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Species Diversity and Relative Abundance of Avifauna in Lake Hawassa and its Adjoining Areas, Southern Ethiopia

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Abstract

This study was conducted to investigate species diversity and relative abundance of birds in Lake Hawassa and its adjoining areas from August 2017 to February 2018. Systematic random sampling techniques at an interval of 3km were used to select sampling grids. Data were analyzed by using PAST Software version 2.17c in analysing biodiversity indices, Bray-Curtis cluster analysis and Individual Rarefaction analysis. The result showed a total of 103 avian species record belonging to 47 families and 14 orders during both the wet and dry seasons. During the wet season, the riverine habitat had the highest avian species diversity (H'=3.60), followed by Lake Hawassa (H'=3.43), whereas during the dry season, Lake Hawassa had the highest avian species diversity (H'=3.70), followed by the riverine habitat (H'=3.67). Highest species richness was recorded in Lake Hawassa in both seasons. Lake Hawassa and Cheleleka wetland had the strongest bird similarity (39.08%) as shown by the Bray-Curtis cluster analysis. The relative abundance score of species during the wet and dry seasons was variable in all the study sites. The results imply the need to conserve the avifauna of the whole study sites through the conservation of their habitats.

Keywords: Bird diversity, Wetland, Richness, Species similarity

Introduction

Ethiopia is blessed with plenty of water resources, long green fields, rich animal husbandry and over all, diverse flora and fauna [1]. The number of bird species varies from literature to literature but the most commonly cited number is 861 species of birds [2]. However, Lepage [3] listed 864, of which 19 endemics, 35 are globally threatened and 1 introduced species and a further 13 are shared only with Eritrea. 214 Palearctic migrants also recorded from Ethiopia [4]. Among these, 45 species have been found to over-summer within the boundaries of the country.

The Ethiopian Central Rift Valley (ECRV) area is also known to have a number of lakes and hydrological features [5] and along with their associated watershed areas are known to harbor millions of resident and migratory water-birds. The Rift Valley lakes and their inflowing rivers however, have been recently challenged to a high degree by land use changes that threaten their ecological integrity and species are being depleted before scientific information about them is obtained [6].

A total of 538 species of birds: More than 65% of the country's total is recorded from the RVL's ecosystem [7]. Of the 29 Ethio-Eritrean endemic bird species, 8 are endemic to the Ethiopian Rift Valley. According to a relative abundance classification system, there are 201 species of birds in the Ethiopian Rift Valley that are common (60-100% chance of being seen), 241 species that are frequent (10-59% chance of being seen) and 96 species that are rare (0-9% chance of being seen) [7].

The study area, Lake Hawassa and its vicinities Tikur Wuha River and Cheleleka wetland are part of the Ethiopian central rift valley ecosystem. Lake Hawassa is a Closed-catchment which is fed both by few ephemeral streams on the north-west and western side of the catchment and by the Tikur Wuha River, which is the only perennial river, enters Lake Hawassa draining the Cheleleka wetland on the north-east side. Lake Hawassa and the eastern part of wetland habitat Cheleleka wetland consist of migratory water birds [2]. As a result, the lake is recognized as an Important Bird Area (IBA) and a potential Ramsar site of Ethiopia [2, 8]. Cheleleka wetland is slightly acidic (humic acid) due to the large biomass degrading in the standing water [9]. Very little is known about the chemistry, physical features and biota of this wetland. Land use land cover changes like urbanization, change of shrub by woodland and bush land in to cultivated land and change of shallow Lake Cheleleka in to a swamp are found to be the major changes in the catchment [10].

Assessment of diversity and distribution of ecosystem resources provide information on the resource that is contained in an ecosystem, resource relationships and the environmental factors that influence their distribution and diversity [11-12]. Shumway, insists that many sites face multiple threats due to incomplete knowledge about the ecology of most aquatic species and limited taxonomic knowledge and incomplete information on species abundance and distribution [13]. However, a systematic bird species list and information on bird species diversity is lacking from this natural lake and the surrounding habitats. This paper, therefore has aimed to investigate the diversity of bird species in and around the Lake, wetland and riverine habitat with its adjacent vegetation type for future protection and management of these decisive sites.

Materials and Methods

Description of the Study Area

Lake Hawassa and the adjoining areas (Tikur Wuha Riverine Habitat and Cheleleka Wetland) were the specific sites where the present study was conducted (Figure 1).

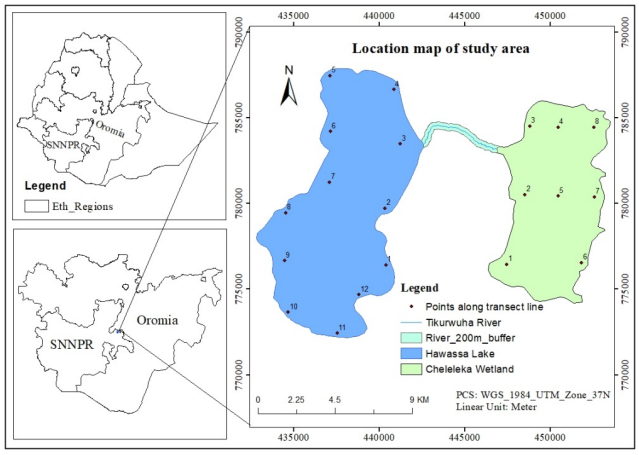


Figure 1: Location map of the study area.

The area comprised parts of Oromya Regional State and Southern Nations and Nationalities Peoples' Regional State. Lake Hawassa is located within the geographical co-ordinates of 6˚45'7"-7˚6'37''N and 38˚23'30"-38˚28'48" E. The Cheleleka wetland habitat occurs between the geographical co-ordinates of 07˚00' 13"-07˚6'37"N and 38˚30'51"-38˚34'44"E.

The riverine habitat of Tikur Wuha River begins at Cheleleka wetland habitat towards Lake Hawassa to the west-south. It is a perennial river and the only tributary rivers that feed Lake Hawassa which drains Lake Cheleleka. The vegetation type of the riverine habitat is riverine woodland with indigenous trees. Cheleleka wetland had a surface area of 14.5 km^2 and a 63 km^2 area of swamp surrounding it [14]. The vegetation of this wetland habitat comprises species of Tall papyrus like grasses indicating that the deposition of transported sediment from the uplands has been in a continuous process of filling the natural reservoir of Cheleleka wetland [15].

The annual average magnitude rain fall of Hawassa and the vicinities is 961 mm and distributed as 50% for Kiremt (June-September); 20% for Bega (October-February) and 30% for Belg season (March-May) [16]. Mean monthly temperatures varied between 17°C and 22°C with mean temperature of 17°C and low in July. The maximum temperature is 27°C and drops to 25.5°c from May to November. The night temperatures decline and sometimes come to zero between December and February and the relative humidity is close to 60% [16].

A preliminary survey was conducted during in the first two week of August 2017. The physical features of the study area were assessed using ground survey. The coordinates of each study site was taken and their boundaries were delineated.

Sampling design

A systematic random sampling technique was used for selecting the actual sampling sites as described by Bibby et al. [17]. From the total area of Lake Hawassa (95.8 km^2), 23.95 km^2, from Cheleleka wetland total area of which (56.6 km^2), 14.15 km^2 and around 75% of the riverine habitat areas were covered for sampling.

Then, line transect method was employed for counting of birds on the shoreline of the Lake and the open wetland habitats at every 3km interval. For the riverine habitat by allocating four blocks observations was made by walking along the bank of the river [18]. A total of 26 transect lines; 4 from riverine habitat, 12 along the shoreline, 1 in the open area of Lake Hawassa and 9 from the open wetland habitat of Cheleleka wetland were taken. 25% of the study area was sampled from the Lake Hawassa and Cheleleka wetland habitats.

To count birds, a transect line of 2 km for the open wetland habitats and lake shoreline by 50-300m sighting distance were selected. In the riverine habitat a length of 1km and a sighting distance ranging from 150-200 m in both sides perpendicular to the riverine buffer zone was followed [19]. The sighting distance varied on either side of transects depending on the species and habitat types as used by Pomeroy [20] and Girma Mengesha et al. [21]. In the open area of the lake, one long transect line of 18 km length was laid projected from south to north direction following Girma Mengesha et al. [21]. Counting of birds was carried out using a boat that was slowly driven along the transect line at a speed of between 5 and 10 km/hr to allow an easy detection of birds during surveys. Then birds within 300meters width on either side of transects were counted.

Data collection

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 bird activity was maximum and on days with good weather conditions [22]. To minimize disturbance during counting, silent movement and appropriate distances from birds were taken into consideration [17]. Weekly visits to the site were made for six months during both wet and dry seasons and an average of 2 weeks was accounted for a month around total of 230 recording hours. During counting of birds the start and end geographical coordinates of each transect were saved in Garmin 72 GPS unit to ensure same transects were repeated during the dry season. Date including starting and finishing time, bird species, number and survey site were recorded. To avoid repeated counting of bird's areas were divided based on their distribution and habitat types [23].

Avian identification was based on different morphological features such as plumage pattern, size, shape, color, calls and using field guides [24-25] and observations were assisted by Nikon binoculars. Photographs and videos were taken by using digital camera to justify the species type for those species which were difficult to identify. At each sampling transect line and during each counting session a species heard without being seen was recorded once to avoid overestimation of Population due to repeated singing by the same individual [24]. The song and call records of Chappuis [26] and Hammick [27] were used to relate with the songs and calls of birds heard during the survey period. Finally, birds checklist was prepared on the basis of their scientific names, common names and IUCN status as per Bird Life international [8] and Redman et al. [25].

Data analysis

Statistical Product Services and Solutions (SPSS) Version 20 software was used to do the statistical analysis. Paleontological Statistics (PAST) Software version 2.17c was used in analyzing biodiversity indices, Bray-Curtis cluster analysis and Individual Rarefaction analysis. It is a free statistical software package for paleontological data analysis which enables measures of diversity to be calculated [28]. Relative abundance of avian species was determined using encounter rates following Bibby et al. [19]. 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 a figure of birds per hour for each species. It was calculated as:

$$\text{Encounter rate} = \frac{\text{total number of individual birds observered}}{\text{periods of observation in hour}} \times 100$$

Abundance categories were < 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) [17,19].

Results

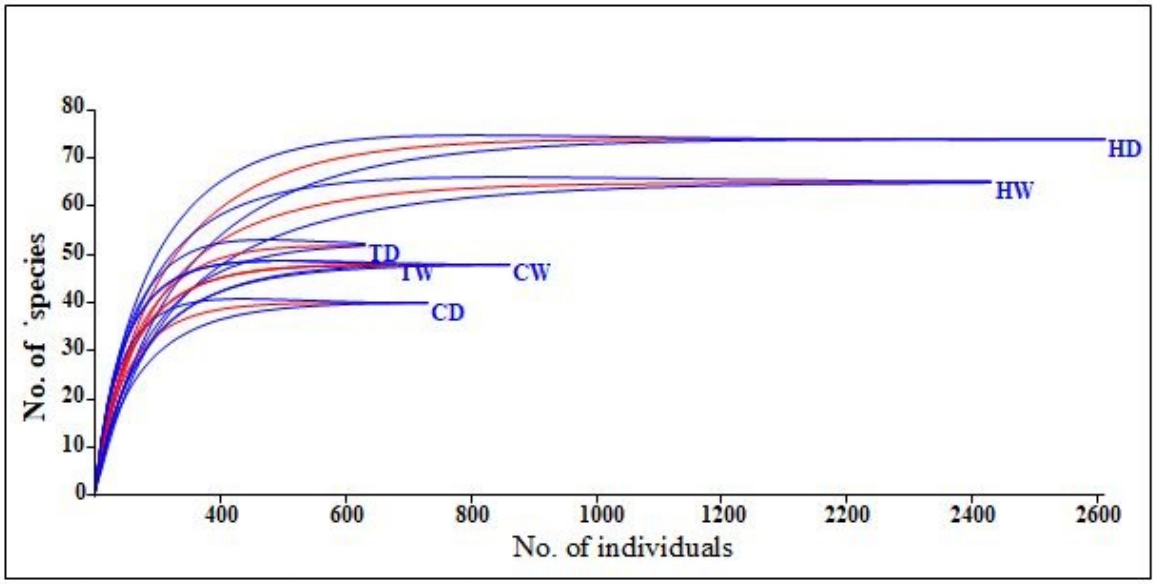
Species Richness

A total of 103 species of birds grouped into 47 families and 14 orders were recorded during the two seasons wet and dry from the three study sites (Table 1). Among the 14 orders *Passeriformes* dominates with 24 species followed by *Coliiformes* (16), *Ciconiifores* (14) and *Bucerotiformes* (13). The least species was recorded in the order *Accipitriformes, Charadriiformes, Columbiformes* and *Piciformes* one species each (Table 1).

Order	Total number of species recorded	No. of species in Lake Hawassa	No. of species in Tikur Wuha	No. of species in Cheleleka Wetland
Ciconiifores				
Accipitriformes	3	2	2	2
Anseriformes	13	11	3	10
Bucerotiformes	1	1	1	
Charadriiformes	14	13	7	5
Ciconiifores	16	13	4	14
Coliiformes	1		1	
Columbiformes	6	5	5	1
Coraciiformes	7	5	5	2
Cuculiformes	2	1	1	1
Gruiformes	3	2	1	1
Passeriformes	24	14	21	10
Pelicaniformes	9	9	1	4
Piciformes	1		1	
Psittaciformes	2		2	
Total	**103**	**76**	**55**	**51**

Table 1: Bird Species recorded from Lake Hawassa and its adjoining areas during the study period.

Individual rarefaction curves shown that Lake Hawassa had the highest curve during both wet and dry seasons which is rarefied above 60 species and down beyond 2600 individuals. Whereas the riverine habitat and Cheleleka wetland have the lowest curve which indicates fewer than 60 species (Figure 2).



HW: Lake Hawassa Wet Season; HD: Lake Hawassa Dry Season; TW: Tikur Wuha Riverine Habitat Wet Season; TD: Tikur Wuha Riverine Habitat Dry Season; CH: Cheleleka Wet Land Wet Season; CD: Cheleleka Wet Land Dry Season.

Figure 2: Individual Rarefaction curves for avifauna in three study sites during wet and dry seasons.

Species Diversity, Evenness and Dominance

The Shannon-Weiner diversity index revealed that highest avian species diversity (H'=3.60) was recorded in Tikur Wuha riverine habitat during wet season followed by Lake Hawassa (H'=3.43) and the least (H′=3.42) was recorded in Cheleleka wetland in the same season. During the dry season, the highest avian species diversity was recorded in Lake Hawasa (H′=3.70) followed by Tikur Wuha riverine habitat (H'=3.60) the least diversity of avian species during the dry season was recorded in Cheleleka wetland (H'=3.41). The highest and the lowest even distribution of species during wet season were recorded in the Tikur Wuha riverine habitat (E=0.93) and Lake Hawassa (E=0.83) respectively. For the whole seasons the highest species evenness was recorded in the riverine habitat (H'=0.93). During wet season Lake Hawassa had the highest dominance index (0.10) (Table 2).

Study site	Season	species richness	Abundance (no. of individuals)	D	H´	H´/H´max
Lake Hawasa	Wet	65	2443	0.1	3.43	0.83
	Dry	74	2614	0.06	3.7	0.86
	Both	64	2530	0.05	3.54	0.85
Riverine Habitat	Wet	48	696	0.03	3.6	0.93
	Dry	52	636	0.03	3.67	0.93
	Both	48	681	0.02	3.51	0.91
Cheleleka Wetland	Wet	48	875	0.02	3.42	0.89
	Dry	40	748	0.04	3.41	0.82
	Both	38	835	0.02	3.38	0.83

D=Simpson's Dominance Index; H´= Shannon-Wiener Index; H´/H´max= Evenness; H´max= ln(S)

Table 2: *Avian* species abundance, diversity and evenness during wet and dry seasons.

Seasonal similarity of avian species

During the study the highest species similarity was recorded in riverine habitat (SI=0.96) followed by open water of Lake Hawassa (SI=0.92) and the least was in the Cheleleka wetland (0.86) (Table 3).

Study sites	Season		common species	SI
	Wet	Dry		
Lake	65	74	64	0.92
Riverine	48	52	48	0.96
Swamp/Wetland	48	40	38	0.86

Table 3: Species similarity (SI) during the wet and dry seasons along the different study sites.

Avian Similarities in the study sites

Cluster analysis (Fig. 3) shows the similarity of the three study sites, in which Lake Hawassa and Cheleleka wetland formed the first clade which means that these sites shared mostly the same avifaunal species. These sites have the highest similarity percentage, 39.08%. Tikur wuha riverine habitat is less related to Lake Hawassa and Cheleleka wetland, with a percentage similarity of 13.08%.

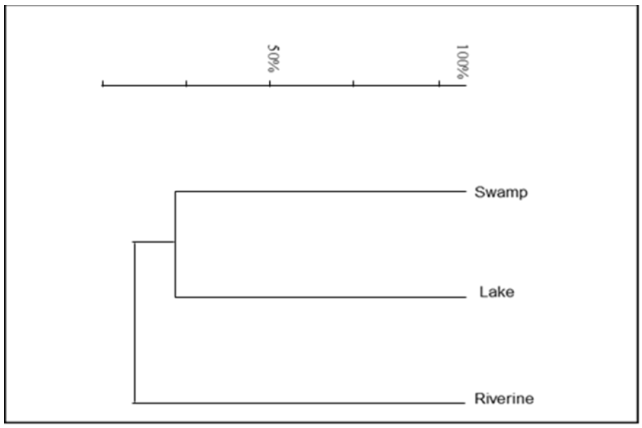


Figure 3: Similarity of species composition and their distributions of birds across the three study sites in Lake Hawassa and the eastern part of wetland habitats (Bray-Curtis Cluster Analysis-single link).

Relative Abundance

The relative abundance scores of species during the wet season showed that 31, 10 and 21 species were frequent 32, 35 and 25 were common 2, 3 and 2 were abundant at Hawassa Lake, Tikur Wuha Riverine habitat and in Cheleleka Wetland, respectively. During the dry season 39, 6 and 21 species were frequent 31, 36 and 17 species were common 4, 6 and 2 were abundant at Lake Hawassa, Tikur Wuha riverine habitat and in the Cheleleka wetland, respectively. Rare and uncommon species were not registered at both seasons. The most recorded species were locally abundant and frequent (Figure 4).

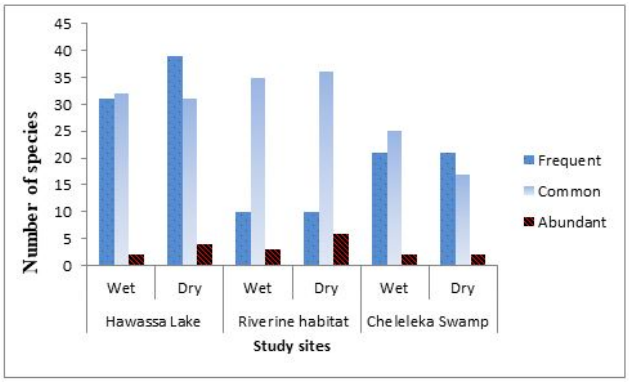


Figure 4: Abundance rank of bird species in the study area during both wet and dry seasons.

Discussion

The Mixed terrestrial and aquatic vegetation on the study area were found to support large number of bird species as compared to specific habitat type. The highest individual rarefaction curves shown during both wet and dry seasons in Lake Hawassa indicates that the species richness is highest in this habitat and that a rigorous sampling in this Habitat will only retrieve a few additional species [29]. However, Tikur wuha riverine habitat and Cheleleka wetland had the lowest curve which showed that species richness is lowest in these habitats. This means that more sampling effort in the habitats would likely to retrieve more new species [30]. Ellis and Betts [31] reported that rarefaction allows comparison of species richness at a standardized sample size and avoids confusing genuine differences in species richness with differences in sampling effort.

Batary et al. [32] reported that a high species diversity of birds suggests that there is high tree diversity in the area, while Martin and Blackburn [33] pointed out that a lower diversity value might be due to anthropogenic activities in the area which have resulted to low niche competition. In natural habitats where the intervention of humans is less and minimum, the diversity as well as the evenness of species is higher than the fragmented ones where intensive farming is carried out [34]. Differences in feeding habits and habitats could also increase diversity, evenness and species richness [35]. This shows that Lake Hawasa and riverine habitat are likely composed of diverse vegetation. The highest number of individuals and species, as well as high species diversity in Lake Hawasa, was observed to be due to the edge effects. Edge effects refer to the biotic and abiotic contrasts between adjacent habitat types. It may include alteration of the biotic and abiotic factors [36-37]. Moreover, Harvey et al. [38] reported that tree covers in secondary and riparian forests would be associated with higher animal species richness and abundance since they are likely to provide resources and habitat for the species originally present in the area than highly modified tree covers. This supports the high species richness and diversity in Lake Hawasa and riverine habitat, which are adjacent to the secondary forests. Riparian forests are also important because this type of forest provides forage to forest-dependent bird species. Furthermore, it was shown by Styring et al. [39] that canopy height, secondary canopy development, and shrub cover are important factors in increased species richness and diversity of bird communities.

During wet season, results show higher species dominance in Lake Hawassa. Probably because a lot of nesting sites available in the Lake shore line and food availability, Marabou Stork (*Leptoptilos crumeniferus*) was found to be the dominant species with a highest dominance index. Dominance results when one or several species control the environment and conditions and influence associated species [40]. A high index implies that a dominant bird species exists in this habitat [41-42]. A study conducted by Demeke Datiko and Afework Bekele [23] in Lake Ziway indicated that Marabou Stork was abundant species during wet season. During the dry season, some species might abandon the area, decreasing the number of individuals in unhealthy habitats [43]. Lee and Rotenberry [44] stressed that modification of the natural environment affects the relative abundance of species. Moreover, as noted by Monadjem et al. [45], Marabou storks are known to move large distances. Similarly, large movements in other large colonial-breeding scavenging birds have been recorded in Namibia [46]. Similar situations might also contribute to seasonal variations in the abundance of the birds in the present study area. The presence of highest species evenness during the whole season in the riverine habitat indicates that the riverine habitat may support

distribution of generalist and opportunistic bird species that can exploit the available resources [47].

The relative abundance of bird species during seasons might be related to the availability of food, habitat condition and breeding season 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 [48].

Most bird species in Lake Hawassa and its adjoining areas were locally common and frequent. This might be the high detectability of birds in open water and open wetland habitats compared to areas with high forest vegetation cover, which causes low visibility. This is in agreement with Forcey et al. [49], McCallum [50] and Skinner et al. [51].

Conclusion and Recommendations

The presence a high number of species suggests that Lake Hawassa and its adjoining areas are key conservation sites of birds. The seasonal variation in avian species and number of individuals in the study area was related to the differences in resource availability between habitats. During both seasons, the highest species richness and individuals of species were recorded in Lake Hawassa among other study sites. More sampling efforts in Cheleleka wetland could likely yield to a higher number of species. High species diversity was recorded in Tikur wuha riverine habitat and Lake Hawassa during wet and dry seasons, respectively. This shows that both habitats are important for birds that provide the necessary requirements such as food, water and nesting and breeding sites. Most avian species recorded were locally common and frequent. Marabou stork, Egyptian goose and white winged black tern were the most abundant species in Lake Hawassa, Cheleleka wetland and Tikur wuha riverine habitat respectively. Generally the study sites harbour diverse bird species. However, interferences with this system were observed. Therefore, conservation measures are needed to protect the biological diversity of the area.

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