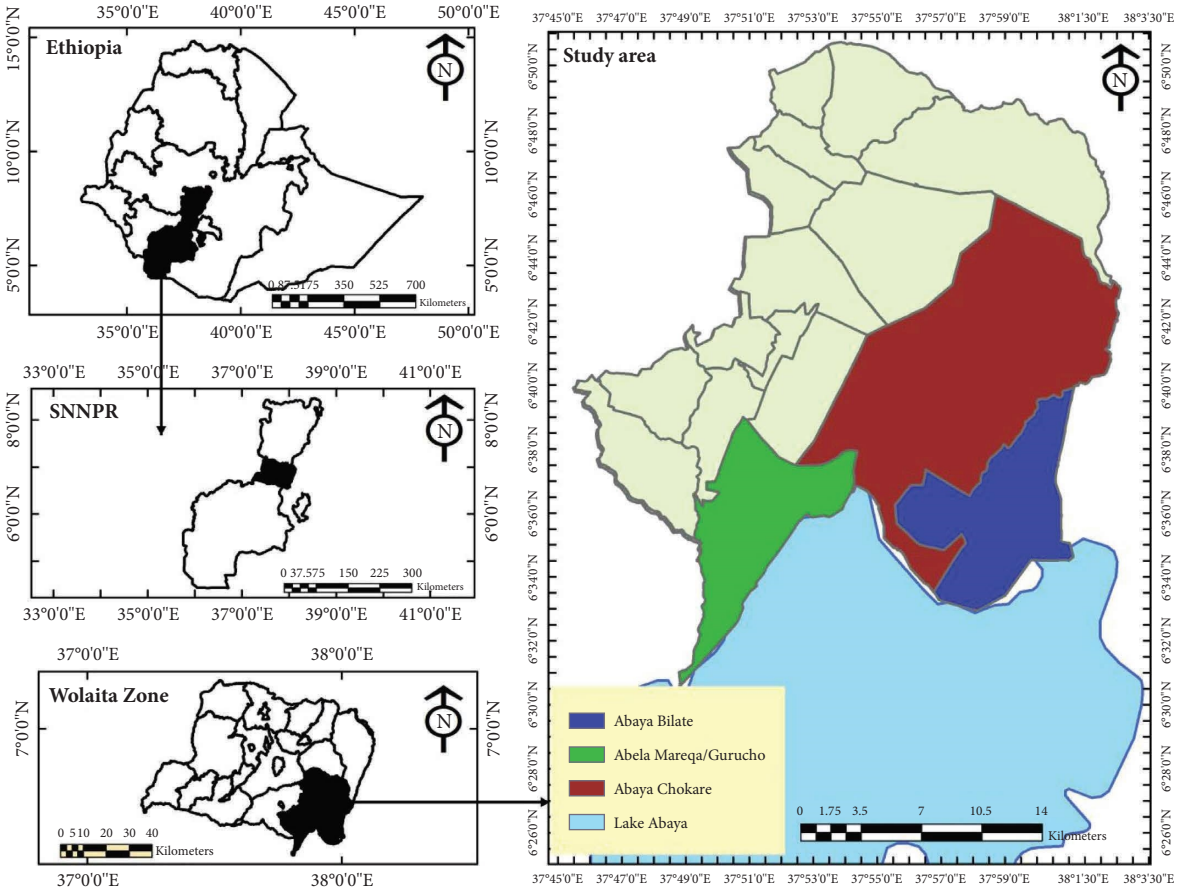

Figure 1: The wetland area in the northwest of Lake Abaya.

$$E = \frac{H'}{\text{Hmax}}, \tag{3}$$

where E denotes the Shannon–Wiener evenness index, H' denotes the Shannon–Wiener diversity index, and $H_{\max} = \ln S$ is the natural logarithm of the total number of species (S).

Data collected during the study period were analyzed using SPSS version 22. A chi-square test was used to test the difference in species richness among the study months. The Pearson correlation coefficient was used to evaluate the significance of the difference between the total number of bird species and the mean number of birds counted in each month.

The relative abundance of avian species was determined following the work of Bibby et al. [26, 32] (using the encounter rates that give crude ordinal scales of abundance, i.e., abundant, common, frequent, uncommon, and rare).

$$\text{Encounter rate} = \frac{\text{total number of birds observed}}{\text{observation time in hours}} \times 100\%. \tag{4}$$

The abundance category was <0.1 for rare, 0.1–2.0 for uncommon, 2.1–10.0 for frequent, 10.1–40.0 for common, and 40+ for abundant, i.e., the number of records per 100 field hours [21]. For each category, the following abundance scores were given: 1 (rare), 2 (uncommon), 3 (frequent), 4 (common), and 5 (abundant).

3. Results

A total of 34 bird species grouped under 12 orders and 18 families were recorded throughout the study seasons. Among these bird species, the family Ardeidae ($N = 6$, 17.64%) has the highest number of avian species, followed by the families Threskiornithidae, Sturnidae, and Threskiornithidae (each with $N = 4$, 11.76%), Charadriidae ($N = 3$, 8.82%), and Columbidae ($N = 2$, 5.88%), while each of the remaining families has the lowest number of species (each with $N = 1$, 2.94%). Among the avian species, only *Bostrychia carunculata* (2.94%) was endemic to Ethiopia and Eritrea, 30 (88.3%) were residents, two (5.9%) were migrants, and one (2.9%) was partially migrant (Table 1).

The highest and lowest diversity of birds were observed during May ($H' = 3.4$) and February ($H' = 3.13$), respectively. The highest evenness distribution of the birds was observed during July ($E = 0.093$), whereas the lowest was during February ($E = 0.088$) (Table 2).

May had the most bird species recorded ($N = 30$), and February had the fewest ($N = 23$). The mean number of species is calculated by dividing the average number of species by the number of days in each month (Table 3).

Table 1: The composition of avian species in the study area.

Orders	Families	Common names	Scientific names	Number of records		IUCN category
				Dry	Wet	
Passeriformes	Monarchidae	African paradise-flycatcher	*Terpsiphone viridis*	12	0	LC
Suliformes	Anhingidae	African darter	*Anhinga rufa*	16	56	LC
Charadriiformes	Jacanidae	African jacana	*Actophilornis africanus*	14	20	LC
Pelecaniformes	Threskiornithidae	African spoonbill	*Platalea alba*	18	24	LC
Pelecaniformes	Threskiornithidae	Australian white ibis	*Threskiornis molucca*	18	0	LC
Pelecaniformes	Ardeidae	Black-headed heron	*Ardea melanocephala*	4	4	LC
Charadriiformes	Glareolidae	Black-winged pratincole	*Glareola nordmanni*	16	0	NT
Cuculiformes	Cuculidae	Blue-headed coucal	*Centropus monachus*	2	34	LC
Pelecaniformes	Ardeidae	Cattle egret	*Bubulcus ibis*	34	78	LC
Charadriiformes	Charadriidae	Crowned lapwing	*Vanellus coronatus*	28	12	LC
Columbiformes	Columbidae	Dusky turtle dove	*Streptopelia lugens*	34	52	LC
Anseriformes	Anatidae	Egyptian goose	*Alopochen aegyptiaca*	42	52	LC
Passeriformes	Sturnidae	Greater blue-eared starling	*Lamprotornis chalybaeus*	22	28	LC
Pelecaniformes	Ardeidae	Great egret	*Ardea alba*	30	48	LC
Passeriformes	Laniidae	Gray-backed fiscal	*Lanius excubitoroides*	2	36	LC
Pelecaniformes	Ardeidae	Gray heron	*Ardea cinerea*	10	22	LC
Pelecaniformes	Ardeidae	Goliath heron	*Ardea goliath*	0	14	LC
Pelecaniformes	Threskiornithidae	Wattled ibis	*Bostrychia carunculata*	2	54	LC
Pelecaniformes	Scopidae	Hamerkop	*Scopus umbretta*	0	22	LC
Pelecaniformes	Ardeidae	Intermediate egret	*Ardea intermedia*	2	18	LC
Columbiformes	Columbidae	Red-eyed dove	*Streptopelia semitorquata*	30	37	LC
Passeriformes	Sturnidae	Superb starling	*Lamprotornis superbus*	22	20	LC
Passeriformes	Hirundinidae	White-tailed swallow	*Hirundomegaensis*	18	20	VU
Passeriformes	Sturnidae	White-billed starling	*Onychognathus albirostris*	18	16	LC
Charadriiformes	Charadriidae	African wattled lapwing	*Vanellus senegallus*	10	14	LC
Pelecaniformes	Threskiornithidae	African sacred ibis	*Threskiornis aethiopicus*	2	62	LC
Passeriformes	Passeridae	Swainson's sparrow	*Passer swainsonii*	8	74	LC
Ciconiiformes	Ciconiidae	Saddle-billed stork	*Ephippiorhynchus senegalensis*	0	10	LC
Coraciiformes	Alcedinidae	Pied kingfisher	*Ceryle rudis*	16	20	LC
Passeriformes	Sturnidae	Rüppell's starling	*Lamprotornis purpuroptera*	6	0	LC
Anseriformes	Anatidae	White-faced whistling duck	*Dendrocygna viduata*	28	58	LC
Passeriformes	Vangidae	White-crested helmetshrike	*Prionops plumatus*	2	20	LC
Charadriiformes	Charadriidae	Three-banded plover	*Charadrius tricollaris*	8	22	LC
Ciconiiformes	Ciconiidae	Marabou stork	*Leptoptilos crumenifer*	4	63	LC
Total				478	1010	

Note. LC = least concern, NT = near threatened, and VU = vulnerable.

Table 2: The diversity of bird species in the study area.

Month	Species richness	H'	H max	E
January	25	0.287	3.21	0.089
February	23	0.277	3.13	0.088
March	28	0.303	3.33	0.091
May	30	0.311	3.33	0.091
June	29	0.308	3.36	0.091
July	27	0.298	3.29	0.093

Table 3: Margalef's richness index as a function of mean SE.

Month	Total number of species	Mean ± SE
January	25	23.75 ± 3.5
February	23	22.75 ± 3.38
March	28	25.25 ± 4.27
May	30	26.25 ± 7.04
June	29	25.75 ± 5.82
July	27	24.75 ± 9.29

The abundance of avian species in the study area was correlated with the season. The total number of birds counted was 1010 and 478 during the wet and dry seasons, respectively (Table 4).

Out of 34 bird species recorded, 13 (38%) were frequent, four (11.8%) were common, four (11.8%) were rare, 12 (35.3%) were abundant, and the rest (2.9%) were uncommon (Table 5). Among these bird species, *Anhinga rufa*, *Ardea alba*, *Ardea goliath*, *Ephippiorhynchus senegalensis*, and *Onychognathus albirostris* are endangered, whereas the dusky turtle dove is critically endangered.

In the study area, the relative abundance of bird species during the dry season was distributed as follows: abundant (51.9%), uncommon (5.9%), frequent (14.2%), common (17.3%), and rare (10.7%). During the wet season, 45.5%, 2.4%, 21%, 13.9%, and 17.2% of the bird species were abundant, uncommon, frequent, common, and rare, respectively (Figure 2).

4. Discussion

Thirty-four bird species were identified during the study period, and they were grouped into 12 orders and 18 families. In southern Ethiopia's Hawassa Lake and a portion of the Eastern Wetland Habitats, 103 bird species from 47 families and 14 orders were identified during the wet and dry seasons, according to Gibru and Mengesha's study from 2021. In comparison with the current study, theirs revealed a higher diversity of wetland bird species. Given that many bird species prefer wetlands as feeding sites, this may be explained by the fact that Hawassa Lake is larger than the current study area and may be associated with the highest diversity and number of bird species. Sizes of habitat patches, the availability of local resources, and vegetation types all have an impact on the diversity and quantity of bird species [33]. Bird species diversity may increase as a result of the variety of nesting and foraging opportunities offered by the different vegetation [34]. Since there are more vegetation layers, there are more bird niches available, which increases the variety of avian species [35].

Wetland birds in the study area were observed at various times of the year or throughout the survey period. While other birds were seen only during the dry season, some were seen only during the wet season. There were several bird species that had a lot of birds at certain times during the study period. The wet season experienced the greatest diversity of bird species. This has to do with the existing bird species having access to sufficient amounts of food, nesting locations, and water. The availability of resources and favorable climatic conditions may also be responsible for the variation in bird species [25]. According to [36, 37], seasonal variations in rainfall and food availability have influenced the composition and number of species. A decrease in vegetative productivity, a reduction in the availability of feed, and the poor quality of nesting sites for birds may all be factors in the decline of certain bird species during the dry season. The birds might not get as much rain as they require because this is the sole outcome of a lack of rain. According to Chace and Walsh [38], birds shift between different habitat types based on the presence of food and caves.

There was not a significant variation in the number of bird species in the study area throughout the months. The current study revealed that the month of May had the highest species richness, and the month of February had the lowest species richness. This might be due to the presence of migrant species such as kites and bee-eaters during May and the fact that most local bird species were experiencing less-than-ideal weather conditions during February. *Streptopelia lugens*, *Vanellus coronatus*, *Ardea alba*, and *Streptopelia semitorquata* were all common during the month of March. For instance, throughout the study period, it was observed that grazing animals and cutting trees from the locals to use as firewood were regular actions. These activities may disturb avian species during their mating seasons and lead to a decline in the number of bird species in the area. The abundance of common bird species in the area was related to the dray's suitability for meeting the demands of birds during dry and wet seasons. According to Mengesha and Afework [29, 39], seasonality impacts the bird population's access to food and cover, which in turn affects mating success and ultimately the survival of the species.

In the study area during the dry seasons, *Alopochen aegyptiaca, Bubulcus ibis, Streptopelia lugens,* and *Ardea alba* had the most records. Contrarily, *Centropus monachus* was the least numerous species of bird discovered during the dry season. Additionally, *Passer swainsonii* was the most frequent bird species recorded during the wet season. Habitat characteristics and bird species' behavior may be linked to a greater number of rare and frequent species than abundance and uncommon species occurrence. In agreement with this, Wilson et al. [40] observed that it seemed as though habitat conditions were related to the rarity of a number of species. Thiolloy [41] made the argument that species are continuously rare because of either their wide home ranges or their patchy distribution in the area. The bird populations shift due to seasonal differences in the availability of food supplies and the rainfall's obvious seasonality [22]. The diversity and abundance of avian species have been shown to be influenced by a number of environmental factors, including food, temperature, and competition [42]. According to Manasvini [43], a greater number of birds in a habitat may be caused by the composition of the vegetation that makes up the majority of that habitat, or it may be influenced by the topography, floral diversity, anthropogenic activities, and predation.

The number of bird species varied greatly between the dry and wet seasons. This may be the result of seasonal weather variations, when birds may not be able to handle the climate. Another factor in the variation of bird species in the study area could be their migration to a new location in search of a different feeding environment.

5. Implications for Conservation

Based on current information, this research area can be considered one of the best places for bird species in

Table 4: The abundance of avian species in different seasons.

Species name	Family	Order	Avian species seasonal abundance					
			Dry			Wet		
			Jan	Feb	Mar	May	June	July
Terpsiphone viridis	Passeriformes	Monarchidae	0	12	0	0	0	0
Anhinga rufa	Suliformes	Anhingidae	0	4	12	18	20	18
Actophilornis africanus	Charadriiformes	Jacanidae	4	3	7	6	5	9
Ardea cinerea	Pelecaniformes	Ardeidae	0	0	18	8	6	10
Platalea alba	Pelecaniformes	Threskiornithidae	4	6	8	0	0	0
Threskiornis molucca	Pelecaniformes	Threskiornithidae	2	1	1	0	2	2
Ardea melanocephala	Pelecaniformes	Ardeidae	0	4	12	0	0	0
Glareola nordmanni	Charadriiformes	Glareolidae	1	1	0	16	18	0
Centropus monachus	Cuculiformes	Cuculidae	14	0	20	35	10	33
Bubulcus ibis	Pelecaniformes	Ardeidae	8	9	11	4	8	0
Vanellus coronatus	Charadriiformes	Charadriidae	22	5	7	28	24	0
Streptopelia lugens	Columbiformes	Columbidae	19	0	23	20	11	21
Alopochen aegyptiaca	Anseriformes	Anatidae	2	8	12	9	9	10
Lamprotornis chalybaeus	Passeriformes	Sturnidae	12	6	12	10	19	19
Ardea alba	Pelecaniformes	Ardeidae	2	0	0	7	16	13
Lanius excubitoroides	Passeriformes	Laniidae	5	5	0	7	7	8
Ardea goliath	Pelecaniformes	Ardeidae	0	0	0	5	5	4
Bostrychia carunculata	Pelecaniformes	Threskiornithidae	0	0	2	12	10	32
Scopus umbretta	Pelecaniformes	Scopidae	0	0	0	6	7	9
Ardea intermedia	Pelecaniformes	Ardeidae	0	0	2	5	5	8
Streptopelia semitorquata	Columbiformes	Columbidae	10	15	5	11	17	9
Lamprotornis superbus	Passeriformes	Sturnidae	7	15	0	0	0	20
Hirundo megaensis	Passeriformes	Hirundinidae	8	10	0	10	5	5
Onychognathus albirostris	Passeriformes	Sturnidae	8	3	7	3	6	7
Vanellus senegallus	Charadriiformes	Charadriidae	4	2	4	4	6	4
Passer swainsonii	Passeriformes	Passeridae	0	0	2	20	20	22
Ephippiorhynchus senegalensis	Ciconiiformes	Ciconiidae	0	2	6	34	30	10
Ceryle rudis	Coraciiformes	Alcedinidae	0	0	0	5	5	0
Lamprotornis purpuroptera	Passeriformes	Sturnidae	6	10	0	17	3	0
Dendrocygna viduata	Anseriformes	Anatidae	5	1	0	0	0	0
Prionops plumatus	Passeriformes	Vangidae	0	0	28	35	23	0
Charadrius tricollaris	Charadriiformes	Charadriidae	2	0	0	12	8	0
Leptoptilos crumenifer	Ciconiiformes	Ciconiidae	7	1	0	14	4	4
Threskiornis aethiopicus	Pelecaniformes	Threskiornithidae	2	0	2	36	15	12
Total monthly records			154	123	201	397	324	289

Table 5: The relative abundance of avian species in the study area.

Abundant	Common	Frequent	Uncommon	Rare
Terpsiphone viridis	*Bubulcus ibis*	*Actophilornis africanus*	*Streptopelia lugens*	*Anhinga rufa*
Ardea cinerea	*Vanellus coronatus*	*Platalea alba*		*Ardea alba*
Threskiornis molucca	*Lanius excubitoroides*	*Centropus monachus*		*Ephippiorhynchus senegalensis*
Ardea goliath	*Lamprotornis chalybaeus*	*Ardea melanocephala*		*Prionops plumatus*
Ardea intermedia		*Alopochen aegyptiaca*		
Ceryle rudis		*Bostrychia carunculata*		
Streptopelia semitorquata		*Scopus umbretta*		
Lamprotornis superbus		*Lamprotornis purpuroptera*		
Hirundo megaensis		*Threskiornis aethiopicus*		
Dendrocygna viduata		*Passer swainsonii*		
Charadrius tricollaris		*Vanellus senegallus*		
Leptoptilos crumenifer		*Onychognathus albirostris*		
		Ardea melanocephala		

Ethiopia's southern region. Additional research is required to determine the conservation status of the local birds and any threats to their survival. The study area has been identified as rich in avian species; therefore, responsible organizations and stakeholders should fully examine the value of bird species, including their habitat. Other scholars might utilize this information as a starting point for additional investigation into the importance and challenges

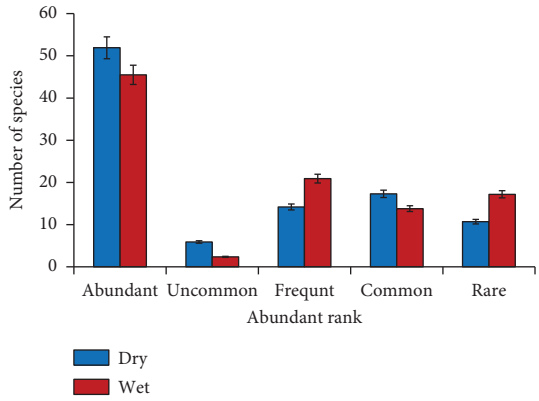

Figure 2: Bird species' abundance ranks during the dry and wet seasons.

facing those avian species. In addition, it will provide pertinent data that policymakers and decision-makers may use to update the country's current avian species conservation and wetland management strategies.

Data Availability

The datasets generated and analyzed during the current study are included within the article.

Ethical Approval

The study was approved by the Institutional Research Review Board (IRB) of Wolaita Sodo University.

Disclosure

All authors agreed to make this original research work public.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Authors' Contributions

All authors contributed to the study's conception and project design. Samuel Bekele and Wondimagegnehu Tekalign prepared the material, collected the data, and conducted the analysis. All contributors provided feedback on earlier drafts of the article after Samuel Bekele wrote the original draft. All authors have read and approved the manuscript.

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