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**Diversity and Relative Abundance of Birds in Six
Selected Church Forests Located in Addis Ababa**

*MSc thesis submitted in Partial Fulfillment of the Requirements for the
Degree of Master of Science in Biology*

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Abstract

A survey of birds' species diversity and abundance was conducted from October to April, 2016. The method used for the study was the Time-spaced point count method. The survey was conducted in six selected church forests of Addis Ababa: Aboye, Asco-Gabriel, Philipos, Petros We-Paulos, Addisu Michael and Amanuel Cathedral. The study was carried out 6 days per month in October, December, and February, and 8 days per month in April. A total of 100 field hours equally distributed in 3 months (October, December, and February) and 28 hours in April were used during the survey. Twenty one species, which belonged to 5 Orders and 17 Families, were recorded. The most common species was common grey-headed sparrow (*Passer griseus*) and the least common species was Mountain thrush (*Turdus abyssinicus*). The overall diversity index was (H: 2.70) and evenness value was 0.88. All of the churches have the same number of species; twenty one each. This could be due to proximity of the churches to each other in location. Similarly, the diversity and evenness indices of the churches did not show noticeable variation. The highest diversity and evenness indices were (H: 2.70) and (E: 0.89), respectively; and the lowest diversity and evenness indices were (H: 2.67) and (E: 0.88), respectively. It is recommended that conservation of church forests by all concerned bodies should be practiced since the churches are suitable habitats and refuge for a diverse group of avifauna. Since those small patches play an important role in biodiversity conservation and these natural holy places are maintained through traditional methods of community based conservation that do not require governmental involvements, incorporating these sites into conservation networks could enhance the effectiveness of protected areas by covering a wider variety of habitats and by harnessing the support of local people.

Key words: Abundance, birds, biodiversity, churches, Addis Ababa

1. Introduction

There are an estimated 10,000 living species of birds. The fossil record indicates birds evolved from theropod dinosaurs 200 to 150 million years ago, and the earliest known bird is the late Jurassic Archaeopteryx. Globally, 1223 species of birds or about 12% of the total of 9,998 extant described bird species are deemed endangered or threatened with extinction by IUCN's 2009 Red List (Frank, 1995).

Ethiopia is one of the world's rich biodiversity countries. Its high biodiversity is due to a very diverse set of ecosystems ranging from humid forest and extensive wetlands to the desert of the afar depression. This in turn is due to the variation in climate, topography and vegetation. The extensive and unique conditions in the highlands of the country have contributed to the presence of a large number of endemic species. The flora of Ethiopia is very diverse with an estimated number between 6500 and 7000 species of higher plants, of which about 15% are endemic. It has been said that Ethiopia is the 5th largest floral country in Africa (EWNHS, 1996). The country is also rich in its faunastic diversity. The larger mammals are mainly concentrated in the south and south west boarder and adjacent areas of the country. There are also plain games along the stretch of the Great Rift Valley System (Ethiopian Wild Life and Natural History Society, EWNHS, 1996). Mountain massifs in the north are also home to many endemic species of mammals, particularly the Walia Ibex (*Capra walie*), Semien Fox (*Canis simensis*) and Gelada baboon (*Theropithecus gelada*). About 277 species of mammals, 861 species of birds, 201 reptiles (over 87 species of snakes, 101 lizards and 13 species of tortoises and turtles), 63 amphibians and 145 species of fresh water fish are known from Ethiopia (EWNHS, 1996).

Ethiopian is a very important country ornithologically. Some 861 species of birds have been recorded, of which at least 596 are resident and the rest are seasonal migrants, including 176 from the Palearctic (Frank, 2006). Thirty two species of global conservation concern have been recorded (Appendix 3).

Of these, *Aythya nyroca*, *Aquila clanga*, *Aquila heliaca*, *Falco naumanni*, *Crex crex*, *Circus macrourus*, *Gallinago media*, *Glareola nordmanni*, and *Acrocephalus griseldis* are non-breeding migrants from Palearctic while *Phoenicopterus minor* is a non-breeding visitor from elsewhere in the afro-tropics, the remainder are resident (EWNHS, 2000).

Birds are mainly threatened due to destruction of their habitats. A new report released on 7th October 1999 by Birdlife International shows that 1200 bird species (one in 8 or 12% of the world's birds) are facing a real risk of becoming extinct in the next 100 years (Ash and Atkins, 2009). Bird life international also reports that a further 600-900 species are close to begin added to the threatened list. Queen Noor, Honorary president of Bird Life International said: "The prospect of 1 in 8 of our birds disappearing forever is unthinkable." Dr. Jerry Bertrand, Chairman of Birdlife International commented: "Birds are the major indicators of the state of our environment as they are highly sensitive to change, so they give us early warning signs of future environmental crises. Importantly, problem beyond birds are generally also rich for other forms of biodiversity" (Padoa-Schiopa et al., (2006).

Habitat loss and degradation is the major threat. The majority of birds are threatened by deforestation of the burning of vegetation, commercial logging, subsistence farming, plantations, and arable farming and mining. A decline in the quantity of the habitat can be as detrimental as the loss of the habitat itself, for example through grazing by livestock and selective logging. Introduced species are particularly important factor for island birds where indigenous species lack natural defenses. Hunting for food and trade also take their toll. Habitat destruction is the greatest problem. Although threatened birds occur in many different habitats, nearly 900 species (75% of all threatened bird species) live in forests. With the tropical rainforests being extremely rich in bird species, the report highlights Asia and the Americas as particularly important regions. The top countries with the most birds at risk are Brazil (111 species), Indonesia (91 species) and China (82 species), while the highest densities of threatened species in the world occur in the island nation of Philippines. In Malaysia, there are 35 threatened bird species. At least 74 species, including the passenger pigeon, have become extinct since 1800 although extinction is a natural process; the fossil record shows that on average only one bird species dies out

every 100 years. During the last 200 years, the rate of extinction has been at least 40 times greater than this. This recent rapid loss of species can be attributed directly to people's destructive and non-sustainable impact on the world. Countries with the most threatened birds are: Brazil (111), Indonesia (91), China (82), Colombia (81), Peru (79), India (70), Philippines (69), Ecuador (65), New Zealand (65), United States(65), Mexico(49), Australia(46), Argentina(42), Thailand(42), Myanmar(42), Vietnam(38), Russian federation(35), Japan(34), Papua New Guinea(32), Madagascar(30) and Tanzania(30)(Birdlife International,2010).

20,000 Important Bird Areas, sites critically important for the conservation of the world's birds, are being identified by Birdlife International worldwide on the basis of threatened species and other factors. Sixty-nine sites, which account for 0.35% of the world's Important Bird Areas, have been identified so far in Ethiopia. Less than 20% of the world sites are currently protected (WCMC,2005).

Birdlife International partnership launches Birdlife 2000, a strategy that will be implemented by all Birdlife partner organizations. With 66 partners, programmes in 105 countries, 2,150,000 members, over 3,000 staff and a budget of US \$ 170 million, Birdlife is one of the largest global conservation networks (WCMC, 2005).

Birdlife 2000 plan of action includes:

1. Rescue from extinction all globally threatened species: face the challenge of the extinction of 12% of world's birds.
2. Keep common birds common and protect the wider environment: prevent future crisis by influencing policies and practices affecting the wider environment. It means working with governments, producers and consumers to improve the way we exploit vital natural resources (crops, timber, fish, water).
3. Action for sites: Identify and protect "Important Bird Areas", the sites critical for the conservation of the world's bird.

4. Action for habitats: Maintain and restore the quality and extent of natural habitats in the wider environment.
5. Raise awareness and people's support: Increase the number of people who value biodiversity.
6. Benefit people's quality of life through birds: Integrate birds and people's needs. People depend on biodiversity and natural resources. The sustainable use of these resources is crucial to many people's quality of life. Poverty alleviation and environment care are strictly connected (WCMC, 2005).

Birdlife 2000 places a strong emphasis on the human dimension, recognizing that birds and biodiversity conservation will be achieved only through involving people.

Bird life international is responsible for compiling the bird section of the internationally recognized IUCN Red List of Threatened species, the official list of plants and animals at risk of extinction.

Importance of Churches and Holy places in avian biodiversity

Communities around the world, including Ethiopia traditionally protect natural sites that are dedicated to ancestral spirits or deities such as Orthodox churches and Catholic churches. Such sites cover a wide variety of habitats and are often located in biodiversity rich regions (Chandrakanth et al., 2004).

Case studies on sacred groves (Bruner et al., 2001) show that these small forest patches play an important role in biodiversity conservation. Furthermore, natural sacred sites are maintained through traditional methods of community based conservation that do not require Government involvement. Incorporating these sites into conservation networks could enhance the effectiveness of protected areas by covering a wider variety of habitats and by harnessing the support of local people. One of the components of biodiversity conserved by protection of forests is birds.

Sacred sites are thought to be the cornerstones of biodiversity conservation and the safest strong holds for wildlife (Bruner et al., 2001). Since the first national park was set up in Yellowstone, in 1872, some 104,791 protected areas have been established around the world, representing around 12% of the Earth's land surface (WCMCO, 2005). However, only 6% of this formally protected land surface lies within the areas recognized as biodiversity hotspots. One of these protected areas is sacred sites. Such sites are found on every continent except Antarctica and include a wide variety of habitats. As a network, the sacred groves in a region can preserve a sizeable portion of the local biodiversity in areas where it would not be feasible to maintain large tracts of protected forests and where protected reserves would be unlikely to receive local support. Although more research is needed on the role of sacred groves in biodiversity conservation, in landscape connectivity and how these traditional sites can be integrated into existing conservation management practices, the existence of forests of sacred sites has come under threat in many places (Chandrakanth et al. ,2004). It is therefore important to develop management approaches that encourage the conservation of these sites. Ironically, established conservation programs do not recognize the value of traditional institutions despite the existing evidence for their effectiveness in biodiversity conservation and pressure from researchers to include them in local and regional conservation planning (Colding and Folke 2001; Chandrakanth et al. ,2004). One of the components of biodiversity is birds. Birds are land, water and tree living animals so the forests of these sites are the homes for many bird species. This research is aimed at surveying the bird diversity of the aforementioned 6 selected churches of Addis Ababa.

2. Objectives

2.1. General objective

The general objective of the study was to study the species diversity and relative abundance of birds at six selected church forests in Addis Ababa.

2.2. Specific objectives

The study aimed at achieving the following specific objectives:

- To produce species list.
- To document relative abundance of bird species in the church forests.
- To assess the monthly variation of avian diversity.
- To assess the species diversity and evenness of the church forests.
- To identify most and least abundant bird species.

3. The Study area and Methods

3.1. The study area

The six churches included in the study are located in Kolfe-Keranio and Addis Ketema sub-cities of Addis Ababa (Table 1).

Table 1. Location of the six churches in two sub-cities of Addis Ababa.

No	Church	Sub city
1	Asco Gabrael	Kolfe Keranio
2	Philipos	Kolfe Keranio
3	Fetno Aboye	Kolfe Keranio
4	Amanuel Cathedral	Addis Ketema
5	Petros We-Paulos	Addis Ketema
6	Addisu Michael	Addis Ketema

Addis Ababa is located at an elevation of 2,324 meters and geographic coordinates of 9° 1' 48" N and 38° 44' 24" E (Fig. 1). The forests of each church are composed of similar types of indigenous trees although their abundance varies from church to church. The main types of trees in these churches are *Juniperus procera* (tid), *Podocarpus falcatus* (zigba), *Erythrina brucei* (korch), *Acacie abyssinica* (girar), *Olea europaea* (weira), *Ficus surur* (shola).

Figure 1. Map showing the location of the church forests of the present study



3.2. Methods

Sampling area of 2 km x 3 km was selected in each forest. Selection was conducted randomly from a mid-portion of the available sacred groves. Time-spaced point scan survey (following Bibby et al., 1999) was carried out at selected hours of the day when activity of birds was maximum; 7:00 - 9:00 a.m. (morning) and 3:00 - 5:00 p.m. (afternoon). The selected churches were surveyed for 4 months (October, December, February and April). Surveys were conducted for two consecutive days/week; 3 weeks/month. During the last month (April), for 2 consecutive days/ week; 4 weeks/ month. The study was totally conducted for 100 hours at all churches. Four of the six churches (Asco Gabriel, Amanuel Cathedral, Petros We-Paulos, Philipos) were studied for 17 hours each and two (Aboye and Addisu Michael) were studied for 16 hours each. The observer stood at a random spot and recorded birds for 5 minutes. Newly encountered bird species and the number of individuals sighted were recorded. The observer assigned identification key to new species based on unique characters (such as Amharic name, feather type and size, body size, strips on head, beak color and size, size of tail, etc.) until proper identification of the species using Collin's Field Guide on Bird's of East Africa (Perlo, 2009). At the end of the five minutes, the observer randomly walked around for thirty seconds for about 25 meters and stopped at another scanning point. In doing so, an attempt was made to survey the sampling block evenly. The survey continued in a similar manner until the end of each morning and afternoon.

3.3. Data Analysis

Diversity Index

Shannon's Diversity Index (H') was used to assess the diversity of birds. It was calculated as:

$$H' = -\sum p_i \ln p_i, \text{ where:}$$

H' = Shannon's Diversity Index.

P_i = Proportion of the i^{th} species relative to the total number of individuals in the community.

\ln = natural logarithm.

Evenness (Equitability) Index (E)

Shannon's Evenness Index (E) was used to measure equitability of species. It was calculated as:

$$E = \frac{H'}{H_{\max}}, \text{ where:}$$

E = Shannon Evenness Index

H' = Shannon diversity index

$H_{\max} = \ln S$ = natural logarithm of the total number of species.

Relative abundance

The relative abundance of species was assessed using ordinal rank of abundance given below.

Table 2. Ordinal Rank of abundance (Bibby et al., 1999)

Encounter rate /100 hours	Rank
<0.1	Rare
0.1 - 2.0	Uncommon
2.1 - 10.0	Frequent
10.1 - 40.0	Common
>40.0	Abundant

4. Results

4.1. Number of species

A total of 18,515 bird sightings which belonged to 21 species, 5 orders and 17 families were recorded from the six churches (Table 3). Of these, 2 species: wattled ibis (*Bostrychia carunculata*) and Abyssinian wood-pecker (*Dendropicos abyssinicus*), are endemic to Ethiopia.

Table 3. List of species recorded from the six forest churches in Addis Ababa

No	Order	Family	Scientific name	Common name	Status
1	Passeriformes	Turdidae	<i>Turdus abyssinicus</i>	Mountain thrush	Resident
2	Passeriformes	Fringillidae	<i>Serinus tristriatus</i>	Brown-rumped Seedeater	Resident
3	Passeriformes	Estrildidae	<i>Lagonistica senegala</i>	Red-billed Fire-finch	Resident
4	Passeriformes	Zosteropidae	<i>Zosterops abyssinicus</i>	Abyssinian White-eye	Resident
5	Passeriformes	Passeridae	<i>Passer griseus</i>	Common Grey-headed Sparrow	Resident
6	Passeriformes	Viduidae	<i>Vidua chalybeata</i>	Village Indigo Bird	Resident
7	Passeriformes	Corvidae	<i>Corvus albus</i>	Pied Crow	Sedentary
8	Passeriformes	Ploceidae	<i>Ploceus baglfecht</i>	Baglfecht Weaver	Resident
9	Passeriformes	Monarchidae	<i>Terpsiphone viridis</i>	African Paradise Monarch	Sedentary
10	Passeriformes	Corvidae	<i>Corvus crassirostris</i>	Thickbilled Raven	Sedentary
11	Passeriformes	Threskiornithidae	<i>Bostrychia carunculata</i>	Wattled Ibis	Sedentary

12	Passeriformes	Nectariniidae	<i>Nectarinia tacazze</i>	Tacazze Sunbird	Resident
13	Passeriformes	Muscicapidae	<i>Cossypha semirufa</i>	Ruppell's Robin Chat	Sedentary
14	Passeriformes	Tyrannidae	<i>Muscicapa comitata</i>	Slaty Flycatcher	None recorded
15	Passeriformes	Fringillidae	<i>Crithagra striolatus</i>	Streaky Seedeater	Resident
16	Passeriformes	Estrildidae	<i>Uraeginthus bengalus</i>	Red-cheeked Cordon-bleu	Resident
17	Columbiformes	Columbidae	<i>Columba guinea</i>	Speckled Pigeon	Resident
18	Columbiformes	Columbidae	<i>Streptopelia lugens</i>	Dusky Turtle-dove	Sedentary
19	Accipitriformes	Accipitridae	<i>Milvus aegyptius aegyptius</i>	Yellow-billed Kite	African Migrant
20	Coliiformes	Coliidae	<i>Colius striatus</i>	Speckled Mouse-bird	Sedentary
21	Piciformes	Picidae	<i>Dendropicor abyssinicus</i>	Abyssinian Wood-pecker	Sedentary

4.2. Relative abundance

The three most abundant species of the six churches were grey-headed sparrow (*Passer griseus*), brown-rumped seedeater (*Serinus tristriatus*) and pied crow (*Corvus albus*) (Table 4).

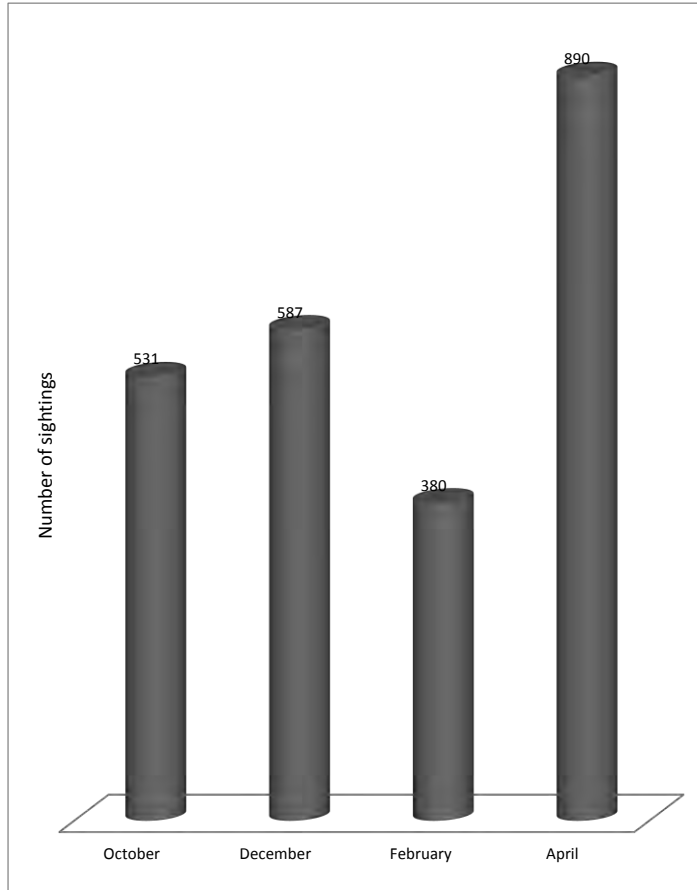
Table 4. Ordinal rank of abundance of species and their pattern of abundance among the six churches

No	Species	Encounter rate/100 hr							Rank
		Asco Gabriel	Aboye	Amanuel Cathedral	Petros We-Paulos	Philipos	Adisu Michael	Total	
1	<i>Passer griseus</i>	385	341	435	418	417	392	2388	abundant
2	<i>Serinus tristriatus</i>	404	347	331	267	375	357	2081	abundant
3	<i>Corvus albus</i>	276	223	426	339	392	363	2049	abundant
4	<i>Lagonistica senegala</i>	332	285	333	281	361	284	1876	abundant
5	<i>Streptopelia lugens</i>	306	275	341	341	293	295	1851	abundant
6	<i>Milvus aegyptius aegyptius</i>	275	161	239	273	279	236	1463	Abundant
7	<i>Columba guinea</i>	296	186	229	204	232	258	1386	abundant
8	<i>Muscicapa comitata</i>	156	140	126	168	172	115	877	abundant
9	<i>Crithagra striolatus</i>	119	118	136	94	96	99	662	abundant
10	<i>Bostrychia carunculata</i>	96	82	88	94	117	90	567	abundant
11	<i>Nectarinia tacazze</i>	120	68	102	100	77	73	540	abundant
12	<i>Ploceus baglafecht</i>	59	78	70	69	114	89	479	abundant
13	<i>Vidua chalybeate</i>	61	55	56	99	50	64	385	abundant

14	<i>Corvus crassirostris</i>	52	41	78	56	65	48	340	abundant
15	<i>Zosterops abyssinicus</i>	31	35	51	53	59	43	272	abundant
16	<i>Dendropicos abyssinicus</i>	40	29	67	46	48	38	268	abundant
17	<i>Uraeginthus bengalus</i>	36	37	41	44	52	32	242	abundant
18	<i>Collius striatus</i>	28	36	30	45	38	43	220	abundant
19	<i>Cossypha semirufa</i>	22	32	43	37	36	29	199	abundant
20	<i>Terpsiphone viridis</i>	28	32	36	28	36	29	189	abundant
21	<i>Turdus abyssinicus</i>	30	28	33	33	31	26	181	abundant

4.3. Monthly variations of most and least abundant species

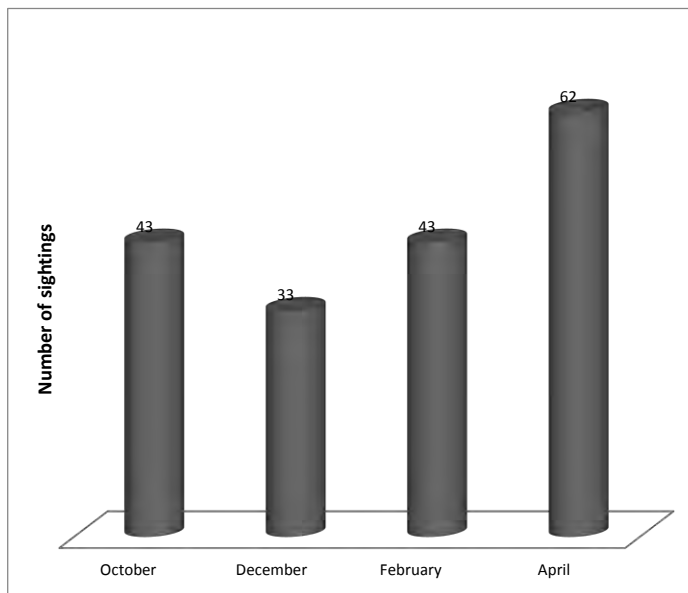
The most abundance species in all churches was common grey-headed sparrow (*Passer griseus*) with a total of 2388 (12.89%) sightings), Brown-rumped seedeater (*Serinus tristriatus*) and pied crow (*Corvus albus*) were the second and third most abundant species with sightings of 2081 and 2049 / 100 hours, respectively (Table 4). The monthly variations of sightings of common grey-headed sparrow (*Passer griseus*) in October, December, February and April were 531,587,380 and 890, respectively (Fig.2).



Months

Figure 2. Number of sightings of common grey-headed Sparrow at each month

The least abundant species in all churches was Mountain thrush (*Turdus abyssinicus*), 181 (0.98%) individuals followed by African paradise monarch (*Terpsiphone viridis*) and ruppell's robin chat (*Cossypha semirufa*), with sightings of 189 and 199/100 hours, respectively (Table 4).The monthly variations of sightings of Mountain thrush/ Abyssinian thrush (*Turdus abyssinicus*) species in October, December, February and April were 43, 33, 43 and 62, respectively (Fig.3).

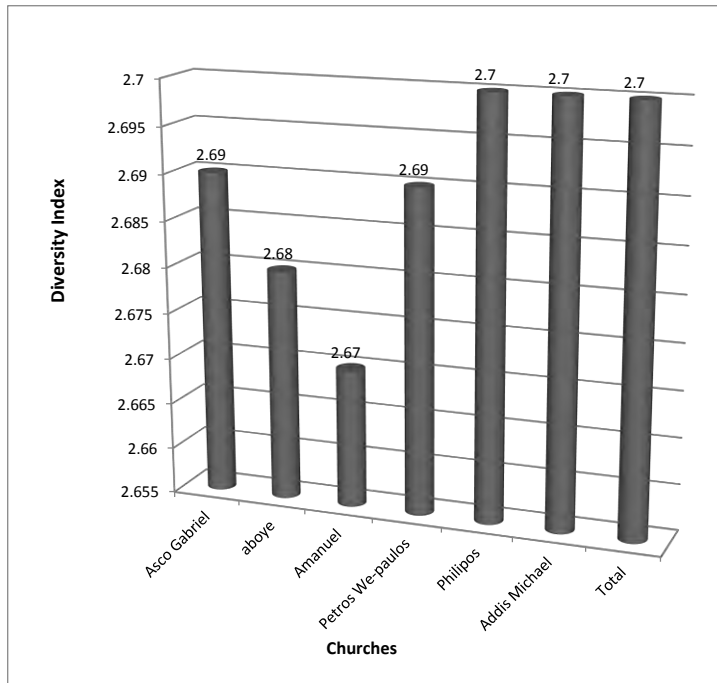


Months

Figure 3. The number of individuals of white-tailed ant-thrush in each month

4.4. Diversity index

Philipos and Addisu Michael Churches had the highest diversity index (H: 2.70) while Amanuael Cathedral had the lowest (H: 2.67). The overall diversity index for the combined data of all the churches was 2.7 (Fig. 4).

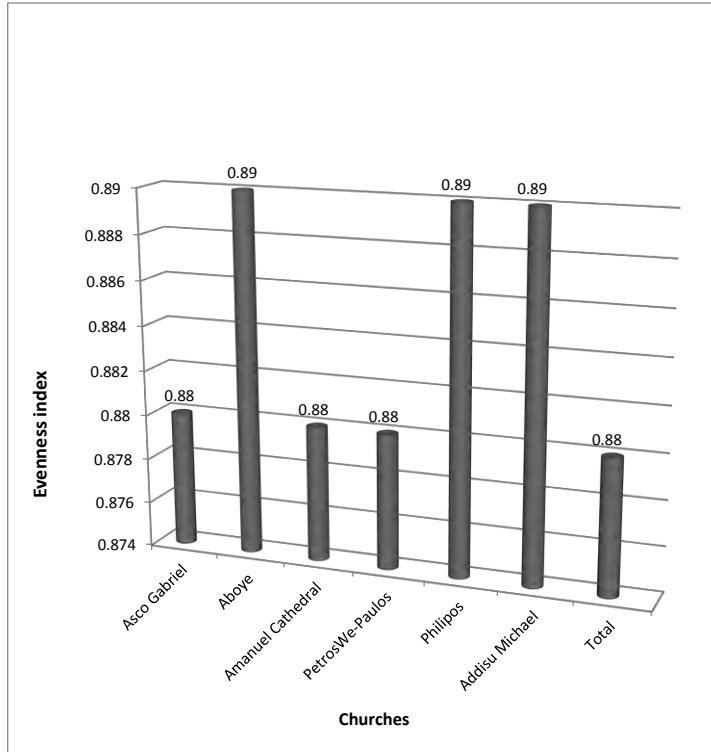


Overall

Figure 4. Diversity Index at each church and the overall diversity index for the combined data

4.5. Evenness index

The Evenness Index showed very little variation between the churches with Aboye, Philipos and Addisu Michael having the highest values (E: 0.89) while the rest have the lowest (E: 0.88). The overall evenness index was 0.88 (Fig 5).



Overall

Figure 5. Evenness index at each church and the overall evenness index for the combined data.

5. Discussion

When compared to avifauna of Entoto Natural Park and escarpment (Kalkidan Esayas and Afework Bekele, 2011), these churches have a far less species diversity. With regard to their species richness, the studied churches are homes for 21 species belonging to 17 families and 5 orders whereas the Natural Park and escarpment (including the church) is the home for 124 species belonging to 44 families and 14 orders. With regard to their Shannon's Index of diversity, the highest and the lowest Shannon's index of diversity of the six selected churches were (H: 2.70) and: (H 2:67), respectively, whereas the highest and lowest Shannon's index of diversity of the Natural Park and escarpment were (H: 3.98) and (H: 2.74), respectively. With regard to Evenness Index of avifaunal diversity, the highest and lowest Evenness Index of the 6 selected churches were (E: 0.89) and (E: 0.88), respectively, whereas the evenness index of the Natural Park and its escarpment (including Entoto church) were (E: 0.99) and (E: 0.75), respectively (Appendix 2, number 3). With regard to the relative abundance of the two study areas, in the six selected churches, all species were abundant, whereas in the Entoto Natural Park and escarpments (including the Entoto Church) 150 (52.4%) were frequent, 32 (11.25 %) were common, 74 (25.9%) uncommon and 4 (1.4 %) were rare, but there were no abundant species.

This variation in avifaunal diversity could be due to the high floristic composition and vegetation complexity of the Entoto Natural Park and the escarpment (including the Entoto church) and low vegetation complexity and floristic composition of the 6 selected churches; and the better availability of food and lesser clearance of the forest in Entoto Natural Park and the escarpment (including the church) and the less food availability and more clearance of forests in the 6 selected churches for construction purposes. Besides the above reasons, the study on the Natural Park and escarpment involves three different types of habitats (forest, farmland and church forest) whereas the six selected churches involve only church forest habitat (Appendix 2, number 3).

When compared to avifaunal diversity of Chebera Churchura National Park (Dereje Woldeyohannes, 2006) (Appendix 2, number 1), the Natural Park is home for 137 species belonging to 52 families. This could be due to altitudinal difference between the study

area of Chebera Churchura (1440-1835 m) and the six selected churches (averagely 2,324 m), and the presence of different habitats (wooded grassland, montane woodland, riparian forest and woodland) in Chebera Churchura and only church forest habitats in the six selected churches. On top of this, the study in Chebera Churchura has been carried out in wet and dry seasons, whereas in the six selected churches it has been carried out only during dry seasons.

When compared with the avifaunal diversity of Geto and Gembejo areas of southwest Shoa (Teklu Gosaye, 2011) (Appendix 2, number 4), Geto and Gembejo areas are homes for 120 species belonging to 39 families and 15 orders. In terms of Shannon's Diversity Index of the two study areas, the highest and lowest diversity indices of the selected churches were (H: 2.70) and (H: 2.67), respectively, whereas in Geto and Gembejo areas, they were (H: 3.3) and (H: 1.94), respectively. These could be due to the occurrence of the study in wet and dry seasons in Geto and Gembejo areas and only during the dry season in the six selected churches. These variations could also be due to diversified habitats (plain, shrub land, and garden, woodland, farmland and ericaceous habitats) of Geto and Gembejo areas when compared to a single habitat type (church forest) of the six selected churches. The larger gap in highest and lowest diversity indices in Geto and Gembejo areas (when compared with the closer difference in the selected churches) could be due to the vegetation differences between the woodland (highest Shannon's Diversity Index) and the ericaceous (lowest Shannon's diversity index) habitats.

When compared with avifaunal diversity of Addis Ababa Abattoirs Enterprise (Hiwot Hibiste, 2007) (Appendix 2, number 6), the enterprise is home for 21 species belonging to 10 families and 4 orders, with the same number of species but different number of orders and families from this study on the six selected church forests. Eventhough the same in number of species, the types of the species were not the same. This could be due to habitat differences since the habitat of the enterprise is largely piles of bones, scraps and offal (suitable largely for carnivores) but the habitat of the selected churches of my study area is church forest. In addition to this, the study on the six selected churches was carried out only during the dry season, whereas the study on the enterprise was carried out both during the dry and wet seasons.

When compared with the bird diversity of Beheretsigie, Central and Ferencye Recreational Parks in Addis Ababa, Ethiopia (Elizabeth Girma, 2007) (Appendix 2, number 7), the Recreational Parks are homes to 102 species belonging to 39 families. In terms of Shannon's Diversity Index, the highest and lowest diversity indices of the recreational parks were (H: 3.75) and (H: 3.23), respectively, whereas that of the six selected churches were (H: 2.70) and (H: 2.67), respectively. These variations in species composition and diversity indices could be due to habitat type differences. The types of habitats of the recreational parks are forests mixed with plains whereas the habitat of the six selected churches is church forest. Besides this, the study on the recreational sites was carried during wet and dry seasons, whereas that on the six selected churches was carried out only during the dry season.

When compared with the avifaunal diversity of residential birds in selected church forests of Tigray Region (Hailemariam Areaya et al., 2013) (Appendix 2, number 8), the selected churches in Tigray Region are homes to 65 species of birds, more than three folds of the number of bird species of the church forests of the six selected churches. This could be due to altitudinal variations (Dega, Weina-Dega and Kola) of the place of the church forests where the study has been carried out in Tigray Region, whereas the study in the six selected churches was carried out in, more or less, similar altitude. This in turn could change the vegetation composition of the areas.

When compared with the avifaunal diversity of Dbla church forest in eastern Tigray (Kalayu Mesfin and Gebremedhin Teklu, 2014) (Appendix 2, number 9), the church forest is home to 21 species of birds belonging to 10 families and 4 orders, the same in number of species with the study in the six selected churches but different in number of families and number of orders. This could be due to latitudinal differences of the 2 study areas. Besides this, it could also be due to the fact that my study was carried only during the dry seasons, but that of the Dbla church forest was carried out both during the dry and wet seasons.

When compared with a survey on birds of the Yayu forest (Gebrecherkos Woldegeorgis and Tilaye Wube, 2012) (Appendix 2, number 10), Yayu forest is the home for 112

species belonging to 37 families, much more than the species and family number of my study. This variation could be due to habitat and altitudinal variations between the two study areas.

When compared with the avifaunal diversity of birds of the Addis Ababa Bole International Airport (Tsigereda Desalegn, 2011) (Appendix 2, number 2), the Airport sheltered 74 bird species belonging to 31 families and 13 orders, whereas the six selected churches sheltered only 21 species belonging to 17 families and 5 orders. With regard to Shannon's Diversity Index, the airport's highest and lowest diversity indices were (H: 4.06) and (H: 3.71), respectively, whereas those of the six selected churches were (H: 2.70) and (H: 2.67), respectively. These variations could be due to habitat variations; the study at the airport involved 3 different habitat types (garden, grassland and water body), whereas the six selected churches involved only church forests. . On top of this, the study on the airport was carried out during the wet and dry seasons but the study on the selected churches was carried out only during the dry season. These differences in the comparison are in line with that of Telleria and Santos (1994), habitat structure affects the distribution of individual species as indicated by Telleria and Santos (1994). Besides habitat size, foraging modes (Willis, 1974) and floristic composition (Wiens and Roterberry, 1981; Marone, 1995) have influence in the distribution of the species. These are also in line with that of Chace and Walish (2006) birds respond to changes in vegetation composition and structure, which in turn affects their food resources and that of (Beals, 1970) for birds, rainfall regimes and other associated environmental changes are important in determining breeding seasons and annual cycles in many regions, including Ethiopia.

All studied church forests sheltered the same number of bird species (twenty one) because they are geographically close. Morand (2000) showed that two areas may share the same number of species not because they are similar in area and/ or diversity, but because they are geographically close which allows individuals to move easily from one island to another. Even though there is no difference in species number and types among the six surveyed churches, there were differences in number of individuals of each species, index of diversity, evenness index and relative abundance.

The highest species diversity was recorded at Philipos and Addisu Michael churches and the least was recorded at Amanuel Cathedral church. This could be due to the larger forest composition of Philipos and Addisu Michael churches and the least forest composition of Amanuel Cathedral church. Larger forest patches supported more bird species than smaller ones as reported by (Suarez-Rubio & Tomlinson, 2009) at forest birds in India. This is consistent with the present finding that the higher in plant composition, the greater bird species supported (Philipos and Addisu Michael).

The three most abundant species among the 6 churches were the common grey-headed sparrow (*Passer griseus*), brown-rumped seedeater (*Serinus tristriatus*), and pied-crow (*Corvus albus*). Even from these, the most abundant was the common-grey-headed sparrow (*Passer griseus*). This could be due to the presence of suitable plants for nesting and food, as well as the grains given by church communities. This is in agreement with the findings of Hiwot Hibste (2007) that deal with the species composition, abundance and activity pattern of birds of Addis Ababa Abattoirs Enterprise. Although the abundance of birds changes from months to months, the common grey-headed sparrow remained numerically the most abundant throughout the study period in the six churches.

The least abundant species were Mountain thrush (*Turdus abyssinicus*), African Paradise Monarch (*Terpsiphone viridis*) and Ruppell's Robin Chat (*Cossypha semirufa*). Even from these, the least abundant was Mountain thrush (*Turdus abyssinicus*). This could be due to the absence of muddy areas that have a better availability of this specific bird's food. This could also be due to difficulty in detecting the bird because of its elusive behavior and shyness. Thinh (2006) pointed out that each avian species in a given habitat such as forest has its own probability of being detected, which is usually less than 100%. Pomery and Dranzoa (1997) explained that many forest species are difficult to detect, especially those that live in understories.

The greatest number of sightings of common grey-headed sparrow (*Passer griseus*) (the most abundant species) was recorded in April. This could be due greater vegetative composition, especially grasses resulting from the abundant and unexpected rainfall in in March and April due to El Nino since these increase availability of food and rate of

reproduction. The least number was recorded in December. This could be due to lower vegetative composition, especially grasses resulting from absence of rainfall in November and December since these lead to lesser food availability and lower reproduction rate. These are in agreement with that of Telleria and Santos (1994) habitat structure affects the distribution of individual species. They are also in line with that of (Willis, 1974) besides habitat size; foraging modes and floristic composition (Wiens and Roterberry, 1981; Marone, 1995) have influence in the distribution of the species. Chace and Walish (2006) also indicated that birds respond to changes in vegetation composition and structure, which in turn affects their food resources. (Beals, 1970), furthermore, pointed out that for birds, rainfall regimes and other associated environmental changes are important in determining breeding seasons and annual cycles in many regions, including Ethiopia.

Birds are known to be bio-indicators of the overall ecological status of the small forest patches in the holy places and other wildlife reserves. The most common and abundant species (focal species) are used to monitor any significant disturbance of ecological balance of a natural area. This is why knowledge in population size is valued for its importance in conservation practices (Gebrecherkos Woldegeorgis and Tilaye Wube, 2012; Johnson, 1980; Padoa-shioppa et al., 2006).

In general, the results of the study showed that selected church forests are home for 21 species of birds, which belonged to 5 orders and 17 families. This indicates that they contribute to the biodiversity conservation and sustainability of birds. Besides this, the relative abundance of the birds showed that churches are suitable undisturbed habitats for the biodiversity of birds since all the observed birds were abundant.

Even though they are important sites for bird biodiversity conservation, these forests are under threat since the church administrators and their allies in Addis Ababa remove them to clear the land for various construction purposes such as shops, schools, residence for priests and others.

This is widely observed in three of the six churches studied. These churches are Petros We-Paulos, Philipos and Addisu Michael churches. To conserve biodiversity of birds and other wildlife, I strongly recommend that all of us, including the government to do more

in order to avoid clearing of church forests. I also recommend the government, the church community and the biological communities to do more to use them as important ecotourism sites.

In conclusion, this study indicates that churches are important components of forest patches for the conservation of biodiversity of birds and other wildlife.

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7. Appendices

Appendix 1. Species of birds identified during the study period



Turdus abyssinicus



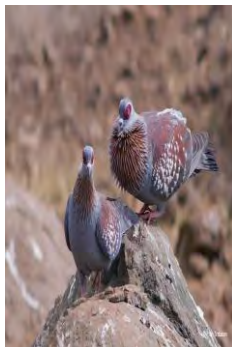
Serinus tristriatus



Lagonistica senegala



Lagonistica senegala



Columba guinea



Zosterops abyssinicus



Milvus aegyptius
aegyptius

Source: Wikipedia



Zosterops abyssinicus



Passer griseus



Vidua chalybeate



Corvus albus



Dendropicos abyssinicus



Ploceus baglafecht



Terpsiphone viridis



Streptopelia lugens

Source:Wikipedia



Bostrychia carunculata



Corvus crassirostris



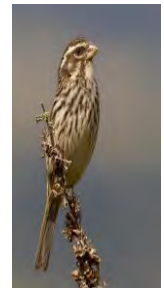
Nectarinia tacazze



Cossypha semirufa



Muscicapa comitata



Crithagra striolatus



Nectarinia tacazze (male)



Uraeginthus bengalus

Source: Wikipedia

Appendix 2. Comparison with other studies

	Year of the research	Habitat	Location	Number of species	Number of families	Number of orders	Study season	Method used	Highest and lowest Diversity Index, respectively
1	2006	Wooded grassland Montane woodland Riparian forest Woodland	SNNP	137	52	NS	Wet and dry	Time species count	NS
2	2011	Garden, grassland, water body	Addis Ababa	74	31	13	Wet and dry	Transect count and point count	4.06, 3.71
3	2011	Forest, farmland and church compound	Addis Ababa	124	44	14	Wet and dry	Point count method	3.73, 2.92
4	2011	Plain habitat Shrubland Garden Woodland Farmland Erica	Oromia	120	39	15	Wet and dry	Line-transect Point count	3.3, 1.94
5	2010	Forest eucalyptus plantation Farmland Church	Addis Ababa	124	44	14	Wet and dry	Point count Line-transect Total count	3.73, 2.92
6	2007	Piles of bones Scraps Offal	Kirkos sub city/A.A.	21	10	4	Wet and dry	Point count	NS
7	2007	Recreational park	A.A./Cherkos, Nifas silk Lafto, Yeka SS/	102	39	NS	Wet and dry	Total count	3.75, 3.23

8	2013	Church forests	Tigray	65	NS	NS	Kola,de ga andwei na dega	Lne-transect Point count	3.42,2.42
9	2014	Church forest	Tigray	21	10	4	Wet and dry	Point count	NS
10	2012	Forest	Oromia/ Ilu Aba Bora zone	112	37	NS	Wet and dry	Timed Species count	NS

Appendix 3. Birds of Global Conservation Concern in Ethiopia

No.	Scientific name	Status
1	<i>(Sarothrura ayresii</i>	Endangered
2	<i>Turaco ruspolii</i>	Endangered
3	<i>Heteromirafra sidamoensis,</i>	Endangered
4	<i>Serinus flavigula</i>	Endangered
5	<i>Serinus ankoberensis</i>	Endangered
6	<i>Aythya nyroca</i>	Vulnerable
7	<i>Aquila clanga</i>	Vulnerable
8	<i>Aquila heliaca</i>	Vulnerable
9	<i>Falco naumanni</i>	Vulnerable
10	<i>F.fasciinucha</i>	Vulnerable
11	<i>Francolinus harwoodi</i>	Vulnerable
12	<i>Grus carunculatus</i>	Vulnerable
13	<i>Crex crex</i>	Vulnerable
14	<i>Mirafra degodiensis</i>	Vulnerable
15	<i>Hirundo megaensis</i>	Vulnerable
16	<i>Serinus xantholaema</i>	Vulnerable
17	<i>Zavattariornis stresemanni</i>	Vulnerable

18	<i>Balaeniceps rex</i>	Near Threatened
19	<i>Phoenicopterus minor</i>	Near Threatened
20	<i>Circus macrourus</i>	Near Threatened
21	<i>Rougetius rougetii,</i>	Near Threatened
23	<i>Eupodotis humilis</i>	Near Threatened
24	<i>Glareola nordmanni</i>	Near Threatened
25	<i>Streptopelia reichenowi</i>	Near Threatened
26	<i>Mirafra pulpa,</i>	Near Threatened
27	<i>Macronyx flavicollis</i>	Near Threatened
28	<i>Cercomela dubia</i>	Near Threatened
29	<i>Acrocephalus griseldis</i>	Near Threatened
30	<i>Sylvietta philippae</i>	Near Threatened
31	<i>Emberiza cineracea</i>	Near Threatened
32	<i>Gallinago media</i>	Near Threatened