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THE ROLE OF CHURCH FORESTS IN AVIAN CONSERVATION: THE CASE IN TAKUSSA DISTRICT, NORTHWESTERN ETHIOPIA

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ABSTRACT: Many remnant indigenous trees and shrubs in Ethiopian Orthodox churches are known for preserving different plant species, and then used as a home for many species of birds. The main objective of the present study was to investigate the role of church forests in conserving avian species as a function of diversity analyses in three selected church forests of Takussa District, west Gondar Administrative Zone of Amhara Region. To get sufficient data on diversity and relative abundance of birds, twenty-one sampling point stations were placed in the three church forests using stratified sampling techniques. Data were collected for a total of 48 days covering both the dry and wet seasons. A total of 68 bird species were recorded, of which two were endemic to Ethiopia, seven were shared with Eritrea, while the remaining were uncommon, frequent, and common species to the study sites. The mean bird species diversity was highest in Goye Merry church forest (H'=3.5), and lowest in Arema Gebrael church forest (H'=2.9). The effect of season did not show significant difference in determining the avian diversity across the study sites ($F_{1, 295}$ =1.416, P=0.235), whereas the effect of habitat on the three study sites showed a significant difference ($F_{2, 295}$=840.53, P=0.000). The highest diversity of birds is recorded in Goye Merry church forest which is relatively with structurally complex habitat. The difference in the diversity of birds is mainly attributed to the difference in plant species composition and characteristics of forests. These results suggest that structurally complex Ethiopian Orthodox church forests have the potential for conservation of different bird species.

Key words/phrases: Birds, church forest, conservation, diversity, habitat association

INTRODUCTION

Globally, more than 10,000 species of birds that belong to 29 orders, 287 families, and 2,000 genera are known to science (Gill, 1994). More than 50% of the extant avian species belong to the order Passeriformes (Lepage, 2020). There are over 1,850 bird species in Africa with two endemic bird orders, and ten endemic families, and Africa is second to South America in terms of the number of bird species (Sinclair and Ryan, 2003).

Ethiopia is a country with varied topography. The altitude ranges from 125 m b. s. l. in the Dallol depression to 4620 m a. s. l. at Ras Dashen. As a result, it has various climatic zones that encompass from lowlands to highlands with rich biodiversity (Yilema Abebe and Geheb Kim, 2003). A total of 862 bird species are known in Ethiopia (Lepage, 2020). Each species shows altitudinal preferences from extreme lowlands to extreme highlands. This variation is associated with differences in species' habitat, food, and other ecological requirements.

In Ethiopia, 73 important bird areas have been identified (Shimelis Aynalem and Afework Bekele, 2008). This covers an area of approximately 47,757 km^2, of which 41% comprises wetlands, while the remaining represents other types of ecosystems (Mengistu Wondafrash, 2003). The presence of unique conditions in the highlands serves as a climate refugia leading to the presence of a number of endemic species. The Amhara Region of Ethiopia consists of 75% of the central Ethiopian highland important bird areas (Shimelis Aynalem and Afework Bekele, 2008).

Avian community composition, microhabitat selection and habitat association can be affected by different landscape features including elevation, topography, proximity to water, forest patch size and distance between patches, and the extent of the forest edge (Mallet-Rodriguse *et al*., 2010). Environmental factors that affect plant distribution and community structure can influence the spatial distribution patterns, relative abundance, and richness of avian species (Yenew Genet and Dessalegn Ejigu, 2017; Endihnew Tesfa *et al*., 2020).

Most of the Ethiopian landscape is highly altered by anthropogenic activities such as

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agriculture, overgrazing, and deforestation. This leads to local or global extinction, if not to migration (Aerts *et al*., 2008). However, many indigenous trees and shrubs are still found standing in the Ethiopian Orthodox churches, which is historically known for preserving trees (Colwell, 2010). According to Sharma *et al*. (1999), church forests attract birds from areas where deforestation and land degradation have occurred due to the impact of ongoing human activities.

The Ethiopian Orthodox church forests are playing a major role in the conservation of biodiversity (Alemayehu Wassie and Demel Teketay, 2006). In the regulation and rule of the Ethiopian Orthodox church, cutting any tree within the churches' compound is completely forbidden (Colwell, 2010). As a result, aged indigenous trees that are totally lost from many places in the country are still standing within the church compounds. Avian species diversity in the country in general and in the Ethiopian Orthodox church forests in particular are not fully recorded, and the importance of the church forests in bird conservation is not well studied. Thus, this study focuses to investigate the role of church forests for avian conservation.

METHODS

Description of the study areas

The present study was conducted in three selected church forests; namely Goye Merry, Enferdeba Michael, and Arema Gebrael at Takussa District of Amhara Region (Fig. 1). The capital town of the District, Deligi, is located 135 km northwest of Bahir Dar city, and 95 km southwest of Gondar town. The study sites are located between 12˚0'0" - 12˚30'0"N latitude, and 36˚30'8" - 37˚0'0" E longitude at an altitudinal range of 1200-2300 m a.s.l. The rainfall pattern in the area is unimodal with the highest (298.5 mm) recorded in August, and the lowest (1.76 mm) in February. The average annual minimum and maximum temperatures were 20˚C in January and 33˚C in April, respectively.

Goye Merry church forest has an area of 15 ha, and it is found in Goye Kebele 21 km from Deligi town to south-western direction. The church is surrounded by agricultural fields to the east and north, road to the south, and rural villages to the west. It is characterized by dense forest that comprises large trees and shrubs. The second study site, Enferdeba Michael church forest, has an area of 7 ha and it is found in Chanki Bergen Kebele, and is located 12 km from Deligi town to the south. The type of vegetation cover in this church is characterized by sparsely distributed trees and more shrubs. This church forest is closer to Lake Tana and the Baska River. It is surrounded by roads to the north and the remaining part by agricultural fields. Arema Gebrael church forest, the third site, has an area of 5 ha, and it is found in Arema Biderkun Kebele which is located at 28 km from Deligi town to the west. It is relatively covered with dense trees and shrubs. This church forest is bordered by the road to the south and agricultural fields to the east. The church forest is buffered by another natural forest in the northern and western directions. Some of the dominant tree species common in the three church forests include *Cordia africana*, *Olea* species, *Rosa abyssinica*, *Acacia abyssinica, Ficus vasta, Prunus africana,* and *Buddlej apolystachya*.

Data collection

A reconnaissance survey was conducted in October 2017 to assess the habitats of the three selected church forests and to acquaint the researcher with the study sites. The three church forests were selected based on the vegetation structure giving emphasis to the assemblage of plant species and the ground cover they provide. The number of sampling units was determined by stratified random sampling technique depending on the size and type of vegetation cover of the sites. Point count method was used to observe and record all the birds seen (Bibby *et al*., 2012).

The number of point count stations was determined based on the size of each church forest habitat. Proportional to their areas; 12, 6, and 3 points count stations were placed at Goye Merry, Enferdeba Michael, and Arema Gebrael church forests, respectively. The start of point stations was marked 20 m away from the main church building to minimize disturbance. The

point transect routes, carrying the point count stations with a fixed radius of 25 m, were set up at 100-250 m intervals to avoid double counting in each point count station. Since birds' activity pattern is time dependent, reverse counting was carried out to allow observers to detect birds that could have been missed at the beginning and/or the end of the counting route. All birds seen were recorded in 15-minute counts by the observer (Weber *et a*l., 2008). During the first three minute of the recording period, the observer stood still and quiet at a suitable vantage point, while in the later part of the period, the he/she slowly rotated 360° to collect the actual bird data within the point station (Hosteler and Martin, 2001; Laiolo *et al*., 2004). To minimize the effect of time and weather conditions on bird detectability, point counts were undertaken early in the morning between 06:00 and 09:00 a.m., and late in the afternoon between 3:00 and 6:00 p.m., when most of the bird species were active under calm weather conditions (Canterbury *et al.,* 2000). Individuals encountered within the fixed radius point and unlimited radiuses were recorded at first detection (Bibby *et al*., 2012). The unlimited radius count was considered to get a better picture of species richness in the study area.

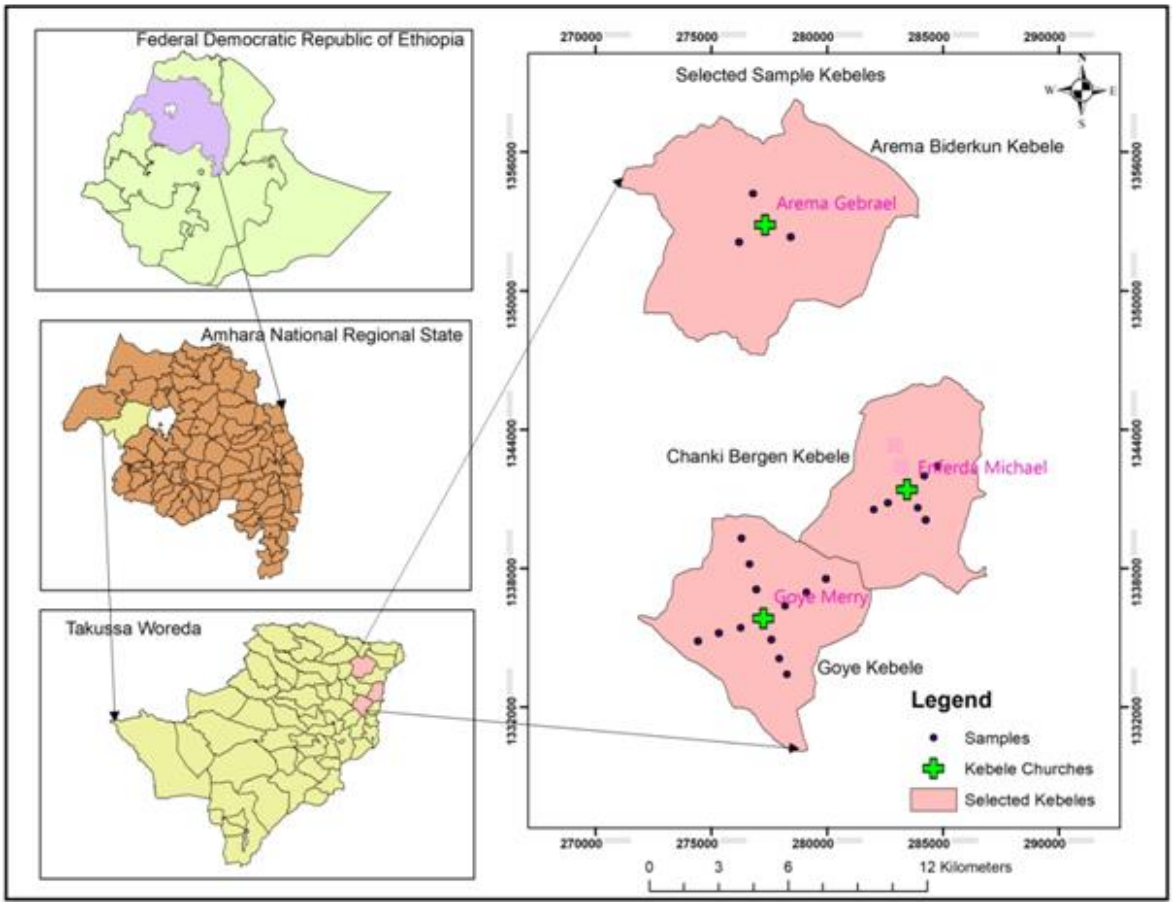

Figure 1: Map of the study areas

A total of 16 field visits each with three consecutive days that resulted in 48 field days were carried out on the three church forests during both the dry and wet seasons. The dry season data were collected from January to March 2018, while data for the wet season were collected from June to August 2018. Direct observation, photographs from bird field guide book (Stevenson and Fanshawe, 2002), and 8x32 binoculars aided identification were carried out

to identify species and to record the number of individuals based on different morphological features such as plumage pattern, color, body size, and shape (Redman *et al*., 2009).

Data analyses

Analyses of data were made by using different diversity indices including Shannon Wiener Diversity Index (H'), and Simpson's Index of Diversity (D). When two communities may have the same species richness but if they differ by relative species abundance or evenness their overall diversity will be different. Simpson's index of Diversity gives more emphasis on relative abundances (Eqution.1), while Shannon Diversity Index deals more about species richness (Equation 2). Encounter rate was used to give ordinal scale of relative abundance (Equation 3) for the five abundance categories such as rare, uncommon, frequent, common, and abundant, with the corresponding scores of < 0.1, 0.1-2.0, 2.1-10.0, 10.0-40.0, and > 40, respectively (Bibby *et al*., 1992). The effects of season and habitat type on species diversity across the selected church forests were analyzed using ANOVA.

$$D=1-\frac{\sum n(n-1)}{N(N-1)} \quad \text{..... (1)}$$

where, n=the total number of birds of a particular species, N=the total number of birds of all species in the habitat

$$H' = -(\sum PilnPi) \quad \text{..... (2)}$$

where, pi= the proportion of the species relative to the total number of species

$$Relative\ abandance = \frac{\text{Total number of individual in a particular species}}{\text{Total number of individual in all species}} * 100$$

..... (3)

$$E=H'/Hmax \quad \text{.....(4)}$$

where,

E=Shannon-Wiener evenness index;

H'=Shannon-Wiener diversity index

H max = lnS= natural logarithm of the total number of species (S)

RESULTS

Species composition

A total of 68 bird species belonging to 16 orders and 38 families were recorded in the three church forests. Seasonal data indicated that 62 and 59 bird species were identified during the dry and the wet seasons, respectively, of which 52 species were common for both seasons. Eight species were recorded only during the dry season, and two species only during the wet season (Table 1). The highest number of families was recorded under order Passeriformes 18 (47.37%), followed by order Coraciiformes 3 (7.89%) (Fig. 2). Of the total richness, order Passeriformes accounted for the largest proportion (54.92%). Abyssinian long claw (*Macronyx flavicollis*), and white-winged cliff chat (*Monticola semirufus***)** were endemic to Ethiopia, and seven species were shared with Eritrea.

Species diversity

The Shannon-Weiner diversity index revealed that the highest avian species diversity (H'=3.5) was recorded in Goye Merry church forest during the dry season, and the lowest (H' =2.9) was from Arema Gebrael church forest in the same season. Avian species were unevenly distributed in the three selected church forests as indicated by the evenness value. Goye Merry church forest avian distribution was observed to be the most during both the dry and wet seasons (E= 0.87, 0.86), while the lowest evenness was recorded in Arema Gebrael church forest during the dry and wet seasons (E= 0.76, 0.79), respectively (Table 2).

Table 1. List of bird species recorded from the three church forests during the dry and wet seasons

Common name	Scientific name	Family	Order	Seasons		
				Dry	Wet	Both
Abyssinian Crimson wing	*Cryptospiza salvadorii*	Estrildidae	Passeriformes	√	√	√
Abyssinian Ground thrush	*Zoothera piaggiae*	Turdidae	Passeriformes	√	√	√
Abyssinian Long claw **(E)**	*Macronyx flavicollis*	Motacillidae	Passeriformes	√	√	√
Abyssinian Oriole **(EE)**	*Oriolus monacha*	Oriolidae	Passeriformes	√	√	√
Abyssinian Slaty Flycatcher **(EE)**	*Melaenornis chocolatinus*	Muscicapidae	Passeriformes	√	√	√
Abyssinian Woodpecker **(EE)**	*Dendropicos abyssinicus*	Picidae	Piciformes	√	√	√
African Citril	*Serinus citrinelloides*	Fringillidae	Passeriformes	√	√	√
African Fish Eagle	*Haliaeetus vociter*	Acciipitridae	Accipitriformes	√	√	√
African Golden Oriole	*Oriolus auratus*	Orolidae	Passeriformes	√	√	√
Abyssinian Hill-Babbler	*Sylvia abyssinica*	Sylviidae	Passeriformes	√	√	√
African Paradise-Flycatcher	*Tersiphone viridis*	Monarchidae	Passeriformes	√	√	√
African Reed Warbler	*Acrocephalus baeticatus*	Acrocephalidae	Passeriformes	√	√	√
African White-backed Vulture	*Gyps africanus*	Accipitridae	Accipitriformes	√	√	√
Baglafecht Weaver	*Ploceus Baglafecht*	Ploceidae	Passeriformes	√	√	√
Banded Barbet **(EE)**	*Lybius undatus*	Lybiidae	Piciformes	√	√	√
Black-bellied Bustard	*Eupodotismelanogaster*	Otididae	Otidiformes	X	√	X
Black Crowned Crane	*Balearica pavonina*	Gruidae	Gruiformes	√	√	√
Village Weaver	*Polceus cacullatus*	Polceidae	Passeriformes	√	√	√
Black-winged Lovebird **(EE)**	*Agapornis taranta*	Psittacidae	Psittaciformes	√	√	√
Black-winged Stilt	*Himantopus himantopus*	Recurvirostridae	Charadriiformes	√	√	√
Blue-cheeked Bee-eater	*Merops persicus*	Meropidae	Coraciformes	√	√	√
Bush Petronia	*Petronia dentate*	Passeridae	Passeriformes	√	X	X
Cinnamon Bracken Warbler	*Bradypterus cinnamomeus*	Locustellidae	Passeriformes	√	√	X
Clapperton's Francolin	*Francolinus clappertoni*	Phasianidae	Galliformes	X	√	√
Egyptian Goose	*Alopochen aegyptiacus*	Anatidae	Anseriformes	√	√	X
Fan-tailed Raven	*Corvus rhipidurus*	Corvidae	Passeriformes	√	√	√
Garden Warbler	*Sylvia borin*	Sylviidae	Passeriformes	√	√	√
Giant Kingfisher	*Megaceryle maxima*	Alcedinidae	Coraciiformes	√	√	√
Gillett's Lark	*Mirafra gilltti*	Alaudidae	Passeriformes	√	√	√
Golden Pipit	*Tmetothylacus tenellus*	Motacillidae	Passeriformes	√	√	√
Greater Blue-eared Starling	*Lamprotornis chalybaeus*	Sturnidae	Passeriformes	√	√	√
Grey Wagtail	Motacilla cinerea	Motacillidae	Passeriformes	√	√	√
Groundscraper Thrush	*Psohocichla litsipsirupa*	Turdidae	Passeriformes	√	X	X
Hemprich's Hornbill	*Tockus hemprich*	Bucerotidae	Coraciiformes	√	√	√
Hadada Ibis	*Bostrychia hagedash*	Threskiornithidae	Pelecaniformes	√	X	X
Helmeted Guineafowl	*Numida meleagris*	Numididae	Galliformes	√	X	X
Hooded Vulture	*Necrosyrtes monachus*	Accipitridae	Accipitriformes	√	√	√
Isabelline Wheatear	*Oenanthe isabellina*	Turdidae	Passeriformes	√	√	√
Laughing Dove	*Streptopelia senegalensis*	Columbidae	Columbiformes	√	√	√
Lesser Blue-eared Starling	*Lamprotornischloropterus*	Sturnidae	Passeriformes	√	√	√
Levaillant's Cuckoo	*Oxylopus levaillantii*	Cuculidae	Cuculiformes	√	√	√

Long-billed Pipit	*Anthus similis*	Motacillidae	Passeriformes	√	√	√
Long-tailed Cisticola	*Cisticola angusticaudus*	Cisticoidae	Passeriformes	√	√	√
Northern Carmine Bee-eater	*Merops nubicoides*	Meropidae	Coraciiformes	√	√	√
Pied Crow	*Corvus albus*	Corvidae	Passeriformes	√	√	√
Pied Wheatear	*Oenanthe pleschanka*	Turdidae	Passeriformes	√	√	√
Plain- backed Pipit	*Anthus leucophrys*	Motacillidae	Passeriformes	X	√	√
Purple Heron	*Ardea purpurea*	Ardeidae	Pelecaniformes	X	√	X
Red-billed Firefinch	*Lagonostica rubricate*	Estrildidae	Passeriformes	√	√	X
Red-cheeked Cordon-bleu	*Uraeginthus bengalus*	Estrildidae	Passeriformes	√	√	√
Red-eyed Dove	*Streptopelia semitorquata*	Columbidae	Columbiformes	√	√	√
Ring-necked Dove	*Streptopelia capicola*	Columbidae	Columbiformes	√	√	√
Sacred Ibis	*Threskiornis aethiopicus*	Threskiornithidae	Pelecaniformes	√	√	√
Simple Greenbul	*Chlorocichal simplex*	Pycnonotidae	Passeriforme	√	X	X
Speckled Mousebird	*Colius striatus*	Coliidae	Coliiformes	√	√	√
Speckled Pigeon	*Columba guinea*	Columbidae	Columbiformes	√	X	X
Spectacled Weaver	*Ploceus ocularis*	Polceidae	Passeriformes	√	√	√
Spoted Eagle Owl	*Bubo africanus*	Strigidae	Strigiformes	√	√	√
Spur-winged Goose	*Plecterus gambensis*	Anatidae	Anseriformes	√	√	X
Stout Cisticola	*Cisticola robustus*	Cisticolidae	Passeriformes	√	√	√
Swainson's Sparrow	*Passer swainsonii*	Passeridae	Passeriformes	√	√	√
Wattled Ibis **(EE)**	*Bostrychia carunculata*	Threskiornithidae	Pelecaniformes	√	X	X
White-cheeked Turaco	*Tauraco leucotis*	Musophagidae	Musophagiformes	√	√	√
White-winged Cliff Chat(**E)**	*Monticola semirufus*	Muscicapidae	Passeriformes	√	√	√
Tiny Cisticola	*Cisticola nanus*	Cisticolidae	Passeriformes	√	X	X
Thick-billed Raven**(EE)**	*Corvus crassirostris*	Corvidae	Passeriformes	√	√	√
Yellow-Fronted Tinkerbird	*Pogoniulus chrysoconus*	Lybiidae	Piciformes	X	√	√
Yellow Wagtail	*Motacilla flava*	Motacillidae	Passeriformes	√	√	X

(E = endemic to Ethiopia, EE =shared with Eritrea, √ = present, X = absent

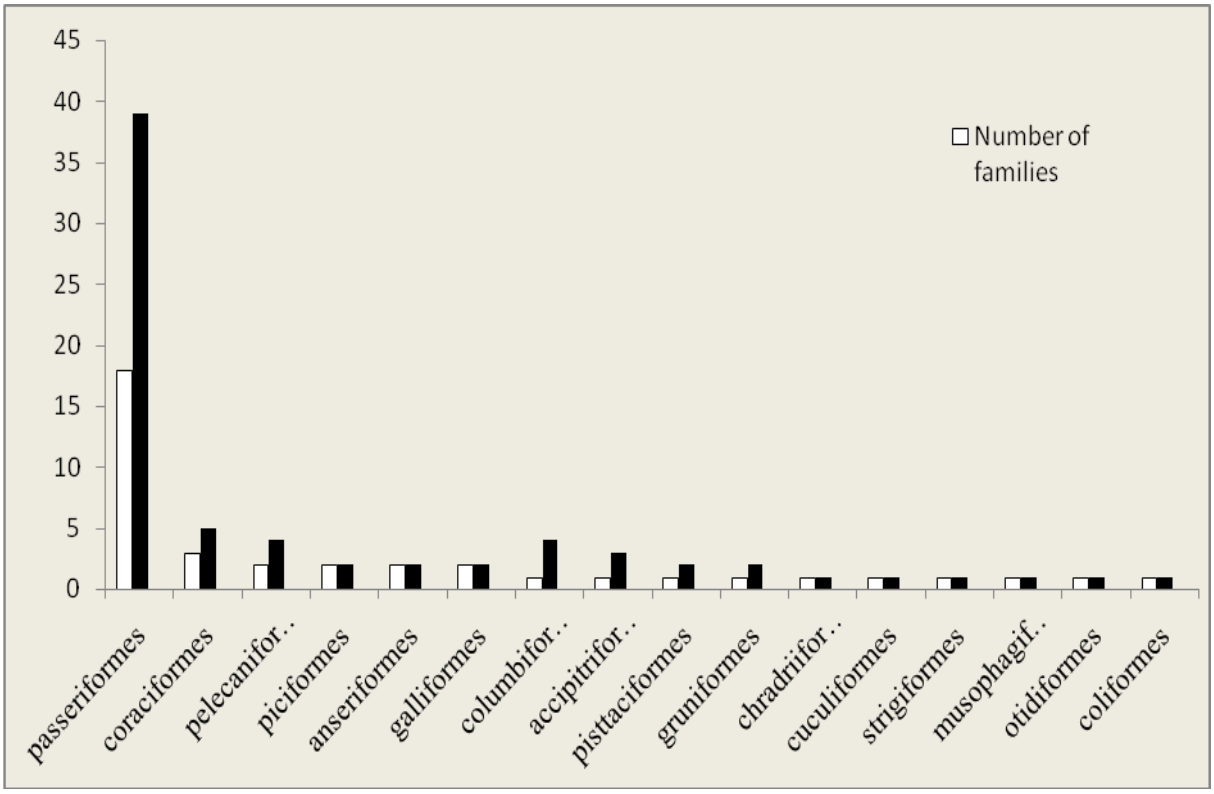

Figure 2: Avian species richness of the study area

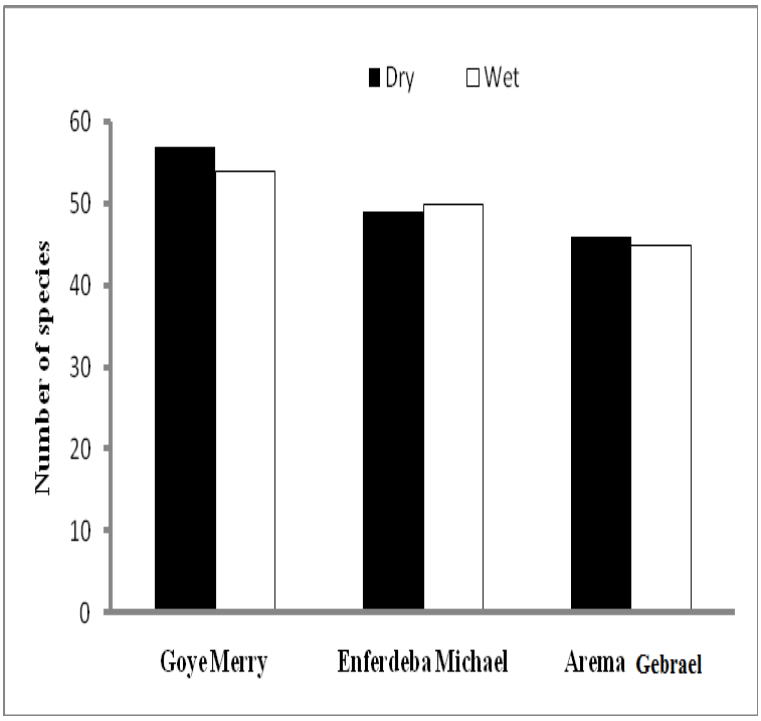

Figure 3: Number of avian species recorded during both the wet and dry seasons

Table 2. Avian species diversity in the three church forests during the dry and wet seasons

Study area	Season	No of species (S)	Total abundance	ln(S)	H'	D	E
Goye Merry	Dry	57	2500	4.04	3.5	0.96	0.87
	Wet	54	2470	3.99	3.44	0.97	0.86
	Both	50	2300	3.91	3.25	0.94	0.83
Enferdeba Michael	Dry	49	1250	3.89	3.3	0.95	0.85
	Wet	50	1400	3.91	3.38	0.95	0.86
	Both	45	1200	3.81	3.10	0.94	0.81
Arema Gebrael	Dry	46	1300	3.83	3.26	0.94	0.85
	Wet	45	1120	3.81	2.9	0.93	0.76
	Both	40	1000	3.69	2.9	0.93	0.79

ln (S): is natural logarithm of the total number of species (S) H': is Shannon-Wiener Diversity Index; D: is Simpson's Index of Diversity; E: is Evenness

Species diversity of birds was not statistically significant between the dry and wet seasons ($F_{1, 295}$ =1.416, P=0.235). Moreover, the effect of season and habitat type of the three church forests on diversity of species did not show statistically significant difference ($F_{2, 295}$ =2.289, P =0.103). However, avian species composition across the different study sites showed statistically significant difference ($F_{2, 295}$ = 849.53, P = 0.000).

The relative abundance was determined based on the results of encounter rate of birds in Goye Merry, Enferdeba Michael, and Arema Gebrael church forests during the dry and wet seasons. The results showed that 121(40.06%) of the individual birds encountered were frequent, 108 (35.76%) were uncommon, and 73(24.18%) were common (Table 3). The Simpson's diversity index results revealed that the three church forests are relatively diverse in their avian species relative abundance that confirm the probability that two individuals randomly selected from a sample within each church forest will belong to different species.

Table 3. Relative abundance of birds in church forests during the dry and wet seasons

Study site	Season	uncommon species	frequent species	common species
Goye	Dry	19	22	13
Merry	Wet	19	20	14
Enferdeba	Dry	17	21	13
Michael	Wet	19	17	14
Arema	Dry	17	20	10
Gebrael	Wet	17	21	9

DISCUSSION

The three selected church forests harbor 68 avian species including two endemic species to Ethiopia, and seven endemic species shared between Ethiopia and Eritrea. In the present study, birds belonging to order Passeriformes are the most abundant which is in line with Yenew Genet and Dessalegn Ejigu (2017) that revealed the same trend of higher Passeriformes abundance in studies conducted in Apini and Dikuma forest patches, Awi Administrative Zone.

The highest species diversity in Goye Merry church forest might be due to the presence of denser trees, less tangled understory, fruiting and flowering trees and relatively wider size of the church forest compound. The same result was also reported by Yenew Genet and Dessalegn Ejigu (2017), and Nabaneeta and Gupta (2010) that bird species diversity and relative abundance is influenced by the size of habitat patches, the availability of food sources and vegetation composition of the area. Similarly, small forest patch and tree size, and lower tree cover might be the prominent factors for the lowest diversity of birds in Enferdeba Michael church forest during both seasons. Besides, natural homogeneity and heterogeneity of habitats, abundance of large trees, dead woods and multi-layered stand canopies affect bird communities (Naka and Cintra, 2012).

Enferdeba Michael church forest harbors more granivores and insectivores bird species than Arema Gebrael church forest, and this might be related to the preference of birds to more grassland, shrubby and open areas with sparse vegetation to feed on insects and grasses. Birds prefer open areas with sparse vegetation mostly to forage on insects in tree foliage attracted by flowers and fruits (Rajpar and Zakaria, 2010). Moreover, some wetland species such as the Egyptian goose *(Alopochen*

aegyptiacus), spur-winged goose *(Plecterus gambensis)* were observed in this church forest because it is located very close to Lake Tana and the Baska River.

Arema Gebrael church forest showed least diversity and evenness of avian species. As reported by Wiens (1996); the relative abundance, distribution and diversity of birds depend on a combination of different factors including territory size, vegetation composition, and structure of the forest. However, the presence of other natural forests closer to this church forest may have its contribution to the occurrence of different species of avifauna in this small church forest.

Although seasonal variations are known to affect the availability of various food items causing a major influence in the distribution of birds by limiting food and vegetation cover availability (Girma Mengesha and Afeworke Bekele, 2008), the effect of season on avian diversity among the three selected church forests did not show significant difference. The wet season helps flowering plants to flourish and as a result, species get plenty of food items in almost all the habitats. However, due to the presence of minimum disturbance at the church forests, habitats remain productive and provide sufficient food source and cover for the species during the dry season too. Nevertheless, habitats were found to cause significant variation in the diversity of avian species among the three study sites. This variation might mainly depend on the presence of different plant species and characteristics of forests.

Uncommon bird species such as Clapperton's francolin (*Francolinus clappertoni)*, African fish eagle (*Haliaeetus vociter)*, and laughing dove (*Streptopelia senegalensis)* were more abundant in Goye Merry church forest than other church forests. This might be due to the suitability of the area as it satisfies their food and cover requirements during both the dry and wet seasons, and their demand for relatively large home range sizes. This was also in line with Tsigereda Dessalegn (2011) where the presence of large number of uncommon species in a certain area could be related to large home range needs of the species. However, a few common avian species including African golden oriole *(Oriolus auratus*), Abyssinian crimson wing (*Cryptospiza salvadorii)*, and Abyssinian oriole (*Oriolus monacha*) were observed to use the same habitat both during the dry and wet seasons. The presence of nectar feeding insects and large branched fruiting trees might have contributed to the occurrence of those species in such church forests.

CONCLUSION

The present study showed that the three selected church forests could support different bird species. Majority of the avian species recorded in the study areas were grouped under order Passeriformes. Motacillidae, Metropidae, Columbidae, Turdidae, and Ploceidae are the most widely distributed families in the three selected church forests. Two endemic bird species of Ethiopia and seven endemic species shared with Eritrea were identified in the study sites.

The presence of 68 species of birds in the present study sites revealed the importance of church forests for avifauna conservation, and this can be considered as a potential for biodiversity conservation in Ethiopia. Thus, the church forest is used as a model to ensure conservation of biodiversity in the country.

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