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Diversity, Distribution and Relative abundance of the Avian Fauna of
Denkoro Forest Proposed National Park

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ABSTRACT: *The study was carried out to investigate the diversity, distribution and relative abundance of avian fauna in Denkoro priority Forest Area covering wet and dry seasons from August 2007 to March 2008. The study area was stratified based on the vegetation types. Four habitat types: Forest, Erica woodland, Grassland and Farmland were identified. Each vegetation type was used as sample site. Point count and line transect methods were employed. The data were collected in the morning and late afternoon. A total of 154 species of birds were identified. Erica woodland habitat had the highest species diversity ($H = 3.332$) during the wet season and Forest habitat had the highest species diversity ($H = 3.850$) during the dry season. The species richness of birds during the wet season was between 15-28 and that of the dry season ranged between 25-47. Simpson's similarity Index indicated the highest similarity between Forest and Erica and Forest and Grassland during the wet season. During the dry season, the highest species similarity was observed between the Forest and Erica woodland. The mean number of individuals showed significant difference between habitats. Season had significant effect on bird abundance ($p < 0.0001$). The interaction of season and habitat was statistically significant ($p < 0.05$). The chi-square analysis for the habitat association of birds showed significant difference based on vegetation types ($p < 0.001$). Deforestation habitat fragmentation, agricultural expansion and settlement are the main threats for the avian fauna. Hence, conservation measures should be taken to protect the wildlife in the area.*

Keywords: species diversity, distribution, relative abundance species richness species similarity, point count, line transect, Denkoro Forest, threat, conservation.

1. INTRODUCTION

Ethiopia is located in the northeast of Africa between 03° 40' and 18° N latitude and 33° and 48° longitude. It has a wide range of climate and topographic features. The topographic variation ranges from the lowest depression of Dallol (116 m bsl) to the highest point of Ras Dashen (4620 m asl) (Ethiopian Mapping Authority, 1988; BirdLife International, 2001; Vivero Pol, 2001; IUCN, 2003).

The topography of Ethiopia is divided into highland and lowland. The main block of the highland was split into two along a northeast/southeast axis by forming the Great Rift Valley (Hillman, 1993). The highest summit Simien Mountain is sometimes called “the Roof of Africa” (Drake, 1977). Ethiopia possesses 80% of the African high ground above 3,000 m (Yalden, 1983). There is greater area of land above 1,500 m in Ethiopia than any other African country (BirdLife International, 2001).

The biodiversity of Ethiopia deserved attention regionally and globally because of a very diverse set of ecosystems ranging from humid forest and extensive wetlands in the west to the desert of Afar depression in the northeast. The country possesses high diversity of flora and fauna that occur from the highest mountain to the lowest hottest places on earth (WCMC, 1991; Hillman, 1993). According to the criteria of Conservation International (1996), recently, Ethiopia is considered one of the biodiversity hot spot regions of the world i.e. countries which are biologically rich with many endemic species. The country consists of many species, ecosystems and genetic diversity and high level of endemism. Concerning birds, there are several endemic bird areas (EBAs), which occur in a variety of montane grassland-scrub mosaic habitats in central and northern parts of the highland from near Addis Ababa extending northward. The boundary of the EBA is based on the documented records and altitudinal limits of restricted range bird species present (EWNHS, 1996; Stattersfield *et al.*, 1998).

Many of the regions of Ethiopia were covered with thick natural forest and woodland with varieties of trees and wild animals. 40% of the country's landscape was covered with natural

forest and woodland but, due to serious human pressure, at present, it is left with less than 2.7% of the original plant cover. This has also brought relative decline in wild animal species. Destruction of habitat, excessive human predation, introduction of toxic chemicals and natural uncontrolled events have threatened about 1,000 species world wide (Gill, 1995).

Even though Ethiopia is rich in biodiversity, they are not fully documented and conserved. Therefore, it is essential to carry out studies in the identification of the biodiversity of the country, conservation sites and preservation of endangered species targeting birds and other wild animals. Many of these bird species including the endemic forms occur in Amhara National Regional State.

The Amhara National Regional State is located in the northwestern part of the country. The region covers an area of 138,658 km² and is divided into seven administrative zones. The topography of the region ranges from 1,000 m asl to the top of Ras Dashen 4620 m asl. Most of the region covers the central Ethiopian plateau. It has deep river gorges and the largest Lake in the country, Lake Tana (EWNHS, 1996). The variation in topography resulted in various agro-climatic zones classified as 'Weina Dega,' 'Dega' and 'Kola.' The region is known for varieties of its flora and fauna including endemic ones.

The region as a whole holds most of the areas associated with unique bird species, among these eight species are endemic to Ethiopia (BirdLife International, 2001). The area is considered as the central Ethiopian highland Endemic Bird Area (EBA) (EWNHS, 1996). There is a need to identify areas where these unique species occur to make maximum conservation, because birds are strong red light indicators of environmental degradation. They give early warning signals of environmental crises. Birds are indicators of biodiversity as well as monitors of environmental change such as level of contaminations and environmental impact (Greenwood and Furness, 1993; Sutherland, 2000).

Most of the Amhara region has lost its previous forest cover due to increased human pressure on the natural vegetation. The increase in the density of human population resulted in massive destruction and overexploitation of the natural resources. The land is exposed

resulting in severe erosion. The cutting down of trees resulted in the destruction of habitats. Other than this, there was also continuous hunting of wild animals for various reasons. One of the few remaining natural forests in the region is Denkoro Forested area in Debre Sina Woreda of the Southern Wello Zonal Administrative Region.

The main objective of the present study is to provide primary information on the diversity, distribution and relative abundance of the avian fauna of Denkoro forest.

2. LITERATURE REVIEW

Birds are, numerically the most successful terrestrial vertebrates on the terrestrial environment (Welty, 1975). According to Kotpal (1985), the world population of birds is nearly 100 billion. Birds make up less than half a percent of global animal species diversity (Jews, *et al.*, 2004). The power of flight is a means of quick direct access to almost any spot on earth. They can feed on variety of food items and build homes on infinite variety of sites (Welty, 1975). They are the only animals that have feathers, and the only living vertebrates apart from bats that have evolved wings and powered flight (BirdLife International, 2007).

Birds appear to be quite variable. They differ considerably in size, body proportion, colour, song, behaviour and ability to fly. They were able to become flying machines largely through evolutionary gifts of feathers, powerful wings, hollow bones, endothermism, remarkable respiratory system and large strong heart. These adaptations all fulfill two prime requirements for birds: high power and low weight (Wetly, 1975, BirdLife International, 2007). Birds have evolved constant body temperature (endothermism) like mammals that make energetic activity possible in all habitats (Welty, 1975; Feduccia, 1996).

Birds occupy almost every conceivable niche from polar ice caps, highest peaks of Himalayas and slopes of Andes to the roughest seas, darkest humid jungles, the most barren deserts and crowded cities (Kotpal, 1985). Birds occupy varied habitats that are denied to other animals. Despite their ability to fly, some species are restricted to special regions occupying definite geographical region or particular kinds of habitat. Many avian populations have become adapted to particular climatic conditions. Distribution of birds varies not only

by altitudinal differences but also by latitudinal differences. Tropical regions have high species richness than temperate regions (ICBP, 1990).

Species of birds increase or decrease based on complexity of the habitat. As the vegetation component increases, the number of bird species in a terrestrial environment increases (MacArthur and MacArthur, 1961). For terrestrial communities the number of bird species as well as their diversity is strongly positively correlated with aspects of the structural complexity of vegetation (MacArthur, 1964; Recher, 1969; Karr and Roth, 1971). Species diversity increases with vertical foliage height diversity (Moss, 1978). This indicates that the more complex the structure or composition of the vegetation, the more diverse the species of birds present in the habitat. Lowest bird species diversity occurs in even aged monoculture plantation without under growth. In such dense forests, the canopy suppresses the under story by shading, as a result species richness is minimized (Urban and Smith 1989).

Species richness increases as climatic variation decreases. Unpredictable climatic variation is a form of disturbance for bird species. Environmental factors influence species richness (Oindo *et al.*, 2001). Seasonal irregularities lead birds to migration in order to search for alternative food source available and breeding sites (Alerstam, 1990). Various bird migration systems have evolved in response to particular temporal and spatial changes in the environment, and most of the aspects of these migratory systems for example orientation; energetics and timing have been shaped by evolutionary selective pressure associated with changes in time and space (Gautherax, 1979; Bauchinger and Klaason, 2005). Birds perform long range movements or migrations. Traveling alone or in flocks, they navigate with precision, dividing their habitats between places that are far apart. Unlike many other animals, birds need abundant food all the year round. Migration allows them to exploit seasonal changes and to breed where the food supply is best (BirdLife International, 2007).

Species diversity is not determined by any single factor but the outcome of many contributing factors. Patterns of variation in species diversity are patterns of variation in many biophysical factors as well as anthropogenic processes that could conceivably influence biological diversity (Diamond, 1988).

Within sites, it is fairly evident that habitat is likely to be important determinant factor in the distribution and number of birds. Variations in habitats might be natural origin, for instance by soil type, along a gradient of rainfall or by altitude. Important variations might have human origin, such as the degree of deforestation (Bibby *et al.*, 1998; ICBP, 1990; Satterfield *et al.*, 1998). Temporal diversity of birds during breeding season is the result of specific feeding differences together with temporal diversity in the availabilities of different food resources (Ricklefs, 1966).

According to Roth (1976), patchiness of habitat increases species diversity. Shrublands with increased patchiness have more species than grasslands. Forests with more vegetation layers or volume have fewer bird species than patched shrublands.

The elevation of a place may have a relationship in determining birds and habitat association. Increase in altitude decreases in complexity of the vegetation, which in turn decreases the diversity and distribution of birds.

Birds are one of the most important components of biodiversity. This can be indicated by their ecological, economical and aesthetic values. From the earliest times, birds have captured the imagination of people the world over. Their flight, songs, colour displays and migrations are among the world's most compelling natural wonders (ICBP, 1990). Birds, not only indicate biological diversity, but the quick change taking place in the environment. Ornithologists have a distinct contribution to make biodiversity conservation by improving our understanding of the planet, the location of biodiversity and threats it faces from non-sustainable practices (Pomeroy and Dranzoa, 1997; Bibby *et al.*, 1998).

Birds are conspicuous and possess diagnostic calls or songs that are necessary to identify them in the field (Wallace and Maham, 1975; Sutherland, 2000). Birds are associated with mankind. They have vital economic importance such as source of food, clothes and tools for humans. They also serve as game animals, pest control agents and means of cleaning the environment (Kotpal, 1985). One economic importance of birds is their contribution in seed

and fruit dispersal. It is well known that many fruit producing plants and birds species are co-evolved to disperse the plants both in tropics and temperate region (Wilkinson, 1997).

One indispensable contribution birds made to our civilization was to provide quills for writing. Birds are used as symbols of honour and health. Their study has helped mankind to understand the physics of flight (Harrison and Smith, 1993).

Besides their numerous contributions, many bird species are pests because they conflict with different human activities. Pest birds reduce productivity of cereal crops and horticulture. Some introduced species compete and displace native species. The collision of birds poses serious safety hazards to aircraft. The collisions of birds are costly and potentially deadly to people and wildlife (Seamans *et al.*, 2007).

Currently many species of birds are in danger of extinction. This problem is associated with human activities such as destruction or fragmentation of bird habitats for agriculture, settlement and environmental pollution. There is a need to know more about birds and their habitat requirements in order to protect them (ICBP, 1990).

Ethiopia has five climatic zones and nine vegetation zones. The presence of many climatic regions has made a very suitable ground for the existence of different species of birds. According to BirdLife International (2001), Ethiopia has 69 IBAs covering at least 47,757 km². Some 923 bird species have been recorded from Ethiopia of which 21 species are endemic and 19 species are globally threatened (Lepage, 2008). Even though the country possesses varieties of bird species, birds of forest habitats are poorly known. The present study, therefore, attempts to study the diversity, distribution and relative abundance of avian fauna in Denkoro Forest

3. OBJECTIVES

3.1 *General objective*

The general objective of the present study is to determine the diversity, distribution and relative abundance of avian fauna in Denkoro Forest.

3.2 *Specific objectives*

The specific objectives of the study are:

- To determine the species composition and distribution of Avifauna.
- To identify the habitat association of the avifauna.
- To estimate the population size of each bird species.
- To determine the impact of season on the habitat preference of birds.
- To investigate the impact of human activities on the avian fauna and recommend management plan

4. STUDY AREA

The study area, Denkoro Priority Forest Area is a proposed National Park. The area is located in southern Wello Zone Administration (SWZA). It lies about 16 km North of Debre Sina Woreda town, Mekane Selam between coordinates of 10° 50'-10° 53'N latitude and 38° 40'-38° 54'E longitude (Ethiopian Mapping Authority, 1988). Denkoro Forest lies along the boundaries of Debre Sina and Sayint (Densa) Woredas. The largest part of the forest area is located in Debre Sina Woreda. Previously, the Forest covered an area of 5,500 ha (55 km²). However, the Forest has been reduced from its original size due to deforestation and clearing for agriculture and settlement particularly on the side of Densa Woreda.

The region has different topographic features ranging from lowland to mountain areas (Fig.1). Denkoro Forest has altitudes ranging between 2,300-3,665 m asl. The actual thick forest covers 19.60 km² of land while the rest of the forest lies in the coldest part of Afroalpine and this covers 35.4 km² area of land (Anonymous, 2004).

The floristic composition of Denkoro Forest consists of 174 species of vascular plants which are classified as herbs, shrubs and trees (Abate Ayalew *et al.*, 2006). The thick forest region is provided with varieties of naturally growing trees and other plants while the coldest mountain region (Afroalpine habitat) is covered mainly with grass (*Fistuca abyssinica*) and *Erica* woodland. The area also possesses various types of natural caves.

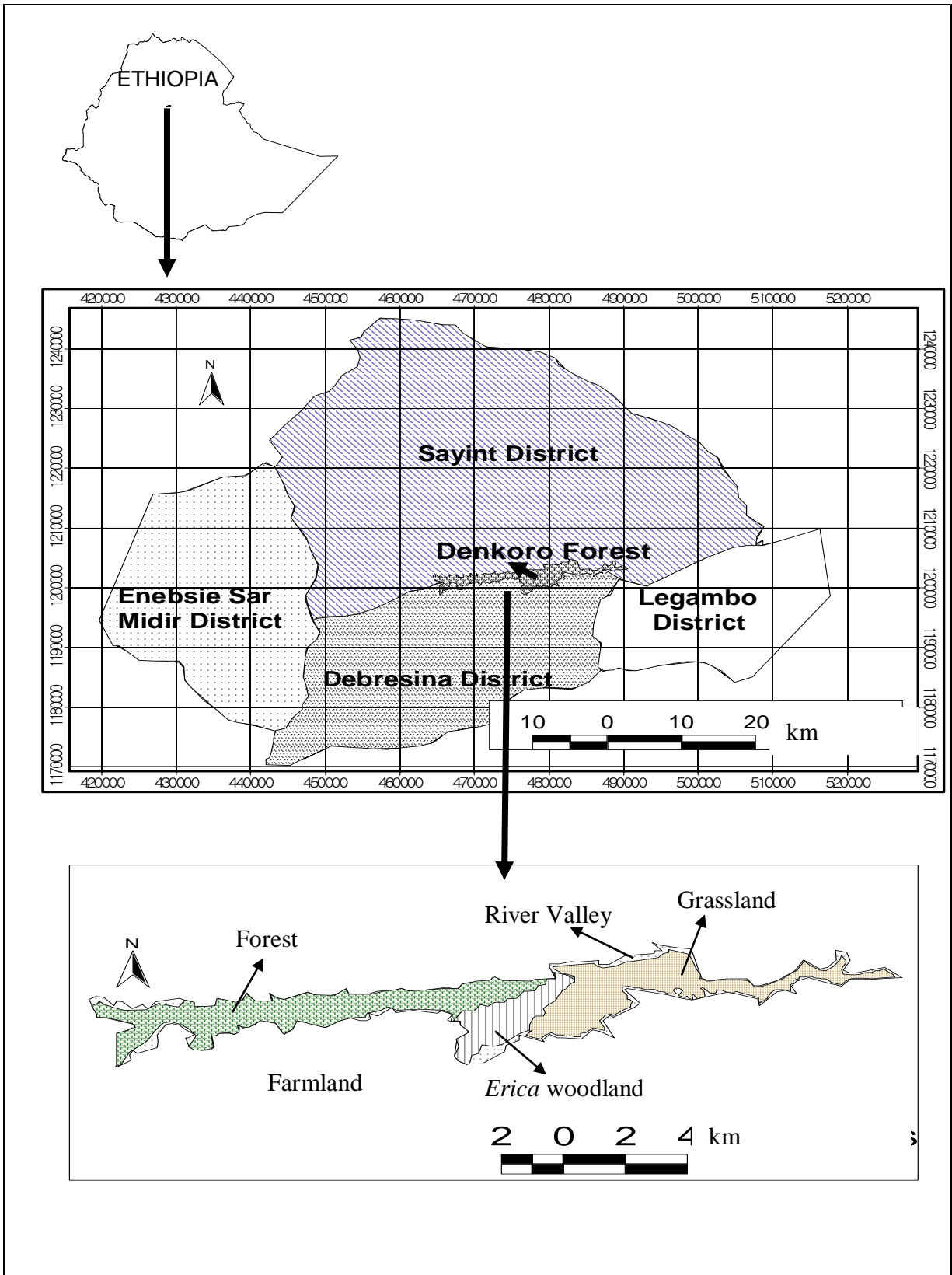


Figure 1. Map of the study area with habitat types.

The Rainfall in Denkoro Forest is bimodal. Data obtained from the Ethiopian Metrological agency show the rainfall and temperature record from 2001-2007 (Fig. 2). Based on the data recorded, the small rainfall distribution is between January and May while the actual rainfall extends from June to September. The greatest precipitation is during the months of June and August. The amount of annual rainfall ranges between 600 -1,000 mm.

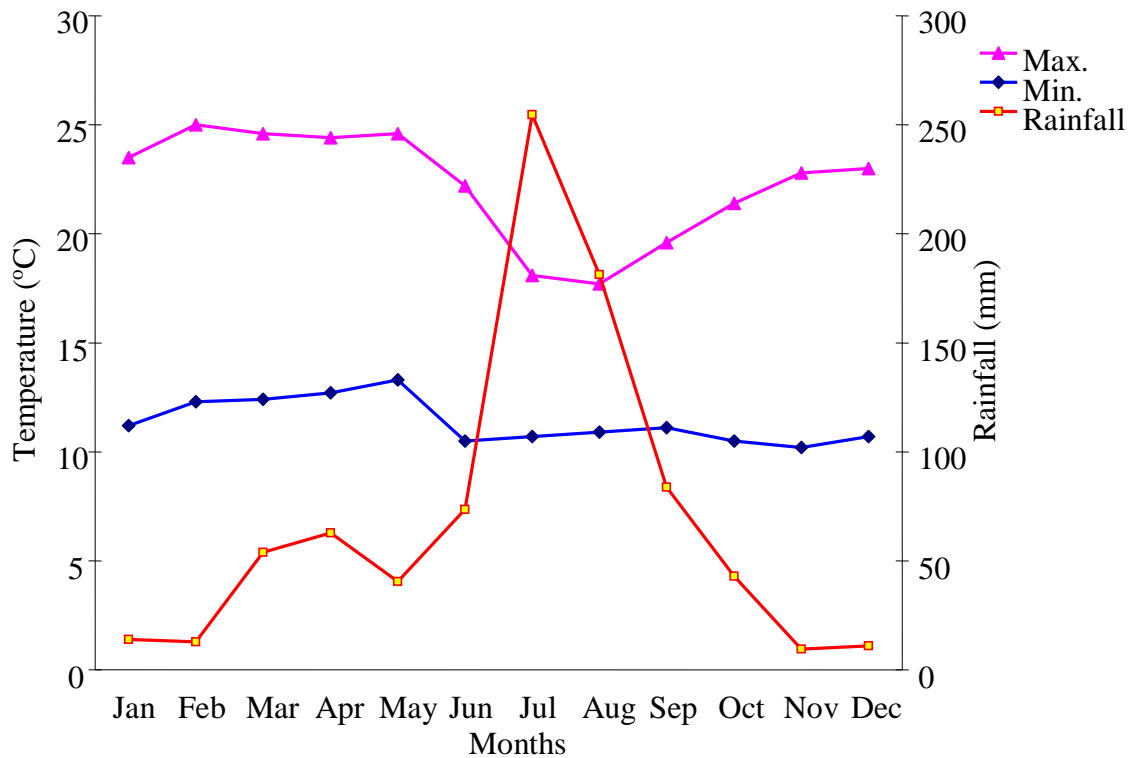


Figure 2. Rainfall and temperature recorded from 2001-2007 in Denkoro Forest (Source: Ethiopian Metrological Agency, 2001-2007).

Denkoro Forest and its surrounding areas fall into different climatic zones known as Woina Dega, Dega and Wurch. The mean monthly minimum temperature ranges between 10.5°C and 12.7°C while the mean maximum temperature ranges between 17.7°C and 25°C. The minimum temperature (10.5°C) is recorded during the months of June and February.

The study area is surrounded by agricultural land. The settlers of the region are the Amhara people. The farmers use traditional agricultural practices. Some of the farmers live in the centre and near the forested area particularly in the southern end of the thick forest. These

people regularly make threats to the forest and wild animals living there. The main agricultural production is cereal crops such as barley (*Hordeum vellgare*), wheat (*Triticum sativum*) and legumes such as lentils (*Lenis culineris*). In addition to this farmers keep livestock and the forest is the source of honey for many farmers. Population increment has resulted in the encroachment of the forest to collect firewood, construction materials and grass (*Fistuca* sp.) for sell.

The habitats of the study area can be grouped into four main parts: thick Forest, *Erica* woodland, Grassland and Farmland area (Plates 1-3).



Plate 1. View of the forest habitat during wet season (Photo: Tebebe Teklemariam, August, 2007).



Plate 2. View of the *Erica* woodland during the wet season (Photo: Tebebe Teklemariam, August, 2007).



Plate 3. View of the grassland during the wet season (Photo: Tebebe Teklemariam, August, 2007).

The Forest lies both in the valleys and mid-altitude area. The dry evergreen montane forest is characterized by different kinds of huge trees of various sizes. The common tree species include *Juniperus procera*, *Hagenia abyssinica*, *Olea europea*, *Dombeya torrida*, *Ekbergia capensis*, *Prunus africana* and *Podocarpus falcatus*. At higher altitude, Afro alpine and scrub vegetation and moorland cover most of the area. The typical shrub species include *Erica arborea* and *Hypericum revolutum* with giant lobelia (*Lobelia rhynchopetalum*). The dominant grass species covering most of the area is *Festuca* sp. The area of land surrounding the forest, *Erica* woodland and the grassland is used for agriculture. At present the forest area is guarded by 48 scouts recruited from the local people.

5. MATERIALS AND METHODS

5.1 Materials

Materials used during the study period include Nikon Binoculars (12x4055° NF), digital camera, field guides, geographic positioning system (GPS 72), data sheets, notebooks and a topographic map.

5.2 Methods

5.2.1 Preliminary survey

Preliminary survey was carried out during the last two weeks of August 2007. In this survey, the study sites and habitats were identified. Some time was spent to become familiar with songs and calls of birds in the area (Ralph, 1985). The habitats identified during the survey were classified into four: Forest habitat, *Erica* woodland, *Festuca abyssinica* grassland and Farmland. Random blocks were selected for the Forest and *Erica* woodland habitats and transect for the Grassland and Farmland habitats (Krebs, 1999). The habitats were classified based on the vegetation types. Point count method was used to count birds in the Forest and *Erica* woodland habitats (Pomeroy, 1992; Bibby *et al.*, 1992; Moffat and Minot, 1994). The diversity of birds was indicated by the Shannon Wiener Index (1949).

Shannon Wiener Index (H') is calculated by the formula: $H' = -\sum P_i \ln P_i$ Where,

P_i = Proportion of total number of individual in i^{th} species.

\ln = Natural logarithm

H' = Shannon-Wiener Index (index of species diversity)

Evenness of bird distribution in the habitats was calculated using the formula:

$E = H'/H_{\max}$ Where,

E = Shannon-Wiener evenness index

$H_{\max} = \ln S$ = Natural logarithm of the total number of species in each site.

S = number of species in each site

Species richness of each habitat was calculated using the formula:

$RI = S-1/\ln I$ Where,

S = number of species in each habitat

I = total number of individuals or species in each habitat.

Simpson's Similarity Index was used to investigate the similarity between different habitats in relation to the composition of species.

Simpson's Index (SI) = $2C/A+B$ Where,

A = the number species in habitat A

B = the number of species in habitat B

C = the number of common species for both habitat.

After the preliminary survey data collection was conducted for both wet and dry seasons. The data for wet season was collected during the months of September and October 2007. The first data collection for the dry season was conducted from December 2007 to January 2008 and the second session from February to March 2008.

Based on the vegetation types, 6 blocks were randomly identified for the Forest habitat and 4 blocks for *Erica* woodland. Line transect sampling method was designed for open Grassland and Farmland habitats. Each block had an area of 1x1 km and a total of 10 km² area was covered in the Forest and woodland habitats. The blocks were separated from each other by 250-300 m. Within each block, random point counting sites were selected. Based on the density of vegetation, each point had an interval of 150-200 m to avoid under or overestimation during the counting process. The observer and his assistant stand at a

particular point for a fixed time (10 minutes) and all birds that can be seen or heard are recorded within a fixed radius or arbitrary range of 25 m (Pomeroy, 1992; Sutherland 1996; Bibby *et al.*, 1998).

Line transects were used for a large and relatively uniform areas of Grassland and Farmland habitats (Biddy *et al.*, 1992). A total of 6 transects was designed each with 1 km distance. Transects were widely spaced and are separated from each other by 500 m. Counting of birds was carried out within a band length of 25 m at both sides by walking along the transect line.

5.2.2 Sample design

Counting points (stations) were randomly selected. In each point, a maximum of 10 minutes elapsed to count all birds seen or heard (Sutherland, 1996). GPS was used to locate the points in each block. During the first 3 minutes, the observer and his assistant stand quietly at the counting site just to allow birds to settle. The latter 7 minutes were used to record all birds that were seen or heard (Bibby *et al.*, 1992). After observation and recording in the data sheet, the observer and his assistant move to the next point to do similar activities. The amount of time required to move between points is dependant upon topography, access, and the geographic lay out of points. The physical character of the terrain will influence the design of optimal sampling regimes (Biskirk and McDonald, 1995). Species seen within 25 m radius around the observer are used for the data analysis while those which are seen and recorded out of the 25 m radius are used to indicate species richness of the study area.

5.2.3. Data Collection

Before collecting the data, the main habitat types were identified and recorded. Representative pictures of the habitats were taken. Several blocks were designed that can possibly represent the whole study area. The counting of birds was carried out using naked eyes and binoculars. For bird identification, field guide books (Mackworth-Praed and Grant, 1955; Williams, 1963; ICBP, 1990; Harrison and Smith, 1993; Bond, 1993; Perlo, 1995; Stevenson and Fanshawe, 2002; Sinclair and Ryan, 2003) were used.

Plants were identified based on information obtained from the local people and herbarium scientific name of the plants were taken from study of Abate Ayalew *et al.* (2006). The survey was carried out by walking on foot through all the habitat types and random blocks formed on the vegetation types and transects in the field. The location of the sites was marked by wrapping coloured tape round certain trees (Sutherland, 1996). Counting of bird species within the designed blocks and counting stations were conducted in the morning from 6:30 -10:20 a.m. and afternoon 3:00-6:30 p.m. (Bibby *et al.*, 1998; Centerbury, *et al.*, 2000). The points were visited from the opposite end when counting is repeated (Wang and Finch, 2002; Crozier and Gawlik, 2002). Data collection was carried out in all four habitats during wet and dry seasons (Pomeroy, 1992).

5.2.4 Data analysis

The diversity of species of birds in the habitat is expressed by means of Shannon and Wiener Index (H'). The similarity of different habitats is compared using Simpson's similarity Index (SI). Species richness was calculated using the richness index formula: $(RI) = S-1/\ln I$. The data collected during the bird survey was analyzed using SPSS software. To test the hypothesis of the given data, ANOVA (LSD when there are similar means), t-test and Chi-square tests were applied. The relative abundance of birds was also determined using encounter rates (Encounter rate = Total number of individuals recorded divided by the total time elapsed to count birds times 100).

6. RESULTS

A total of 154 species of birds belonging to 15 orders and 40 families was identified during the wet and dry season count (Table 1). Among these, six species are endemic to Ethiopia. These include: Abyssinian catbird (*Parophasma galinieri*), Abyssinian black-headed siskin (*Serinus nigriceps*), Abyssinian long claw (*Marcronyx flavicollis*), Abyssinian woodpecker (*Dendropicos abyssinicus*), and Harwood's francolin (*Francolinus harwoodi*), White-collared pigeon (*Columba albitorgues*). Additional eight species of birds are restricted to Ethiopia and Eritrea. These include Black-headed forest oriole (*Oriolus monancha*), Black-winged lovebird (*Agapornis taranta*), Thick-billed Raven (*Corvus crassirostris*), Wattled Ibis (*Bostrychia carunculata*), White-backed Black Tit (*Parus leuconotus*), White-billed Starling (*Onychognathus albirostris*), White collared Pigeon (*Columba albitrogues*) and White-winged Cliffchat (*Thamnolaea semirufa*).

During the wet season a cumulative number of 94 species were recorded while 115 species of birds were registered during the dry season. The highest number of species is recorded for the family Muscicapidae and lowest for Threskiornithidae, Scopidae, Scolopacidae, Pasittacidae, Meropidae, Upupidae, Platsteiridae, Monarchidae, Oriolidae and Malaconotidae. From all species of birds registered, 16 species were Palearctic migrants, 12 Intra-African migrants and one species was Local migrant.

Table 1. Birds recorded during wet and dry seasons (* Birds observed during the wet season, † Local Migrants, + Birds observed during the dry season, ‡ Endemics, ★ Paelearctic Migrants, ● Near threatened, ▲ Intra-African Migrants, ◆ Rare).

Family	Common name	Scientific name
Accipitridae	European Honey- buzzard +★	<i>Pernis apivours</i>
	Yellow Billed Kite ▲	<i>Milvus aegypticus</i>
	Black kite *▲	<i>Milvus migrans</i>
	Hooded Vulture *	<i>Necrosyrtes monachus</i>
	Lammergeier	<i>Gypaetus barbatus</i>
	Rupell's Vulture *	<i>Gyps rueppellii</i>
	Pallid Harrier + ▲ ●	<i>Circus macrourus</i>
	African Harrier-Hawk	<i>Ployboroides typus</i>
	Tawny Eagle †	<i>Aquila rapax</i>
	Crowned Hawk-eagle *	<i>Stephanoaetus coronatus</i>
	Augur Buzzard	<i>Buteo augur</i>
	Red-Necked Buzzard	<i>Buteo auguralis</i>
	Verreaux's Eagle * ▲	<i>Aquila berreauxii</i>
	Wahlberg's Eagle *▲	<i>Aquila wahlbergi</i>
Grass hopper Buzzard ▲	<i>Butastur rufipennis</i>	
Mountain Buzzard	<i>Buteo oreophilus</i>	
Alaudidae	Thekala Lark	<i>Galerida theklae</i>
	Erlanger's Lark	<i>Clandrella erlangeri</i>
Anatidae	Egyptian Goose +	<i>Alopochen aegyptiaca</i>
	Ruddy shelduck *	<i>Tadorna ferruginea</i>
Apodidae	Nyanza Swift *▲	<i>Apus niansae</i>
	Pallid Swift ★	<i>Apus pallidus</i>
	Alpine Swift ▲	<i>Tachymarpis melba</i>
Bucerotidae	Abyssinian ground-Hornbill	<i>Bucorvus abyssinicus</i>
	Hemprich's Hornbill	<i>Tockus hemprichii</i>
	Eastern yellow –billed Horn bill	<i>Tockus flavirostris</i>
Cisticolidae	Ethiopian Cisticola	<i>Cisticola lugubris</i>
	Stout Cesticola *	<i>Cisticola robustus</i>
	Foxy Cisticola *	<i>Cisticola troglodytes</i>
	Tiny Cisticola +	<i>Cisticola nana</i>
	Pectoral- patch Cisticola	<i>Cisticola brunnescens</i>
	Tawny-flarked Prinia +★	<i>Prinia subflava</i>
Columbidae	White collared Pigeon *	<i>Columba albitorgues</i>
	Speckled Pigeon	<i>Collumba guinea</i>

...Cont'd

	Olive Pigeon *	<i>Columba arquatrix</i>
	Dusky Turtle-Dove *	<i>Streptopelia lugens</i>
	Lemon Dove *	<i>Columba larvata</i>
	Red-eyed Dove *	<i>Streptopelia semitorquata</i>
	Ring-necked Dove	<i>Streptopelia capicola</i>
Corvidae	Cape Crow	<i>Corvus capensis</i>
	Pied Crow	<i>Corvus albus</i>
	Fan-tailed Raven	<i>Corvus rhipidurus</i>
	Thick-billed Raven	<i>Corvus crassirostris</i>
Cuculidae	Klaas' Cuckoo + ▲	<i>Chrysococcyx klaas</i>
	African Emerald Cuckoo * ▲	<i>Chrysococcyx cupreus</i>
	Blue-headed coucal +	<i>Centropus monachus</i>
Estrildidae	Abyssinian Crimson- wing *	<i>Cryptospiza salvadorii</i>
	Red-checked Cordonblue +	<i>Uraeginthus bengalus</i>
	African (blue-billed) Fire finch	<i>Lagonostda rubricata</i>
	Jameson's Fire finch+	<i>Lagonostica rhodopareia</i>
Falconidae	Common Kestrel ▲	<i>Falco tinnunculus</i>
	Lanner Falcon	<i>Falco biarmicus</i>
Fringillidae	Black-headed Siskin ▶	<i>Serinus nigriceps</i>
	African citril +	<i>Serinus citrinelloides</i>
	Yellow rumped Seed- eater +	<i>Serinus xanthopygius</i>
	Starky Seedeater +	<i>Serinus striolatus</i>
	Brown-rumped Seedeater +	<i>Serinus tristriatus</i>
Indicatoridae	Cassin's Honey Guide	<i>Proditiscus insignis</i>
	Lesser Honey Guide	<i>Indicator minor</i>
Laniidae	Red-backed Shrike+★	<i>Lanius collurio</i>
	Rufous -tailed Shrike +★	<i>Lanius isabellinus</i>
	Common Fiscal+	<i>Lanius collaris</i>
	Masked Shrike +★	<i>Lanius nubicus</i>
	Southern Gray shrike+	<i>Lanius meridionalis</i>
Malaconotidae	Tropical Boubou	<i>Laniarius aethiopicus</i>
Meropidae	Blue-breasted Bee-eater +	<i>Merops Variegatus</i>
Monarchidae	African Paradise Flycatcher+	<i>Terpsiphone viridis</i>
Motacillidae	African Pipit +	<i>Anthus cinnamomeus</i>

...Cont'd

	Long-billed Pipit +	<i>Anthis similes</i>
	Tawny Pipit	<i>Anthus campestris</i>
	Plain-backed Pipit +	<i>Anthus Leucophrys</i>
	Red throated Pipit +	<i>Anthus cervinus</i>
	Tree Pipit +	<i>Anthus trivialis</i>
	Abyssinian Long Claw + ▶ ●	<i>Macronyx flavicollis</i>
	White Wagtail +★	<i>Motacilla alba</i>
	Yellow Wagtail +★	<i>Motacilla flava</i>
	Mountain Wagtail	<i>Motacilla clara</i>
Muscicapidae	Pale flycatcher	<i>Bradornis pallidus</i>
	African Gray Flycatcher+	<i>Bradornis microrhynchus</i>
	Abyssinian Salty- Flycatcher	<i>Melaenornis chocolatinus</i>
	Spotted Flycatcher *★	<i>Muscicapa striata</i>
	Rupell's Robin-Chat	<i>Cossypha semirufa</i>
	Rufous-tailed Scrub Robin +	<i>Cercotrichas galactotes</i>
	Black Scrub-Robin +	<i>Cercotrichas podope</i>
	Common Redstart *★	<i>Phoenicurus phoenicurus</i>
	Whinchat	<i>Saxicola rubetra</i>
	African stone Chat *★	<i>Saxicola torquatus</i>
	Rupell's black Chat +	<i>Myrmecocichla melaena</i>
	Pied Wheatear +★	<i>Oenples chanka</i>
	Cyprus Wheat ear +	<i>Oenanthe cypriaca</i>
	Isabelline Wheatear +★	<i>Oenanthe isabellina</i>
	Familiar Chat +	<i>Cercomela familiaris</i>
	Moorland Alpine Chat	<i>Cercomela sordida</i>
	White-winged Cliff- Chat +	<i>Thamnolaea semirufa</i>
Musophagidae	White- chicked Turaco	<i>Turaco leucotis</i>
	Eastern Grey Plantain-eater +	<i>Crinifer zonurus</i>
Nectariniidae	Scarlet chested Sunbird*	<i>Chalcomitra senegalensis</i>
	Tacazze Sunbird	<i>Nectarinia tacazze</i>
	Malachite Sunbird	<i>Nectarinia famosa</i>
	Beautiful Sunbird *	<i>Cinnyris pulchellus</i>
	Shining Sunbird *	<i>Cinnyris habessinicus</i>
	Nile valley Sunbird *	<i>Hedydipna metallica</i>
Oriolidae	Black-headed Oriole	<i>Oriolus monacha</i>
Paridae	White winged Black-Tit*	<i>Melaniparus leucomelas</i>
	White backed Black-Tit	<i>Melaniporus leuconotus</i>

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Passeridae	Swainson's Sparrow Yellow-spotted Petronia	<i>Passer swainsonii</i> <i>Petronia pyrgita</i>
Pasittacidae	Black-winged Love Bird	<i>Agaporuis taranta</i>
Phasianidae	Crested Francolin Scaly Francolin Harwood's Francolin • ▶ Chestnut-naped Francolin * Mooreland Francolin * Erckel's Francolin + Common Quail * Butten Quail *	<i>Francolinus sephaena</i> <i>Francolinus squamatus</i> <i>Francolinus harwoodi</i> <i>Francolinus castaneicollis</i> <i>Francolinus psiloaemus</i> <i>Francolinus erckelii</i> <i>Coturnix coturnix</i> <i>Turnix sylvatica</i>
Picidae	Abyssinian Wood Pecker ▶ Gray-headed Wood Pecker + Brown-backed Wood Pecker +	<i>Dendropicos abyssinicus</i> <i>Dendropicos spodocephalus</i> <i>Dendropicos obsoletus</i>
Platysteiridae	Brown-throated Wattle –eye +	<i>Platysteira cyanea</i>
Ploceidae	White-browed Sparrow Weaver+ Red-headed Weaver Baglafaecht Weaver * Village Weaver + Red-billed Quelea+ Yellow Bishop *	<i>Plocepasser mahali</i> <i>Anapllctes rubriceps</i> <i>Ploceus baglafaecht</i> <i>Ploceus cucullatus</i> <i>Quelea quelea</i> <i>Euplectes capensis</i>
Pycnonotidae	Common Bulbul + Northern Brownbul +	<i>Pycnonotus borbatus</i> <i>Phylastrephus strepitans</i>
Scolopacidae	Temminck's Stint +★◆	<i>Calidris temminckii</i>
Scopidae	Hamerkop +	<i>Scops umbretta</i>
Strigidae	African Scops-Owl +▲	<i>Otus senegalensis</i>
Sturnidae	Rupoell's Glossy String White billed Starling * Red wing Starling Greater Blue –eared Glossy Starling * Red-billed Oxpecker +	<i>Lamprotornis purpuroptera</i> <i>Onychognathus albirostris</i> <i>Onchognathus morio</i> <i>Lamprotornis chalbaeus</i> <i>Buphagus erythrorhynchus</i>
Sylviidae	Cinnamon Bracken- Warbler + Wood Warbler *★◆ Common Chiffchaff+	<i>Bradypterus cinnamomeus</i> <i>Phylloscopes sibilatrix</i> <i>Phylloscopus collybita</i>

...Cont'd		
	Willow Warbler +★	<i>Phylloscopus trochilus</i>
Threskiornithidae	Wattled Ibis	<i>Bostrychia carunculata</i>
Timaliidae	African Hill Babbler + Rufous Chatterer + White-rumped Babbler Abyssinian Catbird+ ▶	<i>Pseudoalcippe abyssinia</i> <i>Turdoides rubiginosa</i> <i>Turdoides leucopygia</i> <i>Parophasma galinieri</i>
Turdidae	Little Rock-Thrush + Abyssinian Ground Thrush Ground Scraper Thrush Olive thrush Song Thrush +	<i>Monticola rufocinereus</i> <i>Zoothera Piaggiae</i> <i>Psophocichla litripsirupa</i> <i>Turdus olivaceus</i> <i>Twidus philomelos</i>
Upupidae	Eurasian Hoopoe +	<i>Upupa epop</i>
Zosteropidae	Broad-ringed White eye * White breasted White eye *	<i>Zosterops poliogastrus</i> <i>Zosterops abyssinicus</i>

6.1. Diversity

During the wet season, the highest diversity of bird species was recorded in the *Erica* woodland habitat followed by the Forest and the lowest diversity of species was found in the Farmland (Table 2).

Table 2. Diversity of bird species during the wet season.

Sites	Species					
	richness	Abundance	H'	H _{max}	H'/H _{max}	D'=1-Σpi ²
Forest	22	273	2.752	3.091	0.890	0.914
<i>Erica</i> woodland	28	272	2.997	3.332	0.899	0.933
Grassland	16	120	2.648	2.773	0.954	0.917
Farm land	15	104	2.617	2.708	0.966	0.921

During the dry season, the highest species diversity was obtained in the Forest habitat followed by *Erica* woodland and the lowest species diversity was found in the Grassland

habitat (Table 3, Fig. 4). Farmland had the highest even distribution of species during the wet season while *Erica* woodland had the highest even distribution during the dry season. Forest habitat had the highest species diversity and Grassland habitat had the highest even distribution for both seasons (Table 4).

Table 3. Diversity of bird species during the dry season

Sites	Species					
	richness	Abundance	H'	H _{max}	H'/H _{max}	D'=1-Σpi ²
Forest	47	707	3.424	3.850	0.889	0.957
<i>Erica</i> woodland	43	429	3.105	3.296	0.942	0.941
Grassland	25	174	2.935	3.219	0.911	0.931
Farm land	37	281	3.361	3.611	0.930	0.956

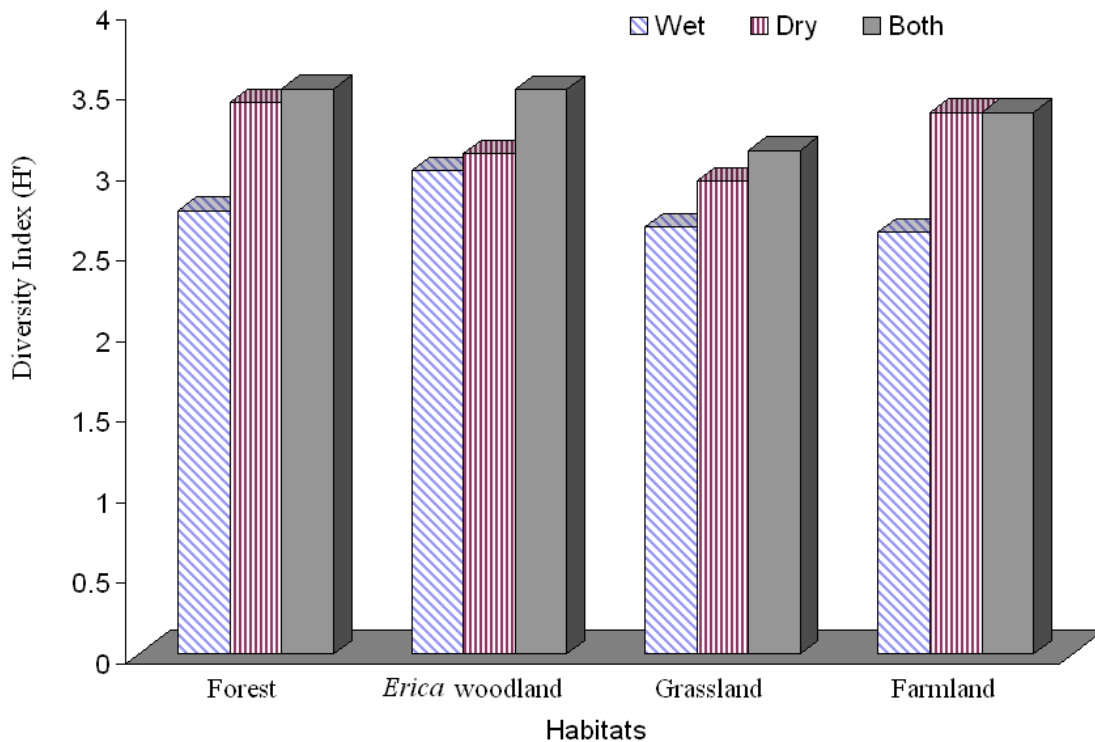


Figure 3. Diversity index of birds during, wet, dry and both seasons for all habitats

Table 4. Diversity of bird species of the combined seasons.

Sites	Species					
	richness	Abundance	H'	Hmax	H'/Hmax	D'=1- $\sum p_i^2$
Forest	55	980	3.507	4.007	0.875	0.958
Erica woodland	57	701	3.503	4.043	0.866	0.953
Grass Land	33	294	3.126	3.497	0.893	0.938
Farm land	40	385	3.361	3.689	0.911	0.955

6.2. Species richness

During the wet season, species richness of birds was between 15 and 28 and during dry season it ranged from 25 to 47 in the four habitats (Fig.4). In the Forest habitat during the wet season, the highest number of individuals recorded was for Black headed Oriole (RI = 5.48) and the lowest number of individuals was recorded for Moorland Alpine Chat

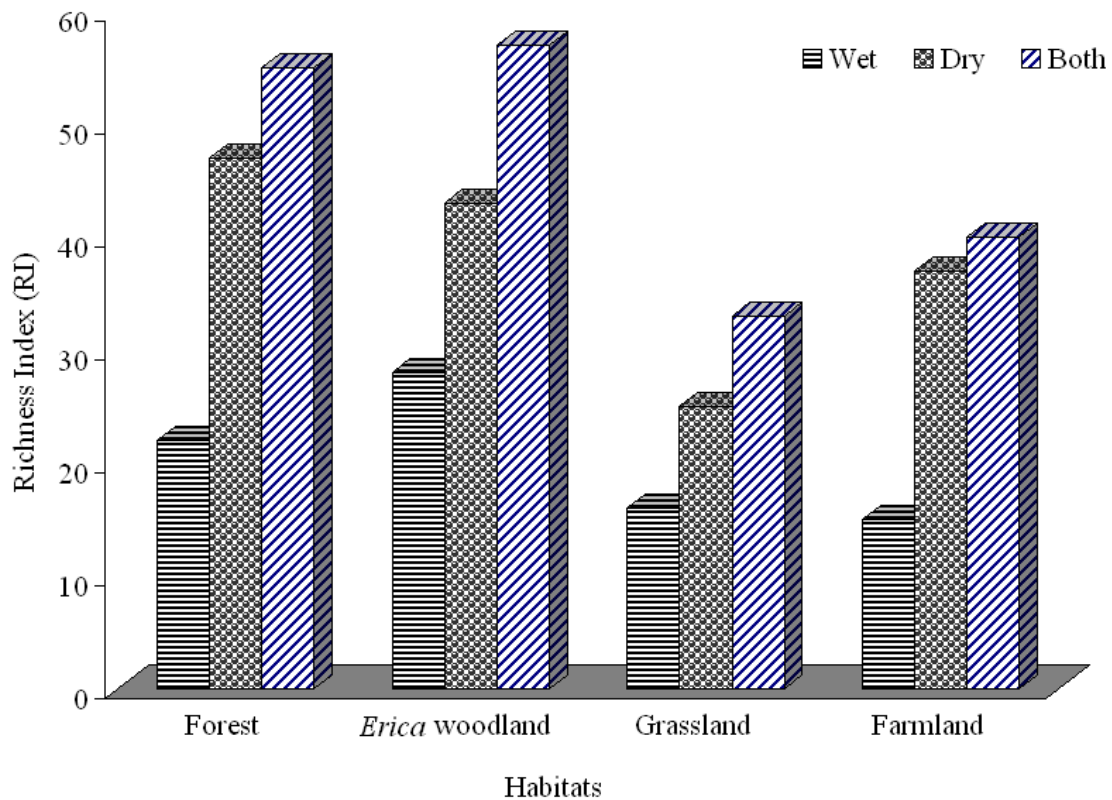


Figure 4. Species richness of birds in the four habitats

and Common Quail (RI = 30-29). During the dry season, African Paradise Flycatcher has the highest number of individuals (RI = 11.47), while Egyptian Goose, Hamerkop, Abyssinian ground Hornbill and Wood Warbler had the lowest number of individuals (RI = 66.36).

In the *Erica* woodland, during the wet season White rumped Babbler had the highest number of individuals (RI = 7.47) and the lowest number of was recorded for Mountain Buzzard and Common Redstart (RI = 38.95). During the dry season, Lesser honey guide had the highest number of individuals (RI = 11.03) and European honey Buzzard had the least.

In the Grassland habitat, during the wet season, Moorland Alpine Chat had the highest number of individuals (RI = 5.00) and Greater blue-eared Glossy Starling and Stout Cisticola had the lowest number of individuals (RI = 10.82). Palid Swift and Moorland Alpine Chat had the highest number (RI = 7.76), While Olive Thrush and Common Quail had the lowest number (RI = 34.62) during the dry season. During the wet season in the Farmland habitat, the highest number of individuals was registered for Moorland Alpine Chat (RI = 5.63), while the lowest number was registered for Olive Thrush (RI = 20.19). During the dry season, maximum number of individuals was recorded for Fun tailed Raven (RI = 11.18) and the lowest for Red billed Quelea (RI = 51.93).

6.3. Species similarity

During the wet season, more bird species similarity was observed between Forest and *Erica* woodland and between Forest and Grassland habitats (SI = 0.36). Least similarity was observed between Forest and Farmland habitats (SI = 0.10). During the dry season highest similarity was observed between Forest and *Erica* (SI = 0.32) and the least similarity was between *Erica* and Farmland (SI = 0.10) (Tables 5- 7, Fig. 5). The highest bird species similarity was observed between Forest and *Erica* during both seasons (RI = 0.45) and least similarity was seen between *Erica* and Farmland habitats (SI = 0.10).

Table 5. Similarity of species between habitats during the wet season.

Habitats	Forest	<i>Erica</i> woodland	Grassland	Farmland
Forest	—	9(0.36)	7(0.36)	2(0.10)
<i>Erica</i> woodland		—	7(0.31)	5(0.23)
Grassland			—	3(0.19)
Farmland				—

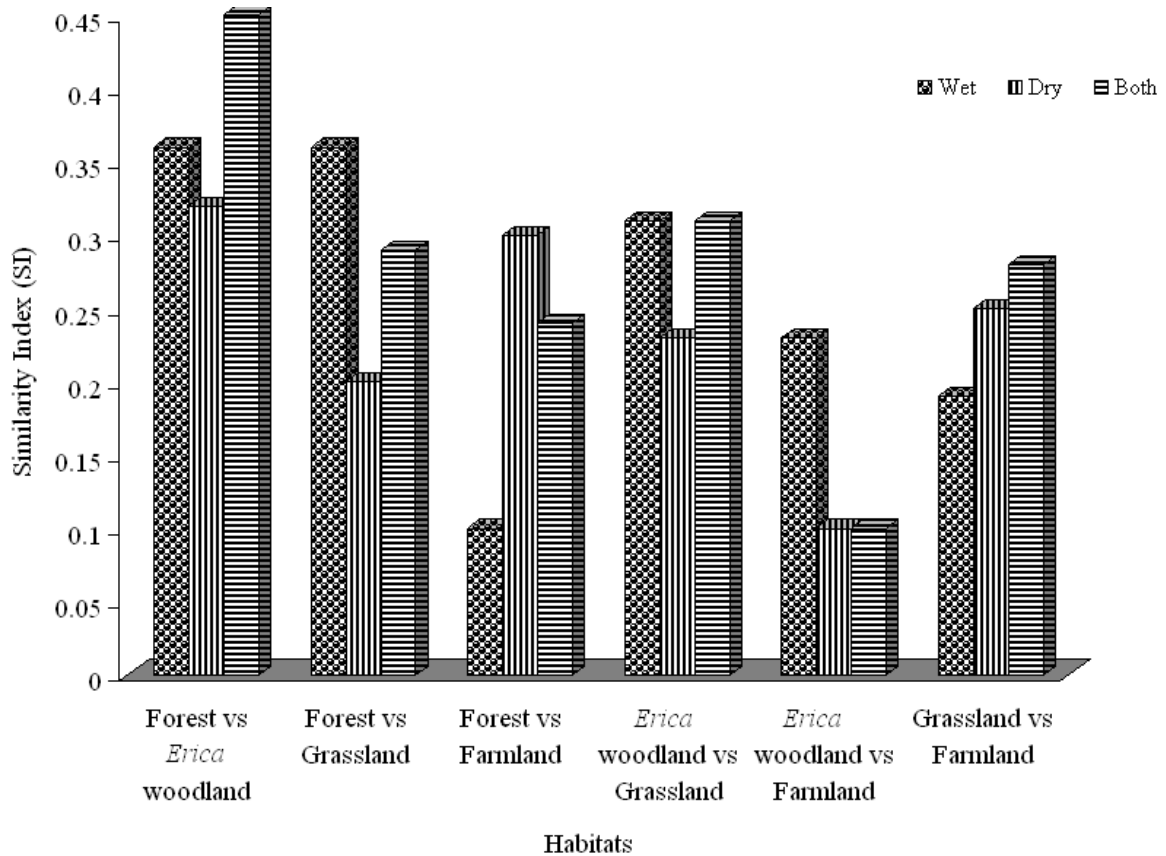


Figure 5. Bird species similarity index between the four habitats

Table 6. Similarity of species between habitats during the dry season.

Habitats	Forest	<i>Erica</i> woodland	Grassland	Farmland
Forest	—	15(0.32)	9(0.20)	13(0.30)
<i>Erica</i> woodland		—	8(0.23)	4(0.10)
Grassland			—	8(0.25)
Farmland				—

Table 7. Similarity of species between habitats during both seasons

Habitats	Forest	<i>Erica</i> woodland	Grassland	Farmland
Forest	—	25(0.45)	13(0.29)	12(0.24)
<i>Erica</i> woodland		—	14(0.31)	10(0.10)
Grassland			—	11(0.25)
Farmland				—

The percentage comparison of species similarity during the wet and dry seasons within the same habitat showed the presence of high species similarity in the Grassland habitat followed by the Forest. The least similarity was seen in the *Erica* woodland habitat (Table 8).

Table 8. Seasonal species similarity with in the same habitat

Habitats	Species		Common species	Similarity between seasons (%)
	Wet season	Dry season		
Forest	22	47	16	46.30
<i>Erica</i> woodland	28	43	13	42.25
Grassland	16	25	20	48.78
Farmland	15	37	15	57.69

6.4. Distribution

The total number of species recorded in the study area during the wet and dry seasons was 154. The distribution of birds is dependent upon food preference. Some species were restricted to a single habitat while others occupy two or more habitats. The highest number of species was recorded for the *Erica* woodland habitat during the wet season while the Forest

habitat had the highest species number during the dry season. The lowest species number was registered for the Farmland and Grassland habitats during the wet and dry seasons, respectively (Table 9)

Table 9. Distribution of different bird families in the four habitats

(✓ = present, × = absent).

Family	Habitat types			
	Forest	<i>Erica</i> woodland	Grassland	Farmland
Accipitridae	✓	✓	✓	×
Alaudidae	×	×	✓	✓
Anatidae	✓	×	×	×
Apopidae	×	×	✓	✓
Bucerotidae	✓	×	✓	✓
Cisticolidae	×	✓	✓	×
Columbidae	✓	✓	✓	✓
Corvidae	×	✓	✓	✓
Cuculidae	✓	×	×	×
Estrildidae	✓	×	×	×
Falconidae	×	✓	✓	×
Fringillidae	×	✓	✓	✓
Indicatoridae	✓	✓	×	×
Lanidae	✓	✓	✓	×
Malaconotidae	✓	✓	×	×
Meropidae	×	✓	×	×
Muscicapidae	✓	✓	×	×
Musophagidae	✓	×	×	×
Mutacillidae	×	✓	✓	×
Mutacillidae	×	✓	✓	×
Nectarinidae	✓	✓	×	×
Oriolidae	✓	×	×	×
Paridae	✓	✓	×	×
Pasitacidae	×	✓	×	×
Passiridae	✓	×	×	✓
Phasianidae	×	✓	×	✓
Picidae	✓	✓	×	✓
Platyrhidae	✓	×	×	×
Ploceidae	×	×	✓	✓
Pyconotidae	✓	×	×	×
Scolopacidae	×	×	×	✓
Scopidae	✓	×	×	×
Strigidae	×	✓	×	×
Sturidae	✓	✓	✓	✓
Sylviidae	✓	×	×	×

	...Cont'd			
Threskiornithidae	×	✓	×	✓
Timaliidae	✓	✓	×	×
Turdidae	✓	✓	✓	✓
Upupidae	✓	×	×	×
Zosteropidae	✓	✓	✓	×

6.5. Abundance

During the wet season, there were 22, 28, 16 and 15 species recorded with 273, 272, 120 and 104 individuals in the Forest, *Erica* woodland, Grassland and Farmland habitats respectively. The mean number of individuals observed showed no significant difference between all habitats at 0.05 significance level ($df = 3$, $F = 2.04$, $p > 0.05$) (Table 10).

Table 10. Mean birds abundance with standard error of the mean (SEM)

Season	Habitat	N	M \pm SEM	
wet	Forest	6	45.5 \pm 8.25	
	<i>Erica</i> woodland	4	68 \pm 13.50	
	Grassland	3	40 \pm 7.77	
	Farmland	3	34.67 \pm 2.60	
Dry	Forest	6	117.83 \pm 7.33	a*
	<i>Erica</i> woodland	4	107.25 \pm 8.52	a b
	Grassland	3	58 \pm 6.40	c
	Farmland	3	93.67 \pm 3.38	b

*The same letters indicate absence of significance between habitats.

During dry season, the numbers of species recorded were 47, 43, 25, and 38 with 707, 429, 174 and 281 individuals for the Forest, *Erica*, Grassland and Farmland habitats respectively. The mean number of individuals observed was statistically significant between habitats ($df = 3$, $F = 10.14$, $p < 0.001$). This indicates that the difference in habitat had significant effect on the abundance of birds during the dry season compared to the wet season. The significance was observed between Forest and Grassland, *Erica* and Grassland and Farmland and Grassland.

The study indicated that season has significant effect on bird abundance and distribution within a given habitat. Birds counted during the dry season were more than birds counted during the wet season except at the Grassland habitat which showed no significance difference between wet and dry seasons. In the Forest habitat the abundance of birds between two seasons was significant ($t = 6.554$, $p < 0.001$). In the *Erica* woodland habitat, the abundance of birds between seasons was significant ($t = 2.459$, $p < 0.05$). In the Farmland habitat, the abundance of birds between two seasons was significant ($t = 13.821$, $p < 0.001$). Univariate analysis for the interaction between habitat and season showed significant difference ($df = 3$, $F = 3.548$, $p < 0.05$).

Analysis of the mean difference in species number (species richness) during the wet ($df = 3$, $F = 3.242$, $p < 0.05$) and the dry ($df = 3$, $F = 20.249$, $p < 0.001$) seasons showed significant difference between habitats. The difference was between Forest and Grassland, Forest and Farmland, *Erica* and Grassland, *Erica* and Farmland (Figs. 6 and 7).

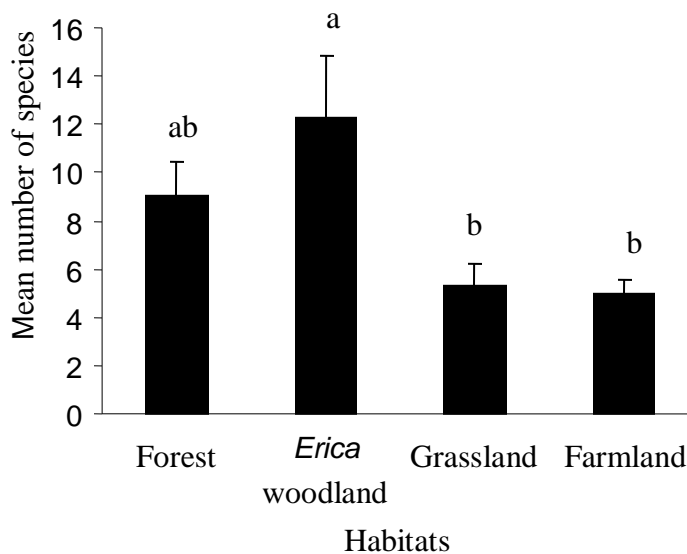


Figure 6. Mean comparison of species number with least significance difference (LSD) during the wet season (same letters show absence of mean difference).

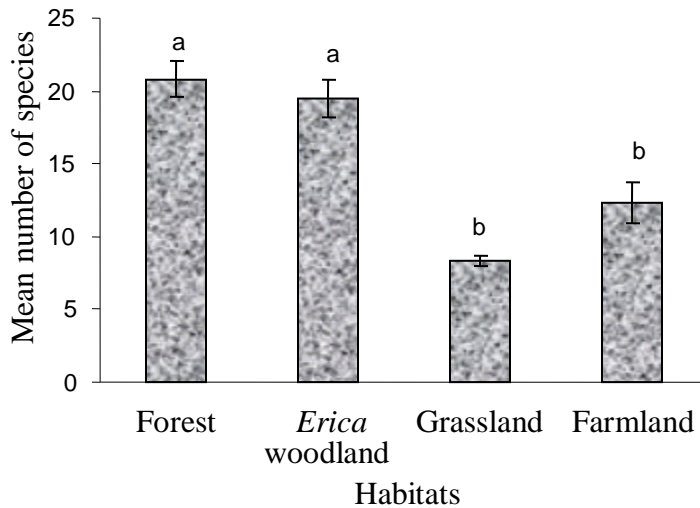


Figure 7. Mean comparison of species number with least significance difference (LSD) during the dry season

The relative abundance of birds during the wet and dry seasons was determined using encounter rate data and the birds are listed as rare, uncommon, frequent and common (Appendix 1-8).

6.6. Habitat association

The analysis of habitat association has revealed that the distribution of birds is associated to vegetation types. At the Forest habitat, during the wet season, the analysis showed a high significant difference in habitat association ($\chi^2 = 230.284$, $p < 0.001$). This indicates that there was strong interaction between birds and vegetation types. Similarly, during the dry season, there was a high significant difference in habitat association in the Forest habitat ($\chi^2 = 707.598$, $p < 0.001$), showing positive interaction between birds and vegetation. In *Erica* woodland during the wet season, there was a high significant difference in habitat association ($\chi^2 = 417.787$, $p < 0.001$). In the Grassland habitat, the habitat association of birds was statistically significant during the wet and dry seasons ($\chi^2 = 37.867$, $p < 0.001$, $\chi^2 = 123.989$, $p < 0.001$) respectively. In the Farmland habitat during the wet season the habitat association of birds was not statistically significant ($\chi^2 = 18.308$, $p = 0.193$), which shows

the absence of strong link between birds and vegetation types. However, during the dry season the habitat association was statistically significant ($\chi^2 = 169$, $p < 0.001$).

7. DISCUSSION

The number of species in an area is the simplest measure of diversity and it is called species richness (Pomeroy, 1992; WCMC, 1994; Krebs, 1999). Seasonal irregularity and structurally diverse vegetation type influence species richness and stability (Karr, 1976; Estades, 1997). Patterns in species diversity are influenced by spatial and temporal scale at which both organisms and factors that determine the species richness of this group operate (Diamond, 1988; Bohning-Gaese, 1997). The diversity of birds in an area reflects the availability of critical resources (Mills *et al.*, 1991). The Floristic composition of the four habitats is different. Due to this there was a marked difference in the diversity of birds. During the wet season, the highest species diversity was recorded in the *Erica* woodland habitat followed by the Forest (Plates 1 and 2) and the lowest diversity was observed in Farmland habitat followed by the Grassland (Plate 3)

The difference in species diversity in the Forest and *Erica* woodland habitats was very small. This might be due to the presence of suitable resources or complexity of vegetation in both habitats. For terrestrial communities the number of bird species as well as their diversity is strongly positively correlated with aspects of the structural complicity of vegetation (MacArthur, 1964; Wilson, 1974; Moss, 1978; Erdelen, 1984; Lee and Rotenberry, 2005; Thinh, 2006). In the Grassland and Farmland habitats, there was similar number of species during the wet season, but there was significant increase in species diversity in the Farmland habitat during dry season. This might be due to increase in food availability in the Farmland habitat during the dry season compared to the wet season (Ormerod and Watkinson, 2000; Stephens *et al.*, 2003). The increase and decrease of species diversity at different habitats and seasons might be due to migration of birds from one habitat to the other in search of food (Macarthur, 1964; Karr, 1976 and Adeyemo and Ayodele, 2005).

During the dry season, the diversity of bird species of all habitats has increased, but it was not significant for the Grassland habitat. This might be due to the lack of heterogeneity of vegetation composition. An ecosystem dominated by a single structure homogenizes the operational scales and determines species diversity of several species groups (Jews, *et al.*, 2004). The grassland habitat is highly dominated by one type of grass species (*Fistuca sp.*). When the diversity of bird species was compared by combining the two seasons, each habitat showed an increase in bird diversity. However, it was slightly higher in *Erica* woodland habitat than in the Forest. During the wet season and when seasons are combined higher species richness was seen in the *Erica* woodland while it was higher for the Forest during the dry season. The high species richness in the *Erica* woodland might be due to the patchiness effect of the *Erica* than the Forest that dominates the development of under growth. Patchiness (horizontal variability in the type of profiles) is the principal factor affecting bird species diversity compared to vegetation layers to support ground species (Roth, 1976).

Different researches have revealed that species richness is highest in fragmented areas. Forest edges, open habitats and early successional areas have higher fragmentation. Fragmented areas reflect higher habitat diversity that attract new species. But species richness decreases as patchiness becomes more isolated (Rivard *et al.*, 1999; Hejl *et al.*, 2002; Manu *et al.*, 2007). According to these studies, high species diversity occurs in the periphery of the Forest than in the centre because of the presence of horizontal foliage. The highest evenness value was seen in the Farmland habitat which had the smallest species richness. This agrees with the idea of Krebs (1999), which states that evenness is independent of species richness. During the dry season highest evenness value was seen for *Erica* woodland habitat. Forest and *Erica* woodland generally have high species richness due to high structural complexity (Farley *et al.*; 1994; McPherson, 2007).

The present study has investigated the presence of high species diversity during the dry season. The difference in species richness might be the influence of climatic variation such as temperature and rainfall, topography, vertical and horizontal vegetation structure (Karr, 1980; Cueto and deCasenave, 1999; Oindo *et al.*, 2001; Davies *et al.*, 2007). Even though, there was a significant increase in species richness in each habitat, Grassland and Farmland

habitats had lower richness than the Forest and *Erica* woodland habitats. This is because the vegetation structure of the Forest and *Erica* are complex vertically and horizontally which provide suitable food resources and nesting grounds for various kinds of birds. Vegetation is an important proximate factor while gradients of microclimate, especially temperature and moisture are ultimate factor through direct physiological pressures on birds or indirectly 10 through distribution and availability of food resources (Karr, 1983; Jansen, *et al.*, 2001; Van Ransburg *et al.*, 2002)).

The analysis of bird species similarity during wet season indicated the presence of high species similarity between the Forest and *Erica* woodland and between Forest and grassland habitats and the lowest similarity between Forest and Farmland habitats. The similarity between the Forest and *Erica* might be due to two reasons 1) *Erica* woodland starts at the end of the Forest habitat vertically. 2) There is similarity in vegetation composition, so that the two habitats support more or less similar species. This coincides with the idea of Karr (1980), which states that faunas under similar ecological conditions are more or less similar to each other in species richness and topographic structure than faunas under different ecological conditions.

The less similarity between Forest and Farmland habitats might be due to the difference in altitude and variation in vegetation structure. These differences in altitude and vegetation structure result in different adaptations. Elevation affects the condition of physical environment and the kind and amount of resources available for breeding and foraging activities. The composition and structure of bird communities change along elevation gradients (Hejl *et al.*, 2002). During the dry season the highest species similarity was again between the Forest and *Erica* woodland and the least similarity was between *Erica* woodland and Farm land. This might be due to the higher dissimilarity of the two habitats in elevation and vegetation types.

A species distribution can be expressed as its presence or absence in certain habitat where bird data is collected (Bibby and Burgess, 1992). In the present study, the distribution of the four habitat types was identified. It was found that some species are distributed in different

habitats while others were restricted to a particular habitat. The distribution of birds is dependent upon food preference. The Forest and *Erica* woodland habitats were occupied by small sized birds which were distributed along vertical and horizontal strata of the vegetation. The Grassland and Farmland habitats were mainly occupied by large sized species of birds in addition to limited number of small sized species of birds. The large sized birds inhabiting the Grassland and Farmland habitats were mainly birds of prey feeding on large population of rodents. These included Kites, Eagles, Buzzards, Harriers and Falcons. The birds in the Forest and *Erica* woodland habitats were mainly nectar collectors, frugivores, seed eaters and insectivores. The appearance or disappearance of some species from specific habitat during wet or dry seasons might be due to the movement of birds in or out (migration). It is also true that the researcher can fail to observe some of the cryptic species even though birds are present, especially in the forest area. The abundance of birds and the diversity of their communities are difficult things to measure (Pomeroy and Dranzoa, 1997).

The chi-square analysis of the habitat association of birds during wet and dry seasons was statistically significant except the Farmland habitat during the wet season. The dependence of birds upon their habitat is determined by structural complexity of vegetation (Macarthur, 1964). But the habitat association of birds in the Farmland habitat was not significant during the wet season. This might be due to poor supply of food in the Farmland in comparison to the dry season that provides numerous seed eating birds.

There are potentially a number of complex causes for changes in the number of birds, but food, habitat condition, predators, disease and competition are important indicators (Gregory *et al.*, 2004). The present study has analyzed the effects of habitat, season and the interaction of season and habitat on bird abundance. In the analysis of the effect of habitat on bird abundance the mean number of individuals observed between habitats was not statistically significant, for the wet season while it was significant for the dry season. The absence of significance during the wet season between habitats might be due to poor supply of food in each habitat.

The study indicated that season has a significant effect on bird abundance. There were more individual birds counted during the dry season than the wet season. Seasonal variation affects the availability of resources which also affect reproduction as well as survival of individuals. Birds generally produce young when there is ample food (Wyndham, 1985). There is no doubt that food resources of birds are affected by seasonal variation (Karr, 1976). Productivity increases with increasing rainfall, and number of individuals increases when productivity is high (Diamond, 1988). The interaction of habitat and season also showed significant difference on bird abundance. This may be an indication that productivity of a particular habitat increases or decreases with seasonal variation which in turn affects total population size.

8. THREATS

Denkoro forest is one of the remnants of the previous natural Forest cover in Ethiopia. The area is rich in various kinds of endemic plants and animals. However, it is highly exposed to anthropogenic threats. For agriculture, logging and grazing by livestock. According to Allen and O'Conner (2000), expansion and intensification of land use creates habitat for non-native species and native omnivores and granivores associated with Forest edges and human built environments. Intensive land use homogenizes the environment and thereby facilitates the replacement of a relatively diverse group of human intolerant species with a smaller number of opportunistic, human-tolerant species (Rapport *et al.*, 1985; Marsden and Whiffin, 2003).

The present study tried to assess the anthropogenic threats in the study area. According to the information from the local people, previously the forest cover was larger than the present size specially the greatest part of the forest on the side of Densa Woreda was cleared for agriculture and settlement. The forest is shrinking in size in all direction from time to time. Due to the population increase and repeated cultivation of the farmland, productivity has decreased which resulted in the encroachment of the forest for fire wood, construction materials and grass for domestic animals (Plate 4).



Plate 4. The defrosted part of the forest for settlement and agriculture (Photo: Tebebe Teklemariam, August, 2007).

Habitat structure is the major determinant of birds species diversity (Martin and Possingham, 2005). Loss of habitats results in loss of breeding and roosting sites of the Forest birds. This in turn results in decrease of species diversity of the Forest birds. It may be critical to understand the relationships between the ecology of forest birds which depend on primary or secondary forest to survive (Sodhi, 2001). The cutting down of trees in many of the forest habitat results in fragmentation.

Habitat loss and degradation is not limited only to the forest area, the grassland and *Erica* woodland habitats are also affected by livestock grazing of the people living inside and around the habitats. If these threats continue, undoubtedly the bird species diversity in the area declines. The threat would be especially dangerous for the unique and rare endangered species.

9. CONCLUSION AND RECOMMENDATIONS

9.1. Conclusion

The present study of avian fauna in Denkoro Forest has identified 154 species of birds, which is a big potential for the region. The species identified were observed in the Forest, *Erica* woodland, Grassland and Farmland habitats. The area consisted of endemic, Palearctic, Intra-African migrants and globally threatened species. Many of the birds identified were highland biome species. The study indicated high species diversity and richness compared to the size of the forest.

There was high significant variation in species both by habitat differences and seasonal variation. The seasonal variation depends upon climatic condition, while the variation in habitat is dependent upon the type of vegetation and altitude of the area. Distribution of species is associated to habitat types and habitat association is related to vegetation in the habitat. The abundance of birds in different habitats was significant during the dry season. Abundance was also affected by seasonal variation and the interaction of both.

Habitat destruction and degradation has continued in the study area from time to time. Deforestation, habitat fragmentation, agricultural expansion and settlement are the main threats on avifauna of the area.

9.2 Recommendations

The study area is a proposed National Park which is suitable ground for the survival of various kinds of bird species and other wild animals. In order to conserve these avian fauna and other wild animals the vegetation of the area should be maintained. Therefore, the following recommendations are very essential to take conservation measures:

- The people living in the Park should be displaced and given other appropriate places to avoid regular encroachment in to the Forest.

- The regional state should design awareness creation programmes so that the local people in the area should bring about attitudinal change about protection and conservation of wildlife of the area.
- Appropriate budget should be allocated to run all possible conservation activity.
- Ecological studies should be conducted on the vegetation types and other wild animals to get full information about wild life resource in the region.
- The area has full potential to be source of income from tourism industry, so basic infrastructures such as electricity, telecommunication, roads and guest houses should be constructed.
- The habitats of birds and other wild animals should be protected and the local people should have to participate in the conservation programme.
- The local people should get benefit from income generated from the Park.

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11. APPENDICES

Appendix 1. Relative abundance of birds in the Forest habitat during the wet season.

Species	Number of individuals per 100 field hours	Abundance Score	Rank
Abyssinian Crimson wing	33.33	4	Common
Abyssinian ground Thrush	10.33	3	Frequent
Abyssinian Salty fly catcher	13.33	3	Frequent
Abyssinian Wood Pecker	5	2	Uncommon
African blue billed Fire finch	8.33	3	Frequent
Beautiful Sunbird	4.16	2	Uncommon
Black headed Oriole	40	4	Common
Common Quail	1.66	1	Rare
Malachite Sunbird	2.5	1	Rare
Moorland Alpine Chat	1.66	3	Rare
Pale Flycatcher	7.5	3	Frequent
Red wing Starling	10	3	Frequent
Rupell's Robin Chat	10	3	Frequent
Scarlet Chested, Sun bird	5.83	3	Uncommon
Shining Sunbird	4.16	2	Uncommon
Takazze Sunbird	8.33	3	Frequent
Tropical Boubou	5	2	Uncommon
White backed Black	12.5	3	Frequent
White chicked Turaco	14.16	3	Frequent
White winged Black Tit	4.16	2	Uncommon
Wood Warbler	6.60	2	Uncommon
Yellow spotted Peteronia	4.16	2	Uncommon

Appendix 2. Relative abundance of birds in the Forest habitat during the dry season

Species	Number of individuals per 100 field hours	Abundance Score	Rank
Abyssinian Ca Bird	17.5	3	Frequent
Abyssinian ground Hornbill	1.66	1	Rare
Abyssinian ground Thrush	4.16	2	Uncommon
Abyssinian Salty fly catcher	33.33	4	Common
Abyssinian Woodpecker	5	2	Uncommon
African blue billed Fire finch	5	4	Uncommon
African grey Flycatcher	6.66	3	Frequent
African paradise Flycatcher	45.83	4	Common
Black headed Oriole	44.16	4	Common
Black headed Robin	4.16	2	Uncommon

...Cont'd

Blue Headed Coucal	17.5	4	Common
Brown throated Watle eye	1.66	1	Rare
Cassin's Honey Bird	6.66	3	Frequent
Common Chifchaf	11.66	3	Frequent
Common Fiscal	6.66	3	Frequent
Eastern gray plantain eater	4.16	2	Uncommon
Eastern Yellow billed Hornbill	5	2	Uncommon
Egyptian Goose	1.66	4	Rare
Eurasian Hoopoe	12.5	3	Frequent
Familiar Chat	5.83	2	Uncommon
Hamerkop	1.66	2	Uncommon
Hemprich's Horn bill	8.33	3	Frequent
Klaas' Cuckoo	5	2	Uncommon
Lesser Honey guide	41.66	4	Common
Little Rock Thrush	3.33	2	Uncommon
Malachite sunbird	3.33	2	Uncommon
Masked Shrike	10	3	Frequent
Northern brown Bull	2.5	1	Rare
Olive Thrush	29.16	3	Frequent
Pale Flycatcher	33.33	4	Common
Palid Swift	6.66	3	Frequent
Red chicked Cordon blule	5	2	Uncommon
Red wing Starling	20	3	Frequent
Ring necked Dove	5	4	Uncommon
Rupell's Black Chat	4.16	4	Uncommon
Rupell's robin Chat	17.5	3	Frequent
Rupell's Starling	5	2	Uncommon
Scaly Francolin	3.33	2	Uncommon
Swinson's Sparrow	15	3	Frequent
Talcazze Sunbird	15.16	3	Frequent
Tiny Cisticola	15.83	3	Frequent
Tropical Boubou	3.33	2	Uncommon
White backed Black Tit	40.83	4	Common
white breasted White eye	5	2	Uncommon
Whinchat	11.66	3	Frequent
White chicked Turaco	10	3	Frequent
Wood Warbler	1.66	1	Rare

Appendix 3. Relative abundance of birds in *Erica* woodland habitat during the wet season

Species	Number of individuals per 100 field hours	Abundance score	Rank
Black headed Siskin	18.75	3	Frequent
common Red Start	2.5	1	Rare
Crested Francolin	7.5	3	Frequent
Familiar Chat	8.75	3	Frequent
Lesser Honey guide	36.25	4	Common
Malachite Sunbird	10	3	Frequent
Morland Alpine Chat	27.5	3	Frequent
mountain Buzzard	2.5	1	Rare
Olive Thrush	15	3	Frequent
Pale Flycatcher	13.75	3	Frequent
Palid Swift	7.5	3	Frequent
Pectoral patch Cisticola	6.25	2	Uncommon
Red eyed Dove	5	2	Uncommon
Red wing Starling	5	2	Uncommon
Rupell's Robin Chat	5	2	Uncommon
Scaly Francolin	6.25	2	Uncommon
Scarlet chested Sunbird	5	2	Uncommon
Specked Pigeon	5	2	Uncommon
Spotted Flycatcher	5	2	Uncommon
Swinson's Sparrow	5	2	Uncommon
Takazze Sunbird	13.75	3	Frequent
Tiny Cisticola	11.12	3	Frequent
Whinchat	5	2	Uncommon
Whit backed Black Tit	37.5	4	Common
White billed Starling	7.5	3	Frequent
White breasted White eye	7.5	3	Frequent
White Rumped Babbler	46.25	4	Common
White winged Black Tit	7.5	3	Frequent

Appendix 4. Relative abundance of birds in the *Erica* woodland habitat during the dry season

Species	Number of individuals per 100 field hours	Abundance score	Rank
Abyssinian Catbird	11.25	3	Frequent
Abyssinian salty Flycatcher	11.25	3	Frequent
African grey Flycatcher	11.25	3	Frequent
African Hill Babbler	6.25	2	Uncommon

...Cont'd

African Olive Pigeon	5	2	Uncommon
African Paradise Flycatcher	35	4	Common
African scops Owl	5	2	Uncommon
Black winged Love Bird	7.5	3	Frequent
Blue breasted Bee-eater	5	2	Uncommon
Brown backed Wood pecker	3.75	2	Uncommon
Cassin's honey Bird	10	3	Frequent
Chest nuped Francolin	5	2	Uncommon
Cinnamon bracken Warbler	10	3	Frequent
Common Bulbul	6.25	2	Uncommon
Common Chifchaf	3.75	2	Uncommon
Common Fiscal	5	2	Uncommon
Erckel's Francolin	6.25	2	Uncommon
European honey Buzzard	2.5	1	Rare
Familiar Woodpecker	27.5	3	Frequent
Har wood's Francolin	5	2	Uncommon
Lesser Honey Guide	8.75	3	Frequent
Malachite Sunbird	56.25	4	Common
Moorland Alpine Chat	6.25	2	Uncommon
Moorland Alpine Chat	10	3	Frequent
Moorland Francolin	10	3	Frequent
Olive Thrush	26.25	3	Frequent
Pale Flycatcher	27.5	3	Frequent
Pear spotted Owlet	7.5	3	Frequent
Pectoral patch Cistiola	3.75	4	Common
Rufous Chatterer	6.25	4	Common
Rupell's Robin Chat	7.5	3	Frequent
Spotted Flycatcher	5	2	Uncommon
Tawny-flanked Primia	3.75	2	Uncommon
Tawny Pipit	3.75	2	Uncommon
Thick billed Raven	7.5	3	Frequent
Tiny Cisticola	35	4	Common
Tree Pipit	6.25	2	Uncommon
Whinchat	11.25	3	Frequent
White backed Black Tit	46.25	4	Common
White billed Starling	7.5	3	Frequent
white Wagtail	7.5	3	Frequent
white rumped Babbler	32.5	4	Common
Willow Warbler	6.25	2	Uncommon

Appendix 5. Relative abundance of birds in the Grass land habitat during the wet season.

Species	Number of individuals per 100 field hours	Abundance score	Rank
Alpine Swift	8.33	3	Frequent
Augur Buzzard	13.33	3	Frequent
Black headed Siskin	10	3	Frequent
Greater blue eared Glossy Starling	6.66	3	Frequent
Ground scraper Thrush	10	1	Rare
Moorland Alpine Chat	33	4	Common
Pale Flycatcher	13.33	3	Frequent
Red wing Starling	13.33	3	Frequent
Scarlet chested Sunbird	11.66	3	Frequent
Stout Cisticola	6.66	3	Frequent
Takazze Sunbird	10	3	Frequent
Thekala Lark	26.66	3	Frequent
White browed sparrow Weaver	10	3	Frequent
White browed sparrow Weaver	8.33	3	Frequent
Yellow spotted Petronia	8.33	3	Frequent

Appendix 6. Relative abundance of birds in the Grassland habitat during the dry season

Species	Number of individuals per 100 field hours	Abundance score	Rank
Abyssinian Long Claw	5	2	Uncommon
African Pipit	8.83	3	Frequent
Alpine Swift	8.33	3	Frequent
Black headed Siskin	5	2	Uncommon
Common Fiscal	6.66	3	Frequent
Common Quail	3.33	2	Uncommon
Eastern yellow billed Hornbill	8.33	3	Frequent
Familiar Chat	5	2	Uncommon
Ground scraper Thrush	11.66	3	Frequent
Long billed Pipit	6.66	3	Frequent
Malachite Sunbird	6.66	3	Frequent
Moorland Alpine Chat	36.66	4	common
Olive Thrush	3.33	2	Uncommon
Pale Flycatcher	8.33	3	Frequent
Palid Harrier	6.66	3	Frequent

...Cont'd

Palid Swift	36.66	4	common
Pectoral peach Cistcola	6.66	3	Frequent
Pied Wheatear	6.66	3	Frequent
Red wing Starling	18.33	3	Frequent
Song Thrush	10	3	Frequent
Thekala Lark	28.33	3	Frequent
Whinchat	13.33	3	Frequent
White backed Black Tit	28.33	3	Frequent
White Wagtail	5	2	Uncommon
Yellow Wagtail	8.33	3	Frequent

Appendix 7. Relative abundance of birds in Farmland habitat during the wet season

Species	Number of individuals per 100 field hours	Abundance score	Rank
Cape (Black) Crow	16.66	3	Frequent
Erlanger's Lark	10	3	Frequent
Fun tailed Raven	10	3	Frequent
Ground Scraper Thrush	11.66	3	Frequent
Moorland Alpine Chat	20	3	Frequent
Olive Thrush	3.33	2	Uncommon
Pied Crow	6.66	3	Frequent
Red necked Buzzard	8.33	3	Frequent
Rupell's Starling	10	3	Frequent
Speckled Pigeon	6.66	3	Frequent
Swinson's Sparrow	11.66	3	Frequent
Thekala Lark	18.33	3	Frequent
Wattled Ibis	16.66	3	Frequent
White rumped Bubbler	16.66	3	Frequent
Yellow Bishop	6.66	3	Frequent

Appendix 8. . Relative abundance of birds in the Farmland habitat during the dry season

Species	Number of individuals per 100 field hours	Abundance score	Rank
Abyssinian ground Horn bill	6.66	3	Frequent
African Citril	6.66	3	Frequent
Black scrub Robin	6.66	3	Frequent
Brown rumped Seed eater	10	3	Frequent
Cape (black)Crow	20	3	Frequent

...Cont'd

Egyptian Goose	3.33	2	Uncommon
Enlarger's Lark	30	3	Frequent
Familiar chat	8.33	3	Frequent
Funtailed Raven	41.66	4	Common
Ground scraper Thrush	16.66	3	Frequent
Isabelline Wheat ear	6.66	3	Frequent
Moorland Alpine Chat	30	3	Frequent
Mountain Wagtail	6.66	3	Frequent
Olive Thrush	8.33	3	Frequent
Palid Swift	25	3	Frequent
Pied Crow	6.66	3	Frequent
Pied Wheatear	10	3	Frequent
Red billed Qualia	3.33	2	Uncommon
Red Throated Pipit	5	2	Uncommon
Red wing Starling	3.66	2	Uncommon
Ring necked Dove	5	2	Uncommon
Rufous tailed Shrike	5	2	Uncommon
Rupell's Black Chat	8.33	3	Frequent
Rupell's Starling	16.66	3	Frequent
Scaly Francolin	5.66	2	Uncommon
Song Thrush	8.33	3	Frequent
Stearky Seedeater	6.66	3	Frequent
Swinson's Sparrow	20	3	Frequent
Teminik's Stint	13	3	Frequent
Thekala Lark	30	3	Frequent
Tropical Boubou	6.66	3	Frequent
Wattled Ibis	36.66	4	Common
White bakced Black Tit	11.66	3	Frequent
White rumped Babbler	10	3	Frequent
Yellow Bishop	13.33	3	Frequent
Yellow rumped Seed eater	6.66	3	Frequent
Yellow Wagtail	13.33	3	Frequent

<3.04 Rare, 3.04 – 6.38 Uncommon, 6.39 – 30.43 Frequent, 30.44 – 122 Common, > 122 Abundant.

Appendix 9. Additional pictures



