ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

FACULTY OF LIFE SCIENCES
ZOOLOGICAL SCIENCES PROGRAM UNIT

ECOLOGICAL AND SYSTEMATIC ZOOLOGY STREAM

SPECIES DIVERSITY AND ABUNDANCE OF BIRDS OF ADDIS ABABA BOLE INTERNATIONAL AIRPORT

By: **Tsigereda Dessalegn**

Advisor: **Professor Afework Bekele**

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A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN BIOLOGY

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ABSTRACT

Ecological investigation of species diversity and abundance of birds was conducted from August 2010 to March 2011 in Addis Ababa Bole International Airport. Transect count and point count methods were used to investigate the abundance of birds. Observation was conducted by periodically walking along the study area early in the morning and late in the afternoon. Different diversity indices and statistical methods (Chi-square test and correlation) were used to analyze data collected during the field survey. Movement patterns, seasonal and temporal bird distribution as well as birds strike records were investigated. A total of 74 bird species grouped under 13 orders and 31 families were recorded. August had the lowest species diversity (H'=3.71), species evenness (E=0.61) and species richness (41). The highest species diversity, evenness and richness were recorded in December (H'=4.06), January (E=0.74) and September (61), respectively. Variation in abundance of birds was statistically significant between seasons and months. Abundance score of uncommon bird species was high both during the wet and dry seasons using encounter rate. Appropriate management of bird attractant sites is very important to discourage birds from the airport.

Key words: Abundance, bird strike, management, species diversity

1. Introduction and Objectives

1.1. Introduction

Patterns of species composition and diversity are the results of historical, evolutionary and ecological processes. The species composition in a given area is mostly explained by historical factors such as dispersal events, geographical isolation, and extinction due to past climatic and geological events, and in much less extent by some ecological factors such as competition and predation (Barrantes and Sandoval, 2009). A number of variables have been found to influence bird species diversity within a landscape. These include the area of habitat patch in which the species nests, the amount of habitat within the landscape, degree of fragmentation and vegetation characteristics of the habitat (MacArthur, and MacArthur, 1961).

Both individualistic and interactive factors may be involved in maintaining species richness and composition of an area. Differences in species richness and composition among localities within a landscape and among landscapes may be due to species interactions as well as the interaction of each species with the abiotic environment. Environmental heterogeneity in the form of spatial variation in habitat and local climate can affect species distributions (Veech and Crist, 2007). The abundance and distribution of animals are also affected by scale-dependent hierarchical processes that disturb the links between habitat suitability and their numbers (Telleria *et al.*, 2009.

Birds are among the most easily defined and readily recognized categories of animals, due to the presence of feather, which is unique to them. In addition to feathers, the development of forelimbs as wings, mostly for flight; feathered tail that serves for balancing, steering and lifting; toothless horny beak and skeleton exhibiting unique adaptations, mainly for flight and bipedal locomotion are characteristics of birds (Wallace and Mahan, 1975; Padian and Chiappe, 1998).

Birds are both visually and acoustically conspicuous organisms of most ecosystems. Because they are comparatively easy to identify, birds have received considerable attention of humans

(McLay, 1974; Whelan *et al*., 2008). Although they occupy most of the earth's surface, most species are found only in particular regions and habitats, whereas others are cosmopolitan (Van Tyne and Berger, 1959). Patterns of abundance and distribution of birds are strongly related to environmental factors, which determine their presence and activity. The power of flight allows them to move easily through the air and yet they are perfectly adapted to every environment that fit their requirements for successful reproduction and survival (Welty, 1975; Estrella, 2007).

Throughout human history, people have always tried to enhance their comfort. In so doing, they intervene in natural habitats and greatly decrease the area of naturally functioning ecosystems worldwide (Hannah *et al.*, 1994; Remes, 2003). Diversity and extent of natural habitats will continue to decline as human populations increase and alter landscape for development (Petit *et al.*, 1999). Such activities transformed natural areas by establishing towns, building houses, gardens and public parks, which create entirely artificial environments. Factors determining which species can coexist with human settlement include the presence and patch size of native vegetation as well as competition with exotic species and non-native predators. The structure and floristic attributes of planted vegetation as well as supplementary feeding by humans affect the level of such coexistence (Chace and Walsh, 2006).

The effective management of human activities in wildlife areas is an important conservation issue, as the footprint of human influence continues to expand and incidental impacts of human activities spread into more areas. Such expanding anthropogenic activity is widely perceived to lead to negative consequences for the wildlife beyond habitat loss alone. Understanding how animals respond to anthropogenic activities is fundamental to resolving potential conflicts between humans and animals. There are numerous ways in which it is possible to study animal responses, but changes in an animal's behavior are often the most obvious consequences of anthropogenic activities (Beale, 2007).

Distribution, abundance, reproductive success and behaviour of animal species are often sensitive to habitat change caused by human activities. Birds have been particularly useful as indicators to evaluate effects of habitat chansge because they are easy to watch, and the populations of many decrease or increase when the landscape is modified by such activities. They are well-known indicator taxa due to their sensitivity to environmental perturbations, relevance to ecosystem functioning and relative ease in sampling (Posa and Sodhi, 2006). They are indicators and useful models for studying variety of environmental changes (Sutherland and Green, 2004; Urfil *et al*., 2005; Estrella, 2007). Many of them have adapted with the changes that humans have inflicted on the ecosystem.

Urbanization concerns all environmental changes associated with urban development. It can be characterized as an increase in human habitation, coupled with increased per capita energy consumption and extensive modification of the landscape. It creates a system that does not depend principally on local natural resources to persist. Urban areas are usually warmer, have artificial lighting regimes and are with more polluted. These areas have relatively little and often exotic vegetation in a landscape dominated by street pavement and concrete buildings when compared with natural areas (Mcdonnell and Pickett, 1990; Slaabbekoorn and Ripmeester, 2007). Urbanization often results in extensive modification of the natural environment (Dickman and Doncaster, 1987).

The development and the continual expansion of urban areas have not only destroyed natural habitats, but also have drastically changed the environmental and ecological conditions of these areas. Consequently, species that have settled in these new man made ecosystems are exposed to considerable alternations in environmental conditions (Partecke *et al*., 2005). Birds are important for the ecosystem as they play various roles as bio-indicators of different kind of environmental changes like urbanization (Padmavathy *et al.*, 2010). Urban environments provide birds with considerable quantities of food and roosting sites especially in gardens and parks (Dorst, 1974). Some species could be attracted to such areas since it introduces new exploitable resources such as water, ornamental plants and grasses (Posa and Sodhi, 2006).

Birds have adapted to life in urban areas and look for food in gardens, farms and rubbish dumps (Morgan, 2004). Airports are one of the structural features in urban environments. The natural environment and other human activities inside and near the vicinity of airports attract a wide range of wildlife including birds. Airports provide a wide variety of natural and human-made habitats that offer food, water and cover. Most airports support ample and diverse food items such as seeds, leaves, insects, earthworms and small mammals in the vicinity. Airport areas provide certain birds with nesting, roosting, food, shelter and other facilities (Brown *et al.*, 2001: Sutherland *et al.*, 2004).

Cliff-nesting birds look for favourable nesting sites on or within buildings. Domestic pigeons, crows and kites are easily attracted by certain architectural features, electric poles and other airport facilities. Occasionally, food becomes available through careless waste disposal practices by nearby restaurants and kitchens from airlines. Many airports have inadequate garbage disposal systems that permit access to various food items. These are favourite areas for several species of birds. Nearby sewage outlets may also provide food for birds and other wildlife ((Jennings, 1975).

Birds of all types are drawn to open water for drinking, bathing, roosting and protection. Rainy periods provide temporary water pools at many airports. Many airports have permanent bodies of water near or between runways for landscaping, flood control, or waste water disposal purposes. These permanent sources of water provide foraging ground for a variety of bird species, with small fish, tadpoles, frogs, insect larvae, other invertebrates and edible aquatic plants. Temporary and permanent waters, including ponds, burrowed pits, swamps, and lakes attract groups of birds (Jennings, 1975; Klem, 1990).

Birds were the foremost animals to suffer from human actions. Clearly, an aircraft poses a hazard to birds and there is empirical evidence that birds utilize anti-predator strategies in response to human disturbance similar to strategies used when encountering a predator. Thus, in an applied context, anti-predator behaviours can help us to understand the mechanisms behind the responses of wildlife to different types of human activities (Bernhardt *et al*., 2010).

There are occasions where birds get in conflict with humans due to the damage they cause. Too often the destructive influence of human activities on bird populations is recognized only after substantial damage has been done (Klem, 1990). Virtually all human activities can affect bird populations either positively or negatively (Donnelly and Marzluff, 2004). This could especially be true for birds of prey, given their low densities, large home ranges, and the resulting scale at which they operate (Berry *et al.*, 1998). Hazard caused by bird aggregation occurs in or near airports. Birds become a special hazard to aircraft, because they can fly and overcome barriers. They may interfere dangerously with human activities by causing accidents to aircraft, mainly on landing and take-off. Most of such hazards have fortunately involved only material, though often severe losses. Modern, high-speed jet engines are highly vulnerable to damage during bird strn growth around the world, caused by some urban disequilibrium, combined with the expansion of air transportation in most of the countries result in an increase of bird strike statistics. The problem affects a great majority of countries, assuming different characteristics for each peculiar geographic region. Worldwide innumerable material resources have been invested by the air transport industry as a whole to deal with the bird strike problem. Reducing bird strike accidents is a goal pursued by untiring aviation safety specialists of all nationalities (Claudio and Bastos, 2000).

Aircrafts are not usually part of bird’s natural environment, but their attempt to use the same airspace at the same time results in collision. The collision of birds with aircraft (bird strike) and is a worldwide phenomenon and has been observed since the beginning of aviation. Many species of birds compete for airspace with departing and approaching aircraft at airports, worldwide. This result in bird strikes, which contribute to a substantial jeopardy to the safety record and financial well being of airport operators (Kuzir and Inica, 1998; Dale, 2009). The problem has increased in the past decade because of increasing populations of many wildlife species, including birds that are hazardous to aviation as well as due to the increase in the number of flights. A bird or a flock of birds that suddenly takes on from a runway or a surrounding area will collide with incoming or departing aircrafts. It can possibly result in death, delay, injuries, material damage and economic loss (Dolbeer, 2009).

Various studies and documents of the International Civil Aviation Organization (ICAO) show that bird strike becomes a serious problem in areas where airports are situated, in places with different ecological setup such as nearness to water bodies, farmland, grassland, garbage dumps and along migratory routes. Ideally, when a new airport is planned, a site with a low biological capability should be chosen to minimize the effect of bird hazard. An 'anti-bird' attitude should be maintained throughout the design, construction and operation of the new airport. Sudden bird problems at existing airfields need immediate attention. However, extensive change in the airport habitat is usually costly and time-consuming (Blokpoel, 1976).

The numbers of operational airlines and airliners have increased consistently over the past years and this growth is projected to continue (Robinson, 2000). Between 1990 and 2008, more than 87,000 bird–aircraft collisions were reported to the US Federal Aviation Administration (FAA) which represented more than US$600 million in direct and indirect costs to US Civil Aviation annually. (Thorpe, 2005; Bernhardt *et al.*, 2010). The risk of aircraft collisions with wildlife is increasing as air traffic volume increases. Contributing factors include increase in high hazard bird populations, increase in air traffic volumes, plus the restriction of open space environments suitable for birds outside of airports due to urban encroachment (Hesse *et al*., 2009).

The majority of wildlife strike occurs inside or in the vicinity of the airport. According to ICAO (International Civil Aviation Organization), 90% of the strike occurs during landing, takeoff and associated phases of flight. The wild animals that are involved in strike are largely birds. Birds in the vicinity of airfields are known to present a permanent hazard for aircrafts during take-off and landing. Large ground dwelling animals can also be a problem to airport operation or aircraft movement during landing and take-off. The number of strike also varies from season to season (Kuzi and Inica, 1998).

Each airfield is attractive to birds for a different variety of reasons, and the reasons vary with the species of birds involved and the time of year. Birds can be attracted to airports for food (e.g., earthworms, grasshoppers, and seeds), water, and shelter; and because the airports provide suitable nesting habitat or woods for overnight roosting. Each species of bird has its own behaviours, habitat preferences, preferred foods, loafing and roosting habits, flocking tendencies, and times of seasonal occurrence. As well, features that are nearby or even at some distance from airfields can create different bird hazards to aircraft safety at each airport. Nevertheless, there are some characteristics of birds and requirements of bird control that are common to most airports (Solman, 1981).

Ever since the recognition of birds as hazards to aircraft safety, there has been serious interest in techniques and products that could control this hazard. Indeed, the need for effective bird control measures at airports has only increased over the years. The constantly expanding level of air traffic, and the development of larger, faster, and quieter jet-engined aircraft, has raised the risk of serious bird strikes. It is important that the airport authorities show due diligence by employing bird control measures that are appropriate for their particular situations (Bomford, 1990; Belant *et al.*, 1997).

When it is difficult to get rid of birds and other wildlife from an airfield, the airport can be modified to make it less attractive to them. Several habitat management practices make airports less attractive for birds. These include eliminating standing water source, removing or thinning trees, removing and managing grass height. Buildings can be modified to reduce or eliminate roosting and nesting sites of birds. Once the features that attract birds and other wildlife to the airport are known, they can be removed or changed to reduce their attractiveness. This approach is called habitat manipulation, because it involves alterations of the habitat (or living space) of the birds. Changes in the airport environment are useful in removing the more obvious bird and other wildlife attractants, but it will be impossible to change the airport completely free from birds (Hesse, 2009).

Airfield vegetation can be managed not to attract wildlife. The first and probably most important criterion for selecting airfield vegetation is that it should not be suitable for use as food by hazardous wildlife. If an animal does not use vegetation for foraging, it will be less likely to use it for resting because it will spend little time at that location. Raptors are attracted to airports because of rodents and other small animals that are harboured by tall, poorly maintained grass stands and borders (Dolbeer, 2009).

An ecological study covering all seasons should be made before any major habitat management changes are carried out. Such an investigation of an airport and immediate vicinity should indicate how many birds and other wildlife are there in the area, which species are involved, how the species are distributed and why they are there. To describe basic bird movement patterns at the airfield, it is important to quantify the overflying rate in relation to species, flock size, flight direction, time spent crossing the active runway, flight height and bird behaviour. How these factors are influenced by environmental conditions and airfield activity also requires examination (Fennessy *et al.,* 2005). Studies should also focus on the birds and other fauna of the area as well as human activities such as agricultural and waste disposal operations (Blokpoel, 1976).

Addis Ababa Bole International Airport (AABIA), which is the study area, is one of the sites known for diversity and abundance of bird species. The community assemblage of bird population in the area consists of collection of populations of different densities that require similar environmental condition. The airport and its vicinity have a number of habitats available to support diverse bird species. The airport was found to be characterized by birds of high diversity. The vegetation structure and rainfall played important roles in determining the species diversity and richness of the birds (Elizabeth Yohannes, 1996).

The present study focuses on gathering information on the species composition, and abundance of birds in this area. Monitoring bird numbers, activity pattern and abundance in the study area generates a complimentary source of data, which is more suited to the management of bird control programs. The survey carried out also assessed the strike risk posed to aircraft by birds and other wildlife.

1.2. Objectives

1.2.1. General Objective

The general objective of the study is to investigate the species diversity and abundance of birds at the AABIA.

1.2.2. Specific Objectives

The study aims at achieving the following specific objectives:

- To study species diversity of birds in AABIA
- To study abundance of birds
- To correlate activity of birds with time of the day, weather and season
- To identify major bird attractant features within and in the surrounding of the study area
- To identify habitats and habitat association of these birds
- To investigate movement patterns of birds with respect to arrival, departure and surface movement of aircrafts

2. Study Area and Methods

2.1. Location and Area

The Addis Ababa Bole International Airport is located in the Bole area, 6 km south east of the centre of Addis Ababa city and 65 km north of Debre Zeyit at an elevation of 2400 m above sea level (Fig. 1). It consists of two alternate runways, five taxiways connecting the two runways and two taxiways connecting the old runway with the main and service aprons as well as ring road. Natural habitats within the area include grassland, which is the dominant feature of the area, wetlands, swampy areas, water bodies, bushlands and woodlands. The study area also includes terminal buildings, fire fighting and rescue station, control towers, security and perimeter fences, fuel stations, offices, cafeterias, gardens and other areas with significant human activities. Master plan of AABIA is given in Fig. 2.

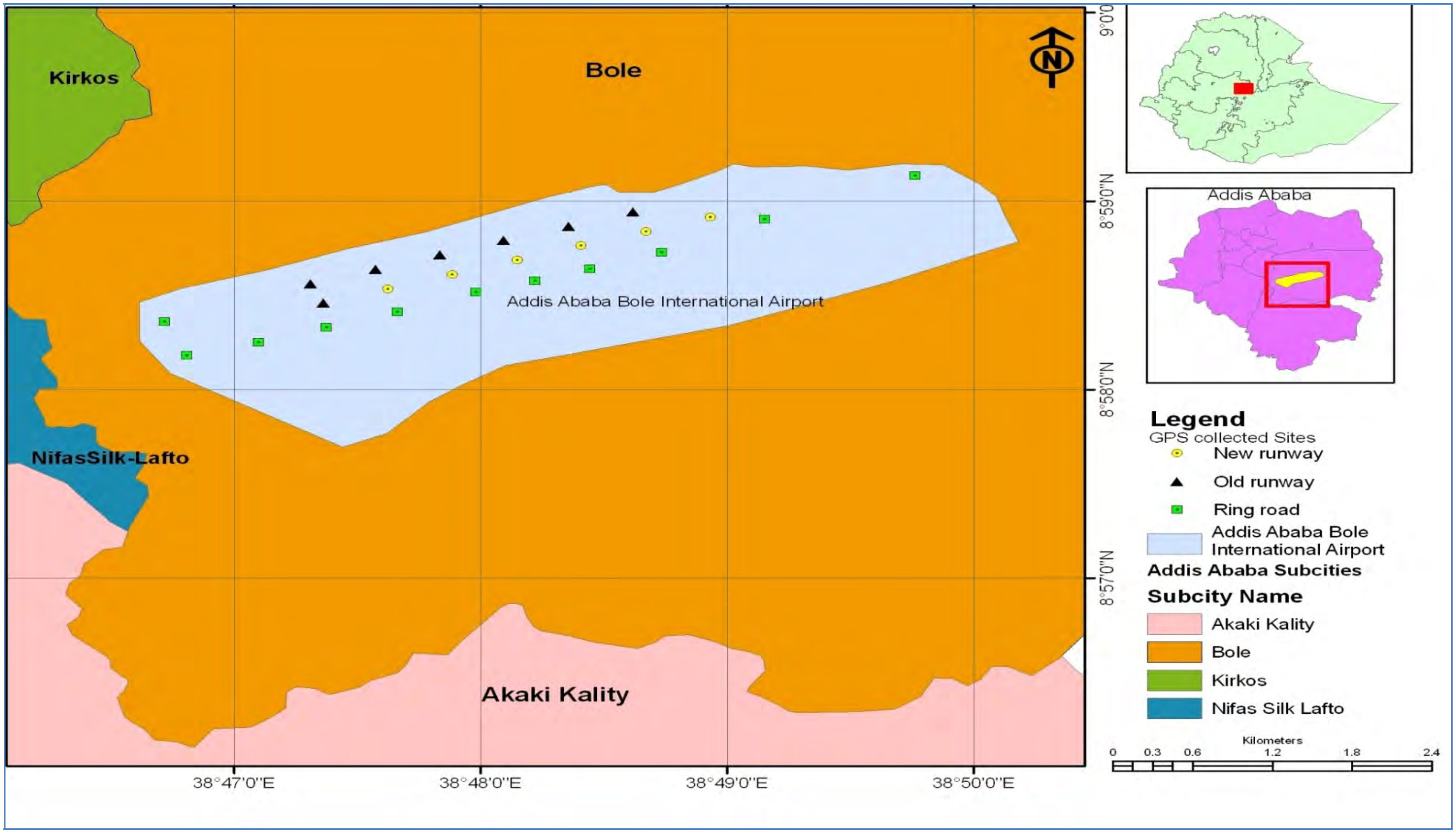

Figure 1Figure 1. Location map of the study area with GPS coordinate points (Source: Landsat Satellite Image, 2000 and GPS Reading).

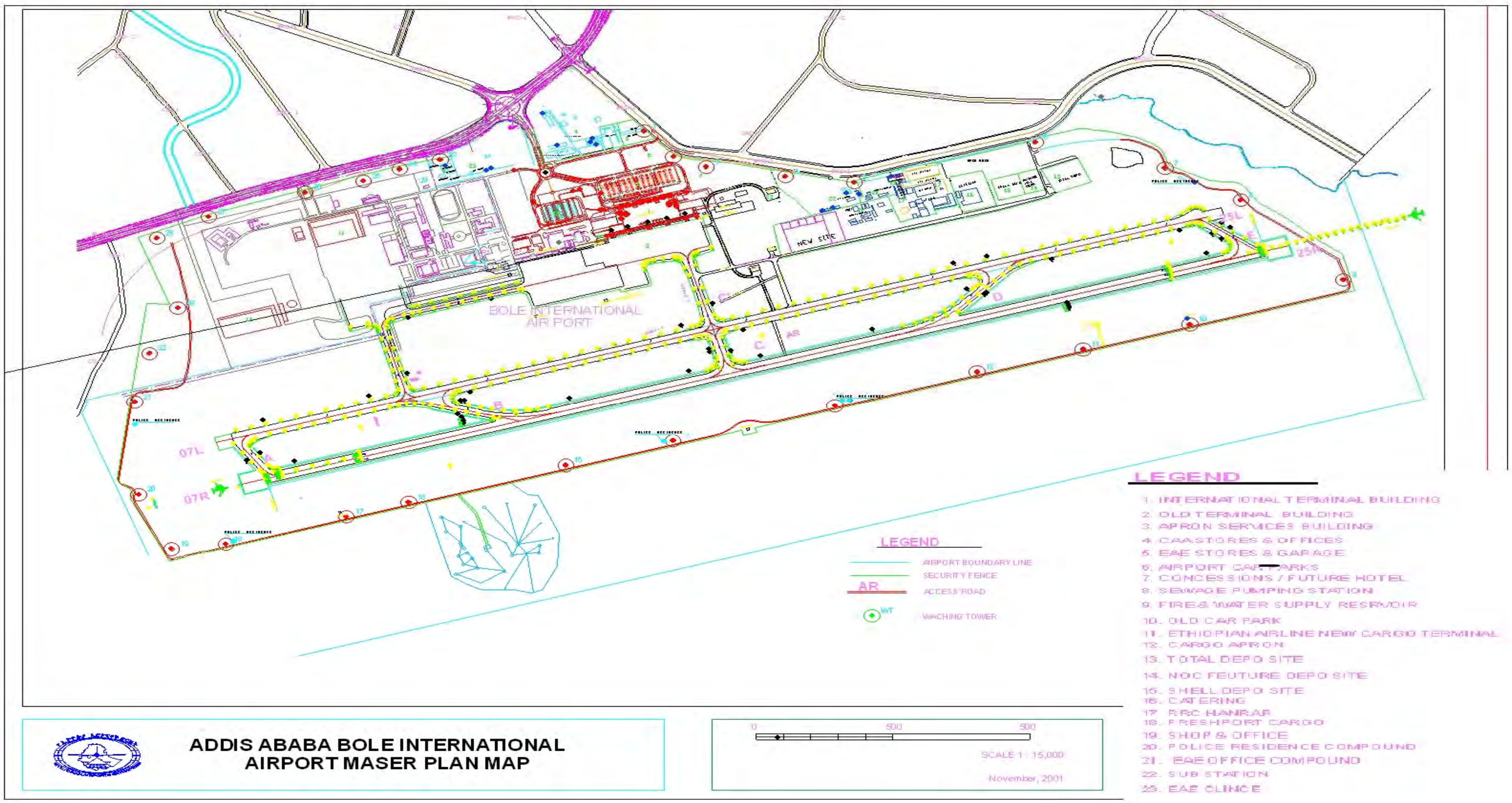

Figure 2. Master plan map of the Addis Ababa Bole International Airport

2.2. Climate

The average monthly maximum and minimum temperature around Bole area were recorded in March (25.52 ^{0}C) and December (7.40 ^{0}C), respectively, from the year 2000 up to 2010 (National Meteorological Service Agency, 2011) (Fig. 3)

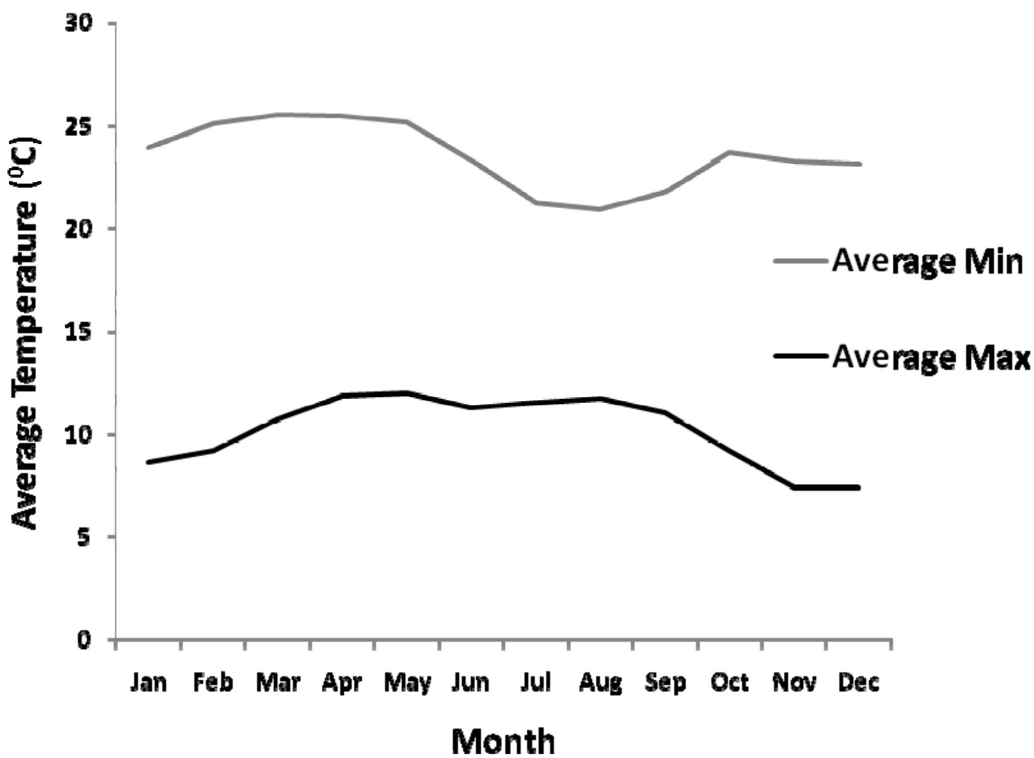

Figure 3. Monthly average monthly maximum and minimum temperature (^{0}C) of Bole area from year 2000-2010 (Source: National Meteorological Service Agency, 2011).

The highest and lowest average rainfall intensities occur in August (254.7 mm) and November (7.1 mm), respectively (National Meteorological Service Agency, 2011) (Fig. 4).

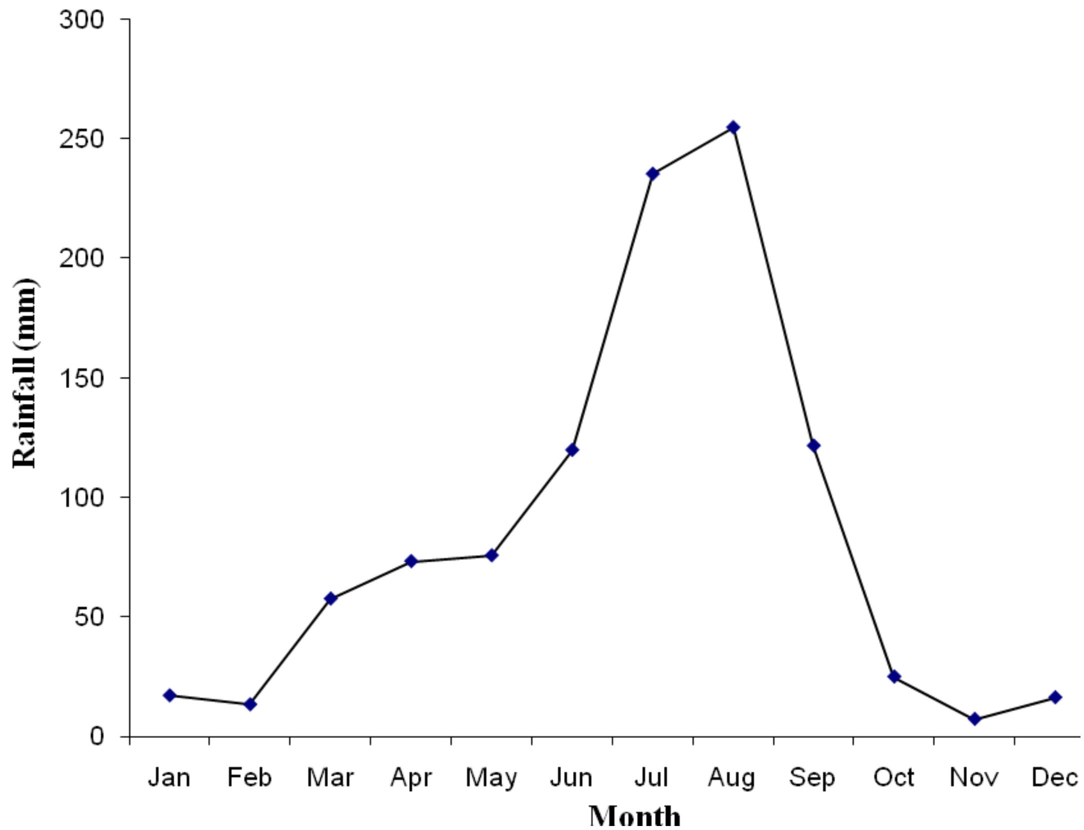

Figure 4. Average monthly rainfall (mm) of Bole area from year 2000-2009 (Source: National Meteorological Service Agency, 2011).

The area is known with strong wind, which sustains throughout the year. The wind intensity is usually high during early morning and late afternoon hours, especially during the rainy season.

2.3. Materials and Methods

2.3.1. Materials

The following materials have been used during the survey:

- Binoculars (8x408.2)
- Garmin GPS 72
- Digital cameras
- Field guide books
- Data sheets
- Note books

2.3.2. Sampling Design

Transect count and point count methods were used to study the abundance of birds in and around the airport (Bibby *et al.*, 1998; Manley *et al.*, 2006, Lambert *et al.*, 2009). Activities, numbers, types and locations of birds were recorded during a fixed amount of time at each point. Stations for the point count method were selected depending on the activity and position of birds. The start of transects was sited randomly while positioning the points to produce unbiased density estimates (Bibby *et al.,* 1998). Points for the transect count method were placed by walking along the two runways and the ring road. GPS was used to mark the transect points (Table 1).

Transect count method was used for the two runways and the ring road. Transects for the runways were divided into seven blocks. The ring road was divided into eleven blocks using GPS markings. The points, which were marked using the GPS were spaced 500 to 600 meter apart for runways and 400 to 700 meter apart within the ring road. Density estimates using this method was carried out through periodic walking along these roads (Appendix 1).

Stations for the point count method were selected depending on the abundance and activity of birds. This method was used for species that are small, flocking and difficult to identify in most occasions (Bibby *et al*., 1998). This count was used at different stations within the ring road, runways, taxiways, apron areas, water bodies and garden areas A unit time of 5 to 15 minutes was used for the count (Appendix 2).

Table 1. Points for the point count and transect count methods

Area sampled	**Total area (Km^2)**	**No. of points for the point count method**	**No. of blocks for the transect count method**
Old runway	0.1665	2	7
New runway	0.171	5	7
Taxiways	0.063802	7	–
Ring road	7.8	11	11
Apron	0.121119	5	–
Garden areas	0.03	7	–
Water body and wetlands	–	3	–

Habitats in the area with significant attraction for birds are shown in Plates 1 to 5.

Plate 1. *Bidens sp.* during the wet season (September, 2010; Photo: Tsigereda Dessalegn)

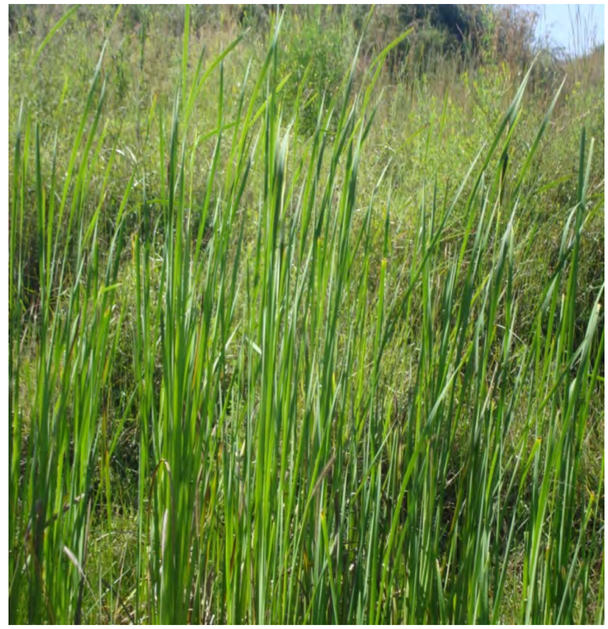

Plate 2. The grassland during the wet season (August, 2010; Photo: Tsigereda Dessalegn)

Plate 3. Garden area (October, 2010; Photo: Tsigereda Dessalegn)

Plate 4. Water body (January, 2011); Photo: Tsigereda Dessalegn)

Plate 5. The grassland during the dry season (February, 20011; Photo: Tsigereda Dessalegn)

2.3.3. Data Collection

A preliminary survey was conducted in August, 2010. Ecological investigation of the study area and its surroundings were gathered during this period. Identification of birds in the study area was also conducted.

Detailed study was carried out from August, 2010 to March, 2011. The wet season survey was carried out from August to October, 2010 while the remaining months were for dry season investigation. Ecological investigation of the species diversity, and abundance of the birds was carried out by periodically walking within the study area, on a daily basis as well as on alternative days. Type, number of individuals, activity pattern, habitat association and approximate flight height of birds of the area were carried out during the study period. This information was correlated with time of the day, weather condition and season of the year.

Data collection was carried out early in the morning from 7:00 to 10:00 a.m. and in the late afternoon from 3:00 to 6:00 p.m., when the activity of birds is prominent (Bibby *et al.,* 1998). The habitats and sites which were conducive to birds for access to food, water resources, nesting and roosting were also observed during the present study.

Birds in the study area were observed using naked eyes and binoculars for better identification as well as hand tally during counting. Digital camera photographs were also used for further confirmation of the bird species. Field data sheet was used to record the identified species. GPS was used to locate the points for the bird counting methods. Identification and categorization of birds to their respective taxonomic groups was done based on field guide books (Sinclair and Ryan, 2003; Redman *et al.,* 2009).

2.3.4. Data Analysis

Analysis of the data was made possible using different diversity indices and encounter rates to estimate relative abundances. The species diversity of the area for each month was given in terms of Shannon-Weaver diversity Index (Shannon and Weaver, 1949). Shannon-Weaver diversity Index is calculated as:

$$H' = -\sum (Pi \ln Pi)$$ where:

H' = Shannon-Weaver Index

Pi = Proportion of the i^{th} species

ln = Natural logarithm

Species evenness, which measures the pattern of distribution of the bird populations present in the area, was evaluated using Shannon-Wiener evenness Index (E) as follows:

$\mathbf{E = H'/ H_{max}}$ where:

E = Shannon-Wiener Evenness Index

H' = Shannon-Wiener diversity Index

H max = ln S= natural logarithm of the total number of species (S) in each month (Tramer, 1969)

Encounter rate method was used to explain a species list with an index of relative abundance based on the number of encounters with individuals per block of time. It was calculated as:

$$\text{Encounter rate} = \frac{\text{Total Number of Individual Birds Observed}}{\text{Period of Observation in Hours}} \times 10$$

Encounter rate was used to give a crude ordinal scale of abundance (Bibby *et al*., 1998) as given in Table 2.

Table 2. Encounter rates used to give a crude ordinal scale of abundance

Abundance Category	Abundance score	Ordinal scale
<0.1	1	Rare
0.1–2.0	2	Uncommon
2.1–10.0	3	Frequent
10.1–40.0	4	Common
40.0+	5	Abundant

Data collected during the study period was analyzed using SPSS (version 17.0) statistical program. Chi-square test was used to investigate the effect of season on abundance of birds. Correlation was used to evaluate significance of difference between total species count and mean species count of each month of the study period. Graphs were used to explain results of the data analyzed after being employed using Microsoft Excel.

3. Results

3.1. Species Composition

A total of 74 species of birds grouped under 13 orders and 31 families were recorded. Family Passeriformes (52.7%) had the highest number of species. The lowest number of species was under the Families Psittaciformes (1.4%), Apodiformes (1.4%) and Coliformes (1.4%) with one species each. Most of the birds in the study area were observed throughout the study period. Out of the species recorded in the area 1 species (1.35%) was endemic, 2 (2.70%) resident, 5 (6.75%) endemic to Ethiopia and Eritrea, 17 (22.97%) migrant and 49 (66.23%) resident and partially migrant. The only endemic bird species in the study area was the Abyssinian longclaw (Table 3).

Table 3: List of bird species recorded from Addis Ababa Bole International Airport

🗪 = Endemic, ♥ = Endemic to Ethiopia and Eritrea, ✒ = Migrant,

🐈 = Resident, unmarked species = Resident and Partially Migrant

🏛 = Species of birds recorded from point count method

Common Name	Scientific Name	Family	Order
Abdim's Stork🗪🏛	*Ciconia abdimii*	Ciconiidae	Ciconiiformes
Abyssinian Longclaw🗪	*Macronyx aurantiigula*	Motacillidae	Passeriformes
African Citril	*Serinus leucopygius*	Fringillidae	Passeriformes
African Silverbill	*Lonchura cantans*	EStrildidae	Passeriformes
African Fish Eagle	*Haliaeetus vocifer*	Acciipitridae	Falconiformes
African Pied Wagtail	*Motacilla aguimp*	Motacillidae	Passeriformes
Augur Buzzard	*Buteo augur*	Acciipitridae	Falconiformes
Baglafecht Weaver	*Ploceus baglafecht*	Ploceidae	Passeriformes
Black Headed Heron	*Ardea melanocephala*	Ardeidae	Falconiformes
Black Kite✒	*Milvus migrans*	Acciipitridae	Falconiformes
Black Shouldered Kite	*Elanus caeruleus*	Acciipitridae	Falconiformes
Black-Eared Wheatear✒	*Oenanthe hispanica*	Turdidae	Passeriformes
Black-Winged Lapwing	*Vanellus coronatus*	Charadriidae	Charadriiformes

Cont'd…

Black-Winged Lovebird♥	*Agapornis taranta*	Psittacidae	Psittaciformes
Bronze Mannikin	*Lonchura cucullata*	Estrildidae	Passeriformes
Brown-Rumped Seed-Eater🏛	*Serinus tristriatus*	Fringillidae	Passeriformes
Cape Rook	*Corvus capensis*	Corvidae	Passeriformes
Cattle Egret✒	*Bubulcus ibis*	Ardeidae	Ciconiiformes
Cinnamon-Breasted Bee-Eater✒	*Merops oreobates*	Meropidae	Coraciiformes
Cinnamon-Breasted Bunting	*Emberiaz tahapisi*	Emberizidae	Passeriformes
Common Bulbul	*Pycnonotus barbatus*	Pycnonotidae	Passeriformes
Common Fiscal	*Lanius collaris*	Lanidae	Passeriformes
Common Kestrel✒	*Falco tinnunculus*	Falconidae	Falconiformes
Common Moorhen🏛	*Gallinula chloropus*	Rallidae	Gruiformes
Common Rock Thrush✒	*Monticola saxatilis*	Turdidae	Passeriformes
Crimson-Rumped Waxbill	*Estrilda rhodopyga*	Estrilidida	Passeriformes
Dusky Turtle Dove	*Streptopelia lugens*	Columbidae	Columbiiformes
Egyptian Goose🏛	*Alopochen aegyptiaca*	Anatidae	Anseriformes

Cont'd…

Ethiopian Swallow	*Hirundo aethiopica*	Hirundinidae	Passeriformes
European Bee-Eater	*Merops apiastes*	Meropidae	Coraciiformes
European Swallow	*Hirundo rustica*	Hirundinidae	Passeriformes
Glossy Ibis	*Plegadis falcinellus*	Threkiornithidae	Ciconiiformes
Greater Blue-Eared Starling	*Lamprotornis chalybaeus*	Sturnidae	Passeriformes
Grey-Backed Fiscal	*Lanius excubitoroides*	Laniidae	Passeriformes
Groundscraper Thrush	*Psophocichla litsitsirupa*	Turdidae	Passeriformes
Hamerkop	*Scopus umbretta*	Scopidae	Peliccaniiformes
Hooded Vulture	*Necrosyrtes monachus*	Acciipitridae	Falconiformes
Isabelline Wheatear	*Oenanthe isabellina*	Turdidae	Passeriformes
Kittlitz's Plover	*Charadrius pecuarius*	Charadriidae	Charadriiformes
Little Swift	*Apus affinis*	Apodidae	Apodiformes
Long-Billed Pipit	*Anthus similis*	Motacillidae	Passeriformes
Long-Crested Eagle	*Laphaetus occipitalis*	Acciipitridae	Falconiformes
Long Tailed Cormorant	*Phalacrocorax africanus*	Phalacrocoracidae	Pelacaniformes
Northern Wheatear	*Oenanthe oenanthe*	Turdidae	Passeriformes

Cont'd…

Pallid Harrier🐦	*Circus macrourus*	Accipitridae	Falconiformes
Pied Crow	*Corvus albus*	Corvidae	Passeriformes
Pied Wheatear🐦	*Oenanthe oenanthe*	Turdidae	Passeriformes
Pin-Tailed Whydah	*Vidua macroura*	Viduidae	Passeriformes
Red-Billed Firefinch	*Lagonosticta senegala*	Estrildidae	Passeriformes
Red-Billed Oxpecker	*Buphagus erythrorhynchus*	Sturndidae	Passeriformes
Red-Cheeked Cordon-bleu	*Uraeginthus bengalus*	Estrildidae	Passeriformes
Red-Eyed Dove	*Streptopelia roseogrisea*	Columbidae	Columbiiformes
Red-Rumped Swallow🐦	*Hirundo lucida*	Hirundinidae	Passeriformes
Rouget's Rail♥🏛	*Rougetius rougetii*	Rallidae	Gruiformes
Ruppell's Starling	*Lamprotornis purpuroptera*	Sturnidae	Passeriformes
Sacred Ibis	*Threskiornis aethiopicus*	Threkiornithidae	Ciconiiformes
Speckled Mousebird	*Colius striatus*	Coliidae	Coliiiformes
Speckled Pigeon	*Columba guinea*	Columbidae	Columbiiformes
Spur-Winged Plover🏛	*Vanellus spinosus*	Charadriidae	Charadriiformes
Streaky Seed-Eater🐕	*Serinus gularis*	Fringillidae	Passeriformes
Swainson's Sparrow	*Passer swainsonii*	Passeridae	Passeriformes

Cont'd…

Tacazze Sunbird	*Nectarinia tacazze*	Nectariniidae	Passeriformes
Tawny Eagle	*Aquila rapax*	Accipitridae	Falconiiformes
Thekla Lark	*Galerida theklae*	Alaudidae	Passeriformes
Thick-Billed Raven♥🏛	*Corvus crassirostris*	Corvidae	Passeriformes
Village Weaver	*Ploceus cucullatus*	Estrildidae	Passeriformes
Wattled Ibis♥🏛	*Bostrychia carunculata*	Threskiornithidae	Ciconiiformes
White-Backed Vulture	*Gyps africanus*	Accipitridae	Falconiiformes
White-Collared Pigeon♥	*Columba albitorques*	Columbidae	Columbiiformes
Winding Cisticola🐕	*Cisticola galactotes*	Cisticolidae	Passeriformes
Yellow Wagtail🐦	*Motacilla flava*	Motacillidae	Passeriformes
Yellow-Billed Duck🏛	*Anas undulate*	Anatidae	Anseriformes
Yellow-Billed Kite	*Milvus aegyptius*	Accipitridae	Falconiiformes
Yellow-Mantled Widowbird	*Euplectes macroura*	Estrildidae	Passeriformes

Some of the bird species in the study area showed relatively high number of individuals at restricted months of the survey period. These include Abdims stork, cattle egret, Ethiopian swallows, swifts, kites and yellow billed ducks (Figs. 5, 6, 7, 8, 9 and 10).

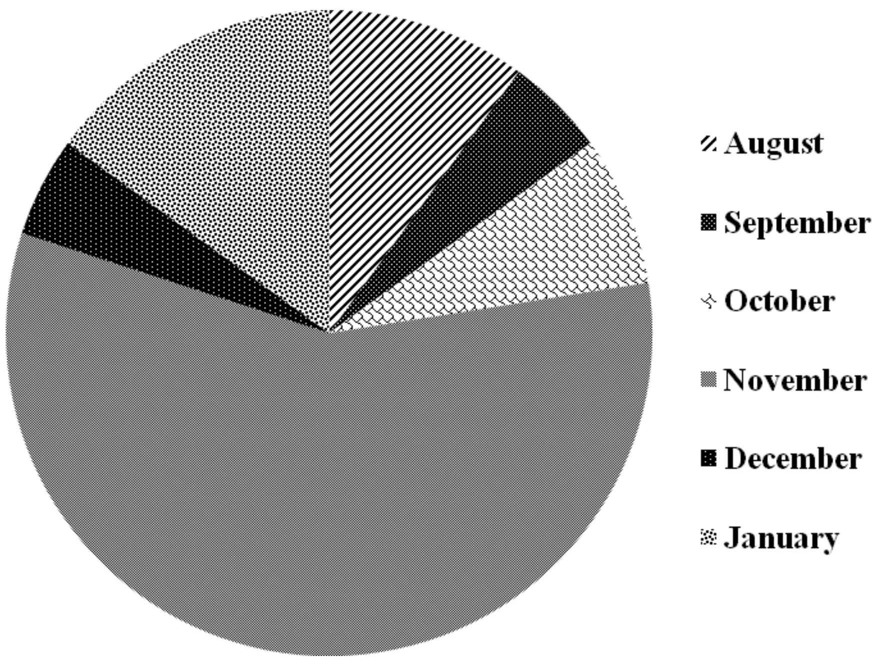

Figure 5. Abundance of Abdim's storks

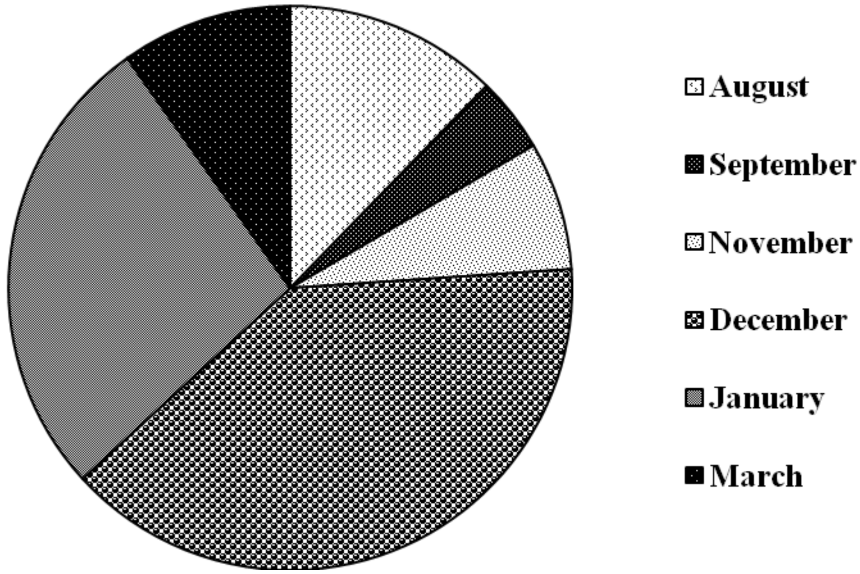

Figure 6. Abundance of cattle egrets

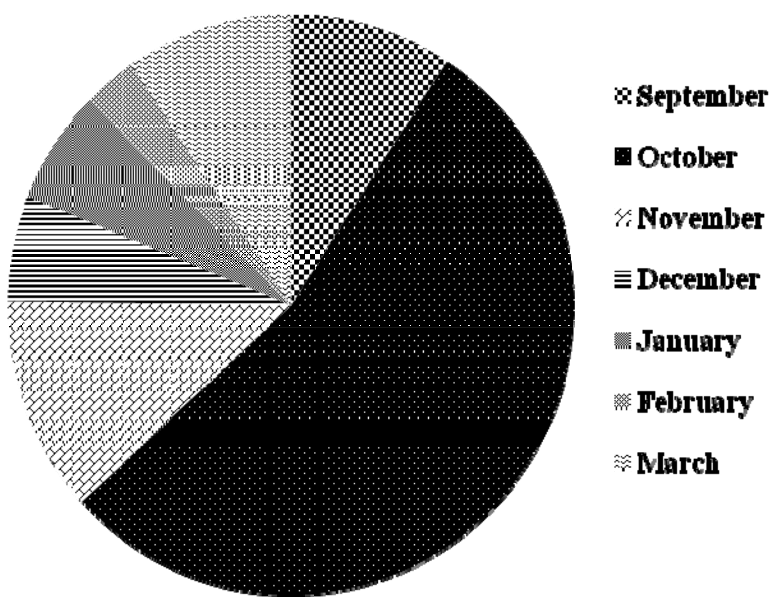

Figure 7. Abundance of Ethiopian swallows

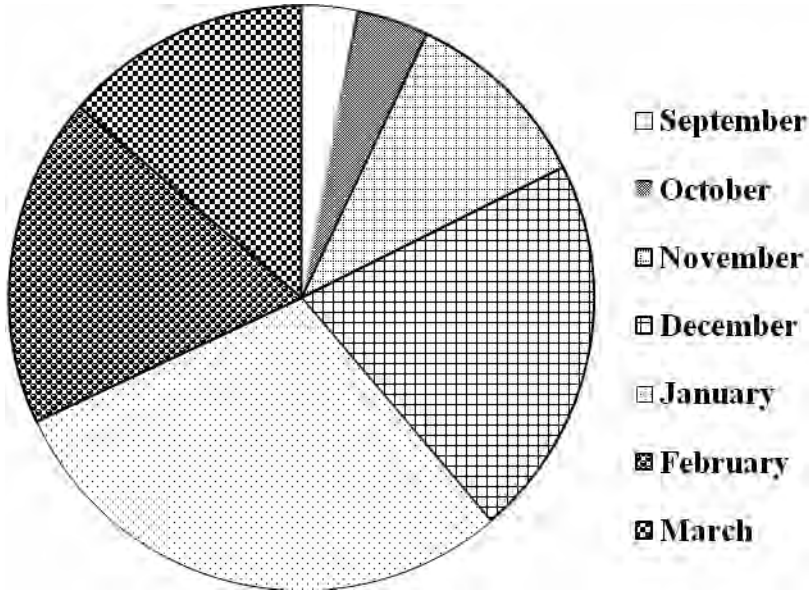

Figure 8. Abundance of kites

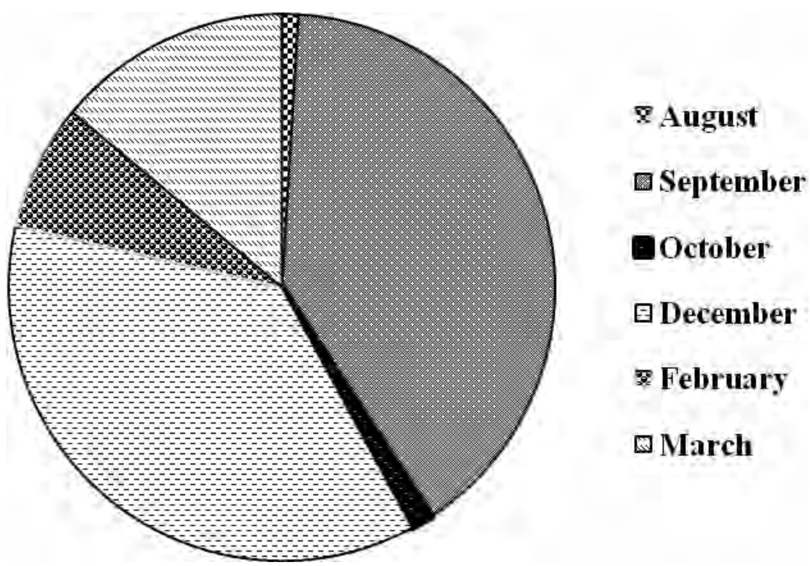

Figure 9. Abundance of swifts

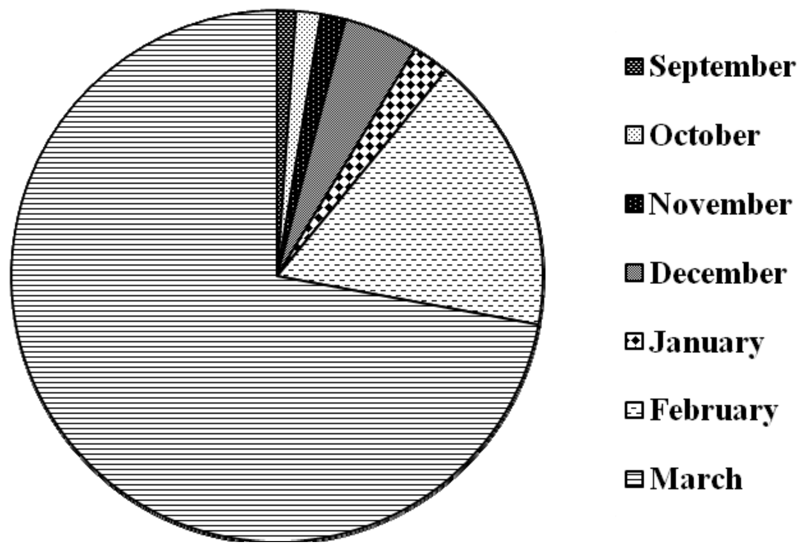

Figure10. Abundance of yellow billed ducks

Few species of birds were observed only during restricted months of the study period (Table 4).

Table 4. Bird species abundant only during restricted months

(P= Present)

Species Name	**Month**							
	Aug	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
Abdim's stork	P	P	P	P	P	P		
Bee-eater		P	P					
Black headed heron			P	P	P	P	P	P
Black winged lapwing		P				P		
Glossy ibis					P			
Hamerkop	P	P			P			
Kite		P	P	P	P	P	P	P
Long crested eagle		P				P		
Pallid harrier			P	P	P	P	P	P
Spur winged plover						P	P	P
Thick billed raven		P	P	P	P	P		

3.2. Species diversity

The highest and lowest diversity of birds were observed during December (H'= 4.06) and August (H'= 3.71), respectively. The highest even distribution of birds was observed during January (E= 0.74), whereas the lowest was during August (E= 0.61) (Table 5).

Table 5. Species diversity of birds in the study area

Month	Species Richness	H'	Hmax	E
August	41	2.25	3.71	0.61
September	61	2.71	4.11	0.66
October	55	2.64	4.01	0.66
November	52	2.85	3.95	0.72
December	58	3.06	4.06	0.75
January	55	3.05	4.01	0.76
February	43	2.64	3.76	0.70
March	50	2.60	3.91	0.66

3.3. Species Richness

The highest number of bird species was recorded during September (61) and the lowest during August (41). The average number of species for the respective number of days for each month gives the mean number of species. The result of the data showed that, the mean number and the total number of bird species of each month correlated positively (R^2 =0.55) (Table 6).

Table 6. Species richness: Mean ± SE (Correlation factor, R^2 =0.55)

Month	Total Species	Mean ± SE
August	41	34± 11.87
September	61	54± 10.99
October	55	52 ±3.96
November	52	47 ±7.91
December	58	53 ±8.35
January	55	52 ±4.84
February	43	40 ±4.83
March	50	44 ±8.79

3.4. Abundance

Abundance of birds in the study area was correlated with season. Individual of 9863 and 15218 were counted during the wet (August up to October) and dry (November up to March) seasons, respectively.

Chi-square test for the abundance of birds in the study period for each month showed that there was statistically significant difference between observed and expected counts of each species ($P<0.05$). Abundance of birds at each month is given in Table 7.

Table 7. Variation in abundance of birds between months of the study period

	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Chi-Square	2316.714	3566.556	2316.714	3769.079	4276.821	3939.295	3518.383	3756.177
Df	17	24	17	25	28	26	23	25
P	.0	.0	.0	.0	.0	.0	.0	.0

Likewise, the Chi-square test for abundance of birds in the study period for the two seasons showed that there was statistically significant difference between observed and expected counts of each species ($P<0.05$) (Table 8).

Table 8. Variation in abundance of birds between the two seasons

	Wet season	**Dry season**
Chi-Square	27568.880	46673.123
Df	33	48
P	.0	.0

3.5. Relative Abundance

Abundance score and ordinal scale of birds in the study area using encounter rate is given in Appendices 3 and 4. Relative abundance of birds in the study area during the wet season showed that most of the species being uncommon (62.9%), frequent (20%), abundant (8.6%), common (4.3%) and rare (4.3%). During the dry season, 41.8% of the bird species were uncommon, 29.9% frequent, 16.4% common, 6.0% abundant and 6.0% rare (Fig. 11).

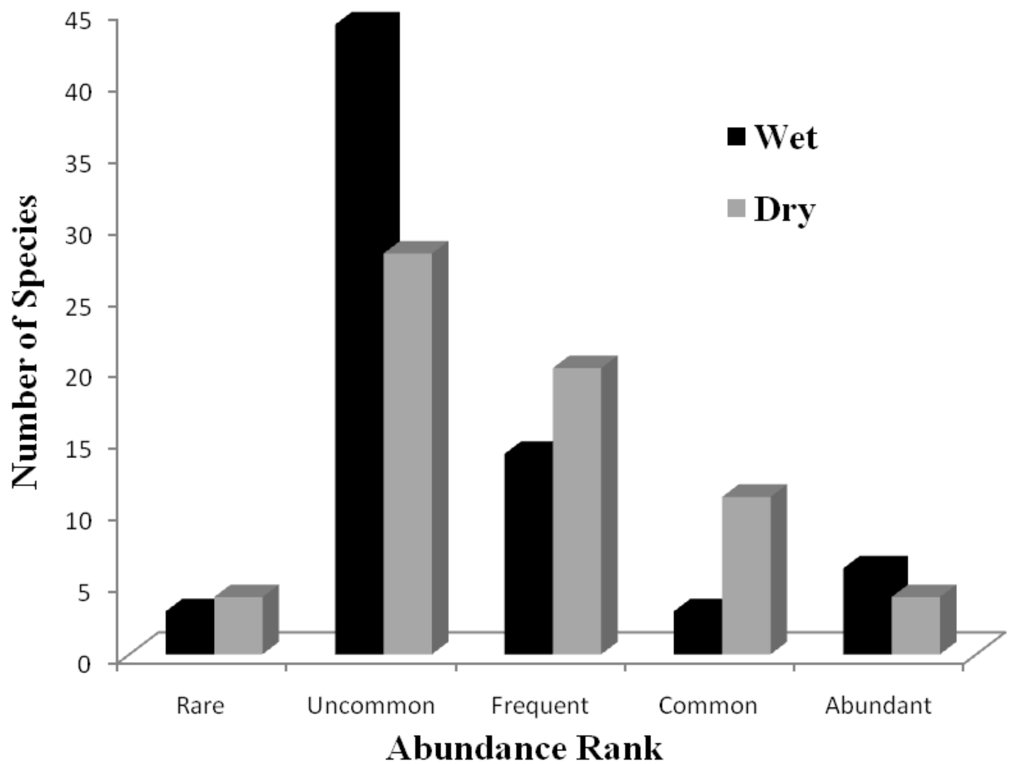

Figure 11. Abundance rank of bird species in the study area during both seasons.

3.6. Bird Attractant Features

The most important factor in determining how a bird forages is to identify the distribution of its food. Birds in the study area were seen attracted by food resources available in and around the airport. The airfield vegetation, which incorporated seed bearing plants and farmlands around the airport vicinity, attracts granivorous birds. The airfield vegetation also inhabits invertebrates, rodents and snakes. These features attract birds. Improper dumping of food left over from arriving and departing aircrafts, residence of security polices, cafeterias, and catering services are other attractants for birds in the study area. The wetlands, swampy areas and other water bodies are found to be attractant as water and food resource site for some of the birds.

All birds need undisturbed places to rest and roost both during the day and at night to avoid predation (Weller, 1999). Birds in the study area prefer different sites for resting, roosting and nesting. These include both man made and natural habitats. Human induced attractants such as roofs of terminal buildings and offices, light poles, antennas and related features were found to be attractant for birds to nest, rest and roost. Trees within and around the vicinity of the airport are the natural habitats observed for birds to perform such activities.

3.7. Movement Pattern of Birds

Movement pattern was investigated for those birds that usually cross the study area, in particular the runways. This pattern was correlated with the time of the day, season of the year and activities performed by the birds after such movements. The parameters used to study such pattern were flock size, flight direction and flight height of birds. The investigation of such pattern was carried out to correlate activity of the birds with respect to arrival, departure and surface movement of aircrafts. This in turn helps to study behavioral responses of birds to aircraft movement and to identify high risk bird species with respect to strikes. Birds that usually perform such activities include pigeons, doves, crows, rooks, egrets, geese, ducks, swallows, starlings and ibises.

3.8. Other Wildlife Species

Habitats in the airport harbour vertebrates, insects and other invertebrates. These included vegetation around the airfield, in the gardens, around the ring road and in the vicinity of the airport. This in turn resulted in the attraction of birds to the area.

Bees were observed in large populations after the blooming of Meskel flower (*Bidens* sp.) during September and October. Grasshoppers usually were observed jumping out of the vegetation of the airfield on to the runways. Earthworms, caterpillars and snails bask on the runways following rains. Beetles and butterflies often were flying during the study period.

Snakes and lizards were observed inhabiting the grassland and bushy areas in the study area. Frogs and toads were seen within the ditches formed on the runways following the rain during the wet season. Direct observation and indirect evidences show the presence of vertebrates in the area. These include larger mammals like hyaena, jackal and hare as well as small mammals like rodents, which were observed directly. Shed off quills of porcupine were used as indirect evidence for their presence in the area. Domestic animals around the airfield and ring road included cats, dogs and cattle.

A number of bird strikes were recorded in Addis Ababa Bole International Airport (AABIA), during the survey period. Various species of birds and other wildlife were involved in the strike. 90% of the strikes occur on or in the vicinity of the airport. The strike records witnessed during the study period are presented in (Table 9). These strikes resulted in material damage as well as delay of arrival and departure of flights.

Table 9. Strike records during the study period

Date	**Strike By**	**Number of Individuals**
September 27, 2010	European Bee-eater	8
October 4, 2010	Tawny Eagle	1
October 15, 2010	Ethiopian Swallow	1
November 9, 2010	Black Kite	1
November 11, 2010	Yellow Billed Kite	1
November 19, 2010	Yellow Billed Kite	1
December 21, 2010	Bat	1
December 20, 2010	Jackal	1
December 31, 2010	Yellow Billed Kite	1
December 31, 2010	Black Kite	4
March 5, 2011	Hyaena	1

4. Discussion

Birds in the study area were observed either throughout the survey period or during specific times of the year only. Some birds were observed exclusively during the wet season while others only during the dry season. There were also bird species with high number of individuals at specific times of the study period. These all were due to the availability of resources and favourability of the weather conditions. Food resources are the most important attractant feature for the birds.

Bird species richness and abundance are influenced by local resource 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 resources that are essential for a species or a group of species have a non-uniform distribution in space (Nabaneeta and Gupta, 2010). Species richness of birds in the study area for each month does not show significant difference. The highest species richness was recorded in September. This was due to the presence of migrant species such as kites and bee-eaters observed at this time of the study period. The least species richness was recorded in August, which was due to the less favourability of the weather for most birds. The abundance of birds in the study area showed that there is statistically significant variation between months as well as between seasons. This was also determined by the presence and absence of resourcess on which birds depend at different times of the year.

Uncommon bird species were very abundant in the area because of the favourability of the area to satisfy their requirements during both seasons. These birds were observed foraging on food and water resources available within and around the study area. These include food wastes available around apron service areas, cafeterias, waste disposal sites and farmlands around the airport. The natural habitats and man made artifacts were also major attractant features for the birds to be present in the study area. Trees in ornamental settings or woodlots provide roosting habitats for species of small, flocking birds. Trees also provide nesting sites for raptors which are commonly struck at airports (Lyon and Caccamise, 1981). The birds usually perch and roost on trees in and around the airport as well as light poles, antennas, roofs of buildings and hangar areas.

Bird response to grass of different heights differed by species due to the different patterns of habitat use by the birds (Solman 1973). Small sized birds, which belong to the order Passeriformes were observed feeding, resting and roosting on the grasses as well as bushes most of the time. The availability of seed-bearing plants within the grasslands and invertebrates attracted these birds to be present in the area. The grasses and bushes were also nesting and roosting sites for some of these birds. The birds were usually observed within habitats on the sides of the runways, around the ring road and in the gardens, due to the availability of such resources.

Sparrows and weavers as well as thick billed raven were observed foraging on food wastes around security police residences and cafeterias. The fiscals perch on poles and fences to have a look over their food, which are worms and insects and forage on. Cattle grazing (although outside the security fence and within the perimeter fence) of the study area provided food for few birds. These include oxpeckers, which feed on invertebrates (like ticks) from the body of the cattle, wagtails and egrets (Ciconiiformes) which forage on insects and worms disturbed by their hooves, while grazing.

Birds observed in the air are swallows and swifts (Apodiformes). These birds forage on insects and pick them while flying. Crows forage on food wastes and garbage dumps around apron service areas, security police residences, cafeterias and garden while rooks forage on worms and other invertebrates around grasslands as well as food wastes. These birds perch on poles, roof and fences. Therefore, the availability of resources is the main attractant.

Vultures, most of the time, were observed soaring during mid-morning. Harriers, kestrels and black shouldered kites flutter in the air beating their wings to look over the exact spots of their prey and catch them. These birds foraged on small mammals, insects, other invertebrates and reptiles that inhabit in the grassland.

Grassland management in the runway environment should be aimed at reducing bio-productivity and thus reducing the availability of food for birds. This aim is realized by taking away the mown grass immediately after mowing. Lawn mowing, results in increased soil fertility as compared with the main area of grass, resulting in more worms. This means, there are potentially more birds foraging on the worms, which include buzzards and herons (Brough and Bridgman, 1980). Augur buzzards and black headed herons, in the study area, usually rest on the ground to forage on small mammals and invertebrates. The grass on the sides of the runways was mowed after it got dry (during November) and tied up together. It was then put there for periods of time. Augur buzzard was seen resting on it to look over the prey. These birds forage on small mammals, insects and reptiles which inhabit the grasslands.

Yellow billed kites and black kites, which are migrant birds, forage on food wastes dumped in different parts of the study area. Pieces of papers and plastics around the airfield also attract these birds. Eagles were observed performing different activities in the area. Tawny eagles usually fly in the air during mid-morning. Long crested eagles with low abundance were observed resting on termite mounds between grasslands on the side of the runways. The African fish eagles usually perch on poles closer to the water body to look over its prey.

Wattled ibises and sacred ibises were observed foraging on food wastes, from cafeterias and residences of security polices within the area. Glossy ibises were observed foraging around swampy areas as well as flying above the runways. Abdim's storks, on the other hand, forage on worms and other invertebrates between grasses in the gardens. These groups of birds use the area mainly as their foraging site.

Cormorants, geese and ducks swim and forage in the water body found in the study area. Moorhens forage in the vegetation of the water body. There is also a water body closer to the security fence of the airport, which could possibly attract these birds. Plovers were observed foraging within ditches formed around the runways, because of rain and around the shores of the water body. Rouget's rail also foraged within swampy areas in the study area. All these sites are valuable attractants for the species.

Seasonal blooming of Meskel flowers (*Bidens* sp.) during September and October resulted in the existence of large population of bees in the area. Bee-eaters were attracted to forage on the flying insects, particularly bees. The birds forage on the bees usually while flying. These migrant bird species were observed visiting the area during this period of the survey. The heat produced on the runways was also another attractant feature of the area for the birds to bask on.

Doves and pigeons forage on seeds and grains available in the vicinity of the airport because of the presence of farmlands. They also feed on invertebrates between the grasses as well as food wastes around apron service areas. They usually frequent flock foraging. These birds mostly roost under roofs of buildings and hangars as well as on dumped aircrafts.

Following heavy rains, large numbers of worms sometimes move out of the soil adjacent to the runway looking for a dry place. This could easily attract birds to prey on (Bruder *et al.*, 1997). Hamerkops visited the area in restricted months of the study period. They were attracted by insects coming out of the termite mounds during the rainy season and water available for drinking in the study area.

Season of the year and time of the day determine the significance of activity of birds. Activity of birds is prominent early in the morning and late afternoon hours. Most birds in the study area crossed runways sidewise to their foraging sites during the morning and to their roosting sites during late afternoon. Season of the year also affects birds. During the study period, birds were seen with less significant activities when the weather condition was cold, cloudy and very windy. Seasonal distribution of birds in the study area was determined by resources available for them to perform different activities. As a result, some birds were observed throughout the study period while others not.

Individuals of most species were not distributed randomly and most populations exhibit fluctuations in abundance across space and over time. Factors that may cause fluctuations include variation in weather or food supply, the ability of individuals to disperse to new areas and species interactions such as predation or competition (Toms *et al.*, 2002). Some of the bird species were observed in restricted months of the study period only. This was mainly due to the availability of resources that can attract the birds at different times of the year. Migration to Africa to spend the winter also increased the population of some of the migrant bird species in the area.

Species composition of airfield vegetation may affect the relative attractiveness of airfields for birds and small mammals (Baker and Brooks, 1981). Some of the birds in the study area were observed in large numbers during particular time of the survey period. Swifts and swallows were observed in large numbers during September and October due to the presence of large population of insects. Insects and worms disturbed by hooves and breaths of cattle grazing in and the airport provided food for cattle egrets. This resulted in high population of these bird species during December.

The temporal decoupling between food resources and bird numbers, variable climate harshness in different regions or the inability of individuals to reach isolated areas affect migratory bird populations (Telleria *et al.*, 2009). Kites, which are migrant birds, were present during the dry season due to the favourability of the weather and availability of resources in the study area. Human disturbances of the water body in the vicinity of the airport resulted in the movement of the yellow billed ducks in to the water body inside the study area. This resulted in high population of yellow billed ducks during March.

Less abundance and activity of birds of prey were observed after the celebration of the Ethiopian Christmas and Epiphany holidays. This could probably be due to the birds leaving the area and visiting villages in search of food resources.

Flock foraging was observed in doves and pigeons. These birds cross the study area, in particular the runways, to forage on food resources available on the farmland in the vicinity of the airport. They also depended on food wastes available around sites with significant human activities, like residences, cafeterias and apron service areas. The birds cross the runways southeast and southwest in the mornings from the site where they rest and roost to foraging areas. They usually fly back to their roosting sites northeast and northwest directions, during the late afternoon. Hangar areas and other buildings were their roosting sites, while the farmlands were their foraging area. White collared pigeons were the most abundant bird species throughout the study period, which cross the runways with the higher flock size of up to 150 individuals. Speckled pigeons and doves crossed runways with a flock size of 10 to 40. An approximate flight height of 20 to 40 m was common in these birds.

Starlings cross runways during early morning to gardens in the study area where they perform foraging activities in northeast direction. Gardens harboured insects and other invertebrates. In the late afternoon hours, they fly southwest to roost on trees found within the perimeter fence of the study area and in the vicinity of the airport. A flock size of 14 to 40 and an approximate flight height of 30 to 40 m were commonly observed in these groups of birds. Swallows and swifts were observed flying in most occasions. They cross the runways in every direction at different time of the day with a flock size of 1 to 30, and an approximate flight height of 5 to 20 m. Most insects do not seem to fly much above the surrounding vegetation and consequently insect-eating species must seek them there (Liechti and Bruder, 2002). Therefore, these birds use such flight heights, so that they can pick up insects while flying.

Crows and rooks cross runways in pairs, solitarily or in groups of 3 to 11 individuals on average. They fly early in the mornings to north direction to forage on resources available around apron service areas. They were also observed crossing the runways towards southeast and southwest directions of the airport to roost during late afternoon. Trees around the airport were used as their roosting sites.

Ibises, egrets, geese and ducks are the other bird groups that frequent crossing the airport. Ibises and egrets cross runways with an average flock size of 2 to 15, with an approximate flight height of 30 to 50 m in the northwest direction during early morning and southwest to roost in the late afternoon. Ducks and geese cross runways in pairs or solitarily, with an approximate flight of 10 to 20 m, in the northwest direction where the water body is located.

Wildlife species commonly involved in strikes have increased markedly in the last few decades. The volume of air traffic also increased substantially. The existence of birds in the vicinity of airport runways and flight paths present serious hazards to air traffic, particularly during take-off, climb and landing approaches when the loss of one or more engines can jeopardize the safety of flight. Such collisions with birds have resulted in economic as well as human life losses (Bruder *et al.*, 1997; Elizabeth Yohannes and Afework Bekele, 1998; Drewitt and Langston, 2008). Aircraft collisions with wildlife could pose safety and financial threat to the civil aviation.

Collisions between birds and aircraft were witnessed during the study period. Such strikes resulted in material damages as well as delay of departure and arrival of aircrafts. Birds involved in such activities included bee-eaters while basking on the runways, swallows while crossing runways as well as kites and eagles while flying around the runways in search of food. Kites show anti-predatory behaviour against an arriving or departing aircraft by trying to chase after it. This makes them highly vulnerable to strikes and evidently they were the causes for 50% of such accidents in the study area.

Although animal collisions are not known to have caused any fatalities, significant damage is caused every year as a result of collision with domestic and wild animals (Thorpe, 2005). Wildlife other than birds in the study area could also pose strikes. During the study period, there were strikes of aircrafts and mammals. The mammals involved were bat, jackal and hyaena. All of these strikes occurred at night and resulted in material damage to the aircrafts. The carcasses of the animals hit were found to be attractant for birds of prey on the days after the strikes. Fortunately, bird-chasing and fire station personnel usually handle the cleaning of such carcass from the airfield to secure safety air trafficking. These strikes occurred either during arrival or departure of aircrafts.

4.1. Conclusion and Recommendations

Addis Ababa Bole International Airport which is located in the southern part of Addis Ababa is known to support a rich and diverse bird community. The airport has a number of natural and human induced bird attractant features. Natural habitats within the study area included grasslands, swampy areas, water body, bushes and trees. Human induced attractants are roofs of buildings, light poles, antennas, cafeterias and other areas with significant human activities. The area possesses favourable places for birds to nest, rest, roost and a good access to food as well as water resources. These and other factors attract large number and various species of birds to visit the area at different situations and use the airspace as a transient route.

The grassland which is the dominant feature of the area, harobours seed bearing plants, and inhabits rodents, reptiles, insects and other invertebrates. The wetlands, swampy areas and other water bodies were also found to be attractant as water and food resource. Food wastes around different parts of the study area also play a great role in attracting birds. Man made architectural features attract birds to use the area as their resting and roosting sites.

Most of the birds in the study area were uncommon as well as resident and partially migrant. August was the month with the lowest species diversity and richness. September and December on the other hand showed the highest species richness and species diversity, respectively. There was significant difference in bird abundance between the two seasons as well as among the months of the study pseriod

The activity pattern of birds showed that, they use the study area as their foraging, resting, roosting and nesting site. The routine movement of birds in the area showed that some birds cross the runways sideways at different time of the day. Flight direction and approximate flight height were also investigated. The presence of these birds in the airport poses aircraft bird strikes.

On the basis on the results of the study, the following recommendations are suggested:

- Habitat management is necessary to provide the airport environment that discourages birds perching, nesting, roosting or foraging.

- Appropriate management of grassland habitat and other vegetation can effectively discourage birds. This could also help in the removal of invertebrates and small mammals that inhabit the grassland and can reduce birds of prey from the area.

- Removal of termite mounds found between the grassed areas on the sides of the runways, which was observed being an important source of food for most of the birds, in particular during the wet season.

- It is also important to eliminate any nesting sites within the airport boundary.

- Removal of seed bearing and flowering vegetation as well as insects from the airfield area on which birds may depend up on.

- Drainage of swampy and wetland areas that could attract birds as source of food as well as water for some species.

- Appropriate management of food wastes and other garbage from cafeterias, arriving aircrafts and security police residence within the airport.

- Prevent the establishment of human induced sites that are attractive to birds to rest and roost in the area. These include hangar areas, dumped aircrafts and roofs of building that attract some birds in particular doves and pigeons.

- Removal of trees (except used for ornamental purposes in the gardens) around the ring road and in the vicinity of the study area to eliminate roosting site.

- Establish of regulations to develop and implement effective bird control plan in and around the airport.

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Appendix 1. Field data sheet used for transect count method

Date
Transect number
Weather

Time observed	Type of Bird	Group Size	Activity	Distance from the ground	Habitat	Remark

Appendix 2. Field data sheet used for point count method

Date ___________________________

Station Number ___________________

Weather ___________________

Start time	Unit Time (min)	Habitat	Birds	Group size	Activity	Notes

Appendix 3. Relative abundance of birds during the wet season**.**

Species	Number of individuals per 10 field hours	Abundance	Rank
Abdim's Stork	0.5	Uncommon	2
Abyssinian Longclaw	1.0	Uncommon	2
African Silverbill	0.1	Rare	1
African Fish Eagle	0.9	Uncommon	2
Augur Buzzard	3.4	Frequent	3
Baglafecht Weaver	4.8	Frequent	3
European Swallow	0.2	Uncommon	2
Black Headed Heron	0.3	Uncommon	2
Black Kite	2.0	Uncommon	2
Black Shouldered Kite	1.5	Uncommon	2
Black-Eared Wheatear	0.1	Rare	1
Black-Winged Loverbird	0.5	Uncommon	2
Bronze Mannikin	0.3	Uncommon	2
Brown-Rumped Seed-Eater	0.9	Uncommon	2
Cape Rook	22.6	Common	4
Cattle Egret	1.6	Uncommon	2
Cinnamon-Breasted Bunting	0.2	Uncommon	2
Common Bulbul	1.0	Uncommon	2
Common Fiscal	6.2	Frequent	3
Common Kestrel	0.9	Uncommon	2
Common Moorhen	0.6	Uncommon	2
Common Rock Thrush	0.1	Rare	1

Crimson-Rumped Waxbill	0.8	Uncommon	2
Dusky Turtle Dove	88.2	Abundant	5
Egyptian Goose	1.6	Uncommon	2
Ethiopian Swallow	44.8	Abundant	5
European Bee-Eater	13.9	Common	4
Greater Blue-Eared Starling	40.4	Abundant	5
Grey-Backed Fiscal	0.6	Uncommon	2
Groundscraper Thrush	0.5	Uncommon	2
Hamerkop	0.2	Uncommon	2
Hooded Vulture	0.2	Uncommon	2
Isabelline Wheatear	2.5	Frequent	3
Kittlitz's Plover	0.9	Uncommon	2
Little Swift	7.6	Frequent	3
Long-Billed Pipit	1.4	Uncommon	2
Long-Crested Eagle	0.2	Uncommon	2
Mountain Thrush	0.3	Uncommon	2
Northern Wheatear	0.2	Uncommon	2
Pallid Harrier	0.7	Uncommon	2
Pied Crow	60.6	Abundant	5
Pied Wheatear	1.5	Uncommon	2
Pin-Tailed Whydah	0.6	Uncommon	2
Red-Billed Firefinch	0.1	Uncommon	2
Red-Billed Oxpecker	0.5	Uncommon	2
Red-Cheeked Cordon-bleu	0.5	Uncommon	2
Red-Eyed Dove	9.2	Frequent	3
Red-Rumped Swallow	2.4	Frequent	3

Rouget's Rail	0.3	Uncommon	2
Ruppell's Starling	18.5	Common	4
Sacred Ibis	0.3	Uncommon	2
Speckled Mousebird	1.2	Uncommon	2
Speckled Pigeon	60.6	Abundant	5
Streaky Seed-Eater	0.2	Uncommon	2
Swainson's Sparrow	6.1	Frequent	3
Tacazze Sunbird	0.6	Uncommon	2
Tawny Eagle	1.9	Uncommon	2
Thekla Lark	1.7	Uncommon	2
Thick-Billed Raven	2.0	Frequent	3
Village Weaver	0.8	Uncommon	2
Wattled Ibis	2.4	Frequent	3
Cinnamon Breasted Bee-Eater	6.0	Frequent	3
White-Backed Vulture	0.6	Uncommon	2
White-Collared Pigeon	118.0	Abundant	5
Winding Cisticola	7.0	Frequent	3
Yellow Wagtail	0.1	Uncommon	2
Yellow-Billed Duck	0.4	Uncommon	2
Yellow-Blled Kite	4.1	Frequent	3
African Citril	0.9	Uncommon	2
Yellow-Mantled Widowbird	9.2	Frequent	3

Appendix 4. Relative abundance of birds during the dry season.

Species	Number of individuals per 10 field hours	Abundance	Rank
Abdim's Stork	1.3	Uncommon	2
Abyssinian Longclaw	3.1	Frequent	3
African Silverbill	15.9	Common	4
African Fish Eagle	0.7	Uncommon	2
Augur Buzzard	5.4	Frequent	3
Baglafecht Weaver	17.2	Common	4
European Swallow	3.9	Frequent	3
Black Headed Heron	2.0	Frequent	3
Black Kite	19.1	Common	4
Black Shouldered Kite	4.1	Frequent	3
Black-Eared Wheatear	2.7	Frequent	3
Black-Winged Lapwing	0.6	Uncommon	2
Black-Winged Loverbird	0.3	Uncommon	2
Bronze Mannikin	1.4	Uncommon	2
Brown-Rumped Seed-Eater	1.4	Uncommon	2
Cape Rook	25.9	Common	4
Cattle Egret	5.8	Frequent	3
Common Bulbul	0.3	Uncommon	2
Common Fiscal	17.6	Common	4
Common Kestrel	5.5	Frequent	3
Common Rock Thrush	0.2	Uncommon	2

Crimson-Rumped Waxbill	0.0	Rare	1
Dusky Turtle Dove	59.2	Abundant	5
Egyptian Goose	7.2	Frequent	3
Ethiopian Swallow	19.2	Common	4
Glossy Ibis	0.1	Uncommon	2
Greater Blue-Eared Starling	50.3	Abundant	5
Grey-Backed Fiscal	0.4	Uncommon	2
Groundscraper Thrush	0.9	Uncommon	2
Hamerkop	0.2	Uncommon	2
Hooded Vulture	0.1	Rare	1
Isabelline Wheatear	6.9	Frequent	3
Little Swift	7.6	Frequent	3
Long-Billed Pipit	8.1	Frequent	3
Long-Crested Eagle	0.0	Rare	1
Long Tailed Cormorant	0.1	Uncommon	2
Northern Wheatear	1.7	Uncommon	2
Pallid Harrier	3.3	Frequent	3
Pied Crow	60.4	Abundant	5
Pied Wheatear	4.9	Frequent	3
Pin-Tailed Whydah	0.0	Rare	1
Red-Billed Oxpecker	0.9	Uncommon	2
Red-Billed Duck	0.8	Uncommon	2
Red-Cheeked Cordon-bleu	0.5	Uncommon	2
Red-Eyed Dove	10.2	Common	4
Red-Rumped Swallow	0.5	Uncommon	2

Rouget's Rail	0.2	Uncommon	2
Ruppell's Starling	8.7	Frequent	3
Sacred Ibis	11.6	Common	4
Speckled Mousebird	1.0	Uncommon	2
Speckled Pigeon	22.1	Common	4
Spur-Winged Plover	0.3	Uncommon	2
Streaky Seed-Eater	0.6	Uncommon	2
Swainson's Sparrow	6.2	Frequent	3
Tacazze Sunbird	0.2	Uncommon	2
Tawny Eagle	2.0	Uncommon	2
Thekla Lark	1.9	Uncommon	2
Thick-Billed Raven	0.9	Uncommon	2
Wattled Ibis	0.3	Uncommon	2
White-Backed Vulture	1.5	Uncommon	2
White-Collared Pigeon	164.3	Abundant	5
Winding Cisticola	7.0	Frequent	3
Yellow Wagtail	2.4	Frequent	3
Yellow-Billed Duck	11.0	Common	4
Yellow-Blled Kite	7.0	Frequent	3
African Citril	13.8	Common	4
Yellow-Mantled Widowbird	9.3	Frequent	3

DECLARATION

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

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Date : July, 2011

The thesis has been submitted with my approval as a supervisor

Name: Afework Bekele (Professor)

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