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Avian diversity and feeding Guild structure of Urban Birds: The case of Jimma Town, South West Ethiopia

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Declaration

Hereby I declare that this study entitled the avian diversity and feeding guild structure of urban birds is my original work submitted by me for the award of Msc degree in ecology and systematic zoology at Jimma University.

Place.....

Name.....

Date.....

Signature.....

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Abstract

Birds are among the most significant members of biodiversity with enormous ecological, economic, and aesthetic values. Ethiopia is one of the most avifauna rich countries in Africa. Despite the diversity of avifauna in the country little ornithological researches have been done particularly in urban ecosystem. Therefore, this study was aimed at recording the species diversity, relative abundance and feeding guild structure of urban birds in Jimma town. Three habitat types including building sites, vegetation patches and waste dumping site were identified and Point count method was used to collect the data of birds. The data were analyzed using Shannon-Weiner diversity index, Sorenson's similarity index, Chi-square and generalized linear model. A total of 3259 individual birds were recorded in the town. The highest species diversity was recorded during dry season in each habitats with $H'=3.77$, $H'=3.45$ and $H'=1.68$ in vegetation patches, building sites and waste dumping sites respectively, While the least diversity was recorded during wet season with $H'=3.36$, $H'=2.97$ and $H'=1.59$ in vegetation patches, building sites and waste dumping sites respectively. The species diversity did not have significant difference with seasons ($\chi^2=2.000$, $p>0.05$, $df=1$) and habitat types ($\chi^2=6.000$, $p>0.05$, $df=4$). The species abundance was not statistically significant ($\chi^2=6.00$, $p>0.05$, $df, 4$) with habitat types and seasons ($\chi^2=2.00$, $p>0.05$, $df, 1$) in the study area. Five feeding guilds were recorded including insectivore (28,29.16%), granivore (21,21.87%), omnivore (20,20.83%), scavenger (18, 18.75%) and frugi-nectare (9, 9.37%) in building sites where as insectivore (43, 41.35%), granivore (16, 15.38%), omnivore (25, 24%), scavenger (8, 7.69%) and frugi-nectare (12, 11.54%) in vegetation patches and insectivore (1, 9.09%), omnivore (3, 27.27%) and scavenger (7, 63.63%) in waste dumping site. Generalized linear model shows that the abundance of all feeding guilds was significantly ($p < 0.05$) interacted with habitat types except scavengers in waste dumping site. The abundance of insectivore and omnivore showed significant ($p<0.05$) interaction with dry season whereas frugi-nectare, granivore and scavenger did not show any significant ($p>0.05$) interaction. Enhancing the qualities of the urban landscape via reforestation, creating green areas, and providing a buffer against human activity are recommended to enhance the diversity and abundance of birds in the city.

Keywords: diversity, feeding guilds, Jimma town, relative abundance, urban birds

1. Introduction

Birds are one of the most well-known and varied groups of modern vertebrates (Brusatte *et al.* 2015). They are more well-known than other vertebrate groups, abundant in numerous habitats, and occur all across the world (Whelan *et al.*, 2015). With enormous ecological, economic, and aesthetic values, birds are among the most significant members of biodiversity (Girmay *et al.*, 2020). They perform a variety of ecosystem services, such as pollination, seed distribution, and insect pest management, and they are significant bio indicators (Waltert *et al.*, 2004).

The world is increasingly becoming more urbanized, and many formerly bio diverse regions are becoming impervious surfaces. The amount of habitat available for migratory and breeding birds is decreased as a result of this loss of natural habitat, which also causes local bird communities to be dominated by urban dweller and urban utilizer species (Partridge and Clark, 2018). Despite the fact that urbanization reduces biodiversity, it simultaneously produces vast habitats that are utilized by a variety of creatures, including birds (Ciach and Fröhlich, 2017). By offering birds a different habitat for foraging and nesting throughout the breeding season, wooded roadways in urban areas can improve the connectivity of urban landscapes (Fernández-Juricic & Jokimäki, 2001). The inter seasonal stabilization of the species mix of wintering birds depends on urban infrastructure (buildings, roads, and trash dumps) (Ciach and Fröhlich, 2017). For example, bird species that nest in buildings or cavities have a variety of diets that are advantageous to the way-of-life of the residents (Jokimäki *et al.*, 2016). Little green spaces serve as crucial habitats for both summer and winter bird communities (Carbó-Ramrez and Zuria, 2011).

Africa has a sizable and varied avifauna. There are over 1,850 different bird species in Africa, of which about 1,450 of them are permanent residents in sub Saharan Africa. Two orders like the Coliiformes (which includes six species of mousebirds) and the Struthioniformes (which includes the ostrich), are unique to sub-Saharan Africa. Sub-Saharan Africa is also home to thirteen other taxonomic groups (Shorrocks and Bates, 2015). Countries in Sub-Saharan Africa are undergoing unprecedented levels of urbanization and growth (Ofori *et al.*, 2018). Numerous African cities are situated in biodiversity hotspots despite the fast population growth and high rates of urbanization in those countries (Chamberlain, 2017). For instance, the diversity of birds in Musanze City, Rwanda is larger than that of the national park and other nearby natural

habitats, demonstrating the significance of maintaining not only local wildlife's natural habitats but also urban areas where birds, in particular, are more frequently found (Gatesire *et al.*, 2014). In Kilimanjaro region city in Tanzania, sewage stabilization pond and dumpsite are artificial habitats that comparatively maintain rich bird community (Massawe, 2017).

Ethiopia is one of the most avifauna rich countries in Africa (Mola *et al.*, 2021). Among the more than 1850 avian species in Africa, 926 of them are found in Ethiopia, of which 16 are endemic (Redman *et al.*, 2009). Despite the country was avifauna rich, focus was given to natural habitats while little attention has given to urban birds. Only birds of few towns were investigated. Buildings serve as breeding sites and microhabitats that provide obstructive cover to lower the risk of predation in Bahir dar city (Alemu *et al.*, 2020). Jimma town is one of the towns in Ethiopia where findings has not conducted yet, rather the natural habitats around were investigated. For available information on the avifauna of the area focus was only on the birds of extensive wetlands surrounding the Jimma town (Mekonnen and Aticho, 2011) and some coffee forests (Rodrigues and Fischer, 2018). Therefore, this study was aimed to investigate the species diversity, relative abundance and feeding guild structure in Jimma town.

1.1. Statement of the problem

Most bird species prefer to inhabit natural habitats based on their habitats' quality in terms of food accessibility, shelter, and breeding grounds to maintain their viable populations (Tessfa *et al.*, 2020). Some bird species, however, are substantially more numerous in disturbed urban environments than in natural habitats like wetlands and forest habitats. The species that are more prevalent in the disturbed area include urban species, species that nest in holes, species that nest in buildings, and corvids. Most likely as a result of the urban infrastructure, structures, and nest boxes that these birds use as resources and are more accessible in the disturbed habitat than in the forest setting (Huhta and Sulkava, 2014). Birds flock to urban areas in the winter because cities offer a reliable source of food and generally consistent weather. For instance, cities provide corvids with desirable winter habitats (Szala *et al.*, 2020).

Ethiopia is the avifauna rich country in africa. So far information on birds in Ethiopia is from national parks (Mengesha and Bekele, 2008; Girmay *et al.*, 2020) and wet lands (e.g. Aynalem and Bekele, 2008; Woldemariam *et al.*, 2018). However, little attention has given to birds dwelling in most of the urban areas of the country. Jimma town is one of the towns in Ethiopia which is characterized by both natural and human made features which are suitable for birds to inhabit. The major areas that birds inhabit in the town include sacred areas, residential areas, green areas, wet lands surrounding, waste dumping areas etc. The town may provide the birds with roosting sites, foraging sites and other ecological functions. Though Jimma town has relatively best bird attracting areas to harbor different bird species, no study has been conducted so far, there for this study aimed to close this information gap.

1.2. Research questions

1. What bird species inhabit the Jimma town?
2. Does the diversity of birds in Jimma town vary among habitat types and seasons?
3. Does the abundance of the birds vary between seasons and habitat types?
4. What is the relative abundance of bird species in Jimma town?
5. What habitats share more bird species in common in jimma town?

6. What are the feeding guilds inhabiting the Jimma town?

1.3. Objectives of the study

1.3.1. General objective

The general objective of this study was to record the species diversity and relative abundance and feeding guild structure of urban birds the case of Jimma town, Southwest Ethiopia.

1.3.2. The specific objectives of the present study were:

- To record the diversity of bird species in Jimma town.
- To assess variation of bird species diversity among habitats and seasons.
- To determine the seasonal variation in the abundance of birds.
- To assess the relative abundance of bird species in the town.
- To determine species similarity among habitat types in Jimma town.
- To describe avian feeding guild diversity in Jimma town.

1.4. Significance of the study

For certain reasons, some bird species endures and capable of performing best in human habitation areas, such as urban areas several factors are reported for why some bird species used urban areas as best Refuge either for wintering, feeding or breeding. Understanding this will help for protection of potential areas in urban ecosystem that are most used by birds. Understanding this will also help to recommend certain modification in cities and towns so as to increase areas for birds such as plantation, green areas, conserving vegetation in sacred areas, education institutions and other suitable areas inhabited by birds. Therefore, this study will fill information gaps and provide important conservation implication for the urban birds.

2. Literature review

2.1. Habitats of birds

Birds may choose different habitats based on vegetation structure and biological interactions like aggressive behavior (Borges and Carvalhaes, 2000). The availability of nesting materials and a sufficient amount of food makes the forest habitat to have the greatest diversity and relative number of birds (Tessfa *et al.*, 2020). Bird survival depends on a mosaic of forest ecosystems at various altitudes (Dendup *et al.*, 2021). Patterns of species richness, abundance, and composition of bird assemblages are influenced by differences in habitat characteristics among structural stages (Casas *et al.*, 2016). The richness and diversity of birds in habitats at lower elevations increase, while they gradually decline as one ascends to higher elevations (Dendup *et al.*, 2021). Compared to edge and matrix ecosystems, core locations had noticeably more species (Watson *et al.*, 2004).

Wetland birds use a range of habitats and rely on a mosaic of microhabitats to survive. Paddy fields with stray trees and dispersed vegetation cover provide the marsh birds with cozy refuge and good foraging grounds (Kumar and Gupta, 2009). Avian species richness is high in wetlands with intermediate vegetation coverage (Webb *et al.*, 2010). The abundance, distribution, and diversity of wetland bird species have been significantly influenced by a unique collection of microhabitat characteristics, including vegetation composition and structure, as well as climatic variables (Rajpar and Zakaria, 2011).

2.2. Impact of urbanization on bird communities

Urbanization is a global phenomenon that is posing serious risks to biodiversity through the extinction of species and biotic homogenization (Filloy *et al.*, 2019). Human activity alters the terrain, resulting in the creation of novel habitat types with novel environmental characteristics. Urbanization is having an increasing negative impact on natural ecosystems (Seress and Liker, 2015). Through the local demise of unusual bird species and the expansion of the same common urban bird species over wide geographic areas, urbanization homogenizes avian ecosystems (Slabbekoorn, 2013). Urban-dwelling birds must adapt to new circumstances. In contrast to their native habitats, birds in urban settings are exposed to increased human presence, which

frequently causes stress in the birds (Mikula, 2014). The presence of birds in cities is a sign that particular species can adapt to city life, including the growth of artificial habitats (Winarni *et al.*, 2022). Birds should adapt to the new circumstances in order to survive in their urban habitat. When a region becomes urbanized, the avifauna is drastically transformed, with many species disappearing. This causes a huge loss of local biodiversity (Isaksson, 2018). Urban tolerant species are medium-sized, generalist foragers that use cavities and canopy areas for nesting while urban avoiders are either small or very large, specialized foragers that nest on or near the ground as well as in the canopy or shrub layer (Conole and Kirkpatrick, 2011).

2.3. The Diversity of urban birds

Urban landscapes that exhibit sufficient vegetation heterogeneity, complexity and connectivity support diverse bird communities, including endemic subspecies of conservation value (Sanz and Caula, 2015). Species adapted to a wide range of environmental conditions may be better able to tolerate human-disturbed habitats. Urban birds have a much wider range of environmental tolerance than rural birds (Bonier *et al.*, 2007). Within human settlements, there are several different habitats where species with different tolerances to certain aspects of urban life can live (Tryjanowski *et al.*, 2017). Cities are important sites for many endangered species that nest in tree cavities and buildings (Jokimäki *et al.*, 2018).

The diversity of species in urban areas appears to be most dependent upon the availability of patches of natural and semi-natural habitats (Baker *et al.*, 2010). Overall, the bird communities of urban environments appear highly dependent on the type and structure of the vegetation (White *et al.*, 2005). A functional network of green spaces is important for the maintenance of the ecological dimension of a sustainable urban landscape. Sufficient amounts of natural vegetation such as large trees and a multi-layered vegetation structure are important components for maintaining high bird species diversity in urban green spaces (Sandstrom *et al.*, 2006). Bird abundance, diversity, and the survival of endemic and uncommon species all benefit greatly from the natural landscape features and diversified land use seen in green spaces. Additionally, migratory birds have habitats in the green spaces (Vallejo Jr *et al.*, 2009). Whatever the biodiversity quality of the peri urban landscape, site-specific actions such as shrub and tree

planting, water restoration and increasing vegetation diversity can change bird diversity in towns and improve the quality of human–wildlife contacts (Clergeau *et al.*, 2001).

2.4. Distribution and habitat selection of birds in urban areas

The urban landscape encompasses a broad spectrum of variable environments, ranging from abandoned sites to heavily modified urban landscapes (White *et al.*, 2005). Urban areas vary in characteristics, such as human population size and biophysical context, which can influence ecological structure and functioning within the urban area (Gagne *et al.*, 2016). Characteristics of urban structures, such as spatial configuration and distribution of building types, are some of the factors influencing the distribution pattern and abundance of bird species in urban areas (Utama and Nurvianto, 2022).

Habitat heterogeneity clearly differentiated in terms of availability of food and habitat resources and landscape features (natural or human-modified), plays a crucial role in bird species composition and population structure (Panda *et al.*, 2021). The composition and density of bird species nesting in cities are determined by building types, structure and maturity of urban greenery, and habitat diversity (Ciach and Fröhlich, 2017). Different types of habitats allow different species of birds to thrive. The presence of species in a habitat is influenced not only by external factors constituting the characteristics of the habitat, but also by intrinsic factors such as feeding habits and the ability of birds to use the resources of the environment (Hudin *et al.*, 2019).

Environmental attributes such as tree cover, tree structure and the presence of water bodies are essential to maintaining abundant and more bird communities and the functional richness throughout urban settlement matrix (Mbiba *et al.*, 2021). Urbanized habitats differ from natural habitats in several ecological characteristics, including climate, food availability, predation strength and competition (Liker *et al.*, 2008). Bird species richness and abundance have increased with less urbanization (Villegas and Garitano-Zavala, 2010). A broad environmental tolerance may predispose some birds to thrive in urban habitats (Bonier *et al.*, 2007). Variation in densities of urban-adapted native and exotic birds in suburban habitats indicate levels of adaptation that predict vulnerability to habitat change over time (Heezik and Adams, 2014).

2.5. Human-Bird interaction in urban areas

Interactions with nature can improve the well-being of city dwellers and increase their interest in biodiversity (Lopez *et al.*, 2020). The spatial distribution of biodiversity and people varies across landscapes and is critical to the provision of ecosystem services and benefits. The high density of humans and often birds in urban areas leads to frequent human-bird interactions (Cox *et al.*, 2018). Direct interactions between humans and nature are crucial in many ways, with particular attention paid to their impact on human health and well-being (Soga and Gaston, 2020). The interactions of local people with birds and the knowledge related to habitats and habits varied according to people's daily life activities and the ways of inter-generational transmission of knowledge. The interactions identified respond to several motivations. The most intense are those of utilitarian nature (three types of use are recognized: nutritional, medicinal, and ornamental (Romero-Bautista *et al.*, 2020). Open spaces, especially recreation areas, appear to be important locations for bird observations and other land uses such as water and roadways also provided opportunities for people to observe birds (Lopez *et al.*, 2020).

2.6. The community structure of urban birds

Community of bird species groups vary greatly in terms of habitat type, food availability, and residence status (Zhou *et al.*, 2012). Habitat characteristics are crucial for determining the diversity of urban bird populations and the ways that community's assembly together (Zhao *et al.*, 2023). The existence of native forest has the biggest impact on the makeup of bird communities, but site size and urbanization also has an impact on specific ecological groups. (Dale, 2017). Increases in structural complexity, species richness of woody vegetation, and supplemental feeding appear to have good effects on urban bird assemblages while human disturbance have a negative impact (Evans *et al.*, 2009). The availability of various food sources is crucial in determining the composition of bird communities (Barth *et al.*, 2015). In comparison to urban and wild land habitat, the suburban habitat has a more complex bird community structure in terms of higher species richness, higher species diversity, and higher evenness (Verma and Murmu, 2015).

Seasonal variations in species richness, diversity, and composition of species and species groups are observed in bird communities (Zhou and Chu, 2014). Compared to bird groups found in less

urbanized areas, urban bird communities experience less pronounced seasonal changes (Leveau *et al.*, 2021).

2.7. The feeding guild structure of birds

A feeding guild is a community of species that share a common food source within a habitat (Tanalgo *et al.*, 2015). The basic aspect of bird's ecological niche and dietary adaptations is its diet which plays a vital role in understanding its ecology and evolution (Ghosh *et al.*, 2022). The presence of people in urban areas may provide different bird feeders (Panda *et al.*, 2021). Urbanization alters the habitat by changing the vegetation's structure and making erratic human-made food available. Numerous bird species can adapt to these altered settings (Jagruti and Geeta, 2017). Globally, the abundance of feeding guilds like omnivorous, ground and tree nester species are sensitive to building characteristics, while some others like insectivorous and granivorous species as well as roof nesters are benefit from green space conservations (Pellissier *et al.*, 2012).

2.8. Potential threat to urban birds

Anthropogenic sources are increasingly posing serious challenges to birds, particularly in urban areas where significant ecological effects may have an impact on relationships between different species (Santiago-Alarcon and Delgado-V, 2017). Many anthropogenic causes of mortality, such as cat predation, building and vehicle collisions, power line collisions, power line electrocutions, communication tower collisions, and wind turbine collisions, directly cause the death of birds (Loss *et al.*, 2015). One of the main human-caused causes of direct avian mortality is bird crashes with structures (Nichols *et al.*, 2018). Long-distance or nocturnal travellers are substantially more likely than year-round inhabitants or diurnal migrants to die in crashes (Arnold and Zink, 2011). Despite early morning being the time when the majority of bird accidents occur, birds that migrate primarily during the day have a lower risk of being struck by buildings. This may be due to subtle behavioral or physiological variations between diurnal and nocturnal migrants (Nichols *et al.*, 2018).

Windows can enhance the chance of pet predators preying on injured birds in addition to causing the sudden death of many of the colliding birds (Rebolo-Ifrán *et al.*, 2021). Predation by cats is

the major cause of bird death in some limited populations of particular species in urban environments (Baker *et al.*, 2008). The most affected species are passerines, both granivorous and insectivorous (European Robin (*Erithacus rubecula*), Dunnock (*Prunella modularis*), Greenfinch (*Carduelis chloris*), who can frequently be found feeding on the ground or visiting feeders in the winter (Pavisse *et al.*, 2019).

Artificial lights at night also cause high mortality of seabirds, one of the most endangered groups of birds globally. Fledglings of burrow-nesting seabirds, and to a lesser extent adults, are attracted to and then grounded (i.e., forced to land) by lights when they fly at night (Rodríguez *et al.*, 2017).

2.9. Behavioral response of urban birds to urban environment

An urban bird's capacity to withstand a wide range of environmental conditions, including disturbed habitat, may be influenced by behavioral, physiological, and ecological adaptability. The ability of a bird to adapt behavior in reaction to unfamiliar circumstances, to fend off the physiological repercussions of breeding in an urban setting, or to make use of novel resources like food or nesting locations are just a few examples of this flexibility (Bonier *et al.*, 2007). Birds' basic life-sustaining behaviors, such as breeding, foraging, and flight, can be influenced by human proximity. Birds' vigilance and evasion behavior are more intense when human density rises in urban parks, which are significant natural shelters for birds due to the wide variations in human activity over time (Prestes *et al.*, 2018).

When a human is approaching, the flight distance of urban and rural bird populations differs, with urban individuals having much shorter flight distances. There is a long history of adaptation of species with relatively short flight distances in urban populations. Additionally, bird species with very short flight distances have relatively large populations in urban areas, indicating that these species have benefited from urbanization (Moller, 2008). Birds modify their flight distance to the speed restriction, which may lessen the likelihood of collisions and fatality while increasing the amount of time spent foraging (Legagneux and Ducatez, 2013).

The primary urban elements known to interfere with the timing and structure of avian singing activity are noise and light pollution (Marin-Gomez and Macgregor-Fors, 2021). Ultimately,

birds on territories with high levels of anthropogenic noise have more challenges in defending their territory and fewer possibilities for mating (Luther *et al.*, 2016)

3. Materials and Methods

3.1. Descriptions of Study Area

Jimma is the largest city in southwestern Ethiopia (Lollo, 2016). The town is located in Oromia National Regional State 352 km Southwest of Addis Ababa, the capital city of Ethiopia (Dires *et al.*, 2016). Its geographical coordinates are about 7°41' N latitudes and 36°50' E longitudes (Sorsa *et al.*, 2020). The altitude of the city ranges from 1700 to 1277 m above sea level .Two Rivers, Awetu and Kito, cross the town (figure 1). Awetu crosses the center of the town, and Kito flows along the western end (Haddis *et al.*, 2014). The daily mean temperature of the town ranges from 20°C to 25°C year-round and the average annual rainfall is 1500mm (Girma *et al.*, 2021). Maximum precipitation and heavy rain occurs during the three months period, June to August, with minimum rainfall in December and January, making practically Jimma to be recognized by two major seasons as dry season December-May and rainy or wet season June-November (Mekonnen *et al.*, 2019).

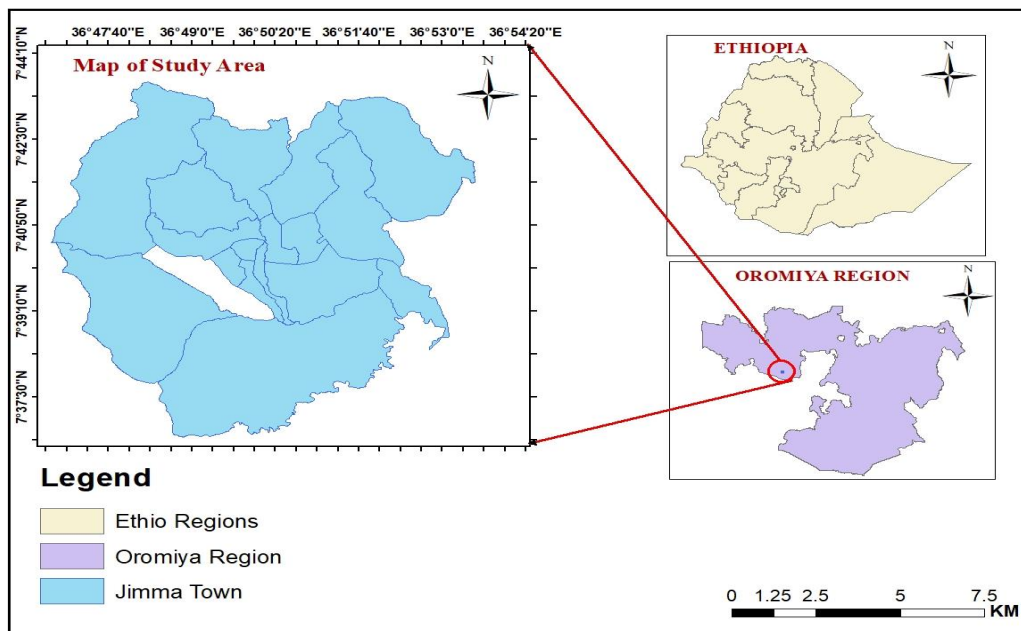


Figure.1. Map of the study area

3.2. Preliminary study

Preliminary study was conducted for the first two weeks in the month of February 2023 prior to data collection.

3.3. Research design

The study area was classified in to three habitat types: building site, vegetation patches and waste dumping site based on preliminary surveys and Google earth imaginary image. Within a Google earth 35 vegetation patches which have (total areas, 274 hectare) whose area ranges from 0.38 hectare to 110 hectare was identified. A total of 13 vegetation patches with an area of (126 ha) were randomly selected from the total vegetation patches for survey. The building site was covered about 4248 hectares and divided into 43 blocks of different size. Of these blocks, 21 were randomly selected for this study. The whole waste dumping site was purposively selected for survey due to the area was small (5 ha only) and was a potential site for birds in the town. Point counts of 50m radius were set in each of habitat types (Issa, 2019). A total of about 129 point count stations were surveyed in the study area. The number of sampling points within each vegetation patches and block were proportional to size of sampling site (Alemu *et al.*, 2020).

3.4. Method of Data Collection

The data collection was conducted from March 2023 to August 2023 involving both dry (March and April) and wet (July and August) seasons.

3.4.1. Point count method

Point count method was used to collect data because point count methods are the efficient method and used to collect data in areas where there is no route or difficult places. Point counts are appropriate in urban areas due to build up structures (Heezik and Seddon, 2012). Point counts were set in each habitat types for surveying. The minimum distance of 150m to 250m were maintained between each point count stations using Global Positioning System to avoid double counting of the same individual species of birds (Bibby *et al.*, 1998). Observation on birds was taken twice a day (in the early morning from 06:00 to 09:30 am and late in the afternoon from 16 :30 to 18:30 pm for a total of six hours in a day following (Areaya *etal.*, 2013). Observation during heavy rainfall and foggy days were avoided because of lack of visibility (Chettri *et al.*, 2005).

To minimize disturbance during count, a waiting period of 3 to 5 minutes prior to counting was applied (Girmay *et al.*, 2020). The bird species were recorded in a radius of 50 m for period of 10 min (Issa, 2019). The point counts stations surveyed in the morning at first day were surveyed in after noon on next day and reversely.

Bird identifications and counting of individuals was conducted by direct observations with naked eyes or using binoculars (figure 2). The observed species was differentiated by their external morphologies like wing, leg, tail, beak, color etc. The observed birds were identified on site using birds field guide book (Redman *et al.*, 2016). The species were identified and recorded on the data sheet prepared for that purpose (Girmay *et al.*, 2020).



Figure2. Observation of birds by binocular



Figure3. Birds observed in building site



Figure 4. Birds observed in vegetation patches



Figure 5. Waste dumping site birds

3.4.2. Guild identification based on their diet

The feeding guild of birds was assigned to their dietary type based on information from literatures as (Karjee *et al.*, 2022; Shafe *et al.*, 2022). Therefore, the identified species was classified based on diet types such as; insectivores, frugi-nectare, granivores, scavengers and omnivore) following (Wilman *et al.*, 2014).

3.5. Data computation and Analysis

The species diversity of birds was determined by the formula $H' = - \sum p_i * \ln p_i$, Where H' is Shannon–Wiener index, p_i is estimated as n_i/N , where n_i is the proportion of the total population of the i th species and N is the total number of individuals which is $N = \sum n_i$ (Shannon & Weaver, 1949)

The evenness index (J') was calculated by the following equation. $J' = \frac{H'}{\ln S}$

Where: H = Shannon Weiner diversity index and S = Number of species

Richness index (D) was calculated by the following equation

$$D = \frac{s - 1}{\ln N}$$

Where: D = Richness index, S = Total number of species and N = Total number of individuals
Ln=natural logarithm following (Kiros *et al.*, 2018).

Abundance data was summarized per habitat types. The relative abundance of the bird species was determined by using the expression:

$$\text{Relative abundance (\%)} = \frac{n}{N} \times 100$$

Where, n is the numbers of individuals of particular species that was recorded and N is the total number of individuals of all species recorded (Girma *et al.*, 2016). The relative abundance and species diversity index was computed in Excel version 2010 based on formatted formulas above following (Abie *et al.*, 2019).

Chi-square test was used to determine the variations of abundance of birds with seasons following (Desalegn *et al.*, 2021). The variation of species diversity with habitat types and seasons was also determined by chi-square test. The statistical analysis was performed by using the spss version 20 software.

3.5.1. Community similarity and feeding guild analysis

Generalized linear model was used to determine the interaction of habitat type and season with the feeding guilds of birds. The proportion of every guild from each habitat was calculated as: number of species of the i guild in habitat j relative to the total number of species in habitat j $\times 100$ following (Panda *et al.*, 2021). Sorensen's coefficient was used to determine the community similarity among habitats by using the following formula. The formula depends on the number of habitat such as $CC=2C/ (A+B)$, $CC=3D/ (A+B+C)$, so on. $CC= 2C/ (A+B)$ Where; CC= Sorensen's coefficient, A= number of species that occur in site A. B= number of species that occur in site B. C= number of species that occur in both site A and B following (Genet and Ejigu, 2017)

4. Result

4.1. Taxonomic distribution of bird taxa

A total of 3259 individuals that belongs to 99 bird species representing 40 families were recorded from Jimma town in different habitats during both seasons survey period (Table 1). During the dry season Accipitridae was represented by highest number of species (13) species followed by Columbidae which had 10 species while sixteen families were represented by single species appendix (I). Columbidae was represented by the highest number of species (six species) during wet season survey whereas eighteen families were represented by single species Appendix (I).

The highest number of individuals was observed in building sites during both dry season (1137) and wet season (598), while the least was recorded in waste dumping site (304) followed by vegetation patches with (324) individuals during wet season survey (Table 1).

Table1. Number of individuals in habitats per survey season

Habitat types	Season	Number of individuals	Relative abundance (%)
Building sites	Dry	1137	34.8
	Wet	598	18.4
Vegetation patches	Dry	568	17.4
	Wet	324	9.9
Waste dumping site	Dry	328	10.1
	Wet	304	9.3

4.2. Species diversity and evenness

During the dry season survey, a total of 61 bird species were observed in building areas, while 63 species were observed in vegetation patches. On the other hand, during the wet season survey, 35 species and 41 species were observed in building sites and vegetation patches, respectively. Whereas, 6 species were recorded in dry season and 5 species in wet season at waste dumping site (Table 2). The highest species diversity was recorded in the vegetation patches ($H'=3.77$) followed by building sites ($H'=3.45$) during dry season while slightly low species diversity was

recorded in wet season $H'=2.97$ and $H'=3.36$ in building sites and vegetation patches respectively, meanwhile the least species diversity was recorded in waste dumping site in both dry and wet season $H'=1.68$ and $H'=1.59$ in dry season and wet season respectively (Table 2). During the whole study period the highest species diversity was recorded in vegetation patches followed by building sites while waste dumping site become least species diverse habitat in the study area. The species diversity was high in each habitat type in dry season as compared to that of wet season in the area. The pattern of species richness was similar with respect to species diversity in habitat types per survey season (Table 2). The species recorded in waste dumping site were distributed evenly in both seasons with an index of $J'=0.94$ and $J'=0.99$ in dry and wet seasons respectively whereas that of vegetation patches was $J=0.91$ in dry season and $J=0.93$ in wet season indicating that the habitat was slightly even distributed as compared to waste dumping site. In both dry and wet season the least evenness index was recorded in building site as compared to waste dumping site and vegetation patches with an index of $J=0.83$ and $J=0.88$ in dry and wet season respectively indicating that the species in that habitat was less evenly distributed as compared to other habitats in the area (Table 2). In general species were distributed evenly in wet season than dry season in all habitat types in the area (Table 2).

Table 2. The species diversity, evenness and species richness in habitat types per survey season.

Habitat type	Season	No. Species	Diversity(H')	Evenness(J)	Richness index (D)
Building site	Dry	61	3.45	0.84	8.67
	Wet	35	2.97	0.88	5.32
Vegetation patch	Dry	63	3.77	0.91	9.78
	Wet	41	3.36	0.93	6.92
Waste dumping sites	Dry	6	1.68	0.94	0.86
	Wet	5	1.59	0.99	0.70

The variation of species diversity among habitat types and between seasons was determined by chi-square test. The species diversity did not have significant difference with seasons ($\chi^2=2.000$, $p>0.05$, $df=1$) and habitat types ($\chi^2=6.000$, $p>0.05$, $df=4$) in the study area.

4.3. The abundance of birds

In dry season, Swanson's sparrow (*Passer griseus*) was the most abundant species in building areas than other species with 96 individuals whereas brown snake eagle (*Circaetus cinereus*), dark chanting goshawk (*Melierax metabates*), fork-tailed drongo (*Dicrus adsimilis*), fan tailed widowbird (*Euplectes axillaris*), marabou stork (*Leptoptilos crumenifer*), northern puffback (*Dryoscopus gambensis*) and pied crow (*Corvus albus*) were the least abundant species in building areas all represented by one individual (table 3). Hadada ibis (*Bostrychia hagedash*) was outnumbered all other species in case of number of individuals during the dry season in vegetation patch with 38 individuals while lesser spotted eagle (*Aquila clanga*) and wood land king fisher (*Halcyon senegalensis*) had the least species abundance in the same habitat, one individual each (table 3).

During the wet season, speckled pigeon (*Columba guinea*) was the abundant species in building site with 60 individual whereas little weaver (*Ploceus luteolus*), mountain thrush (*Turdus(Olivaceus) abyssinicus*) and yellow billed kite (*Milvus (Migrans) aegyptius*) were the least abundant species in building sites with one individual each (table 3). Grey backed camaroptera (*Camaroptera brachyuran*) was the most abundant species from recorded species in vegetation patch with 29 individuals while Ethiopian bou bou (*Laniarius aethiopicus*) was the least abundant species recorded in vegetation patch with only one individual in wet season (table 3).

In waste dumping sites white backed vulture becomes the abundant species with 77 individuals and 75 individuals in dry and wet season respectively. On the other hand yellow billed kite was the least abundant species with 12 individuals in dry season while marabou stork was the least abundant species with 43 individuals in wet season (table 3).

The abundance of birds did not show any significant ($\chi^2=6.00$, $p>0.05$, $df, 4$) difference with habitat types and ($\chi^2=2.00$, $p>0.05$, $df, 1$) season in the study area.

Table 3. Summary of the abundance of birds

Season	Habitat type	Species name	Abundance
Dry	Building site	Swansons sparrow	96
		Brown snake eagle	1
		Dark chanting goshawk	1
		Fork- tailed drongo	1
		Fan tailed widowbird	1
		Marabou stork	1
		Northern puffback	1
		Pied crow	1
	Vegetation patches	Hadada ibis	38
		Lesser spotted eagle	1
		Woodland king fisher	1
	Waste dumping site	White backed vulture	77
		Yellow billed kite	12
Wet	Building site	Speckled pigeon	60
		Little weaver	1
		Mountain thrush	1
		Yellow billed kite	1
	Vegetation patches	Grey backed camaroptera	29
		Ethiopian bou bou	1
	Waste dumping site	White backed vulture	75
	Marabou stork	43	

4.4. The relative abundance of birds

During dry season Swanson’s sparrow (*Passer griseus*) was the species with the highest relative abundance (8.4%) in building site whereas Hadada ibis (*Bostrychia hagedash*) was relatively the abundant species (6.69%) in vegetation patches. In waste dumping site habitat white backed vulture (*Gyps africanus*) was the dominant species in case of relative abundance (24.48%) in dry season (Table 4). In contrast nine species had the lowest relative abundance (0.09%) in building site whereas two species with relative abundances of (0.18%) were the species with the least relative abundance record in in vegetation patches meanwhile Yellow billed kite (*Milvus (migrans)aegyptius*) had the least relative abundance (3.66%) in waste dumping site in dry season (Table 4).

On the other hand during wet season study period speckled pigeon (*Columba guinea*) was the species with the highest relative abundance (10.03%) whereas three species were recorded with the lowest relative abundance (0.17%) in building site. In vegetation patches Grey Backed Camaroptera (*Ermomela canescens*) had the highest relative abundance (8.95%) while Ethiopian Bou Bou (*Laniarius aethiopicus*) had the least relative abundance (0.31%) in wet season survey period. White backed vulture (*Gyps africanus*) was the species with the highest relative abundance (24.67%) meanwhile Marobou Stork (*Leptoptilos crumenifer*) with the least relative abundance record (14.14%) in waste dumping site (Table 4).

Table 4. Summary of species having the highest and lowest relative abundance in habitat types per survey season

Species	Season	Habitat type	Relative abundance (%)	Rank
Swanson’s sparrow	Dry	Building	8.4	
Hadada ibis	Dry	Vegetation patches	6.69	High
White backed vulture	Dry	Waste dumping site	24.48	
Dark Chanting Goshawk	Dry			
Fork-Tailed Drongo				
Fan Tailed Widowbird				
Marobou Stork		Building site	0.09	
Northern Puffback				

Pied Crow				Low
Brown snake eagle				
Short toed snake eagle				
Wattled ibis				
Lesser Spotted Eagle	Dry	Vegetation patches	0.18	
Wood land king fisher				
Yellow billed kite	Dry	Waste dumping site	3.66	
speckled pigeon	Wet	Building	10.03	
Grey Backed Camaroptera	Wet	Vegetation patches	8.95	High
White backed vulture	Wet	Waste dumping site	24.67	
Little Weaver	Wet	Building site		
Mountain Thrush			0.17	
Yellow billed kite				
Ethiopian Bou Bou	Wet	Vegetation patches	0.31	Low
Marabou stork	Wet	Waste dumping site	14.14	

The relative abundance was also determined at family level in each habitat type per seasons. In dry season study period ciconiidae and dicruridae in building sites and apodidae and motacillidae in vegetation patches were the families with the least relative abundance while columbidae become the highest relative abundance in building site and vegetation patches. Threskiornithidae had the least relative abundance record whereas Accipitridae had the highest in waste dumping site (Table 5).

During wet season columbidae was the family having the highest relative abundance while Lybiidae and Platysteiridae families with the least in building sites. Malaconotidae and ciconidae had the highest relative abundance record in vegetation patches and waste dumping respectively while cisticolidae and accipitridae were the families with the least relative abundances in vegetation patches and waste dumping sites respectively (Table 5).

Table 5. Families with minimum and maximum relative abundances in each habitat types

Season	Habitat types	Families	Number of species	Number of individuals	Relative abundance (%)
		Ciconiidae	1	1	0.09

Dry	Building	Dicrurida	1	1	0.09	
		Columbidae	9	161	14.16	
		Apodidae	1	3	0.53	
	Vegetation	Motacillidae	1	3	0.53	
		Columbidae	4	52	9.15	
		Threskiornithidae	1	35	10.67	
Wet	Waste dump	Accipitridae	3	159	48.48	
		Lybiidae	1	2	0.33	
		Platysteiridae	1	2	0.33	
	Building	Columbidae	5	125	20.90	
		Vegetation	Malaconotidae	1	1	0.31
			Cisticolidae	1	29	8.95
Waste dump	Ciconidae	1	43	14.14		
	Accipitridae	2	139	45.72		

4.5. The community similarity of birds

The similarity index showed that the highest community similarity of bird species was recorded between building sites and vegetation patches in both seasons, furthermore the community similarity between vegetation patches and building sites were more similar in wet season than dry season (Table 6). The least community similarity was recorded between vegetation patches and waste dumping site in both seasons. The community was more dissimilar between waste dumping site and vegetation patches in wet season as compared to dry season (Table 6).

Table 6. Sorensen's similarity index among habitat types within seasons

Habitats	Similarity index in dry season	Similarity index in wet season
Building site verses vegetation patch	0.483	0.63
Building site verses waste dumping site	0.25	0.33

4.6. The diversity of bird feeding guilds

During the study period, five feeding guilds were identified in the area, such as insectivores, omnivores, granivores, frugi-nectarivores, and scavengers (table 7). In terms of species number, insectivores were the dominant feeding guild, with 43 species in vegetation patches, 28 species in building sites and one species record in waste dumping site. Omnivores come second, with 25 species in vegetation patches, 20 species in building sites and 3 species in waste dumping site. Granivores had 21 species in building sites, 15 species in vegetation patches and had no species record in waste dumping site habitat. Scavenger had 18 species in building sites, 8 species in vegetation patches and 7 species in waste dumping site. Lastly, frugi-nectarivores had 12 species in vegetation patches, 9 species in building sites and there was no species record of this guild in waste dumping site (table 7).

The study recorded the highest proportional percentages of scavenger (63.63%) in waste dumping site followed by insectivores (41.35%, 29.16%) in vegetation patches and building sites respectively and omnivores with (27.27%, 24%) in waste dumping site and vegetation patches respectively. Meanwhile, the least proportional percentages were recorded for granivore and frugi-nectare (0%) in waste dumping sites followed by scavengers (7.69%) in vegetation patches and frugi-nectarivores (9.37%) in building sites (Table 7).

Table 7. The percentage proportion of feeding guilds in each habitat types

Habitat type	Feeding guilds	Number of species	Proportional percentage
Building site	Insectivores	28	29.16
	Frugi-nectarivores	9	9.37
	Granivores	21	21.87
	Omnivores	20	20.83
	Scavengers	18	18.75
Vegetation patches	Insectivores	43	41.35
	Frugi-nectarivores	12	11.54
	Granivores	16	15.38
	Omnivores	25	24
	Scavengers	8	7.69

Waste dumping site	Insectivores	1	9.09
	Omnivores	3	27.27
	Scavengers	7	63.63

The bird guilds showed variable responses to habitat types and seasons (Table 8). Except for scavengers in waste dumping site the abundance of all feeding guilds was significantly interacted with habitat types (all, $p < 0.05$). The abundance of insectivore and omnivore showed significant ($p < 0.05$) interaction with dry season whereas frugi-nectare, granivore and scavenger did not show any significant (all, $p > 0.05$) interaction with dry season (Table 8). The interaction of wet season with the abundance of feeding guilds was set as redundant by model.

Table 8. Generalized linear model results whereby the abundances of the bird guilds were included in the models as response variable and habitat types and seasons as an interaction estimates.

Parameter	Estimate	Std. Error	95% Wald Confidence Interval		p-value
			Lower	Upper	
Intercept	4.042	.0671	3.911	4.173	.000
[diet type=frugi-nectare] * [habitat type=building]	-.948	.1158	-1.175	-.721	.000
[diet type=frugi-nectare] * [habitat type=vegetation patches]	-1.832	.1284	-2.084	-1.580	.000
[diet type=granivore] * [habitat type=building]	-.904	.0951	-1.090	-.717	.000
[diet type=granivore] * [habitat type=vegetation patches]	-1.777	.1132	-1.998	-1.555	.000

[diet type=insectivore] * [habitat type=building]	-1.445	.1050	-1.651	-1.239	.000
[diet type=insectivore] * [habitat type=vegetation patches]	-1.917	.0997	-2.112	-1.721	.000
[diet type=insectivore] * [habitat type=waste dumping]	-.318	.1998	-.709	.074	.112
[diet type=omnivore] * [habitat type=building]	-1.318	.0938	-1.502	-1.134	.000
[diet type=omnivore] * [habitat type=vegetation patches]	-2.188	.1080	-2.400	-1.977	.000
[diet type=omnivore] * [habitat type=waste dumping]	-.070	.1041	-.274	.134	.500
[diet type=scavenger] * [habitat type=building]	-1.285	.0774	-1.436	-1.133	.000
[diet type=scavenger] * [habitat type=vegetation patches]	-1.804	.1257	-2.050	-1.558	.000
[diet type=frugi- nectare] * [season=dry]	.146	.1107	-.071	.363	.188
[diet type=granivore] * [season=dry]	.097	.0796	-.059	.253	.223
[diet type=insectivore] * [season=dry]	-.169	.0827	-.331	-.007	.041
[diet type=omnivore] * [season=dry]	.433	.0733	.289	.576	.000
[diet type=scavenger] * [season=dry]	.045	.0778	-.108	.197	.566

5. Discussion

Vegetation patches exhibit high species diversity than building sites and waste dumping sites, with the highest diversity in the dry season and the least diversity in the wet season in all of the habitat types. This might be because of the expansion of buildings at higher rate in the town and due to the fact that different bird species have their own tolerance capacity to the changing environment and their own habitat choices, the species diversity of birds in the area may be high in vegetation patches than building and waste dumping sites. Therefore, due to changing environment in an area most of the birds use the nearby vegetation patches as refuge but still the building site is habitat for some of the birds which had the capacity to tolerate the site.

A similar finding reported by Rashid *et al.* (2020) stated that the diversity of bird species show negative association with building area and a positive correlation with vegetation cover. In comparison to the Greenway and Periphery, the City Center and Residential zones have generally lower bird species richness (Sandstrom *et al.*, 2006). Because highly urbanized cities are made up of a dense network of buildings and impervious surfaces, certain bird species that are less tolerant to urban environments may find sanctuary in urban green spaces (Wong *et al.*, 2023).

The least species diversity of birds was recorded in waste dumping sites and this may be due to the habitat was near to road and the disturbance from the vehicles may influence some of the species in the area. As reported by Tesfahunegny and Assefa (2023) the diversity of birds in waste dumping areas near to road was small due to disturbance as compared to other dumping sites. Additionally, due to the area was available by food preferred by scavenger species and more over due to the habitat was near to abattoir which attracts scavengers and in nature the scavenger species are competitive and have an ability to attack the other species, the diversity might be small. This was encouraged by Alemu *et al.* (2020) findings who reported that due to there is more food available, predator populations can increase in urban waste disposal sites which can have a great influence on small bird populations confirming the existence of other species but not in higher number. In my personal view sometimes there was an attack on birds by dogs around the waste dumping site. Therefore, this may cause a sense of fear on some bird species that inhabit the area.

The species diversity of birds did not show significant variations with habitat types probably this might be because of suitability of habitat and availability of food in the area. This finding agree with Rija *et al.* (2014) who reported that the diversity did not show significance variations among habitats that have similar vegetation structures. Habitats that have similar resources to support birds cause this to happen (Mulwa *et al.*, 2012). This study contradicts with Sulemana *et al.* (2022) investigations who reported that the species diversity of birds was significantly varied among habitat types.

Seasonal variation in bird species diversity was not significant possibly due to the absence of seasonal migrations and availability of food resources in the area agree with the findings of (Awash and Tekalign, 2023). These variations might be due to the availability of resources, habitat suitability and migratory behavior of birds (Mengesha and Bekele, 2008). On the other hand the present study contradicts the findings of Panda *et al.* (2021) according to their findings the species diversity was significantly different with seasons due to the presence of migratory species and the creation of appropriate habitat conditions for the resident species.

The abundance of birds did not showed significant variations with habitat types this might be because the availability of food, habitat preference, nesting sites. Similar with Derebe *et al.* (2023) who reported that the abundance of birds could not show variations due to availability of a range of food items, water, and cover in the area. This finding contradicts with the findings of (Desalegn and Negussie, 2022) who reported that variations in abundance among habitats is related with habitat structures and feeding habits. (Gibru and Biru, 2022) reported that nesting places and food availability are the main factors influencing the variation in bird species abundance across habitats.

The abundance of birds did not show significant variations with season similar with (Esayas and Bekele, 2011). Presumably due to the constant availability of resource, no competition and absence of seasonal migrations in the area. In contrast some findings revealed that the abundance of birds was varied between seasons (Asmare *et al.*, 2023). Seasonal variations in rain fall and food availability are the causes of seasonal fluctuations in the abundance of bird species (Gibru and Mengesha, 2021).

The highest bird species similarity was recorded in wet season than dry season in two pairs vegetation patches vs building sites and building sites vs waste dumping site. This may be due to the habitats share some habitat structures and food resources similar with (Tessfa *et al.*, 2020). Shiferaw and Yazezew, (2021) reported that habitats that are close to each other has high species similarity. According to Desalegn and Negussie (2022) the presence of similar plant species shared between habitat types that serve as a habitat for bird species that attracted to it would cause high species similarity among habitats. The highest community dissimilarity was observed among vegetation patches and waste dumping sites in wet season than dry season. This may be due to the habitat type share less food resources and their habitat structure is different.

Depending on their environment, which is determined by several elements like food supply, vegetation cover, predator availability, and other considerations, each guild has a varied tolerance capacity and resource requirement (Katuwal *et al.*, 2016).

The species richness of insectivore was high in vegetation patches than building sites in urban areas. Probably this may be due to most insects attracted to plants to feed on their flowers, commonly insectivore birds species may also be highly attracted to wards the vegetation areas. The present study agrees with the previous findings reported by Beskardes (2020); Ordóñez-Delgado *et al.* (2022); Lim and Sodhi (2004) who revealed that insectivorous bird species shows positive association towards the vegetation patches around the urban areas. Since insectivorous birds are more sensitive to disturbance and often reluctant to go through densely populated regions, there is a positive correlation between their richness and patch connectivity (Martensen *et al.*, 2008).

As compared to building site and vegetation patches habitats waste dumping site harbor the least species of insectivore bird species. Perhaps due to the competition from scavengers and overcrowding of their species in the site for the availability of the resource of choice, the insectivore and also other guild groups may not inhabit the site as the other habitat types.

Granivore bird species are frequently observed in building sites than vegetation patches and waste dumping site. Possibly this could be because of the availability of preferred food resources especially around mill areas and market places where grains are sold. The present study corresponds with the investigations of Cristaldi *et al.* (2017) reported that granivore bird species

was numerous in urban areas because of the presence of plentiful food in cities. According to Peacock *et al.* (2007), some birds have the capacity to adapt to urban environments due to the availability of a range of food items and nesting/roosting places provided by buildings and human resources. Granivorous species appear to be more adapted to urban settings (Lim and Sodhi, 2004). As reported by Ordóñez-Delgado *et al.*, (2022) in contrast to insectivorous birds, granivorous birds exhibited a positive reaction in relation to the urbanization gradient. Granivore species are not recorded in waste dumping site probably because of habitat preference and absence of available food of choice.

The number of species of frugi-nectare guild was high in vegetation patches as compared with that of building sites and waste dumping site in the town may be because of they feed on flowers and pollens of plants in the town. A significant rise in the functional richness of frugivores-nectarvores is correlated with increases in shrub cover (Melo and Piratelli, 2023). Frugivores and Nectarivores are associated with fruit and nectar feeding which in turn had a great role in seed dispersal and pollination respectively (Sekercioğlu, 2006). There are several different kinds of nectarivores that pollinate flowers: opportunistic, or generalist (Kiepiel *et al.*, 2022). Frugi-nectare bird species are also not recorded in waste dumping site possibly due to competition, habitat and food preference factors.

The species diversity of omnivore trophic feeding guild was huge in vegetation patches than building sites and waste dumping sites. Presumably this may be because of more available food of interest in vegetation patches. As reported by Morelli *et al.* (2023) the amount of greenery in urban areas led to a rise in omnivorous bird species. On the contrary some studies were inconsistent with this result, as reported by Suarez-Rubio *et al.* (2023) commonly omnivore birds are positively interacted with urban areas.

The species richness of scavenger was high in building sites than vegetation patches and waste dumping sites probably may be due to the habitat was wide and rich with the preferred food like human lefts and other carcasses materials in the area than vegetation patches. In waste dumping site their species might be low as compared with that of building sites due to the site was small in area and lead to hot competition. The removal of carcasses from the environment by scavenging species contributes significantly to ecosystem services and improves human hygiene (Inger *et al.*, 2016; García-Jiménez *et al.*, 2022).

6. Conclusion and Recommendations

6.1. Conclusion

In both dry and wet seasons the diversity of birds in the town was highest in vegetation patches than building sites and waste dumping site, Demonstrating that small fragments or remnant patches serve as a refuge for bird species that inhabit urban areas. Even if the patches in the town cover small area they harbor high bird species diversity. Therefore, increasing the green areas and protecting the remnant trees in towns could highly increase the species diversity of birds in towns. Moreover increasing the vegetation patches in towns will have also great role in attracting and increasing the species diversity of most feeding guilds like insectivore, frugi-nectare and omnivore. The town having diversified trophic feeding guilds would get more ecological advantage than those who had the lowest guild diversity. Waste dumping site exhibit low species diversity due to external factor like vehicle disturbance and attacking from pets and other intrinsic factors like competition. Building sites exhibit intermediate diversity as compared to other habitats due to the site share some similar resources and habitat structures with the remaining habitats. The site also shares more similar bird species with the remaining habitats because of these reasons. Therefore, the species similarity across habitat types depends on the similarity of habitat structures and resources that the habitats share in common. Several factors like resource availability, migrations, and food and habitat preferences determine the abundance of birds across the habitat types and survey seasons.

6.2. Recommendations

The current government gives a great attention to expanding tourism attracting sites in different parts of the country; the town will be one of the best bird watching sites if conservation focus will be given to it properly. The finding revealed that vegetation patches in town serve as refuge for several bird species even if they cover small area. Urban planners should give attention to increasing tree plantations along road ways and green spaces and conserving remnant trees in the town. The study also revealed that size of the habitat and human actions cause reduction of species diversity. Therefore urban planners and concerned bodies should provide conservation strategies through which the sites could be conserved and protected from being affected by urban expansion. The habitat that has high species diversity could have also high guild diversities. Therefore, providing the way of increasing species diversity will have also play a great role in rising feeding guild diversities.

Further studies should be conducted in the area especially on;

1. The relations of bird's community with plant species in the towns so as to increase the plantation of plant species that attract more bird species, with the density of buildings, with size of population in different parts of the town and even with the effects of vehicles and number of pedestrians.
2. The detail study should also be conducted on the feeding guilds in case of weather they are adapted to change their diet from previous to other due to changing of the natural habitats.

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Appendix: I

The number of species of families per seasons

Number of species		
Name of families	dry season	Wet season
Accipitridae	13	5
Alcedinidae	2	2
Apodidae	1	0
Ardeidae	2	1
Bucerotidae	2	1
Ciconiidae	2	3
Cisticolidae	4	0
Coliidae	1	1
Columbidae	10	6
Corvidae	5	4
Cuculidae	1	0
Dicruridae	1	0
Estrildidae	5	3
Falconidae	1	0
Fringillidae	0	1
Hirundinidae	2	2
Indicatoridae	2	1
Laniidae	3	0
Lybiidae	1	1
Malaconotidae	3	1
Meropidae	2	1
Monarchidae	1	1
Motacillidae	2	1
Muscicapidae	5	4
Nectariniidae	3	2
Oriolidae	2	1
Passeridae	1	1
Phoeniculidae	1	1
Picidae	1	1
Platysteiridae	2	1
Ploceidae	5	4
Psittacidae	1	1
Pycnonotidae	1	1
Scopidae	1	1

Sturinidae	1	0
Sylviidae	1	0
Threskiornithidae	4	2
Turdidae	2	2
Viduidae	1	0
Zosteropidae	3	3

Appendix II: the species abundance in each habitat types per survey season

Species		dry season				wet season			
Commonname	Scientific name	Guild typ.	Build	Vegeta.	Waste	build	vegeta	Waste	
Abyssinian Oriole	<i>Oriolus monacha</i>	Omnivore	0	12	0	0	8	0	
Abyssinian Slaty Fly Catcher	<i>Melaenornis chocolatinus</i>	Insectivore	7	6	0	11	0	0	
Abyssinian Wax Bill	<i>Estrilda ochrogaster</i>	Granivore	6	0	0	0	0	0	
Abyssinian White Eye	<i>Zosterops abyssinicus</i>	Insectivore	42	8	0	0	10	0	
African Citiril	<i>Serinus citrinelloides</i>	Granivore	0	0	0	0	5	0	
African Dusky Fly Catcher	<i>Muscicapa adusta</i>	Insectivore	13	2	0	0	4	0	
African Grey Fly Catcher	<i>Bradornis microrhynchus</i>	Insectivore	17	0	0	0	0	0	
African Grey Hornbill	<i>Tockus nasutus</i>	Insectivore	0	2	0	0	0	0	
African Paradise Fly Catcher	<i>Terpsiphone viridis</i>	Insectivore	35	31	0	23	17	0	
African Pgy my King Fisher	<i>Ceyx pictus</i>	Insectivore	0	3	0	0	0	0	
African Thrush	<i>Turdus pelios</i>	Omnivore	10	6	0	0	13	0	
Baglafaecht Weaver	<i>Ploceus</i>	Insectivore	8	3	0	0	4	0	

		<i>baglafaecht</i>						
Barn Swallow	<i>Hirundo rustica</i>	Insectivore	0	9	0	0	5	0
Black And White Mannikin	<i>Spermestes bicolor</i>	Granivore	0	8	0	0	0	0
Black Billed Wood Dove	<i>Turtur abyssinicus</i>	Granivore	0	9	0	0	0	0
Black Billed Wood Hoopoe	<i>Phoeniculus somaliensis</i>	Insectivore	0	4	0	0	3	0
Black Crowned Tchagra	<i>Tchagra senegalus</i>	Insectivore	2	0	0	0	0	0
Black Headed Batis	<i>Batis erlangeri</i>	Insectivore	6	5	0	2	3	0
Black Headed Heron	<i>Ardea melanocephala</i>	Scavenger	0	3	0	0	0	0
Black Headed Oriole	<i>Oriolus larvatus</i>	Omnivore	0	3	0	0	0	0
Black Kite	<i>Milvus migrans</i>	Scavenger	46	0	0	0	0	0
Black Winged Love Bird	<i>Agapornis taranta</i>	Omnivore	0	3	0	0	10	0
Blue -Breasted Bee-Eater	<i>Merops (variegatus) Lafresnayii</i>	Insectivore	0	3	0	0	0	0
Blue Headed Coucal	<i>Centropus monachus</i>	Scavenger	0	5	0	0	0	0
Bronze Manikin	<i>Spermestes cucullata</i>	Granivore	0	25	0	0	23	0
Brown Snake Eagle	<i>Circaetus cinereus</i>	Scavenger	1	0	0	0	0	0
Brown-Throated Wattle-Eye	<i>Platysterira cyanea</i>	Insectivore	4	0	0	0	0	0
Bruce's Green Pigeon	<i>Treron waalia</i>	Frugi-Nectare	7	4	0	0	0	0

Cape Crow	<i>Corvus capensis</i>	Omnivore	5	0	0	0	0	0
Cardinal Wood Pecker	<i>Dendropicos fuscescens</i>	Insectivore	0	5	0	0	3	0
Common Bul Bul	<i>Pycnonotus barbatus</i>	Frugi-Nectare	64	16	0	39	13	0
Common Buzzard	<i>Buteo buteo</i>	Scavenger	4	0	0	0	0	0
Common Fiscal	<i>Lanius collaris</i>	Insectivore	2	0	0	0	0	0
Croaking Cisticola	<i>Cisticola natalensis</i>	Insectivore	0	5	0	0	0	0
Dark Caped Yellow Warbler	<i>Chloropeta natalensis</i>	Insectivore	0	5	0	0	0	0
Dark Chanting Goshawk	<i>Melierax metabates</i>	Scavenger	1	0	0	0	0	0
Double Toothed Barbet	<i>Lybius bidentatus</i>	Omnivore	0	7	0	0	2	0
Ethiopian Bou Bou	<i>Laniarius aethiopicus</i>	Omnivore	0	5	0	5	1	0
Fan Tailed Raven	<i>Corvus rhipidurus</i>	Omnivore	21	7	0	45	3	0
Fork-Tailed Drongo	<i>Dicrus adsimilis</i>	Insectivore	1	0	0	0	0	0
Fan Tailed Widowbird	<i>Euplectes axillaris</i>	Granivore	1	0	0	0	0	0
Greater Blue-Eared Starling	<i>Lamprotornis chalybaeus</i>	Omnivore	0	5	0	0	0	0
Greater Honey Guide	<i>Indicator indicator</i>	Frugi-Nectare	0	5	0	0	9	0
Green Backed Eremomela	<i>Ermomela canescens</i>	Insectivore	0	4	0	0	0	0
Grey Backed Camaroptera	<i>Camaroptera brachyura</i>	Insectivore	25	27	0	30	29	0

Grey Headed King Fisher	<i>Halcyon leucocephala</i>	Insectivore	0	0	0	0	3	0
Grey Kestrel	<i>Falco ardosiaceus</i>	Scavenger	2	0	0	0	0	0
Hadada Ibis	<i>Bostrychia hagedash</i>	Insectivore	91	38	0	52	5	0
Hooded Vulture	<i>Necrosyrtes monachus</i>	Scavenger	44	5	70	6	0	64
Hamer Kop	<i>Scopus umbretta</i>	Scavenger	7	0	0	6	0	0
Laughing Dove	<i>Spilopelia senegalensis</i>	Granivore	6	0	0	2	0	0
Lesser Spotted Eagle	<i>Aquila clanga</i>	Scavenger	4	1	0	0	0	0
Little Bee Eater	<i>Merops pusillus</i>	Insectivore	0	8	0	0	12	0
Little Egret	<i>Egretta garzetta</i>	Insectivore	0	12	0	0	4	0
Little Weaver	<i>Ploceus luteolus</i>	Omnivore	15	0	0	1	0	0
Marobou Stork	<i>Leptoptilos crumenifer</i>	Scavenger	1	0	68	0	0	43
Montane White Eye	<i>Zosterops poliogastrus</i>	Frugi-Nectare	0	10	0	6	7	0
Mountain Thrush	<i>Turdus(olivaceus) abyssinicus</i>	Omnivore	55	16	0	0	2	0
Namaqua Dove	<i>Oena capensis</i>	Granivore	4	0	0	0	3	0
Northern Black Fly Catcher	<i>Melaenornis edolioides</i>	Insectivore	0	3	0	0	3	0
Northern Puffback	<i>Dryoscopus gambensis</i>	Insectivore	1	0	0	0	0	0
Nyanza Swift	<i>Apus niansae</i>	Insectivore	0	3	0	0	0	0
Pied Crow	<i>Corvus albus</i>	Scavenger	1	0	0	0	0	0

Red Backed Shrike	<i>Lanius collurio</i>	Insectivore	0	7	0	0	0	0
Red Billed Fire Finch	<i>Lagonosticta senegala</i>	Granivore	50	6	0	0	3	0
Red Cheeked Cardon Blue	<i>Uraeginthus bengalus</i>	Granivore	9	4	0	10	0	0
Red Collared Widow Bird	<i>Euplectes ardens</i>	Omnivore	0	0	0	2	0	0
Red Eyed Dove	<i>Streptopelia semitorquata</i>	Granivore	23	2	0	23	8	0
Ring Nacked Dove	<i>Streptopelia capicola</i>	Granivore	18	37	0	33	5	0
Rock Pigeon	<i>Columba livia</i>	Granivore	5	0	0	7	0	0
Rock Martin	<i>Ptyonoprogne fuligula</i>	Insectivore	3	0	0	0	0	0
Ruppell's Robin Chat	<i>Cossypha semirufa</i>	Insectivore	43	25	0	25	21	0
Sacred Ibis	<i>Threskiornis aethiopicus</i>	Insectivore	7	0	35	0	0	61
Scarlet Chested Sun Bird	<i>Chalcomitra senegalensis</i>	Omnivore	21	26	0	23	4	0
Short toed snake eagle	<i>Circaetus gallicus</i>	Scavenger	1	0	0	0	0	0
Silvery cheeked horn bill	<i>Bycanistes brevis</i>	Frugi-Nectare	29	15	0	14	18	0
Speckled mouse bird	<i>Colius striatus</i>	Frugi-Nectare	33	6	0	22	12	0
Speckled pigeon	<i>Columba guinea</i>	Granivore	89	0	0	60	0	0
Spectacle weaver	<i>Ploceus ocularis</i>	Insectivore	0	6	0	0	0	0
Swainsons sparrow	<i>Passer griseus</i>	Granivore	96	15	0	45	6	0
Tacazze sun bird	<i>Nectarinia tacazze</i>	Omnivore	0	4	0	0	0	0

Tawny eagle	<i>Aquila rapax</i>	Scavenger	0	2	0	0	0	0
Tawny flanked prinia	<i>Prinia subflava</i>	Insectivore	4	0	0	0	0	0
Thick billed raven	<i>Corvus crassirostris</i>	Omnivore	17	16	66	9	8	61
Variable sun bird	<i>Cinnyris venustus</i>	Omnivore	12	2	0	0	12	0
Village indigobird	<i>Vidua chalybeate</i>	Granivore	0	4	0	0	0	0
Village weaver	<i>Ploceus cucullatus</i>	Omnivore	77	20	0	24	13	0
Vinaceous dove	<i>Streptopelia vinacea</i>	Granivore	4	0	0	0	0	0
Wahlberg's honey bird	<i>Prodotiscus regulus</i>	Insectivore	0	3	0	0	0	0
Wattled ibis	<i>Bostrychia carunculata</i>	Insectivore	1	0	0	0	0	0
White backed vulture	<i>Gyps africanus</i>	Scavenger	0	0	77	7	0	75
White collared pigeon	<i>Columba albitorques</i>	Granivore	5	0	0	0	0	0
White-crested helmet shrike	<i>Eurocephalus rueppelli</i>	Insectivore	0	4	0	0	0	0
White wag tail	<i>Motacilla alba</i>	Insectivore	3	3	0	0	4	0
Wire tailed swallow	<i>Hirundo smithii</i>	Insectivore	0	0	0	3	0	0
Wood land king fisher	<i>Halcyon senegalensis</i>	Insectivore	3	1	0	0	3	0
Yellow billed kite	<i>Milvus (migrans)aegypt</i>	Scavenger	18	19	12	1	0	0
Yellow wagtail	<i>Motacilla flava</i>	Insectivore	5	0	0	0	0	0
Yellow white eye	<i>Mosterops senegalensis</i>	Frugi-Nectare	2	0	0	0	3	0

Appendix III: Dry season species relative abundance per habitat type

Species Commonname	dry season					
	Building	RA(%)	Vegetation patch	RA(%)	Waste dumping site	RA(%)
Abyssinian Oriole	0	0	12	2.11	0	0.00
Abyssinian Slaty Fly Catcher	7	0.62	6	1.06	0	0.00
Abyssinian Wax Bill	6	0.53	0	0.00	0	0.00
Abyssinian White Eye	42	3.69	8	1.41	0	0.00
African Citril	0	0	0	0.00	0	0.00
African Dusky Fly Catcher	13	1.14	2	0.35	0	0.00
African Grey Fly Catcher	17	1.50	0	0.00	0	0.00
African Grey Hornbill	0	0	2	0.35	0	0.00
African Paradise Fly Catcher	35	3.08	31	5.46	0	0.00
African Pgymy King Fisher	0	0.00	3	0.53	0	0.00
African Thrush	10	0.88	6	1.06	0	0.00
Baglafaecht Weaver	8	0.70	3	0.53	0	0.00
Barn Swallow	0	0	9	1.58	0	0.00
Black And White Mannkin	0	0	8	1.41	0	0.00
Black Billed Wood Dove	0	0	9	1.58	0	0.00
Black Billed Wood Hoopoe	0	0	4	0.70	0	0.00
Black Crownned Tchagra	2	0.18	0	0.00	0	0.00
Black Headed Batis	6	0.53	5	0.88	0	0.00
Black Headed Heron	0	0	3	0.53	0	0.00
Black Headed Oriole	0	0	3	0.53	0	0.00
Black Kite	46	4.05	0	0.00	0	0.00
Black Winged Love Bird	0	0.00	3	0.53	0	0.00
Blue -Breasted Bee-Eater	0	0.00	3	0.53	0	0.00
Blue Headed Coucal	0	0.00	5	0.88	0	0.00
Bronze Manikin	0	0.00	25	4.40	0	0.00
Brown Snake Eagle	1	0.09	0	0.00	0	0.00
Brown-Throated Wattle-Eye	4	0.35	0	0.00	0	0.00
Bruce's Green Pigeon	7	0.62	4	0.70	0	0.00
Cape Crow	5	0.44	0	0.00	0	0.00
Cardinal Wood Pecker	0	0.00	5	0.88	0	0.00
Common Bul Bul	64	5.63	16	2.82	0	0.00
Common Buzzard	4	0.35	0	0.00	0	0.00
Common Fiscal	2	0.18	0	0.00	0	0.00

Croaking Cisticola	0	0	5	0.88	0	0.00
Dark Caped Yellow Warbler	0	0	5	0.88	0	0.00
Dark Chanting Goshawk	1	0.09	0	0.00	0	0.00
Double Toothed Barbet	0	0.00	7	1.23	0	0.00
Ethiopian Bou Bou	0	0.00	5	0.88	0	0.00
Fan Tailed Raven	21	1.85	7	1.23	0	0.00
Fork-Tailed Drongo	1	0.09	0	0.00	0	0.00
Fan Tailed Widowbird	1	0.09	0	0.00	0	0.00
Greater Blue-Eared Starling	0	0.00	5	0.88	0	0.00
Greater Honey Guide	0	0.00	5	0.88	0	0.00
Green Backed Eremomela	0	0.00	4	0.70	0	0.00
Grey Backed Camaroptera	25	2.20	27	4.75	0	0.00
Grey Headed King Fisher	0	0.00	0	0.00	0	0.00
Grey Kestrel	2	0.18	0	0.00	0	0.00
Hadada Ibis	91	8.00	38	6.69	0	0.00
Hooded Vulture	44	3.87	5	0.88	70	21.34
Hamer Kop	7	0.62	0	0.00	0	0.00
Laughing Dove	6	0.53	0	0.00	0	0.00
Lesser Spotted Eagle	4	0.35	1	0.18	0	0.00
Little Bee Eater	0	0.00	8	1.41	0	0.00
Little Egret	0	0.00	12	2.11	0	0.00
Little Weaver	15	1.32	0	0.00	0	0.00
Marobou Stork	1	0.09	0	0.00	68	20.73
Montane White Eye	0	0.00	10	1.76	0	0.00
Mountain Thrush	55	4.84	16	2.82	0	0.00
Namaqua Dove	4	0.35	0	0.00	0	0.00
Northern Black Fly Catcher	0	0.00	3	0.53	0	0.00
Northern Puffback	1	0.09	0	0.00	0	0.00
Nyanza Swift	0	0.00	3	0.53	0	0.00
Pied Crow	1	0.09	0	0.00	0	0.00
Red Backed Shrike	0	0.00	7	1.23	0	0.00
Red Billed Fire Finch	50	4.40	6	1.06	0	0.00
Red Cheeked Cardon Blue	9	0.79	4	0.70	0	0.00
Red Collared Widow Bird	0	0.00	0	0.00	0	0.00
Red Eyed Dove	23	2.02	2	0.35	0	0.00
Ring Naked Dove	18	1.58	37	6.51	0	0.00
Rock Pigeon	5	0.44	0	0.00	0	0.00
Rock Martin	3	0.26	0	0.00	0	0.00
Ruppell's Robin Chat	43	3.78	25	4.40	0	0.00

Sacred Ibis	7	0.62	0	0.00	35	10.67
Scarlet Chested Sun Bird	21	1.85	26	4.58	0	0.00
Short toed snake eagle	1	0.09	0	0.00	0	0.00
Silvery cheeched horn bill	29	2.55	15	2.64	0	0.00
Speckled mouse bird	33	2.90	6	1.06	0	0.00
Speckled pigeon	89	7.83	0	0.00	0	0.00
Spectacle weaver	0	0.00	6	1.06	0	0.00
Swainsons sparrow	96	8.44	15	2.64	0	0.00
Tacazze sun bird	0	0.00	4	0.70	0	0.00
Tawny eagle	0	0.00	2	0.35	0	0.00
Tawny flanked prinia	4	0.35	0	0.00	0	0.00
Thick billed raven	17	1.50	16	2.82	66	20.12
Variable sun bird	12	1.06	2	0.35	0	0.00
Village indigobird	0	0.00	4	0.70	0	0.00
Village weaver	77	6.77	20	3.52	0	0.00
Vinaceous dove	4	0.35	0	0.00	0	0.00
Wahlberg's honey bird	0	0.00	3	0.53	0	0.00
Wattled ibis	1	0.09	0	0.00	0	0.00
White backed vulture	0	0.00	0	0.00	77	23.48
White collored pigeon	5	0.44	0	0.00	0	0.00
White-crested helmet shrike	0	0.00	4	0.70	0	0.00
White wag tail	3	0.26	3	0.53	0	0.00
Wire tailed swallow	0	0.00	0	0.00	0	0.00
Wood land king fisher	3	0.26	1	0.18	0	0.00
Yellow billed kite	18	1.58	19	3.35	12	3.66
Yellow wagtail	5	0.44	0	0.00	0	0.00
Yellow white eye	2	0.18	0	0.00	0	0.00

Appendix IV: wet season species relative abundance per habitat type

Species Commonname	wet season					
	Building	RA(%)	Vegetation patch	RA(%)	Waste dump	RA(%)
Abyssinian Oriole	0	0.00	8	2.47	1	0.33
Abyssinian Slaty Fly Catcher	11	1.84	0	0.00	0	0.00
Abyssinian Wax Bill	0	0.00	0	0.00	0	0.00
Abyssinian White Eye	6	1.00	10	3.09	0	0.00
African Citril	0	0.00	5	1.54	0	0.00
African Dusky Fly Catcher	0	0.00	4	1.23	0	0.00
African Grey Fly Catcher	0	0.00	0	0.00	0	0.00
African Grey Hornbill	0	0.00	0	0.00	0	0.00
African Paradise Fly Catcher	23	3.85	17	5.25	0	0.00
African Pgy my King Fisher	0	0.00	0	0.00	0	0.00
African Thrush	17	2.84	13	4.01	0	0.00
Baglafaecht Weaver	0	0.00	4	1.23	0	0.00
Barn Swallow	0	0.00	5	1.54	0	0.00
Black And White Mannkin	0	0.00	0	0.00	0	0.00
Black Billed Wood Dove	0	0.00	0	0.00	0	0.00
Black Billed Wood Hoopoe	0	0.00	3	0.93	0	0.00
Black Crownned Tchagra	0	0.00	0	0.00	0	0.00
Black Headed Batis	2	0.33	3	0.93	0	0.00
Black Headed Heron	0	0.00	0	0.00	0	0.00
Black Headed Oriole	0	0.00	0	0.00	0	0.00
Black Kite	0	0.00	0	0.00	0	0.00
Black Winged Love Bird	0	0.00	10	3.09	0	0.00
Blue -Breasted Bee-Eater	0	0.00	0	0.00	0	0.00
Blue Headed Coucal	0	0.00	0	0.00	0	0.00
Bronze Manikin	0	0.00	23	7.10	0	0.00
Brown Snake Eagle	0	0.00	0	0.00	0	0.00
Brown-Throated Wattle-Eye	0	0.00	0	0.00	0	0.00
Bruce's Green Pigeon	0	0.00	0	0.00	0	0.00
Cape Crow	0	0.00	0	0.00	0	0.00
Cardinal Wood Pecker	0	0.00	3	0.93	0	0.00
Common Bul Bul	39	6.52	13	4.01	0	0.00
Common Buzzard	0	0.00	0	0.00	0	0.00
Common Fiscal	0	0.00	0	0.00	0	0.00
Croaking Cisticola	0	0.00	0	0.00	0	0.00

Dark Caped Yellow Warbler	0	0.00	0	0.00	0	0.00
Dark Chanting Goshawk	0	0.00	0	0.00	0	0.00
Double Toothed Barbet	2	0.33	2	0.62	0	0.00
Ethiopian Bou Bou	5	0.84	1	0.31	0	0.00
Fan Tailed Raven	45	7.53	3	0.93	0	0.00
Fork-Tailed Drongo	0	0.00	0	0.00	0	0.00
Fan Tailed Widowbird	0	0.00	0	0.00	0	0.00
Greater Blue-Eared Starling	0	0.00	0	0.00	0	0.00
Greater Honey Guide	0	0.00	9	2.78	0	0.00
Green Backed Eremomela	0	0.00	0	0.00	0	0.00
Grey Backed Camaroptera	30	5.02	29	8.95	0	0.00
Grey Headed King Fisher	0	0.00	3	0.93	0	0.00
Grey Kestrel	0	0.00	0	0.00	0	0.00
Hadada Ibis	52	8.70	5	1.54	0	0.00
Hooded Vulture	6	1.00	0	0.00	64	21.05
Hamer Kop	6	1.00	0	0.00	0	0.00
Laughing Dove	2	0.33	0	0.00	0	0.00
Lesser Spotted Eagle	0	0.00	0	0.00	0	0.00
Little Bee Eater	0	0.00	12	3.70	0	0.00
Little Egret	0	0.00	4	1.23	0	0.00
Little Weaver	1	0.17	0	0.00	0	0.00
Maroubou Stork	0	0.00	0	0.00	43	14.14
Montane White Eye	6	1.00	7	2.16	0	0.00
Mountain Thrush	1	0.17	2	0.62	0	0.00
Namaqua Dove	0	0.00	3	0.93	0	0.00
Northern Black Fly Catcher	0	0.00	3	0.93	0	0.00
Northern Puffback	0	0.00	0	0.00	0	0.00
Nyanza Swift	0	0.00	0	0.00	0	0.00
Pied Crow	0	0.00	0	0.00	0	0.00
Red Backed Shrike	0	0.00	0	0.00	0	0.00
Red Billed Fire Finch	19	3.18	3	0.93	0	0.00
Red Checked Cardon Blue	10	1.67	0	0.00	0	0.00
Red Collared Widow Bird	2	0.33	0	0.00	0	0.00
Red Eyed Dove	23	3.85	8	2.47	0	0.00
Ring Naked Dove	33	5.52	5	1.54	0	0.00
Rock Pigeon	7	1.17	0	0.00	0	0.00
Rock Martin	0	0.00	0	0.00	0	0.00
Ruppell's Robin Chat	25	4.18	21	6.48	0	0.00
Sacred Ibis	0	0.00	0	0.00	61	20.07

Scarlet Chested Sun Bird	23	3.85	4	1.23	0	0.00
Short toed snake eagle	0	0.00	0	0.00	0	0.00
Silvery cheeched horn bill	14	2.34	18	5.56	0	0.00
Speckled mouse bird	22	3.68	12	3.70	0	0.00
Speckled pigeon	60	10.03	0	0.00	0	0.00
Spectacle weaver	0	0.00	0	0.00	0	0.00
Swainsons sparrow	45	7.53	6	1.85	0	0.00
Tacazze sun bird	0	0.00	0	0.00	0	0.00
Tawny eagle	0	0.00	0	0.00	0	0.00
Tawny flanked prinia	0	0.00	0	0.00	0	0.00
Thick billed raven	9	1.51	8	2.47	61	20.07
Variable sun bird	17	2.84	12	3.70	0	0.00
Village indigobird	0	0.00	0	0.00	0	0.00
Village weaver	24	4.01	13	4.01	0	0.00
Vinaceous dove	0	0.00	0	0.00	0	0.00
Wahlberg's honey bird	0	0.00	0	0.00	0	0.00
Wattled ibis	0	0.00	0	0.00	0	0.00
White backed vulture	7	1.17	0	0.00	75	24.67
White colloed pigeon	0	0.00	0	0.00	0	0.00
White-crested helmet shrike	0	0.00	0	0.00	0	0.00
White wag tail	0	0.00	4	1.23	0	0.00
Wire tailed swallow	3	0.50	0	0.00	0	0.00
Wood land king fisher	0	0.00	3	0.93	0	0.00
Yellow billed kite	1	0.17	0	0.00	0	0.00
Yellow wagtail	0	0.00	0	0.00	0	0.00
Yellow white eye	0	0.00	3	0.93	0	0.00

Appendix V: The relative abundance of families in each habitat type per survey season

Families	Dry season			Wet season		
	Building site	Vegetation patches	Waste dumping	Building site	Vegetation patches	Waste dumping
Accipitridae	10.47	4.75	48.48	-	-	45.72
Alcedinidae	0.26	0.70	-	-	-	-
Apodidae	-	0.53	-	-	-	-
Ardeidae	-	2.64	-	-	-	-
Bucerotidae	2.55	2.99	-	-	5.56	-
Ciconiidae	0.09	-	20.73	-	-	14.14
Cisticolidae	2.55	6.34	-	-	8.95	-
Coliidae	2.90	1.06	-	-	3.70	-
Columbidae	14.16	9.15	-	-	4.94	-
Corvidae	3.87	4.05	20.12	-	3.40	40.13
Cuculidae	-	0.88	-	-	-	-
Dicruridae	0.09	-	-	-	-	-
Estrildidae	5.72	7.57	-	-	8.02	-
Falconidae	0.18	-	-	-	-	-
Fringillidae	-	-	-	-	1.54	-
Hirundinidae	0.26	1.58	-	-	1.54	-
Indicatoridae	-	1.41	-	-	2.78	-
Laniidae	0.18	1.94	-	-	-	-

Lybiidae	-	1.23	-	-	0.62	-
Malaconotidae	0.26	0.88	-	-	0.31	-
Meropidae	-	1.94	-	-	3.70	-
Monarchidae	3.08	5.46	-	-	5.25	-
Motacillidae	0.70	0.53	-	-	1.23	-
Muscicapidae	7.04	6.34	-	-	8.64	-
Nectariniidae	2.90	5.63	-	-	4.94	-
Oriolidae	2.64	-	-	-	2.47	-
Passeridae	8.44	2.64	-	-	1.85	-
Phoeniculidae	0.70	-	-	-	0.93	-
Picidae	0.88	-	-	-	0.93	-
Platysteiridae	0.88	0.88	-	-	0.93	-
Ploceidae	8.88	5.11	-	-	5.25	-
Psittacidae	0.53	-	-	-	3.09	-
Pycnonotidae	5.63	2.83	-	6.52	4.01	-
Scopidae	0.62	1.00	-	-	-	-
Sturinidae	-	0.88	-	-	-	-
Sylviidae	-	0.88	-	-	-	-
Threskiornithidae	8.71	6.69	10.67	8.70	1.54	
Turdidae	5.72	3.87	-	3.01	4.63	-
Viduidae	-	0.70	-	-	-	-
Zosteropidae	3.87	3.17	-	2.01	6.17	-
