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SPECIES COMPOSITION, DISTRIBUTION, RELATIVE ABUNDANCE AND HABITAT ASSOCIATION OF AVIFAUNA OF WOF WASHA NATIONAL FORESTRY PRIORITY AREA, ETHIOPIA

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TABLE OF CONTENTS

Page

LIST OF TABLES Page

LIST OF FIGURES Page

LIST OF PLATES Page

LIST OF APPENDICES

Page

Abstract: *Species composition, distribution, abundance and habitat association of birds were surveyed from Wof Washa National Forestry Priority Area (NFPA) and its surroundings along the Ankober-Debre Sina Escarpment from August 2007 to March 2008. Several major habitat types were identified that include dense forest, bushland, modified habitat, farmland, grassland and rocky areas. A point count method with fixed radius (radius = 25 m) and unlimited radius count and line transect methods were used during the study in randomly selected sites. Altogether 158 species of birds were recorded during the time of study. Among these 11 were intra-African migrants, 17 were Palearctic migrants, 4 were Ethiopian endemics, 9 were endemics shared with Eritrea, 101 were resident birds and 5 were globally threatened birds associated with diversified vegetation types of the area*. 22 and 35 species were recorded exclusively for the wet and dry season, respectively. *The most common habitat preference of avian species with the greatest diversity and richness was the interaction with indigenous plants that produce flowers/nectars, fruits and seeds in the forest habitat and barley crops in the farmland whereas the least interaction of birds was in areas with Eucalyptus plantation of the modified habitat. The abundance and distribution of birds among habitat types were significantly different ($P < 0.05$). The species distribution and abundance were affected by the vegetation type, season and the interaction between season and habitat types ($P < 0.05$). Wof Washa NFPA supports wide varieties of species of birds with relatively high number of endemics. The species richness of the area was increased with habitat heterogeneity that provides available resources for food and cover.*

Key words/Phrases: ***Avifauna, habitat association, relative abundance, seasonal variation, species diversity, species richness, Wof Washa***.

1. INTRODUCTION

Ethiopia is a country with a broad range of geomorphic provinces and encompasses a unique area in both culture and ecology. Ecologically, it has diverse sets of ecosystems, ranging from humid forest and extensive wetlands to deserts like the Afar Depression, supporting a wide variety of life forms (Hillman, 1993; EWNHS, 1996; Viveropol, 2001; http://www. Ethiopia-Wikipedia). The high and rugged mountains, deep gorges, incised river valleys and vast rolling plains of the country show its topographic diversity. The altitudinal difference with the highest peak at Ras Dashen (4,620 m above sea level) and a minimum of 116 m below sea level in the Afar Depression is the main reason that makes Ethiopia as one of the very few countries that are rich in biodiversity (Hillman, 1993; Shibru Tedla, 1995; EWNHS, 1996). These wide ranges of altitudes have given the country a variety of ecologically distinct areas with three climatic zones that lead to the evolution of endemic species as a result of ecological isolation.

The physical conditions and variations in altitudes have resulted in the diversity of climate, soil, flora and fauna. Moreover, the extensive and unique conditions especially in the highlands have contributed to the existence of high number of endemicity (Hillman, 1993; EWNHS, 1996; Viveropol, 2001; Horacio and Gebeyehu Bizuneh, 2003). The enormous geographical diversity with diverse habitat types contributes to the highly diversified avifauna and very high floristic diversity (Hillman, 1993; EWWHS, 1996). In comparison to other similar parts of the world, the wildlife of Ethiopia is rich in diversity (Hillman, 1993). Ethiopia is also distinguished from all other African countries by the extent of its highlands (Yalden, 1983) and is one of the most physically and biologically diverse countries in the world (Leykun Abune, 2000; http://www. Ethiopia-Wikipedia).

Habitats vary greatly in diversity and distribution of animal life, particularly that of birds (Wallace, 1955; Pomeroy, 1992). Topographical variability and temperature are identified as the most important global predictors of avian species richness (Karr, 1980; Davies *et al*., 2007). In terms of its avifauna, Ethiopia is one of the most significant countries among the mainland Africa (Urban and Brown, 1971). Its avifauna represents a mixture of east and west African, Palearctic and some strikingly unusual endemics. Currently, the Ethiopian Wildlife and Natural History Society (EWNHS) has identified 69 Important Bird Areas (IBAs) and three globally

recognized Endemic Bird Areas (EBAs) to Ethiopia. IBAs are internationally important for birds and to conserve much of the biodiversity. They are also key biodiversity areas (BirdLife International, 2007).

The present study was conducted in Wof Washa National Forestry Priority Area (NFPA) of North Shewa Zone of the Amhara Region. The region covers an area of 170,150 km^2, which is 11% of the total area of the country (EWNHS, 1996). Climatically, the region is divided into 'Kola' (hot zone), which covers 31% of the region, 'Woina Dega' (warm zone) covering 44% and 'Dega' (cold zone) covering 25% of the region. About 25% of the total population of the Federal State of Ethiopia is found in this region (http: //www. the Amhara region and its people. htm).

The Amhara Region has 11 Important Bird Areas (IBAs). The region also has central Ethiopian highland Endemic Bird Areas (EBAs) which account over 75% of the region with eight endemic species of the country and twelve highland biome species restricted to Ethiopia and Eritrea (EWNHS, 1996). The presence of these endemic and restricted bird species in such part of the region is due to the diverse habitat and agro-climatic zones in the central highlands (EWNHS, 1996; Pol, 2006). Wof Washa National Forestry Priority Area (NFPA) is one of the 69 IBAs of Ethiopia and of the 11 IBAs of the Amhara Region. As this area is surrounded by farmlands (cultivation and grazing) with serious human encroachment, the threat for bird species as well as the whole biodiversity increases from time to time. The present study attempts to determine the current species composition, distribution, relative abundance and habitat association of birds of Wof Washa NFPA and its surroundings along Ankober - Debre Sina Escarpment.

2. LITERATURE REVIEW

The single unique feature that distinguishes birds from other animals is their feather. No other vertebrate group bears such an easily recognizable identification tag (Lanyon, 1963; Wilson, 1980; Gill, 1995; Smith, 1996; Travers, 1996; Purves *et al*., 1998; Hickman *et al*., 2001). Although some fish can soar on outstretched fins; and mammals such as flying squirrels and bats can fly with varying agility, the most familiar flying vertebrates with full mastery of air are members of the class Aves (Wessells and Hopson, 1988; Ricklefs, 1990; Hickman *et al*., 2001). Thus, birds are adapted for flight and their ability to fly is an important survival mechanism affording escape from terrestrial enemies. However, the best prevention to sudden attack from the air is the existence of a concealing (cryptic) colouration with their habitats (Lanyon, 1963). The prevalence of greenish birds in the forest canopy and predominantly brownish birds on the forest floor and in other ground niches exemplify the general trend toward a resemblance of plumage colouration to the birds' immediate surroundings. All birds do not fly. Some such as penguins, ostriches, emus, cassowaries and rhea can not fly due to their smaller wings (Peterson, 1957; Fisher and Peterson, 1964; Davis and Solomon, 1986; Hickman *et al*., 2001).

Birds are evolutionary descendants of the dinosaurs. The oldest known fossilized bird; *Archaeopteryx*, is a perfect evolutionary link between reptiles and modern birds (Lanyon, 1963; Stefferud and Nelson, 1971; Raven and Johnson, 1999; Guttman and Hopkins, 1999; Hickman *et al*., 2001; Campbell and Reece, 2002). The Class Aves contains more species distributed over nearly the entire earth than other class of vertebrates except the boney fishes (Fisher and Peterson, 1964). At present, birds are the most successful and highly diverse of all terrestrial vertebrates. One reason why birds are so abundant is that they can eat almost all types of animal and plant materials and their distribution patterns are closely related to the availability of food (Peterson, 1957; Peterson, 1963; Davis and Solomon, 1986; Gill, 1995; Hickman *et al*., 2001; BirdLife International, 2007).

The species number, distribution and phylogenetic relationships of birds are better known on a world scale than any other group of organisms (Newton and Dale, 2001). The current classification of extant birds is a hierarchical arrangement of roughly 29 orders, 201 families, over 2,000 genera and 10,010 species living in diverse habitats (Wessells and Hopson, 1988;

Gill, 1995; Avibase, 2007; Lepag, 2008). More than 50% of the extant species of birds belongs to the Order Passeriformes (Gill, 1995; Travers, 1996; Purves *et al*., 1998; Guttman and Hopkins, 1999; Hickman *et al*., 2001). The various Zoogeographical Regions differ greatly in the number of bird families, genera and species that they can support. Ethiopia has a total of 924 bird species, of which, 21 are endemic, 3 are rare and 19 are globally threatened (Avibase, 2007).

Even though many other animals have migratory habits, birds are by far the best examples (Lanyon, 1963; Fisher and Peterson, 1964; Wilson, 1980). Since many birds die in storms, some eaten by predators and many more starve to death; migration is the greatest adventure in the life of birds (Peterson, 1963).

Birds appeal to people for their attractive, often breath-taking colours, spectacular migration and fascinating habits (Wilson, 1980; Davis and Solomon, 1986; Smith, 1996). Many birds are beneficial to man: they provide meat and eggs for food, involve in pollination, disperse seeds and fruits, consume numerous grasshoppers, mosquitoes and other insect pests and make our environment more pleasant (Clout and Hay, 1989; Pomeroy, 1992). One of the most important current and future uses of birds is as an indicator of environmental conditions and is being used as key component in environmental impact assessment (Pomeroy, 1992; WCMC, 1992; Furness and Greenwood, 1993; BirdLife International, 2007). As birds are wide ranging in habitat distribution and tend to be at or near the top of the food chain, they are regarded as good ecological indicators. As they also quickly respond to ecological disturbances, bird population survey has been used regularly in scientific studies to assess the general health of the ecosystem. Thus, birds are useful indicators of habitat quality and they are monitors of environmental changes (Furness and Greenwood, 1993; Gill, 1995; Urfi *et al*., 2005; Weber *et al*., 2006; BirdLife International, 2007).

Even though birds have a number of significant role played to human, their life was threatened from time to time. The diversity of birds is not determined in all cases by the same single factor, but it is the outcome of many contributing factors (Jansen *et al*., 2001). For the majority of birds, deforestation, commercial logging, subsistence farming, plantation and mining are the major causes of threats (Brooke and Birkhead, 1991; Stattersfield *et al*., 1998; Francis and Shirihai, 1999; Fuentes, 1999). A decline in the quality of habitat through grazing by livestock, selective

logging and agricultural intensification are detrimental factors for the loss of the habitat leading to a decline among the grassland, forest and farmland birds (Whited *et al*., 2000, Hejl *et al*., 2002; Gregory *et al*., 2004). Food supply can affect the bird diversity, abundance, breeding ecology, body condition, ranging behaviour, and/or flocking behaviour (Sodhi, 2002). Food and habitat quality and quantity have been identified as primary limiting factors that influence avian population distribution (Jansen *et al*., 2001). Bird species diversity has been associated with vertical complexity of vegetation (MacArthur and MacArthur, 1961). Habitat structure is a major determinant of bird species diversity (Martin and Possingham, 2005). Habitats with a complex structural design can support more species than habitats with a simple structural design, as the former would provide more resources and/or opportunities for microhabitat segregation (Vivkery *et al*., 2001).

Birds respond to variation in vegetation structure (MacArthur and MacArthur, 1961; Sodhi, 2002) and are attracted to different vertical vegetation strata within different habitats (Roth, 1976; McPherson and Jetz, 2007). The availability of resources for birds diminishes and physical conditions become more adverse for some birds at higher elevations (Karr and Roth, 1971; Rabenold, 1993; Waterhouse *et al*., 2002). Birds use specific parts of the forest canopy for food, nesting and travel routes (Enger and Smith, 2000; Betts *et al*., 2006). The loss of forest habitats comes with profound modifications of both the composition and configuration of landscapes that can aggravate the decline of forest birds (Belisle *et al*., 2001; Thinh, 2006). Habitat loss and fragmentation affect forest birds through direct loss of breeding habitats, detrimental edge effects such as increased nest predation and brood parasitism and possibly by limiting movements among the remaining forest patches (Belisle *et al*., 2001; Manu *et al*., 2007). Forest resource extraction can affect bird species composition through alteration of vegetation structure (Kumar and Shahabuddin, 2006). The ecological and life history traits in association with forest loss due to climatic changes and human impacts explain the narrow distribution of most endemic forest bird species (Cofre *et al*., 2007). Forest restricted bird species have smaller geographic ranges compared to edge and secondary growth species (Wiedenfeld, 1991; Westphal *et al*., 2003; Wijesinghe and Brooke, 2005). When natural habitats are disturbed, the species that have restricted distribution, particularly the endemic species, often lack adaptability and hence are less

able to tolerate the modified conditions than the wide spread species (Goodyear, 1992 as cited in Wijesinghe and Brooke, 2005).

Humans have been the most important factor that determines the number and distribution of birds in diverse habitats. The activities of human and birds have been intertwined for a long time (Peterson, 1963; Wilson, 1980). Man drastically alters the evolution of a region by selectively reducing the possible number of ecological niches. Human impacts on distribution can also influence the overall avian richness of the area (Davies *et al*., 2007).

Our ability to destroy habitats outdistances the ability of the birds to escape (Wilson, 1980). The negative attitude of people towards birds as crop pests threatens the life of birds (Viveropol, 2001). The removal or alteration of forest, the planting of crops and the over-grazing of natural grasslands have disturbed the environment to the extent of eliminating or greatly reducing a range of many forest and grassland birds. Modified landscape dominated by successional forest alters regional bird species richness and abundance (Westphal *et al*., 2003; Diaz *et al*., 2005) and the occurrence of forest birds within a mixed habitat is influenced by landscape composition (Peh *et al*., 2006; Manu *et al*., 2007). Not all activities of man have been detrimental to bird life. Some species such as starlings and house sparrows are far more abundant and more widely distributed birds on earth as a result of human impact (Hickman *et al*., 2001). Gardens, parks and residential communities provide a great diversity of ecological niches and are generally rich in birdlife. However, repeated attacks of human on the natural habitat of birds, particularly of the endemics and restricted range species, greatly affect their life.

Repeated attacks and encroachment by locals for farming, grazing, fire wood and timber collection have greatly endangered the most precious indigenous trees found at Wof Washa NFPA, thereby, endangering the forest fauna. Birds are one of the forest taxa that are endangered by such activities. The total area of the forest has also been declining from time to time due to damages caused through time. Even though the locality possesses diverse fauna and flora, it is being threatened (EWNHS, 1996). Thus, to sustain the area with its fauna and flora for future use, the status of the habitat requires successive studies.

3. OBJECTIVES

3. 1. General objective

The general objective of the present study is to conduct a detailed survey and describe the current species composition, distribution, relative abundance and habitat association of the avifauna of Wof Washa NFPA along the Ankober-Debre Sina Escarpment.

3. 2. Specific objectives

- To determine the species composition and richness of avifauna.
- To determine the habitat association of birds in the study area.
- To determine the distribution of birds in the area.
- To enumerate the factors that determine the distribution of birds in the study area.
- To recommend a management plan for better protection of the forest with its diverse faunal composition.

4. THE STUDY AREA

The study area is Wof Washa National Forestry Priority Area (NFPA) in the Ankober - Debre Sina Escarpment. Wof Washa NFPA occurs in North Shewa Zone of the Amhara National Regional State (ANRS) between 39^0 42'- 39^0 50' E and 09^0 40'- 09^0 50' N. It is located northeast of Debre Birhan Town, the capital of North Shewa Zone and is approximately 220 km northeast of Addis Ababa, mainly in an inaccessible area on the very steep side of the Rift Valley. The major part of the forest is located at 30 km south of Debre Sina which takes four hours walk on foot along the escarpment. Wof Washa NFPA is one of the eleven protected forest areas in the ANRS. The forest stretches from southeast to northwest along the Rift Valley Escarpment between Ankober and Tarma Ber Woredas covering an area of 13,000 ha (EWNHS, 1996). Ankober Woreda shares the south and southeastern part of the forest while Tarma Ber Woreda shares the eastern and northeastern part, and Baso and Worana Woreda share the western part of the forest (Fig. 1). All these three Woredas are administered under the North Shewa Zone of the ANRS.

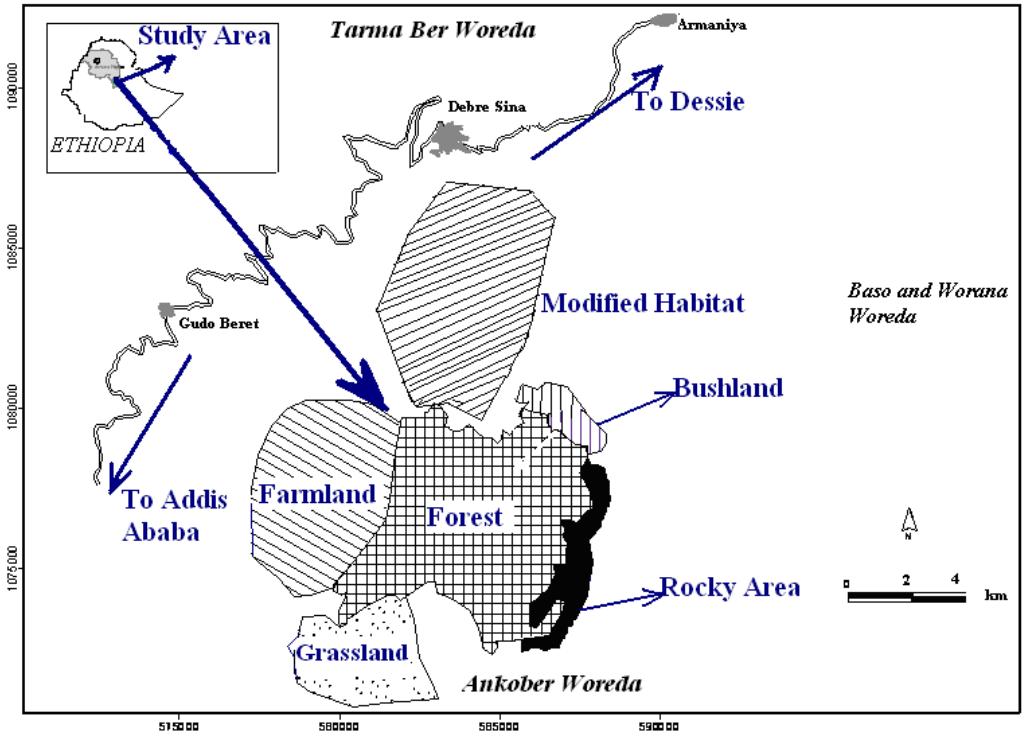

Figure 1. Map of the study area with habitat types.

The elevation of the area ranges from 1,650 m in the eastern part, near Tach Gorebela to 3,730 m above sea level near Kundi – the peak of the ridge (EWNHS, 1996; BirdLife International, 2007). The topographic features of the area are mountainous, uneven, rising and falling with deeply incised valley bottoms characterized by pockets of plateau. This altitudinal range and topographic variation occur within a distance of 3 to 4 km, forming a deep steep. As the only natural forest remaining in the area, the Wof Washa forest has been protected by its inaccessibility.

There are 43 Kebeles or Peasant Associations (PAs) in and around the forest. According to the general survey conducted for the North Shewa Zone in 1994, out of the 43 PAs in and around the forest areas, four are fully within the forest. The 43 PAs have 7,270 households with 36,100 family members (http: //www. Sunarma. org. /Wof Washa. htm). King Zera Yacob, during his reign in the late 15th Century, declared the Wof Washa Forest as the "King's Forest" ("Crown Forest"). In 1880, Emperor Menelik II formally declared the Wof Washa forest, a State Reserve Forest, the first of its kind in Ethiopia (http://www. Sunarma. org/ Wof Washa. htm).

Temperature of the area ranges from a mean minimum of 11^{o}C to a mean maximum of 20^{o}C (EWNHS, 1996). However, there are no compiled and full metrological records that show monthly temperature variation in the area. The monthly and yearly temperature variation was taken from metrological records of Debre Birhan Town – the nearest town to the study area. The lowest temperature of the area was recorded between October and December, while the maximum records were between February and June (Fig. 2). The annual rainfall is estimated at about 1,000 mm at the lower altitudes and 1,400 mm at the peak of the ridges (EWNHS, 1996; http://www.Sunarma.org /Wof Washa. htm). According to the Ethiopian National Meteorological Service Agency, the maximum amount of rainfall was recorded between July and September. Bimodal rainfall is observed in the area (Fig. 2).

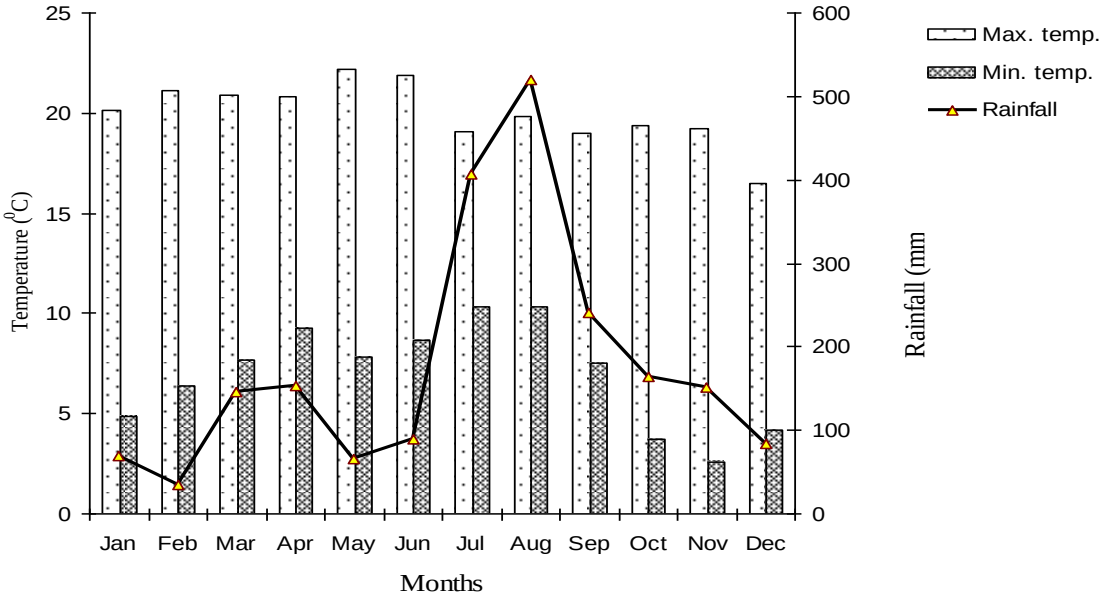

Figure 2. Mean monthly variation of temperature and rainfall in the study area (2001 – 2007).

Wof Washa forest is an ecosystem composed of a highland montane, mixed (broad leaved and conifer) forest, with varieties of wildlife. The main plant species found within the forest are *Hagenia abyssinica, Olea europaea cuspidata, Prunus africana, Maytenus obscura, Buddleja polystachya, Solanecio gigas* and *Juniprus procera* at the higher altitudes, with *Podocarpus fulcatus, Carissa edulis, Iiex mitis, Measa lanceolata, Cordia africana, Croton macrostachyus, Ekbergia capensis, Climatis simensis, Rosa abyssinica, Cymbopogon pospischilii* and *Allophylus abyssinicus* in the lower altitudes. At altitudes of 3,000 m and above, the Afro alpine moorland with some short *Erica arborea, Hypericum revolutum* and giant *Lobelia* spp. replace the large trees. There are also widespread patches of the endemic *Kniphofia foliosa*, and clumps of shrubby *Helichrysum* spp. and *Festuca* grasses. The herb layer within the forest is greatly diversified and rich in species. *Eucalyptus globulus* plantation was also observed in some areas.

Spotted hyaena (*Crocuta crocuta*), rock hyrax (*Procavia capensis*), crested porcupine (*Hystrix cristata*), common duiker (*Sylvicapra grimia*), klipspringer (*Oreotragus oreotragus*), Menilik's bushbuck (*Tragelaphus scriptus meniliki*), gelada baboon (*Theropithecus gelada*), grivet monkey (*Cercopithecus aethiops*), genet cat (*Geneta geneta*) and different species of rodents and bats are the major wild mammals found in the study area.

5. MATERIALS AND METHODS

5.1. Materials

In this study, binocular, mega pixel digital camera, global positioning system (garmin GPS III plus), measuring tape, walkman sized tape recorder, data sheets, note books and field guides (Mackworth-Praed and Grant, 1952; Williams and Peterson, 1963; Urban and Brown, 1971; William and Arlot, 1980; Harrison and Greensmith, 1993; Howard and Moore, 1994; Perlo, 1995; Viveropol, 2001; Stevenson and Fanshwe, 2002; Sinclair and Ryan, 2002) were used.

5.2. Methods

5. 2. 1. Preliminary study

Ecological survey of birds in the Wof Washa NFPA was carried out during the last two weeks of August (2007) to gather basic information about the area. The information was collected from concerned government authorities (North Shewa Zone and Ankober, Tarma Ber, Baso and Worana Woredas Agricultural and Rural Development Offices) and the local people living in and around the study area. The topographical features together with the vegetation coverage of the area were assessed. The knowledge of the indigenous people was used for habitat identification and sample selection.

Based on the vegetation structure, the study area was randomly identified into forest, farmland, grassland, bushland, rocky area and modified habitats. All these habitats occurred between Ankober and Tarma Ber Woredas along the escarpment. Using garmin GPS III plus, the vertical and horizontal coordinates and altitude of each survey site was taken during this survey.

Plate 1. Rocky area during the wet season.

Plate 2. Grassland during the wet season.

(Photo: Sisay Hailu, November, 2007)

Plate 3. Rocky area during the dry season.

Plate 4. Grassland during the dry season.

(Photo: Sisay Hailu, December, 2007)

Plate 5. Bushland during the dry season.

Plate 6. Forest habitat during the dry season.

(Photo: Sisay Hailu, December, 2007)


Plate 7. Modified habitat during the dry season. Plate 8. Farmland during the dry season.
(Photo: Sisay Hailu, December, 2007)

5. 2. 2. Sampling design

Based on the topography and vegetation structure of the habitats, the sampling sites with a series of counting points and line transects were randomly specified and permanently marked within the study area. The global positioning system (garmin GPS III plus) was used to determine the coordinates and altitude of the predetermined point count and transect paths. The pre-assigned points and transects were widely spread through the study area and visited regularly in sequence during each counting session of both dry and wet seasons. Each randomly selected representative grid site was numbered and separated by the natural boundaries where the longitudinal and altitudinal coordinates of the boundaries were marked.

The total area of Wof Washa NFPA was classified into six major habitat types approximately covering an area of 26 km^2 (20% of the area) out of 130 km^2. The open areas including the farmland, grassland, and rocky areas covering approximately an area of 5 km^2, 4 km^2 and 3 km^2, respectively were classified into blocks, each separated by 250 m. In the forest, bushland and modified habitats, a total of 98 points were identified covering approximately an area of 7 km^2, 3 km^2, and 4 km^2, respectively, with a 25 m radius and 150–250 m gap between each census points.

Point count and line-transect techniques were employed to examine bird – habitat relationships and relative bird abundance. Following Sutherland (2000), the two techniques were employed on the principles of recording birds along a pre-defined route within a pre-defined survey unit. In

line transects, birds were recorded continually along a pre-defined route. However, for point count, birds were recorded at regular intervals of 3 to 5 minutes along the route and for 5 to 10 minutes count at each point. Both auditory and visual identifications were used to record birds. In line transect technique, transects were located within randomly allocated 1 km x 1 km grid squares. Birds seen and heard were recorded continually along a strip of 1 km transect with 25 m on either side of the transect line, making a total width of 50 m. Transects on a plot were far apart with a range of 250 – 300 m to ensure that the same individual was not counted in different transects. Following Gibbons *et al*. (1996), to maximize the chance of recording all species and as detectability varies seasonally, each transect was censused twice. The location where the bird was first observed and all individuals heard and seen within the predetermined transect were recorded by moving slowly on foot along the predetermined routes. An assistant was involved to flush birds gently out of bushes and grasses. The line transect method was applied in the farmland, open grassland and rocky areas where the habitats were homogenous and the vegetation did not limit the observer and his assistant from walking through the survey sites. In the dense forest, alpine and bush vegetation, fragmented habitats with uneven terrain and modified habitats, point count method was applied both with a fixed radius of 20 to 25 m and unlimited radius count. Following Buskirk and McDonald (1995), all points were located away to avoid noise from roads. Both the observer and the assistant moved, stopped and relaxed at pre-defined spots to allow birds a period of 3 to 5 minutes to settle before counting was performed (Sutherland, 1996). To reduce over-representation of conspicuous species, a list of birds within 20 to 25 m of the observer was recorded (Pomeroy, 1992).

5. 2. 3. Data collection

Based on the information collected and sites selected during the preliminary survey field data concerning the diversity, distribution, relative abundance and habitat association of the avian fauna of Wof Washa NFPA were collected and recorded. Following DeGraaf and Chadwick (1987) and Pomeroy (1992), birds were censused at the same locations through four session surveys covering both the wet and dry seasons from August 2007 to March 2008. Twenty three days from the first three weeks of September (2007) and twenty two days from the last weeks of October to the first two weeks of November (2007) were for wet season. On the other hand, the

two sessions from the mid of December (2007) to the first two weeks of January (2008) and the first three weeks of March (2008) were for the dry season. The collection of data was carried out based on the weather condition and time of the day when most of the avian species were active. Data were collected early in the morning from 6:30 a.m. to 10:00 a.m. and late afternoon from 3:30 p.m. to 6:00 p.m. (Spencer, 1963; Buskirk and McDonald, 1995; Centerbury *et al*., 2000). As birds flying over a transect might not be associated with that specific habitat, flyovers were entered into the bird checklist information, but were excluded from relative abundance analysis.

The type and group number of avian species were recorded by means of direct watching supplemented with binocular and indirect observation using their calls. Based on the type of habitats and their vegetation cover, fixed radius and unlimited distance line-transect and point count techniques were used for data collection at randomly chosen sites. The position of the sites was recorded using garmin GPS III plus and marked on topographic map of the area. Variable transect length was employed depending on the nature of the habitats and type of birds counted. The gap between blocks and points in closed habitats was from 150 to 200 m while it was about 250 to 300 m in open habitats (Bibby *et al*., 1992; Pomeroy, 1992; Sutherland, 1996; Sutherland, 2000).

Field guides were used to identify and categorize birds observed during the study period. The type of vegetation in the study sites was identified by the observer and the local people in and around the area with their vernacular names. The scientific name of the vegetation was obtained from the National Herbarium.

5. 2. 4. Data analysis

The data collected during the wet and dry seasons were organized and the species diversity and their relative abundances were compared between different vegetation communities through the similarity indices measures. The community structure of birds of each habitat was described in terms of Shannon-Weaver Diversity Index (H'). Following Shannon and Weaver (1949), Shannon-Weaver Index was evaluated as:

$H' = -\Sigma (P_i \ln P_i)$ where,

H' = Shannon-Weaver Index

P_i = Proportion of the i^{th} species

ln = Natural logarithm

Simpson's Index of Diversity (D) was used to evaluate the relative abundance of birds in each habitat for both dry and wet season species using the formula:

$D = 1- (\Sigma P_i)^2$ where,

D = Simpson's Diversity Index

P_i = Proportion of individual species

To see the evenness (the pattern of distribution) of birds in the study area, the Shannon-Weaver Evenness Index (E) was calculated using the equation:

$E = H'/ H_{max}$ where,

E = Shannon-Weaver Evenness Index

H'= Shannon-Weaver Diversity Index

H_{max} = lnS = Natural logarithm of the total number of species (S) in each site (Southwood and Henderson, 2000).

The Richness Index (RI) of each species was determined using the formula:

RI = S-1/ lnI where,

S = number of species in each habitat

ln = Natural logarithm

I = Number of individual or species in each habitat

In reference to the composition of species, Simpson's Similarity Index (SI) was used to assess the similarity of species existence between different habitats using the formula:

SI = 2C/A+B where,

SI = Simpson's Similarity Index

A = Number of species that occur in habitat A

B = Number of species that occur in habitat B

C = Number of common species that occur in habitats A and B

In order to evaluate the habitat preference of birds in each vegetation zone of dense forest, farmland, modified habitat, and bushland, Chi-square test was employed.

The data obtained during the survey were analyzed using a scientific calculator and SPSS-13.0 software. General linear model (GLM) was used to see the effects of interaction of season and habitat type on the bird's abundance and distribution. One-way analysis of variance (ANOVA) was used for habitat comparison in terms of their bird abundance in a given season. For mean abundance comparison, the least significant difference (LSD) was used. Pair-wise t-test was used to compare the abundance of birds in the same habitat between seasons. Graphs were drawn on Microsoft Excel computer program. Encounter rate (dividing the number of individuals recorded to the time elapsed during the study and then multiplied by one hundred) was used to determine the relative abundance score and rank of each species.

6. RESULTS

A total of 158 bird species belonging to 15 orders and 44 families were identified in the study area during the wet and dry season surveys (Table 1).

Table 1. Bird species recorded in Wof Washa NFPA (E = Endemic to Ethiopia, EE = Endemic to Ethiopia and Eritrea, D = Bird observed during the dry season, W = Bird observed during the wet season, ♠ = Palearctic migrants, ♣= Intra-African migrants and those unmarked are resident birds).

Family	Common name	Scientific name
Accipitridae	Black Kite D	*Milvus migrans*
	Hooded Vulture	*Necrosyrtes monachus*
	Egyptian vulture	*Neophron percnopterus*
	White-backed Vulture	*Gyps africanus*
	Rüppell's Griffon	*Gyps ruppellii*
	Lammergeier	*Gypetus barbatus*
	Lappet-faced Vulture	*Torgos tracheliotus*
	Black-breasted Snake eagle♣	*Circaetus pectoralis*
	Pallid Harrier D♠	*Circus macrourus*
	Rufous-chested Sparrowhawk	*Accipiter rufiventris*
	Grasshopper Buzzard D	*Butastur rufipennis*
	Mountain Buzzard	*Buteo oreophilus*
	Augur Buzzard	*Buteo augur*
	Tawny Eagle	*Aquila rapax*
	Verreaux's Eagle	*Aquila verreauxii*
	Steppe Eagle D♣	*Aquila nipalensis*
Alaudidae	Rufous-naped Lark	*Mirafra africana*
	Thekla Lark	*Galerida theklae*
	Crested Lark	*Galerida cristata*
Anatidae	Blue-winged Goose EE	*Cyanochen cyanopterus*
	Egyptian Goose	*Alopochen aegyptiacus*

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Apodidae	Scarce Swift	*Schoutedenapus myoptilus*
	Alpine Swift	*Tachymarptis melba*
	Common Swift [W]	*Apus apus*
	Nyanza Swift	*Apus niansae*
	Pallid Swift [D♠]	*Apus pallidus*
	Little Swift [W]	*Apus affinis*
	Horus Swift [W♣]	*Apus horus*
	White-rumped Swift [W♣]	*Apus caffer*
Ardeidae	Cattle Egret [D]	*Bubulcus ibis*
Bucerotidae	Hemprich's Hornbill	*Tockus hemprichii*
	Silvery-cheeked Hornbill	*Ceratogymna brevis*
	Abyssinian Ground Hornbill [W]	*Bucorvus abyssinicus*
Campephagidae	Gray Cuckoo-shrike [D]	*Coracina caesia*
Caprimulgidae	Abyssinian (Montane) Nightjar	*Caprimulgus poliocephalus*
Charadriidae	Black-winged Lapwing [W]	*Vanellus melanopterus*
Cisticolidae	Tawny-flanked Prinia	*Prinia subflava*
	Pale Prinia [D]	*Prinia somalica*
	Pectoral-patch Cisticola	*Cisticola brunnescens*
Coliidae	Speckled Mousebird	*Colius striatus*
Columbidae	Speckled Pigeon	*Columba guinea*
	White-collared Pigeon [EE]	*Columba albitorques*
	Lemon (Cinnamon) Dove	*Columba larvata*
	Dusky Turtle Dove	*Streptopelia lugens*
	Red-eyed Dove [W]	*Streptopelia semitorquata*
	Ring-necked Dove	*Streptopelia capicola*
	Laughing Dove	*Streptopelia senegalensis*
Corvidae	Pied Crow	*Corvus albus*
	Fan-tailed Raven	*Corvus rhipidurus*
	Thick-billed Raven [EE]	*Corvus crassirostris*
	Cape Crow	*Corvus capensis*
Cuculidae	Senegal Coucal	*Centropus senegalensis*
Emberizidae	Cinnamon-breasted Bunting [D]	*Emberiza tahapisi*

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	Ortolan Bunting [D]	*Emberiza hortulana*
Estrildidae	Red-billed Firefinch	*Lagonostica Senegala*
	Red-cheeked Cordonbleu	*Uraeginthus bengalus*
	Yellow-bellied Waxbill	*Estrilda quartinia*
	Yellow-breasted Waxbill	*Estrilda paludicola*
	Red-rumped Waxbill	*Estrilda charmosyna*
Falconidae	Lesser Kestrel [D♠]	*Falco naumanni*
	Common (European) Kestrel [D♠]	*Falco tunnunculus*
	African Hobby [D♣]	*Falco cuvierii*
	Peregrine Falcon	*Falco pergrinus*
Fringillidae	Ankober Serin [E]	*Serinus ankoberensis*
	Abyssinian (Black-headed) Siskin [E]	*Serinus nigriceps*
	Abyssinian Citril	*Serinus citrinellodes*
	Streaky-headed Siskin (Seed eater)	*Serinus gularis*
	Streaky Siskin (Seed eater)	*Serinus striolatus*
	Brown-rumped Siskin (Seed eater)	*Serinus tristriatus*
Hirundinidae	Banded Martin [D]	*Riparia cincta*
	Plain Martin	*Riparia paludicola*
	Rock Martin [D♣]	*Ptyonoprogne fuligula*
	Ethiopian Swallow [D♣]	*Hirundo aethiopica*
	Crag Martin	*Hirundo rupestris*
	Red-rumped Swallow [D♠]	*Cecropis daurica*
Indicatoridae	Greater Honey Guide	*Indicator indicator*
	Lesser Honey Guide [W]	*Indicator minor*
	Cassin's Honey Guide [W]	*Prodotiscus insignis*
Laniidae	Common Fiscal [D]	*Lanius colaris*
Malaconotidae	Tropical Boubou	*Laniarius aethiopicus*
Meropidae	Little Bee-eater [D♣]	*Merops pusillus*
	European Bee-eater [D♠]	*Merops apiaster*

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	Blue-breasted Bee-eater	*Merops variegatus*
Monarchidae	African Paradise Flycatcher[♣]	*Terpsiphone viridis*
Motacillidae	African Pied Wagtail	*Motacilla aguimp*
	Yellow Wagtail [D♠]	*Motacilla flava*
	Mountain Wagtail	*Motacilla clara*
	Abyssinian Longclaw [E]	*Macronyx flavicollis*
	Plain-backed Pipit [D]	*Anthus leucophrys*
	Bush Pipit [D]	*Anthus caffer*
Muscicapidae	Abyssinian Slaty-flycatcher [EE,W]	*Melaenornis chocolatinus*
	Spotted Flycatcher [W♠]	*Muscicapa striata*
	African Dusky Flycatcher [W]	*Muscicapa adusta*
	Pale Flycatcher [W]	*Bradornis pallidus*
	Rüppell's Robin Chat	*Cossypha semirufa*
	White-browed Robin Chat	*Cossypha heuglini*
	Northern Wheatear [D♠]	*Oenanthe oenanthe*
	Mourning Wheatear [D]	*Oenanthe lugens*
	Pied Wheatear [D]	*Oenanthe pleschanka*
	Heuglin's Wheatear [D♣]	*Oenanthe heuglini*
	Abyssinian Black Wheatear [D]	*Oenanthe lugubris*
	Common Stone Chat[♠]	*Saxicola torquata*
	Moorland (Alpine) Chat	*Cercomela sordida*
	Brown-tailed Chat	*Cercomela scotocerca*
	Rüppell's Black Chat [EE]	*Myrmecocichla melaena*
	White-winged Cliff Chat [EE]	*Thamnolaea semirufa*
Musophagidae	White-cheeked Turaco	*Tauraco leucotis*
Nectariniidae	Collared Sunbird	*Hedydipna collaris*
	Tacazze Sunbird	*Nectarinia tacazze*
	Bronze Sunbird	*Nectarinia kilimensis*
	Variable Sunbird	*Cinnyris Vanuatu*
	Amethyst Sunbird [W]	*Chalcomitra amethystina*
Passeridae	Grey-headed Sparrow	*Passer griseus*
	Swainson's Sparrow	*Passer swainsonii*

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Phasianidae	Moorland Francolin	*Francolinus psilolaemus*
	Erckel's Francolin	*Francolinus erckelii*
	Common Quail [D] [♣]	*Coturnix coturnix*
Picidae	Grey-headed Woodpecker	*Dendropicos spodocephalus*
Ploceidae	Spectacled Weaver	*Ploceus ocularis*
	Baglafecht Weaver	*Ploceus baglafecht*
	Little Weaver [W]	*Ploceus luteolus*
	Black-headed Weaver	*Ploceus melanocephalus*
	Lesser-masked Weaver	*Ploceus intermedius*
	Yellow-crowned Bishop [W]	*Euplectes afer*
	Yellow Bishop [W]	*Euplectes capensis*
	Yellow-shouldered Widowbird [W]	*Euplectes macrourus*
	Red-collared Widowbird [W]	*Euplectes ardens*
Psittacidae	Red-headed Lovebird	*Agapornis pullarius*
	Black-winged Lovebird [EE]	*Agapornis taranta*
Pycnonotidae	Common Bulbul	*Pycnonotus barbatus*
Scopidae	Hamerkop [W]	*Scopus umbretta*
Strigidae	African Woodowl [D]	*Strix woodfordii*
Sturnidae	Greater Blue-eared Starling[D]	*Lamprotornis chalybaeus*
	Red-winged Starling	*Onychognathus morio*
	Slender-billed Starling	*Onychognathus tenuirostris*
	White-billed Starling [EE]	*Onychognathus albirostris*
	Red-billed Oxpecker	*Buphagus erythrorhynchus*
Sylviidae	Marsh (European) Warbler [D♠]	*Acrocephalus palustris*
	Brown Woodland Warbler	*Phylloscopus umbrovirens*
	Common Chiffchaff[♠]	*Phylloscopus collybita*
	Wood Warbler[♠]	*Phylloscopus sibilatrix*
	Willow Warbler[♠]	*Phylloscopus trochilus*
	Blackcap[♠]	*Sylvia atricapilla*
	Garden Warbler	*Sylvia borin*
	Cinnamon Bracken Warbler	*Bradypterus cinnamomeus*

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Threskiornithidae	Sacred Ibis [W]	*Threskiornis aethiopicus*
	Wattled Ibis [EE]	*Bostrychia carunculata*
Timaliidae	White-rumped Babbler	*Turdoides leucopygius*
	Abyssinian Catbird E	*Parophasma galinieri*
Turdidae	Little-rock Thrush	*Monticola rufocinereus*
	Blue-rock Thrush [D♠]	*Monticola solitarius*
	Abyssinian Ground Thrush	*Zoothera piaggiae*
	Ground Scraper Thrush	*Psophocichla litsipsirupa*
	Olive Thrush	*Turdus olivaceus*
Upupidae	African Hoopoe [D♠]	*Upupa epops*
Viduidae	Pin-tailed Whydah [W]	*Vidua macroura*
	Village Indigobird [D]	*Vidua chalybeata*
Zosteropidae	Montane (Broad-ringed) White-eye	*Zosterops poliogastrus*

6. 1. Species composition

Among the recorded avian species, the Order Passeriformes is the most dominant and largest order with the highest number of families (23) and species (95). The number of species per family ranged from 1 to 16 where the highest number of species was recorded for Families Accipitridae and Muscicapidae, whereas the least number was recorded in 15 families. The six randomly selected habitats possessed both different and common species composition during the wet and dry seasons. Among the 158 avian species, 22 and 35 species were recorded exclusively for the wet and dry seasons, respectively. One hundred and one species were recorded as residents. A total of 13 endemics out of which nine species (*Bostrychia carunculata, Cyanochen cyanopterus, Columba albitorques, Agapornis taranta, Myrmecocichla melaena, Thamnolaea semirufa, Corvus crassirostris, Melaenornis chocolatinus, Onychognathus albirostris*) which are

shared with Eritrea and four Ethiopian endemics (*Macronyx flavicollis, Parophasma galinieri, Serinus ankoberensis and Serinus nigriceps)* that belonged to fiveorders and 11 families, were recorded during the study period. In addition, globally threatened species such as *Serinus ankoberensis*, and *Falco naumanni* (vulnerable) and *Macronyx flavicollis* and *Circus macrourus* (near threatened) were also recorded. Highland biome restricted range species like *Serinus ankoberensis, Myrmecocichla melaean, Bostrychia carunculata, Cyanochen cyanopterus, Agapornis taranta, Thamnolaea semirufa, Corvus crassirostris* and *Onychognathus albirostris* were observed during the study period. Among the recorded avian species, 11 were Intra-African migrants and 17 were Palearctic migrants.

6. 2. Species diversity

The diversity and distributional patterns (evenness) of avian species in the different vegetation type of the study area showed statistically significant difference ($F = 4.629$, $df = 5$, $P < 0.05$) and ($F = 4.533$, $df = 5$, $P < 0.05$). During the wet season, the highest avian species diversity (H'= 3.247) was observed in the modified habitat followed by the forest habitat (H'= 3.121) and the farmland (H'= 3.052). The least diversity of avian species (H'= 2.832) was recorded in the grassland. During the wet season, the highest even distribution (E = 0.815) was observed in the forest habitat (Table 2).

Table 2. Avian species diversity during the wet season.

Habitat	number of species	Abundance	H'	H_{max}	H' / H_{max}	D
Forest	46	1,258	3.121	3.829	0.815	0.935
Farmland	53	2,877	3.052	3.970	0.768	0.928
Modified Habitat	61	2,191	3.247	4.111	0.789	0.940
Bushland	41	698	2.987	3.714	0.804	0.917
Grassland	36	1,935	2.832	3.584	0.790	0.901
Rocky Area	28	831	2.908	3.714	0.804	0.907

H' = Shannon-Wiener Diversity Index, D' = Simpson's Index of Diversity, H_{max} = ln (total number of species, S) = lnS and H'/ H_{max} = Evenness

During the dry season, the highest species diversity (H'= 3.396) was observed in the modified habitat and the least avian species diversity (H'= 2.87) was observed in the rocky area (Table 3). The highest even distribution was observed in the forest habitat followed by the bushland during the dry season, whereas the least even distribution was observed in the farmland.

Table 3. Avian species diversity during the dry season.

Habitat	Number of species	Abundance	H'	H_{max}	H' / H_{max}	D
Forest	53	1,928	3.346	3.970	0.849	0.940
Farmland	60	3,589	3.176	4.094	0.775	0.937
Modified Habitat	76	2,973	3.396	4.331	0.784	0.949
Bushland	40	800	3.121	3.689	0.846	0.920
Grassland	46	1,583	3.081	3.807	0.792	0.915
Rocky Area	32	645	2.870	3.466	0.828	0.903

During both the wet and dry seasons, the highest species diversity (H' = 3.414) was observed in the modified habitat followed by the forest habitat (H' = 3.327). However, the least diversity (H' = 3.015) was obtained at the rocky area (Table 4). The highest even distribution of avian species was also observed in the forest habitat.

Table 4. Avian species diversity during wet and dry seasons.

Habitat	Number of species	Abundance	H'	H_{max}	H / H_{max}	D
Forest	60	3,186	3.327	4.094	0.812	0.938
Farmland	76	6,466	3.268	4.331	0.754	0.928
Modified Habitat	85	5,164	3.414	4.443	0.768	0.945
Bushland	54	1,498	3.189	3.989	0.799	0.919
Grassland	59	3,518	3.078	4.078	0.754	0.916
Rocky Area	45	1,476	3.015	3.807	0.792	0.910

6. 3. Number of species

The species number of bird in the six habitats showed variation and was ranged from 28 to 61 during the wet season and from 32 to 76 during the dry season. However, the species abundance ranged from 45 to 85 in both seasons combined. While the modified habitat was with the highest species number, the least record was from the rocky area during the wet and dry seasons.

During the wet season, yellow-belled waxbill (*Estrilda quartinina*) was with the highest number of individuals (Richness Index, RI = 8.6) and black-breasted snake eagle (*Circaetus pectoralis*) was with the least number of individuals (RI = 40.9) in the forest habitat. During the dry season, montane (broad-ringed) white-eyes (*Zosterops poliogastrus*) were the highest in number (RI = 9.2), whereas African woodowl (*Strix woodfordii*) was the least (RI = 75) in the forest habitat. In the farmland, baglafecht weavers (*Ploceus baglafecht*) were with the highest number of individuals during the wet and dry seasons with RI = 8.5 and RI = 9.8 respectively. While Abyssinian ground hornbill (*Bucorvus abyssinicus*) was with the least number of individuals (RI = 75) during the wet season, Pallid harrier (*Circus macrourus*) as well as lesser kestrel (*Falco naumanni*) (RI = 85.1) were the least during the dry season. In the modified habitat, baglafecht weavers (*Ploceus baglafecht*) were the largest in number of individuals (RI =10.6) and hamerkop (*Scopus umberetta*) and lammergeier (*Gypaetus barbatus*) were the least in number of individuals (RI = 86.6) during the wet season. During the dry season, baglafecht weaver (*P. baglafecht*) were also with the largest number of individuals (RI = 12.8) and lesser kestrel (*F. naumanni*) were with the least number of individuals (RI = 68.3). White-collared pigeon (*Columba albitorques*) was the highest in number of individuals (RI = 7.9), laughing dove (*Streptopelia senegalensis*) was the least in number of individuals (RI = 27.7) in the bushland during the wet season. During the dry season, however, fawn-breasted waxbill was the highest in number of individuals (RI = 6.6) and common fiscals (*Lanius colaris*) was the least number of individuals (RI = 56.3). In the grassland, Abyssinian (black-headed) siskin (*Serinus nigriceps*) was the highest in number (RI = 5.8) and hamerkop (*Scopus umbretta*) and Abyssinian ground hornbill (*Bucorvus* abyssinicus) were the least in number of individuals (RI = 50.5) during the wet season. However, white-collared pigeon (*Columba albitorques*) was the highest (RI = 8.1) and lesser kestrel (*Falco naumanni*) was the least in number of individuals (RI = 64.9) during the dry season. In the rocky area, during the wet season, moorland (alpine) chat (*Cercomela sordida*)

was the highest in number of individuals (RI = 6.1), whereas black-breasted snake eagle (*Circaetus pectoralis*) were the least (RI = 40.4). The moorland (alpine) chat (*C. sordida*) was also with the highest in number of individuals (RI = 7.2) during the dry season and peregrine falcon (*Falco pergrinus*) and pallid harrier (*Circus macrourus*) were the least in number of individuals (RI = 46.2) during this season.

6. 4. Species similarity

6. 4. 1. Seasonal species similarity

Within the same habitat (vegetation type), the highest seasonal similarity (74%) of avian species was observed in the modified habitat. In this vegetation type, 51 bird species were common during the wet and dry season surveys. The least seasonal avian similarity (46%) was obtained in the rocky area, where 14 species were common during wet and dry seasons (Table 5).

Table 5. Seasonal avian species similarity within the same habitat.

Habitats	W_T	D_T	Common species	SI	Species similarity %
Forest	46	53	34	0.69	69
Farmland	53	60	38	0.67	67
M. Habitat	61	76	51	0.74	74
Bushland	41	40	26	0.64	64
Grassland	36	46	20	0.48	48
Rocky Area	28	32	14	0.46	46

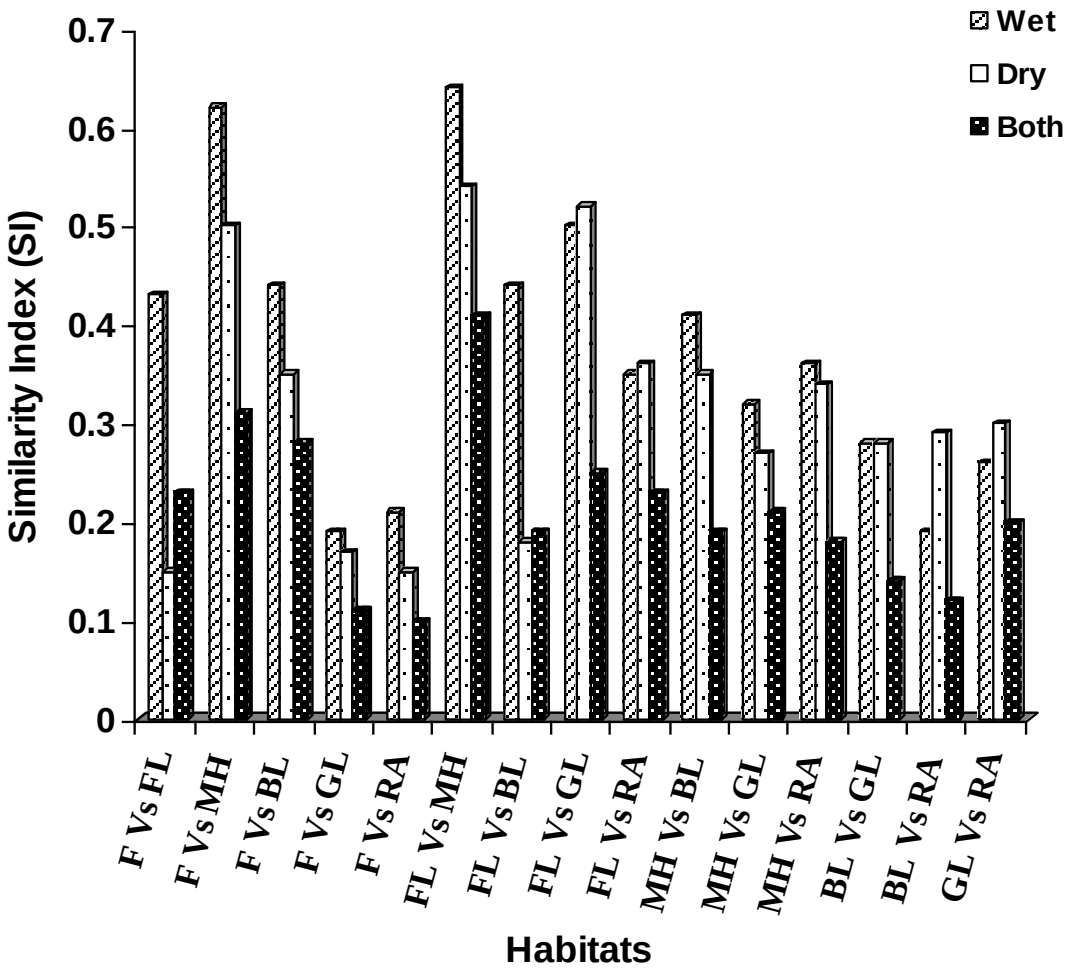
W_T = Total No. of species during the wet season
D_T = Total No. of species during the dry season
SI = Simpson's Similarity Index

6. 4. 2. Species similarity among the habitat types

Avian species similarity between different habitats showed variation between seasons. The value for avian species similarity during the wet season was different from that of the dry season record. The modified habitat and farmland showed the highest avian species similarity during the wet and dry seasons with different values of bird species similarity. During the wet season, more avian species similarity (SI = 0.64) was obtained between the modified habitat and farmland. The least species similarity (SI = 0.19) was observed between the forest habitat and grassland and the bushland and rocky area (Table 6). During this season, the species similarity index between the forest habitat and the bushland and the bushland and farmland were nearly the same (SI = 0.44) (Fig. 3).

Table 6. Wet season avian species similarity among the habitat types.

Habitats	Forest	Farmland	Modified Habitat	Bushland	Grassland	Rocky Area
Forest	-	0.43	0.62	0.44	0.19	0.21
Farmland		-	0.64	0.44	0.50	0.35
Modified Habitat			-	0.41	0.32	0.36
Bushland				-	0.28	0.19
Grassland					-	0.26
Rocky Area						-



(F = Forest, BL = Bushland, FL = Farmland, GL = Grassland, MH = Modified Habitat, RA = Rocky Area).

Figure 3. Avian species similarity among the habitat types.

During the dry season, the highest similarity value (SI = 0.54) was observed between the farmland the modified habitat followed by the farmland and grassland (SI = 0.52). The least avian species similarity (SI = 0.15) was observed between the forest habitat and the farmland and forest and the rocky area (Table 7, Fig. 3). During this season, the species similarity between the bushland and forest habitat and the bushland and the modified habitat was nearly the same (SI = 0.35).

Table 7. Dry season avian species similarity among the habitat types.

Habitats	Forest	Farmland	Modified Habitat	Bushland	Grassland	Rocky Area
Forest	-	0.15	0.50	0.35	0.17	0.15
Farmland		-	0.54	0.18	0.52	0.36
Modified Habitat			-	0.35	0.27	0.34
Bushland				-	0.28	0.29
Grassland					-	0.30
Rocky Area						-

During both seasons, avian species similarity ranged from a minimum value of 0.1 to a maximum value of 0.41. The maximum value (SI = 0.41) was observed between the farmland and modified habitat. The avian species similarity value between the forest habitat and rocky area (SI = 0.10) was the minimum (Table 8, Fig. 3).

Table 8. Avian species similarity among the habitat types during both seasons.

Habitats	Forest	Farmland	Modified Habitat	Bushland	Grassland	Rocky Area
Forest	-	0.23	0.31	0.28	0.11	0.10
Farmland		-	0.41	0.19	0.25	0.23
Modified Habitat			-	0.19	0.21	0.18
Bushland				-	0.14	0.12
Grassland					-	0.20
Rocky Area						-

6. 5. Avian abundance

Abundance was distributed differently among the vegetation types with the highest number of individuals recorded from farmlands followed by the modified habitat and the least number of individuals recorded from the rocky area. Since the variance of the total observation of each study site was found to be higher than their mean, the raw data were log transformed for analysis of variance (ANOVA). The one-way analysis of variance (ANOVA) showed that the abundance of individuals recorded at each habitat during wet and dry seasons was significantly different ($F= 3.849$, $df = 5,20$, $P < 0.05$) and ($F = 15.841$, $df = 5,20$, $P < 0.05$) respectively (Table 9). The means are log transformed values of the raw data.

Table 9. Log-transformed abundance values of birds (Mean $\pm$ SE).

Season	Habitat	Number of blocks	M ± SE
	Forest	7	28.28 ± 1.66a
	Farmland	5	31.40 ± 3.78b
Wet	Modified Habitat	4	39.00 ± 5.24ab
	Grassland	4	24.00 ± 1.25c
	Bushland	3	31.00 ± 0.67ab
	Rocky Area	3	20.33 ± 1.76c
	Total	26	29.42 ±1.53
	Forest	7	34.85 ± 1.96a
	Farmland	5	40.00 ± 3.11b
Dry	Modified Habitat	4	47.00 ± 1.68ab
	Grassland	4	28.00 ± 1.20c
	Bushland	3	28.33 ± 1.20ac
	Rocky Area	3	21.00 ± 0.58c
	Total	26	34.31 ± 1.76

*Means followed by the same letter are not significantly different ($P > 0.05$) and significant differences among habitats in mean bird abundance are indicated by different letters after the mean values of each habitat.

During the wet and dry seasons, the mean number of bird species observed in the forest habitat had significant variation with the farmland, grassland and rocky area ($P < 0.05$) but no significant differences were detected in the forest habitat, modified habitat and bushland ($P > 0.05$). In the modified habitat, the mean number of species obtained showed high significant variation with the rocky area and grassland ($P < 0.05$) but no significant variation with the forest habitat, bushland and farmland ($P > 0.05$). The mean number of species observed in the rocky area showed statistically significant variation with those observed in forest habitat, farmland, modified habitat and bushland ($P < 0.05$). However, there is no significant variation between the rocky area and grassland ($P > 0.05$) (Fig.4).

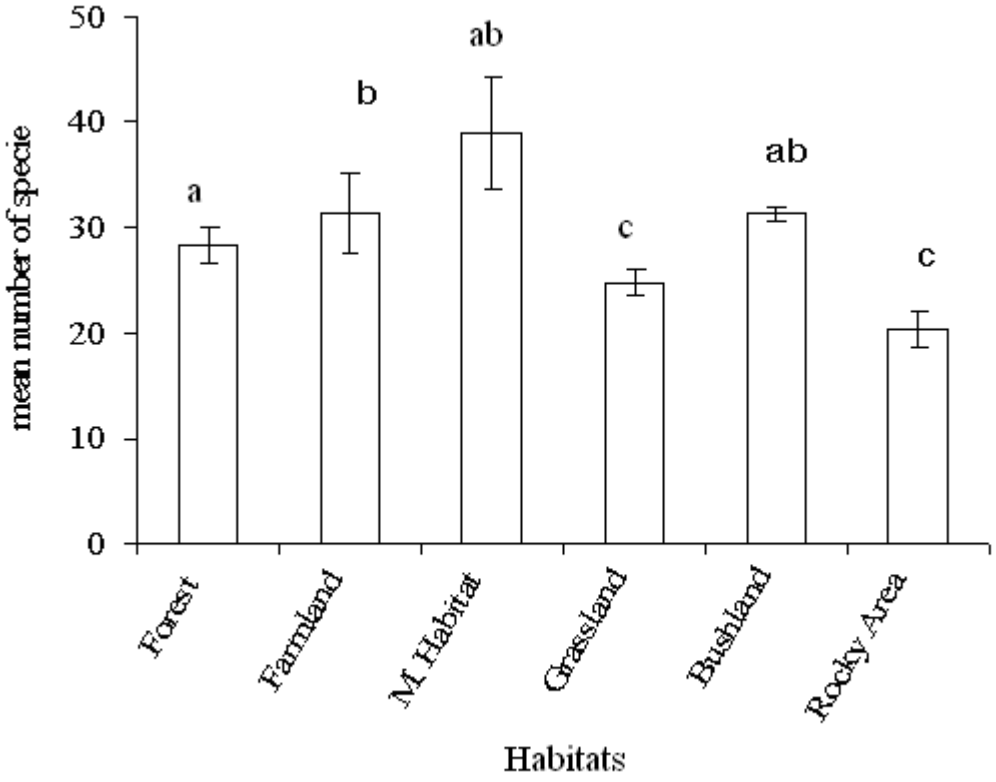


Figure 4. Mean abundance of birds in different habitats.
(Different letters indicate the presence of significant variation among habitats and habitats with mean values represented by the same letter are not significantly different in their bird abundance $P > 0.05$).

Overall abundance of birds increased from 1,258 (wet season) to 1,928 (dry season), from 2,877 to 3,589, 2,191 to 2,973 and from 698 to 800 in forest, farmland, modified habitat and bushland, respectively. However, there was a decrease from 1,935 (wet season) to 1,583 (dry season) in

grassland and from 831 to 645 in rocky habitats. By using the one-way ANOVA (with a general linear model, GLM, and pair-wise T-test equivalent to LSD) these variations in abundance were statistically significant between seasons ($F = 11.006$, $df = 1$, $P<0.05$), habitat types ($F = 102.522$, $df = 5$, $P < 0.05$) and interaction between season and habitats ($F = 8.127$, $df = 5$, $P < 0.05$).

The relative abundance score and rank of each species from the encounter rate are shown from Appendix 1 – 12. During the wet season, the relative abundance score of avian species showed that 22 species were rare, 49 uncommon, 106 frequent, 37 common and 23 abundant (Table 10).

Table 10. Relative abundance of species during the wet season.

	Rank				
Habitat	Rare	Uncommon	Frequent	Common	Abundant
Forest	6	12	19	6	-
Modified Habitat	3	14	22	6	7
Farmland	6	13	17	6	6
Bushland	3	4	27	2	2
Grassland	2	5	13	8	5
Rocky Area	2	1	8	9	3

During the dry season, the relative abundance of avian species showed that 17 were rare, 44 uncommon, 134 frequent, 37 common and 21 were abundant (Table 11).

Table 11. Relative abundance of species during the dry season.

	Rank				
Habitats	Rare	Uncommon	Frequent	Common	Abundant
Forest	3	5	26	7	2
Modified Habitat	2	14	26	6	8
Farmland	6	8	22	5	7
Bushland	-	2	26	2	2
Grassland	3	9	23	9	2
Rocky Area	3	6	11	8	-

6. 6. Habitat association

The interaction of birds with their habitat type to feed, gather nesting materials and roosting sites showed variation among species. The present study identified that both season and habitat types had statistically significant difference in avian species abundance and distribution in the different vegetational zone of the study area. However, the distribution and abundance of birds were more associated to habitat type than seasons. High significant difference was observed among habitat types ($F = 102.52$, $df = 5$, $P < 0.01$) whereas the significant difference among seasons was ($F = 11.006$, $df = 1$, $P < 0.05$). The interaction between habitat and season also showed a high significant difference on the abundance and distribution of birds ($F = 8.13$, $df = 5$, $P < 0.05$).

In the forest habitat, the wet season data showed a high significance difference in their habitat association ($\chi^2_{66} = 254.20$, $P < 0.01$) showing the existence of relation between birds and vegetation type (Table 12). While the highest positive association was observed in areas dominated by fruits, the least interaction was obtained in areas dominated by conifers. During the dry season, there was a high significant difference ($\chi^2_{71} = 218.46$, $P < 0.01$) with a high positive association within forest areas dominated by fruits and the least association was observed in areas dominated by conifer trees (Table 12).

Table 12. Habitat association of birds in the forest habitat during the wet and dry seasons.

Seasons		Flowers and fruits	Fruits	Conifers
Wet	Chi-square	66.21	155.68	32.41
	df	19	33	14
	Sig.	0.000	0.000	0.004
Dry	Chi-square	78.32	102.85	37.29
	df	22	34	15
	Sig.	0.000	0.000	0.001

At the farmland, during the wet season there was a high significant difference ($\chi^2_{53} = 211.67$, $P < 0.01$) in their habitat interaction showing that birds can associate with croplands developed by humans in addition to the natural vegetation (Table 13). A high positive interaction was observed in farmland dominated by barely where it is the dominant crop grown by the local farmers in the area. During the dry season, the habitat association of birds showed a high significance

difference (χ^2_{54} =217.85, P < 0.01) with a high positive interaction in farmlands dominated by barely and lowest interaction in maize farmland (Table 13).

Table 13. Habitat association of birds in the farmland during the wet and dry seasons.

Seasons		Barley	Maize	Beans and pea
Wet	Chi-square	94.87	56.90	59.90
	df	23	17	13
	Sig.	0.000	0.000	0.000
Dry	Chi-square	113.37	48.42	56.06
	df	27	15	12
	Sig.	0.000	0.000	0.000

At the modified habitat, during the wet season there was a high significant difference in habitat association of birds and the vegetation type (χ^2_{65} = 236.20, P < 0.01) (Table 14). Highest positive association was obtained in sites dominated by fruits whereas areas with *Eucalyptus* trees had lowest interaction. During the dry season, a high significant difference (χ^2_{79} = 200.92, P < 0.05) was observed in their habitat association with a high positive association in fruit producing vegetation followed by interaction with fruit and flower producing vegetation (Table 14).

Table 14. Habitat association of birds in the modified habitat during the wet and dry seasons.

Seasons		Fruits and flowers	Fruits	*Eucalyptus* trees
Wet	Chi-square	105.69	108.26	22.25
	df	20	38	7
	Sig.	0.000	0.000	0.002
Dry	Chi-square	70.38	108.48	22.06
	df	33	35	11
	Sig.	0.000	0.000	0.009

During the wet season, the bushland habitat had a high significant difference in their habitat association showing the presence of interaction between birds and the vegetation type (χ^2_{62} = 176.26, P < 0.01). High positive association was obtained in grassy area dominated by fruits and flowers (Table 15). During the dry season, there was a high significant difference (χ^2_{70} = 220.95, P < 0.01) in their habitat interaction in the bushland (Table 15).

Table 15. Habitat association of birds in the bushland during the wet and dry seasons.

Seasons		Flowers and fruits	Fruits	Edges
Wet	Chi-square	54.64	68.74	52.88
	df	20	27	15
	Sig.	0.000	0.000	0.000
Dry	Chi-square	71.33	93.73	55.89
	df	24	29	17
	Sig.	0.000	0.000	0.000

6. 7. Distribution

During the present study, members of the different families of birds were distributed differently among the vegetation types. Based on the suitability of the habitats, some members of birds used the habitat as their fooding and breeding sites and the other habitat for their roosting site after they feed. Members of six families (Culumbidae, Apodidae, Estrilidae, Turdidae, Cisticolidae, and Threskiornithidae), for example, were widely distributed in all habitats. On the other hand, members of four families (Scopidea, Anatidae, Upupidae and Motacillidae) were observed only in one habitat (Table 16).

Table 16. Bird families and habitat types they were recorded ("*"indicate the presence and "X" indicate the absence of a species in each habitat).

	Habitats					
Family	Forest	Farmland	Modified Habitat	Bushland	Grassland	Rocky Area
Ardeidae	X	*	X	X	*	X
Scopidae	X	X	*	X	X	X
Threskiornithidae	*	*	*	*	*	*
Anatidae	X	X	X	X	*	X
Accipitridae	*	X	*	X	X	X
Falconidae	*	*	*	X	*	X
Phasianidae	*	*	X	*	*	X
Charadridae	X	*	X	X	*	X
Culumbidae	*	*	*	*	*	*
Psittacidae	*	X	X	X	X	X
Musophagidae	*	X	X	*	X	X
Cuculidae	*	X	*	X	X	X
Timaliidae	*	X	*	X	X	X
Apodidae	*	*	*	*	*	*
Coliidae	*	X	*	X	X	X

...Cont'd

Meropidae	X	*	*	X	*	*
Upupidae	X	X	X	X	*	X
Bucerotidae	*	X	*	X	X	X
Indicatoridae	*	X	*	X	*	*
Picidae	*	X	X	*	X	X
Strigidae	*	X	X	X	X	X
Alaudidae	X	*	X	X	*	*
Motacillidae	X	X	X	X	*	X
Hirundinidae	X	*	X	*	X	X
Syliviidae	*	X	*	*	X	X
Sycnonotidae	*	X	*	*	X	X
Muscicapidae	*	X	*	*	*	X
Nectariniidae	*	X	*	*	*	X
Zosteropidae	*	X	*	*	X	X
Estrildae	*	*	*	*	*	*
Turdidae	*	*	*	*	*	*
Monarchidae	*	X	*	*	X	X
Malaconotidae	*	X	*	*	x	X
Cisticolidae	*	*	*	*	*	*
Lanidae	X	*	*	*	*	X
Viduidae	X	*	*	*	*	*
Passeridae	X	*	*	*	*	X
Fringillidae	X	*	X	X	*	*
Ploceidae	X	*	*	*	*	*
Corvidae	X	*	*	*	*	*
Sturnidae	X	*	*	*	*	*
Caprimulgidae	X	*	*	X	X	X
Campephagidae	X	*	*	X	X	X
Emberizidae	X	*	*	*	*	*

7. DISCUSSION

7.1. Diversity

The species composition, the number of species and number of individuals differ within the study areas. Abundance of avian species within the study area was distributed differently among habitat types. The number of bird species counted increases with the amount of nectar, seed and fruit producing vegetation in each habitat. The highest number of species observed in the modified habitat and farmland is probably due to the diversity of vegetation that provides heterogeneous habitat for different avian species and the availability of food which birds are attracted. The rocky areas with their limited type of vegetation supported less number of avian species and individuals. Floristic composition and vegetation structure are repeatedly stated habitat variables that determine the abundance of birds in different vegetation types. Many research works supported the importance of habitat structure and the availability of vegetation cover for the number of avian species. Sodhi (2002), and Martin and Possingham (2005) indicated that habitat structure and food supply are the major determinants of avian species diversity. Bird species diversity has been associated with the vertical complexity of vegetation (MacArthur and MacArthur, 1961) and the diversity in bird species could be the result of vertical, horizontal and temporal heterogeneity of the habitat (MacArthur, 1964). In the study area, bird species richness was increased with land cover diversity, which creates suitable condition for food and sites to rest. The significance of vegetation layer for bird species diversity was explained by Moss (1978). As the number of vegetation layer increases, the number of available niches for bird also increases and so does the number of bird species. This is due to the feeding habit of birds that leads to niche separation (MacArthur, 1964; Moss, 1978).

In the present study, species distribution and abundance were affected by the habitat type, season and the interaction between season and habitats to varying degrees where the vegetation type played a major role. Seasonality in number of avian species was observed in the different habitats. During the wet season, there was high diversity of species in the modified habitat followed by the farmland. Seasonal changes in habitat structure and food abundance in most terrestrial habitats influence the diversity of species (Stephens *et al*., 2003; Butler and Taylor, 2005). Karr (1976), Loegering and Anthony (1999) and Oindo *et al*. (2001) also found that the

number of bird species varied seasonally in relation with the availability of resources like food and vegetation strata for cover.

The distribution and abundance of avian species during wet and dry seasons was highly dependent on the type of vegetation and land cover diversity. During the wet season, due to the presence of sufficient vegetation cover with grasses and flowers, the rocky area and grassland habitats attracted different avian species with relatively large number of individuals. However, during the dry season, the number of birds found in the rocky areas and grasslands declined with changes in the nature and density of vegetation structure through grazing by livestock and intentional burning and cutting of trees/bushes by the locals. As a result, birds migrated to the adjacent areas of the edges of the natural forest, bushland and modified habitat. This local migration of birds in search of food and cover was enhanced the diversity of the avian fauna in the modified habitat, bushland and forest habitats and decreased their abundance in the rocky area and grassland. This was in agreement with the studies of MacArthur and MacArthur (1961), Vivkery *et al*. (2001) and McPherson and Jetz (2007) who showed increase in the diversity of species with the amount of vegetation cover, foliage height diversity and habitat heterogeneity. MacArthur (1964), Karr (1976) and Whited *et al*. (2000) also indicated that a decline in the quality of habitat through grazing, selective logging and subsistence farming resulted in the loss of the habitat along with the resident avifauna declined.

During the dry season, the richest and most diversified sites (modified habitat and farmland) showed high measure of avian diversity and similarity. As open areas are easily accessible, sighting of birds for clear identification and counting was easy. As a result, maximum number individuals and species were obtained from the modified habitat and farmland. The modified habitat and forest within and near agriculturally disturbed landscapes possessed the highest species richness. This is because agricultural activities may provide food for birds in the form of flowers, seeds and fruits. The highest species diversity in the modified habitat, farmland and forest is probably due to the great complexity of vegetation structure within the habitats, which creates a variety of niches for different avian species. The high diversity of birds is due to the availability of food and cover for breeding and roosting sites (MacArthur, *et al*., 1962; Jansen *et al*., 2001; Sodhi, 2002).

High number of birds was encountered in areas containing suitable food and covers for their breeding, nesting and roosting sites. The distribution patterns of avian species are determined by identifying the sites where the species exist (Bibby *et al*., 1998). The Moorland (Alpine) Chats, Rüppell's Black Chat, Ankober Serin, and White-winged Cliff chats, for instance, were restricted in the highland rocky areas and moorland grasslands whereas White-cheeked Turaco and Black-headed Lovebirds were recorded in forest habitat nearby streams. However, the absence of some species, particularly smaller ones from an area especially from dense forest, may not reflect their total absence from the area; rather it may reflect a failure to identify and record its presence during the survey. Thus, further detailed study in the area might reveal additional species.

Within the study area, the number of species as well as individuals showed variations. The major factors that govern the diversity of birds in the study area seem to be the availability of forest patches with different vegetation covers, the diversity of land cover, high dependency of birds on nectar, fruit and seed producing vegetation found in the modified habitat, agricultural areas and forest edges with streams, stability of food resources and covers and complexity of habitats. The findings of MacArthur and MacArthur (1961), Karr (1976), Vivkery *et al*. (2001) and Martin and Possingham (2005) are in agreement with this explanation. Even though there are a number of complex causes for variation in the diversity of birds, food supply, habitat quality, stability in feeding, breeding and roosting sites, presence of predators and competition and disease are major factors that cause variation in bird diversity in any area (Gregory *et al*., 2004; Martin and Possingham, 2005).

The distributional patterns (evenness) of birds have revealed high value of evenness in the forest habitat followed by the bushland in the study area. This was probably because the vegetation covers of such habitat did not change much and provide suitable condition for birds during both seasons. Altitude has an effect on the vegetation cover of the habitat and it leads to the change in the abundance and distributional patterns of birds. To this end, Karr and Roth (1971) and Waterhouse *et al*. (2006) showed that at higher elevation availability of resources for birds diminishes and physical conditions become more adverse for some birds.

7.2. Habitat association

To determine the actual environmental factors that limit the distribution and abundance of birds, analysis of habitat association patterns by vegetation type and actual habitat use is essential. Habitat preference, distribution and abundance of avian fauna showed a significant variation depending upon the nature and composition of the vegetation for food and cover from season to season. In the vegetation strata of the forest, farmland, modified habitat, grassland, bushland and rocky areas of the Wof Washa NFPA, species have shown different association with the type of vegetation that comprises the major component of their habitat. Habitat preference of birds varied in different localities and habitat types in the study sites. Species diversity, abundance and habitat association of birds in the study area are comparable to recent data for research works of (Sodhi, 2002; Stephens *et al*., 2003; Butler and Taylor, 2005; Martin and Possingham, 2005; Kumar and Sahahabuddin, 2006, Thinh, 2006, McPherson and Jetz, 2007) who have related the bird species richness, abundance and distribution are correlated with land cover diversity and seasonal changes.

The present study showed the presence of strong association between the habitat type and avian species in which their survival depended upon the basic resources that occur in the habitat. Karr (1976) found that forest birds consume a variety of resources with different foraging behaviour and substrate utilization varying among species, which in turn determine their habitat association. The most common habitat association pattern detected during the wet and dry season surveys was a high positive interaction with areas containing fruiting and flower producing trees and lack of strong association with man-made forest dominated by *Eucalyptus* trees. Areas dominated by flowering plants that produce nectars, fruits and seeds in the study area were highly favoured and visited by many birds during the study period. The findings of Diaz *et al*. (2005) and Davies *et al*. (2007) agree with this idea that modified landscapes dominated by successional man made forest alters bird species richness and abundance. Sodhi (2002) also indicated that bird species richness and abundance were lower in disturbed areas than in primary natural forests.

During the fruiting season, the numbers of frugivores and seed eaters, like Black-winged lovebird, and Brown-rumped siskin, were high and were highly associated with fruiting trees and crops. Insectivorous birds (such as spotted flycatcher) increased with the number of insects available in the area during the wet season and they decreased during the dry season. During the dry season, yellow wagtails, cattle egrets, oxpeckers, starlings, and pied crows were found in areas where livestock graze (grasslands and farmlands). These habitats were preferred by such birds due to the presence of food source like ticks on the skin and insects on the dung of cattle. White-rumped babblers, Senegal coucals and mountain wagtails, were strongly associated with forest habitats connected with streams.

The rocky areas and cliffs contain homogeneous and limited type of vegetation, forcing birds for local migration into other sites during the dry season. This local migration of birds reduces the abundance of birds in the area and increases others. Even though the habitats may be suitable for the survival of birds, factors that are related to food, cover, climate, soil and competition with existing species may greatly limit the presence of the species and reduces its interactions to the given habitat. Thus, black-winged lovebird (*Agapornis taranta*), Abyssinian logclaw (*Macronyx flavicollis*), Ankober serin (*Serinus ankoberensis*), white-winged cliff chat (*Thamnolea semirufa*), Thick-billed raven (*Corvus crassirostris*), moorland (alpine) chat (*Cercomela sordida*) and Rüppell's black chat (*Myrmecocichla melaena*) were found to be as highland biome restricted species, associated with highland vegetation. To this end, Ash (1979) found that Ankober Serin was highly restricted to the highland of Ankober-Debre Sina Escarpment mainly in the rocky cliffs.

8. THREAT TO THE AVIFAUNA IN THE STUDY AREA

During the study period, both anthropogenic factors and natural phenomena are recognized as threat to the avifauna and wildlife of the area. Discussion with the local people and direct observations have helped to assess the effect of natural phenomena, the views of the community and human related threats on the wildlife of the area. Fragmentation of habitats due to intentional burning of the forest, intensive farming, selective logging and flooding in the study area have negative impacts on the distribution, diversity and abundance of birds by influencing habitat use for nesting, reproduction, survival, feeding and roosting. To this end, Belisle *et al*. (2001) found that habitat loss and fragmentation affect forest birds through direct loss of breeding habitats, increased nest predation and brood parasitism and by limiting movements of birds among the remaining forest patches.

The negative effect of forest resource extraction was observed in the study area. Extraction of timber and non-timber products resulted in alteration of the vegetation structure, affecting the species composition (Kumar and Shahabuddin, 2006). Chadwick *et al*. (1986) stated that fuel wood cutting notably reduces foraging and/or nesting opportunities for some birds by decreasing sources of dead and dying wood.

The local farmers were observed clearing the grass, bushes and macrophytes in order to get additional land for settlement, grazing and agricultural lands, which may serve as food, cover, roosting sites and breeding ground for many birds. Due to such intentional activities by the locals, some endemic and restricted range species like the Abyssinian longclaw, Ankober serin and Abyssinian catbird were highly affected in the area. Findings by Whited *et al*. (2000), Stephen *et al*. (2003), Gregory *et al*. (2004) and Diaz *et al*. (2005) confirmed that agricultural activities contributed a lot to the reduction of biological diversity.

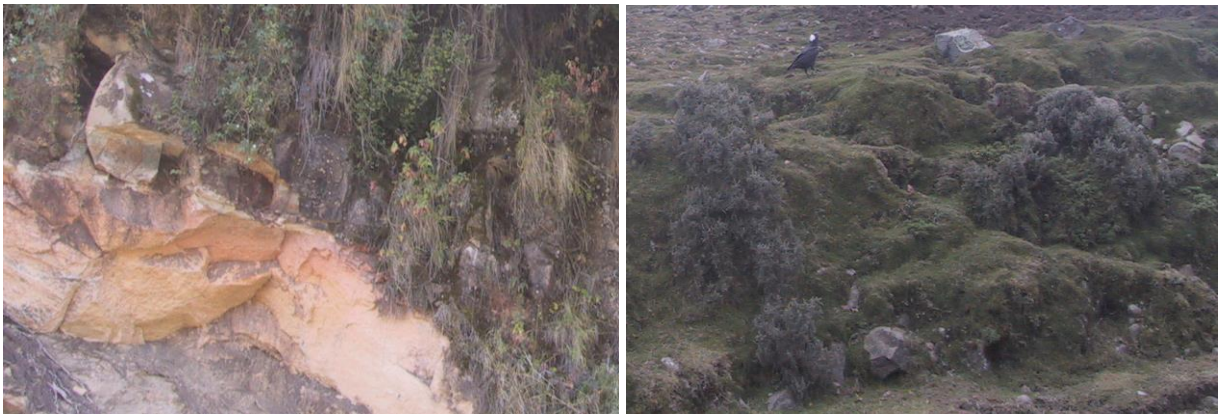


Plate 9. Area being destructed for agricultural activity. (Photo: Sisay Hailu, March, 2008).

The strongly negative attitude of the local people in and around the forest towards birds, particularly on seed eaters and starlings as crop pests, greatly threaten their lives. Local residents were trying to eradicate/ kill these birds by any means. Even they use pesticides in order to kill them. This is in agreement with Viveropol (2001) that the negative attitude of people towards birds affects their lives. Overgrazing of the vegetation by introducing livestock into the forest and grassland habitats greatly affected the avifauna in the study area. To this end, Karr (1976) showed the existence of variation on bird species diversity among grazed and ungrazed grasslands.

In search of additional farmland, grazing land and settlement area, the local people frequently set fire in and around the forest area, bushland and protected grassland areas. This activity causes intentional burning of the forest, bush and grassland which leads to the destruction of food, and reduction of roosting and breeding sites of birds. In addition, fire seriously affects the population of forest dwelling and ground nesting birds through direct effect on eggs and nests. Natural disturbances like flooding and drying of streams in the study area affect the quality of avian habitats. The drying of streams during the dry season resulted in the loss of resources for birds.

The community within and around the forest, both from the upper and lower sides, feel that they have full right to use the resources. As a result some continue to encroach into the forest. Fuel wood, timber and long *Festuca* grasses are illegally sold at the nearby markets of Debre Sina, Shewa Robit, Mezezo, Debre Birhan, Ankober and Aliyu Amba affecting the vegetation cover as well as the fauna of the area. Thus, resources found within the forest area are under heavy threats

of disappearing in the near future due to the change in land and forest management and alarming destruction of the forest due to high human pressure. Resources are diminishing fast and will soon vanish if the current trend of random exploitation of the forest resources within the area continues. Consequently, there is a severe shortage of fuel wood, the drying of streams, loss of valuable, unique and important sources of genetic diversity and long lasting permanent damage to the ecosystem. As a result, endemic fauna, which have no much tolerance for the changing environment will disappear within a short period of time.

9. CONCLUSIONS AND RECOMMENDATIONS

The present survey revealed that Wof Washa NFPA supports a variety of avian species in different vegetation types. During this investigation, 158 species of birds were identified. Among these 4 are exclusively endemic to the country and 9 are endemics to Ethiopia and Eritrea. Since forest birds are difficult to identify and the skill to identify them, the inaccessibility of the area, the conspicuousness of birds, the technique employed during the survey and weather condition influence the data on avian species diversity, further detailed study might reveal additional species in the area. The highest species diversity, richness and evenness obtained in the modified habitat, farmland and dense forest reflect the significance of these habitats for birds by providing the necessary requirements - food, water and cover. The seasonal variation in the number of individual species and their distribution in the study area are closely related to the habitat types.

Wof Washa NFPA is one of the richest areas of genetic biodiversity still existing in the highlands of Ethiopia due to its inaccessibility on steep slopes. The dense and intact Wof Washa NFPA is home for many species of plants and animals. This is due to the diversity in vegetation types of the forest that harbours large number of mammal species including the endemic gelada baboon and other wild animals, besides birds. Thus, it can serve as important centre of biodiversity and tourist attraction. However, the area has a long history of settlement and agriculture, which affect the biodiversity. Even if the changed environments such as the farmland and modified habitats have good avian diversity, the endemic and restricted range species were highly affected. As farmers run short of fertile land on the gentle slopes, they have resorted to cultivating very steep slopes and have even encroached into the forest. Although the forest has been a state forest for many years, the people living in and around the forest still have free access to entry, collect construction and fuel wood as well as other forest products. The locals also use the forest area as grazing land with a hidden temporary refuge, locally called “Kebt Magoria”, for their livestock. The livestock were kept in the forest when the farmers become busy with their agricultural activities and drought in the area.

Thus, protection of the vegetation of the area is crucial for wildlife conservation in general and avifauna in particular. Hence, the vegetation that constitutes Wof Washa NFPA should be

conserved to increase food and cover for feeding, breeding and roosting sites of the avifauna and other wild animals found in the area to maintain the natural ecological balance of the area.

Plate 10. A view of the highly fragmented forest in the study area.
(Photo: Sisay Hailu, March, 2008).

Based on the present study carried out in the Wof Washa NFPA and its surroundings, the following recommendations are made:

- The present threats in the area such as intentional forest burning, grazing, intensive farming and human and livestock encroachment into the forest have negative impact on the diversity and abundance of the whole biodiversity of the area particularly of the avifauna. Thus, it is

essential to take appropriate measures to stop destruction of the remaining natural vegetation in the area.

- Subsistence farming has also expanded even along the steep slopes, destroying the afroalpine vegetation and the moorland. This has resulted in increase in flood and soil erosion. It is, therefore, necessary to encourage the local farmers, by giving sustainable support, to leave the agricultural land to regenerate steep slopes of the area.

- Man-made forests consisting mainly of fast growing exotic trees, *Eucalyptus* would not support many species compared to the natural forest stands. This reduces the available habitat for indigenous flora and fauna. Thus, the practice of planting exotic *Eucalyptus* trees around the high altitude areas should be avoided and planting native trees should be encouraged.

- The area contains relatively large number of endemic birds of the country. It is, therefore, essential that detailed study on the status of these birds be conducted to assess whether the species are in danger of extinction and take proper management and conservation measures.

- The high growth rate of human population leads to the destruction of the habitat. It is, therefore, essential that people living inside the forest should be settled to other sites. This should be worked out through awareness creation of the community and by providing sustainable benefits through logical and well coordinated manners.

- All settlers of the three Woredas (Ankober, Tarma Ber and Baso and Worana) near the forest are engaged in logging of construction and fuel wood, livestock grazing and cutting down of the protected *Festuca* grass to sell in the market. Control of over- exploitation of the habitats is mandatory.

- Promotion of grazing land management through controlled grazing and appropriate stocking densities within the carrying capacity of the given area should be practiced.

- Intentional and/or unintentional fire causes uncontrolled burning and destruction of wide range of forest habitat and damage to wild animals. Thus, it is necessary to build fire- breaks within the forest and control forest fire.

- Attention should be given to developing and maintaining the area as historical site and biodiversity centre. Thus, collaboration among NGOs, the Federal, Regional, Zonal Bureau and Woreda as well as Kebele level with the locals is indispensable.

- Strengthen community and grass root institutions, enhance community participation, local capacity and skill favouring sustainable development and ecosystem conservation.

- The cliffs and mountain edges of the forest are the habitat for Ankober Serin, and other endemic fauna such as gelada baboon and Ethiopian Wolf. Thus, it is mandatory to protect such endemic species by protecting their natural habitats.

- To maintain the whole biodiversity of the area, it will be necessary not only to preserve primary habitats that still exist with few remaining flora and fauna, but also to renew and/or rehabilitate habitats that have already been exploited.

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11. APPENDICES

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

Species	Individuals per 100 field hours	Abundance score	Rank
Wattled Ibis	6.55	3	Frequent
Black-breasted Snake Eagle	1.19	1	Rare
Moorland Francolin	7.14	3	Frequent
Erckel's Francolin	5.36	2	uncommon
Dusky Turtle Dove	12.31	3	Frequent
Lemon Dove	2.38	1	Rare
Red-headed Lovebird	11.31	3	Frequent
Back-winged Lovebird	8.93	3	Frequent
White-checked Turaco	19.64	3	Frequent
Speckled Mousebird	7.14	1	Rare
Blue-breasted Bee-eater	2.98	2	Uncommon
Hemprich's Hornbill	3.57	2	Uncommon
Silvery-checked Hornbill	2.38	1	Rare
Greater Honey Guide	3.57	2	Uncommon
Grey-headed Woodpecker	1.79	1	Rare
African Pied Wagtail	3.57	2	Uncommon
Common Bulbul	7.14	3	Frequent
Abyssinian Ground Thrush	3.57	2	Uncommon
Ground scraper Thrush	8.93	3	Frequent
Olive Thrush	14.28	3	Frequent
Tawny flanked Prinia	7.14	3	Frequent
Pale Prinia	6.55	3	Frequent
Common Chiff Chaff	31.55	4	Common
Wood Warbler	8.33	3	Frequent
Blackcap	5.95	2	Uncommon
Spotted Flycatcher	1.79	1	Rare
African Dusky Flycatcher	5.36	2	Uncommon
Rüppell's Robin Chat	9.52	3	Frequent
African Paradise Flycatcher	5.95	2	Uncommon
White-rumped Babbler	14.88	3	Frequent
Abyssinian Catbird	7.74	3	Frequent
Collared Sunbird	5.95	2	Uncommon
Tacazze Sunbird	8.93	3	Frequent
Bronze Sunbird	8.33	3	Frequent
Variable (Yellow-bellied) Sunbird	10.12	3	Frequent

	…Cont'd		
Amethyst Sunbird	5.95	2	Uncommon
Broad-ringed (Montane) White eye	109.52	5	Common
Tropical Boubou	7.14	3	Frequent
Slender-billed Starling	23.81	3	Frequent
Baglafecht Weaver	41.07	5	Common
Yellow-bellied Waxbill	111.31	4	Common
Fawn breasted Waxbill	44.05	4	Common
Brown-rumped Siskin	95.83	4	Common

<3.04 Rare (1), 3.04 – 6.38 Uncommon (2), 6.39 – 30.43 Frequent (3), 30.44 – 122 Common (4), >122 Abundant (5)

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

Species	Individuals per 100 filed hours	Abundance score	Rank
Wattled Ibis	5.95	2	Uncommon
Moorland Francolin	14.88	3	Frequent
Erckel's Francolin	9.52	3	Frequent
Rufous-chested Sparrow hawk	3.57	2	Uncommon
Dusky Turtle Dove	20.24	3	Frequent
Red-headed Lovebird	11.31	3	Frequent
Black-winged Lovebird	8.93	3	Frequent
White-checked Turaco	22.62	3	Frequent
Speckled Mousebird	10.12	3	Frequent
Crag Martin	30.95	4	Common
Silvery-checked Hornbill	1.78	1	Rare
Greater Honey Guide	3.57	2	Uncommon
Grey- headed Woodpecker	2.38	1	Rare
African Pied Wagtail	2.98	1	Rare
African Woodowl	0.59	1	Rare
Common Bulbul	29.76	3	Frequent
Abyssinian Ground Thrush	4.17	2	Uncommon
Ground scraper Thrush	9.52	3	Frequent
Olive Thrush	19.64	3	Frequent
Tawny flanked Prinia	23.21	3	Frequent
Pale Prinia	7.14	3	Frequent
Brown Woodland Warbler	85.70	4	Common
Common Chiff Chaff	38.69	4	Common
Wood Warbler	18.45	3	Frequent
Willow Warbler	16.67	3	Frequent
Blackcap	6.55	3	Frequent
Garden Warbler	26.79	3	Frequent
Cinnamon-bracken Warbler	8.33	3	Frequent
Rüppell's Robin Chat	12.50	3	Frequent
African Paradise Flycatcher	8.33	3	Frequent
White-rumped Babbler	19.64	3	Frequent
Abyssinian Catbird	8.33	3	Frequent
Collared Sunbird	4.76	2	Uncommon
Tacazze Sunbird	10.71	3	Frequent
Bronze Sunbird	8.93	3	Frequent
Variable (Yellow-bellied) Sunbird	12.50	3	Frequent
Amethyst Sunbird	6.55	3	Frequent

	…Cont'd		
Broad-ringed (Montane) White-eye	167.26	4	Abundant
Tropical Boubou	16.67	3	Frequent
Slender-billed Starling	32.74	4	Common
White-billed Starling	10.12	3	Frequent
Yellow-bellied Waxbill	138.09	5	Abundant
Fawn-breasted Waxbill	57.14	4	Common
Baglafecht Weaver	57.14	4	Common
Brown-rumped Siskin	98.48	4	Common

Appendix 3. Relative abundance of birds in the modified habitat during the wet season.

Species	Individuals per 100 field hours	Abundance score	Rank
Hamerkop	2.08	1	Rare
Wattled Ibis	20.83	3	Frequent
Sacred Ibis	3.13	2	Uncommon
Egyptian Goose	3.13	2	Uncommon
Lammergeier	2.08	1	Rare
Tawny Eagle	77.08	4	Common
Speckled Pigeon	97.92	4	Common
White-collared Pigeon	233.22	5	Abundant
Dusky Turtle Dove	12.50	3	Frequent
Red-eyed Dove	6.25	2	Uncommon
Laughing Dove	3.13	2	Uncommon
White-checked Turaco	13.54	3	Frequent
Speckled Mouse bird	3.13	2	Uncommon
Hemprich's Hornbill	7.29	3	Frequent
Lesser Honey Guide	4.17	2	Uncommon
Greater Honey Guide	7.29	3	Frequent
African Pied Wagtail	3.13	2	Uncommon
Common Bulbul	9.38	3	Frequent
Little Rock Thrush	6.25	2	Uncommon
Olive Thrush	14.58	3	Frequent
Tawny-flanked Prinia	7.29	3	Frequent
Pale Prinia	4.17	2	Uncommon
Garden Warbler	15.63	3	Frequent
Spotted Flycatcher	5.21	2	Uncommon
Rüppell's Robin Chat	6.25	2	Uncommon
White-rumped Babbler	12.50	3	Frequent
African Paradise Flycatcher	9.38	3	Frequent
Collared Sunbird	6.25	2	Uncommon
Tacazze Sunbird	9.38	3	Frequent
Bronze Sunbird	7.29	3	Frequent
Variable (Yellow-bellied) Sunbird	16.67	3	Frequent
Amethyst Sunbird	4.17	2	Uncommon
Broad-ringed (Montane) White eye	145.83	5	Abundant
Tropical Boubou	4.17	2	Uncommon
Pied Crow	35.42	4	Common
Cape Crow	15.63	3	Frequent
Fan-tailed Raven	58.33	4	Common
Thick-billed Raven	22.92	3	Frequent

	...Cont'd		
Red-winged Starling	9.38	3	Frequent
White-billed Starling	17.71	3	Frequent
Spectacled Weaver	19.79	3	Frequent
Baglafecht Weaver	287.50	5	Abundant
Black-headed Weaver	22.92	3	Frequent
Red-billed Firefinch	16.67	3	Frequent
Red-checked Cordonbleu	12.50	3	Frequent
Yellow-bellied Waxbill	178.13	5	Abundant
Fawn-breasted Waxbill	63.54	4	Common
Brown-rumped Siskin	171.88	5	Abundant
Streaky Siskin	82.29	4	Common
Abyssinian (Black-headed) Siskin	189.58	5	Abundant
Abyssinian Catbird	2.08	1	Rare
Grey-headed Sparrow	123.96	5	Abundant

Appendix 4. Relative abundance of birds in the modified habitat during the dry season.

Species	Individuals per 100 field hours	Abundance score	Rank
Wattled Ibis	25.00	3	Frequent
Egyptian Goose	5.21	2	Uncommon
Black Kite	12.50	3	Frequent
Hooded Vulture	6.25	2	Uncommon
Lappet-faced Vulture	17.71	3	Frequent
Rüppell's Griffon	3.13	2	Uncommon
Tawny Eagle	120.83	4	Common
Speckled Pigeon	100.00	4	Common
White-collared Pigeon	286.46	5	Abundant
Dusky Turtle Dove	15.63	3	Frequent
Red-eyed Dove	9.38	3	Frequent
Laughing Dove	4.17	2	Uncommon
White-checked Turaco	19.79	3	Frequent
Speckled Mousebird	4.17	2	Uncommon
Greater Honey Guide	4.17	2	Uncommon
Grey-headed Woodpecker	3.13	2	Uncommon
African Pied Wagtail	4.17	2	Uncommon
Yellow Wagtail	70.83	4	Common
African Wood owl	2.08	1	Rare
Common Bulbul	12.50	3	Frequent
Little Rock Thrush	9.38	3	Frequent
Olive Thrush	17.71	3	Frequent
Tawny-flanked Prinia	8.33	3	Frequent
Pale Prinia	5.21	2	Uncommon
Pectoral Patch Cisticola	3.13	2	Uncommon
Garden Warbler	25.00	3	Frequent
Spotted Flycatcher	7.29	3	Frequent
Rüppell's Robin Chat	7.29	3	Frequent
White-rumped Babbler	15.63	3	Frequent
African Paradise Flycatcher	10.42	3	Frequent
Collared Sunbird	6.25	2	Uncommon
Tacazze Sunbird	9.38	3	Frequent
Bronze Sunbird	7.29	3	Frequent
Variable (Yellow-bellied) Sunbird	12.50	3	Frequent
Broad-ringed (Montane) White eye	154.17	5	Abundant
Common Fiscal	6.25	2	Uncommon
Tropical Boubou	6.25	2	Uncommon

	...Cont'd		
Pied Crow	40.63	4	Common
Cape Crow	25.00	3	Frequent
Fan-tailed Raven	65.63	4	Common
Thick-billed Raven	32.29	4	Abundant
Greater Blue-eared Starling	27.08	3	Frequent
White-billed Starling	30.21	3	Frequent
Red-billed Oxpecker	11.46	3	Frequent
Spectacled Weaver	13.54	3	Frequent
Baglafecht Weaver	361.46	5	Abundant
Red-billed Firefinch	25.00	3	Frequent
Red-checked Cordonbleu	27.08	3	Frequent
Yellow-bellied Waxbill	19.79	3	Frequent
Fawn-breasted Waxbill	218.75	5	Abundant
Village Indigo bird	2.08	2	Rare
Brown-rumped Siskin	206.25	5	Abundant
Streaky Siskin	113.54	4	Common
Abyssinian (Black-headed) Siskin	293.75	5	Abundant
Abyssinian Catbird	3.13	2	Uncommon
Grey-headed Sparrow	179.10	5	Abundant

Appendix 5. Relative abundance of birds in the farmland during the wet season.

Species	Individuals per 100 field hours	Abundance score	Rank
Hamerkop	2.50	1	Rare
Wattled Ibis	15.83	3	Frequent
Egyptian Goose	3.33	2	Uncommon
Black-breasted Snake Eagle	1.67	1	Rare
Augur Buzzard	3.33	2	Uncommon
Moorland Francolin	5.83	2	Uncommon
Crested Lark	8.33	3	Frequent
Thekla Lark	5.83	2	Uncommon
Black-winged Lapwing	6.67	3	Frequent
Speckled Pigeon	109.17	4	Common
White-collared Pigeon	275.83	5	Abundant
Laughing Dove	3.33	2	Uncommon
Hemprich's Hornbill	3.33	2	Uncommon
Abyssinian Ground Hornbill	1.67	1	Rare
African Pied Wagtail	1.67	1	Rare
Mountain Wagtail	7.50	3	Frequent
Common Bulbul	8.33	3	Frequent
Little Rock Thrush	5.83	2	Uncommon
Ground scraper Thrush	13.33	3	Frequent
Garden Warbler	11.67	3	Frequent
African Dusky Flycatcher	5.83	2	Uncommon
Moorland (Alpine) Chat	29.17	3	Frequent
Rüppell's Black Chat	17.50	3	Frequent
White-winged Cliff Chat	5.83	2	Uncommon
African Paradise Flycatcher	3.33	2	Uncommon
Variable (Yellow-bellied) Sunbird	5.00	2	Uncommon
Amethyst Sunbird	2.50	1	Rare
Pied Crow	20.00	3	Frequent
Cape Crow	24.17	3	Frequent
Slender-billed Starling	20.83	3	Frequent
Spectacled Weaver	21.67	3	Frequent
Baglafecht Weaver	386.67	5	Abundant
Black-headed Weaver	18.33	3	Frequent
Lesser-masked Weaver	25.00	3	Frequent
Yellow Bishop	167.50	5	Abundant
Yellow- shouldered Widowbird	118.33	4	Common
Red-collared Widowbird	80.00	4	Common
Red-billed Firefinch	8.33	3	Frequent
Red-checked Cordonbleu	5.00	2	Uncommon

	...Cont'd		
Pin-tailed Whydah	70.00	4	Common
Ankober Serin	5.83	2	Uncommon
Abyssinian Citril	8.33	3	Frequent
Abyssinian (Black-headed) Siskin	171.67	5	Abundant
Streaky-headed Siskin	103.33	4	Common
Brown-rumped Siskin	207.50	5	Abundant
Streaky Siskin	108.33	4	Common
Grey-headed Sparrow	136.67	5	Abundant
Common Stone Chat	2.50	1	Rare

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

Species	Individuals per 100 field hours	Abundance score	Rank
Cattle Egret	18.33	3	Frequent
Wattled Ibis	20.00	3	Frequent
Lammergeier	5.83	2	Uncommon
Pallid Harrier	1.67	1	Rare
Augur Buzzard	4.17	2	Uncommon
Tawny Eagle	7.50	3	Frequent
Steppe Eagle	1.67	1	Rare
Lesser Kestrel	1.67	1	Rare
Moorland Francolin	8.33	3	Frequent
Common Quail	7.50	3	Frequent
Crested Lark	13.33	3	Frequent
Thekla Lark	9.17	3	Frequent
Speckled Pigeon	130.83	5	Abundant
White-collared Pigeon	289.17	5	Abundant
Lughing Dove	5.00	2	Uncommon
Hemprich's Hornbill	2.50	1	Rare
Yellow Wagtail	109.17	4	Common
Plain-backed Pipit	20.00	3	Frequent
Common Bulbul	5.00	2	Uncommon
Little Rock Thrush	5.00	2	Uncommon
Blue Rock Thrush	2.50	1	Rare
Ground scraper Thrush	14.17	3	Frequent
Garden Warbler	15.83	3	Frequent
Moorland (Alpine) Chat	39.17	4	Common
Rüppell's Black Chat	17.50	3	Frequent
White-winged Cliff Chat	9.17	3	Frequent
Common Fiscal	3.33	2	Uncommon
Pied Crow	25.83	3	Frequent
Cape Crow	38.33	4	Common
Greater Blue-eared Starling	74.17	4	Common
Slender-billed Starling	30.00	3	Frequent
Red-billed Oxpecker	8.33	3	Frequent
Baglafecht Weaver	350.83	5	Abundant
Black-headed Weaver	15.83	3	Frequent
Red-billed Fire finch	15.83	3	Frequent
Red-checked Cordonbleu	6.67	3	Frequent
Cinnamon-breasted Bunting	7.50	3	Frequent
Ankober Serin	7.50	3	Frequent
Abyssinian (Black-headed) Siskin	254.17	5	Abundant

...Cont'd

Abyssinian Citril	14.17	3	Frequent
Streaky-headed Siskin	154.17	4	Common
Brown-rumped Siskin	255.00	5	Abundant
Streaky Siskin	143.33	5	Abundant
Grey-headed Sparrow	202.50	5	Abundant
Grey-cuckoo Shrike	3.33	2	Uncommon
Pied Wheatear	4.17	2	Uncommon
Heuglin's Wheatear	7.50	3	Frequent
Common Stone Chat	2.50	1	Rare

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

Species	Individuals per 100 field hours	Abundance score	Rank
Hamerkop	2.08	1	Rare
Wattled Ibis	25.00	3	Frequent
Sacred Ibis	8.33	3	Frequent
Blue-winged Goose	25.00	3	Frequent
Egyptian Goose	14.17	3	Frequent
Augur Buzzard	9.38	3	Frequent
Moorland Francolin	7.29	3	Frequent
Erckel's Francolin	8.33	3	Frequent
Black-winged Lapwing	4.17	2	Uncommon
Speckled Pigeon	130.21	5	Abundant
White-collared Pigeon	310.42	5	Abundant
Laughing Dove	6.25	2	Uncommon
Abyssinian Ground Hornbill	2.08	1	Rare
Crested Lark	20.83	3	Frequent
Thekla Lark	16.67	3	Frequent
African Pied Wagtail	4.17	2	Uncommon
Abyssinian Longclaw	6.25	2	Uncommon
White-billed Starling	41.67	4	Common
Marsh Warbler	9.38	3	Frequent
Ground scraper Thrush	13.54	3	Frequent
Tawny-flanked Prinia	17.71	3	Frequent
Moorland (Alpine) Chat	114.58	4	Common
Cape Crow	62.50	4	Common
Pied Crow	53.14	4	Common
Yellow Bishop	139.58	5	Abundant
Yellow-shouldered Widowbird	90.63	4	Common
Red-collared Widowbird	32.29	4	Common
Pin-tailed Whydah	102.08	4	Common
Abyssinian (Black-headed) Siskin	380.21	5	Abundant
Common Stone Chat	12.50	3	Frequent
Rüppell's Black Chat	3.13	2	Uncommon
Streaky-headed Siskin	117.71	4	Common
Brown-rumped Siskin	140.63	5	Abundant

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

Species	Individuals per 100 filed hours	Abundance score	Rank
Cattle Egret	54.17	4	Common
Wattled Ibis	29.17	3	Frequent
Blue-winged Goose	32.29	4	Common
Egyptian Goose	26.04	3	Frequent
Hooded Vulture	10.42	3	Frequent
Wahlberg's Eagle	4.17	2	Uncommon
Grasshopper Buzzard	4.17	2	Uncommon
Augur Buzzard	10.42	3	Frequent
Pallid Harrier	2.08	1	Rare
Lesser Kestrel	2.08	1	Rare
Moorland Francolin	10.42	3	Frequent
Erckel's Francolin	6.25	2	Uncommon
Common Quail	10.42	3	Frequent
Specked Pigeon	62.50	4	Common
White-collared pigeon	270.83	5	Abundant
African Hoopoe	3.13	2	Uncommon
Rufous-naped Lark	10.42	3	Frequent
Crested Lark	14.58	3	Frequent
Thekla Lark	15.63	3	Frequent
Plain Martin	15.63	3	Frequent
Crag Martin	15.63	3	Frequent
Yellow Wagtail	85.42	4	Common
Abyssinian Longclow	8.33	3	Frequent
Plain-backed Pipit	27.08	3	Frequent
Bush Pipit	20.83	3	Frequent
Ground scraper Thrush	15.63	3	Frequent
Tawny-flanked Prinia	11.46	3	Frequent
Northern (European) wheatear	10.42	3	Frequent
Mourning wheat ear	18.37	3	Frequent
Pied Wheatear	10.42	3	Frequent
Heuglin's Wheatear	12.50	3	Frequent
Moorland (Alpine) Chat	93.75	4	Common
Rüppell's Black Chat	4.17	2	Uncommon
Cape Crow	42.71	4	Common
Pied Crow	64.58	4	Common
White-billed Starling	31.25	3	Frequent
Red-billed Oxpecker	12.50	2	Uncommon
Cinnamon-breasted Bunting	3.13	2	Uncommon
Ortolan Bunting	5.12	2	Uncommon

	...Cont'd		
Pectoral patch Cisticola	4.17	2	Uncommon
Pale Prinia	2.08	1	Rare
Abyssinian (Black-headed) Siskin	313.54	5	Abundant
Greater Blue-eared Starling	16.67	3	Frequent
Streaky-headed Siskin	85.42	4	Common
Brown-rumped Siskin	114.58	4	Common
Banded Martin	26.04	3	Frequent

Appendix 9. Relative abundance of birds in the bushland during the wet season.

Species	Individuals per 100 field hours	Abundance score	Rank
Augur Buzzard	2.78	1	Rare
Moorland Francolin	18.06	3	Frequent
Erckel's Francolin	13.89	3	Frequent
Dusky Turtle Dove	23.61	3	Frequent
Ring-necked Dove	2.78	3	Frequent
Laughing Dove	2.78	1	Rare
White-collared Pigeon	218.06	5	Abundant
White-checked Turaco	12.50	3	Frequent
Senegal Coucal	5.56	2	Uncommon
Rufous-naped Lark	11.11	3	Frequent
Banded Martin	19.44	3	Frequent
Plain Martin	15.28	3	Frequent
Crag Martin	16.67	3	Frequent
Mountain Wagtail	4.17	2	Uncommon
Common Bulbul	9.72	3	Frequent
Little Rock Thrush	8.33	3	Frequent
Ground scraper Thrush	8.33	3	Frequent
Olive Thrush	12.50	3	Frequent
Tawny-flanked Prinia	16.67	3	Frequent
Pale Prinia	8.33	3	Frequent
Blackcap	2.78	1	Rare
Spotted Flycatcher	2.78	1	Rare
Rüppell's Robin Chat	9.72	3	Frequent
Rüppell's Black Chat	8.33	3	Frequent
White-rumped Bubbler	25.00	3	Frequent
Collared Sunbird	8.33	3	Frequent
Bronze Sunbird	5.56	3	Uncommon
Variable (yellow-bellied) Sunbird	13.89	3	Frequent
Tropical Boubou	5.56	2	Uncommon
Little Weaver	12.50	3	Frequent
Black-headed Weaver	23.61	3	Frequent
Baglafecht Weaver	70.83	4	common
Red-checked Cordonbleu	29.17	3	Frequent
Fawn-breasted Waxbill	143.06	5	Abundant
Pin-tailed Whydah	66.67	4	Common
Fan-tailed Raven	23.61	3	Frequent
Abyssinian Citril	9.72	3	Frequent
Common Stone Chat	6.94	3	Frequent

Appendix 10. Relative abundance of birds in the bushland during the dry season.

Species	Individuals per 100 field hours	Abundance score	Rank
Moorland Francolin	23.61	3	Frequent
Erckel's Francolin	23.61	3	Frequent
Dusky Turtle Dove	25.00	3	Frequent
White-collared Pigeon	226.39	5	Abundant
White-cheeked Turaco	16.67	3	Frequent
Rufous-naped Lark	19.44	3	Frequent
Banded Martin	29.17	3	Frequent
Rock Martin	20.83	3	Frequent
Crag Martin	13.89	3	Frequent
Plain Martin	19.44	3	Frequent
Plain-backed Pipit	29.17	3	Frequent
Bush Pipit	26.39	3	Frequent
Common Bulbul	9.72	3	Frequent
Little Rock Thrush	11.11	3	Frequent
Ground Scraper Thrush	12.50	3	Frequent
Olive Thrush	16.67	3	Frequent
Tawny-flanked Prinia	20.83	3	Frequent
Pale Prinia	9.72	3	Frequent
Pectoral Patch Cisticola	4.17	2	Uncommon
Rüppell's Robin Chat	12.50	3	Frequent
Rüppell's Black Chat	11.11	3	Frequent
Common Stone chat	8.33	3	Frequent
Pied Wheatear	13.89	3	Frequent
White-rumped Babbler	33.33	4	Common
Common Fiscal	2.78	2	Uncommon
Tropical Boubou	8.33	3	Frequent
Greater Blue-eared Starling	16.67	3	Frequent
Baglafecht Weaver	86.11	4	Common
Fawn-breasted Waxbill	155.56	5	Abundant
Fan-tailed Raven	27.78	3	Frequent
Cinnamon-breasted Bunting	9.27	3	Frequent
Abyssinian Citril	12.50	3	Frequent

Appendix 11. Relative abundance of birds in the rocky area during the wet season.

Species	Individuals per 100 field hours	Abundance score	Rank
Wattled Ibis	19.44	3	Frequent
Speckled Pigeon	33.33	4	Common
White-collared Pigeon	115.28	4	Common
Hemprich's Hornbill	4.17	3	Frequent
Thekla Lark	40.28	5	Abundant
Crested Lark	31.94	4	Common
Mountain Wagtail	2.78	2	Rare
Little Rock Thrush	16.67	3	Frequent
Moorland (Alpine) Chat	136.11	5	Abundant
Rüppell's Black Chat	6.94	3	Frequent
Brown-tailed Chat	8.33	3	Frequent
White-winged Cliff chat	9.72	3	Frequent
Fan-tailed Raven	51.39	4	Common
Thick-billed Raven	40.28	4	Common
White-billed Starling	12.50	3	Frequent
Red-winged Starling	31.94	4	Common
Common Stone Chat	9.72	3	Frequent
Black-breasted Snake Eagle	2.78	1	Rare
Ankober Serin	4.17	2	Uncommon
Streaky Siskin	118.06	4	Common
Brown-rumped Siskin	80.56	4	Common
Abyssinia (Black-headed) Siskin	127.78	5	Abundant
Baglafecht Weaver	62.50	4	Common

Appendix 12. Relative abundance of birds in the rocky area during the dry season.

Species	Individuals per 100 field hours	Abundance score	Rank
Lammergeier	4.17	2	Uncommon
Peregrine Falcon	2.78	1	Rare
Pallid Harrier	2.78	1	Rare
Augur Buzzard	5.56	2	Uncommon
Mountain Buzzard	4.17	2	Uncommon
Verreaux's Eagel	8.33	3	Frequent
African Hobby	2.78	1	Rare
Wattled Ibis	20.83	3	Frequent
White-collared Pigeon	86.11	4	Common
Thekla Lark	26.39	3	Frequent
Crested Lark	22.22	3	Frequent
Rock Martin	15.28	3	Frequent
Northern (European) Wheatear	6.94	3	Frequent
Mourning Wheatear	5.56	5	Uncommon
Pied Wheatear	8.33	3	Frequent
Heuglin's Wheatear	6.94	3	Frequent
Moorland (Alpine) Chat	119.44	4	Common
Rüppell's Black Chat	9.72	3	Frequent
White-winged Cliff Chat	6.94	3	Frequent
Thick-billed Raven	30.56	4	Common
Fan-tailed Raven	55.56	4	Common
Cinnamon-breasted Bunting	4.17	2	Uncommon
Ankober Serin	6.94	3	Frequent
Streaky Siskin	94.44	4	Common
Brown-rumped Siskin	66.67	4	Common
Abyssinian (Black-headed) Siskin	116.67	4	Common
Baglafecht Weaver	43.06	4	Common
Blue Rock Thrush	4.17	2	Uncommon

DECLARATION

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

Name of the candidate Sisay Hailu

Signature…….Date 21 July 2008