Addis Ababa University

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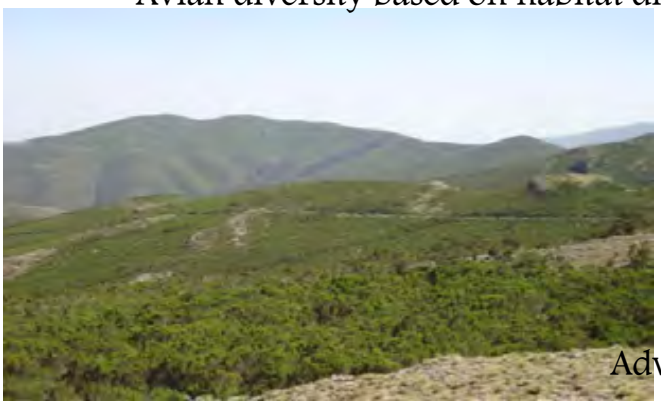
ECOLOGICAL AND SYSTEMATIC ZOOLOGY STREAM

Avian diversity based on habitat difference at Geto and Gembejo areas, southwest Shoa, Ethiopia



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Acronyms and Abbreviations

BCPC ..... British Crop Protection Council

BLI .....BirdLife International

CR .....Critically Endangered

CSA.....Central Statistical Agency

EN .....Endangered

EPA .....Environmental Protection Authority

ER ..... Encounter Rate

EWNHS ..... Ethiopian Wildlife and Natural History Society

IBA.....Important Bird Area

IBC ..... Institute for Biodiversity Conversation

ICBP.....International Council for Bird Protection

IPCC.....Intergovernmental Panel on Climate Change

IUCN..... International Union for Conservation of Nature and Natural Resources

NMSA..... National Meteorological Services Agency

PM..... Palearctic Migrants

SNNP ..... Southern Nations, Nationalities and Peoples

UNEP ..... United Nation Environment Program

VU.....Vulnerable

WCMC .....World Conservation Monitoring Centre

ABSTRACT

The present study on avian diversity based on habitat difference was conducted at Geto and Gembejo in Kersa Malima Woreda in Southwest Shoa Zone of Oromia region, Ethiopia. Six habitats were identified for counting birds using line transect and point count methods. Data were analyzed using Shannon-Weaver and Simpson's diversity Indies and Simpson's similarity index. Altogether 120 species bird were recorded, of which 81 were during the wet season and 112 were during the dry season. They belonged to 39 families and 15 orders. This area holds Endemic species (five only in Ethiopia and seven in highlands of Ethiopia and Eritrea) and six globally threatened species, which have high priority of conservation concern. Plain habitat constitutes the highest number (76) of species, followed by shrubland habitat (65). The highest species diversity index recorded was from woodland habitat during the dry season (H'= 3.3) and lowest was from ericaceous habitat during the dry season (H'= 1.94). Mean difference comparisons of species abundance between garden and shrubland, garden and woodland, garden and *Erica*, and woodland and *Erica* habitats are not significantly different at 0.05 level. Similarly, the multiple comparisons of mean difference of species richness among garden and plain, garden and shrubland, *Erica* and plain, *Erica* and agriculture, *Erica* and shrubland, and *Erica* and woodland habitats are significantly different. The highest species similarity was between dry and wet season of garden habitat (SI=0.87), followed by agriculture habitat during the dry season and shrubland habitat during the dry season (SI=0.85). The demographic growth and the increasing negative impacts of human activities have greatly reduced the resources in this study area. Timely action should be taken to tackle this problem in the study area.

Keywords: birds of Geto and Gembejo, *Erica*, species composition and highland biodiversity

1. INTRODUCTION

1.1. Background

Ethiopia is situated in the Horn of Africa between 3^0N and 15^0N latitude and 33^0E and 48^0E Longitude (EWNHS, 2001; Ash and Atkins, 2009). Ethiopia's major land feature is a massive highland complex of mountains and plateaus bisected by the Great Rift Valley and surrounded by lowlands along much of the edge (Hillman, 1993; Viveropol, 2001). The Great Rift Valley bisects this mountainous plateau, dividing it into northwestern and southeastern highland regions (Gillespie, 2003).

Ethiopia is one of the most physically and biologically diverse countries due to primarily by variations in altitude. This diversity includes physiographic, climatic and edaphic, which resulted in unique and diverse sets of biotic zones ranging from afroalpine to desert communities (Hillman, 1993; Yalden *et al*., 1996). It has an area of over 1,023,050 km^2. It contains various wildlife and wildlife habitats (Yalden, 1983). This helped to create isolated and varied ecological situations. The biological resources are distributed in different biomes mainly the Afrotropical highlands, the Sudan-Guinean, the Sahel-Transitional Zone and the Somali-Masai Biome (Yalden *et al*., 1996).

Ethiopia has 50% of all the afrotropical lands above 2,000 m and 80% of all the lands above 3,000 m asl (Yalden, 1983). Most of the country comprises highland plateaus and mountain ranges that are dissected by numerous streams and rivers. The highlands gradually descend to lowland areas in the east, west and south of the country (EWNHS, 1996; EPA, 1998).

Ethiopia has five climatic zones, defined by altitude and temperature. The hot, arid zone covers the desert lowlands below 500 m, where the average annual rainfall is less than 400 mm and average annual temperatures range between 28°C and 34°C or higher. The warm to hot, semi-arid zone includes those areas with an altitude of 500–1,500 m altitude. Average annual rainfall is around 600 mm and the average annual temperature ranges from 20 to 28°C. The warm to cool, semi-humid zone covers the temperate highlands between 1,500 and 2,500 m altitude. Average annual temperatures vary between 16°C and 20°C, and annual rainfall is generally around 1,200 mm, reaching 2,400 mm in the southwest. The cool to cold humid zone includes

the temperate highlands between 2,500 and 3,200 m altitude, where average temperatures range between 10°C and 16°C, with an annual rainfall of 1,000 mm and up to 2,000 mm in higher areas. The cold, moist temperate zone covers the afro-alpine areas on the highest plateaus between 3,200 and 3,500 m; average temperatures are below 10°C and annual rainfall averages less than 800 mm (EWNHS, 1996; Saavedra, 2009; IBC, 2005; EPA, 1998).

The country is also rich in its faunistic diversity. This biodiversity is not evenly distributed in the country. The larger mammals are mainly concentrated in the south and southwest border and adjacent areas of the country. There are also plain game animals along the stretch of the Great Rift Valley System. Mountain massifs in the north are also home to many endemic species. The flora of Ethiopia is very diverse with an estimated number between 6,500 and 7,000 species of higher plants, which constitute about 12 per cent endemic (Tewolde Brehan Gebre Egziabher, 1991).

For several years, the natural ecosystems of Ethiopia have been altered due to anthropogenic effect and natural factors. Most of the highlands and some of the lowlands have been converted into agricultural and pastoral lands. The vegetation has been used for fuel wood, construction and other purposes. As a result, wildlife resources of the country are now largely restricted to a few protected areas in about 22,829 km^2, which is approximately 2.9% of the of the country's land area (Hillman, 1993).

The diverse habitat types of Ethiopia contributed for the diverse avifauna. In Ethiopia 69 Important Bird Areas (IBAs), which are also important for large number of other taxa are identified by the Ethiopian Wildlife and Natural History Society (EWNHS), following quantitative criteria. These included the already existing protected areas and many other additional sites. In general, according to EWNHS (1996) the birds of Ethiopia are grouped into three biome assemblages:

1. The Afrotropical Highland Biome Species: It holds about 48 species of birds including 7 endemic birds. Bale Mountains National Park is the richest site for this biome assemblage, representing over 80% of the species.

2. The Somali-Massai Biome Species, which is the richest in its species variety and holds over 97 bird species of which 6 are endemic.
3. The Sudan-Guinea Savannah Biome Species, which is poorly known biologically, it holds about 16 species of birds. Gambella is the richest area for this biome.

It is estimated that over 10,000 species of birds exist on the planet earth (Lepage, 2011). According to Lepage (2011), out of the 918 bird species listed for the country, 20 are endemic and 19 are globally threatened species. The number of bird species varies from literature to literature and from time to time. Ethiopia is one of the few countries in the world that possesses a unique and characteristic fauna with a high level of endemism (WCMC, 1991). There are 13 species restricted to the geographical region of Ethiopian highlands and thus shared by Ethiopia and Eritrea (Viveropol, 2001).

In Ethiopia 596 birds are resident and 224 are regular seasonal migrants, including 176 from the Palearctic (Viveropol, 2001). Thirty-one species of global conservation concern. Of these, five (*Sarothrura ayresii*, *Tauraco ruspolii*, *Heteromirafra sidamoensis*, *Serinus flavigula* and *Serinus ankoberensis*) are classified as endangered and 12 as vulnerable. Some of the threatened species are non-breeding migrants from the Palearctic while others are non-breeding visitor from elsewhere in the Afro-tropics. The remainders are residents (Collar *et al*., 1994; EWNHS, 1996).

Even though the country is endowed with unique and diverse biodiversity, many of them are seriously threatened due to anthropogenic effect and natural catastrophes (Hillman, 1993). Much of the Ethiopian landscape from sea level up to 4,000 m is altered by agricultural activities, deforestation and over-grazing. This habitat deterioration is particularly threatening quality of the montane ecosystems and, as a consequence, species are being depleted before scientific information about them is obtained. For these reasons, the present study is important for conservation of montane bird diversity and ecosystems. In previous time, no studies were conducted on birds in these areas. Avian studies are important to determine the importance of the site, habitat requirements of the species, size of a population species, and to understand the population dynamics (Gibbons *et al.,* 1996).

Geto and Gembejo areas are possibly important conservation area in the Ethiopian highlands and have national significance for its watershed coverage in addition to highland biodiversity. It is a source of several streams, which used by the local people and other downstream users.

No attempt has been made to assess existing information on bird diversity, their distribution, status and ecological preference in this study area. This research will hopefully give an insight to the diversity of birds across the area and the conservation problem and possible solutions to address the problem. The present study will help in creating a relatively comprehensive knowledge about the subject of the study exploring the species diversity of Geto area with respect to the habitat association of the species.

1.2. Literature Review

Birds are important for healthy functioning of the ecosystem. Birds control agricultural insect pests, for instance, insectivorous birds (flycatchers, swallows, Warblers and woodpeckers) (Ware, 1988 and Jackson, 1978). This reduces the cost and environmental hazards of chemicals due to chemical usage for insect pest control.

Birds can act as bio-indicators (Gregory *et al*., 2003). They are effective biological barometers as they serve in monitoring environmental changes (Jarvenin and Vaisanen, 1979). Some of the birds are sensitive and have capability of early warning for changes like heavy metal pollution (Furness, 1993; Jarvis, 1993). Marchant *et al*. (1990) and Baillie *et al*. (1997) showed that birds in agricultural land declined as chemicals and other input are applied for agricultural intensification to increase productivity, which at the same time leads to the collapse of many invertebrates and microorganisms. Similarly, many specialized invertebrates and plants to specific habitats declined by land use changes (Donald, 1998; Donald *et al*., 2001).

Birds can be used to indicate the status of biodiversity as a whole where little information exists, and the key places for its conservation. Because of their diversity and mobility, birds can tell us much about overall changes to the environment (BLI, 2002).

The distribution of any species can be influenced by many factors which are mainly categorized under abiotic and biotic factors (Loreau, 2010). This could be climate, availability of suitable

resources, barriers of dispersal and inter-specific interaction with those organisms sharing the same area (Smith, 1992).

The greatest dilemma of life on the earth is how to meet needs and demands without destroying the very ecological components planet important for life and human well being through sustainable development (Marten, 2001). At present, it is difficult for many to find clean, green and stable environment (Schutkowski, 2006).

Over the last many decades, many developing countries have experienced large population increase with declining or stagnant economic conditions. These countries are characterized not only by large increase of their population but also marked by heavy dependency directly on the natural resources for their livelihood (Marten, 2001). As a result, they are frequently been forced to exploit and extract their natural resource base in an unsustainable way in order to meet immediate economic needs. Such situations have accelerated the degradation of natural resources throughout the world (Schutkowski, 2006)

Since humans became the dominant species on the planet, the rate at which other species have become extinct has increased dramatically. Especially since the seventeenth century, technological advances and an ever-expanding human population have changed the natural world as never before (Filar and Haurie, 2009). Species are disappearing faster than they are generated through evolution (Lovegrove, 2007; Rosser and Mainka, 2000). Some biologists estimate that three or more plant and animal species become extinct each day (Benson and Nagel, 2004). Widespread climatic changes, disease, and competition among species can also result in natural extinction.

Humans are endangering species and the natural world primarily in three ways: habitat destruction, commercial exploitation of animals and plants, and the translocation of species from one part of the world to another (Loreau, 2010).

There are two main components to local species diversity: vertical and horizontal. Vertical diversity is the diversity of functionally different types of organisms by their trophic relationships or by other nontrophic interactions (trophic levels, guilds, functional groups).

Humans depend on the Earth's ecosystems for food, shelter, and other essential goods and services. Ecosystems provide well-recognized goods, including timber, forage, fuels, medicines, and precursors to industrial products. Ecosystems also provide under recognized services, such as recycling of water and chemicals, mitigation of floods, pollination of crops, and cleansing of the atmosphere (Chapin, 2006). The overuse or misuse of resources can alter the functioning of ecosystems and the services they provide. Land-use change, for example, can degrade the capacity of watersheds to purify water, leading to large treatment costs to cities. Degradation and loss of wetlands can expose communities to increased damage from floods and storm surges. Decimation of populations of insect pollinators has reduced yields of many crops (Chapin, 2006).

Solutions to environmental concerns are usually complex and it is not always obvious how to determine what information is needed to achieve conservation goals (WCMC, 1998a; Norris and Pain, 2002). This is particularly true when decision-makers have only a hazy idea of their requirements.

Many of the poorest people in the world live in areas with rich biodiversity (IUCN, 2008). While conservationists stress the need for conservation, focus on the areas of high biodiversity is a priority. Working in such areas makes it essential that the linkages between poverty and conservation are understood (Baillie and Groombridge, 1996; Baillie *et al*., 2004).

The IUCN Red List provides evaluations of the conservation status of species by comparing information on distribution, population and trends birds of the world (Fig. 1) over time, with standardized quantitative criteria for each of the categories of threat (critically endangered, endangered and vulnerable). Repeated global assessments have been carried out for all species of birds over period of time (Collar *et al*., 1994, Collar and Andrew, 1998, Butchart *et al*., 2004).

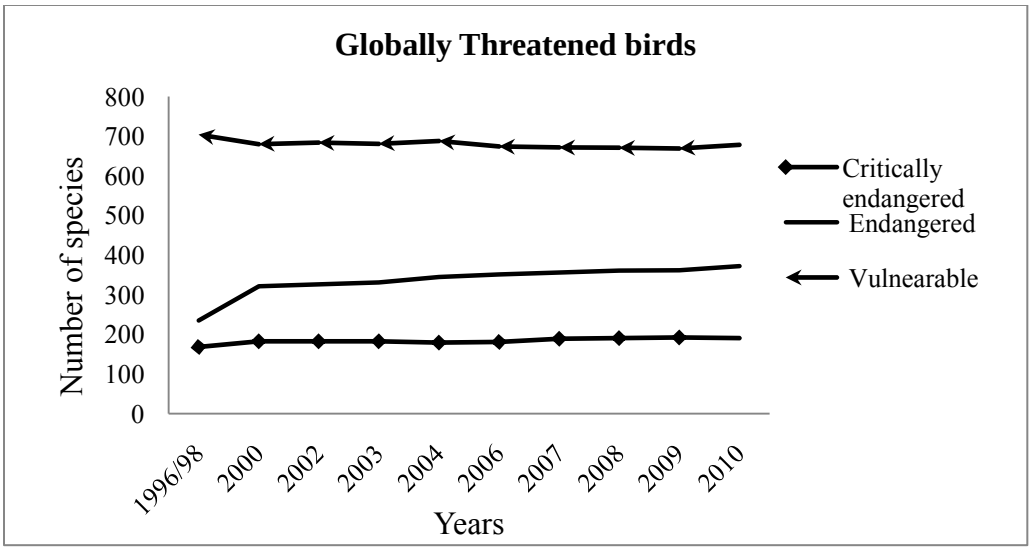

Figure 1: Changes in number of bird species in the threatened categories (CR, EN and VU) from 1996 to 2010 (Modified from: IUCN Red List version 2010.4).

A total of 190 species, which is 2% of the avian species are considered critically endangered facing extremely high risk of extinction in the immediate future, due to human driven threats, for which immediate actions are needed. Some species are already benefiting from conservation, but much more actions are needed (BLI, 2008). About 20% of the world's birds were confined to EBA's, whose area coverage is 2% of the earth's land surface (Statterfield *et al.,* 1998).

The reasons for species declines include habitat loss and degradation, pollution and pesticides, human structures such as towers, and non-native and native species impacts (Pimentel *et al*., 1992). Habitat destruction, fragmentation, and degradation are the largest treat to biodiversity.

Pesticides are significant sources of avian mortality. DDT was the well-known culprit of many species at the top of the food chain (Carson, 1962).

A new threat, which is expected to intensify in the next century, is global climate change (Dessler and Parson, 2003). As the earth warms, birds respond in a number of ways. There is evidence that some species are laying eggs earlier and others may be changing their range and migratory behaviour in response to climate-driven habitat changes. The species is tied to its

breeding sites and their genetic programming may not allow the birds to move to other viable nesting habitat (Schutkowski, 2006).

1.3. Objectives

1.3.1. General Objective

The general objective of the study is to investigate the difference in species composition, distribution and abundance of birds based on habitat change at Geto and Gembejo area in Kersa Malima Woreda, Ethiopia.

1.3.2. Specific Objectives

- To make assessment of species variation that exist within the site at a given altitude range;
- To compare the different habitat sites on the species composition and variation;
- To evaluate the species abundance and distribution in the different habitats and
- To suggest action plans for conservation of bird diversities in Geto and Gembejo areas.

2. THE STUDY AREA AND METHODS

2.1. The Study Area Description

Geto and Gembejo are located southwest of Addis Ababa in Kersa Malima Woreda at around 105 km away from Addis Ababa. The geographic position of study area is within latitude 8.34^0 to 8.47^0 and longitude of 38.20^o to 38.44^o (Fig. 2).

The topography of the area is mountainous and undulating with gentle to steepy slopes. The study area comprises also a flat plain. The area contains a landscape ranging with altitude from 2970 m to 3583 m asl. The lowest altitude is recorded at Geto plain and the highest is in the ericaceous region at mount Gara Dubata. The total extent of the study area is 56 km^2. The study area consists of afroalpine habitat of ericaceous shrubland and ericaceous forest, marshy grassland of Geto plain, shrubland with scattered tree areas, patch woodlands and settlement areas of cultivation and gardens. These habitats are identified during the preliminary survey and marked on the map (Fig. 2).

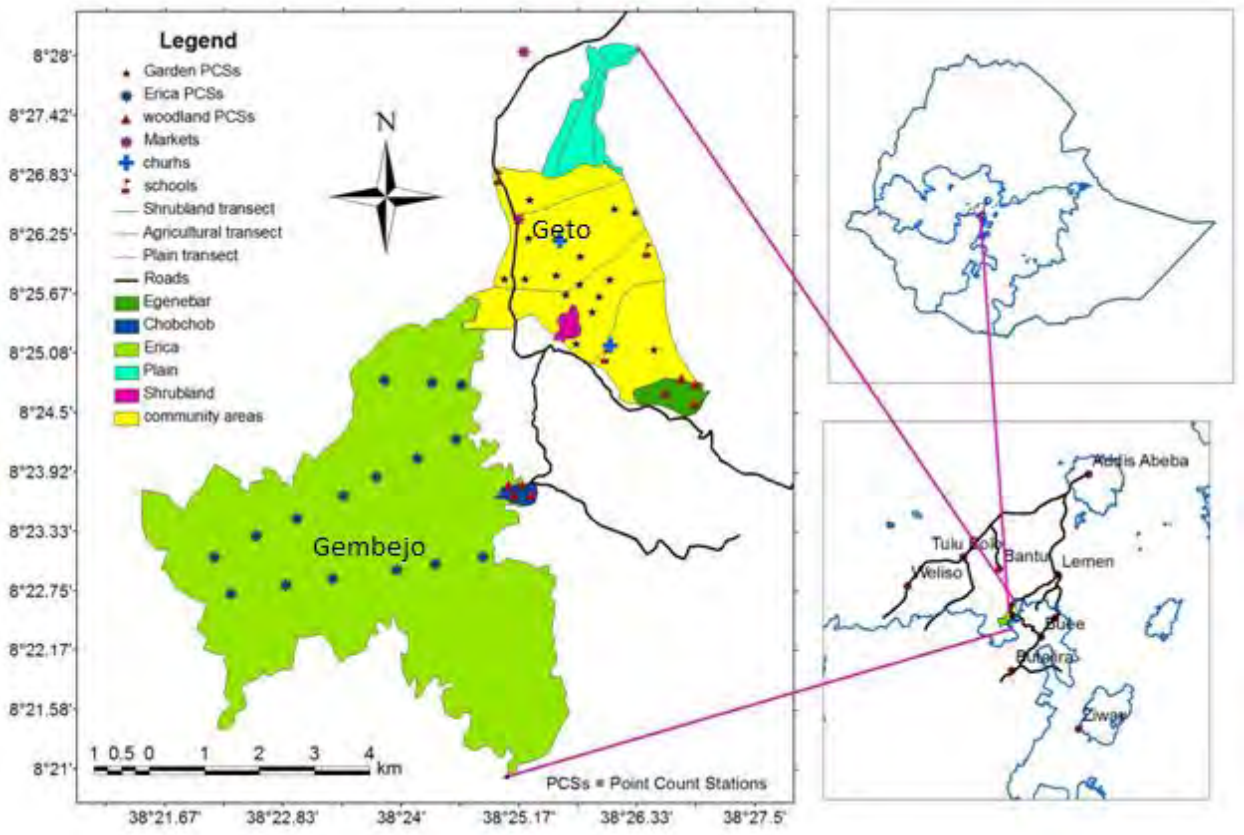

Figure 2. Map of Geto and Gembejo study areas

The weather data have been analyzed from the data recorded at Buee town rainfall and temperature recording station, which is at distance of 22 km distance from the study area. According to the Ethiopian agro-climatic classification, Geto is classified under Dega agro-climatic zone (area ranging from 2,500 to 3,200 m asl and up to 2,000 mm distribution of annual rainfall). The mean annual rainfall is 1062.6 mm per year with variations from 932.2 to 1264.7 mm per year. The area experiences two rainy seasons: heavy rains during July to September and short rains during March. The peak intensity of rainfall occurs in July (243.4 mm) and the lowest in December (10 mm) (National Meteorological Service Agency, 2010) (Fig. 3).

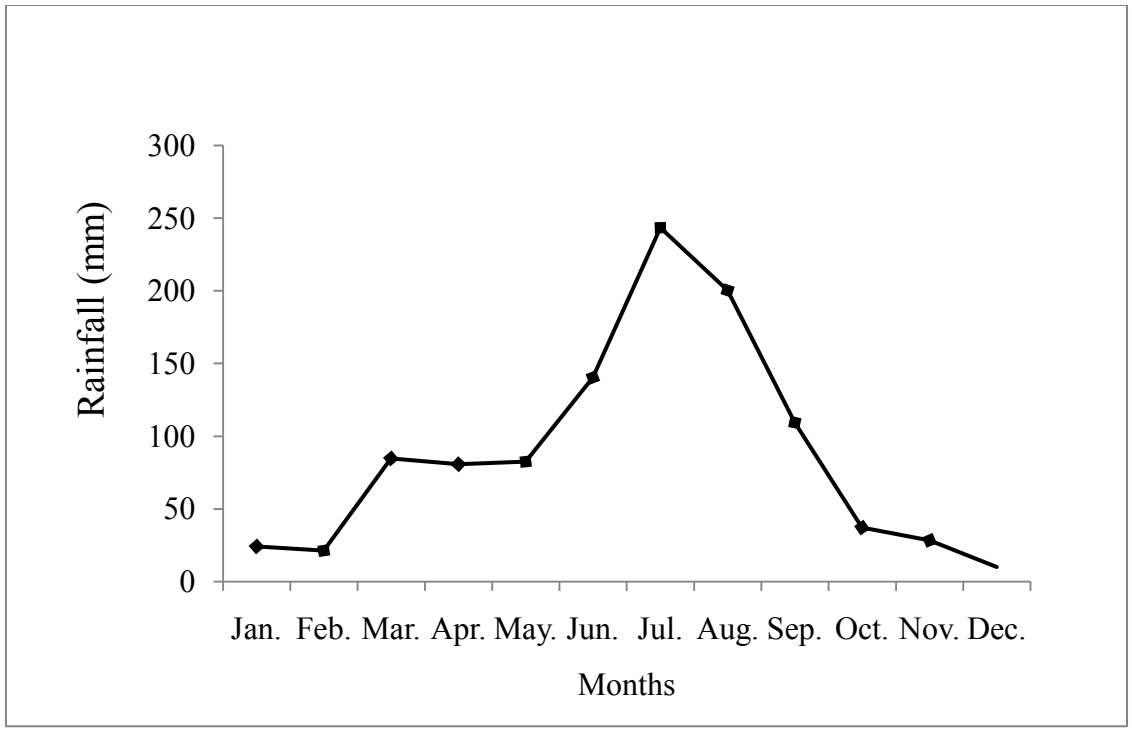

Figure 3. Average monthly rainfall (mm) of Geto and Gembejo areas recorded at Buee town (1995-2005) (Source: NMSA, 2011).

The mean monthly maximum and minimum temperature recorded were 27.3^{o}C in February and 5.8^{o}C in December respectively. The higher temperatures recorded were during the dry season from January to April. The highest and lowest temperatures recorded were 29.6 ^{o}C and 2.9 ^{o}C, respectively. The average monthly maximum and minimum temperature recorded at Buee station, which near to the study area is given in figure 4.

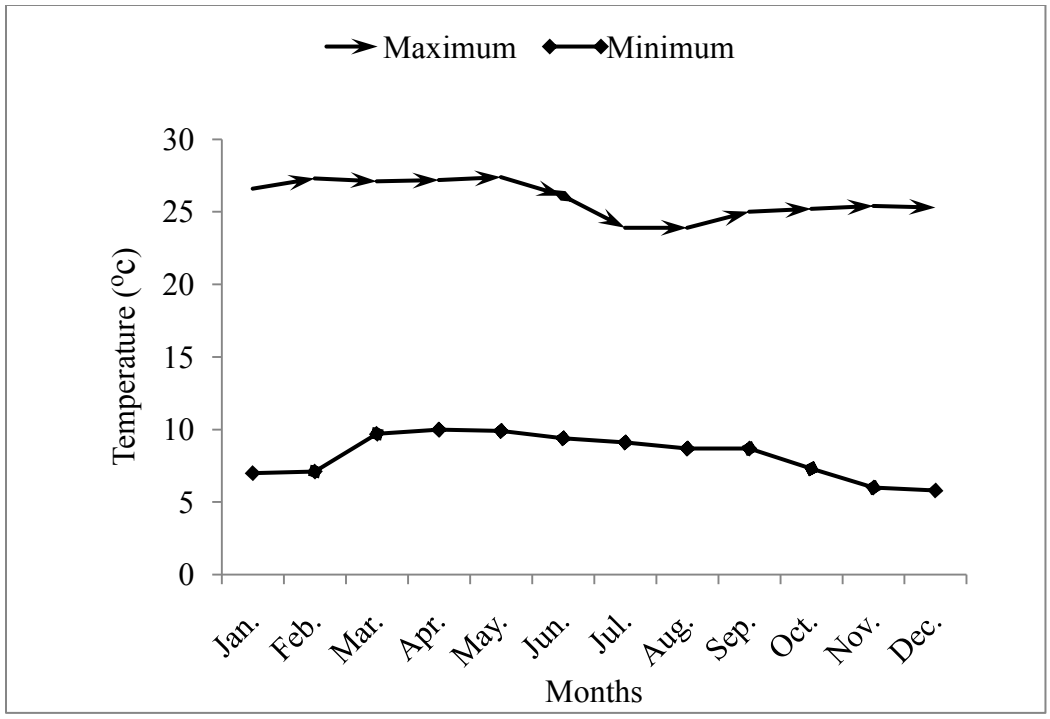

Figure 4. Monthly average maximum and minimum temperature (^{o}C) of Geto and Gembejo area recorded at Buee town during 1999-2008 (Source: NMSA, 2011).

The dominant vegetation of the areas include: *Juniperus procera, Rapanea simensis, Hypericum revolutum, Rosa abyssinica***,** *Juniperus procera*, *Hagenia abyssinica, Echinops, Erica arborea, Helichrysum cymosum, Rosa abyssinica, Arundnaria alpina, Bersama abyssinica, Eucalyptus globules*, *Vernonia amygdalina*, *Eupharbia dumal*, and different species of grasses and shrubs.

In the study area spotted hyena, warthog, grey duikers, Ethiopian hare, Menelik's bushbuck, baboons, mongoose, mole rat, porcupines, wild cats, aardvark, black backed jackal and different species of rodents were the major mammals identified during the study period by direct and indirect observations.

Observation was made in areas of communal livestock grazing habitat, consisting of scattered trees and shrubs, ericaceous area, garden and settlement areas and marshy plain habitats. The main bird habitats identified are shown in plates below (Plates 1 to 6).

Plate 1a. Views of home gardens and agricultural land. Photo: Teklu Gosaye

Agriculture is the main economic activity supporting the livelihood of the households in the study areas. These include farming and livestock husbandry. The main crops produced in the area are: barley, bean, pea, wheat, vegetables, enset, and others using rain fed system. Geto is one of the densely populated areas in Ethiopia.

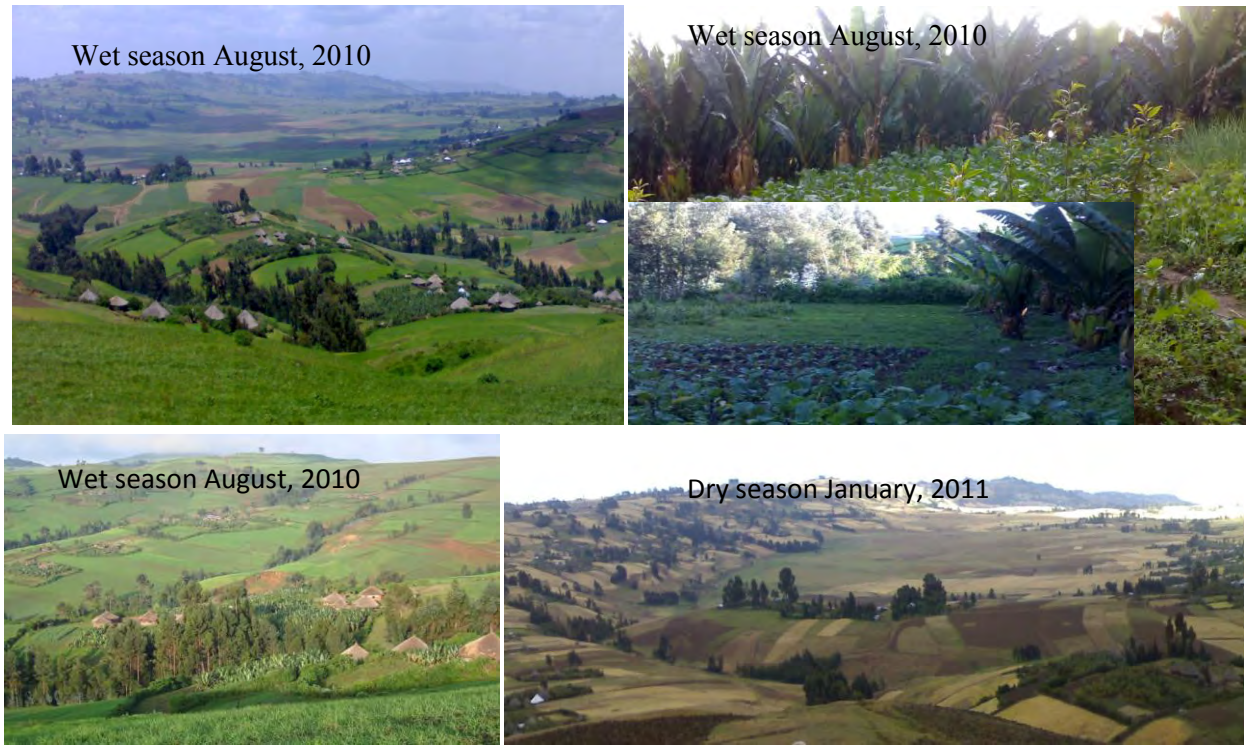

Plate 1b. Views of home gardens and agricultural land. Photo: Teklu Gosaye

Bushland with scattered *Rapanea simensis* trees

This habitat type dominates areas not feasible for agriculture in gently sloping terrains and in gullies. As agricultural land becoming scarce, this area faces pressure of farming which exposes the soil to serious erosion. Traditionally, these areas are used for livestock grazing and firewood collection by the local communities. Vegetation composition of these bushlands are: scattered *Rapanea simensis, Hypericum revolutum, Rosa abyssinica*, *Echinops, Erica arborea, Helichrysum cymosum, Rosa abyssinica, Bersama abyssinica, Eucalyptus globules*, *Vernonia amygdalina*, *Eupharbia dumal* and other grasses and shrubs.

Plate 2**. V**iews of shrubland with scattered trees. Photo: Teklu Gosaye

Geto Plain

This area comprises almost landscape, with swampy areas especially during the summer season following the flood of the water catchment area. This swampy and muddy area is formed as a

result of overflooding and surface water holding during the wet season as a result of flat landscape. The area is particularly important for endemic birds of the country.

Plate 3. Plain habitats during the wet and dry seasons (August 2010 and January, 2011). Photo: Teklu

Woodland

Woodland occurs at two sites of the study area, namely Chobchob and Egenebar. The common trees found in this habitat are: *Juniperus procera, Rapanea simensis, Hypericum revolutum, Rosa abyssinica***,** *Juniperus procera* and *Hagenia abyssinica.*

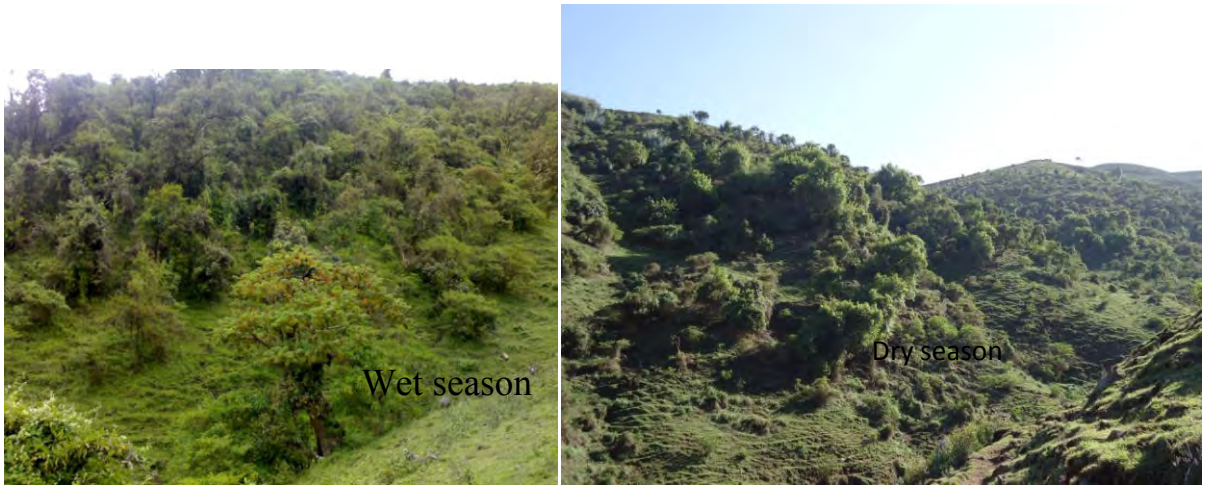

Plate 4. Woodland Habitat. Photo: Teklu Gosaye

Woodlands are being disappeared in the study area and springs and streams are drying during the dry season. Many of the woodland areas have been eliminated by human activities. Woodlands

also occur scattered in marginal and steep slope areas at the periphery of agricultural land (Plate 5.)

Plate 5. Woodland habitat found near agricultural land. Photo: Teklu Gosaye

Ericaceous habitat

This habitat dominated is by *Erica arborea.* Shrubs like *Artemisia, Helichrysum, Ferula* and *Kniphofia* are also recorded in this area. This habitat extends outside of Kersa Malima Woreda towards Sodo Woreda of SNNP Woreda and Gadi Bano Woreda of southwest zone of Oromia region.

Plate 6. Ericaceous habitats. Photo: Teklu Gosaye

Watershed

The mountain chain is drained in four directions by four main streams: Berol, Leman, Kenz and Gaba Hurufa. They join Taji, Awash, Meki and Gibe rivers, respectively. Finally Taji River becomes Awash River at the lower altitude with several streams from other areas (Fig. 5). Eventually, Meki River drains to Lake Zeway, Awash River flows through Koka dam and Gibe River join Omo River and drains to Lake Turkana at the border of Kenya.

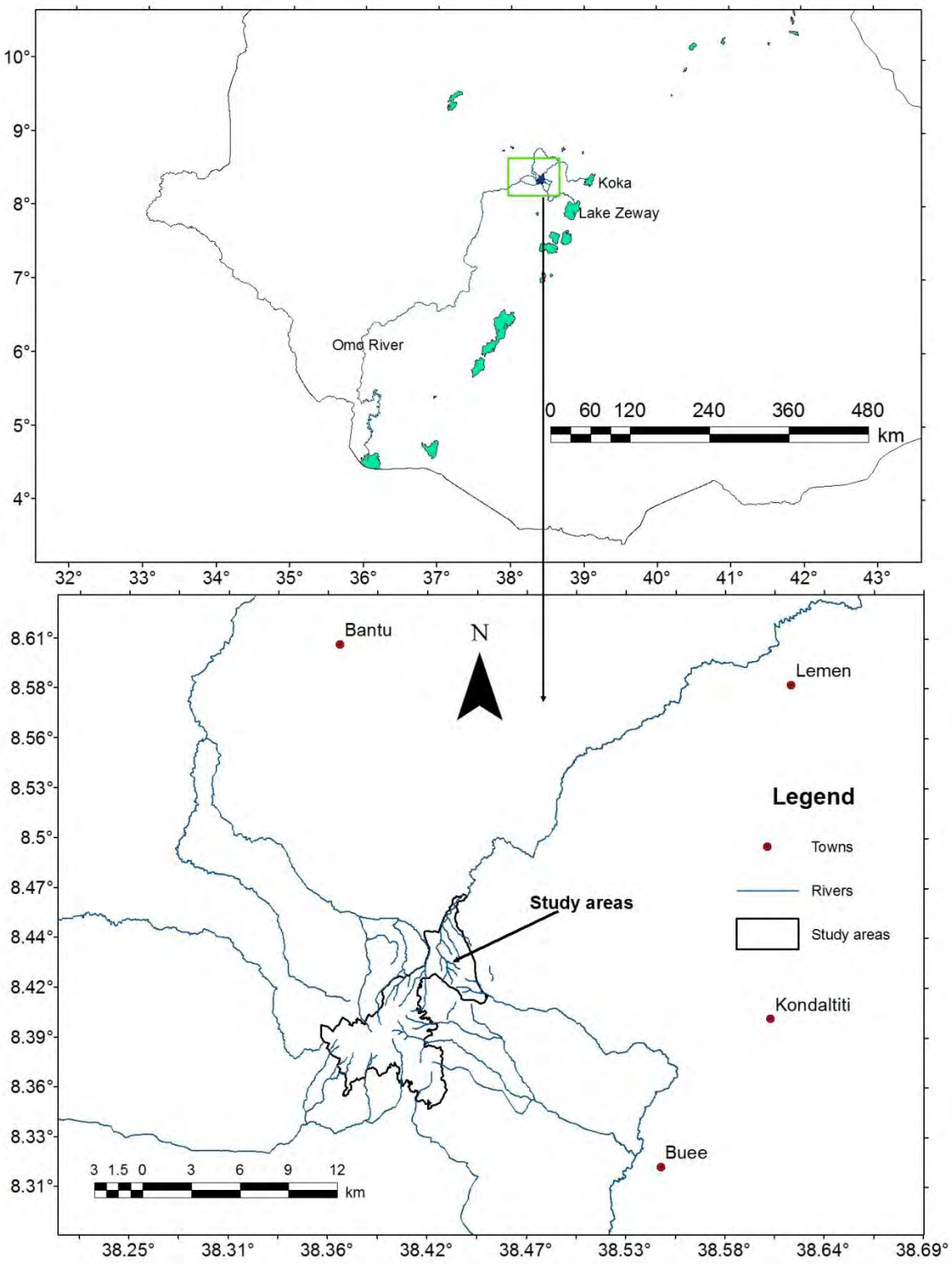

Figure 5. Rivers and watersheds from Geto and Gembejo areas

2.2. Methods

2.2.1. Materials

The following materials were used for the present work: Field guide (Van Perlo, 1995 and Redman *et al*., 2009) for species confirmation, binoculars, GPS (Garmin 72), digital camera, data forms, clipboard, enset string for station identification for repeated counting, and stationery materials.

2.2.2. Methods

Preliminary Survey

A preliminary survey was carried out for five days in the study site during August 8 - 13, 2010 to get familiar with the study area, identifying list of birds by habitat types and select sites to be sampled in the survey. Additional information was gathered from the residents of the area about the settings of the areas. Global Positioning System (GPS) readings were used to locate the positions and to identify the altitudinal ranges of the study site. The area was divided into sampling strata and units that cover the whole area based on habitat type following Buckland *et al.* (1993); Buckland *et al*. (2001) and Bibby *et al*. (2000).

Counting stations and line transects were identified by random selection. Bird identification and habitat identification were conducted for the study area. Six different habitat types were identified in the study area. These were scattered trees and shrubs called Agufi, ericaceous area, garden and settlement areas, woodland, agricultural land and flood plain of marshy habitat.

Sampling Design

Repeated counts on the line transect and point counting station sites were made. This method was also used to analyze changes in number of birds over time (Sutherland, 1996). Data were collected using both point count sampling and transect methods. For point count method, data were recorded by distributing points in the given habitat and selecting points from the distributed points on a random basis. Point count method was used for habitats, where detectability is

limited due to the habitat type. Accordingly, two line transects for Geto plain, three line transects for agricultural land and two line transects at Agufi were laid. The distance between consecutive transects were a minimum of one kilometer. Similarly 8, 15 and 16 point count stations were laid for woodland, gardens and ericaceous area, respectively. All counting stations were distinguished using a conspicuous inset fibre at each station. The distance between consecutive points counting stations were at a minimum of 500 m. Bird surveys were conducted from 06:30 to 10:00 AM during the morning and 3:00 to 6:00PM during the afternoon.

For both methods, the radius point counting stations and the width of the transects were set at bands based on the birds' detectability (Norvell *et al*., 2003; Rosenstock *et al.,* 2002). Point sampling, either point counts or point-transect sampling, are especially popular tools for censusing birds (Bibby *et al.,* 1992). Point counts are widely used to assess relative abundance of birds (Bibby *et al*., 1992; Bibby *et al.*, 1998; Gibbons *et al*., 1996). The survey was conducted along a series of point counting stations by counting the number of birds detected (Buckland, 2006). On each line transects and point counting stations a total of six visits (three for wet season and three for dry season) were carried out. The sequence, in which the transect and stations visited were in systematic alternative way among sampling periods to partially compensate for effects of hourly variation in bird activity (Rodriguez-Ferraro and Blake, 2008).

Data Collection

Data were collected during wet (August to September, 2010) and dry seasons (November to April, 2011). Birds were counted using point and transect line count method of sampling (Buckland *et al*., 2001).

During the survey, assessment of the area was undertaken with the help of local assistants to become familiar with the physical features of the study area and to gather additional information from the local people. Identification of bird species of the study site was carried out using binoculars, field guide, personal experience and call of birds whenever possible.

Transect study based on visual records followed Gibbons *et al.* (1996) were used. Data were recorded by three visits for each line transect and point count station for each season. Data were

collected following methods developed by Bibby *et al.* (2000), Buckland *et al. (*2001) and Bibby (1998). Ten minutes recording period was employed for each point count stations after three minute stabilization period. Birds were counted using distance bands depending on their detectability. The number of all species seen or heard was recorded.

Diversity Indices (Species Diversity, Evenness, Similarity and Species Richness)

Species Diversity

Diversity index is a mathematical measure of species diversity in a community. Diversity indices provided more information about community composition than simply species richness (i.e., the number of species present). They also take the relative abundances of different species into account. Diversity and equitability of species in a given bird community is used to interpret the relative variations between and within the community and help to explain the underlying reasons for such a difference.

Relative abundance was compared between different communities of birds in the study site by using the similarity indices measures. Shannon-Weaver diversity Index (H') (Shannon and Weaver, 1949) and Simpson's diversity Index (Simpson, 1949) were used for the calculation of the diversity of birds in the study site. Normally Shannon-Weaver diversity index varies between 1.5 and 3.5 and rarely exceeds 4.5 **(**Magurran, 1988). This was calculated using the following formula:

$$H = -\sum_{i=1}^{s} pi \ln pi$$

Where,

H' = Shannon-Weaver Index

$\sum$ = sum from species 1 to species S

Pi = Proportion of the i^{th} species to all organisms which belong to the i^{th} species

S = numbers of bird species encountered

ln =Natural logarithm

If p_i is the fraction of all organisms which belonged to the i^{th} species, then Simpson's diversity index (D) is most commonly defined as: Simpson's index of diversity (D) was used to evaluate the relative abundance of birds in each habitat for both wet and dry seasons by using the formula:

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right) = 1 - \sum_{i=1}^{s} pi^2$$

Where,

D = Simpson's Index of Diversity

Pi = Proportion of individual species

n = the total individuals number of a particular bird species

N = the total number of birds of all individual species

Simpson's Diversity Index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. As species richness and evenness increase, diversity also increases (Begon *et al*., 1996; Magurran, 1988).

Evenness (Equitability)

The fundamental means of analyzing species data is to look at the degree of association between species and level of similarity between samples. Evenness is used to quantify the unique representation of a given species against a given hypothetical community in which all species are equally common, such that when all species have equal abundance in the community and hence evenness is maximal (Krebs, 1999). Evenness index coefficient values ranges from 0 (complete dissimilarity to 1 (total similarity) (Kent and Coker, 1992; Nolan and Callahan, 2006). The higher the value of evenness index, the more even the species is in their distribution within the given area. To see the evenness (the pattern of distribution) of birds in the study area, Shannon-Wiener evenness Index (E) was calculated using the equation (Begon *et al*., 1996):

Equitability (Evenness) index is calculated using the formula:

$$E = \frac{H`}{\ln(S),} = \frac{H`}{H_{max}}$$

Where,

E = Shannon-Wiener Evenness Index

H' = Shannon-Wiener diversity Index

S= total number of species in the sample

ln = natural logarithm

Similarity index

Diversity indices measure the degree of uncertainty (if the diversity is high in a given habitat, the sureness of finding a particular species is low). In reference to the composition of species, Simpson's similarity index (SI) was used to assess the similarity of species between two different sites by using the formula:

SI = $\frac{2C}{A+B}$ where,

SI = Simpson's similarity index

A = Number of species that occur in site A

B = Number of species that occur in site B

C = Number of species shared by A and B

Encounter rate

Relative abundance of bird species were determined using encounter time frequency for determining the abundance which includes like: abundant, common, frequent, uncommon and rare species of the area (Bibby *et al*., 1992 and Bibby *et al*., 1998). This has been done by computing encounter rate of each species. Its formula is expressed as follows:

Encounter Rate (ER) = $\frac{\text{Number of birds recorded}}{\text{Number of hours spent searching}}$ x10

Then the results were categorized at intervals of: < 0.1, 0.1-2.0, 2.1-10.0, 10.1-40.0 and 40+. Based on this, the following abundance score was given as 1 (Rare), 2 (Uncommon), 3 (Frequent), 4 (Common) and 5 (Abundant), respectively following Bibby *et al*. (1998).

Data Analysis

From data collected during the wet and dry seasons, species richness, community composition, and species abundance were examined and compared among the six habitats in the study area. Collected data were entered and collated in excel spreadsheets for statistical analysis and data analysis was conducted using appropriate statistical tools, SPSS software package. ANOVA was used to analyze the effect of variables namely season and habitat. Comparison among bird communities were analyzed using the similarity indices. Community structures were described in terms of Shannon-Weaver Diversity index (H') (Shannon and Weaver, 1949).

3. RESULTS

A total of 9919 individuals of 81 species of birds were observed during the wet season and 9191 individuals of 112 species during the dry season in the six types of habitats. These bird species belonged to 39 families of 15 orders representing a total of 120 species in both seasons (Table 1).

Black Headed Siskin, Abyssinian Catbird, Abyssinian Woodpecker and Spot-breasted Lapwing are endemic birds while Abyssinian Long Claw is near threatened endemic bird. Black-winged Lovebird, Blue-winged Goose, White-collared Pigeon, Thick-billed Raven, White-backed Black Tit and Wattled Ibis are endemic shared with Eritrea. Rouget's Rail is a near threatened endemic species shared with Eritrea. Wattled Crane and Pallid Harrier are vulnerable, while Great Snipe is a near threatened species recorded in the study area.

Among these bird species, 28 were migrant species. Lesser kestrel, pallid harrier and great snipe are globally threatened species.

Table 1. Bird species recorded during the study period during both seasons in the six habitat types (D=dry season, W= wet season and the rest are birds recorded in both season, R- Resident in the country, E- Endemic to Ethiopia, EE- Endemic species shared with Eritrea, PM- Palearctic Migrants, PW - breeds in the Palearctic and winters in the country, AM - Intra African Migrant, R/PW - both resident and wintering population, V- Vulnerable and NT- Near Threatened)

Family	common name	Scientific name	Status
	Order Anseriformes		
Anatidae	African Black Duck	*Anas sparsa*	R
	Blue-winged Goose	*Cyanochen cyanopter*	R, EE
	Egyptian Goose	*Alopochen aegyptiacaatus*	R
	Northern Shoveler[D]	*Anas clypeata*	PW
	Yellow-billed Duck	*Anas undulata*	R
	Order Apodiformes		
Apodidae	Alpine Swift	*Tachymarptis melba*	R
	Common (Eurasian) Swift	*Apus apus*	PM
	Little Swift	*Apus affinis*	R
	Mottled Swift	*Tachymarptis aequatorialis*	R
	Order Charadriiformes		
Charadriidae	Spot-breasted Lapwing (Plover)	*Vanellus melanocephalus*	R, E
Jacanidae	African Jacana[W]	*Actophilornis africanus*	R
Scolopacidae	African (Ethiopian) Snipe[W]	*Gallinago nigripennis*	R
	Common Sandpiper[D]	*Actitis hypoleucos*	PW/PM
	Common Snipe[D]	*Gallinago gallinago*	PW/PM
	Great Snipe[D]	*Gallinago media*	PW/PM, NT
	Jack Snipe[D]	*Lymnocryptes minimus*	PW
	Little Stint[D]	*Calidris minuta*	

	Marsh Sandpiper[D]	*Tringa stagnatilis*	PW
	Ruff [D]	*Philomachus pugnax*	PW
	Wood Sandpiper[D]	*Tringa glareola*	PW/PM
	Order Ciconiiformes		
Threskiornithidae	Hadada Ibis	*Bostrychia hagedash*	R
	Sacred Ibis	*Threskiornis aethiopicus*	R
	Wattled Ibis	*Bostrychia carunculata*	R, EE
	Order Columbiiformes		
Columbidae	Dusky Turtle Dove	*Streptopelia lugens*	R
	Speckled Pigeon	*Columba guinea*	R
	White-collared Pigeon	*vanellus melanocephalus*	R, EE
	Order Coraciiformes		
Bucerotidae	Abyssinian (Northern) Ground Hornbill	*Bucorvus abyssinicus*	R
	Order Cuculiformes		
Musophagidae	White-cheeked Turaco	*Tauraco leucotis*	R
	Order Falcaniformes		
Accipitridae	African Goshawk	*Accipiter tachiro*	R
	Augur Buzzard	*Buteo augur*	R
	Black Kite[D]	*Milvus migrans*	R/M
	Yellow Billed-kite	*Milvus aegyptius*	R
	Black-shouldered (Winged) Kite[D]	*Elanus caeruleus*	R
	Hooded Vulture	*Necrosyrtes monachus*	R
	Lammergeier (Bearded Vulture) [D]	*Gypaetus barbatus*	
	Pallid Harrier[D]	*Circus macrourus*	PW, V
	Rufous-chested(breassted)	*Accipiter rufiventris*	R

	Sparrowhawk[D]		
	Shikra (Little Banded Goshawk) [D]	*Accipiter badius*	R
	Tawny Eagle[D]	*Aquila rapax*	R
	White-backed Vulture	*Gyps africanus*	R
	White-headed Vulture	*Trigonoceps occipitalis*	R
Falconidae	African Hobby	*Falco cuvierii*	R
	Common Kestrel[D]	*Falco tinnunculus*	R/PW
	Lesser Kestrel[D]	*Falco naumanni*	PW, V
	Sooty Falcon[D]	*Falco concolor*	PM
	Order Galliformes		
Phasianidae	Erckel's Francolin	*Francolinus erckelii*	R
	Order Gruiformes		
Gruidae	Wattled Crane[W]	*Bugeranus carunculatus*	R, V
Rallidae	Rouget's Rail	*Rougetius rougetii*	R, EE, NT
	Order Passeriformes		
Alaudidae	Erlanger's Lark	*Calandrella erlangeri*	R
	Thekla (Short Crested) Lark	*Galerida theklae*	R
Cisticolidae	Buff-bellied Warbler[D]	*Phyllolais pulchella*	R
	Pectoral-patch Cisticola	*Cisticola brunnescens*	R
	Stout Cisticola[D]	*Cisticola robustus*	R
	Tawny-flanked Prinia	*Prinia subflava*	R
	Winding (Ethiopian) Cisticola	*Cisticola galactotes*	R
Corvidae	Cape Crow (Cape Rook)	*Corvus capensis*	R
	Pied Crow	*Corvus albus*	R
	Thick-billed Raven	*Corvus crassirostris*	R, EE
Estrildidae	African Firefinch	*Lagonosticta rubricata*	R
	Red-billed Firefinch	*Lagonosticta senegala*	R

	Red-billed Pytilia	*Pytilia lineata*	R
	Yellow-bellied Waxbill	*Estrilda quartinia*	R
Fringillidae	Black Headed (Ethiopian) Siskin	*Serinus nigriceps*	R, E
	Brown-rumped Seedeater	*Serinus tristriatus*	R
	Streaky Seedeater	*Serinus striolatus*	R
Hirundinidae	Banded Martin	*Riparia cincta*	
	Barn Swallow[D]	*Hirundo rustica*	PW/PM
	Common (Northern) House Martin[D]	*Delichon urbicum*	PW/PM
	Ethiopian Swallow	*Hirundo aethiopica*	R
	Mosque Swallow	*Cercropis senegalensis*	R
	Red-chested Swallow	*Hirundo lucida*	R
	Red-rumped Swallow[D]	*Cercropis daurica*	PW/PM
	Rock Martin	*Ptyonoprogne fuligula*	R
Laniidae	Common Fiscal or Fiscal Shrike	*Lanius collaris*	R
	Tropical Boubou	*Laniarius aethiopicus*	R
Motacillidae	Abyssinian Long Claw	*Macronyx flavicollis*	R, E, NT
	African Pied Wagtail	*Motacilla aguimp*	R
	Grassland (African) Pipit	*Anthus cinnamomeus*	
	Mountain Wagtail	*Motacilla clara*	R
	Swainson's Sparrow	*Passer swainsonii*	R
	Tawny Pipit[D]	*Anthus campestris*	PW
	Tree Pipit[D]	*Anthus trivialis*	PW/PM
	White Wagtail[D]	*Motacilla alba*	PW/PM
	Yellow Wagtail[D]	*Motacilla flava*	PW/PM
Muscicapidae	Abyssinian Slaty Flycatcher[W]	*Melaenornis chocolatinus*	R

	African Dusky Flycatcher[W]	*Muscicapa adusta*	R
	African (Common) Stonechat[D]	*Saxicola torquatus*	R/PW
	Alpine (Moorland) Chat	*Cercomela sordida*	R
	Isabelline Wheatear[D]	*Oenanthe isabellina*	PW/PM
	Nightingale species[D]		PW/PM
	Northern Wheatear	*Oenanthe oenanthe*	PW/PM
	Red-breasted Wheatear	*Oenanthe bottae*	R
	Rüppell's Robin-Chat	*Cossypha semirufa*	R
	Thrush Nightingale[D]	*Luscinia luscinia*	PM
Nectariniidae	Beautiful Sunbird	*Cinnyris pulchellus*	R
	Malachite Sunbird	*Nectarinia famosa*	R
	Shining Sunbird	*Cinnyris habessinicus*	R
	Tacazze Sunbird	*Nectarinia tacazze*	R
	Variable Sunbird	*Cinnyris venustus*	R
Paridae	White-backed Black Tit	*Parus leuconotus*	R, EE
Ploceidae	Baglafecht Weaver	*Ploceus baglafecht*	R
	Speke's Weaver	*Ploceus spekei*	R
	Yellow Bishop	*Euplectes capensis*	R
Pycnonotidae	Common Bulbul	*Pycnonotus barbatus*	R
Sturnidae	Greater Blue-eared Starling	*Lamprotornis chalybaeus*	R
	Red-billed Oxpecker	*Buphagus erythrorhynchus*	R
	Red-winged Starling	*Onychognathus morio*	R
Sylviidae	Brown Woodland Warbler	*Phylloscopus umbrovirens*	R
	Cinnamon Bracken Warbler	*Bradypterus cinnamomeus*	R
	Garden Warbler[D]	*Sylvia borin*	PM
	Willow Warbler[D]	*Phylloscopus trochilus*	PW/PM

Timaliidae	Abyssinian Catbird	*Parophasma galinieri*	R, E
Turdidae	Groundscraper Thrush	*Psophocichla litsitsirupa*	R
Turdidae	Moutain (Olive) Thrush	*Turdus abyssinicus (olivaceus)*	R
Viduidae	Pin-tailed Whydah	*Vidua macroura*	R
Zosteropidae	Montane (Broad-ringed) White-eye	*Zosterops poliogastrus*	R
Motacillidae	Richard's Pipit	*Anthus novaeseelandie*	
	Order Pelicaniiformes		
Scopidae	Hamerkop[W]	*Scopus umbretta*	R
	Order Piciformes		
Picidae	Abyssinian (Gold-mantled)Woodpecker[D]	*Dendropicos abyssinicus*	R, E
	Order Psittaciformes		
Psittacidae	Black-winged Lovebird	*Agapornis taranta*	R, EE
	Order Stigiformes		
Strigidae	Cape Eagle Owl	*Bubo capensis*	R
	Greyish Eagle Owl	*Bubo cinerascens*	R

Order passiformes contained the highest number of family and species, which encompassed 21 families and 68 species composition in the study area (Table 2). Eight orders are represented by single family and three families represented by single species in the study area.

Table 2. Composition of bird orders in the study site

Orders	Number of family	Number of species
Anseriformes	1	5
Apodiformes	1	4
Charadriiformes	3	11
Ciconiiformes	1	3
Columbiiformes	1	3
Coraciiformes	1	1
Cuculiformes	1	1
Falcaniformes	2	16
Galliformes	1	1
Gruiformes	2	2
Passeriformes	21	68
Pelicaniiformes	1	1
Piciformes	1	1
Psittaciformes	1	1
Stigiformes	1	2
Total	39	120

The highest species was recorded in Geto plain area during the dry season (72 species), followed by shrubland during the dry season (63 species) and the lowest was 24 species from *Erica* habitat during the wet season (Table 3). The number of species is high during dry season (Table 5). The highest number of bird abundance recorded was 3281 from plain habitat during the wet season and the lowest abundance was from woodland habitat during the dry season. The highest species diversity recorded was (H'=3.3) from woodland habitat during dry season and the lowest

(H'=1.94) from ericaceous habitat during the dry season. Even though greater species diversity was recorded during the dry season, abundance birds were greater during the wet season. The evenly distributed species were from woodland habitat during the dry season (E= 0.83) and the less evenly distributed species were from ericaceous habitat during the dry season.

Table 3. Species diversity among habitats during the wet and dry seasons.

Habitat	Altitudinal range asl (m)	Seaso	Species Richness	Abundance	H'	H'max	E	D'
Plain	2970-3005	wet	48	3281	2.76	3.87	0.71	0.91
		dry	72	2802	3.19	4.28	0.75	0.94
Agriculture	2981-3350	wet	46	2613	3.13	3.83	0.82	0.94
		dry	52	2123	2.96	3.95	0.75	0.93
Gardens	3010-3320	wet	32	964	2.49	3.47	0.72	0.88
		dry	37	1161	2.69	3.61	0.74	0.9
Shrubland	3190-3340	wet	53	1456	2.94	3.97	0.74	0.92
		dry	63	1488	3.16	4.14	0.76	0.94
Woodland	3005-3302	wet	48	797	3.16	3.87	0.82	0.94
		dry	54	740	3.3	3.99	0.83	0.95
Erica	3120-3583	wet	24	808	2.32	3.18	0.73	0.86
		dry	28	877	1.94	3.33	0.58	0.73

From the multiple comparisons of mean difference of species abundance (Table 4) by using LSD the comparison between garden and shrubland, garden and woodland, garden and *Erica*, and woodland and *Erica* habitats are not significantly different at 0.05 level. The rest comparisons are significantly different at the same level of value. Similarly, the multiple comparisons of mean difference of species richness between garden and plain, garden and shrubland, *Erica* and plain, *Erica* and agriculture, *Erica* and shrubland, and *Erica* and woodland are significantly different. The rest species richness comparisons are not significantly different at the same value of level.

Table 4. Multiple pair-wise comparisons of mean difference in species abundance and richness in different habitats using LSD

		Abundance		Species richness	
(I) Habitat	(J) Habitat	Mean Difference (I-J)	Sig.	Mean Difference (I-J)	Sig.
Plain	Agriculture	673.50*	.018	11.00	.224
	Gardens	1979.00*	.000	25.50*	.020
	shrubland	1569.50*	.000	2.00	.813
	Woodland	2273.00*	.000	9.00	.310
	Erica	2199.00*	.000	34.00*	.006
Agriculture	Gardens	1305.500*	.001	14.50	.124
	shrubland	896.00*	.005	-9.00	.310
	Woodland	1599.50*	.000	-2.00	.813
	Erica	1525.50*	.000	23.00*	.030
Gardens	shrubland	-409.50	.096	-23.50*	.027
	Woodland	294.00	.207	-16.50	.088
	Erica	220.00	.330	8.50	.335
shrubland	Woodland	703.50*	.015	7.00	.421
	Erica	629.50*	.023	32.00*	.008
Woodland	*Erica*	-74.00	.734	25.00*	.022

*. The mean difference is significant at the 0.05 level

Abundance rank score using encounter rate is given in Table 5. Ordinal scales of avian abundance rank in the study period are shown as appendices (appendixes 1-12).

Generally, abundant species were higher during the wet season than during the dry season. During both seasons, the uncommon ranks were high.

Table 5. Relative abundance of avian species during the wet and dry season using encounter rates

		Abundance rank				
Habitat	Season	Rare	Uncommon	Frequent	Common	Abundant
Plain	wet	2	17	15	6	8
	dry	7	30	12	17	6
Agriculture	wet	2	14	10	17	3
	dry	1	20	14	14	1
Gardens	wet	-	14	8	7	3
	dry	-	15	9	10	3
Woodland	wet	-	18	12	16	2
	dry	-	20	21	12	1
Shrubland	wet	2	19	14	11	7
	dry	-	25	15	15	8
Erica	wet	1	7	8	5	3
	dry	2	11	8	6	1

The highest common species recorded between two habitats as shown in Table 6 was, between agriculture and shrubland habitat during the dry season (common species=49) followed by plain habitat during the wet season and plain habitat during the dry season (common species=45). The lowest common species were recorded among habitats of *Erica* and gardens in both seasons (common species= 10).

Table 6. Number of common species of birds recorded in all the habitat types.

Habitat		Plain		Agriculture		Gardens		Woodland		Shrubland		*Erica*	
	Season	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	
Plain	wet	45	32	31	15	16	22	21	30	30	19	19	
	dry		35	41	17	22	25	30	33	41	22	24	
Agriculture	wet			35	20	21	26	26	34	35	20	19	
	dry				23	26	27	32	39	49	20	20	
Gardens	wet					30	27	26	29	28	10	10	
	dry						26	29	28	32	10	10	
Woodland	wet							43	37	36	16	16	
	dry								37	44	15	17	
Shrubland	wet									36	18	17	
	dry										19	19	
Erica	wet											20	

Species Similarity

The highest species similarity was obtained between garden habitats during the wet and dry seasons (SI=0.87) followed by between agriculture and shrubland habitat during the dry season (SI=0.85). The least species similarity between habitats recorded was between garden habitat during the wet season and *Erica* habitat during the dry season (Table 7).

Table 7. Species similarity (proportion) of common species within and among habitats during both seasons.

Habitat	Season	Plain		Agriculture		Gardens		Woodland		Shrubland		*Erica*	
		wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry
Plain	wet	1.00	0.74	0.67	0.61	0.37	0.37	0.45	0.41	0.59	0.54	0.52	0.49
	dry		1.00	0.59	0.66	0.32	0.40	0.41	0.47	0.53	0.60	0.45	0.48
Agriculture	wet			1.00	0.71	0.51	0.51	0.55	0.52	0.69	0.64	0.57	0.51
	dry				1.00	0.55	0.58	0.54	0.60	0.75	0.85	0.53	0.50
Gardens	wet					1.00	0.87	0.68	0.60	0.69	0.59	0.36	0.33
	dry						1.00	0.61	0.64	0.63	0.64	0.33	0.31
Woodland	wet							1.00	0.84	0.74	0.65	0.44	0.42
	dry								1.00	0.70	0.75	0.38	0.41
Shrubland	wet									1.00	0.63	0.47	0.43
	dry										1.00	0.44	0.42
Erica	wet											1.00	0.77
	dry												1.00

4. DISCUSSION

Five endemic species of Ethiopia and seven endemic species shared with Eritrea are recorded from this study area. Therefore Geto and Gembejo can be considered as Important Bird Areas as endemic bird species occur in this area. Species that are greatest conservation concern exist at low level of population size. These areas also hold six globally threatened species. One species is endemic to Ethiopia and the second one is endemic to Ethiopia and Eritrea. Wattled Crane, Lesser Kestrel, Pallid Harrier and Great Snipe are globally threatened species. These species are uncommon to find in the study areas as they are rated on encounter rate scale. They were recorded through repeated visit to the study site. This low level population may be due to unsuitability of habitat for these globally threatened species.

Relatively, the plain habitat has high diversity of birds. This may be due to the abundant food especially during wet season as many of invertebrates breed in the marshy habitats. The next high diversity of birds was in the shrubland habitat may be due to the diverse array of micro-habitat like trees, openland, grassland and shrubs. Generally, the number of bird species increased during the dry season as a result of the arrival of migratory birds to the study site. The seasonal variation species richness is significant at plain and shrubland habitat. This was mainly due arrival of the migratory birds and they select these habitats.

Even though greater species diversity was recorded during the dry season, abundance birds were greater during the wet season. This is due to abundant resource availability for many of the bird species during the wet season. The seasonal abundance variations of plain and agricultural habitat are significantly different. This is due to temporal change in the habitat components. Morris *et al*. (1958) stated that when there is an outbreak of insects, many bird species switch to feed on such insects. As a result of this, birds immigrate into an area experience an outbreak. In this study area during wet season there was abundant flying insect at the same time there was abundant swifts, swallows and martins in numerous numbers feeding on aerial insects. Many of the birds decreased in abundance during the dry season as food source became scarce. The plain tends to dry during the dry season. This created unfavorable condition for reproduction of many

of the invertebrates which birds use as food. The agricultural area affects the abundance of birds as seasonal crops are harvested.

The distribution, richness and abundance of many bird species are determined by the configuration and composition of the habitat components that comprises a major element of their habitat (Block and Brennan, 1993). Species diversity of this study area is related to the number of food guilds exist within the habitats. Some of the habitats contain diverse guilds, which increases the diversity and abundance of species as some groups of birds feed on invertebrates and insects, some on flowers, some on seeds and some parts of the plants like leaves.

As habitat changed across the study area, any particular bird species may appear, increase in abundance, decrease, and absent as habitat becomes more or less suitable for its persistence. These changes in individual species abundance, whether they occur independently of one another or influenced by interactions with other bird species (Wiens, 1989; Cody, 1974), create a dynamic assemblage of species, leading to the expectation that changes in habitats should be mirrored by changes in the composition of avian communities.

Features in the habitat such as the physical structure or configuration of the vegetation (physiognomy) and its plant species composition (floristics) (Rotenberry, 1985; Block and Brennan, 1993) affect birds. Based on an analysis of structurally simple grassland and shrubsland habitat types, Rotenberry (1985) observed that physiognomic features appeared to be more important among-habitat comparisons. All habitats the study area have different physical structure and configuration.

The woodland has the highest species diversity and evenness index. This was due to the rich habitat diversity that woodland presents with respect to both structure and species composition of their dominant element, trees. As different tree species provide different opportunities for foraging (in terms of both the food items they support and the microhabitats in which to seek those items), placement of nests, and sheltering from the predators, it is reasonable to suppose that different assemblages of birds will be found in different assemblages of trees as observed in the field.

According to IUCN (2008), out of the 15 endemic birds of Ethiopia, 10 are threatened species and out of the10,027 described bird species of the world 1,240 bird species threatened species, (12% of described species). In the present study area, one species is endemic and globally threatened. Its current status is uncommon in this study area. EWHNS (1996) and Collar *et al*. (1994) stated that 32 of the Ethiopian bird species are threatened. Accordingly, this study area holds six globally threatened species. So, more emphasis should be given to protect such localities.

In Geto and Gembejo, *Erica* community has a lower diversity and evenness index than the other habitat types. This may be due to the uniform habitat of ericaceous vegetation and the occurrence of frequent fire.

Some birds occur in all habitats. For instance, swifts and swallows were in all habitats in the area during the wet season. The seasonal variation in bird abundance related to habitat status and other resources. It was realized that some birds stay in the same habitat in both seasons either in fluctuating or stable number as some of them change their habitat or migrate from the area. For instance, Yellow bishop use cropland and bushland areas during crops were on the field. When crop was harvested they tend to concentrate to bushland and woodland areas. The population of Egyptian Goose decreased by 40% during the dry season in the plain as some of them migrate to other places. This movement is related to the habitat quality and abundance of food resources. In the plain area, during the wet season most birds evenly distributed. During dry season birds tend to concentrate in areas of having resources.

Species composition and number of individuals differed in different habitats within and among the six habitats of Geto and Gembejo. This difference in habitat selection is due to the evolutionary factors conferring survival value on habitat selection and behavioural factors (Bartholomew, 1958). The six habitats have different levels of vegetation composition, which results in different level food availability for birds. It is known that suitability of habitats for birds can be affected by food supply and shelter (Whittaker, 1975).

Conservation issues and Threats

Areas unsuitable for agriculture production within the study area can have multifunctional importance: soil protection, water catchment protection, flood control protection, riparian buffer protection, wildlife protection and rare ecosystem protection. However, these have deteriorated due to agricultural expansion. This highland vegetation is useful for collection of fuel wood, construction materials, medicinal plants, ground water holding and for grazing. It also provides food, shelter and breeding areas for many birds other wild animals. This vegetation also prevents soil erosion and regulates the watershed in the surrounding area. Some of the habitats are important water catchment for many rivers. Even though this area has multiuse, it is now under severe pressure of destruction caused by deforestation.

The threat to the biodiversity of the present study area is mainly man-made. The demographic growth and the increasing negative human activities have greatly reduced the resources in the study area leading to conflicts with the objectives of sustainable development.

Eucalyptus globules is dominating the riverine and the marginal land as it is needed for economic return and construction material for the local people. It is the major threat for the indigenous trees and other biodiversity of the area. It is also expanding to agricultural land. This plant is transported and sold nearby towns including Addis Ababa. The local people should be informed in making decision on *Eucalyptus* plantation. It threatens the plain habitats as plantation has already expanded through the periphery.

Most of the shrubland, woodland and hill terrains are being converted to agricultural land and bareland resulting in erosion. As a result the biodiversity of the area is being reduced. This will have negative effects on birds.

Farmers started drying these wetlands by making channels and dams at the edge of the plain following their private land nearby the plain area (Plate 7). Previously, this plain was used as communal land. This activity resulted in the destruction of the breeding grounds available for some of the birds specially the endemic birds like blue winged goose. The destruction and conversion of this area to agricultural land will definitely affect the food source and breeding ground of some of birds.

Plate 7. Threats to the biodiversity of the area and bird species

As a result of fuel wood collection, intense grazing and farming, the study area is extremely threatened. Deliberate fire is also a major threat to ericaceous vegetation. This activity may result in the elimination of fire sensitive plants to get fresh grazing ground. The second reason why they burn this habitat is for the security of their livestock from thieves and wildlife predators like jackal and hyenas. At the time, left over *Erica*, which is dry will serve for the purpose of firewood consumption.

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Ornithological importance of the area is unquestionable as it holds range restricted species and globally threatened species. This study area is the home of some globally threatened species as well as endemic birds of Ethiopia. But, the area is given less attention of conservation action.

The current effort to conserve these areas and its avian diversity is scarce and the long term survival of range restricted birds are threatened by ongoing and expanding changes in land-use system and vegetation changes. No conservation effort is given to this study area, to tackle problems of severe deforestation, and land degradation from severe human pressure. Habitat degradation and loss is the major threat. The majority of birds are threatened by burning of vegetation, commercial logging, subsistence farming and plantations. A decline in the quality of the habitat can be detrimental as the loss of the habitat.

The conservation of Geto and Gembejo afroalpine habitat is very important for the ecological and hydrological systems of the Gembejo Mountains, including the afroalpine and montane habitats used by diverse types of species including rare and endemic species while also contributing to the social and economic well being of the present and future generations. The hydrological system of the area is very important for the local and downstream users. Local communities partially or totally depend on many of its natural resources such as grass, timber and non-timber forest products and fuel wood.

Most of the land in the area is steep slope and is highly exposed to soil erosion. The main threats facing this area are human pressure for agricultural expansion and demand for grazing land. Some of the birds share their ranges with human settlements. Birds still struggle to survive in these interfered habitats as local people change the land-use system. The plain area is being converted to agricultural land and garden areas for home garden products. This human activity caused the loss of habitat for birds especially the breeding grounds of Blue winged goose. There is no guarantee for future of many of the biodiversity in the area as there is no conservation effort.

5.2. Recommendations

It is important to prepare nursery site for indigenous tree seedling to promote indigenous tree rehabilitation.

The main cause of the degradation of the habitat of the area is the low level of the community livelihood; and therefore it is important to improve the livelihood of the community.

Coordinated conservation effort is very important to lessen the danger to biodiversity of the area. The government should attempt to mobilize the local community to tackle the problems of soil erosion and land degradation. Conservation and enhancement of biodiversity of the area should involve all stakeholders: farmers, local and international NGOs, governmental institution, researchers, fund raising body and other bodies, who have interest on the biodiversity of the area.

Creation of awareness about the increasing need to pursue conservation strategy, which enables to safeguard the biodiversity and their habitats in particular, should be developed.

Bird species depend on various habitats. Unless the threat is removed, survival of species are in question. Therefore, the following recommendations are forwarded for the protection and conserving of bird populations:

- Important breeding sites, especially sensitive habitats, such as marshy plain area should be protected.
- Habitat loss and fragmentation should be reduced through planning and good management practices and protecting important habitats
- The amount of habitat available should be increased through ecological restoration and enhancement.
- Education should be given to the public about the importance of birds and the need to protect and restore the habitats.
- Management action should be supported by research followed by monitoring scheme to obtain information on the status of species and their threats.

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Appendices

Appendix 1. Encounter rate of birds in the plain habitat during the wet season.

Species	Number of individuals /10 hours	Rank	Class or relative abundance
Erlanger's Lark	7.67	3	Frequent
Thekla (Short Crested) Lark	8.67	3	Frequent
Alpine Swift	0.33	2	Uncommon
Little Swift	0.09	1	Rare
Mottled Swift	66.67	5	Abundant
Pectoral-patch Cisticola	0.67	2	Uncommon
Tawny-flanked Prinia	0.11	2	Uncommon
Winding (Ethiopian) Cisticola	2.56	3	Frequent
Yellow-bellied Waxbill	2.67	3	Frequent
Black Headed Siskin	0.33	2	Uncommon
Brown-rumped Seedeater	14.00	4	Common
Streaky Seedeater	6.33	3	Frequent
Banded Martin	66.67	5	Abundant
Ethiopian Swallow	30.67	4	Common
Mosque Swallow	66.67	5	Abundant
Red-chested Swallow	83.33	5	Abundant
Rock Martin	40.00	4	Common
Common Fiscal	0.33	2	Uncommon
Tropical Boubou	0.33	2	Uncommon
Abyssinian Long Claw	0.33	2	Uncommon
African Pied Wagtail	3.00	3	Frequent
Grassland (African) Pipit	16.67	4	Common
Mountain Wagtail	1.33	2	Uncommon
Alpine (Moorland) Chat	2.67	3	Frequent
Red-breasted Wheatear	0.08	1	Rare
Yellow Bishop	4.00	3	Frequent

Pin-tailed Whydah	1.56	2	Uncommon
Spot-breasted Lapwing (Plover)	10.67	4	Common
Dusky Turtle Dove	0.67	2	Uncommon
Speckled Pigeon	0.11	2	Uncommon
African Jacana	9.78	3	Frequent
Rouget's Rail	2.00	2	Uncommon
African (Ethiopian) Snipe	6.00	3	Frequent
Hamerkop	6.11	3	Frequent
Red-billed Oxpecker	1.33	2	Uncommon
Groundscraper Thrush	6.22	3	Frequent
Moutain (Olive) Thrush	3.00	3	Frequent
Augur Buzzard	0.56	2	Uncommon
Hooded Vulture	1.00	2	Uncommon
Yellow billed Kite	4.00	3	Frequent
Egyptian Goose	63.33	5	Abundant
Blue-winged Goose	116.67	5	Abundant
Yellow-billed Duck	2.22	3	Frequent
Cape Crow (Cape Rook)	173.33	5	Abundant
Pied Crow	0.11	2	Uncommon
Wattled Crane	1.67	2	Uncommon
Hadada Ibis	5.00	3	Frequent
Wattled Ibis	173.33	5	Abundant
Sacred Ibis	25.78	4	Common

Appendix 2. Encounter rate of birds in the plain habitat during the dry season.

Species	Number of individuals /10 hours	Rank	Class or relative abundance
Erlanger's Lark	11.67	4	Common
Thekla (Short Crested) Lark	16.33	4	Common
Alpine Swift	0.09	1	Rare
Little Swift	0.33	2	Uncommon
Mottled Swift	26.67	4	Common
Buff-bellied Warbler	0.08	1	Rare
Pectoral-patch Cisticola	10.33	4	Common
Stout Cisticola	0.33	2	Uncommon
Tawny-flanked Prinia	2.00	2	Uncommon
Winding (Ethiopian) Cisticola	2.67	3	Frequent
Yellow-bellied Waxbill	5.00	3	Frequent
Black Headed (Ethiopian) Siskin	2.33	3	Frequent
Brown-rumped Seedeater	25.33	4	Common
Streaky Seedeater	27.00	4	Common
Banded Martin	27.67	4	Common
Barn Swallow	73.33	5	Abundant
Ethiopian Swallow	3.00	3	Frequent
Mosque Swallow	0.08	1	Rare
Red-chested Swallow	11.67	4	Common
Red-rumped Swallow	37.33	4	Common
Rock Martin	9.33	3	Frequent
Common Fiscal or Fiscal Shrike	0.33	2	Uncommon
Tropical Boubou	0.33	2	Uncommon
Abyssinian Long Claw	0.33	2	Uncommon
African Pied Wagtail	0.33	2	Uncommon
Grassland (African) Pipit	26.67	4	Common
Mountain Wagtail	0.09	1	Rare

Tawny Pipit	7.00	3	Frequent
White Wagtail	1.67	2	Uncommon
Yellow Wagtail	77.00	5	Abundant
African (Common) Stonechat	0.33	2	Uncommon
Alpine (Moorland) Chat	26.67	4	Common
Isabelline Wheatear	0.08	1	Rare
Northern Wheatear	0.33	2	Uncommon
Red-breasted Wheatear	26.33	4	Common
Yellow Bishop	26.78	4	Common
Pin-tailed Whydah	2.89	3	Frequent
Spot-breasted Lapwing (Plover)	3.33	3	Frequent
Dusky Turtle Dove	3.33	3	Frequent
Speckled Pigeon	1.67	2	Uncommon
White-collared Pigeon	73.67	5	Abundant
Erckel's Francolin	0.67	2	Uncommon
Rouget's Rail	2.33	3	Frequent
Common Sandpiper	0.33	2	Uncommon
Common Snipe	0.33	2	Uncommon
Great Snipe	0.09	1	Rare
Jack Snipe	4.00	3	Frequent
Little Stint	0.09	1	Rare
Marsh Sandpiper	0.67	2	Uncommon
Ruff	0.33	2	Uncommon
Wood Sandpiper	0.67	2	Uncommon
Red-billed Oxpecker	0.33	2	Uncommon
Groundscraper Thrush	22.00	4	Common
Moutain (Olive) Thrush	11.78	4	Common
Augur Buzzard	0.22	2	Uncommon
Black Kite	0.67	2	Uncommon
Yellow billed Kite	5.00	3	Frequent
Black-shouldered (Winged) Kite	1.00	2	Uncommon

Hooded Vulture	0.33	2	Uncommon
White-headed Vulture	0.33	2	Uncommon
Pallid Harrier	0.33	2	Uncommon
African Black Duck	0.33	2	Uncommon
Egyptian Goose	26.67	4	Common
Blue-winged Goose	95.00	5	Abundant
Yellow-billed Duck	2.00	2	Uncommon
Abyssinian Ground Hornbill	0.33	2	Uncommon
Cape Crow (Cape Rook)	64.00	5	Abundant
Pied Crow	0.33	2	Uncommon
Common Kestrel	1.00	2	Uncommon
Lesser Kestrel	0.33	2	Uncommon
Hadada Ibis	6.67	3	Frequent
Wattled Ibis	106.67	5	Abundant
Sacred Ibis	10.33	4	Common

Appendix 3. Encounter rate of birds in the farmland habitat during the wet season.

Species	Number of individuals /10 hours	Rank	Class or relative abundance
Thekla (Short Crested) Lark	22.40	4	Common
Alpine Swift	0.09	1	Rare
Little Swift	0.20	2	Uncommon
Mottled Swift	18.00	4	Common
Pectoral-patch Cisticola	8.60	3	Frequent
Tawny-flanked Prinia	10.60	4	Common
Winding (Ethiopian) Cisticola	10.40	4	Common
Red-billed Firefinch	0.20	2	Uncommon
Yellow-bellied Waxbill	10.20	4	Common
Black Headed (Ethiopian) Siskin	30.60	4	Common
Brown-rumped Seedeater	42.40	5	Abundant
Streaky Seedeater	24.20	4	Common
Ethiopian Swallow	15.60	4	Common
Mosque Swallow	6.20	3	Frequent
Red-chested Swallow	18.80	4	Common
Rock Martin	14.00	4	Common
Abyssinian Long Claw	0.20	2	Uncommon
African Pied Wagtail	0.20	2	Uncommon
Grassland (African) Pipit	3.00	3	Frequent
Mountain Wagtail	0.20	2	Uncommon
Swainson's Sparrow	1.80	2	Uncommon
Alpine (Moorland) Chat	42.00	5	Abundant
Tacazze Sunbird	5.60	3	Frequent
Variable Sunbird	1.20	2	Uncommon
Baglafecht Weaver	12.00	4	Common
Speke's Weaver	7.40	3	Frequent
Yellow Bishop	84.20	5	Abundant

Pin-tailed Whydah	1.00	2	Uncommon
Montane White-eye	0.80	2	Uncommon
Dusky Turtle Dove	12.40	4	Common
Speckled Pigeon	12.60	4	Common
White-collared Pigeon	29.20	4	Common
Erckel's Francolin	5.60	3	Frequent
Greater Blue-eared Starling	0.80	2	Uncommon
Red-winged Starling	5.60	3	Frequent
Groundscraper Thrush	12.60	4	Common
Moutain (Olive) Thrush	25.20	4	Common
Augur Buzzard	2.60	3	Frequent
Yellow billed Kite	9.00	3	Frequent
Hooded Vulture	1.40	2	Uncommon
White-headed Vulture	0.20	2	Uncommon
Cape Crow (Cape Rook)	3.40	3	Frequent
Pied Crow	0.20	2	Uncommon
Thick-billed Raven	0.60	2	Uncommon
African Hobby	0.09	1	Rare
Wattled Ibis	16.80	4	Common

Appendix 4. Encounter rate of birds in the farmland habitat during the dry season.

Species	Number of individuals /10 hours	Rank	Class or relative abundance
Erlanger's Lark	0.09	1	Rare
Thekla (Short Crested) Lark	22	4	Common
Alpine Swift	0.2	2	Uncommon
Little Swift	0.2	2	Uncommon
Mottled Swift	8.4	3	Frequent
Pectoral-patch Cisticola	7.8	3	Frequent
Tawny-flanked Prinia	10.6	4	Common
Winding (Ethiopian) Cisticola	5.6	3	Frequent
Yellow-bellied Waxbill	9.6	3	Frequent
Black Headed Siskin	24.2	4	Common
Brown-rumped Seedeater	39.6	4	Common
Streaky Seedeater	22.4	4	Common
Ethiopian Swallow	3.2	3	Frequent
Barn Swallow	19.2	4	Common
Mosque Swallow	3.8	3	Frequent
Red-chested Swallow	6.2	3	Frequent
Rock Martin	6.8	3	Frequent
Abyssinian Long Claw	0.2	2	Uncommon
African Pied Wagtail	0.2	2	Uncommon
Grassland (African) Pipit	4	3	Frequent
Mountain Wagtail	0.2	2	Uncommon
Swainson's Sparrow	1.6	2	Uncommon
Alpine (Moorland) Chat	38.2	4	Common
Yellow Wagtail	0.2	2	Uncommon
Tacazze Sunbird	5.67	3	Frequent
Variable Sunbird	1.13	2	Uncommon

Baglafecht Weaver	11.93	4	Common
Speke's Weaver	7.4	3	Frequent
Yellow Bishop	40.2	5	Abundant
Pin-tailed Whydah	0.93	2	Uncommon
Dusky Turtle Dove	12.4	4	Common
Speckled Pigeon	12.53	4	Common
Greater Blue-eared Starling	1.2	2	Uncommon
White-collared Pigeon	29.13	4	Common
Erckel's Francolin	3.47	3	Frequent
Red-winged Starling	5.6	3	Frequent
Groundscraper Thrush	12.67	4	Common
Moutain (Olive) Thrush	25.27	4	Common
Augur Buzzard	2.6	3	Frequent
Black Kite	0.6	2	Uncommon
Yellow billed Kite	2.4	3	Frequent
Black-shouldered Kite	2	2	Uncommon
Pallid Harrier	0.2	2	Uncommon
Hooded Vulture	1.4	2	Uncommon
Rufous-chested Sparrowhawk	0.87	2	Uncommon
Tawny Eagle	0.33	2	Uncommon
White-headed Vulture	0.6	2	Uncommon
Cape Crow (Cape Rook)	2	2	Uncommon
Pied Crow	0.8	2	Uncommon
Thick-billed Raven	0.6	2	Uncommon
African Hobby	0.2	2	Uncommon
Wattled Ibis	25.2	4	Common

Appendix 5. Encounter rate of birds in the home gardens habitat during the wet season.

Species	Number of individuals /10 hours	Rank	Class or relative abundance
Tawny-flanked Prinia	9.20	3	Frequent
Red-billed Firefinch	0.40	2	Uncommon
Yellow-bellied Waxbill	11.60	4	Common
Brown-rumped Seedeater	60.00	5	Abundant
Streaky Seedeater	26.40	4	Common
Red-chested Swallow	0.40	2	Uncommon
Swainson's Sparrow	1.60	2	Uncommon
Abyssinian Slaty Flycatcher	0.40	2	Uncommon
African Dusky Flycatcher	0.40	2	Uncommon
Alpine (Moorland) Chat	71.60	5	Abundant
Rüppell's Robin-Chat	5.20	3	Frequent
Beautiful Sunbird	0.40	2	Uncommon
Malachite Sunbird	0.40	2	Uncommon
Tacazze Sunbird	11.20	4	Common
Variable Sunbird	2.80	3	Frequent
Baglafecht Weaver	6.00	3	Frequent
Speke's Weaver	0.40	2	Uncommon
Yellow Bishop	79.60	5	Abundant
Montane White-eye	6.40	3	Frequent
Cinnamon Bracken Warbler	0.40	2	Uncommon
Abyssinian Catbird	0.40	2	Uncommon
Dusky Turtle Dove	3.20	3	Frequent
Speckled Pigeon	3.60	3	Frequent
White-collared Pigeon	4.00	3	Frequent
Erckel's Francolin	13.60	4	Common
Red-winged Starling	13.60	4	Common

Groundscraper Thrush	19.60	4	Common
Moutain (Olive) Thrush	29.20	4	Common
Augur Buzzard	1.60	2	Uncommon
Yellow billed Kite	2.00	2	Uncommon
Pied Crow	0.40	2	Uncommon
Wattled Ibis	0.80	2	Uncommon

Appendix 6 Encounter rate of birds in the home gardens habitat during the dry season.

Species	Number of individuals /10 hours	Rank	Class or relative abundance
Buff-bellied Warbler	11.60	4	Common
Tawny-flanked Prinia	4.80	3	Frequent
Red-billed Firefinch	0.40	2	Uncommon
Yellow-bellied Waxbill	10.40	4	Common
Brown-rumped Seedeater	62.00	5	Abundant
Streaky Seedeater	25.20	4	Common
Red-chested Swallow	0.40	2	Uncommon
African Pied Wagtail	0.40	2	Uncommon
Swainson's Sparrow	0.80	2	Uncommon
Alpine (Moorland) Chat	63.20	5	Abundant
Rüppell's Robin-Chat	5.60	3	Frequent
Beautiful Sunbird	0.80	2	Uncommon
Malachite Sunbird	0.40	2	Uncommon
Tacazze Sunbird	15.20	4	Common
Variable Sunbird	3.20	3	Frequent
Baglafecht Weaver	6.80	3	Frequent
Speke's Weaver	0.40	2	Uncommon
Yellow Bishop	87.60	5	Abundant
Montane White-eye	12.80	4	Common

Cinnamon Bracken Warbler	0.40	2	Uncommon
Garden Warbler	36.00	4	Common
Willow Warbler	0.40	2	Uncommon
Abyssinian Catbird	0.40	2	Uncommon
Dusky Turtle Dove	4.00	3	Frequent
Speckled Pigeon	1.60	2	Uncommon
White-collared Pigeon	6.40	3	Frequent
Erckel's Francolin	19.20	4	Common
Red-winged Starling	14.40	4	Common
Groundscraper Thrush	24.00	4	Common
Moutain (Olive) Thrush	36.00	4	Common
Augur Buzzard	2.40	3	Frequent
Black Kite	1.60	2	Uncommon
Yellow billed Kite	3.00	3	Frequent
Pied Crow	0.40	2	Uncommon
Common Kestrel	0.80	2	Uncommon
Lesser Kestrel	0.40	2	Uncommon
Wattled Ibis	3.20	3	Frequent

Appendix 7. Encounter rate of birds in the woodland habitat during the wet season.

Species	Number of individuals /10 hours	Rank	Class or relative abundance
Alpine Swift	0.67	2	Uncommon
Little Swift	0.67	2	Uncommon
Mottled Swift	13.33	4	Common
Brown Woodland Warbler	0.67	2	Uncommon
Cinnamon Bracken Warbler	0.67	2	Uncommon
Tawny-flanked Prinia	14.00	4	Common
Red-billed Firefinch	0.67	2	Uncommon
Red-billed Pytilia	0.67	2	Uncommon
Yellow-bellied Waxbill	8.00	3	Frequent
Black Headed (Ethiopian) Siskin	12.00	4	Common
Brown-rumped Seedeater	29.33	4	Common
Streaky Seedeater	40.00	4	Common
Ethiopian Swallow	19.33	4	Common
Red-chested Swallow	19.33	4	Common
Common Fiscal or Fiscal Shrike	4.67	3	Frequent
African Pied Wagtail	0.67	2	Uncommon
Mountain Wagtail	0.67	2	Uncommon
Abyssinian Slaty Flycatcher	0.67	2	Uncommon
African Dusky Flycatcher	0.67	2	Uncommon
Alpine (Moorland) Chat	64.67	5	Abundant
Rüppell's Robin-Chat	11.33	4	Common
Beautiful Sunbird	10.00	3	Frequent
Malachite Sunbird	4.00	3	Frequent
Shining Sunbird	4.67	3	Frequent
Tacazze Sunbird	16.00	4	Common
Variable Sunbird	6.67	3	Frequent

White-backed Black Tit	28.67	4	Common
Baglafecht Weaver	7.33	3	Frequent
Speke's Weaver	0.67	2	Uncommon
Yellow Bishop	72.00	5	Abundant
Montane White-eye	17.33	4	Common
Common Bulbul	5.33	3	Frequent
Abyssinian Catbird	12.67	4	Common
Dusky Turtle Dove	2.67	3	Frequent
Speckled Pigeon	2.00	2	Uncommon
White-collared Pigeon	0.67	2	Uncommon
White-cheeked Turaco	10.67	4	Common
Erckel's Francolin	17.33	4	Common
Black-winged Lovebird	0.67	2	Uncommon
Groundscraper Thrush	21.33	4	Common
Moutain (Olive) Thrush	34.00	4	Common
African Goshawk	0.67	2	Uncommon
Augur Buzzard	2.67	3	Frequent
Hooded Vulture	2.67	3	Frequent
White-headed Vulture	2.00	2	Uncommon
Yellow billed Kite	4.00	3	Frequent
Cape Eagle Owl	2.00	2	Uncommon
Greyish Eagle Owl	2.00	2	Uncommon

Appendix 8. Encounter rate of birds in the Woodland habitat during the dry season.

Species	Number of individuals /10 hours	Rank	Class or relative abundance
Alpine Swift	0.67	2	Uncommon
Little Swift	0.67	2	Uncommon
Mottled Swift	0.67	2	Uncommon
Tawny-flanked Prinia	15.33	4	Common
Red-billed Firefinch	0.67	2	Uncommon
Red-billed Pytilia	0.67	2	Uncommon
Yellow-bellied Waxbill	7.33	3	Frequent
Black Headed (Ethiopian) Siskin	16.00	4	Common
Brown-rumped Seedeater	30.67	4	Common
Streaky Seedeater	38.67	4	Common
Barn Swallow	8.00	3	Frequent
Common House Martin	2.00	2	Uncommon
Ethiopian Swallow	5.33	3	Frequent
Red-chested Swallow	6.00	3	Frequent
Red-rumped Swallow	5.33	3	Frequent
Common Fiscal or Fiscal Shrike	7.33	3	Frequent
African Pied Wagtail	0.67	2	Uncommon
Grassland (African) Pipit	0.67	2	Uncommon
White Wagtail	0.67	2	Uncommon
Alpine (Moorland) Chat	72.00	5	Abundant
Nightingale species	0.67	2	Uncommon
Rüppell's Robin-Chat	10.00	3	Frequent
Beautiful Sunbird	10.00	3	Frequent
Malachite Sunbird	4.00	3	Frequent
Shining Sunbird	4.67	3	Frequent
Tacazze Sunbird	17.33	4	Common

Variable Sunbird	7.33	3	Frequent
White-backed Black Tit	28.67	4	Common
Baglafecht Weaver	7.33	3	Frequent
Speke's Weaver	0.67	2	Uncommon
Abyssinian Woodpecker	0.67	2	Uncommon
Montane White-eye	21.33	4	Common
Cinnamon Bracken Warbler	0.67	2	Uncommon
Brown Woodland Warbler	0.67	2	Uncommon
Garden Warbler	12.67	4	Common
Common Bulbul	5.33	3	Frequent
Abyssinian Catbird	16.00	4	Common
Dusky Turtle Dove	3.33	3	Frequent
Speckled Pigeon	5.33	3	Frequent
White-collared Pigeon	5.33	3	Frequent
White-cheeked Turaco	8.00	3	Frequent
Erckel's Francolin	19.33	4	Common
Black-winged Lovebird	0.67	2	Uncommon
Groundscraper Thrush	31.33	4	Common
Moutain (Olive) Thrush	30.67	4	Common
African Goshawk	0.67	2	Uncommon
Augur Buzzard	6.67	3	Frequent
Black Kite	1.33	2	Uncommon
Hooded Vulture	3.33	3	Frequent
White-headed Vulture	2.00	2	Uncommon
Pallid Harrier	0.67	2	Uncommon
Yellow billed Kite	6.40	3	Frequent
Cape Eagle Owl	2.00	2	Uncommon
Greyish Eagle Owl	2.67	3	Frequent

Appendix 9. Encounter rate of birds in the shrubland with scattered tree habitat during the wet season.

Species	Number of individuals /10 hours	Rank	Class or relative abundance
Erlanger's Lark	0.67	2	Uncommon
Thekla (Short Crested) Lark	39.33	4	Common
Alpine Swift	0.67	2	Uncommon
Little Swift	0.67	2	Uncommon
Mottled Swift	40.00	4	Common
Pectoral-patch Cisticola	27.33	4	Common
Tawny-flanked Prinia	10.00	3	Frequent
African Firefinch	0.09	1	Rare
Yellow-bellied Waxbill	23.33	4	Common
Black Headed (Ethiopian) Siskin	45.33	5	Abundant
Brown-rumped Seedeater	148.67	5	Abundant
Streaky Seedeater	56.67	5	Abundant
Ethiopian Swallow	14.67	4	Common
Mosque Swallow	0.67	2	Uncommon
Red-chested Swallow	20.00	4	Common
Rock Martin	4.00	3	Frequent
African Pied Wagtail	0.67	2	Uncommon
Grassland (African) Pipit	0.67	2	Uncommon
Mountain Wagtail	0.67	2	Uncommon
Swainson's Sparrow	2.67	3	Frequent
Abyssinian Slaty Flycatcher	0.67	2	Uncommon
African Dusky Flycatcher	0.67	2	Uncommon
Alpine (Moorland) Chat	130.00	5	Abundant
Rüppell's Robin-Chat	9.33	3	Frequent
Beautiful Sunbird	3.33	3	Frequent
Malachite Sunbird	4.67	3	Frequent

Variable Sunbird	4.00	3	Frequent
White-backed Black Tit	0.67	2	Uncommon
Baglafecht Weaver	20.00	4	Common
Speke's Weaver	0.67	2	Uncommon
Yellow Bishop	112.67	5	Abundant
Pin-tailed Whydah	0.09	1	Rare
Montane (Broad-ringed) White-eye	10.00	3	Frequent
Cinnamon Bracken Warbler	8.00	3	Frequent
Brown Woodland Warbler	16.00	4	Common
Abyssinian Catbird	0.67	2	Uncommon
Dusky Turtle Dove	14.67	4	Common
Speckled Pigeon	2.00	2	Uncommon
White-collared Pigeon	16.00	4	Common
Erckel's Francolin	2.67	3	Frequent
Red-winged Starling	14.67	4	Common
Groundscraper Thrush	62.00	5	Abundant
Moutain (Olive) Thrush	78.67	5	Abundant
African Goshawk	0.67	2	Uncommon
Augur Buzzard	7.33	3	Frequent
Hooded Vulture	2.00	2	Uncommon
White-headed Vulture	0.67	2	Uncommon
Yellow billed Kite	3.40	3	Frequent
Cape Crow (Cape Rook)	2.67	3	Frequent
Thick-billed Raven	2.67	3	Frequent
African Hobby	0.67	2	Uncommon
Wattled Ibis	0.67	2	Uncommon
Cape Eagle Owl	1.33	2	Uncommon

Appendix 10. Encounter rate of birds in the shrubland with scattered tree habitat during the dry season.

Species	Number of individuals /10 hours	Rank	Class or relative abundance
Erlanger's Lark	4.67	3	Frequent
Thekla (Short Crested) Lark	41.33	5	Abundant
Alpine Swift	0.67	2	Uncommon
Little Swift	0.67	2	Uncommon
Mottled Swift	16.67	4	Common
Pectoral-patch Cisticola	34.67	4	Common
Tawny-flanked Prinia	13.33	4	Common
Yellow-bellied Waxbill	24.67	4	Common
Black Headed (Ethiopian) Siskin	48.00	5	Abundant
Brown-rumped Seedeater	84.00	5	Abundant
Streaky Seedeater	57.33	5	Abundant
Barn Swallow	16.00	4	Common
Ethiopian Swallow	6.67	3	Frequent
Mosque Swallow	0.67	2	Uncommon
Red-chested Swallow	8.00	3	Frequent
Red-rumped Swallow	10.67	4	Common
Rock Martin	0.67	2	Uncommon
African Pied Wagtail	0.67	2	Uncommon
Grassland (African) Pipit	0.67	2	Uncommon
Mountain Wagtail	0.67	2	Uncommon
White Wagtail	0.67	2	Uncommon
Yellow Wagtail	14.00	4	Common
Tree Pipit	0.67	2	Uncommon
Swainson's Sparrow	6.00	3	Frequent
Alpine (Moorland) Chat	142.00	5	Abundant
Ruppell's Robin-Chat	6.67	3	Frequent

Beautiful Sunbird	5.33	3	Frequent
Malachite Sunbird	6.00	3	Frequent
Tacazze Sunbird	19.33	4	Common
Variable Sunbird	4.67	3	Frequent
White-backed Black Tit	0.67	2	Uncommon
Baglafecht Weaver	17.33	4	Common
Speke's Weaver	0.67	2	Uncommon
Yellow Bishop	116.00	5	Abundant
Pin-tailed Whydah	0.67	2	Uncommon
Montane White-eye	14.00	4	Common
Cinnamon Bracken Warbler	8.00	3	Frequent
Brown Woodland Warbler	16.00	4	Common
Garden Warbler	0.67	2	Uncommon
Abyssinian Catbird	0.67	2	Uncommon
Dusky Turtle Dove	17.33	4	Common
Speckled Pigeon	4.00	3	Frequent
White-collared Pigeon	22.67	4	Common
Erckel's Francolin	11.33	4	Common
Red-winged Starling	2.00	2	Uncommon
Groundscraper Thrush	64.00	5	Abundant
Moutain (Olive) Thrush	78.67	5	Abundant
African Goshawk	0.67	2	Uncommon
Augur Buzzard	6.67	3	Frequent
Black Kite	0.67	2	Uncommon
Black-shouldered (Winged) Kite	0.67	2	Uncommon
Hooded Vulture	2.67	3	Frequent
White-headed Vulture	0.67	2	Uncommon
Pallid Harrier	0.67	2	Uncommon
Rufous-chestedSparrowhawk	0.67	2	Uncommon
Tawny Eagle	0.67	2	Uncommon
Yellow billed Kite	6.40	3	Frequent

Cape Crow (Cape Rook)	16.00	4	Common
Common Kestrel	0.67	2	Uncommon
Thick-billed Raven	4.00	3	Frequent
African Hobby	0.67	2	Uncommon
Wattled Ibis	1.33	2	Uncommon
Cape Eagle Owl	3.33	3	Frequent

Appendix 11. Encounter rate of birds in the ericaceous habitat during the wet season.

	Number of individuals /10 hours	Rank	Class or relative abundance
Alpine Swift	0.38	2	Uncommon
Little Swift	0.38	2	Uncommon
Mottled Swift	58.46	5	Abundant
Pectoral-patch Cisticola	64.23	5	Abundant
Tawny-flanked Prinia	0.38	2	Uncommon
Winding (Ethiopian) Cisticola	0.09	1	Rare
Brown-rumped Seedeater	0.77	2	Uncommon
Streaky Seedeater	1.15	2	Uncommon
Banded Martin	18.85	4	Common
Ethiopian Swallow	27.69	4	Common
Red-chested Swallow	17.31	4	Common
Rock Martin	5.77	3	Frequent
Mountain Wagtail	7.69	3	Frequent
Alpine (Moorland) Chat	59.23	5	Abundant
Red-breasted Wheatear	7.31	3	Frequent
White-collared Pigeon	11.15	4	Common
Erckel's Francolin	10.77	4	Common
Augur Buzzard	2.31	3	Frequent

Hooded Vulture	0.77	2	Uncommon
White-headed Vulture	0.38	2	Uncommon
Yellow billed Kite	4.80	3	Frequent
Cape Crow (Cape Rook)	8.85	3	Frequent
Pied Crow	2.69	3	Frequent
Thick-billed Raven	3.46	3	Frequent

Appendix 12. Encounter rate of birds in the ericaceous habitat during the dry season.

Species	Number of individuals /10 hours	Rank	Class or relative abundance
Alpine Swift	0.09	1	Rare
Common (Eurasian) Swift	0.38	2	Uncommon
Little Swift	0.38	2	Uncommon
Mottled Swift	31.92	4	Common
Pectoral-patch Cisticola	0.38	2	Uncommon
Tawny-flanked Prinia	0.38	2	Uncommon
Winding Cisticola	0.38	2	Uncommon
Brown-rumped Seedeater	1.15	2	Uncommon
Streaky Seedeater	1.15	2	Uncommon
Banded Martin	10.00	3	Frequent
Barn Swallow	31.92	4	Common
Ethiopian Swallow	7.31	3	Frequent
Red-chested Swallow	4.23	3	Frequent
Red-rumped Swallow	19.62	4	Common
Rock Martin	12.31	4	Common
Mountain Wagtail	0.38	2	Uncommon
African (Common) Stonechat	10.00	3	Frequent
Alpine (Moorland) Chat	164.23	5	Abundant
Red-breasted Wheatear	0.09	1	Rare

White-collared Pigeon	11.54	4	Common
Erckel's Francolin	11.15	4	Common
Black-winged Lovebird	2.31	3	Frequent
Augur Buzzard	2.31	3	Frequent
Hooded Vulture	1.15	2	Uncommon
Lammergeier	0.38	2	Uncommon
Yellow billed Kite	5.20	3	Frequent
Cape Crow (Cape Rook)	9.62	3	Frequent
Pied Crow	1.54	2	Uncommon

Appendix 13. Point count data sheet

Point Count Data Sheet

Survey area _____ Date_____ Observer_____
Starting time _____ Finishing Time _____
Site description and habitat type _____
_____
_____
GPS location (starting) _____ Duration of count _____
Weather condition _____

Station No	Station code	Bird species (common name)	Number of individuals

Appendix 14. Line transect count data sheet

Line Transect Count Data Sheet

Survey area _____ Date_____ Start altitude_____
Observer_____ Site number_____ End altitude _____
Starting time _____ Finishing Time _____
Site description and habitat type _____
_____
_____
GPS location starting _____ Finishing _____
Weather condition _____

Transect No	Transect code	Bird species (common name)	Number of individuals

DECLARATION

I undersigned, declare that this thesis is my original work. It has not been for a degree in this or any other university and all the source materials used for this thesis have been properly acknowledged.

Name: Teklu Gosaye

Signature: _____

Date: July, 2011

The thesis has been submitted with my approval as a supervisor

Name: Professor Afework Bekele

Signature: _____

Date: July, 2011