Heliyon 9 (2023) e17127

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Species diversity, relative abundance, and distribution of avifauna in different habitats within Lewi Mountain, Awi zone, Ethiopia

Yonas Derebe [a], Binega Derebe [b,*], Melkamu Kassaye [a], Amare Gibru [c]

[a] Department of Forest and Climate Science, College of Agriculture, Food and Climate Science, Injibara University, Ethiopia
[b] Department of Natural Resource Management, College of Agriculture, Food and Climate Science, Injibara University, Ethiopia
[c] Ethiopian Biodiversity Institute, P.O. Box- 30726, Addis Ababa, Ethiopia

ARTICLE INFO

Keywords:
Richness
Endemic
Wetland
Forest
Shrubs
Settlement
Habitat

ABSTRACT

Almost all habitats on the planet are home to birds, from the lowest deserts to the highest mountains. Birds have proved to be excellent indicators of biodiversity or productivity as they are easily observed and are relatively well known compared to other animals. Although bird species are distributed across the globe, habitat destruction, fragmentation, and loss have adversely affected their survival and distribution. Therefore, this study is an attempt to prepare a baseline data on avifaunal diversity with their relative abundance and species richness in different habitats within Lewi Mountain Awi zone, Ethiopia from December 2018 to October 2020, including both the wet and dry seasons. The sampling sites were stratified based on land cover features, and transect count techniques were employed. The data were summarized per season and habitat type in the excel spreadsheet throughout the study period. In this study, one-way ANOVA was used to determine the effect of habitat type on species diversity and abundance. T-tests are also use to analyze bird populations among seasons. A total of 1591 individuals, 56 bird species belonging to 29 families and 12 orders were identified during the two seasons. The Wetland habitat had the highest species diversity index (H' = 3) with high evenness index (J = 0.88) during the dry season followed by the open shrubs habitat (H' = 2.97) with the highest evenness index (J = 0.95). The settlement had the lowest species diversity (H' = 2.17) and the lowest evenness index (J = 0.8) in the same season. During the wet season, disturbed forests recorded the highest Shannon-Weiner diversity index (H' = 3.2) with the highest evenness (J = 0.92) followed by Wetland habitat (H' = 2.97) with high evenness index (J = 0.87). During dry and wet seasons, the abundance of birds' species in different habitat types did not differ significantly ($F = 1.91$, $p = 0.193$, $df = 3$) and ($F = 1.579$, $p = 0.199$, $df = 3$), respectively. From all studied habitats, the overall mean abundance of bird species between dry and wet seasons was significantly different ($F = 3642$, $P \leq 0.001$, $df = 1$). In conclusion, settlement had the lowest species diversity and the lowest evenness index in the research area for the entire season. The habitats are important to the conservation of birds, so good habitat management is required, such as minimizing agricultural expansion and over-grazing, demarcating the forest habitats for wild species only, and creating awareness among local communities.

* Corresponding author.
E-mail address: binegaderebe@gmail.com (B. Derebe).

https://doi.org/10.1016/j.heliyon.2023.e17127
Received 23 June 2022; Received in revised form 5 June 2023; Accepted 8 June 2023
Available online 8 June 2023

1. Introduction

As a result of Ethiopia's diverse ecosystems, Ethiopia is home to a variety of flora, and faunas [1]. Due to their proximity to places with rich biodiversity, the increased extension of productive lands around the world during the past few decades has greatly contributed to biodiversity loss [2]. Understanding how various land-use trajectories affect biodiversity is necessary to make educated decisions about the conservation of species in altered settings [3]. Mountainous environments have distinctive species communities that are the main focus of conservation efforts [4,5]. Global warming and changes human land us, such as grazing pressure and deforestation, are considered major threats to biodiversity in mountain regions, affecting the abundance of bird species and causing their distribution toward mountain tops because most of the time the gentle slop areas are occupied by human beings due to slow run-off (high soil fertility) compare to mountains [4,5]. To minimize the human factors birds may move to mountains. It is expected that the diversity and extent of natural habitats will continue to decline as the human population grows and the landscape is modified for development [6–8]. The decline of birds in the area is caused by forest loss, invasive species, poorly planned infrastructure development, environmental pollution, overexploitation, human-induced climate change, and poverty [7,9]. Human pressure reduces the forest's ability to harbor different bird species [10,11]. Bird diversity and abundance are negatively affected by habitat disturbance [10,12]. The fact that birds are easily observed and relatively well known, compared to other animals, makes them excellent indicators of biodiversity or productivity [13,14]. Birds are excellent environmental monitors and have been employed as "bio-monitors" [15]. Ecological bio-indicators are species or groups of species whose ecological features (such as presence/absence, abundance, and so on) clearly reflect the ecosystem's abiotic or biotic environment [16,17]. Birds are mobile, able to disperse to more advantageous locations from less favorable environments [14]. It is possible for birds to adapt to any environment that meets their reproduction and survival requirements [7,18]. Study on the richness and distribution of bird species is crucial for conservation efforts in various biodiversity protection areas [19–21]. Among the most important components of biodiversity, birds have enormous ecological, economic, and aesthetic benefits [10]. Seed dispersal is assisted by fruit-eating birds. A variety of birds contribute to the pollination of flower nectar's and wild birds are also used as food sources around the world as a bush meat [10,22]. Birds eat pests, pollinate flowers, disseminate seeds, scavenge carrion, cycle nutrients, and alter the environment for the advantage of other species [23]. A variety of functions are performed by bird communities within terrestrial ecosystems, making them important components of biodiversity [24].

Local, regional, and historical factors, such as competition (especially in food, and water with other species including human being), habitat variability, and current and past climate, all influence bird species richness [25]. Among birds, some species are representative of peculiar (one particular) place or landscapes [26]. Such species may have specific habitat requirements and are thus vulnerable to environmental changes [14]. Ethiopia is an enormous, biologically diverse country with unique environmental conditions, that make the country have high number of bird species [27]. There are many species of birds in Ethiopia it makes, one of the most bird species diverse countries in Africa [28,29]. The country have 881 bird species, including 19 endemics, 31 globally threatened species, and one introduced species [7]. Furthermore, ecologists and biologists use species diversity and abundance studies to better understand community organization, which is vital for conservation efforts [30]. Despite Ethiopia's vast bird variety and endemism, the habitat destruction, fragmentation, and loss have been noted for decades, all of these are posing a serious threat to bird species' survival [31]. Avian studies, particularly in impoverished nations like Ethiopia, have disregarded bird variety and distribution, as well as their importance in ecosystem functioning. As a result, Ethiopia's bird checklist is still far from comprehensive [32]. In East Africa, fragmentation and degradation of large undisturbed habitats pose major threats to biodiversity [33]. Due to global environmental changes, biodiversity assessments are becoming increasingly urgent [34]. A good understanding of avian diversity and abundance is essential for attracting local and international tourists as well as for preserving the species [10]. There has been limited research on the diversity, distribution, and abundance of avian species in Ethiopia [10]. In the Lewi Mountain and its surrounding areas, no avifauna research has been conducted. Especially species composition, distribution, relative abundance and evenness of the bird fauna of Lewi Mountain and nearby wetlands have not been addressed till date. This study is an attempt to prepare a baseline data on avifaunal diversity with their relative abundance and species richness for Lewi Mountain. Therefore, the present study attempts to fill this gap and recommend bird conservation measures.

2. Materials and methods

2.1. Description of the study area

Awi is one of the zones in the Amhara Region of Ethiopia. The administrative center of the Awi zone is Injibara town [35]. The study was geographically delimited to Awi Zone Banja district in Lewi Mountain. Conceptually, it was delimited to the avifaunal diversity with their relative abundance and species richness in different habitats within Lewi Mountain Awi zone, Ethiopia. Awi zone department of agriculture, 2018 report shows most of the zone is Woyena Dega (72%), followed by Dega (17%), and Kolla (11%). An area ranging in altitude from 700 to 2900 masl in the Amhara region has a better distribution of annual rainfall (800–2700 mm/year) for the region [36,37]. The temperature of the area ranges from 15 to 24 °C. According to the rainfall distribution in the area, the dry season is from December to April, and the wet season is from May to November [37]. From the total area of the zone (8,935,520 ha) of land, 297,133 ha (33.25%) are used for farm practices. However, most of the area in Awi zone 34.02% (76,554 ha plantation, 277,842 ha natural forest) covered with forest area. Range land and grazing land covers 24.3% (217,138 ha) area of land from total area and other land uses like infrastructure and settlement covers 8.38% (74,853 ha) area land according to the "Awi Zone Agricultural Offices Annual Report," Injibara, 2021. The plants species like *Acacia decorous, Juniperus procera, Cupressus lusitanica, Pinus radiate* [37,38] and *Eucalyptus globulus* were frequently observed in the study area [35,36]. The taxa found in the area are included amphibians, reptiles,

birds, fishes and mammal. Global biodiversity hotspots in the Horn of Africa and Eastern Afromontane, reflecting their highly diverse, unique, and threatened biodiversity [39]. More than 1000 bird species inhabit the Horn of Africa, or nearly half of all sub-Saharan Africa's bird species [39,40]. A total of 1448 species of birds have been recorded in sub-Saharan Africa, which represents around 70% from the whole African [41]. It is home to 79 endemic birds or species that are near endemic, which is the highest number in Africa. Some common bird species in east Africa includes, *Great White Egret, Yellow-billed Egret, Little Egret, Grey Heron, Yellow-billed Stork, Sacred Ibis, Hadada Ibis, Cordon-bleu, Red-billed Firefinch, White-headed Buffalo Weaver, White-billed Buffalo Weaver, Redwing Starling, Blue-eared Glossy Starling, Red-billed Oxpecker, Yellow-billed Oxpecker, Black-headed Oriole, Pied Crow, Fan-tailed Raven* etc [39–42]. Threatened bird species in east Africa includes, White-backed Vulture, Hooded Vulture, Rüppell's Vulture, White-naped Pigeon, White-winged Collared Dove, Mountain Buzzard etc [41]. In Ethiopia, there are 926 species of birds, including 639 residents and 224 seasonal migrants, including 176 from the Palearctic and 48 from inter-African regions [1]. Additionally, 24 species are endemic to Ethiopia, whereas 13 bird species are common to both Ethiopia and Eritrea [1,43]. There are currently 73 hotspots in the country that have been identified as Important Bird Areas (IBAs). Of these 30 sites, 41% represent wetlands, while the remainder are representative of other ecosystems [1,13]. Important Bird and Biodiversity Areas (IBAs) are also used to identify sensitive areas that are relevant to the safeguards of the bird and other biodiversity [43]. Awi zone is one of the IBAs areas in Amhara regions [43]. A combination of livestock rearing and crop production are the primary economic activities in the region, as in other parts of the highlands of the country. Lewi Mountain is found in Awi zone Banja woreda adjacent to Injibara town. It is geographically located between 10°55′ 45″ N to 10°57′ 0″ N latitude and 36° 54′ 45″E to 36° 56′ 0″E longitude at a distance of 440 km North West of Addis Ababa and 120 km south east of Bahir Dar, the capital of Ethiopia and Amhara regional state, respectively (Fig. 1). The study area is characterized by heterogeneous landscape, flora, fauna and habitat types.

2.2. Materials and method

Collecting data for any research depends on the materials available. In order to collect reliable information from the site, specialized materials are required. These materials include a Geographic Position System (GPS), binocular, field guide book, a digital camera, a personal computer, notebook, and pens. A pilot survey was conducted prior to the actual study to gather general information about vegetation cover, access, and roosting and nesting sites for birds in the study area. We collected data between December 2018 and October 2020, including both wet and dry seasons. Rainfall distribution in the area makes December to April the dry season, and May to November the wet season [37]. Wet season extends from September to early November, with the farmland plants at their greenest, and dry season extends from December to early February, when the ground cover fades [44].

2.2.1. Study design and data collection

This study used stratified random sampling because the study area was not uniform in terms of habitat types [45]. The area was

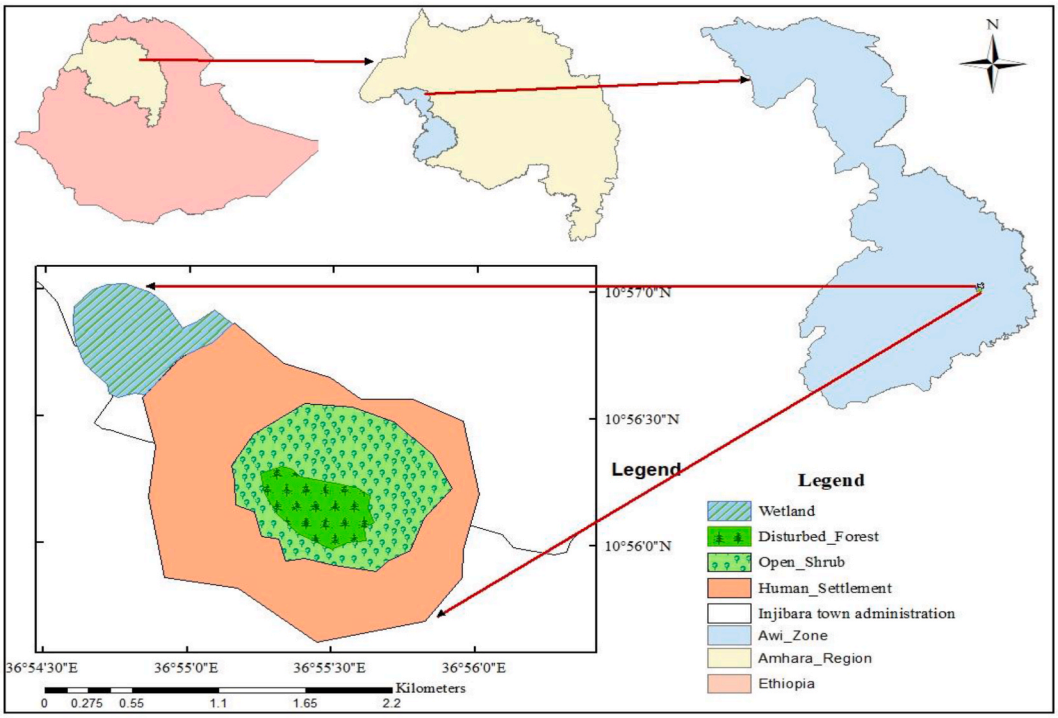

Fig. 1. Map of the study area.

stratified into three natural habitats (disturbed forest, shrub land, settlement and wetland) and human-settlement (Settlement). The area covered by each habitat type was 0.45, 1.05, 2.2 and 0.54 square kilometers (km^2) respectively. To determine the diversity and abundance of bird species, a random sampling design was used across the four stratified habitat types. Bird identifications and counting of individuals were conducted by direct observations using binoculars and field guide books. A line transect method was used to study the diversity, relative abundance, and the distribution of birds in wetland habitat type. Because the wetland is an open habitat (free of trees and shrubs that would impede bird observation), two transect lines were used to count the number of birds. Wetland shapes

Table 1
Species checklist, abundance in both dry and wet seasons, and IUCN conservation status of bird in Lewi Mountain.

Order of species	Family	Scientific name	Common name	Abundance		2021–2022 IUCN-CS
				Dry	Wet	
Passeriformer	Turdidae	*Zoothera piaggiae*	Abyssinian ground trush	66	75	LC
		Turdus abyssinicus	Mountain trush	21	26	LC
		Psophocichla litsitsirupa	Ground scraper trush	6	8	LC
		Onychognathus morio	Red winged starling	17	45	LC
	Pycnonotidae	*Pychonotus barbatus*	Common bulbul	11	23	LC
	Sturnidae	*Lamprotornis chalybaeus*	Greater blue eared starling	22	42	LC
	Corvidae	*Corvus capensis*	Black crown	6	8	LC
		Corvus albus	Pied crown	6	6	LC
	Muscicapidae	*Thamnolaea semirufa*	White winged cliff chat[NE]	8	7	LC
		Oenanthe dubia	Somber rock chat	12	14	DD
		Saxicola torquatus	African stone chat	6	8	LC
		Cossypha heuglin	White brown robin chat	17	18	LC
	Cisticolidae	*Camaroptera brevicaudata*	Grey backed camaroptera	4	4	LC
	Emberizidae	*Emberiza striolata*	Cinnamon breasted bunting	11	13	LC
	Oriolidae	*Oriolus monacha*	Ethiopian oriole	11	25	LC
	Zosteropidae	*Zosterops senegalensis*	Northern yellow white eye	9	7	LC
	Monarchidae	*Terpsiphone rufiventer*	Red belled paradise fly catcher	12	8	LC
	Estrildidae	*Estrilda rhodopyga*	Crimson rumped waxbell	6	4	LC
	Passeridae	*Passer swainsonii*	Swainsons sparrow	15	18	LC
	Malaconotidae	*Laniarius bicolor*	Swamp boubou	4	4	LC
	Nectariniidae	*Nectarinia bocagii*	Bocages sun bird	15	15	LC
		Cinnyris cupreus	Copper sunbird	9	8	LC
		Dreptes thomensis	Jaint sunbird	35	36	VS
		Cinnyris venustus	Variable sun bird	8	11	LC
		Cinnyris chalcomelas	Violet breasted sunbird	14	11	LC
		Cinnyris bifasciatus	Purple bonded sunbird	10	16	LC
		Anthreptes gabonicus	Mangrove sunbird	16	17	LC
	Alaudidae	*Pinarocorys nigricans*	Dusky lark	6	6	LC
	Hirundinidae	*Cecropis daurica*	Red rumped swallow	29	23	LC
	Ploceidae	*Ploceus cucullatus*	Village weaver	55	67	LC
Columbiformer	Columbidae	*Streptopelia semitorquata*	Red eye dove	12	14	LC
		Columba guinea	Speckled pigeon	6	21	LC
		Columba albitorques	White collard pigeon [NE]	4	6	LC
Pelecaniformer	Threskiornithidae	*Threskiornis aethiopicus*	African sacred ibi	45	56	LC
		Bostrychia carunculata	Watled ibis [NE]	11	14	LC
		Bostrychia olivacea	Olive ibis	8	8	LC
	Ardeidae	*Ardea cinerea*	Grey heron	2	4	LC
		Egretta garzetta	Little egret	4	6	LC
		Egretta intemedia	Yellow billed eagret	15	16	LC
Cuculiformer	Cuculidae	*Centropus monachus*	Blue headed coucal	4	6	LC
		Centropus cupreicaudus	Copper tailed coucal	4	4	LC
Gruiformer	Rallidae	*Rougatius rougatti*	Rougats rail [NE]	4	4	NT
		Gallinula chloropus	Common moorhen	6	6	LC
Anseriformer	Anatidae	*Anas undulata*	Yellow billed duck	8	10	LC
		Alopochen aegyptiaca	Egyptian goose	8	8	LC
		Cyanochen cyanopetra	Blue winged goose E	8	8	NT
Accipitriformer	Accipitridae	*Necrosyrtes monacus*	Hooded vulture	11	16	CE
		Buteo	Common buzzard	2	4	LC
		Gyps africanus	White backed vulture	4	2	CE
		Butao augur	Augur buzared	4	2	LC
Coraciiformer	Meropidae	*Merops orientalis*	Little green bee eater	12	8	LC
		Merops pusillus	Little bee eater	36	39	LC
Ciconiiformer	Ciciniidae	*Ciconia*	White billed stork	4	6	LC
Charadriiformer	Charadriidae	*Vanelus spinosus*	Spur-winged lapwing	8	10	LC
Galliformer	Phasianidae	*Pternistis harwoodi*	Hard woods francolin E	2	2	NT
Musophagiformer	Musophagidae	*Turaco leucotis*	White checked turaco [NE]	20	19	LC

N·B., E = Endemic, NE = Endemic to Ethiopia and Eritrea, NT=Near Threatened, LC = Least Concern, CE =Critically Endangered, VS=Vulnerable Species, DD = Data Deficient, CS=Conservation Status.

determined the length of transects, with the longest being 250 m and the short one being 200 m. There was a 200-m spacing between each line transect. The two transects were covered in the sometime by walking, and three data collectors were adjust in each transect. The diversity, quantity, and dispersion of birds were studied using the line transect technique [41,42,44]. The point transect technique was used in disturbed forest, open shrubs, and human settlement habitat types. "Bird communities were surveyed using point counts" [46]. Standing in the center of the point transect and gently observing up to a 50-m radius during the investigation was the most effective way to obtain observational data [47,48]. Observation at each point taken for 15 min [47,49]. Point count observations were made by standing in the center of the point transect and silently observing 360° around 50 m radius [49]. In order to avoid double counting of individual birds, points were separated by 200 m [45]. The first sample points were chosen at random, and thereafter a methodical process (the next point) was followed [50]. A point count method involves counting all individuals seen and heard by observers from a fixed location (census station) over a set period of time [51,52]. The advantage of the point count method was that observers could focus completely on watching birds without having to keep an eye on where they were walking. It also gave observers more time to recognize contact the bird species [17]. During field observation, the birds' common and scientific names were recorded. To identify the bird species, the following three features were used. 1) External morphology (color, shape, size, beak, leg and tail), 2) Song and calls and 3) Habitat type [15]. Some species of birds are restricted in a specific habitat type [53]. Point surveys of bird species were conducted in the mornings from 6:00 to 10:00 a.m. (during sunrise) and in the early evenings from 5:00 to 7:30 p.m. (during sunset) in both dry and wet seasons [32,52]. The frequency of bird observation were three time in dry and three times in wet season in each year. On a data sheet that had been made, each species of bird that had been seen was noted. Double counting of the same species or individual birds at a site was prevented by using simultaneous counting and careful monitoring of birds during the survey. To obtain accurate data, well-experienced researchers and bird experts were involved. Before conducting bird identification, all observers (six collectors, including the authors) received introductory training on how to use the techniques, field materials and tools [30].

2.2.2. Data analysis

Data were summarized seasons per habitat types during study period in the excel spread sheet. SPSS (2020) statistical package was used for the statistical analysis. The effect of seasons on species abundance and richness was analyzed by using paired sample *t*-test and one way ANOVA also used to analysis population difference between habitats. Differences were considered statically significant at the 5% level. Shannon-Weiner Index [14] was used to evaluate the bird species diversity and evenness in the proportion of each species occurring within different habitats for both seasons.

The following formula was used to calculate Shannon diversity index $H' = -\sum pi*\ln(pi)$ (1)

Where H′ is Shannon-winner index, pi is estimated as ni/N, where ni is the proportion of the total population of the ith species and $N = -\sum ni$. This use proportions rather than absolute abundance values to reduce the effects of order of magnitude deference in bird numbers between species.

$$J' = H'/\ln(S) \quad (2)$$

Where J' is Evenness index, H′ is Shannon winner index and used the formula one and S is species richness.

Relative abundance of avian species was determined using percentages (RA) (%) = n/N × 100, where n is the number of individuals of particular species recorded and N is the total number of individuals of the species.

3. Results

3.1. Species richness and abundance of birds

The researchers were expecting more species to be found given the importance of Ethiopia for African and migratory birds. Over the study period, a total of 1591 individuals, 56 bird species belonging to 29 families and 12 orders were identified from the studied areas during the two seasons, wet and dry (Table 1). The order Passeriformer had the highest number of individuals among the recognized species, with an average of 516 (65%) in the two seasons, followed by Pelecaniformer 95.5 (21%). Furthermore, Coraciiformer

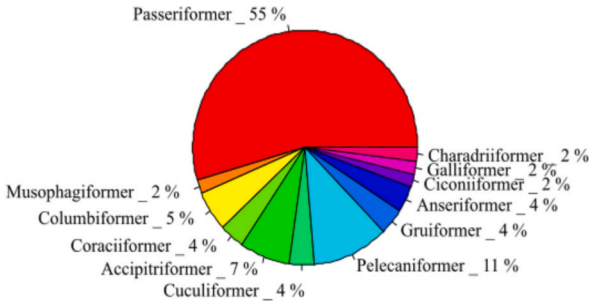

Fig. 2. Number of species recorded from different orders in percent.

(47.5%) and Anseriformer (28%) were at the third and fourth most frequently observed, respectively. During the study, Galliformer was reordered to the lowest order of species from the identified order of birds. Harwood's francolin (*Pternistis harwoodi*) was the only species found in this order, with only two individuals (population) in each season of the study area (Fig. 2). Wild Galliformer are known to be shy and elusive. Male calling betrade they presence during the breeding season. There numbers are ususally underestimated. The only endemic species of Ethiopia that could be found in the research region were the blue-winged geese (*Cynochen cyanopetra*) and the Harwood's francolin (*Pternistis harwoodi*). The White-winged cliff-chat (*Myrmecocichla semirufa*), Wattled ibis (*Bostrychia carunculata*), Rouget's rail (*Ralbus rougetii*), and White collared pigeon (*Columba albitorques*) are all endemic bird species to Ethiopia and Eritrea.

During the dry and wet seasons, the maximum mean abundance of species was observed in disturbed forest habitat (9.56 ± 7.17) and (11.06 ± 8.87), respectively, while the lowest abundance was found in the settlement habitat type (5.75 ± 6.09) and (6.8 ± 7.16) respectively. During the dry and wet seasons, the abundance of bird species not varied significantly between habitat types ($F = 1.91$, $p = 0.19$, $df = 3$) and ($F = 1.57$, $p = 0.19$, $df = 3$) respectively. Disturbed forest habitat type had the highest species richness and number of individuals, followed by wetland habitat type in the study area. However, settlement had the lowest account record for both species number and abundance (Table 2).

3.2. Bird species diversity index

During the dry season, the wetland habitat had the highest species diversity index (H' = 3) and the high evenness index (J = 0.88), followed by the open shrubs habitat (H' = 2.97) and the highest evenness index (J = 0.95). In the same season, settlement had the lowest species diversity (H' = 2.17) and evenness index (J = 0.8) (Table 4). Wetland habitat (H' = 2.97) had the highest Shannon-Weiner diversity index (H' = 3.2) with the most evenness (J = 0.87) during the wet season, followed by disturbed forest (H' = 3.2) with the highest evenness (J = 0.92). Due to high human disturbance, settlement had the lowest species diversity (H' = 2.2) and the lowest evenness index (J = 0.78) in the study area for the entire season (Table 4).

3.3. Relative abundance and distributions of birds

The Abyssinian ground trush (*Zoothera piaggiae*) had the highest relative abundance 9.18% (66 individuals), 8.9% (75 individuals) in both dry and wet seasons, followed by Village weaver (*Ploceus cucullatus*) with a relative abundance of 6.95% (50 individuals), 7.68% (67 individuals) in both dry and wet seasons, respectively. Common buzzard (*Buteo)* is a scarce winter visitor to Ethiopia and expected to be less observed. Also the Francolin is a very shy species and not easy to spot in the wild. The number of bird identified are linear relationships with the relative abundance (Fig. 3). Common buzsared (*Buteo*) and Hard woods francolin (*Pternistis harwoodi*) had the lowest relative abundance in the study area, with 0.28% and 0.28%, respectively (2 individuals in each). (Table 1). Passeriformes (Cinnamon-breasted bunting, Mountain trush, Village weaver, African stonechat, Greater blue-eared starling, Abyssinian ground trush, Red rumped swallow), Columbiformes (Red eye dove and Speckled pigeon), and Coraciiformes (Little green bee-eater and Little bee-eater) were well-represented in all four habitats (Table 5).

4. Discussions

Unique and diversified bird communities can be found in Ethiopia [51]. The number of Important Bird Areas (IBAs) nationally has increased from 69 to 73 since 2003 [54]. However, many of Ethiopia's IBAs have been affected by agricultural activity, deforestation, and overgrazing, similar to the majority of African nations [55–59]. During the study the order of Passeriformes has the highest number of species and population recorded. Similar survey by Ref. [44] the order of Passeriformes has the highest number of species recorder at Ansas Dam and surrounding farmland site, in Debre Berhan Town, Ethiopia. Blue winged geese (*Cynochen cyanopetra*) and Harwood's francolin (*Pternistis harwoodi*) were the only endemic species in Ethiopia, found in the study area and also similarly found both species in Ref. [44] survey. The Wattled ibis (*Bostrychia carunculata*), White collared pigeon (*Columba albitorques*), Rouget's rail (*Ralbus rougetii*), and White-winged cliff-chat (*Myrmecocichla semirufa*) are all endemic bird species to Ethiopia and Eritrea [44]. Species in this group have high levels of specialization and are susceptible to environmental changes due to their specialization [60].

Table 2
The number of population and species of birds' in different habitat type during wet and dry seasons.

Habitat types	Season	Number of species	Number of individuals	Mean	Standard Deviation	Standard Error	df	F	P
Disturbed forest	Dry	32	298	9.56	7.17	1.27	3	1.91	0.13
	Wet	32	354	11.06	8.87	1.57	3	1.579	0.199
Open shrubs	Dry	22	132	5.86	4.32	0.92			
	Wet	24	175	7.29	5.46	1.11			
	Dry	16	89	5.75	6.09	1.52			
Settlement	Wet	16	109	6.81	7.17	1.79			
	Dry	30	200	6.67	7.89	1.44			
Wetland	Wet	31	234	7.55	9.59	1.72			

Paired sample *t*-test shows that, the overall mean abundance of bird population between dry and wet seasons from all studied habitats was significantly difference ($t = -66.108$, $P \leq 0.001$, $df = 6$). Wet season mean of bird abundance was higher (872 ± 6.325) than mean of abundance during dry season (719 ± 5.533 (Table 3).

Table 3
Total mean abundance of bird population in wet and dry season.

Seasons	Mean	Std. Deviation	Std. Error	T	df	P
Dry	719	5.533	2.091	−66.108	6	.000
Wet	872	6.325	2.390			

Table 4
Bird species richness, abundance, diversity and evenness during dry and wet seasons.

Habitat types	Season	Richness	Abundance	Diversity (H′)	Evenness (J)
Disturbed forest	Dry	32	298	2.88	0.84
	Wet	32	354	3.2	0.92
Open shrubs	Dry	22	132	2.97	0.95
	Wet	24	175	2.9	0.9
	Dry	16	89	2.17	0.8
Settlement	Wet	16	109	2.2	0.78
	Dry	30	200	3	0.88
Wetland	Wet	31	234	2.97	0.87

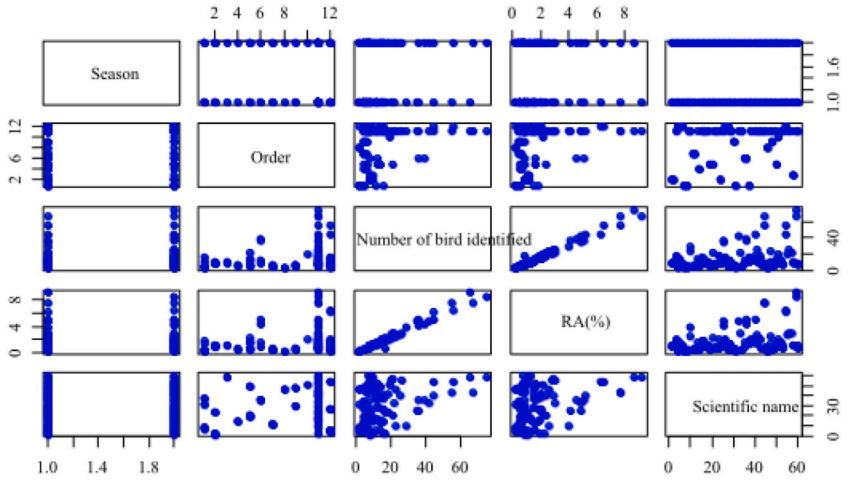

Fig. 3. Entire metrics of scatter plot for four variables.

Similar study by Ref. [44] Wattled ibis (*Bostrychia carunculata),* White collard pigeon (*Columba albitorques),* Rouget's rail *(Ralbus rougetii)* and White winged cliff-chat *(Myrmecocichla)* were included in endemic bird species to Ethiopia and Eritrea. As they are endemic, more conservation is need for these species, because the species with a high degree of specialization are more vulnerable to environmental changes than generalist species with a larger geographic range [61]. Usually, endemic species are more vulnerable to anthropogenic threats and natural changes, which increases the risk of extinction [60]. As climate and land use changes accelerate, natural habitats and species assemblages are being altered, making management interventions critical to halting biodiversity loss [34].

In Gibe Sheleko National Park (GSNP) a total of 112 bird species which belongs to 21 orders were identified [30] and in Wondo Genet Forest, south-central Ethiopia a total of 1672 individuals grouped into 137 bird species were recorded [49]. Other study by Ref. [45] also recorded a total of 112 avian species that belongs to 16 orders and 45 families. Contrasting the other studies, in Lewi Mountain the number of birds' species recorded were lower due to excessive human disturbance like deforestation and overgrazing. More similar studies by Ref. [44] recorded a total of 45 bird species categorized under nine orders and 21 families at Ansas Dam and surrounding farmland sites during both wet and dry seasons. Overall, effects on species richness were stronger than those on bird abundance, with the latter being extremely variable depending on the species planted and the geographic context in which these productive systems exist [62]. In the study area, two endemic and four near-endemic (endemic to Ethiopia and Eretria) bird species were identified from the recoded bird species. Similar study has been recorded Wattled Ibis and White Collared Pigeon as a near endemic (endemic to Ethiopia and Eritrea) [63]. The species distribution in this study did not varied significantly among dry and wet seasons. This could be linked to the abundance of a range of food items, water, and cover during the research period, all of which contributed to the habitat's highest species richness and evenness [63]. "Bird species richness is mediated by local, regional, and historical factors, for example, competition, environmental heterogeneity, contemporary, and historical climate" [25]. In spite of the fact that human settlement in the study covers a larger area, it is only a habitat for a limited number of birds due to human influences. Anthropogenic influences, such as agricultural expansions, were particularly strong in settlement habitat types [12,64]. As ecosystems

Table 5
Relative abundance and distribution of bird species in the four study habitats.

Common name	Scientific name	RA (%)		Habitat types							
				Open shrub		Dense forest		Settlement		Wetland	
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	dry
Abyssinian ground thrush	*Zoothera piaggiae*	8.6	9.2	+	+	+	+	+	+	–	–
Red winged starling	*Onychognathus morio*	5.2	2.4	+	+	+	+	–	–	–	–
Common bulbul	*Pychonotus barbatus*	2.6	1.5	+	+	+	+	–	–	–	–
White -checked turaco	*Turaco leucotis*	2.2	2.8	–	+	+	–	–	–	–	–
Mangrove sunbird	*Anthreptes gabonicus*	1.9	2.2	–	–	+	+	–	–	+	+
Greater blue eared starling	*Lamprotornis chalybaeus*	4.8	3.1	+	+	+	+	–	–	+	+
Speckled pigeon	*Columba guinea*	2.4	0.8	+	+	–	–	+	+	+	+
White collard pigeon [NE]	*Columba albitorques*	0.7	0.6	+	+	+	+	–	–	–	–
Black crown	*Corvus capensis*	0.9	0.8	–	–	–	–	+	+	+	+
White winged cliff chat	*Thamnolaea semirufa*	0.8	1.1	+	+	+	+	–	–	–	–
Somber rock chat	*Oenanthe dubia*	1.6	1.7	+	+	+	+	–	–	–	–
African stone chat	*Saxicola torquatus*	0.9	0.8	+	+	+	+	+	+	+	+
Grey backed camaroptera	*Camaroptera brevicaudata*	0.5	0.6	+	+	+	+	–	–	–	–
Augur buzzard	*Butao augur*	0.2	0.6	–	–	+	+	–	–	+	+
Red eye dove	*Streptopelia semitorquata*	1.6	1.7	+	+	+	+	+	+	+	+
Mountain trush	*Turdus abyssinicus*	3.0	2.9	+	+	+	+	+	+	–	–
Cinnamon breasted bunting	*Emberiza striolata*	1.5	1.5	+	+	+	+	–	–	+	+
Ethiopian oriole	*Oriolus monacha*	2.9	1.5	–	–	+	+	–	–	–	–
Yellow white eye	*Zosterops senegalensis*	0.8	1.3	–	–	+	+	–	–	–	–
Red belled paradise fly catcher	*Terpsiphone rufiventer*	0.9	1.7	–	–	+	+	–	–	+	+
Crimson rumped wax bell	*Estrilda troglodytes*	0.5	0.8	–	–	+	+	–	–	–	–
African sacred ibi	*Threskiornis aethiopicus*	6.4	6.3	–	–	–	–	–	–	+	+
Yellow billed egret	*Egretta intemedia*	1.8	2.1	–	–	–	–	–	–	+	+
Blue headed coucal	*Centropus monachus*	0.7	0.6	–	–	–	–	–	–	+	+
Wattled ibis [NE]	*Bostrychia carunculata*	1.6	1.5	–	–	–	–	+	+	+	+
Rougats rail [NE]	*Rougatius rougatti*	0.5	0.6	–	–	–	–	–	–	+	+
Olive ibis	*Bostrychia olivacea*	0.9	1.1	–	–	–	–	–	–	+	+
Grey heron	*Ardea cinerea*	0.5	0.3	–	–	–	–	–	–	+	+
Yellow billed duck	*Anas undulate*	1.1	1.1	–	–	–	–	–	–	+	+
Little egret	*Egretta garzetta*	0.7	0.6	–	–	–	–	–	–	+	+
Super winged plover	*Vanelus spinosus*	1.1	1.1	–	–	–	–	–	–	+	+
Blue winged goose[E]	*Cyanochen cyanopetra*	0.9	1.1	–	–	–	–	–	–	+	+
Swainsons sparrow	*Passer swainsonii*	2.1	2.1	–	–	–	–	+	+	+	+
Hooded vulture	*Necrosyrtes monacus*	1.8	1.5	–	–	–	–	+	+	+	+
Egyptian goose	*Alopochen aegyptiaca*	0.9	1.1	–	–	–	–	–	–	+	+
Pied crown	*Corvus albus*	0.7	0.8	–	–	–	–	+	+	+	+
White billed stork	*Ciconia*	0.7	0.6	–	–	–	–	–	–	+	+
Swamp boubou	*Laniarius bicolor*	0.5	0.6	–	–	–	–	–	–	+	+
Common buzzard	*Buteo*	0.5	0.3	–	–	–	–	–	–	+	+
Common moorhen	*Gallinula chloropus*	0.7	0.8	–	–	–	–	–	–	+	+
Bocages sun bird	*Nectarinia bocagii*	1.7	2.1	–	–	+	+	–	–	–	–
White backed vulture	*Gyps africanus*	0.2	0.6	–	–	+	+	–	–	–	–
Copper sunbird	*Cinnyris cupreus*	0.9	1.3	–	–	+	+	–	–	–	–
Dusky lark	*Pinarocorys nigricans*	0.7	0.8	+	+	+	+	–	–	–	–
Little green bee eater	*Merops orientalis*	0.9	1.7	+	+	+	+	+	+	–	–
Little bee eater	*Merops pusillus*	4.5	5.0	+	+	+	+	+	+	–	–
Red rumped swallow	*Cecropis daurica*	2.6	4.0	+	+	+	+	+	+	–	–
Jaint sunbird	*Dreptes thomensis*	4.1	4.9	+	+	+	+	–	–	–	–
Variable sunbird	*Cinnyris venustus*	1.3	1.1	–	–	+	+	–	–	–	–
Violet breasted sunbird	*Cinnyris chalcomelas*	1.3	1.9	+	+	+	+	–	–	–	–
Purple bonded sunbird	*Cinnyris bifasciatus*	1.8	1.4	+	+	+	+	–	–	–	–
Hard woods francolin[E]	*Pternistis harwoodi*	0.2	0.3	–	–	+	+	–	–	–	–
White brown robin chat	*Cossypha heuglin*	2.1	0.8	+	+	+	+	–	–	–	–
Ground scraper trush	*Psophocichla litsitsirupa*	0.9	0.8	+	–	–	+	+	+	–	–
Village weaver	*Ploceus cucullatus*	7.7	7.6	+	+	+	+	+	+	+	+
Copper tailed coucal	*Centropus cupreicaudus*	0.5	0.6	–	–	–	–	–	–	+	+

N·B.: RA = Relative abundance; Wet, = Wet season; Dry, = Dry season; E = Endemic; NE = Near to endemic (Endemic to Ethiopia and Eritrea); (+); refers to the species was found in the habitat and (−) refers to the species was not found in the habitat.

are destroyed and transformed into anthropogenic landscapes, many species use these surrogate habitats to survive [65]. In the case of natural forests, clearing them and converting them into plantations of exotic trees may serve as surrogate habitats for species dependent on these habitats includes species dependent on the rainforest [66,67]. The loss of biodiversity is primarily caused by agricultural growth [64,68,69]. For the sake of preserving high bird variety in the entire riparian landscape, the wood cover, which includes trees, bushes, and young saplings, should be maintained, not only trees [50]. Bird abundance and diversity are influenced by

habitat type and size around the world, but especially in developing countries with rapid human population expansion and unplanned urban, agricultural, and industrial development [70,71]. The complexity of the ecosystem enhances the amount of insects, which in turn promotes the diversity and population of birds [52]. Depending on the season, all regions were vital bird habitats, reflecting the varying effects of temperature [48]. As a result of this research, there were many bird species in all study settings, which is good news for bird conservation.

In the rainy season, bird variety, abundance, and evenness were all higher than in the dry season [45]. Between the two research seasons, there was a considerable difference in bird abundance in the study area. Because expected changes in the global environment may differ between seasons, the implications of environmental seasonality on species distributions are critical [48]. The wet season had the maximum abundance of birds, while the dry season had the lowest. This research is similar to that done in and around the Wondo Genet forest in south-central Ethiopia, where there was a substantial change in the mean abundance of bird species throughout the dry and rainy seasons [49,51].

The wetland habitat had the highest species diversity index and the high evenness index. Wetland is most productive ecosystem [72]. Wetlands are essential for feeding, breeding, nesting, and raising young for a wide variety of birds and mammals [73]. Wetland microhabitats offer abundant and high-quality food sources and shelter for avifauna populations all year long [73,74]. More niches, refuges, and possibilities for speciation could be created when environmental variability increases [25]. Diverse habitat types, for example, can provide more niches or complementary resources for different species in a heterogeneous ecosystem [75]. Bird species richness was linked to environmental heterogeneity, habitat filtration, and biotic interactions [25]. The forest patch and its surroundings are important bird habitats [49]. Due to high human disturbance, settlement had the lowest species diversity in the study area due to its high human disturbance. Agricultural intensification has led to a substantial decline of farmland bird populations due to the loss of non-cropped habitats [76]. Even though unique and diversified bird communities can be found in Ethiopia [51], many of Ethiopia's IBAs have been affected by agricultural activity, deforestation, and overgrazing, similar to the majority of African nations (Kirby et al., 2008; Adekola et al., 2012; Limiñana et al., 2012; Kiros et al., 2014; Buechley et al., 2015). The diversity of habitats and degree of isolation both had an impact on the number of bird species (Borges et al., 2019). The diversity of habitats and degree of isolation both had an impact on the number of bird species [77]. Biodiversity in natural and built ecosystems is significantly affected by the quality of the ecological environment [24]. Similarly, despite conservation efforts in several bird-protected areas in Ethiopia, cropland has the lowest species diversity due to severe human disturbance [30]. It is also believed that forest disturbance, habitat fragmentation, pollution, and a modified biogeographical context play a significant role in influencing the variety, abundance, and composition of understory insectivores [24].

The diversity and relative abundance of bird species did not vary much over the study period [63]. This study, on the other hand, found that the relative abundance and richness of species varied between seasons. Throughout the study period, bird distributions varied throughout the studied habitat categories. Columbiformes and Accipitriformes were more plentiful and widely dispersed next to Passeriformes in disturbed forest and open shrubs. Gruiformes, Ciconiiformes and Anseriformes had greater distribution in the wetland habitat and some of them were restricted to this habitat. "Wood vegetation including trees, shrubs, and saplings, contains high bird richness" [50]. Bird species' distribution patterns are usually dictated by the environment's spatial organization and habitat requirements [78]. This is consistent with the findings of this investigation, which revealed habitat specificity and generalization.

5. Conclusion and recommendations

According to the findings, there are 56 species of birds in the area, two of which are endemic to Ethiopia. There are a large number of species records from the researched habitats that are internationally concerned birds. The presence of endemic and globally vulnerable species in the research habitats demonstrates the importance of the study habitats for bird conservation. According to the findings, Abyssinian ground trush (*Zoothera piaggiae*) had the highest abundance, frequency, and sighting index, followed by Village weaver (*Ploceus cucullatus*). Hard woods francolin (*Pternistis harwoodi*), and Blue winged goose (*Cyanochen cyanopetra*) were an Ethiopian endemic bird, had the least abundance, frequency, and sighting index. During the dry season, wetland habitat had the highest species diversity index and the highest evenness index, followed by open shrubs environment with the best evenness index. In both dry and wet seasons, settlement had the lowest species diversity and the lowest evenness index. Wetland habitat had the highest Shannon-Weiner diversity index with the highest evenness index during the wet season, followed by disturbed forest with the highest evenness index. Settlement had the lowest species diversity and the lowest evenness index in the research area for the entire season. The studied environments support a variety of bird species with diverse abundances and ranges, but there is no statistically difference between them. However, there is a large seasonal variance in overall bird abundance. To safeguard the avifauna as well as the area's entire biological variety, conservation measures are required. The study suggests that habitat diversity is more important for biodiversity of bird species. The diversity of wild birds in the area should be investigated further. Because local communities are underinformed about the value of birds, awareness-raising activities should be conducted, at the very least, among those who live in and around bird habitats. Because the area receives little conservation attention, birds' long-term survival is threatened by manmade factors such as urbanization and local community subsistence activities. As a result, immediate management for conservation and population involvement is urgently required.

Author contribution statement

Yonas Derebe: Conceived and designed the experiments; Analyzed and interpreted the data, and Wrote the paper.
Binega Derebe: Conceived and designed the experiments; Performed the experiments; Acquisition of data; Analyzed and

interpreted the data, and Wrote the paper.

Melkamu Kassaye: Analyzed and interpreted the data; Acquisition of data, and Wrote the paper.

Amare Gibru: Contributed reagents, materials, analysis tools or data.

Funding information

This research was funded by Injibara University, College of Agriculture, Food and Climate science.

Availability of data and materials

The data used and analyzed during the current study are available in the hand of the correspondence author for further request if request is available from reviewers without disclosure of the interviewees. We provide the data for valid reason/justification. Anyone who can contact to Binega Derebe. Email: binegaderebe@gmail.com.

Additional information

No additional information is available for this paper.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Acknowledgement

The study was sponsored by College of Agriculture, Food and Climate science, Injibara University, Ethiopia. Special thanks go to responsible Woreda officers and experts in the study area who gave us all the necessary information.

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