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Diversity and Relative Abundance of Birds in Berek Forest, Oromia Special Zone, Berek Woreda,Central Ethiopia

M.Sc. thesis submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Biology

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Abstract

Study of the diversity and relative abundance of birds was conducted from October 2015 to April 2016 in Berek Forest, near Sendafa town of Oromia special Zone, Berek Woreda,Central Ethiopia, using the Timed Species Count System (TSCS). A total of 89,293 individual birds were encountered that belonged to 78 species, 32 families and 13 orders in 100 hours of observation. The observation period was equally distributed between the months of October, December, February and April. The number of species per Order ranged from 1-38, Passeriformes, were represented by 38 species (47.7%) while Coliiformes, Coraciformes, Cuculiformes, and Pelacaniformes were represented by one species only. The number of species per family ranged between 1 and 10. Accipitridae were represented by 10 species followed by Motacillidae with six species. Diversity index was calculated for each sampling month and the highest value was obtained for October (H'=3.8488) and the lowest for December (H'=3.247). The overall diversity during the entire study period was (H'= 3.743).The highest evenness index was registered in December /0.89/and the lowest was in October (0.859) with the total species richness 67 and78 respectively. Abundance score of abundant bird species was highest . 92% of the species scored "Abundant" ordinal scale while 3.84% and 5.1% of the species had ranks of "Common" and "Frequent" respectively. The Cape eagle owl (*Bubo capensis*) was the most abundant species with a total sighting of 8600 followed by Grayish eagle owl (*Bubo cinerascens*) with 6900 sightings. Sooty falcon (*Falco concolor*), Cape rook *(Corvus capensis*), and Long billed pipit (*Anthus similis*) were the least abundant species with <10 sighting records. Most of the birds recorded were residents (57.7%) followed by Palearctic migrants (20.5%). The majority of the species are not within the Red List of threatened species except 2.5% which are Vulnerable. Five of the recorded species; Rouget‟s rail *(Rougetius rougetii*), Wattled ibis *(Bostrychia carunculata*), Thick-billed raven *(Corvus crassirostris*), Abyssinian catbird *(Parophasam galinieri*) and Black-winged love bird (*Agapornis taranta*) are endemic to Ethiopia. For better management planning it is recommended that further studies on habitat diversity and ecology of key stone species should continue.

Keywords: Avian diversity, species composition, Berek forest, relative abundance, diversity index

1. Introduction

Ethiopia has diverse sets of ecosystems, ranging from humid forest and extensive wet lands to deserts like Afar depression, supporting a wide variety of life forms (Hillman, 1993; Ethiopian Wildlife and Natural History Society, EWNHS, 1996; Viveropol, 2001). The high and rugged mountains, deep gorges and vast rolling plains of the country show its topographic diversity (Yalden, 1983). The wide range of altitudinal variation with the highest peak at Ras Dashen (4620 m a.s.l.) and the lowest at the Afar depression (116 m a.s.l.) is the main reason that makes Ethiopia as one of the very few countries that is 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 (tropical, subtropical zone and temperate zones) that led to the diversification of endemic species as a result of ecological isolation (EWNHS, 1996). Topographical variability and temperature are identified as the most important global predictors of avian species richness (Karr, 1980; Davies et al; 2007).

There are over 1850 avian species in Africa, of these 926 are found in Ethiopia, of which 16 are endemic (Redman et al., 2009). Although the taxonomic diversity of these avian groups is known, their habitats are not well studied. In terms of its avian fauna, Ethiopia is one of the most significant countries in Africa (World Conservation Monitoring Center, WCMC, 1991 & 1995). Since Ethiopia contains a wide variety of habitats including high mountains, grasslands, deserts and lowlands, the distribution of avian in the country is quite complex (Urban, 1980).

Most of the avian species occur in Important Bird Areas (IBAs). IBAs are selected based on categories. Some of the categories are globally threatened, restricted range and biome assemblages, and congregation. A total of 1228 IBAs are distributed among 58 countries or territories in Africa and its associated islands (Collar and Stuart, 1985). IBAs cover 7% of the land area of the African Continent. Out of 1228 IBAs, 597 are found in Africa (47%) (Birdlife International, BLI, 2001).

In Ethiopia, there are 69 IBAs which cover an area of about 47,757 km^2 (5%) of the country‟s landmass. Out of these, 39 are unprotected and three are globally recognized as endemic bird areas (EBAs) (Francis and Shirihai, 1991, 1999). EBAs are effective in identifying areas which are important for the maintenance of avian diversity and the diversity of other flora and fauna (EWNHS, 1996).

Berek Forest is a relatively well protected forest mix of natural vegetation and tree plantations. It is expected to harbor a diverse avifauna due to the absence of anthropogenic disturbance. However, no scientific exploration of the forest has been conducted before. Thus, the present study was planned to document and assess the avian diversity of the forest to generate the baseline data.

2. Literature Review

2.1. Diversity of birds

Biological diversity or biodiversity is the term given to the variability among living organisms from all sources including inter alia ,terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part :this includes diversity within species ,between species and of ecosystems.(The Convention on Biological Diversity,CBD,1992). During the 1992 Earth Summit in Rio de Janeiro, world leaders agreed on a comprehensive strategy for `sustainable development`-meeting our needs while ensuring that we leave a healthy and viable world for future generations. However, global biodiversity is being degraded at an alarming rate due to human activities (Skole and Tucker, 1993). The loss of biodiversity often reduces the productivity of ecosystems and their services (Wilson, 1989). It destabilizes ecosystems and weakens their ability to deal with natural disasters such as flood, droughts, and hurricanes, and with human–caused stress, such as pollution and climate changes. One of the first steps towards national biodiversity strategy is to conduct survey in order to find out what exists and to analyze its value and importance, and what is endangered (Australia Biological Resource Study, 2001).

On the basis of the survey results, governments can set measurable targets for conservation and sustainable use. National strategy programs need to be developed or adopted to meet this target. Biodiversity can be measured with quantitative indices of diversity based on richness, the number of elements of biodiversity (usually number of species), evenness and their relative abundance (Magurran, 1988). An increasing amount of ecological research relies on measures of bird species richness to address a range of questions. In addition to research base projects, these methods are gaining widespread use among agencies and extension groups to measure baseline patterns of diversity and gauge the effectiveness of management practices (Freudenberger, 2001: Rosenstock *et al.*, 2002).

The most basic study of avifauna of a site is the preparation of a list of species. A list indicates the diversity of the site, and shows the presence of rare species if any. The number of rare and endemic species and the diversity of the species present at the site can be used as indicator of the importance of different sites or habitats for bird conservation (Bibby *et al.,* 1998: ICBP, 1992). In spite of the great diversity found among the many different kinds of birds, they are perhaps the most homogeneous and most easily recognized class of animals on earth (Wallace and Maham, 1975).

Wetmore (1960) divides the Class Aves into 27 Orders of living birds, and 6 Order of extinct species. About 170 families of living birds are listed in most classifications although much uncertainty exists about the status of some of them. An additional 41 fossil families have been listed by Wetmore (1960). Currently, the class Aves includes 29 Orders, 201 Families, 2073 Genera and 10,010 species (Dereje Woldeyohannis,2006).

2.2. Body size

In size, living birds vary from the diminutive humming birds, many of which weigh less than 4 gm, to the bulky ostrich, which stands 2 m in height and weighs more than 150 kg (Bond, 1947). Generally, the size of the bird is directly proportional to its life span. Large birds like owls, eagles and pelicans survive more than 60 years of age in captivity (Wilson, 1980).

2.3. Habitat

Birds are commonly distributed in different habitats including the polar region, the tropics, in forests and deserts, on mountains and prairie and the ocean and its islands (Wilson, 1980). Avian assemblage shows latitudinal gradient. Tropical regions typically exhibit higher species richness than do those of temperate latitudes. Whether this higher avian species richness is associated with higher overall abundance of birds in an assemblage and/or with lower abundance of individual species is controversial. There are evidences for the higher numbers of specie in the tropics being supported by higher number of individuals (Karr, 1971: Poulsel, 2002). On the other hand, some studies have reported that tropical forest bird assemblages have a higher biomass, but a more similar level of abundance to their temperate counterparts (Terborgh *et al.,* 1990: Thiollay, 1990). In the tropics, greater levels of environmental factors may allow more species to co-exist through increased habitat heterogeneity and enhance niche specialization (Terborgh, 1980: Karr, 1989). Within sites, it is fairly evident that habitat is likely to be an important factor concerned with the distribution and number of birds. Habitat variations may be of natural origin, for instance by soil type, along a gradient of rainfall or by altitude. Of all possible bird habitat associations, elevation is the most commonly cited factor (Bibby *et al*., 1998). However, it is not yet known whether a general relationship between species richness and elevation or even whether a universal explanation or model can be formulated (Colwell and Hurtt, 1994; Rahbek 1995; 1997). Seasonal stability of the habitat affects species composition and abundance of birds. Bird species that face seasonal irregularities in the availability of food sources have two alternatives. A bird may shift to feeding on other resources, or it may move to another area where the original food resource is available. Where there is no seasonal irregularity in food availability and other factors are held constant, a species can maintain itself throughout the year (Karr, 1976). Seasonal variation in avian community structure decreases with increasing vegetation complexity. This is apparently due to the increased buffering of the physical environment by the more complex vegetation (Smythe, 1974). The impact of seasonality varies among the subset of the avian fauna (Karr, 1975). Insectivorous species diversity and abundance generally vary more seasonally than do frugivorous(fruit feeders) species diversity and abundance in structurally mature habitats. The global population size of species varies by many orders of magnitude. Amongst the birds, the rarest comprise a handful of

individuals (Birdlife International, 2000), whilst the most abundant ones have many hundreds of millions (Elliot, 1989). Numerous reasons can be suggested for these differences, including the influence of body size, life history, tropic group, phylogeny and history (Damuth, 1981; Pimm, 1991; Brown, 1995; Gaston and Blackburn,1996; 2000). However, whether singly or in combination, these variables have been found to explain only small to moderate proportions of the variation in population size. Thus, body size, for example, has been widely quoted as an important correlate and perhaps determinant of abundance. With species of a similar size differing in abundance may be by several orders of magnitude (Nee *et al*., 1991; Blackburn *et al*., 1994: Gaston and Blackburn, 1996; 2000).

2.4. Migration

The seasonal distribution of birds is affected by their migration patterns. Migration is not a voluntary one, but is one of necessity caused by climatic conditions such as the food supply and the length of the daylight (Lincoln, 1998). In Eastern Africa, the following three types of migration can be recognized (Mackworth-praed and Grant, 1956): complete, trans-equatorial and local. Complete migration includes those species visiting Eastern Africa during the non-breeding season from Europe or Asia. Trans-equatorial migration includes those species that move either to a more humid or to a drier area for breeding, and in so doing cross the equator. Local migration includes those species, which breed in Southern Africa and move northward in the non-breeding season. Breeding season in birds shows variation. Local climatic conditions and local food supply are probably the main factors governing breeding period. Ground-breeding birds normally nest during the wet season and it may be due to the effect of annual burning of grass and open forest country during the dry season, but it is more likely that food is abundant at this season. Woodland and forest species may breed in any month. The breeding of a species in any one-year at a certain time is not a guarantee that it will breed at the same time the next year, or even at all in that locality (Mackworth-praed and Grant,1956).

2.5. Importance

Birds are one of the most important components of biodiversity. This is reflected by the ecological, economical and esthetic values. It is often asserted that birds are convenient indicators of biodiversity, at least at large scales and that they are useful for monitoring environmental changes. One reason is that birds have long been popular with naturalists, amateurs and professionals and consequently their systematic and distributions are better known than any other comparable groups of animals, with the possible exception of larger mammals (Furness and Green wood, 1993). Birds are highly motivated, extremely efficient and cost-effective insect pest controllers (Pschorn-Walker, 1977). As a group, insectivorous birds display a wide variety of feeding specializations, from hunting in the air (swifts and swallows) to excavating deeply in wood (woodpeckers). Roughly 60% of the approximately 8600 species recognized by Mayr and Amadon (1951) are partly or largely insectivorous. Insect pest outbreaks can annually destroy hundreds of millions of dollars of agricultural and forest products. Birds can alter their diets to feed almost exclusively on an insect pest during an outbreak if it becomes profitable for them to do so. They can develop a search image for this new prey and can learn how to hunt for it more efficiently. Factors that help to determine which type of insects are selected by birds of prey are; insect density, body size and nutritional content, ease of capture, palatability (presence of chemical defenses or parasites), and density of potential competitors (other birds, mammals, ants, spiders, and predacious insects) (Lack, 1954). In 1921, forest and agricultural pests were reduced to 78% by birds resulting in savings of $ 444 million crop and timber losses. The value of birds in terms of economy is beyond our imagination. Their value is not just in their actual consumption of insect pests, but also in their role in keeping future outbreaks to a minimum (Holling, 1988). Birds also serve other purposes in nature. Fruit-eating birds help in dispersal of seeds. Birds eat and digest the pulp of berries and other fruits, but pass the seeds unaffected through their droppings. The seeds may sprout wherever the droppings fall (Clout and Hay, 1989).Certain birds like humming birds and sunbirds pollinate certain flowers that produce nectar. Hummingbirds and sunbirds feed on nectar. As they visit flowers in search of it, they spread pollen from flower to flower.

Birds through the ages have been the source of considerable fascination and folklore, and have been used as symbols. They are arguably the most universally celebrated form of nature, found in pictures, photographs, sculptures, word and song (Cliffordand and Beehler, 1998). At the same time, few species of birds like Quelea (*Quelea quelea*) cause major agricultural loss in some regions of the world.

2.6. Threats

Despite their importance, many species of birds are in danger of extinction due to human activities. These include intensive farming, land reclamation, fertilizers, intensive meadow mowing/silage making during bird breeding season, drainage of formerly extensive wetlands, deforestation and widespread clearance of native forest and woodlands, intensive pine forestation (at the expense of natural broadleaved woodlands), marine and coastal development encroaching on coastal and wetland areas (which are important for bird migration and breeding), intensive development encroaching natural conservation and heritage areas (roads, housing, golf courses, etc.) and pollution (Birdlife International, 2006).

3. Objectives

3.1. General objective

The general objective of the present study was to study the relative abundance and diversity of the avian fauna of the Berek Forest in Oromia Special Zone Surrounding Finfine, Berek Woreda .

3.2. Specific Objectives

The specific objectives of the present study were to:

- document the species list of Berek Forest
- measure the diversity index
- measure the evenness index
- determine the relative rank of abundance of recorded species

4. Description of the Study Area

Berek Forest is located in Oromia Special Zone Surrounding Finfine, Berek Woreda, near Sendafa town at about 52 km from Addis Ababa. The study area is found 13 km from Sendafa town accessed via the gravel road of Dire Dam. The geographic location of the study area is: 9^0 12´44" - 9^0 30"62" N and 38^0 82´86" - 39^0 13´ 82" E; elevation: 2260 to 3440m a.s.l. (Fig 1). The study area has flat plain topography with undulating gentle slopes and few mountainous landscapes (Fig. 2) The forest is transected by the Legedadi and Gedamu Rivers (Zonal Report- Office of Agriculture and Forest Development, Berek Woreda,2015).

According to information obtained from Oromia Forest and Wildlife Enterprise Finfine Branch, Berek Woreda, the total extent of the forest is 94.587 km^2. The forest is discontinued by settlements and farmlands. As a result, it is fragmented into 8 patches namely: Adare (6.53 km^2). Bura Maru (13.653km^2.). Hurufa (19.7702 km^2), Tabo (18.9645 km^2), Lucho (1.0981km^2), Godo (21.4577km^2), Shantami(1.7953 km^2) and Wale Baba(11.3196 km^2) (Personal communication with staff of Agricultural and Forest Development of Berek Woreda). The forest is a mix of eucalyptus plantations and natural vegetation dominated by *Juniperus procera* (Tside), *Podocarpus falcatus* (Zigba), *Accasia abyssinica* (Girar), *Olea europeae* (Weira), Ficus spp. (Shola), and *Rosa abyssinica* (Kega).

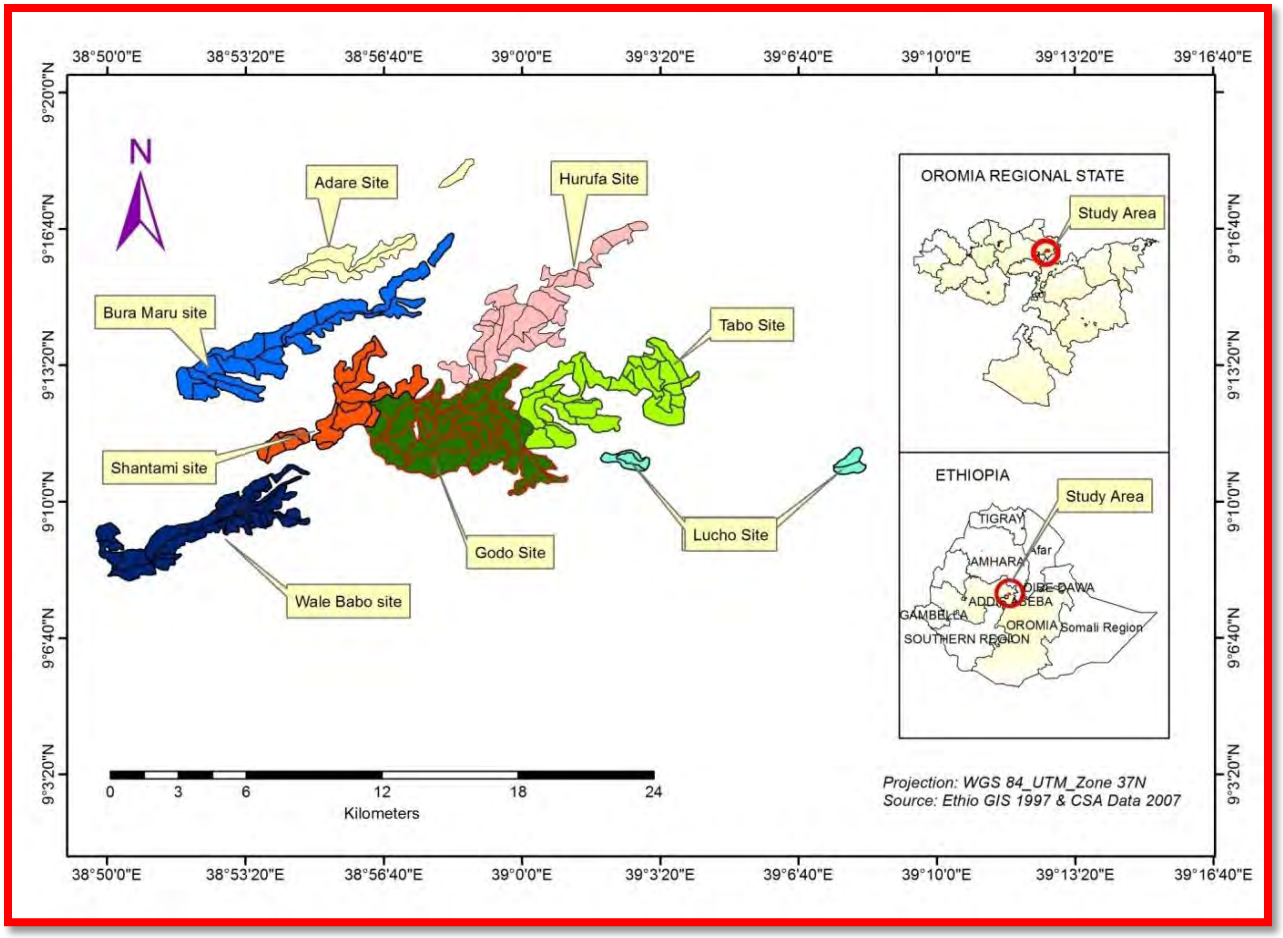

Figure 1. Map of the study area

Mammals such as spotted hyena (*Crocuta crocuta*), dikdiks (*Madoqua kirkii*), common Jackal (*Canis aureus*),leopard (*Panthera pardus*), Bushbuk (*Tragelophus scriptus*), African hare(*Lepus microtis*), Hamadryas baboon (*Papio hamadryas*), molerat (*Heterocephalus glaber*), porcupines (*Hystrix cristata*), African civets (*Civetticts civetta*), wild cats (*Felis silvestris*), aardvark (*Orycteropus afer)*, squirrels (*Sciurus carolinensis*), brown rats (*Rattus norvegicus*) and rodents (*Clinostomus spp*) are common in the study area (Zonal Report-Berek Woreda Agriculture and Forest Development, 2015).

Figure 2: Topography and vegetation of the study area (Photo: Chala Yadeta, 2015)

Climate

The 13 year annual rainfall data (2002-2015, data not available for 2009 and 2012) of the area shows that the area receives rain year round. The average annual rainfall is 1040.7 mm. The maximum rainfall was recorded in 2014 (1294.8 mm) and the minimum in 2015 (332.2 mm) (Figure3-A). The 12 year average monthly rainfall data also showed that the maximum precipitation was obtained between June-August while October-February is the driest period (Figure 3-B). (Source: National Meteorological Service Agency).

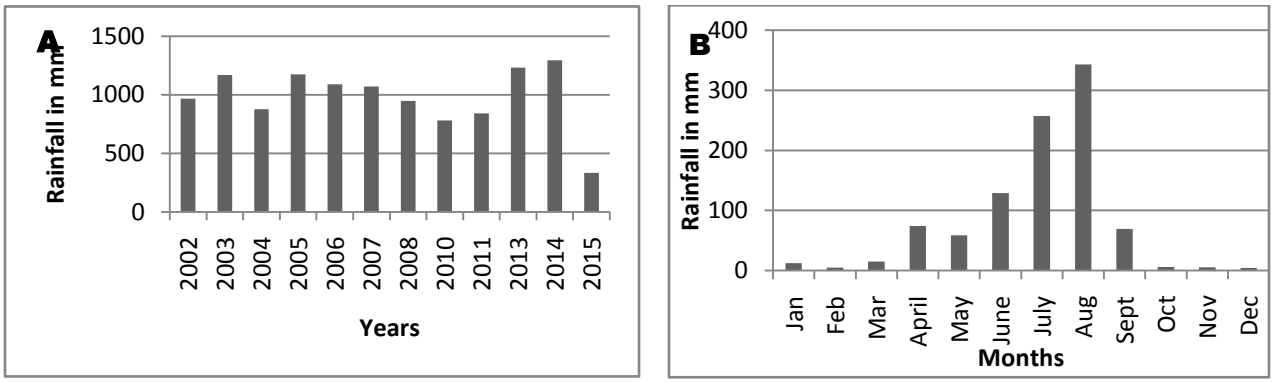

Figure 3. Annual rainfall (A) and monthly average rainfall (B) of the study area between 2002-2015 (data not available for 2009 and 2012) (Source: National Meteorological Service Agency)

The study area is divided in to two thermal zones, which broadly correspond to traditional agro climatic zones: Dega (59%) and Weina dega (41%). The highest temperature recorded in the area was 20^{o}C and the minimum 7^{o}C (Source: Agriculture and Forest Development of Berek Woreda , Zonal Report 2015)

5. Materials and Methods

The time Spaced Species count system (Bibby &Jones,1999) was used to study the avian diversity and abundance of the study area. The sampling plot has a surface area of 2 km x 3km. The observer stood at a random location and scanned birds for five minutes. Newly encountered bird species and the number of individuals sighted were recorded. The observer assigned identification key to new species until proper identification of the species using (Van Perlo B., 2009). The keys included; feather color and patterns, crests, tail length and shape. At the end of the five minutes the observer randomly walked around for 30 seconds and started another five minutes of a scanning period.

There were four months of data collection between October 2015-April 2016 (October, December, February, and April). Twenty four scanning hours were used for the first 3 months and 28 hours for April yielding a total of 100 scanning hours for the study period. Data were collected in three consecutive weekends with 4 hours of scanning per day. Scanning was conducted during the morning (7:00 - 9:00 hrs) and afternoon (15:00 - 17:00 hrs).

The following materials have been used during the study:

- ✓ Binoculars (7x50; Model No 781)
- ✓ Camera , clipboard
- ✓ Field guide book
- ✓ Field Data sheets (See also Appendix-8)
- ✓ Note books, pen, pencils

6. Data Analysis

6.1 Diversity Index

Shannon-Weiner diversity index was used to measure the avian diversity. It was calculated as:

$$H' = -\sum_{i=1} Pi \ln Pi$$

Where:

H' = Shannon- Wiener index
Pi = Proportion of the i^{th} species
ln =Natural Logarith

6.2. Evenness Index

Equitability or evenness index was calculated using Shannon-Wiener Evenness index(E)from the ratio of observed diversity to maximum diversity using the equation. Evenness index is given as:

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

Where:

E= Evenness index

H' = Shannon Wiener Diversity index

H_{max} = Natural log of total number of species

The H_{max} =lns=natural logarithm of the total number of species(s)in each site (Southwood and Henderson,2000)

6.3. Relative abundance

The relative abundance of each species was estimated from encounter rates (sightings) per 100 hours of scanning. This value was used to give each species an ordinal rank of abundance using the ranking scale of (Bibby &Jones, 1999) given below in Table 1:

Table 1. Ordinal scale of abundance (Bibby & Jones, 1999)

Number of sightings	Ordinal scale
<0.1	Rare
0.1-2.0	Uncommon
2.1-10.0	Frequent
10.1-40	Common
>40.0	Abundant

7. Results

7.1. Species composition

A total of 89,293 sightings of birds that belonged to 13 Orders, 32 Families and 78 species were recorded in the four months of the survey. Among them, 5 species are endemic to Ethiopia. The number of species per Order ranged from 1 to 38. Passeriformes are represented by 38 species (48.7%) and orders like Coliiformes, Coraciformes, Cuculiformes and Pelacaniformes are only represented by one species. The number of species per family ranged between 1 - 10. The family Accipitridae was represented by 10 species, while 10 families were represented by a single species. Most families were represented by two or more species (See also Appendix 1). Most of the birds recorded are residents (57.7%); followed by Palearctic migrants (20.5%). Small proportion of the species (2.5%) was vulnerable (See also Appendix 1).

7.2. Relative abundance

Most species (92.3%) were found within the ordinal rank of "Abundant" while 3.84% were “Common” and 5.1% “Frequent”. There were no registered species for "Uncommon "and "Rare" species. Cape eagle owl, grayish eagle owl, African fire finch, great snipe, little stint and Rouge'ts rail were the most abundant species with relative abundance of >5000 sightings. On the other hand, Sooty falcon, Cape rook and Long-billed pipit were the least abundant with <10 sighting records (See also Appendix 7).

7.3.1. Monthly pattern of abundance for the six most abundant species

Cape eagle owl was the most abundant species in the study area with sightings of 8600 (9.63%) followed by Grayish eagle owl with the total sighting of 6900 (7.73%). April seems the more suitable month for cape eagle owl and December for Grayish eagle owl where their numbers were prominent (Table2).

Table2. Monthly pattern for the six most abundant avian species

No	Species	Oct	Dec	Feb	Apr	Total
1	Cape eagle owl	2366	1087	2300	2847	8600
2	Grayish eagle owl	1491	2230	1492	1987	6900
3	African fire finch	2011	1700	1559	1430	6700
4	Great snipe	2040	1802	1575	883	6300
5	Little stint	1825	1317	1604	554	5300
6	Rouget's rail	693	1798	1109	1500	5100

7.3. 2.Monthly pattern of abundance for the three least abundant species

Long billed pipit was the least abundant species in the study area with sightings of 7 (0.008%) followed by Cape rook with 8 sightings (0.009%) (Table 3).

Table 3. Monthly pattern of abundance for the three least abundant species

No	Species	October	December	February	April	Total
1	Sooty falcon	4	3	1	1	9
2	Cape rook	3	1	2	2	8
3	Long billed pipit	1	1	4	1	7

7.4. Diversity and Evenness Indices

7.4.1. Monthly diversity index

The diversity index was highest (H=3.85) in October and lowest in December (H=3.25). However, the overall variation between months was insignificant. The overall diversity index was (H'=3.743) (Fig. 4).

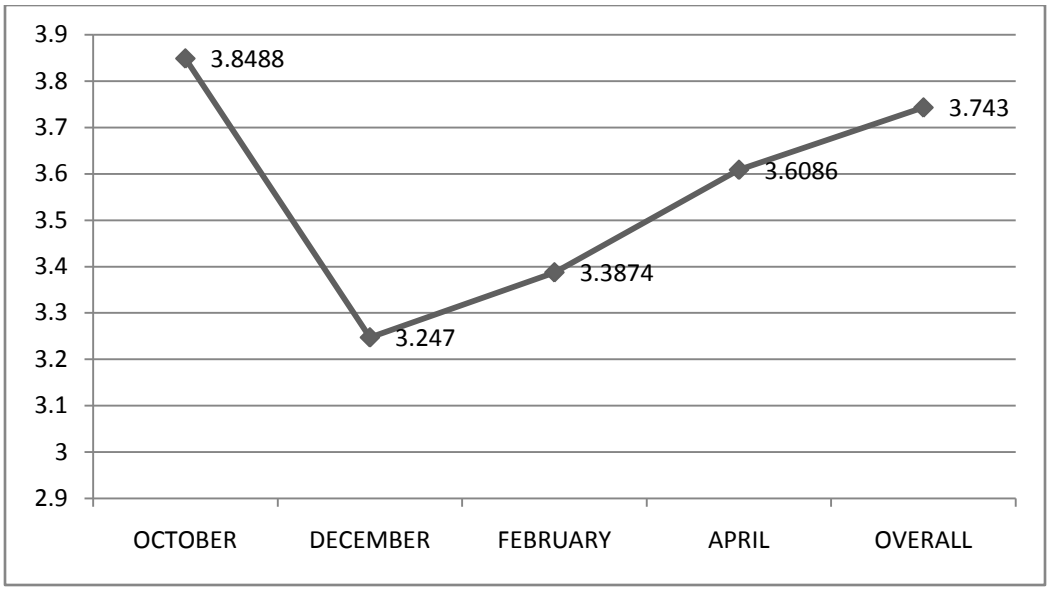

Figure 4. Monthly and overall diversity index of the avian fauna in Berek Forest

7.4.2. Evenness index

Evenness index showed the reverse trend compared to diversity index with December the highest value (E=0.89) and October the lowest (E=0.85).The overall evenness index was 0.86. Again, the variation between months was not large (Figure 5).

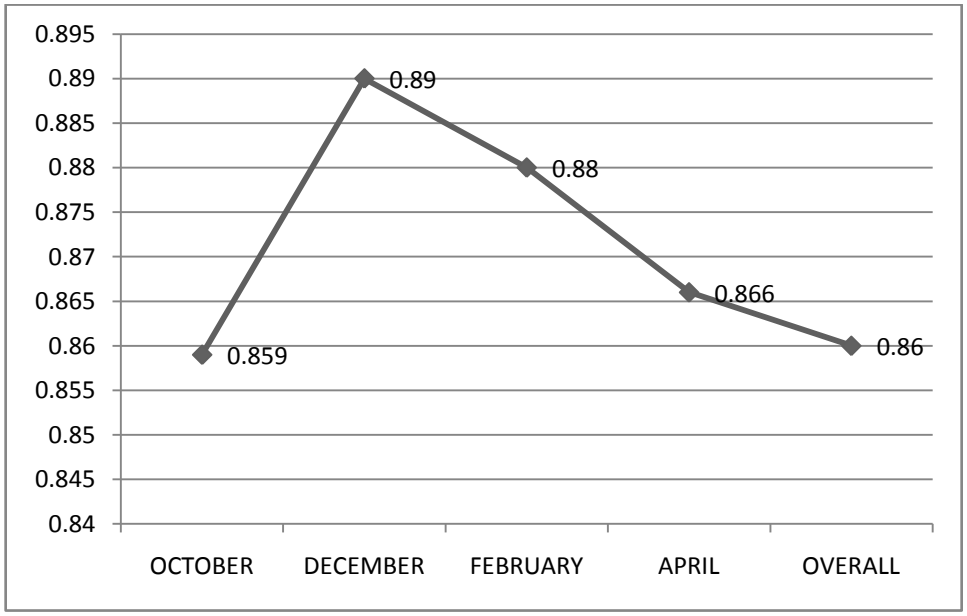

Figure 5: Monthly and overall evenness index of the avian fauna in Berek Forest

8. Discussion

8.1 Species composition

The present study area supports 78 species of birds under 13 orders and 32 families. The area contained greater number of species and population of birds when compared to some studies. For instance, Hayal Desta in Jimma (2006) reported that only 24 species of birds were supported at Boye, Kitto and Koffe wetland habitats (Jimma Zone). Similarly, the study by Hiwot Hibste at Addis Ababa Abattoirs (2007) has reported that 21 species of birds belonging 4 orders and 10 families were supported at Addis Ababa Abattoirs Enterprise. Table 7 provides comparison of avian diversity from previous studies with the present.

Table 4. Relationship of the study area and other research areas

Year of study	Locality	Habitat type	Total number of species	Orders	Families
2016	Berek Forest	Forest	78	13	32
2014	Aksum	Church Forest	21	Not available	Not available
2013	Tigray	Church Forest	65	10	18
2012	Yayu, Illubabor	Forest	112	Not available	37
2011	Entoto	Church Forest	124	14	44
2011	Geto Gembejo	Forest	120	15	39
2011	Bole International Airport	Airport	74	13	31
2008	Ankober	National Forestry	158	Not available	Not available
2008	Wondo Genet	Forest	159	Not available	Not available
2007	AA Abattoirs	Abattoirs	21	Not available	Not available
2006	Chebera Churchura	Forest	137	Not available	Not available
2006	Jimma	Wetland	24	Not available	Not available

Berek forest support greater avian biodiversity when compared to the studies reported by Hayal Desta (2006) in Jimma Zone, Hiwot Hibste at Addis Ababa Abattoirs (2007), Tsigereda Desalegn at Bole International Airport (2011), Hailemariam Areaya in Tigray

(2013) and Kalayu Mesfin in Aksum (2014). The difference could be due to the result of variety of habitat formed because of topography, continuing river (Lege Dadi) which transect the forest, nearby Dam (Lege Dadi Dam) on which aquatic and wetland birds such as long tailed cormorant (*Phalacrocorax africanus*) depends on. The study area also surrounded by agricultural land on which blooming of crops support varieties of birds. For instance, common bulbul (*Pyconotus barbatus*) was numerous in number in the farmlands when the crop was not harvested. Bird species richness and abundance are influenced by local resources availability and vegetation composition in addition to the size of habitat patches. This is because abiotic factors affecting species distribution and interspecies interaction as well as the recourse that are essential for a species or group of species have a non uniform distribution in space (Nabaneeta and Gupta, 2010). In addition the presence of ample resource, especially adequate food supply can increase the richness of avian species at a given area.

Chace and Walsh (2006) indicated that avian diversity responds to changes in vegetation composition and structure which in turn affects their food recourses. The variety of habitat formed also coincides with the idea of MacArthur (1964) which state a large area could conceivably support many bird species.

In contrast the study area maintain lesser species composition when compared to the studies by Dereje W/Yohannis (2006) at Chebera Churchura; Mesay Digafe (2008) at Wondo Genet, Sisay Hailu (2008) at Ankober ,Teklu Gosaye (2011) at Geto Gembejo , Kalkidan Esayas (2011) at Entoto Natural Park and Escarpment, Gebrecherkos Woldegeorgis and Tilaye Wube (2012) at Yayu (Illubabor zone). The reason why the study area support lesser species composition than the above habitats could be due to geographical location, climatic conditions, the abundance of eucalyptus and exotic plantation in such climate, the study area contain small rainfall and narrow agro climatic zones (Dega and Woyna Dega). Further, although the study area could be suitable for some avian species it could not promote numerous biodiversity as the above habitats. This could be due to factors that are related to food, climate, soil, and competition with existing species that may greatly limit the presence of other species and reduces their interaction to a given habitat. This is in agreement with

Crow and Crow (1982) stated that vegetation diversity, rainfall and other environmental variables are significant prediction of Afro – tropical bird diversity and richness.

Birds in the study area are able to find suitable food source in their habitat and consequently one can find greater number of bird species throughout the year. This might be because most of the species 45 (57.7%) are residents although 27% were Palearctic and Intra –African migrants. This is in contrast with the study reported by Kalayu Mesfin (2014) which stated that wetland birds of the Order Ciconiforms, which comprised 25% of the bird species in the area are migratory and migration greatly alters the bird population by changing both its numbers and composition. This has also coincides with the study by Tsigereda Desalegn (2011) which stated that out of the 74 species recorded 17 (22.97%) were migrants and 49 (66.23%) were residents and partially migrants. There is also a linear agreement with the report by Kalkidan Esayas (2011) that states of the total species recorded were intra African migrants, 13 were Palearctic migrants altogether, 13.7% migrants and 81(65%) were residents. Out of 1850 avian species in Africa and 926 in Ethiopia, 665 species are residents, 30 are Palearctic migrants and 69 are Intra-African migrants (Redman et al, 2009) .The seasonal distribution of birds is affected by their migration patterns.

8.2 Relative Abundance

Of the total species in the study area 43.56% were accounted by six species i.e. Cape eagle owl (*Bubo capensis),* Grayish eagle owl (*Bubo cinerascens*), African fire finch (*Longon osticta rubricata*) Great snipe (*gallinago media*) little stint (*calidris minuta*) and Rouget‟s rail (*Rougetius rougetii*). This might be due to the environment conditions such as availability of food, water, weather conditions, availability of dark and quiet areas for the Cape eagle owl and grayish eagle owl, nearby wetland area due to Lege Dadi Dam and surrounding agricultural lands. This is in agreement with the study reported by Tsigereda Desalegn (2011) which stated that birds in the study area were observed either throughout the survey period or during specific times of the year only.

There were also bird species with high number of individuals at specific times of the study period. This could be due to the availability of resources and favorability of weather conditions. Hiwot Hibste (2007) reported that seasonal fluctuations in abundance of

individual species were more extreme, in addition, Hooded vulture , African white backed vulture were well represented in the study area throughout the study period. This can be correlated with the idea in Toms et al., (2002) which indicated the factors that may cause fluctuations in food variation in weather or food supply, the ability of individuals to disperse to new areas and species interactions such as predation or competition. This also agrees with Block and Brennan (1993) indicating the distribution, richens and abundance of many bird species are determined by the configuration and composition of the habitat components that carries a major element of their habitat. In contrast to the abundant birds, Sooty falcon (*Falco Concolor*) Cape rook (*corvus Capenisis*) and long billed pipit (*Anthus Similis*) generally comprised less than 1% of the total birds in the study area. This was probably due to the lack of corresponding food responsible for abundance of Cape rook, the variation of agro-climate of the study area; inter specific competition, migration for Sooty falcon and exposure of the Long billed pipit to harsh conditions. Teklu Gosaye (2011) reported that the population of Egyptian goose decreased by 40% during the dry season as some of them migrate to other places; this movement is related to the habitat quality and abundance of food resources. This also agrees with the study reported by Tsigereda Desalegn (2011) states that some of the bird species were observed in restricted month of the study period only. This was mainly due to the availability of resource that can attract the birds at different times of the year. This is also consistent with Tellaria et al., (2009) states that the temporal decoupling between food resources and bird numbers, variable climate harshness in different regions or the inability of individual to reach isolated areas affects migratory bird populations. In addition, the above idea seem to be consistent with Weller, (1999) that states all birds need undisturbed places to rest and roost both during the day and at night to avoid predation.

8.3 Diversity and Evenness (Equitability) indices

The high number of species observed in the study area was probably due to diversity of vegetation that provide heterogeneous habitat for different avian species and availability of food which attract avian species. The study area demonstrate high index of diversity (H‟= 3.743) and the diversity index of October (H‟= 3.85) is greater than that of December (H‟= 3.25) with small overall variation. This could be due to the fewer number of species and numbers of individual present in December than October. This might indicate little

fluctuation in the number and types of species. This could imply that the supplies of environmental resources, primary production of food availability were more or less similar in types and quantities to support different bird species. This agrees with the study by Hayal Desta (2006) indicating that large habitats with emergent vegetation, macro invertebrates create broader range of food resources and breeding sites support different species of birds. Thus, greater number of species in the area can be attracted. This also partially correlated with the study by Teklu Gosaye (2011) states that the number of bird species increased during the dry season as a result of the arrival of migratory birds to the study site. The seasonal variation species in richness is significant at plain and shrub habitat. This can be correlated with MacArthun and MacAthur (1961) who revealed that bird species diversity and habitat structure are linearly related with the number of species in a particular habitat being proportional to structural diversity. Tramer (1969) also stated that bird diversity increases with the number of vegetation types and open water. As the number of vegetation layer increase, the number of available niches for birds also increases and so does the number of bird species. The evenness value was high in December and low in October. This was probably because of the harshness of the weather in October, and restricted food availability (unripe fruits). Hence equitability (evenness) index showed the reverse trend compared to the diversity index with December the highest (E=0.89) and October the lowest value (E=0.85). Hayal Desta (2006) has reported that Evenness index across three sites Boye (0.777), Kitto (0.848) and Koffe (0.735) showed variability. The study carried out by Kalkidan Esayas (2011) states that the highest and lowest evenness was observed in farmland (E =0.97) and eucalyptus forest (E=0.8) at Entoto. The study area contain lower evenness index than the Entoto Natural Park and Escarpment.

In conclusion, the present study showed that Berek Forest support number of bird species belonging to different families and orders. Furthermore the different niches formed because of the natural topography, the river transecting the forest, the nearby Legedadi dam, the surrounding agricultural plots can be excellent bird attractants. I recommend for further studies on the habitat diversity and ecological dynamics of the forest as input for better management planning.

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10.APPENDICES

Appendix 1: List of Bird species recorded from Berek Forest between October 2015-April 2016

R-Resident; E-Endemic, PM-Palearctic migrant, AM-Intra-African migrant, NT- Near threatened, V-Vulnerable

No	Order	Family	Common Name	Scientific Name	Status
1	Anseriformes	Anatidae	Yellow Billed Duck	*Anas undulate*	*R*
2			African Black Duck	*Anas Sparsa*	*R*
3			Blue-Winged Goose	*Cyanochen cyanopter*	*R*
4			Egyptian Goose	*Alopochen aegyptiacaatus*	*R*
5			Northern Shoveler	*Anas clypeata*	*PM*
6	Apodiformes	Apodidae	Little Swift	*Apus affinis*	*R*
7			Alpine Swift	*Tachymarptis melba*	*R*
8			Mottled Swift	*Tachymarptis aequatorialis*	*R*
9	Charadriiformes	Charradriidae	Black-Winged lapwing	*Vanellus coronatus*	*AM*
10			Spur-Winged plover	*Vanellus spinosus*	*AM*
11		Scolopacidae	Little stint	*Calidris minuta*	*PM*
12			Common snipe	*Gallinago gallinago*	*PM*
13			Great snipe	*Gallinago media*	*NT*
14	Ciconiforms	Ardeidae	Cattle Egret	*Bubulcus ibis*	*PM*
15			Black-Headed Heron	*Ardea melanocephala*	*PM*
16		Threskiornit	Glossy Ibis	*Plegadis facinellus*	*NT*

17		hidae	Sacred Ibis	*Threskiornis aethopicus*	*R*
18			Wattled Ibis	*Bostrychia carunculata*	*E*
19	Coliiformes	Coliidae	Speckled Mouse Bird	*Colius striatus*	*AM*
20	Columbiiformes	Columbidae	Dusky-Turtle Dove	*Strepotpelia lugens*	*R*
21			Red – Eyed Dove	*Streptopelia roseogrisea*	*R*
22			Speckled pigeon	*Clumba guinea*	*R*
23			White Collared Pigeon	*Columba albitorques*	*R*
24	Coraciformes	Meropidae	European Bee-eater	*Merops apiastes*	*PM*
25	Cuculiformes	Musophagidae	White cheeked Turaco	*Tauraco leucotis*	*R*
26	Falconiformes	Acciipitridae	African fish Eagle	*Haliacetus vocifer*	*R*
27			Augur Buzzard	*Buteo augur*	*R*
28			Black Kite	*Milvus migrans*	*R*
29			Black Shouldered Kite	*Eanus caeruleus*	*R*
30			Hooded Vulture	*Necrosyrtes monachus*	*R*
31			Long-Crested Eagle	*Lahaetus occipitalis*	*R*
32			Pallid Harrier	*Circus macrourus*	*V*
33			White – backed vulture	*Gyps affricanus*	*R*
34			African Goshawk	*Acciptiter tachiro*	*R*
35			Yellow Billed kite	*Milvus aegyptius*	*R*
36		Falconidae	Common kestrel	*Falco tinnunculus*	*PM*
37			Sooty falcon	*Falco concolor*	*PM*
38	Gruiformes	Rallidae	Common Moorhen	*Gallinula chloropus*	*PM*

39			Rouget's Rail	*Rougetius rougetii*	*E,NT*
40	Passeriformes	Cisticolidae	Winding cisticola	*Cisticola galactotes*	*R*
		Estrildidae			
41			African silver Bill	*Lonchura cantans*	*NT*
42			Bronze Manikin	*Lochura cucullata*	*R*
43			Red Billed Fire finch	*Longonosticta senegala*	*R*
44			African fire finch	*Longonosticta rubricata*	*R*
45		Fringillidae	African citril	*Serinus leucopygius*	*NT*
46			Streaky seed eater	*Serinus gularis*	*R*
47		Hurundinidae	Ethiopian Swallow	*Hirundo aethipica*	*R*
48			Red- Rumped Swallow	*Hirundo lucida*	*PM*
49			Mosque swallow	*Cercropsi senegalensis*	*R*
50		Laniidae	Common fiscal	*Lanius collaris*	*R*
51			Gray backed fiscal	*Lanius excubitoroides*	*AM*
52			Tropical boubou	*Laniarius aethiopicus*	*R*
53		Motacillidae	African pied wagtail	*Motacilla aguimp*	*R*
54			Long billed pipit	*Anthus similis*	*NT*
55			Yellow wagtail	*Motacilla flava*	*PM*
56			Mountain wagtail	*Motacilla clara*	*R*
57			Tawny pipit	*Anthus compestris*	*PM*
58			Tree pipit	*Anthus trivialis*	*PM*
59		Alaudidae	Thekla Lark	*Galerida theklae*	*R*

60		Corvidae	Cape rook	*Corvus capensis*	*R*
61			Pied crow	*Corvus albus*	*R*
62			Thick billed raven	*Corvus crassirostris*	*E*
63		Nectariniidae	Tacazze Sunbird	*Nectarinia tacazze*	*R*
64		Psittacidae	Black- Winged love bird	*Agapornis taranta*	*E*
65		Pycnonotidae	Common Bulbul	*Pyconotus barbatus*	*R*
66		Passeridae	Swainson's Sparrow	*Passer swainsonii*	*R*
67		Sturnidae	Greater Blue Eared Starling	*Lamprotornis chalybaeus*	*R*
68		Sylviidae	Garden Warbler	*Sylvia borin*	*PM*
69			Willow Warbler	*Phylloscopus trochilus*	*PM*
70		turdidae	Common-Rock thrush	*Monticola saxatilis*	*AM*
71			Ground scraper thrush	*Psophocichla litsitsirupa*	*R*
72			Northern wheat eater	*Oenanthe oenanthe*	*PM*
73			Pied wheat ear	*Oenanthe oenanthe*	*V*
74		Timaliidae	Abyssinian cat bird	*Parophasam galinieri*	*E*
75		Viduidae	Pin Tailed Whydah	*Vidna macroura*	*R*
76	Pelacaniformes	Phalacrocoracidae	Long- Tailed Cormorant	*Phalacrocorax africanus*	*R*
77	Stigiformes	Strigidae	Cape Eagle owl	*Bubo capensis*	*R*
78			Grayish Eagle owl	*Bubo cinerascens*	*R*

Appendix 2: Abundance proportions (pi) used in calculation of diversity index (October)

NO	Species	Observation inoct/Total individuals =Pi	lnpi	Pi ln pi
1	African citril	0.005	**-5.3**	**-0.02**
2	African Silver Bill	0.003	**-5.8**	**-0.02**
3	African Fish Eagle	0.005	**-5.3**	**-0.02**
4	African pied Wagtail	0.0004	**-7.8**	**-0.003**
5	Augur Buzzard	0.043	**-3.15**	**-0.16**
6	Black kite	0.004	**-5.52**	**-0.022**
7	Black Shouldered Kite	0.0003	**-8.11**	**-0.002**
8	Black Winged lap Wing	0.004	**-5.52**	**-0.022**
9	Black Winged love Bird	0.003	**-5.8**	**-0.02**
10	Bronze Mannikin	0.002	**-6.21**	**-0.01**
11	Cape Rook	0.0001	**-9.21**	**-0.001**
12	Cattle Egret	0.005	**-5.3**	**-0.02**
13	Common Bulbul	0.002	**-6.21**	**-0.01**
14	Common Fiscal	0.008	**-4.8**	**-0.04**
15	Common Moor hen	0.001	**-6.9**	**-0.007**
16	Common Rock Thrush	0.008	**-4.8**	**-0.04**
17	Dusky Turtle Dove	0.03	**-3.5**	**-0.11**
18	Ethiopia Swallow	0.008	**-4.8**	**-0.04**
19	European Bee- Eater	0.002	**-6.21**	**-0.01**
20	Glossy Ibis	0.004	**-5.52**	**-0.022**
21	Greater Blue Eared Starling	0.003	**-5.8**	**-0.02**

22	Grey Backed Fiscal	0.002	**-6.21**	**-0.01**
23	Ground Scraper Thrush	0.001	**-6.9**	**-0.007**
24	Hooded Vulture	0.001	**-6.9**	**-0.007**
25	Little Swift	0.006	**-5.12**	**-0.03**
26	Long Billed Pipit	0.00004	**-10.13**	**-0.0004**
27	Long Crested Eagle	0.001	**-6.9**	**-0.007**
28	Long Tailed Cormorant	0.003	**-5.8**	**-0.02**
29	Long Tailed Cormorant	0.009	**-4.7**	**-0.042**
30	Northern Wheat Ear	0.007	**-4.96**	**-0.035**
31	Pied crow	0.003	**-5.8**	**-0.02**
32	Pied Wheat Ear	0.0004	**-10.13**	**-0.0004**
33	Pin Tailed Whydah	0.004	**-5.52**	**-0.022**
34	Red Billed Fire Finch	0.002	**-6.21**	**-0.02**
35	Red Eyed Dove	0.006	**-5.12**	**-0.03**
36	Red Rumped Swallow	0.011	**-4.5**	**-0.05**
37	Sacred Ibis	0.015	**-4.2**	**-0.06**
38	Speckled Mouse Bird	0.03	**-3.5**	**-0.11**
39	Speckled Pigeon	0.0003	**-8.1**	**-0.002**
40	Spur winged Plover	0.002	**-6.21**	**-0.02**
41	Streaky Seed Eater	0.003	**-5.8**	**-0.02**
42	Swanson's sparrow	0.004	**-5.52**	**-0.022**
43	Tacazze sun Bird	0.002	**-6.21**	**-0.02**
44	Thick Billed Raven	0.006	**-5.12**	**-0.03**
45	Thekla Lark	0.005	**-5.3**	**-0.02**
46	Wattled Ibis	0.004	**-5.52**	**-0.022**
47	White Backed Vulture	0.011	**-4.5**	**-0.05**

48	White Collard Pigeon	0.013	**-4.34**	**-0.06**
49	Winding Cisticola	0.004	**-5.52**	**-0.022**
50	Yellow Wagtail	0.006	**-5.12**	**-0.03**
51	Yellow Billed Duck	0.007	**-4.96**	**-0.035**
52	Rouget‟s Rail	0.03	**-3.5**	**-0.11**
53	African Black Duck	0.013	**-4.34**	**-0.06**
54	Blue Winged Goose	0.008	**-4.83**	**-0.04**
55	Egyptian Shoveler	0.03	**-3.5**	**-0.11**
56	Northern Shoveler	0.002	**-6.21**	**-0.02**
57	Alpine Swift	0.006	**-5.12**	**-0.03**
58	Mottled Swift	0.05	**-2.99**	**-0.15**
59	Little stint	0.08	**-2.53**	**-0.2**
60	Common Snipe	0.005	**-5.3**	**-0.02**
61	Great Snipe	0.09	**-2.4**	**-0.22**
62	White Cheeked Turaco	0.02	**-3.9**	**-0.08**
63	African Goshawk	0.0003	**-8.11**	**-0.002**
64	Yellow Billed Kite	0.004	**-5.52**	**-0.022**
65	Common Kestrel	0.002	**-6.21**	**-0.02**
66	Sooty Falcon	0.0002	**-8.5**	**-0.002**
67	African Fire Finch	0.09	**-2.4**	**-0.22**
68	Mosque Wagtail	0.005	**-5.3**	**-0.02**
69	Tropic Bub Bou	0.013	**-4.34**	**-0.06**
70	Mountain Wagtail	0.013	**-4.34**	**-0.06**
71	Tawny Pipit	0.014	**-4.27**	**-0.06**
72	Tree Pipit	0.006	**-5.11**	**-0.03**
73	Abyssinian Cat Bird	0.016	**-4.14**	**-0.07**

74	Cape Eagle Owl	0.1	**-4.6**	**-0.46**
75	Grayish Eagle Owl	0.063	**-2.76**	**-0.17**
76	Garden Warbler	0.04	**-3.21**	**-0.13**
77	Willow Warbler	0.005	**-5.3**	**-0.02**
78	Black Headed Heron	0.002	**-6.21**	**-0.02**
	H'=-∑pilnpi=	**3.8488**		

Appendix 3 : Abundance proportions (pi) used in calculation of diversity index (December)

NO	Species	Observation inoct/Total individuals =Pi	lnpi	pilnpi
1	African citril	0.006	**-5.12**	**-0.03**
2	African Silver Bill	0.0015	**-6.5**	**-0.01**
3	African Fish Eagle	-	**-**	**-**
4	African pied Wagtail	0.00032	**-8.05**	**-0.003**
5	Augur Buzzard	0.05	**-2.99**	**-0.15**
6	Black kite	0.005	**-5.3**	**-0.026**
7	Black Shouldered Kite	-	**-**	**-**
8	Black Winged lap Wing	0.003	**-5.8**	**-0.02**
9	Black Winged love Bird	0.0023	**-6.1**	**-0.014**
10	Bronze Mannikin	0.0022	**-6.12**	**-0.013**
11	Cape Rook	0.00005	**-9.9**	**-0.001**
12	Cattle Egret	0.003	**-5.8**	**-0.017**
13	Common Bulbul	0.0012	**-6.73**	**-0.008**
14	Common Fiscal	0.0063	**-5.07**	**-0.032**

15	Common Moor hen	-	**-**	**-**
16	Common Rock Thrush	0.006	**-5.12**	**-0.03**
17	Dusky Turtle Dove	0.03	**-3.5**	**-0.11**
18	Ethiopia Swallow	0.008	**-4.83**	**-0.04**
19	European Bee- Eater	0.0026	**-5.95**	**-0.015**
20	Glossy Ibis	0.01	**-4.61**	**-0.05**
21	Greater Blue Eared Starling	0.0031	**-5.78**	**-0.018**
22	Grey Backed Fiscal	0.002	**-6.21**	**-0.012**
23	Ground Scraper Thrush	0.0018	**-6.32**	**-0.011**
24	Hooded Vulture	-	**-**	**-**
25	Little Swift	0.006	**-5.12**	**-0.03**
26	Long Billed Pipit	0.00005	**-9.9**	**-0.001**
27	Long Crested Eagle	0.018	**-4.02**	**-0.07**
28	Long Tailed Cormorant	0.0026	**-5.95**	**-0.015**
29	Long Tailed Cormorant	0.008	**-4.83**	**-0.04**
30	Northern Wheat Ear	0.0004	**-7.82**	**-0.003**
31	Pied crow	0.0024	**-6.03**	**-0.014**
32	Pied Wheat Ear	0.00009	**-9.32**	**-0.001**
33	Pin Tailed Whydah	0.007	**-4.96**	**-0.035**
34	Red Billed Fire Finch	0.0025	**-5.99**	**-0.015**
35	Red Eyed Dove	0.006	**-5.12**	**-0.03**
36	Red Rumped Swallow	0.017	**-4.07**	**-0.07**
37	Sacred Ibis	0.016	**-4.14**	**-0.07**
38	Speckled Mouse Bird	0.044	**-3.12**	**-0.14**
39	Speckled Pigeon	0.00023	**-8.38**	**-0.002**
40	Spur winged Plover	0.0018	**-6.32**	**-0.011**

41	Streaky Seed Eater	-	**-**	**-**
42	Swanson's sparrow	0.0031	**-5.78**	**-0.018**
43	Tacazze sun Bird	-	**-**	**-**
44	Thick Billed Raven	0.005	**-5.3**	**-0.026**
45	Thekla Lark	0.005	**-5.3**	**-0.026**
46	Wattled Ibis	0.0025	**-5.99**	**-0.015**
47	White Backed Vulture	0.0086	**-4.76**	**-0.04**
48	White Collard Pigeon	0.0095	**-4.66**	**-0.044**
49	Winding Cisticola	-	**-**	**-**
50	Yellow Wagtail	0.005	**-5.3**	**-0.026**
51	Yellow Billed Duck	-	**-**	**-**
52	Rouget‟s Rail	0.05	**-2.99**	**-0.15**
53	African Black Duck	0.012	**-4.42**	**-0.053**
54	Blue Winged Goose	0.0126	**-4.37**	**-0.055**
55	Egyptian Shoveler	0.021	**-3.86**	**-0.081**
56	Northern Shoveler	-	**-**	**-**
57	Alpine Swift	0.006	**-5.12**	**-0.03**
58	Mottled Swift	0.053	**-2.94**	**-0.156**
59	Little stint	0.06	**-2.81**	**-0.169**
60	Common Snipe	0.006	**-5.12**	**-0.03**
61	Great Snipe	0.082	**-2.5**	**-0.21**
62	White Cheeked Tura co	0.017	**-4.07**	**-0.069**
63	African Goshawk	-	**-**	**-**
64	Yellow Billed Kite	-	**-**	**-**
65	Common Kestrel	0.0008	**-7.13**	**-0.006**
66	Sooty Falcon	0.0001	**-9.21**	**-0.001**

67	African Fire Finch	0.078	**-2.55**	**-0.2**
68	Mosque Wagtail	0.0042	**-5.47**	**-0.023**
69	Tropic Buo Bou	0.011	**-4.5**	**-0.05**
70	Mountain Wagtail	0.013	**-4.34**	**-0.06**
71	Tawny Pipit	0.0092	**-4.69**	**-0.043**
72	Tree Pipit	0.011	**-4.5**	**-0.05**
73	Abyssinian Cat Bird	0.013	**-4.34**	**-0.06**
74	Cape Eagle Owl	0.05	**-2.99**	**-0.15**
75	Grayish Eagle Owl	0.102	**-2.28**	**-0.23**
76	Garden Warbler	0.04	**-3.22**	**-0.13**
77	Willow Warbler	0.004	**-5.52**	**-0.022**
78	Black Headed Heron	0.0018	**-6.32**	**-0.011**
	H'=-∑pilnpi= 3.247			

Appendix 4: Abundance proportions (pi) used in calculation of diversity index (February)

NO	Species	Observation inoct/Total individuals =Pi	lnpi	pilnpi
1	African citril	0.008	**-4.83**	**-0.039**
2	African Silver Bill	0.0013	**-6.65**	**-0.009**
3	African Fish Eagle	0.0036	**-5.63**	**-0.02**
4	African pied Wagtail	0.0008	**-7.13**	**-0.006**
5	Augur Buzzard	0.046	**-3.08**	**-0.142**
6	Black kite	0.008	**-4.83**	**-0.039**

7	Black Shouldered Kite	0.0007	**-7.3**	**-0.005**
8	Black Winged lap Wing	0.0032	**-5.74**	**-0.018**
9	Black Winged love Bird	-	**-**	**-**
10	Bronze Mannikin	0.0028	**-5.88**	**-0.016**
11	Cape Rook	0.00009	**-9.32**	**-0.001**
12	Cattle Egret	0.0036	**-5.63**	**-0.02**
13	Common Bulbul	0.0019	**-6.27**	**-0.012**
14	Common Fiscal	-	**-**	**-**
15	Common Moor hen	0.0002	**-8.52**	**-0.002**
16	Common Rock Thrush	0.0074	**-4.91**	**-0.036**
17	Dusky Turtle Dove	0.028	**-3.58**	**-0.1**
18	Ethiopia Swallow	0.012	**-4.42**	**-0.053**
19	European Bee- Eater	0.0028	**-5.88**	**-0.016**
20	Glossy Ibis	0.015	**-4.2**	**-0.063**
21	Greater Blue Eared Starling	0.0039	**-5.55**	**-0.022**
22	Gray Backed Fiscal	-	**-**	**-**
23	Ground Scraper Thrush	0.0025	**-5.99**	**-0.015**
24	Hooded Vulture	0.0012	**-6.73**	**-0.008**
25	Little Swift	-	**-**	**-**
26	Long Billed Pipit	0.0002	**-8.52**	**-0.002**
27	Long Crested Eagle	0.0313	**-3.46**	**-0.11**
28	Long Tailed Cormorant	0.0029	**-5.84**	**-0.017**
29	Long Tailed Cormorant	0.0085	**-4.77**	**-0.041**
30	Northern Wheat Ear	0.0076	**-4.88**	**-0.037**
31	Pied crow	0.0027	**-5.91**	**-0.016**
32	Pied Wheat Ear	0.00009	**-9.32**	**-0.001**

33	Pin Tailed Whydah	0.0122	**-4.41**	**-0.054**
34	Red Billed Fire Finch	0.0016	**-6.44**	**-0.01**
35	Red Eyed Dove	0.0051	**-5.28**	**-0.027**
36	Red Rumped Swallow	0.0097	**-4.64**	**-0.045**
37	Sacred Ibis	0.017	**-4.07**	**-0.069**
38	Speckled Mouse Bird	0.0223	**-3.8**	**-0.085**
39	Speckled Pigeon	0.0002	**-8.52**	**-0.002**
40	Spur winged Plover	0.0012	**-6.73**	**-0.008**
41	Streaky Seed Eater	-	**-**	**-**
42	Swanson's sparrow	-	**-**	**-**
43	Tacazze sun Bird	0.0012	**-6.73**	**-0.008**
44	Thick Billed Raven	0.0049	**-5.32**	**-0.026**
45	Thekla Lark	0.0049	**-5.32**	**-0.026**
46	Wattled Ibis	0.002	**-6.22**	**-0.012**
47	White Backed Vulture	0.017	**-4.08**	**-0.069**
48	White Collard Pigeon	0.01	**-4.61**	**-0.046**
49	Winding Cisticola	0.0049	**-5.32**	**-0.026**
50	Yellow Wagtail	0.005	**-5.3**	**-0.026**
51	Yellow Billed Duck	0.0086	**-4.76**	**-0.041**
52	Rouget‟s Rail	0.049	**-3.02**	**-0.148**
53	African Black Duck	0.0116	**-4.46**	**-0.052**
54	Blue Winged Goose	0.013	**-4.34**	**-0.056**
55	Egyptian Shoveler	0.036	**-3.32**	**-0.12**
56	Northern Shoveler	0.003	**-5.81**	**-0.017**
57	Alpine Swift	-	**-**	**-**
58	Mottled Swift	0.054	**-2.92**	**-0.158**

59	Little stint	0.071	**-2.65**	**-0.188**
60	Common Snipe	0.0048	**-5.34**	**-0.026**
61	Great Snipe	0.07	**-2.66**	**-0.186**
62	White Cheeked Tura co	0.014	**-4.27**	**-0.06**
63	African Goshawk	0.0008	**-7.13**	**-0.006**
64	Yellow Billed Kite	0.0043	**-5.45**	**-0.023**
65	Common Kestrel	0.0005	**-7.6**	**-0.004**
66	Sooty Falcon	0.00004	**-10.13**	**-0.0004**
67	African Fire Finch	0.069	**-2.67**	**-0.185**
68	Mosque Wagtail	0.004	**-5.52**	**-0.022**
69	Tropic Buo Bou	-	**-**	**-**
70	Mountain Wagtail	0.0116	**-4.46**	**-0.052**
71	Tawny Pipit	0.0088	**-4.73**	**-0.042**
72	Tree Pipit	0.0118	**-4.44**	**-0.052**
73	Abyssinian Cat Bird	0.014	**-4.27**	**-0.06**
74	Cape Eagle Owl	0.102	**-2.283**	**-0.233**
75	Grayish Eagle Owl	0.066	**-2.72**	**-0.18**
76	Garden Warbler	0.038	**-3.27**	**-0.124**
77	Willow Warbler	0.004	**-5.52**	**-0.022**
78	Black Headed Heron	0.0024	**-6.03**	**-0.015**
	H'=-∑pilnpi= 3.3874			

Appendix 5 : Abundance proportions (pi) used in calculation of diversity index (April)

NO	Species	Observation inoct/Total individuls =Pi	lnpi	pilnpi
1	African citril	0.006	**-5.12**	**-0.03**
2	African Silver Bill	0.0023	**-6.07**	**-0.014**
3	African Fish Eagle	0.0035	**-5.65**	**-0.02**
4	African pied Wagtail	0.001	**-6.91**	**-0.007**
5	Augur Buzzard	0.081	**-2.51**	**-0.204**
6	Black kite	0.0049	**-5.32**	**-0.026**
7	Black Shouldered Kite	0.00042	**-7.78**	**-0.003**
8	Black Winged lap Wing	0.0042	**-5.47**	**-0.023**
9	Black Winged love Bird	0.00089	**-7.02**	**-0.006**
10	Bronze Mannikin	0.0025	**-5.99**	**-0.015**
11	Cape Rook	0.00009	**-9.32**	**-0.001**
12	Cattle Egret	0.0042	**-5.47**	**-0.023**
13	Common Bulbul	0.0016	**-6.44**	**-0.01**
14	Common Fiscal	0.0044	**-5.43**	**-0.024**
15	Common Moor hen	0.00014	**-8.87**	**-0.001**
16	Common Rock Thrush	0.0022	**-6.12**	**-0.013**
17	Dusky Turtle Dove	0.029	**-3.54**	**-0.103**
18	Ethiopia Swallow	0.0098	**-4.63**	**-0.045**
19	European Bee- Eater	0.0037	**-5.6**	**-0.021**
20	Glossy Ibis	0.02	**-3.91**	**-0.078**
21	Greater Blue Eared Starling	0.0048	**-0.025**	**-0.0001**

22	Grey Backed Fiscal	0.0016	**-6.44**	**-0.01**
23	Ground Scraper Thrush	0.0029	**-5.84**	**-0.017**
24	Hooded Vulture	0.0018	**-6.32**	**-0.011**
25	Little Swift	0.0043	**-5.45**	**-0.023**
26	Long Billed Pipit	0.00005	**-9.9**	**-0.001**
27	Long Crested Eagle	0.019	**-3.96**	**-0.08**
28	Long Tailed Cormorant	0.0028	**-5.88**	**-0.016**
29	Long Tailed Cormorant	0.0076	**-4.88**	**-0.037**
30	Northern Wheat Ear	0.0097	**-4.64**	**-0.045**
31	Pied crow	0.02	**-3.91**	**-0.078**
32	Pied Wheat Ear	0.0002	**-8052**	**-0.002**
33	Pin Tailed Whydah	0.014	**-4.27**	**-0.06**
34	Red Billed Fire Finch	0.0014	**-6.6**	**-0.009**
35	Red Eyed Dove	0.0045	**-5.4**	**-0.024**
36	Red Rumped Swallow	0.0093	**-4.68**	**-0.044**
37	Sacred Ibis	0.0188	**-3.97**	**-0.075**
38	Speckled Mouse Bird	0.03	**-3.5**	**-0.105**
39	Speckled Pigeon	0.0001	**-9.2**	**-0.001**
40	Spur winged Plover	0.0013	**-6.65**	**-0.009**
41	Streaky Seed Eater	0.00098	**-6.93**	**-0.007**
42	Swanson's sparrow	0.0026	**-5.95**	**-0.015**
43	Tacazze sun Bird	0.0021	**-6.17**	**-0.013**
44	Thick Billed Raven	0.0041	**-5.5**	**-0.023**
45	Thekla Lark	-	**-**	**-**
46	Wattled Ibis	0.0016	**-6.44**	**-0.01**
47	White Backed Vulture	0.0103	**-4.58**	**-0.047**

48	White Collard Pigeon	0.005	**-5.3**	**-0.026**
49	Winding Cisticola	0.0058	**-5.15**	**-0.03**
50	Yellow Wagtail	0.0044	**-5.43**	**-0.024**
51	Yellow Billed Duck	0.0096	**-4.65**	**-0.045**
52	Rouget‟s Rail	0.07	**-2.66**	**-0.186**
53	African Black Duck	0.0125	**-4.38**	**-0.055**
54	Blue Winged Goose	0.0142	**-4.25**	**-0.06**
55	Egyptian Shoveler	0.0212	**-3.85**	**-0.082**
56	Northern Shoveler	0.004	**-5.52**	**-0.022**
57	Alpine Swift	0.0045	**-5.4**	**-0.024**
58	Mottled Swift	0.034	**-3.38**	**-0.115**
59	Little stint	0.026	**-3.65**	**-0.095**
60	Common Snipe	0.0053	**-5.24**	**-0.028**
61	Great Snipe	0.0413	**-3.19**	**-0.132**
62	White Cheeked Tura co	0.0107	**-4.54**	**-0.049**
63	African Goshawk	0.0012	**-6.73**	**-0.008**
64	Yellow Billed Kite	0.0063	**-5.07**	**-0.032**
65	Common Kestrel	0.0001	**-9.2**	**-0.001**
66	Sooty Falcon	0.00005	**-9.9**	**-0.0005**
67	African Fire Finch	0.0668	**-2.71**	**-0.181**
68	Mosque Wagtail	-	**-**	**-**
69	Tropic Buo Bou	0.0098	**-4.63**	**-0.045**
70	Mountain Wagtail	0.011	**-4.5**	**-0.05**
71	Tawny Pipit	0.0054	**-5.22**	**-0.028**
72	Tree Pipit	0.0139	**-4.28**	**-0.059**
73	Abyssinian Cat Bird	0.0128	**-4.36**	**-0.056**

74	Cape Eagle Owl	0.133	**-2.02**	**-0.268**
75	Grayish Eagle Owl	0.093	**-2.38**	**-0.22**
76	Garden Warbler	0.036	**-3.32**	**-0.12**
77	Willow Warbler	0.0029	**-5.84**	**-0.017**
78	Black Headed Heron	0.0031	**-5.78**	**-0.018**
	H'=-∑pilnpi= 3.6086			

Appendix 6. summary of Index of diversity among months in the study area

Month	**October**	**December**	**February**	**April**
H'	**3.8488**	**3.247**	**3.3874**	**3.6086**

Appendix 7: Ordinal rank and percentage proportion of bird species recorded in the Berek Forest

No.	**Species**	**Observation/100hrs**	**Rank**
1	Cape Eagle owl	8600 (9.63%)	abundant
2	Grayish Eagle Owl	6900 (7.73%)	abundant
3	African Fire Finch	6700 (7.5%)	abundant
4	Great Snipe	6300 (7.05%)	abundant
5	Little Stint	5300 (5.94%)	abundant
6	Rouget‟s Rail	5100 (5.71%)	abundant
7	Augur Buzzard	4810 (5.39%)	abundant
8	Mottled Swift	4200 (4.7%)	abundant
9	Garden Warbler	3400 (3.81%)	abundant
10	Dusky Turtle Dove	2720 (3.05%)	abundant
11	Speckled pigeon	2700 (3.02%)	abundant

12	Egyptian Shoveler	2300 (2.58%)	abundant
13	Long Crested Eagle	1550 (1.74%)	abundant
14	Scared Ibis	1500(1.68%)	abundant
15	White Cheeked Turaco	1400 (1.57%)	abundant
16	Abyssinian Cat Bird	1260 (1.41%)	abundant
17	Glossy Ibis	1100 (1.23%)	abundant
18	African Black Duck	1100 (1.23%)	abundant
19	Mountain Wagtail	1090 (1.22%)	abundant
20	Blue Winged Goose	1060 (1.19%)	abundant
21	Red Rumped Swallow	1050 (1.18%)	abundant
22	White Backed Vulture	1050 (1.18%)	abundant
23	Tree Pipit	950 (1.06%)	abundant
24	Ethiopian Swallow	850 (0.95%)	abundant
25	White Collard Pigeon	850 (0.95%)	abundant
26	Tawny Pipit	850 (0.95%)	abundant
27	Pin Tailed Whydah	840 (0.94%)	abundant
28	Northern Wheat Ear	740 (0.83%)	abundant
29	Tropic BuoBou	740 (0.83%)	abundant
30	African Citril	560 (0.63%)	abundant
31	Pallid Harrier	560 (0.63%)	abundant
32	Yellow Billed Duck	560 (0.63%)	abundant

33	Common Rock Thrush	530 (0.59%)	abundant
34	Black Kite	470 (0.53%)	abundant
35	Red Eyed Dove	470 (0.53%)	abundant
36	Yellow Wagtail	470 (0.53%)	abundant
37	Common Snipe	470 (0.53%)	abundant
38	Thick Billed Raven	450 (0.5%)	abundant
39	Common Fiscal	410 (0.46%)	abundant
40	Alpine Swift	370 (0.41%)	abundant
41	Willow Warbler	360 (0.40%)	abundant
42	Cattle Egret	350 (0.39%)	abundant
43	Little Swift	350 (0.39%)	abundant
44	Thekla Lark	350 (0.39%)	abundant
45	Winding Cisti Cola	330 (0.37%)	abundant
46	Yellow Billed Kite	330 (0.37%)	abundant
47	Greater Blue eared starling	320 (0.36%)	abundant
48	Black Winged Love Wing	310 (0.35%)	abundant
49	Mosque Wagtail	300 (0.34%)	abundant
50	African Fish Eagle	268 (0.3%)	abundant
51	Long Tailed- Cormorant	250 (0.28%)	abundant
52	European Bee- Eater	240 (0.27%)	abundant
53	Pied crow	230 (0.26%)	abundant
54	Bronze Mannikin	220 (0.25%)	abundant

55	Wattled Ibis	220 (%)0.25	abundant
56	Black Headed Heron	214 (0.24%)	abundant
57	Swainson‟s Sparrow	210 (0.23%)	abundant
58	Northern Shoveler	210 (0.23%)	abundant
59	Ground Scraper Thrush	180 (0.2%)	abundant
60	African Silver Bill	178 (0.2%)	abundant
61	Red Billed Fire Finch	170 (0.19%)	abundant
62	Common Bulbul	160 (0.18%)	abundant
63	Black Winged love Bird	150 (0.17%)	abundant
64	Spur- Winged Plover	150 (0.17%)	abundant
65	Grey Backed Fiscal	140 (0.16%)	abundant
66	Tacazze Sun Bird	110 (0.12%)	abundant
67	Hooded Vulture	80 (0.09%)	abundant
68	Streaky seed Eater	80 (0.09%)	abundant
69	Common Kestrel	80 (0.09%)	abundant
70	African pied Wagtail	56 (0.06%)	abundant
71	African Goshawk	50 (0.05%)	abundant
72	Black Shouldered Kite	30 (0.03%)	common
73	Common Moor Hen	20 (0.02%)	common
74	Speckled pigeon	20 (0.02%)	common
75	Pied Wheat Ear	10 (0.01%)	frequent
76	Sooty Falcon	9 (0.01%)	frequent
77	Cape Rook	8 (0.009%)	frequent
78	Long Billed Pipit	7 (0.008%)	frequent
	Total	**89,293 (100%)**	

Appendix 8. Timed species count system(TSCS)data sheet for bird survey

Date----------

Launching time----------

Finishing time----------

Month----------

Common name (code) bird sighted	Number of individuals

Additional Notes