

Jimma University



College of Natural Science School of Graduate Studies

Department of Biology

M.Sc. program in Ecology and Systematic Zoology

Influence of habitat types on the diversity and relative abundance of Belete forest bird guilds in shebe-sombo district South-west Oromia, Ethiopia

By: Merga Busha

Advisor: Tadese Habtamu (PhD)

Co-Advisor : Tsegaye Gadisa(PhD)

A thesis submitted to department of biology, college of natural sciences, Jimma university for the partial fulfillment of M.Sc. degree in Biology (Ecology and Systematic Zoology).

June, 2024

Jimma, Ethiopia.

Acknowledgments

I would like to express my deepest appreciation and special thanks to my advisor who supported me research material Dr. Tadese Habtamu and co-advisors Dr. Tsegaye Gadisa for their skillful guidance, understanding in broadening my professional perspective, and provision of unlimited personal support for making this thesis a real throughout this work and also I would like to grate thanks for economical and psychological encouraged me my wife Meseret Amenu, douter Nardos & soon Nato. Secondly this research was funded by the united of Oromia with Jimma University for research purposes. So I would like to thank Jimma University. Also, I would like to thank the Shebe Sombo District Forest Administration and Wildlife Protection Office, and the farmers of the area for allowing me to enter their coffee farm during conduct this research respectively.

Table of contents

Contents

Acknowledgments.....	I
Table of contents.....	II
List of figures.....	IV
List of tables.....	V
Abbreviations and acronyms.....	VI
Abstract.....	VII
1. Introduction.....	1
1.1 Background of the study.....	1
1.2 Statement of the problem.....	4
1. 3. Objectives of the study.....	4
1.3.1. General objective.....	4
1.3.2. Specific objectives.....	4
1.4 Significance of the study.....	5
2. Literature Review.....	6
2.1. Bird diversity and abundance.....	6
2.2. Avian diversity in agricultural landscape.....	6
2.3. Forest as a habitat for bird.....	7
2. 4 . Impacts of forest loss on avian.....	7
2. 5. Bird species in shade coffee.....	8
2. 6 Threats to birds.....	9
2. 6.1. Deforestation.....	9
2.6.2. Forest fragmentation.....	10
2.6.3. Forest degradation.....	10
2.7 Guild structure in forest bird communities.....	11
3. Materials and methods.....	12
3.1. Description of the Study area.....	12
3.3. The study design.....	14
3.4. Data collection.....	15

3.5. Data computation and analysis	15
4. Results.....	17
4.1. Species composition and relative abundance.....	17
4.2. The Species diversity and evenness among three habitats and study seasons of Belete forest.	18
4.3, Relative abundance of birds in wet and dry seasons.....	19
4.4.Species similarity in different habitats and seasons.....	22
4.5. Influence of habitat type on bird species richness, diversity and relative abundance of forest dependent guilds.	23
4.6. Influence of habitat type on the diversity and relative abundance of avian feeding guilds..	25
4.7. Influence of habitat type on bird species richness	28
5. Discussion	29
6. Conclusion	34
7. Recommendation	35
References	36
Appendixes	43
Appendix. 1.....	43
Appendix 2.....	48
Appendix 2 .1.....	48
Appendixes 3	49

List of figures

Figure 1: Map of the study area.....	14
Figure 2: species accumulation rates for birds at Belete forest Shebe sombo district: January 2022 - February 2023.....	23
Figure 3: Influence of vegetation cover type on the abundance of different avian forest-dependent guilds.	25
Figure 4: Influence of vegetation cover type on the abundance ,diversity and richness of avian feeding guild.	35

List of tables

Table 1. Habitat classification and allocation of plots based on area coverage.....	14
Table 2) Bird orders, families , number of species, composition and relative abundance recorded among the three habitat types and seasons at Belete forests of shebe sombo South West Oromia, Ethiopia.....	17
Table 3 Bird species, diversity, richness and evenness during the wet and dry season.....	19
Table 4. Number of bird species, relative abundance and individual birds among habitats and seasons categories.	20
Table 5: The overall bird species similarity index(SI) within habitats during the wet and dry seasons at the study station.	22
Table 6. Similarity index of bird species among habitats during the wet and dry seasons.	22
Table 7: Influence of habitat type on forest dependent guilds of bird species richness , relative abundance and diversity.....	23
Table: 8.Tukey’s HSD test significant results for richness and abundance of avian forest dependent guilds.	24
Table 9: Number of species, relative abundance and diversity of avian feeding guilds in each habitat types.	26
Table 10: Tukey’s HSD test significant results for abundance of avian feeding guilds.....	27
Table 11: Tukey’s HSD test for bird species richness.....	28

Abbreviations and acronyms

- ANOVA= analysis of variance
- asl.= Above sea level
- FAO=food association organization
- HSD=Honestly Significant Difference(Tukey's)
- IBAS = important bird area
- IUCN=international union for conservation of nature
- SPSS= Statistical package for social science
- SNNP= southern nation nationalities and people
- WaBuB= 'Waldaa Bulchiinsa Bosonaa' in afaan Oromo, "Forest Management Association."

Abstract.

Birds are important bio-indicators and provide various ecosystem services including pollination, seed dispersal, and pest control. However, habitat deterioration, fragmentation, and loss pose a threat to them. This study was conducted to assess the influence of habitat types on the diversity and relative abundance of forest birds in the Belete Forest, South West Ethiopia. The research was conducted between January 2023 to August 2023. Based on the vegetation type the study area was classified in to three habitat types (shade coffee, natural forest, and farmland). Line transects and point count methods were used to collect data . Shannon-Weiner indices were used to estimate the avian guilds diversity during both seasons and habitats. One-way ANOVA was performed to determine influence of land cover type on bird avian relative abundance by comparing means of bird between the groups and within the groups across the three land use types. A total of 1361 individual birds distributed in 103 species belonging to 16 orders and 40 families were recorded across all point counts during wet and dry seasons. The greatest relative abundance of bird in shade coffee with (RA= 79.66%) during wet and the lowest in farmland(RA=21.3%) dry sessions was recorded. The results also indicated the highest diversity and evenness of birds in shade coffee with ($H' = 3.651$, $E = 0.597$) while, lower in farmland ($H' = 2.676$, $E = 0.461$) was recorded in both seasons. Between wet and dry highest ($SI = 0.58$) of overall bird species was recorded in shade coffee while, less similarity index with ($SI = 0.48$) were at farmland. In the wet season, there was the greatest relative abundance of bird populations ($SI = 0.92$) between the habitats of shade coffee and natural forests, and the lowest ($SI = 0.16$) between farmland and natural forests during the dry season. Compared in the guild level, the significant difference between natural forest and farmland, shade coffee had higher bird abundance and species richness of carnivores, nectarivores and frugivores whereas insectivores was higher in natural forest ($p < 0.05$) respectively. The abundance and species richness of forest specialists ($p = 0.028$) were higher in natural forest than in other habitats, whereas forest forest generalists ($p = 0.03$) and visitors ($p = 0.022$) status were high in shade coffee than other habitats. However, omnivores in the three habitats and granivores in the natural and shade coffee did not differ substantially ($p > 0.05$). The findings investigated the highest overall bird relative abundance and diversity was recorded in shade coffee during study period. This is because, large and widely spaced shade trees can provide excellent feeding opportunities for many groups of birds especially if the trees were indigenes. Conserving native trees in coffee and occasionally in farmland in the forms of shade, can conserve all groups of birds and even conserving multiple biodiversity. At the same time farmers around Belete forest should be encouraged to plant indigenous tree species in the farms to attract ecological services provided by birds (e.g. pest control, pollination and seed dispersal) additionally, raise national and individual coffee incomes.

Keywords: Diversity, Forest bird, Guild, Habitat types, Relative abundance, Species richness

1. Introduction

1.1 Background of the study

Tropical rainforests worldwide are declining at an alarming rate due to anthropogenic impact (Myers, 2003). About 10,000 living bird species on earth (Gill and Donsker, 2010), one in eight is threatened with global extinction; (Bird Life International 2010; Lees *et al.*, 2022). Areas of particular concern for bird extinction are European farmland such as; grassland birds in North America; Nearctic-Neotropical migrants between South and North America; Palearctic-African migrants between Europe and Africa; waterfowl in Asia; raptors in Africa; and forest, grassland and wetland species in Australia (Bird Life International 2010; Attwood *et al.*, 2009; Olsen 2008). Although habitat change in the tropics is a major concern, these regions have experienced the highest rates of forest loss, fragmentation, and degradation (FAO, 2010; Adhikari *et al.*, 2019). The expansion of agriculture and animal husbandry in East Africa transformed the land from natural vegetation into extensive agricultural ecosystems. Considering habitat loss due to human pressure and that only a small portion of East African territory is protected as conservation areas (Tolima *et al.*, 2020), this change in forests should continue to increase demand (Norton Griffiths & Said, 2010). The biological diversity of the region should be protected and integrated into the agricultural area (Smith *et al.*, 2015).

Ethiopia is one of the Avian-rich countries in Africa, with more than 926 bird species (Forest, 2016). Of the 926 bird species, 24 are endemic to Ethiopia (EBI, 2015; Tesfahunegny, 2016). It is important to understand anthropogenic impacts on the occurrence of avian functional groups because they determine ecosystem functioning (Mulwa *et al.*, 2012). Shaded coffee plantations are important for bird conservation. For example, Neoafrican-Neotropics migratory birds are often as numerous in shady coffee plantations as they are in natural forest habitats (Colorado, 2011). As an extension of horticulture, sustainable agriculture has been proposed as a way to ensure that private land maintains biodiversity and protected areas while providing economic support to people (Hernandez *et al.*, 2013). For example, coffee plantations managed under a floristically and structurally diverse tree canopy have been shown to provide important habitat for diverse

bird communities (Hernandez *et al.*, 2013). Therefore, small coffee agroforestry can host flocks of birds similar to those around the forest. Hence, the maintenance of a heterogeneous landscape with a high-quality matrix within an agro-ecological region enhances bird conservation (Leyequién, De Boer, and Toledo, 2010). Promoting organic coffee cultivation practices that maintain a structurally diverse overstore retains avian species richness and abundance in coffee plantations (Arendt *et al.*, 2020). The ability of coffee agroforestry systems to support migratory endemic, and some near-threatened or vulnerable species than farmlands (Myers, 2018). Birds have greater survivability, fitness, or productivity in coffee plantations compared with other available habitats (natural or artificial), or any species selects coffee plantations over other available habitats for foraging or breeding (Tabur, 2015, and Komar, 2006), and can provide habitat for many tropical birds as well as migratory species (Bakermans *et al.*, 2012). Coffee plantations have higher avian species diversity and abundance than other highly disturbed agricultural habitats and some natural habitats (Tabur, 2015) because; large and widely spaced shade trees can provide excellent feeding opportunities for frugivores, carnivores, and omnivores especially if the trees are native species list (Johnson *et al.*, 2011).

Agricultural expansion during the past 200 years and intensification in the last 50 have been key drivers in global habitat loss and in declines of about 60% of the birds listed on the IUCN red list (Johnson *et al.*, 2011) and also differ significantly in both overall community composition and some aspects of guild composition compared to all forested habitats (Dawson *et al.*, 2011). Regarding functions conserving indigenous plant in the forms of shade can conserve forest understory groups of birds and also potentially benefit the farmers by consuming insects, allowing farmers to avoid the costs and hazards of pesticides (African and Buechley, 2015). The high abundance of granivores in farmlands could be attributed to increasing food or seed resources associated with farmlands (Ndang'ang'a *et al.*, 2013). Forests in Ethiopia are vulnerable to degradation in various places due to agriculture, grazing and other factors (Getu Alemayehu, 2017). Yet, there is a need of information on the suitability of human-modified habitats in sustaining biodiversity. This information is important for understanding the roles and impacts of human-modified landscapes, which serve the dual purpose of conserving biodiversity and supporting the livelihoods of local communities (Watson *et al.*, 2019). Among Ethiopian forests, Belete forest is the part of Belete-gera national forest priority area and one of the Ethiopian important bird and biodiversity areas (IBAS) (Matthias De Beenhouwer and Jan

Martens, 2015). This forest is also considered as commercially important and in Ethiopia (WaBuB, 2006).

According to Komar *et al.*, (2006), Coffee plantations have higher avian species diversity and abundance than other highly disturbed agricultural habitats and some natural habitats because; large and widely spaced shade trees can provide excellent feeding opportunities for frugivores, carnivores, and omnivores, especially if the trees are native species list. There was a greater relative abundance of forest specialists and understory insectivores in the forest, demonstrating that little-disturbed forest is critical for sustaining these at-risk groups of birds and Ethiopian shade coffee is perhaps the most “bird-friendly” coffee in the world (Buechley *et al.*, 2015).

Similar findings of Matthias de Beenhouwer and Jan Martens (2015) the Belete forest also due to fragmentation, has led to the decline of many forest bird species from habitat similar findings of Simultaneously birds and Belete forests is facing enormous pressure from anthropogenic activities which have led to substantial loss of forest cover leading to landscapes dominated by farmlands, grassland and coffee without consideration of other biodiversity. This less of understanding land formation issue of the study area rides to a decrease of bird species and loss of biodiversity of Belete forest. It also as the demand for agricultural land use increased, it was useful to create awareness of which type of agriculture to use to create favorable conditions for birds and which affects bird diversity and relative abundance of functional group so that they can use it themselves. The importance of this study is that the previous bird habitat was converted to agricultural and coffee lands, this activity cause bird relative abundance and diversity among habitats. Therefore, to conserve birds, it is necessary to create awareness of how these human modified habitats are suitable for all bird species and which habitats influenced the bird species. Specifically, this finding fills the gap, to determining the influence of habitat type (shade coffee, farmland, and natural forest) on the diversity and relative abundance of forest bird and feeding guilds of Belete forest South-Western Ethiopia and to develop effective conservation strategies. This information is important as a scientific basis for managing human-modified land-cover types for the purpose of retention and persistence of forest biodiversity.

1.2 Statement of the problem

Although some studies have been conducted on different aspects of biodiversity have been conducted at south west Ethiopia (Buechley *et al.*, 2015), little is known of the impacts of human-induced changes on habitat types and cover on Belete forest birds. The problem of study area; Not farther more research done on the influences of habitat types on the diversity & relative abundance of Belete forest bird in Shebe sombo district south western Ethiopia, Although, it was not understand, the disrupted habitat increased the diversity of forest dependent and feeding guilds bird among the Belete Forest's habitat types. The Shebe district's marginal natural (indigenous) of Belete forest bird habitat is disappearing as a result of human interference and is not protected. This understanding land formation issue of the study area rides to a decrease of bird species and loss of biodiversity in Belete forest Shebe sombo South west Ethiopia.

1. 3. Objectives of the study

1.3.1. General objective

The general objective of this study was to determine the impacts of vegetation cover type on the diversity and relative abundance of forest birds and their feeding guilds of Belete forest Shebe sombo district South-West, Ethiopia.

1.3.2. Specific objectives

- Evaluate the relative abundance of forest birds among habitat types and between seasons in the area.
- To record the feeding guilds diversity of birds in each habitat types of Beleta forest.
- To record forest birds relative abundance in the three habitat types of Belete forest
- To compare the impacts of habitat change on the diversity of birds in Belete forest.

1.4 Significance of the study

As little forest cover remains in Ethiopia and agriculture is the dominant land use, determining avian conservation priorities in the tropics. Birds play an important role in biological systems. But to maintain their benefits, appropriate habitats must be established. The Belete forest and its environs are regarded as habitats for birds that should be preserved. However, human activity has affected the Belete forest and changed the birds' natural habitat. In line with some researchers, the habitat for many guilds of bird natural forest is extra suitable than another habitat, however there are those who argue that birds choose greater in disturbed areas than in natural forests. As a result, the first task is to determine at which habitats bird species are abundant in the study station and to record their abundance.

This finding fills the gap, in determining the influence of habitat type (shade coffee, farmland, and natural forest) on the diversity and relative abundance and to develop effective conservation strategies of forest bird guilds of Belete forest South-Western Ethiopia. This information will have implications on how farmlands and shade coffee plantations can be managed for the benefit of retaining forest birds. Furthermore, birds play a crucial ecological role in forest and agricultural ecosystems, especially pollination, seed dispersal and pest control (Sekercioglu, 2012), making birds good indicators of ecosystem health.

2. Literature Review

2.1. Bird diversity and abundance

The extremely diverse and abundant bird communities in coffee plantations, despite high levels of human disturbance, have attracted many birdwatchers (African and Buechley, 2015). Structurally, shaded coffee plantations fall somewhere between the original natural forest canopy and intensive agriculture, as many trees are scattered throughout the plantation, but not as many as a natural forest (African and Buechley, 2015). As expected, bird species richness and diversity tend to be lower in shaded coffee plantations than in adjacent forest patches in forest checkpoints” (African and Buechley, 2015). Species diversity in shade plantings is almost always reported to be significantly higher than in full sun plantings or other types of monoculture (Arendt *et al.*, 2020). The loss of forest-specific bird diversity in plantations is compensated by the presence of bird species typical of native, disturbed, or open habitats. Many forest understory specialist birds are rare or absent from plantations, even when the shady canopy consists largely of native forest trees, due to the almost complete conversion of the understory to coffee cultivation (Terborgh and Weske, 1969). Middle-class pickers are also negatively impacted by the conversion of forests to shaded coffee plantations (Tejeda-Cruz and Sutherland, 2004).

2.2. Avian diversity in agricultural landscape

The relationships between avian diversity and landscape heterogeneity may vary depending on the aspect of diversity considered: strong positive effects of heterogeneity on taxonomic diversity, but weakly positive or non-significant effects on functional diversity (Lee and Martin, 2017). The change suggests increases in large-bodied granivores or carnivorous birds and declines in some arboreal foragers and nectarivores. Changes in species richness were best explained by changes in noisy miner abundance and levels of surrounding woodland cover (Bain *et al.*, 2020). The study of Sodhi *et al.*, (2011), have shown the importance of vegetation structure and in particular canopy cover (60% or more) for the existence of many forest bird species. Changes in vegetation structure, particularly vegetation heterogeneity, have a significant impact on the abundance and richness of tropical forest birds. In addition to population size, the diversity of bird communities in monoculture agricultural areas has also declined over time (Bhavna and Geeta, 2011). The dominance of a single species in these crops reflects a reduction

in diversity and the possibility that the dominant species has become a beneficial pest of cereal crops (Bhavna and Geeta, 2011).

2.3. Forest as a habitat for bird

According to UNEP, (2011) and Suet, (2013), the world's forests play an important role in maintaining fundamental ecological processes, such as water regulation and carbon storage, as well as in providing livelihoods and supporting economic growth. Forests are among the most diverse and complex ecosystems in the world, providing habitat for a wide variety of flora and fauna (Stratford and Sekercioglu, 2015). In fact, forests are home to around 80% of terrestrial biodiversity on Earth, including most birdlife (Birdlife International, 2012; Ozone, Anhuf, Boulter & Keller, 2003). Birds are found in all major habitat types, but forests are the most important habitat for terrestrial birds supporting 77% of species (Croxall *et al.*, 2012).

Forests provide essential resources needed to complete life cycles, including food for adults, nestlings, and nesting sites. Birds are found in forests at different trophic levels; from primary consumers to vertebrate predators as well as omnivores and scavengers. Because birds are endothermic, their caloric requirement is higher than that of similarly sized ectotherms, and therefore their food demand is higher and likely more sensitive to changes in forest resources (Stratford and Sekercioglu, 2015). As primary consumers, birds obtain nutrients from nectar, fruits, seeds, and vegetative tissues (roots, shoots, and leaves). Birds that consume the vegetative parts of plants can supplement their diet with other protein sources, such as insects (Mikich and Pedro, 2006). Granivores (seed eaters) and frugivores (fruit eaters) are much more common in herbivorous birds (Pizo, 2004). Granite birds get most of their calories from the starch contained in the seeds and there are just over 1,000 bird species that feed mainly on grains (Pizo, 2004).

2.4 . Impacts of forest loss on avian

The destruction of global forests has dramatically increased over the past decades (Keenan, 2018). This destruction is most severe in the tropics, where most natural forests have been converted to agricultural land and forest plantations to meet growing resource demands (FAO, 2016). According to Subasinghe *et al.*, (2014), most tropical forests, which contain much of the world's biodiversity, are still cut down for agriculture and the timber industry. Rural areas with high human population density are particularly vulnerable to forest loss (Wright, 2005).

The conversion of natural forests to plantation forests and croplands has a negative impact on the rich biodiversity associated with forest ecosystems (Lupatini *et al.*, 2013), and this is largely due to the fact that most plantations and agricultural lands have exotic tree species that differ markedly from native forests in composition and structure, leading to different ecological processes and functional outcomes. In natural forests, deforestation causes changes in animal feed corporations through changes in the structure of the food web. Second, deforestation leads to a reduction in fruit tree diversity (Harris & Pimm, 2004). This decrease causes changes in the distribution of food guilds (Gray *et al.*, 2007), with forest-dependent species negatively impacted relative to forest generalists bird and marginal species (Sekercioglu, 2002). In general, habitat loss, especially the conversion of tropical forests into farmlands, settlements and urban development, is the main driver of the biodiversity loss (Donald, 2004; Foley *et al.*, 2005). Natural forests are also lost when they are replaced with monocultures of plantation forests, which result in the simplification of vegetation structure and composition (Sekercioglu, 2002; Kalya *et al.*, 2014).

Plantation forests have fewer resources such as roosting, sheltering and nesting sites for birds and other fauna and, as a rule, have lower species richness and diversity (Zurita, Rey, Varela & Bellocq, 2006; Kalya *et al.*, 2014). Only species that are capable of using a wide range of habitats have the capability to persist in the human-altered portions of landscape (Andren, 1994). Indeed, many studies have demonstrated higher bird species richness and diversity in native forests compared to exotic monocultures such as eucalyptus and conifer plantations (Sekercioglu, 2002; Barlow *et al.*, 2007). Studies of avian feeding guilds in different habitats resulting from land conversion have not been conducted (Gray *et al.*, 2007; Azman *et al.*, 2011). Such studies are crucial for understanding the complexity of ecosystem structure and for providing updated information on each type of habitat in the ecosystem (Azman *et al.*, 2011).

2. 5. Bird species in shade coffee

Shaded coffee plantations are important for bird conservation. For example, neartic-neotropics migratory birds are often as numerous in shady coffee plantations as they are in natural forest habitats (Colorado, 2011). In some landscapes shade coffee plantations have as many or more bird species as local forest plots and given that shade coffee plantations are intermediate on a nuisance gradient between natural forest and other habitats agricultural (Arendt *et al.*, 2020). Apparent species richness in coffee agroforests higher than in forests,

model results showed that omnivores and insectivores were more common in forests when taking into account the heterogeneity of capture probability (Hernandez *et al.*, 2013). As an extension of horticulture, sustainable agriculture has been proposed as a way to ensure that private land maintains biodiversity and protected areas while providing economic support to people (Hernandez *et al.*, 2013). For example, coffee plantations managed under a floristically and structurally diverse tree canopy have been shown to provide important habitat for diverse bird communities (Hernandez *et al.*, 2013). Understory insectivores accounted for a particularly large amount of this difference, with a substantially smaller relative abundance in shade coffee. This is an important finding for efforts to conserve understory insectivores in Africa a highly threatened group of birds and for shade coffee farmers that may benefit from avian pest regulation (Buechley *et al.*, 2015).

Thus, for bird and other wildlife communities, shade coffee can serve as an alternative habitat to forests. Therefore, small coffee agroforestry can host flocks of birds similar to those around the forest. These agroforests are integrated into the usual tropical rural matrix of forest plots and small-scale agriculture. According to Smith *et al.*, (2015), the sun coffee showed less community similarity to hues and had higher species richness and abundance of all major guilds (omnivores, insectivores, and granivores). Negative effects on any guild, while the amount of weeds in the undergrowth increased the variety and abundance of birds by an amount comparable to that of the canopy.

2. 6 Threats to birds

Directly or indirectly, humans have caused the extinction of birds in the wake of our species' establishment on the planet. Human-caused extinctions are best documented from the 16th century onwards, although forensic genetics may show human-caused extinctions prior to that time (Newbold *et al.*, 2013). In other words, deforestation rates are increasing in many tropical forest biodiversity hotspots due to increased production and global trade of agricultural crops such as oil palm, soybeans and corn as human food.

2. 6.1. Deforestation

Deforestation can occur by removing a single area of habitat and leaving the remaining habitat intact. More typically though, deforestation is accompanied by forest fragmentation and both have negative consequences for bird populations (Vetter, 2009). Selective logging can cause

damage to forests which, at medium to high intensities, results in the loss of bird species. Some bird species can tolerate some disturbed habitats and make less use of secondary forests (Rahmani, Islam & Kasambe, 2016). Their capacity to utilize disturbed habitat ought to slow its rate of decline. And with its shorter generation time, it falls in the middle of the pack among the species analyzed here for habitat loss. For these reasons, those bird species in disturbed habitat is actually a good candidate for going from vulnerable to near threatened status. Changes in vegetation structure caused by human intervention have resulted in significant changes in bird richness, taxonomic diversity, abundance, and population composition. This habitat disturbance has also had a negative impact on the richness and abundance of specialized forest species, which could lead to functional homogenization (Vetter, 2009).

2.6.2. Forest fragmentation

Forest fragmentation results from a combination of clearing and the creation of patches of forest within a non-forest matrix. Typically, species numbers are reduced inside forests in forest fragments (Kattan, Alvarez-López and Giraldo, 1994), consistent with species-area relationships. In Neotropical forests, birds seem to be more sensitive to light conditions and changes in vegetation structure, and many are unwilling or unable to cross open habitats that separate forest from forest fragments (Kattan, Alvarez -López and Giraldo, 1994). The loss of species resulting from forest fragmentation is likely to affect the ecosystem services provided by birds (Vergara *et al.*, 2021) .

2.6.3. Forest degradation

Forest degradation drives widespread avian habitat and population declines (Betts *et al.*, 2022). Selective logging can lead to forest degradation, resulting in moderate to high losses of bird species (Holbech, 2005). Habitat loss was associated with population declines for old-forest species. Forest degradation may therefore be a primary cause of biodiversity decline in managed forest landscapes (Betts *et al.*, 2022). The composition of the bird species communities was relatively similar in the degraded forest fragments and the surrounding agricultural land, while the bird community composition found in the near-natural forest block diverged considerably, where forest-dependent bird species occur in comparatively high densities (Mulwa *et al.*, 2021). Most frugivores, insectivorous and nectarivores birds occurred in forest habitats, while granivores bird species dominated the bird communities of agricultural land (Mulwa *et al.*,

2021). The preservation of near-natural cloud forest, including small forest patches, is essential for the conservation of forest-dependent species, and that plantations do not serve as surrogate habitats. Higher bird species diversity in disturbed habitats than in rather intact ones (Riva and Fahrig, 2022)

2.7 Guild structure in forest bird communities.

Vegetation structure and food availability, which vary with plant species and vertical strata, produce particular sets of foraging opportunities for birds. These in turn influence which species can obtain food successfully, and thus can be considered primary determinants of guild structure. This comparison of food utilization patterns of birds in contrasting habitats provides insight into the factors determining bird community organization (Holmes, 2000). Guild structures in forest bird assemblages largely reflect the similarities and differences in forest structure and the distribution and abundance of foraging resources, and result from largely adaptive evolution (Kornan *et al.*, 2013). The upper story bird species were influenced by the forest edge due to factors related to microclimate. However, the response of upper story bird species may vary from species to species and from the forest edge to the interior. The birds selected specific microhabitat and microclimate characteristics that offered optimal food, shelter and breeding sites (Zakaria and Rajpar, 2010). Bird communities strongly respond to seasonal fluctuations in resource availability, but responses differ between feeding guilds (Mulwa *et al.*, 2013). While frugivores seem to respond flexibly to seasonal fluctuations, for instance by tracking fruit resources across habitat boundaries, insectivorous birds appear to be more susceptible to the expected increase in seasonal fluctuations in resource availability (Mulwa *et al.*, 2013).

3. Materials and methods

3.1. Description of the Study area

The study was conducted within and around shade coffee farms, natural forests, and farmland sites in Belete Forest Shebe Sombo District Oromia, Ethiopia. Belete forest is part of the Belete-gera National Forest priority area and is one important bird and Biodiversity Areas (IBAS), in Ethiopia. This forest is found in two districts; Gera and Shebe-sombo of the Jimma zone of the Oromia region, south-west Ethiopia. As the agricultural office of Shebe sombo woreda, 2015 E.C indicates, the forest covers more than 25682ha and the altitude ranges between 1400 and 2970 m above sea level. The forest is located at latitudes $7^{\circ} 30'$ N and $7^{\circ} 45'$ N and longitudes between $36^{\circ} 15'$ E and $36^{\circ} 45'$ E(Fig. 1).

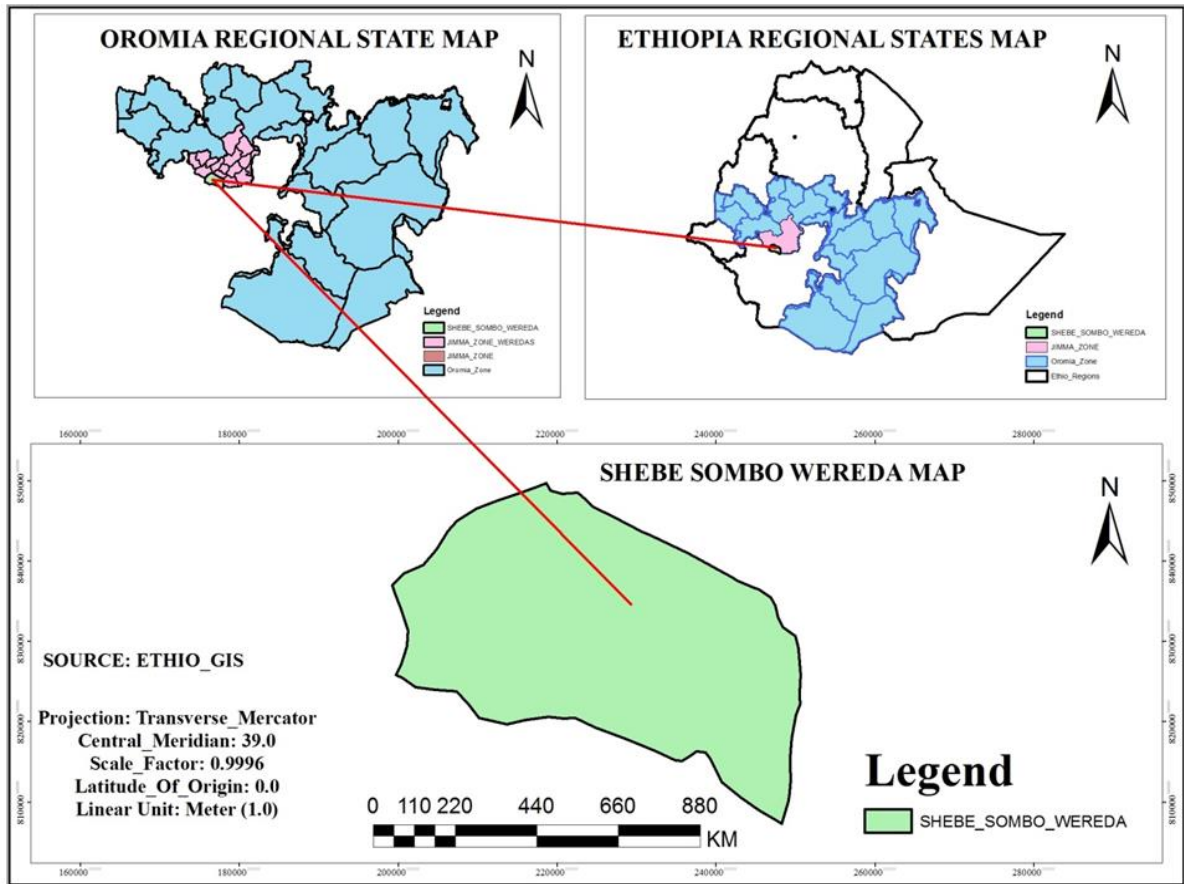


Figure 1: Map of the study area

The area has two distinct dry and wet seasons, with short dry months from (March –April) and long rainfall from (May – February). The mean temperature at 2000 m asl. is 18.4°c whereas the mean annual rainfall is situated around 1780 mm. It is characterized as an afro-montane evergreen forest, dominated by trees like (syzigium Guineans, Oleo welwitchii, Prunus africana, and Pouteria Adolf-Frederic) (Demissew *et al.*, 2004). The climatic condition of the district is composed of about 65% middle-land, 20% lowland, and 15% high-land climate conditions. There is also a moderate distribution of precipitation for various crops and fruits. Shebe-sombo is one of the 20 district located in the Jimma zone. Shebe-sombo district have 22 kebele. According to Shebe- sombo health office center, (2014) E.C. the reported total population of this woreda is 205,173 of these population the income of 117,056 (57.9%) depend on agriculture and coffee. Shebe-sombo is bordered by Hadiya in the north, Seka Chokorsa in the east, Gojeb River in the south, and Gera woreda in the west.

3.2. Preliminary survey and selection of study site

A Preliminary survey was carried out during the second week of June, 2022 for about one week to have basic information on accessibility, topography, infrastructures, and habitat stratification based on vegetation distribution and topographic nature for Belete forest in Shebe sombo district. Furthermore, point count survey was conducted in the three habitat types (natural forest, shade coffee and farmland) to test the applicability of the survey method, before the commencement of the actual data collection. For the habitat survey ten line transects and 180 point count station were laid down for data collection. In addition, all the available literatures about the study area and the ecology of forest birds were intensively reviewed.

3.3. The study design

Following the information gathered during the Preliminary survey, data for the dry season were collected from January - April 2023 and wet season data were collected from May -August ,2023. Sampling plots were randomly selected for each habitat type. The numbers of sampling plots were determined based on the size and the nature of vegetation cover within the study area (Sutherland, 1996; Bibby et al.,1998). The farmlands are composed of small-scale subsistence providing various crops, fruits, vegetables, and isolated trees. Using random sampling design ten line transects each length 600m were established within each of the three habitat types (natural forest, shade coffee plantation, and farmland) in the study area. Six replicate point count plots were established along each transect, each 200 m away from each other and from the roads to decrease disturbance (Bibby *et al.*, 1998). In each of the three habitat types, there were 60 point count and totally,180 point count statin laid in the study station.

Table 1. Sample of habitat classification and allocation based on area coverage

Habitat type	Shade coffee	Natural Forest	Farmland
Area coverage in Km	2.5	2.5	2.5
Proportion of sample	35%	40%	25%
Total number of lines transect	10	10-	10
Number of point counts for each habitat	6/7	6/9	6/8
Total number of point count	60	60	60

3.4. Data collection

For data collection two methods line transect and point count were carried out on the study area. A targeted sampling method were used to select three vegetation types natural forest, farmland and shade coffee plantation in shebe-sombo district. Birds were counted for a limited time using the standard scoring method as described by (Bibby *et al.*, 2000). On arriving at the point count station, birds were allowed time to settle for 1 to 3 minutes. The bird species were recorded within 50-m radius plot is then recorded for a period of 10 minutes by all direction. The counts were conducted between, 06:30hrs, and 10:00hrs early in the morning between 15:00-18:30 in the late evening (Bibby *et al.*, 2000). Birds were recorded and then classified into functional guilds based on habitat and food preferences following African bird classification methods (Kissling *et al.*, 2007). During this study the birds species identification and counting based on their morphology for example the nature of the beak ,color, size ,leg, neck as well as their where they lived in common and feeding type was conducted by direct observations aided by the naked eye, binoculars (10x42) and East Africa field guide book (Redman, Stevenson and Fanshawe, 2009). Sound records and photography were also taken for further confirmation by using a digital camera. The surveyors moved at the same speed on the line selected. Bird species were counted by walking on the line transect on the left and right. All birds seen were recorded and identified using field guide books. Some inconspicuous bird species were identified based on their calls (Aynalem and Bekele, 2008). The bird species were identified and recorded on the bird's datasheet. The classification of birds into habitat preference guilds was guided by the forest dependency classification of (Bennun *et al.*, 2020), where birds are classified as follows; forest specialist (species are true forest birds), forest generalist species may occur in undisturbed forest but are also regularly found in forest strips, edges and gaps and forest visitor. The food classification of African birds(Lopes *et al.*, 2016) has been used to group birds according to their diet: like carnivorous (vertebrates eaters), nectarivores (nectar), frugivores (fruit), granivores (seed), omnivorous, insectivores.

3.5. Data computation and analysis

Data were transferred to normal by using the Shapiro–Walks log. ($x + 1$). All habitat types were plotted in order to evaluate the completeness of point counts and species accumulation

curves. Bird species diversity was calculated using the Shannon-wiener index following (Bibby *et al.*, 2000) as follows;

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

P_i = proportion of the i^{th} species, \ln =natural logarithm, S =number of species in community while bird species richness is expressed as the average number of species on point count stations. Species evenness is often assessed by Shannon equitability index (E) which is calculated by: $E = H' / H_{\text{max}}$, Where; $H_{\text{max}} = \ln(S)$ = natural logarithm of the total number of species (S) in each habitat. Bird abundance was expressed as the average number of birds per point count for all birds and for the respective food and forest dependency guilds. ANOVA test was performed to determine the influence of land cover type on bird relative abundance by comparing means of bird between the groups and within the groups across the three land use types.

Tukey's HSD tests was used to compare the significant differences between avian guild. The analysis was carried out using statistical packages of social science (SPSS) version 26 to determine the impact of habitat type on differences in bird community composition variable, species richness, forest dependence and abundance of foraging guilds.

The Sorensen similarity index (S) was used to measure similarity between habitat types. It is equal to 1 in case of complete species similarity between three habitats and 0 if species of two habitat types are dissimilar. Sorensen similarity index (S) is computed as: $S = 2C / (A + B + D)$ Where, A= Number of species that occur in a site A, B = Number of species that occur in a site B, C = Number of common species that occur in a site A, B and D, D=Number of species that occur in a site D.

4. Results

4.1. Species composition and relative abundance

Across all point plots and seasons, a total of 1361 individual birds were recorded, with 103 species falling into 16 and 40 orders and families, respectively. At the study station, the number of individual bird species among the habitats 698 in shade coffee, 483 in natural forest, and 180 in farmland was recorded. The majority of (54%)of the species are under order Passeriformes was recorded during study seasons (Table 2). The highest number of species was recorded in the family Muscicapidae with number of species (RA=10.87%), Accipitridae (RA=5.24) and followed Columbidae and ploceidae (RA=6.83%), (RA=9.03%) respectively, Meropidae (5) Oriolidae, Nectariniidae, Estrildidae and Picidae (4), Sturnidae, Pycnonotidae, Turdidae and Bucerotidae (3), eleven family (2) species each was recorded. The lowest number of species was recorded from sixteen families, 1 species each (Table 2) and a detailed description is given in (Appendix 1). However, the lowest relative abundance were found in the Buphagidae and Lybiidae families, with (RA= 0.07%) among the three habitat types and seasons(Table 2).

Table 2. Bird orders, families , number of species, composition and relative abundance recorded among the three habitat types and seasons was recorded January-August, 2023 at Belete forests of shebe sombo South West Oromia, Ethiopia.

Order	Family	No of spp.	Total collection	RA%
Passeriformes	Monarchidae	1	22	1.61
	Muscicapidae	10	148	10.87
	Oriolidae	4	61	4.48
	Sturnidae	3	26	1.32
	Pycnonotidae	3	22	1.61
	Malaconotidae	2	23	1.68
	Campephagidae	2	8	0.58
	Ploceidae	6	123	9.03
	Passeridae	2	15	1.10
	Viduinidae	1	3	0.22
	Turdidae	3	53	3.89
	Buphagidae	1	1	0.07
	Motacillidae	2	10	0.73
	Zosteropidae	2	99	7.27
	Sylviidae	2	64	4.70
	Nectariniidae	4	38	2.79
Estrildidae	4	83	6.09	
Laniidae	2	14	1.02	

Table 2. Continued

Order	Family	No of spp.	Total collection	RA%
	Fringillidae	1	13	0.95
	Hirundinidae	1	4	0.29
Coraciiformes	Alcedinidae	2	18	1.3226
	Coraciidae	1	3	0.2204
	Meropidae	5	11	0.8082
Accipitriformes	Accipitridae	10	70	5.1433
Columbiformes	Columbidae	6	93	6.8332
Musophagiformes	Musophagidae	2	14	1.02
Cuculiformes	Cuculidae	2	9	0.66
Bucerotiformes	Bucorvidae	1	12	0.88
	Phoeniculidae	2	22	1.61
	Bucerotidae	3	56	4.11
Piciformes	Picidae	4	12	0.88
	Lybiidae	1	1	0.07
Caprimulgiformes	Apodidae	1	35	2.57
Coliiformes	Coliidea	1	23	1.68
Galliformes	Phasianidae	1	13	0.95
Pelecaniformes	Threskiornithidae	1	15	1.10
Strigiformes	Strigidae	1	3	0.22
Trogoniformes	Trogonidae	1	2	0.14
Psittaciformes	Psittaculidae	1	25	1.83
Falconiformes	Falconidae	1	30	2.20
Total		103	1361	

4.2. The Species diversity and evenness among three habitats and study seasons of Belete forest.

During the wet and dry season the highest species diversity with ($H' = 3.742$) and ($H' = 2.788$) of birds was recorded from the Shade coffee habitat, followed by natural forest habitat ($H' = 3.408$) and ($H' = 2.974$), whereas the least diversity with ($H' = 2.979$) and ($H' = 2.375$) was recorded from the farmland habitat during the study season respectively (Table 3). But the smallest number of

bird species was recorded from the farmland habitat ($H'=2.375$) during dry season (Table 3). The highest abundance at shade coffee with ($N=556$ individuals and 56 species) during wet season were as the lowest at farmland ($N= 39$ and 14species) was recorded during dry session (Table.3). Of the recorded species, six species such as Black-winged lovebird (*Agapornis taranta*), Abyssinian catbird (*Sylvia galinieri*),White-collared pigeon (*Columba albitorques*), Prince ruspoli'sturaco (*Turaco ruspolii*), Golden-backed woodpecker (*Dendropicos abyssinicus*) and Yellow-fronted parrot (*Poicephaluflavifrons*) are endemic to Ethiopia. Two species are endemic to both Ethiopia and Eritrea. But the remaining 95 species were residents the detail information provided on (Appendix 1). Higher bird abundance was recorded in Shade coffee as compared to natural forests and farmlands (Table 3). The evenness of the species distribution is highest in Shade coffee during the wet season ($E = 0.597$) and lowest in farm land during dry season ($E = 0.461$) (Table 3).

Table 3 Bird species, diversity, richness and evenness during the wet and dry season.

Habitat	Session	No.of species	Abundance	H'	D'	E
Shade coffee	Wet	56	556	3.74	0.998	0.597
	Dry	23	142	2.788	0.931	0.566
Natural forest	Wet	48	303	3.4	0.957	0.595
	Dry	31	180	2.97	0.940	0.573
Farmland	Wet	29	141	2.97	0.934	0.456
	Dry	14	39	2.37	0.908	0.451

H' , Shannon-weiner Index; $D', 1 - \sum p_i^2$; $H'/H \max = \text{Evenness}$; $H \max = \ln(S)$; S, The total number of species.

4.3, Relative abundance of birds in wet and dry seasons.

Comparing habitat types the highest number individual species of order Passeriformes during wet and dry seasons in shade coffee 312 and 71, natural forest 181 and 123, farmland 96 and 17 and order Strigiformes in shade coffee 0 and 5 natural forest 0 and 0 was recorded respectively. The greatest relative abundance of birds in shade coffee habitat with ($RA= 79.66\%$) during wet while, farmland the lowest ($RA=21.3\%$) was recorded during dry session. During wet and dry seasons the highest relative abundance of family Muscicapidae was recorded with ($RA=7.4\%$), ($RA= 20.5\%$), Ploceidae ($RA=7.7\%$), ($RA= 12.74\%$) while, less relative

abundance of Buphagidae family with 0 individuals (RA=0.0 %) , 1(RA= 0.1%), was recorded in both season respectively (Table 4).

Table 4. Orders, family, number of bird species in the family, relative abundance and individual birds among habitats and seasons categories.

Order	Family	Total no of spp.	RA(%)		No of individuals in habitat & season					
					Shade coffee		Natural forest		Farmland	
			Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Passeriformes										
	Monarchidae	1	1.6	1.66	7	0	9	6	0	0
	Muscicapidae	10	7.4	20.5	22	7	52	67	0	0
	Oriolidae	4	6.1		46	0	15	0	0	0
	Sturnidae	3	2.6		26	0	0	0	0	0
	Pycnonotidae	3	0.5	3.6	0	12	1	0	4	1
	Malaconotidae	2	1.7	0.83	17	0	0	3	0	0
	Campephagidae	2	0.6	0.55	0	0	0	1	0	0
	Ploceidae	6	7.7	12.7	50	19	17	24	10	3
	Passeridae	2	7.3	2.6	47	22	26	2	0	2
	Viduinae	1	0.6	0.2	0	0	6	2	0	0
	Turdidae	3	3.6	3.88	29	5	5	9	2	0
	Buphagidae	1	0	0.1	0	0	0	1	0	0
	Motacillidae	2	1	0	0	0	4	0	6	0
	Zosteropidae	2	6.3	6.09	47	22	26	2	0	2
	Sylviidae	2	3.7	1.94	8	3	22	1	7	3
	Nectariniidae	4	3	2.22	13	0	14	8	3	0
	Estrildidae	4	7.3	1.66	21	0	0	0	51	6

Table 3. continued

Order	Family	Total no of spp.	RA(%)		No of individuals in habitat & season					
			Wet	Dry	Shade coffee		Forest		Farmland	
					Wet	Dry	Wet	Dry	Wet	Dry
	Laniidae	2	1.1	0.83	6	3	5	0	0	0
	Fringillidae	1	1.3	1.94	10	0	0	7	3	0
Coraciiformes	Hirundinidae	1	1.5	0.55	11	0	0	0	4	2
	Alcedinidae	2	2.8	1.11	14	0	14	4	0	0
	Coraciidae	1	0.3	0	2	0	1	0	0	0
Accipitriformes	Meropidae	5	3.4	1.11	19	3	15	1	0	0
	Accipitridae	10	5.4	4.99	40	15	8	0	6	2
Columbiformes	Columbidae	6	7.5	5.26	53	12	10	2	12	4
Musophagiformes	Musophagidae	2	0.9	1.39	9	2	0	3	0	5
Cuculiformes	Cuculidae	2	1.9	3.32	6	0	0	0	2	1
Bucerotiformes	Bucorvidae	1	0.6	0	10	0	0	0	2	0
	Phoeniculidae	2	2	1.39	15	2	5	0	0	0
	Bucerotidae	3	4	5.26	38	12	2	6	0	1
Piciformes	Picidae	4	2.9	1.94	0	0	23	1	6	6
	Lybiidae	1	0.9	4.16	0	7	9	8	0	0
Caprimulgiformes	Apodidae	1	2.3	3.32	0	0	13	12	0	0
Coliiformes	Coliidae	1	2.1	0	15	0	0	0	8	0
Galliformes	Phasianidae	1	1.3	0	8	0	3	0	2	0
Pelecaniformes	Threskiornithidae	1	0.4	3.32	0	3	0	9	4	0
Strigiformes	Strigidae	1	0	1.39	0	5	0	0	0	0
Trogoniformes	Trogonidae	1	0.2	0.83	2	0	0	0	0	3
Psittaciformes	Psittaculidae	1	1.5	2.77	13	10	0	0	3	0
Falconiformes	Falconidae	1	1.9	3.05	0	0	19	11	0	0
Total		103		556	142	303	180	141	39	

Note: (RA) Refers Relative abundance, wet= wet season and Dry = dry season

4.4. Species similarity in different habitats and seasons

The highest similarity index ($SI= 0.58$) of overall bird species between wet and dry season was recorded at Shade coffee and natural forest respectively while less similarity index with ($SI= 0.48$) were at farmland (Table 5).

Table 5: The overall bird species (SI) within habitats during both seasons at the study station.

Habitat type	Wet	Dry	Common species	SI	SI%
Shade coffee	43	9	15	0.58	58
Natural forest	35	16	14	0.54	55
Farmland	22	7	7	0.48	48

During the wet season; 31, 23, and 21 species were frequent in shade coffee, Natural forest and farmland habitats, respectively, while during the dry season 15, 28, and 9 species were frequent in shade coffee, Natural forest, and farmland habitats, respectively. During wet season the common species in shade coffee and natural forest (25), in shade coffee and farm (15) and natural forest and farm (8) while at dry season the common species in shade coffee and natural forest (9), in shade coffee and farm (3) and natural forest and farm (4) was recorded. The highest similarity of avian communities ($SI=0.92$) was recorded between the shade coffee and natural forest habitats during the wet season, while the least species similarity was recorded between natural forest and farmland ($SI=0.16$) habitats (Table 6).

Table 6. Similarity index of bird species among habitats during the wet and dry seasons.

Habitat types	Natural forest		farmland		Shade coffee	
	Wet	Dry	Wet	Dry	Wet	Dry
Natural forest	-	-	0.36	0.16	0.92	0.41
Farmland	-	-	-	-	0.57	0.33

Number of species recorded from all point count station was higher in shade coffee than other habitat types. All species accumulation plots reached an asymptote indicating that sampling was complete, that further sampling could not add new species (Fig. 2)

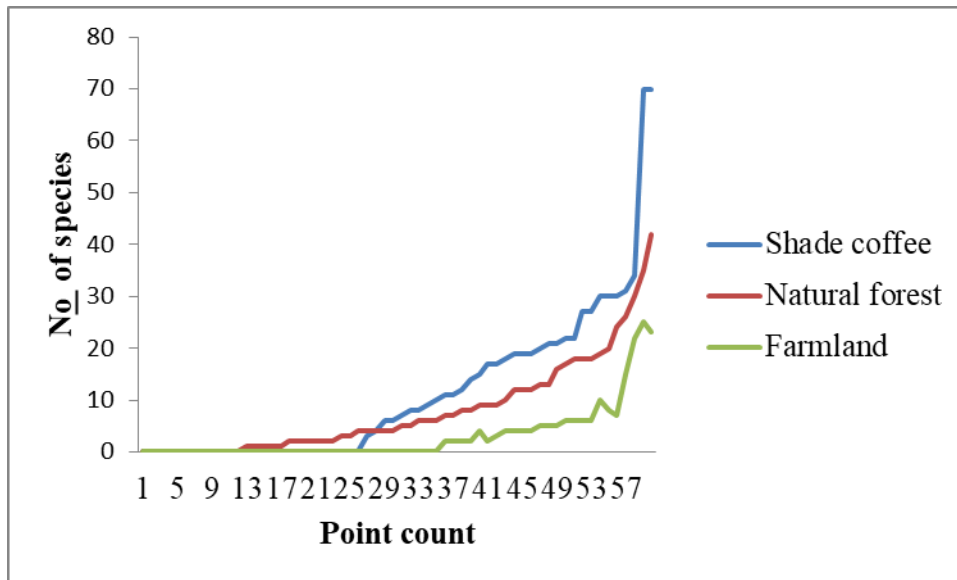


Figure 2: Species accumulation rates for birds at Belete forest Shebe sombo district: January 2023 - February 2024.

4.5. Influence of habitat type on bird species richness, diversity and relative abundance of forest dependent guilds.

A large proportion of relative abundance and diversity of birds recorded in this study were forest-dependent species in shade coffee including, visitors (f) individual numbers 349 (RA=38.11%, H'=3.278), forest generalist (F) 227 (RA=39.97%, H'=2.327), Specialist(FF) 133 (RA=19.05%, H' =2.66), non-forest 20 (RA= 2.87%, H'==1.40), while in natural forest (f) 113 (RA=23.40%, H'= 3.07),(F) 48 (RA= 9.94%, H'= 2.222) ,(FF) 253(RA = 52.38%, H'= 2.6), in farmland(f) (RA=43.89%, H'= 2.661),(F) (RA= 28.89%, H'= 1.8) ,(FF) (RA = 17.78%, H'= 2.1) and non-forest (RA= 9.44%, H'==1.66) respectively (Fig.3, and Table 7).

Table 7: Influence of habitat type on forest dependent guilds of bird species richness , relative abundance and diversity.

Guilds	habitats											
	Shade coffee				Natural forest				Farmland			
	S	Ni.	RA%	H'	S	Ni	RA%	H'	S	Ni	RA%	H'
Visitors	40	266	38.11	3.33	33	113	23.40	3.07	17	79	33.89	2.66
Generalist	21	227	39.97	2.33	10	48	9.94	2.22	8	52	28.89	1.8
Specialist	18	133	19.05	2.67	21	253	52.38	2.6	10	32	17.78	2.1
Non-forest bird	3	20	2.87	1.40	2	69	14.29	1.03	6	17	9.44	1.67

S = species, Ni =number of individuals, (RA) = indicate relative abundance, (H') = diversity.

The three land-use types showed significant differences in relative richness of various habitat dependent guilds, forest visitors species were high ($F_{2, 177} = 9.699, P < 0.05$) in shade coffee and lower in forest and farmland, non-forest bird were higher ($F_{2, 177} = 3.015, P\text{-value} < 0.05$) in shade coffee, and specialist were higher ($F_{2, 177} = 11.225, P\text{-value} < 0.05$) in natural forest than other habitat and there was a significant difference in the abundance of generalist bird ($F_{2, 177} = 9.699, P < 0.05$) and high in shade coffee at 95% Confidence interval (Table 8). Significant differences were further analyzed using post hoc Tukey's HSD test at 95% confidence level, the analysis showed significant differences in relative richness of avian forest dependence guilds among the three cover types (Table 8).

Table: 8. Tukey's HSD test significant results for richness and abundance of avian forest dependent guilds.

Dependent variable	Habitat Type	Habitat Type	F	Sig.	Mean difference
Visitors	Shade coffee	Natural forest	9.699	.000*	.02233*
	Natural forest	Shade coffee		.000	-.02233
		Farm land		.0. 966	.00039
	Farm land	Shade Coffee		.001	-.02194
Generalist	Shade Coffee	Natural forest	3.015	0.03*	.01883*
		Shade Coffee		0.03*	-.01883
	Natural forest	Farm land		0.501	0.01883
	Farm land	Shade Coffee		0.018*	-.03767
Specialist	Shade coffee	Natural forest	11.225	.000*	-.02800*
	Natural forest	Shade coffee		.000	.02800*
		Farm land		0. 019*	.01883
	Farm land	Shade Coffee		.002*	-.02211*
Non -forest bird	Shade coffee	Natural forest	6.620	.001*	.00900*
		Farm land		.039*	-.01214*
	Natural forest	Shade coffee		.001	.00900*
	Farm land	Natural forest		.039	.01214*

(*) indicates significance differences ($P\text{-value} < 0.05$), (I=habitat 1 ,J= Habitat 2)

Shade coffee had the highest abundance of forest generalist and forest visitors while, natural forest had the higher forest specialist avian species. Farmland had low bird abundance than other forest- vegetation type (Fig.3).

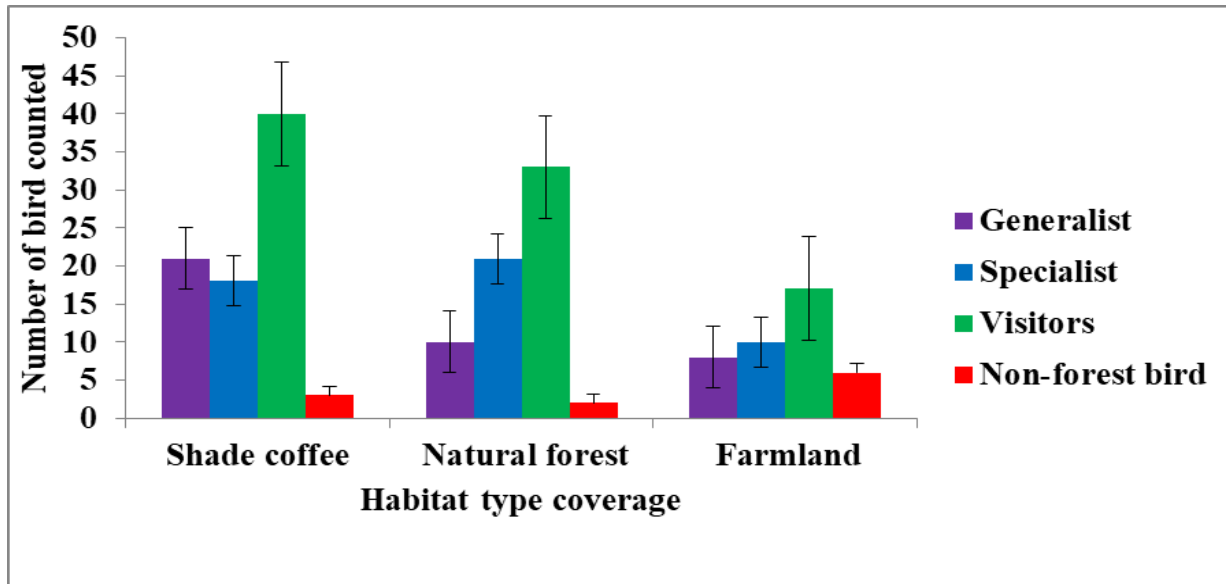


Figure3: Influence of vegetation cover type on the abundance of different avian forest-dependent guilds.

4.6. Influence of habitat type on the diversity and relative abundance of avian feeding guilds.

The relative abundance and diversity of bird feeding guilds recorded in shade coffee which includes frugivores(F) individual 345 (RA=49.4, $H'=2.672$) omnivores 46(RA=7.74, $H'=1.698$) and carnivores $n=52$ (RA= 8.02, $H'=1.96$),in natural forest insectivores 389 (RA=80.3, $H'=3.254$) nectarivores 32 (RA= 6.63, $H'=1.357$, $H'=2.09$) in farmland granivores 97 (RA=13.89, $H'=2.11$) the highest species was recorded (Fig. 4 and Table 9).Shade-coffee had the highest richness and abundance of bird feeding guilds like frugivores, omnivores and carnivores, Natural forest had the highest relative abundance and diversity of insectivores. But less bird abundance ,richness and diversity in farmland than other habitat type(Fig.4). The relative richness of avian feeding guilds was also differed within different land-use types (Fig.4, and Table 9).

Table 9: Number of species, relative abundance and diversity of avian feeding guilds in each habitat types.

Feeding guild	Among Habitat types number of species, individuals, relative abundance & diversity											
	Shade coffee				Natural forest				Farmland			
	S	Ni	RA	H'	S	Ni	RA	H'	S	Ni	RA	H'
Insectivores	21	157	22.5	2.76	34	389	80.5	3.25	8	28	15.6	1.74
Granivores	10	73	10.5	2.09	10	37	7.66	2.13	13	97	13.9	2.15
Frugivores	20	345	49.4	2.67	10	14	2.9	1.79	6	22	12.2	1.03
Nectarivores	4	32	7.74	1.69	1	13	1.86	1.00	1	3	1.67	.636
Omnivores	6	54	6.63	1.36	2	6	1.24	.693	4	11	6.11	1.29
Carnivores	9	56	8.02	1.64	4	5	1.04	1.9	6	19	7.56	1.37

S = indicates species, Ni = number of individuals, RA = relative abundance, H' = diversity

There were significant differences in relative richness and abundance of insectivores ($F_{2, 177} = 5.483$, $P < 0.05$), Frugivores ($F_{2, 177} = 14.126$, $P\text{-value} < 0.05$), Nectarivores ($F_{2, 177} = 15.049$, $P < 0.05$), and Carnivores ($F_{2, 177} = 6.074$, $P\text{-value} < 0.05$) among the three vegetation cover types. But, there was no significant difference in the abundance of Granivores ($F_{2, 177} = 0.817$, $P > 0.05$), and Omnivores ($F_{2, 177} = 2.843$, $P > 0.05$) among the three types of vegetation cover (Table 10). Significant differences were further analyzed using post hoc Tukey's HSD test at a 95% confidence level. There was a significant difference in the abundance of insectivores among Natural forests and Shade-coffee ($P\text{-value} = 0.035$), Shade-coffee and Farmland ($P\text{-value} = 0.006$). Similarly, there was a significant difference in the abundance of frugivores among natural forest and shade coffee ($P\text{-value} = 0.000$), shade coffee, and farmland ($P\text{-value} = 0.000$). Likewise, there was a significant difference in the abundance of nectarivores between Natural forest and shade coffee ($P\text{-value} = 0.000$) and natural forest and farmland ($P\text{-value} = 0.000$). The finding also showed that there was a significant difference in the abundance of carnivores among natural forest and Shade-coffee ($P\text{-value} = 0.036$) and natural forest and farmland ($P\text{-value} = 0.003$). But there was no significant difference in the abundance of granivores between shade coffee and natural forest, and omnivores among three types of vegetation cover ($P\text{-value} > 0.05$) (Table 10).

Table 10: Tukey's HSD test significant results for abundance of avian feeding guilds

Dependent Variable	Habitat one(I)	(J)habitat two	Mean difference. (I-J)	Sig.
insectivores	Shade coffee	Natural Forest	-.01583*	.035
	Natural Forest	Shade coffee	.01583*	.035
		Farm land	.01983*	.006
	Farm land	Natural Forest	-.01983*	.006
frugivores	Shade coffee	Natural Forest	.06033*	.000
	Natural Forest	Shade coffee	-.06033*	.000
		Farm land	.05850*	.000
	Farm land	Natural Forest	-.05850*	.000
nectarivores	Shade coffee	Natural Forest	.06033*	.000
	Natural Forest	Farm land	.06167*	.000
		Shade coffee	-.06033*	.000
	Farm land	Shade coffee	-.06167*	.000
carnivores	Shade coffee	Natural Forest	.01583*	.036
	Natural Forest	Farm land	.02133*	.003
		Shade coffee	-.01583*	.036
	Farm land	Shade coffee	-.02133*	.003

*Indicates significance (P-value<0.05), (I=habitat 1 ,J= Habitat 2, (I-J)= species abundance of the first habitat minus species abundance of the second habitat.

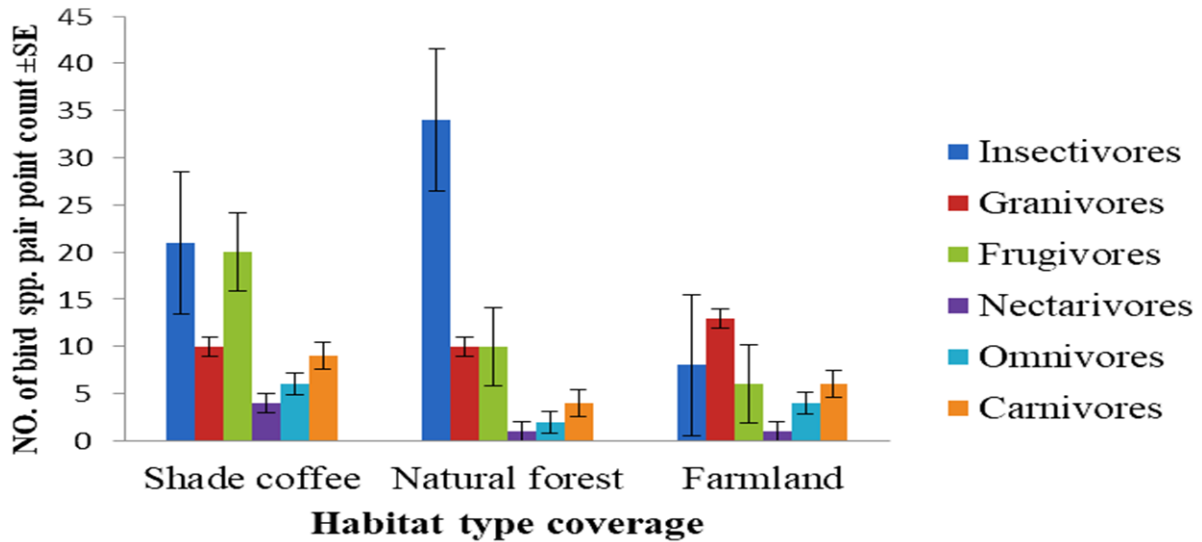


Figure 4: Influence of vegetation cover type on the abundance, diversity and richness of avian feeding guild.

4.7. Influence of habitat type on bird species richness

There was a significant difference in species richness among the three vegetation cover types ($F_{2, 177} = 9.08, P = 0.000$), with shade coffee recording the highest species richness and farmland the lowest (Table: 11). The mean differences of bird abundances and species richness among the three habitat types (I-J) results showed that shade coffee had higher bird richness and farmland the lowest bird richness (Table 11).

Table 11: Tukey's HSD test for bird species richness

Habitat Type	Habitat Type	Sig.	Mean Difference (I-J)
Natural forest	Shade-coffee	.188	-.02816
	Farmland	.000	.05834*
Shade-coffee	Natural forest	.188	.02816*
	Farmland	.042	.08650*
Farmland	Natural forest	.000	-.05834
	Shade-coffee	.042	-.08650

(I) indicated habitat 1, (J) habitat 2, (-) species habitat 1 is less richest than habitat 2

5. Discussion

This study provides insights into the impacts of habitat type (shade coffee, natural forest, and farmlands) on the diversity and relative abundance of forest bird guilds in Belete forests of southwest Oromia, Ethiopia. The results suggest that shade coffee plantations may sustain a high bird relative abundance and species diversity. A total of 1361 individual birds 103 species belonging to 16 and 40 order and families was recorded respectively across all habitats and seasons. The majority (54%) of the species are under order Passeriformes was recorded during study seasons. In line with this study Desalegn, and Tessie *et al.*, (2020) found that Passeriformes was the most dominant order and also; avian species seasonally shift their diet to feed on a different set of resources (Borghesio and Laiolo, 2004). In the levels of family the highest Muscicapidae and the lowest was recorded from Buphagidae and Lybiidae species. During wet season the highest, while the lowest relative abundance of avian species was recorded during dry season. According to Mulwa *et al.*, (2013) birds seem to respond flexibly to seasonal fluctuations, for instance by tracking fruit resources across habitat boundaries. The diversity index shows shade-coffee had higher birds followed natural forest and lower in farmland was recorded from the study station. This results may be except; insectivores and forest specialist bird among the three vegetation types shade coffee farms can provide habitat for many tropical bird guilds for feeding, nesting and different activity than farmland and natural forest, similar findings of the (Bakermans *et al.*, 2012), during wet season the highest diversity of birds in shade coffee was also recorded. This might be due to an increased frequency of fruiting and flowering trees. Similar findings in deed by Borghesio and Laiolo, (2004) avian species seasonally shift their diet to feed on a different set of resources.

The lowest diversity of birds in farmland was recorded during dry season. This might be because the farmlands are covered by major crops such as sorghum, maize (Zeamayz) and different vegetables, and thus food availability gets depleted after the harvesting period during the dry season. Rana (2005) also reported that intensive farming in natural habitats affects the diversity of species. Additionally, land conversion for agricultural expansion might force birds to migrate to nearby other habitats. Among the three habitat types shade coffee had the highest

relative abundance and diversity of forest dependent guild including visitors and generalist only highest forest specialist in natural forest. Changes in vegetation composition and structure caused by human disturbance in our study station (Asefa *et al.*, 2015a, 2015b) have led to considerable changes in bird richness, abundance, and assemblage composition. The findings suggested that shade coffee may be beneficial for generalist species (including several migratory species but poor for forest specialists. Other similar suggestions have been made for the region, for example “bird friendly” shade coffee farms, that, although they result in the loss of primary forests, maintain high overall avian species richness (Buechley *et al.*, 2015). It is widely believed that generalist species would benefit from disturbance, while specialists may be negatively affected (Vazquez & Simberloff, 2002). The highest similarity of avian species was recorded between the shade coffee and natural forest habitats during the wet season, while the least species similarity was recorded between natural forest and farmland habitats during dry (Table 6). Bird communities strongly respond to seasonal fluctuations in resource availability, but responses differ between feeding guilds (Mulwa *et al.*, 2013). Number of species recorded from all point count station was higher in shade coffee than other habitat types (Fig. 2).

Comparison of the significance differences in shade coffee frugivores, carnivores, Nectarivores and forest-dependent birds (e.g. visitors and generalist) while; natural forest habitat had insectivores & forest specialist with (p value < 0.05) and overall guild types shows higher significant differences in shade coffee than other habitat type. Agroforestry systems with some native cover also maintain a significantly larger proportion of important avian guilds such as frugivores, omnivores and carnivores, and their respective services (Sekercioglu 2012). There was a significant difference in species richness among the three vegetation cover types ($F_{2, 177} = 9.08, P = 0.000$), with shade coffee recording the highest overall species richness and farmland the lowest (Table 11). The mean differences of bird abundances and species richness among the three habitat types (I-J) results showed that shade coffee had higher bird richness and farmland the lowest bird richness (Table 11). The results suggest that the greater relative abundance and richness of frugivores, Carnivores and strata generalists in shade coffee systems may thus, be positively related to disturbance, Shade coffee systems with some native cover maintain a significantly larger proportion of important avian guilds such as frugivores, carnivores, nectarivores and also resources provided by shade

trees and also shade coffee were open vegetation complexity. Frugivores seem to respond flexibly to seasonal fluctuations, for instance by tracking fruit resources across habitat boundaries, insectivorous birds appear to be more susceptible to the expected increase in seasonal fluctuations in resource availability (Mulwa *et al.*, 2013).

The specific value for frugivores birds of just a few fruit-producing shade trees has been documented (Carlo *et al.*, 2004). The findings of Jones *et al.*, (2002) birds in shaded coffee plantations apparently forage mostly in the tree canopies, where the majority of arthropod (Greenberg *et al.*, 2000), fruit and nectar resources are located. Additionally, large and widely spaced shade trees can provide excellent feeding opportunities for frugivores, carnivores, and nectarivores, especially if the trees are native species list (Johnson *et al.*, 2011), (Komar, 2006) which is consistent with this results.

The highest relative abundance and diversity of insectivores was recorded in natural forest (Table 9 and fig. 4). This result is due to the natural forest shrubs themselves support notoriously more insect numbers, due to the presence of indigenes trees, heterogeneity and complexity of natural forest vegetation type is attract birds for nesting and detecting against prey. Insectivorous birds significantly reduce (by up to 80%) arthropod presence and leaf damage of the coffee shrubs themselves and other farms (Greenberg *et al.*, 2000). Similar finding is as surprising as predicted in the natural forest the greatest relative abundance of forest specialist birds and insectivores was recorded (Table 7 & 8). This result may be a natural forest habitat providing adequate foods and which had higher tree density and more diverse vegetation heterogeneity than the studded habitat. Additionally shade coffee habitat harbors less insect for insectivores bird guild..

Accordingly the findings and many researchers indicated that, less relative abundance of insectivores was recorded in shade coffee habitat and farmland. Thus, a reduction in the abundance of insectivorous species in shaded monoculture is probably related to seasonal changes in resource availability, coupled with impoverished tree diversity. Also insectivores influenced due to both defenses within the coffee leaves and farm partially due to insecticide application, but native flowering trees can provide both insect and nectar resources for birds (Kammerichs-Berke *et al.*, 2022).

The highest abundance of granivores in farmland was recorded among study stations. This could be attributable to availability of food resources associated with farmlands since

substantial amounts of weed-seed grains are held in cultivations and fallow lands that may provide food especially for seedeaters, canaries, doves, sparrows, and weavers. This is supported research done by(Ndang'ang'a *et al.*, 2013). Similar findings the increased presence of grasses in open agricultural areas contributes to the higher number of granivores birds which can become major seed predators and agricultural pests, especially when non-crop species are not producing seeds.

Granivores bird species were more common in farmlands than any other feeding guild (Mahiga, Samuel Njuki. 2016). In the study sites, the shade coffee mostly high and farmland less comprised both primary and secondary forest, in addition to crops with retained canopy trees, whereas the natural forest patches were typically dominated by natural forest growth with less shrubby understory and open habitat (Mitiku 2013, Asefa *et al.*, 2015b). Therefore, it is possible that the higher bird species diversity and abundance in the shade coffee resulted from the high diversity of structural habitat elements in these forests compared with the natural forest patches. Indeed, structural heterogeneity of vegetation is known to exert a stronger influence on bird diversity than canopy cover (Davies and Asner 2014). Comparisons with different analysis, birds have greater survivability, fitness, or efficiency in coffee plantations compared with other available habitats (natural or artificial), or any species selects coffee plantations over other accessible territories for foraging or breeding (Tabur, 2015, and Komar, 2006). This study supports the concept that shade coffee is valuable to birds in natural forests in the Belete montane forests of Ethiopia. This findings is by the line(Leyequién, De Boer, and Toledo, 2010), Belete shade coffee is rich in a variety of native woody trees and the open canopy is conducive to bird movement especially for visitors, generalist birds and frugivores, carnivores, and nectarivores because, it has a widely spaced shrub that easily provides food that are the reasons for the abundances. This research supported by Mulwa *et al.*, (2013) bird communities responses differ between feeding guilds. The findings investigated the highest overall bird relative abundance and diversity was recorded in shade coffee during study period. This is because; large and widely spaced shade trees can provide excellent feeding opportunities for many groups of birds especially if the trees are native species list. Conserving native trees in coffee and occasionally in farmland in the forms of shade, can conserve all groups of birds and even conserving multiple biodiversity. Conserving and managing shade-coffee and forest remnants for bird species should be considered as a

complementary rather than a contradictory strategy for bird conservation. Management efforts should therefore focus on conserving all forested habitats, including agroforestry systems, to maintain bird species composition and dynamics.

6. Conclusion

The distribution of birds in different habitats is based on the availability of food, and vegetation cover. Accordingly, the findings investigate the highest avian species diversity and relative abundance was recorded in shade coffee habitat during wet and dry sessions than natural forest and farmland. During wet season the highest similarity of avian communities between the shade coffee and natural forest habitats, while the least between natural forest and farmland habitats during dry season was recorded. Comparing avian guild level among habitat types there was also a greater bird diversity and abundance in shade coffee habitat including frugivores, carnivores, nectarines, and visitors while, in natural forest higher forest specialists and insectivores birds were recorded but less relative abundance was recorded in farmland at the study stations. This result is may be in shade coffee large and widely spaced shade trees and medium vegetation complexity makes favorable conditions for bird movement and can provide excellent feeding opportunities for the above bird guilds. Less abundance and diversity of insectivores and specialist avian guilds in shade coffee and farmland than in natural forest habitats of Belete forest. Because of simple vegetation heterogeneity in shade coffee, open farmland as well as poor abundance of insects impacted insectivores and forest specialist bird guild. Also forest specialist bird always needs interior undisturbed forest rarely in non-forest habitat. Additionally; applications of insecticide in shade coffee and farmland decrease the number of insects. The decline in bird populations on agricultural land is due to the destruction of wood plants increasing their vulnerability, and also poor fruit and nectars. Corroborating the present study avian diversity between primary forests and shade coffee farms in Ethiopia, our study supports the value of human-modified habitats for bird conservation, even if they are somewhat disturbed.

7. Recommendation

The Belete forest is not a protected area like a truism, and further research is needed to create management and farmers awareness and show more birds like forest specialist birds, and insectivores in shade coffee and farmland habitats. Moderating native trees in farmland just like the shade coffee vegetation surrounding the Belete forest and can spare all groups of birds and all biodiversity from termination. Farmers should be encouraged to plant indigenous tree species on the farms to attract ecological services provided by birds e.g. pest control, pollination, and seed dispersal additionally, raise national and individual coffee incomes. Conserving native trees in coffee and occasionally in farmland in the forms of shade, can conserve all groups of birds and even conserving multiple biodiversity.

References

- Abrahamczyk, stefan, and michael kessler. 2010. “hummingbird diversity, food niche characters, and assemblage composition along a latitudinal precipitation gradient in the bolivian lowlands.” *Journal of ornithology* 151(3): 615–25
- Adhikari, Jagan Nath, Bishnu Prasad Bhattarai, and Tej Bahadur Thapa. 2019. “factors affecting diversity and distribution of threatened birds in chitwan national park, nepal.” *Journal of threatened taxa* 11(5): 13511–22.
- African, This, and Evan Buechley. 2015. “Shade Coffee Is for the Birds : But Even in the Ethiopian Home of Arabica , Forests Are Needed Too.” (February): 1–4.
- Arendt, Wayne J. *et al.*, 2020. “Avian Community Density and Distribution Patterns among Nicaraguan Conventional and Organic Shade-Coffee Plantations.” *Agricultural Sciences* 11(01): 27–53.
- Azman, and Nur M. 2011. “avian diversity and feeding guilds in a secondary forest, an oil palm plantation and a paddy field in riparian areas of the kerian river basin, perak, malaysia.” *Tropical life sciences research* 22(2): 45–64.
- Bakermans, Marja H., Amanda D. Rodewald, Andrew C. Vitz, and Carlos Rengifo. 2012. “Migratory Bird Use of Shade Coffee: The Role of Structural and Floristic Features.” *Agroforestry Systems* 85(1): 85–94.
- Baumann, Matthias *et al.*, 2020. “declining human pressure and opportunities for rewilding in the steppes of eurasia.” (may): 1058–70.
- Bain, Glen C. *et al.*, 2020. “changing bird communities of an agricultural landscape: declines in arboreal foragers, increases in large species.” *Royal society open science* 7(3).
- Betts, Matthew G. *et al.*, 2022. “Forest Degradation Drives Widespread Avian Habitat and Population Declines.” *Nature Ecology and Evolution* 6(6): 709–19.
- Binyam T., Hailu Ab , Eduardo Eiji Maeda, A , Janne Heiskanen A , Petri Pellikka . 2015. Long-term effects of different forest regeneration methods on mature forest birds publications. A university of helsinki, department of geosciences and geography, baddis ababa university, p.o.box: 1176.

- Buechley, Evan R., Cağan H. Şekerciöğlü, Anagaw Atickem, Gelaye Gebremichael., James Kuria Ndungu, Bruktawit Abdu Mahamued, Tifases Beyene, Tariku Mekonnen, And Luc Lens. 2015. “importance of ethiopian shade coffee farms for forest bird conservation.” *Biological conservation* 188:50–60.
- Buechley, Evan R. *et al.*, 2015. “Importance of Ethiopian Shade Coffee Farms for Forest Bird Conservation.” *Biological Conservation* 188: 50–60.
- Bytebier, Benny, and Hubert kurzweil. 2005. “field guide to ethiopian orchids.” *Journal of east african natural history* 94(2): 371–72
- Colorado, G. 2011. “birds and mixed-species flocks in the andes.” *Dissertation*.
- Dawson, Jeff *et al.* , 2011. “bird communities of the lower waria valley , morobe province , papua new guinea : a comparison between habitat types.” 4(3): 317–48.
- Food and agriculture organization. 2016. Food and agriculture organization of the united nations *state of the world 's forests*
- Forest, Garemba. 2019. “species composition, relative abundance and habitat association of birds in arbegona, garemba forest, southern ethiopia.” *Advances in life science and technology*(march).
- Gray, Michael a., sandra l. Baldauf, peter j. Mayhew, and jane k. Hill. 2007. “the response of avian feeding guilds to tropical forest disturbance.” *Conservation biology* 21(1): 133–41.
- Getu Alemayehu (2017). Plant diversity and ethnobotany of medicinal and wild edible plants in amaro district of southern nations, nationalities and peoples region and gelana district of oromia region, southern ethiopia.phd thesis, addis ababa university, ethiopia.
- Gebrehiwot, K, and k Hundera. 2014. “species composition, plant community structure and natural regeneration status of belete moist evergreen montane forest, oromia regional state, southwestern ethiopia.” *Momona ethiopian journal of science* 6(1): 97.
- Gove, Aaron D., Kristoffer Hylander, Sileshi Nemomisa, and Anteneh Shimelis. 2008. “Ethiopian Coffee Cultivation-Implications for Bird Conservation and Environmental Certification.” *Conservation Letters* 1(5): 208–16.
- Hernandez, Sonia M. *et al.*, 2013. “coffee agroforests remain beneficial for neotropical bird community conservation across seasons.” *Plos one* 8(9).
- Haslem, Angie, and Andrew F. Bennett. 2008. “Birds in Agricultural Mosaics: The Influence of Landscape Pattern and Countryside Heterogeneity.” *Ecological Applications* 18(1):

185–96.

- Holbech, Lars H. 2005. “the implications of selective logging and forest fragmentation for the conservation of avian diversity in evergreen forests of south-west ghana.” *Bird conservation international* 15(1): 27–52.
- Holmes, Richard T. 2000. “determinants communities : of guild structure in forest bird an intercontinental comparison ’.” (1979).
- James, F. C & Wamwer. (1982). Relationships between temperate forest bird communities and vegetation structure. *Ecology*, 63, 159-171.
- Johnson, Ron J., Julie A. Jedlicka, John E. Quinn, and James R. Brandle. 2011. *Global Perspectives on Birds in Agricultural Landscapes*.
- Juma, Frank, Frank A Fogarty, Peter Njoroge, and Matthew D Johnson. 2022. “Bird Abundance and Diversity in Shade Coffee and Natural Forest in Kenya.” *Global Ecology and Conservation* 39: e02296.
- Kattan, Gustavo H., Humberto Alvarez-López, And Manuel Giraldo. 1994. “fragmentación forestal y extinción de pájaros: san antonio 80 años más tarde.” *Conservation biology* 8(1): 138–46.
- Keenan, Rod. 2018. “forest loss has halved in the past 30 years, latest global update shows.” *The conversation*.
- Kissling, W. Daniel, Carsten Rahbek, And Katrin Böhning-Gaese. 2007. “food plant diversity as broad-scale determinant of avian frugivore richness.” *Proceedings of the royal society b: biological sciences* 274(1611): 799–808.
- Komar, Oliver. 2006. “Priority Contribution. Ecology and Conservation of Birds in Coffee Plantations: A Critical Review.” *Bird Conservation International* 16(1): 1–23.
- Korňan, M. *et al.*, 2013. “convergence in foraging guild structure of forest breeding bird assemblages across three continents is related to habitat structure and foraging opportunities.” *Community ecology* 14(1): 89–100.
- KoLeyequién, Eurídice, W. F. de Boer, and Víctor M. Toledo. 2010. “Bird Community Composition in a Shaded Coffee Agro-Ecological Matrix in Puebla, Mexico: The Effects of Landscape Heterogeneity at Multiple Spatial Scales.” *Biotropica* 42(2): 236–45.
- Lack, P C, W leuthold, and C Smeenk. 1980. “check-list of the birds of tsavo east national park, kenya.” *Journal of the east africa natural history society* 170: 1–25.

- Lee, Myung Bok, And James A. Martin. 2017. “avian species and functional diversity in agricultural landscapes: does landscape heterogeneity matter?” *Plos one* 12(1).
- Lopes, Leonardo E., Alexandre M. Fernandes, Matthew C.I. Medeiros, And Miguel Ângelo Marini. 2016. “a classification scheme for avian diet types.” *Journal of field ornithology* 87(3): 309–22.
- Lupatini, Manoeli *et al.*, 2013. “land-use change and soil type are drivers of fungal and archaeal communities in the pampa biome.” *World journal of microbiology and biotechnology* 29(2): 223–33.
- Matthias De Beenhouwer And Jan Mertens. 2015. “Biodiversity express survey (bes) 3, belete-gera forest, Ethiopia, 2014.” (august): 1–24.
- Mahiga, Samuel Njuki. 2016. “Influence of vegetation type and structure on forest bird.” (March).
- Melo, Marcos Antônio, Marco Aurélio G. DA SILVA, and Augusto João Piratelli. 2020. “Improvement of Vegetation Structure Enhances Bird Functional Traits and Habitat Resilience in an Area of Ongoing Restoration in the Atlantic Forest.” *Anais da Academia Brasileira de Ciencias* 92: 1–22.
- Mitiku, A. A. (2013). Afromontane avian assemblages and landuse in the Bale Mountains of Ethiopia: Patterns, processes and conservation implications. M.S. thesis, University of Pretoria, Pretoria, South Africa.
- Mulwa, Moses, Mike Teucher, Werner Ulrich, and Jan Christian Habel. 2021. “Bird Communities in a Degraded Forest Biodiversity Hotspot of East Africa.” *Biodiversity and Conservation* 30(8–9): 2305–18.
- Mulwa, ronald k., eike lena neuschulz, katrin böhning-gaese, and matthias schleuning. 2013. “seasonal fluctuations of resource abundance and avian feeding guilds across forest-farmland boundaries in tropical africa.” *Oikos* 122(4): 524–32.
- Myers, Samantha. 2018. “Avian Diversity and Abundance in Three Different Vegetative Landscapes around a Shade-Grown Coffee Plantation on Mount Totumas , Chiriquí Highlands , Panamá.” *Independent Study Project (ISP)*: 1–27
- Nalwanga, Dianah, Derek Pomeroy, Juliet Vickery, and Philip W. Atkinson. 2012. “A comparison of two survey methods for assessing bird species richness and abundance in tropical farmlands.” *Bird study* 59(1): 83–95.

- Newbold, Tim, Hollie Booth, Drew W Purves, And Proc R Soc B. 2013. “ecological traits affect the response of tropical forest bird species to land-use ecological traits affect the response of tropical forest bird species to land-use intensity receive free email alerts when new articles cite this article - sign up in the bo.” (january).
- O’Brien, Timothy TG, and MF Margaret Kinnaird. 2003. “Caffeine and Conservation.” *Science* 300(5619): 587.
- Ojija, Fredrick, and Ndaki Marco Manyanza. 2022. “Community Structure, Conservation Status, and Functional Groups of Bird Species in Mbeya Range Forests, Tanzania.” *Journal of Basic & Applied Sciences* 18: 33–46.
- Rahmani, Asad R., M. Zafar-Ul Islam, and Raju M. Kasambe. 2016. “important bird and biodiversity areas in india priority sites for conservation.” *Bombay natural history society, indian bird conservation network, royal society for the protection of birds and birdlife international (u.k.)*. (november): 157–58.
- Reid, Walter V. 1998. “Biodiversity hotspots.” *Trends in ecology and evolution* 13(7): 275–80.
- Riva, Federico, and Lenore Fahrig. 2022. “Small Patches Are Disproportionately Important for Biodiversity Conservation, despite Ecosystem Decay.” *Research Square - Preprint* (June): 1–18.
- Sekercioglu, Cagan H. 2012. “Bird functional diversity and ecosystem services in tropical forests, agroforests and agricultural areas.” *Journal of ornithology* 153(suppl. 1): 153–61.
- Sena Gashe, Afework Bekele, Girma Mengesha, and Addisu Asefa. 2018. “Consequences of deforestation and bird diversity in the hamuma forest, south-western ethiopia.” *Ethiopian journal of science* 41(1): 15–33.
- Smith, C. *et al.*, 2015. “Bird communities in sun and shade coffee farms in kenya.” *Global ecology and conservation* 4: 479–90. [Http://dx.doi.org/10.1016/j.gecco.2015.09.004](http://dx.doi.org/10.1016/j.gecco.2015.09.004)
- S. N. Mahiga, Influence of vegetation type and structure on forest bird community composition at Nanyuki forest block , westernMt. Kenya (Unpublished masters thesis [master, thesis], KaratinaUniversity, Karartina, Kenya, 2016.
- Sodhi, Navjot S., Cağan H. Şekercioglu, Jos Barlow, and Scott K. Robinson. 2011. “ecological functions of birds in the tropics.” *Conservation of tropical birds* (december): 68–108.
- Sohil, Asha, and Neeraj Sharma. 2020. “Assessing the Bird Guild Patterns in Heterogeneous

- Land Use Types around Jammu, Jammu and Kashmir, India.” *Ecological Processes* 9(1).
- Soini, Eija. 2006. “Bird Diversity and Land Use on the Slopes, Tanzania.” *Africa Zoology* 41(2). <http://africanzoology.journals.ac.za/pub/article/view/355>.
- Subasinghe, Kalya, Amila P. Sumanapala, and Senarathge R. Weerawardhena. 2014. “the impact of forest conversion on bird communities in the northern flank of the knuckles mountain forest range, Sri Lanka.” *Journal of Asia-Pacific Biodiversity* 7(4): 367–73. [Http://dx.doi.org/10.1016/j.japb.2014.07.004](http://dx.doi.org/10.1016/j.japb.2014.07.004).
- Swallow, Brent *et al.*, 2006. “The Potential for Agroforestry to Contribute to the Conservation and Enhancement of Landscape Biodiversity.” *World Agroforestry into the Future*: 95–101.
- Taye, Dessalegn, Melaku Wale, and Bahir Dar. 2017. “diversity, abundance and threats of avian species in Koga Dam and its surroundings, north-western Ethiopia.” 40(2): 60–73.
- Tejeda-Cruz, César, and William J. Sutherland. 2004. “bird responses to shade coffee production.” *Animal Conservation* 7(2): 169–79.
- Tesfahunegny, Weldemariam. 2016. “a catalogue for endemic birds of Ethiopia a catalogue for endemic birds of Ethiopia.” (January).
- Tolimir, Miodrag *et al.*, 2020. “the conversion of forestland into agricultural land without appropriate measures to conserve some leads to the degradation of physical and rheological soil properties.” *Scientific Reports* 10(1): 1–12.
- Tropical forests: the main deforestation fronts author (s): Norman Myers published by: Cambridge University Press stable url: <https://www.jstor.org/stable/44521724> tropical forests: the main deforestation fronts *.” 1993. 20(1): 9–16.
- Vancutsem, Christelle *et al.*, 2021. “Long-Term (1990–2019) Monitoring of Forest Cover Changes in the Humid Tropics.” *Science Advances* 7.
- Vazquez, D. P. & Simberloff, D. (2002). Ecological specialization and susceptibility to disturbance: conjectures and refutations. *Am. Nat.* 159: 606–623.
- Vergara, Pablo M. *et al.*, 2021. “landscape-scale effects of forest degradation on insectivorous birds and invertebrates in Austral temperate forests.” *Landscape Ecology* 36(1): 191–208.
- Vetter, John. 2009. “impacts of deforestation on the conservation status of endemic birds in the north Maluku endemic bird area from 1990–2003.” (May): 88.
- Watson, Keri B. *et al.*, 2019. “effects of human demand on conservation planning for

biodiversity and ecosystem services.” 33(4): 942–52.

Whelan, Christopher J., Daniel G. Wenny, and Robert J. Marquis. 2008. “Ecosystem services provided by birds.” *Annals of the new york academy of sciences* 1134(November 2017).

Appendixes

Appendix. 1

Registration of birds and their numbers in different cover types, noting their order, family, seasons, forest dependency guild and foraging guilds in Beleta forest in shebe district, January 2022- February 2023. Bird names are arranged taxonomically and are assigned the following numbers (Eanhs, 2009); forage guilds are assigned based on the major food items described by (Kissling *et al.*, 2007). Relative abundance.

common name	Species name	No of spp. among habitats & guilds						Feeding guild	Forest association
		shade coffee		Natural forest		Farmland			
		wet	dry	wet	dry	wet	dry		
Africanparadise flycatcher	<i>Terpsiphoneviridis</i>	7	0	9	6	0	0	I	f
Spotted flycatcher	<i>Muscicapa striata</i>	3	0	2	0	0	0	I	f
African shrike- flycatcher	<i>Bias flammulatus aequatorialis</i>	0	0		13	0	0	I	FF
Abyssinian salty flycatcher	<i>Dioptrornis chocolatinus</i> EE	0	0	9	4	0	0	I	FF
Northern black flycatcher	<i>Melaenornis edolioides</i>	0	0	8	0	0	0	I	FF
White-browed robin-chat	<i>Cossypha h. heuglini</i>	0	0	18	0	0	0	I	FF
Semi collared flycatcher	<i>Ficedula semitorquata</i>	0	0	0	39	0	0	I	Nonf
Ruppell's black-chat	<i>Myrmecocichla melaena</i>	0	7	9	8	0	0	I	FF
Pale flycatcher	<i>Bradornis pallidus</i>	5	0	0	1	0	0	I	FG
African dusky flycatcher	<i>Muscicapa adusta</i>	5	0	0	7	0	0	I	f
Dusky crested flycatcher	<i>Trochocercus nigromitratus</i>	8	0	6	0	0	0	I	FF
Abyssinian oriole	<i>Oriolus monacha</i>	6	0	0	0	0	0	I	FG
Black-headed oriole	<i>Oriolus larvatus rolli</i> EE	21	0	0	0	0	0	F	FF
Western black-headed oriole	<i>Oriolus brachyrhynchus laetior</i>	19	0	0	0	0	0	F	FG
Montane oriole	<i>Oriolus percivali</i>	0	0	15	0	0	0	I	FF

Whit crowned starling	<i>Lamprotornis albicapillus</i>	8	0	0	0	0	0	F	f
Magpie starling	<i>Speculipastor bicolor</i>	9	0	0	0	0	0	F	f
Greeter blue-eared starling	<i>Lamprotornischalyb aeus</i>	9	0	0	0	0	0	F	f
Fischer's greenbul	<i>Phyllastrephus fischeri</i>	0	0	1	0	0	0	I	FF
Terrestrial brownbul	<i>Phyllastrephus terrestris suahelicus</i>	0	0	0	0	0	0	I	f
Common bulbul	<i>Pycnonotus barbatus</i>	0	12	0	0	4	1	O	FG
Tropical boubou	<i>Laniarius ethiopicus</i>	0	0	0	0	0	3	I	f
Eastern nicator-	<i>Nicator gularis</i>	17	0	0	3	0	0	I	f
Red-billed oxpecker	<i>Buphagus erythrorhynchus</i>	0	0	0	1	0	0	I	f
Mountain wagtail	<i>Motacilla aguimp vidua</i>	0	0	4	0	0	0	I	f
African pipit	<i>Anthus cinnamomeus</i>	0	0	0	0	6	0	I	f
Abyssinian white-eye	<i>Zosterops abyssinicus flavilateralis</i>	0	0	23	0	0	0	I	Nonf .
Broad-ringed white-eye	<i>Zosterops poliogastrus</i>	47	22	3	2	0	2	F	FG
African emerald cuckoo	<i>Chrysococcyx cupreus</i>	0	0	0	2	0	0	I	FF
Red-chested cuckoo	<i>Cuculus s. Solitaries</i>	0	0	6	0	0	0	I	FF
Little weaver	<i>Ploceus luteolus luteolus</i>	15	0	4	3	0	0	G	f
Black capped social weaver	<i>Pseudonigrita cabanisi</i> E	0	8	10	8	0	0	I	FF
Baglafaecht weaver	<i>P. Baglafaecht</i>	0	0	2	10	0	0	I	FF
Lesser masked weaver	<i>Ploceus i.intermedius</i>	0	0	0	3	5	0	G	f
Golden palm weaver	<i>Ploceus bojeri</i>	12	0	0	0	0	3	F	f
Ruppell's weaver	<i>Ploceus galbula</i>	23	11	1	0	5	0	F	f
Grey headed sparrow	<i>Passer griseus</i>	0	0	3	1	5	0	G	f
House sparrow	<i>P. Domesticus indicus</i>	0	0	0	0	0	6	G	f
Pin-tailed whydah	<i>Vidua macroura</i>	0	0	2	0	1	0	G	FG
Abyssinian catbird	<i>Sylvia galinieri</i> E	0	0	34	0	2	2	I	FF
Yellow-vented eremomwla	<i>Eremomela flavicrissalis</i>	8	3	8	1	5	1	I	f
Variable sunbird	<i>Nectariniavenusta</i>	11	0	0	8	0	0	N	f

Olive sunbird										Nonf
	<i>Nectarinia olivacea</i>	0	0	7	0	3	0	N	.	
Tacazze sunbird	<i>Nectarinia tacazze</i>	0	0	6	0	0	0	N	FF	
Scarlet-chested sunbird	<i>Chalcomitra</i>									
	<i>senegalensis</i>	2	0	1	0	0	0	N	f	
African firefinch	<i>Lagonostictarubric</i>									Nonf
	<i>atahildebrandti</i>	9	0	0	0	1	0	G	.	
Red-billed firefinch	<i>L.</i>									
	<i>senegalaruberrima</i>	0	0	0	0	13	0	G	f	
Black and white manikin	<i>Lonchura bicolor</i>	12	0	0	0	21	0	G	FG	
Bronze manikin	<i>Lonchura cucullata</i>									
	<i>scutata</i>	0	0	0	0	13	6	G	FF	
Common fiscal	<i>Zootheraguttatafisc</i>									
	<i>heri</i>	0	0	0	4	0	0	I	f	
Taita fiscal	<i>Turdusolivaceus</i>									
	<i>abyssinicus</i>	0	14	0	3	2	0	O	FG	
Spotted ground thrush	<i>Lanius collarish</i>									
	<i>umeralis</i>	6	3	2	0	0	0	I	FG	
Olive thrush	<i>Laniusdorsalis</i>	0	0	3	0	0	0	I	f	
Abyssinian gruound trush	<i>Geokichla piaggiae</i>	23	0	5	2	0	0	I	FF	
Yellow-crowned canary	<i>Serinus s.canicollis</i>									
	<i>flavertex</i>	10	0	0	4	3	0	G	FG	
Ethiopian swallow										Nonf
	<i>Hirundo aethiopica</i>	11	0	0	0	4	8	C	.	
African pygmy-kingfisher	<i>Ispidina picta</i>	7	0	14	4	0	0	I	f	
Woodland kinfisher	<i>Halcyon s.</i>									
	<i>Senegalensis</i>	7	0	0	0	0	0	O	f	
Littile bee-eater	<i>Eurystomus</i>									
	<i>glaucurus</i>	2	0	1	0	0	0	G	FG	
Cinnamon-chested bee-eater	<i>Merops pusillus</i>									
	<i>cyanosticus</i>	5	2	5	0	0	0	I	f	
Swallow-tailed bee-eater	<i>Meropsoreobates</i>	4	1	3	1	0	0	I	FF	
Somali bee-eaters	<i>Merops hirundineus</i>	4	0	1	0	0	0	I	FF	
Somali-bee-eaters	<i>Merops revoilii</i>	6	0	0	0	0	0	I	FG	
Broadbilled roller	<i>Merops revoilii</i>	0	0	6	0	0	0	I	FG	
African hawk-eagle	<i>Aquila spilogaster</i>	0	1	0	0	0	0	C	f	
African goshawk	<i>A.tachirosparsimfas</i>									
	<i>ciatus</i>	0	3	1	0	0	1	C	FG	
Augur buzzard	<i>Buteoa.augur</i>	0	5	0	0	4	0	C	f	
Lizardbuzzard	<i>Caupifalco.m.mono</i>									
	<i>gramicus</i>	3	0	2	0	0	0	C	f	
African harrier-hawk	<i>Polyboroides t.</i>									
	<i>Typus</i>	7	0	1	0	0	0	C	FG	
Eurasian sparrowhawk	<i>Accipiter nisus</i>	0	3	0	0	0	0	C	FG	
Common buzzard	<i>Buteo buteo</i>	6	3	2	0	0	0	C	FG	

Tawny eagle	<i>Aquila rapa</i>	0	0	0	0	1	0	C	FG
Ayre's hawk eagle	<i>Hieraaetus ayresii</i>	24	0	1	0	0	0	C	f
Black-chested snake eagle	<i>Circaetus pectoralis</i>	0	0	1	0	1	0	C	f
Tambourine dove	<i>Turturympanistria</i>	6	0	6	0	0	0	G	FF
Laughing dove	<i>Streptopelia senegalensis</i>	4	0	0	0	4	2	G	f
Lemon dove	<i>Aploppelial.larvata</i>	17	15	0	2	2	0	F	FG
African green pigeon	<i>Treroncalvagibberifrons</i>	20	0	0	0	0	0	F	FF
Dusky turtle dove	<i>Streptopelia lugens</i>	4	0	0	0	6	0	G	FF
Blue-spotted wood dove	<i>Columba albitorques</i> E	2	0	4	0	0	2	G	FG
Prince ruspoli's turaco	<i>Turaco ruspolii</i>) E	5	1	0	2	0	0	F	f
Bare-faced go-away bird	<i>Corythaixoides personatus</i>	4	2	0	1	0	0	F	f
Klaas's cuckoo	<i>Chrysococcyx klaas</i>	4	0	0	0	2	1	I	f
Blue headed coucal	<i>Coliusstriatuskikuyuensis</i>	15	0	0	0	8	0	F	f
Abyssinian ground hornbill	<i>Bucorvus abyssinicus</i>	10	0	0	0	2	0	O	f
Silvery cheeked horn bill	<i>Bycanistesbrevis</i>	24	6	0	0	0	0	F	FF
Redbilld horn bill	<i>Tockuseerythrorhynchus</i>	5	1	2	0	0	0	F	FG
Trumpeter hornbill	<i>Bycanistes bucinator</i>	9	0	0	6	0	1	G	f
Forest wood-hoopor	<i>Phoeniculus castaneiceps brunneiceps</i>	0	4	4	0	0	0	I	FF
White-heded wood-hoopor	<i>Phoeniculus bollei jacksoni</i>	12	2	1	0	0	0	F	FG
Golden-backed woodpecker	<i>Dendropicos abyssinicus</i> E	5	0	2	0	0	0	I	f
Brown-backed woodpecke	<i>Picoidesobsoletusingenens</i>	0	0	0	0	2	0	I	f
African gray woodpecker	<i>Dendropicos goertae</i>	0	0	0	0	0	0	I	f
Cardinal woodpecker	<i>Dendropicos pusillusaffinis</i>	0	0	0	0	0	0	I	f
Doble-toothed barbet	<i>Lybius bidentatus aequatorialis</i>	1	0	0	0	0	0	F	FG
White-rumped swift	<i>Apuscaffer</i>	0	0	23	12	0	0	I	FF
Speckled mousebird	<i>Coliusstriatuskikuyuensis</i>	5	0	0	0	8	0	F	f
Scaly francolin	<i>Pternistis</i>	8	0	3	0	2	0	O	FG

Hadada ibis	<i>squamatus</i>								
	<i>Bostrychia</i>								
	<i>hagedash</i>								
	<i>brevirostris</i>	0	0	0	8	4	0	I	FG
African wood owl	<i>Strixwoodfordiinigr</i>								
	<i>icantior</i>	0	3	0	0	0	0	O	FG
Bar-tailed trogon	<i>Apaloderma</i>								
	<i>vittatum</i>	2	0	0	0	0	0	I	f
Yellow-fronted parrot	<i>Poicephalus</i>								
	<i>flavifrons</i> E	13	10	0	0	2	0	F	FG
Sprosser nightingale	<i>Luscinia luscinia</i>	0	0	19	11	0	0	I	FF

EE= refers endemic to Ethiopia & Eretria, E = endemic to Ethiopia, FF= forest specialist bird, f= forest visitors, FG= forest generalist, Nonf.= nonforest bird, I= insectivore, G= granivores, F= frugivores, N= nectarivores, C= carnivores, O= omnivores, Wet= wet season and Dry refers= dry season.

Appendix 2.

Appendix 2 .1. some pictures shows during establishing sample piloting study area, counting and recording birds from Belete forests shebe-sombo district south western Oromia, Ethiopia and some bird pictures recorded among different habitat types January to August 2023.



(Fig1)



Fig2



Fig 3



Fig 4

Fig 1, 2, 3 & 4 shows during establishing line transect and recording birds from point counts in study area January 2023- August 2023.

Appendix 3. Pictures of birds recorded among different study areas(shade coffee , natural forest and farmland) forest birds of Belete forest shebe sombo district south-western Oromia, Ethiopia January to August 2023.



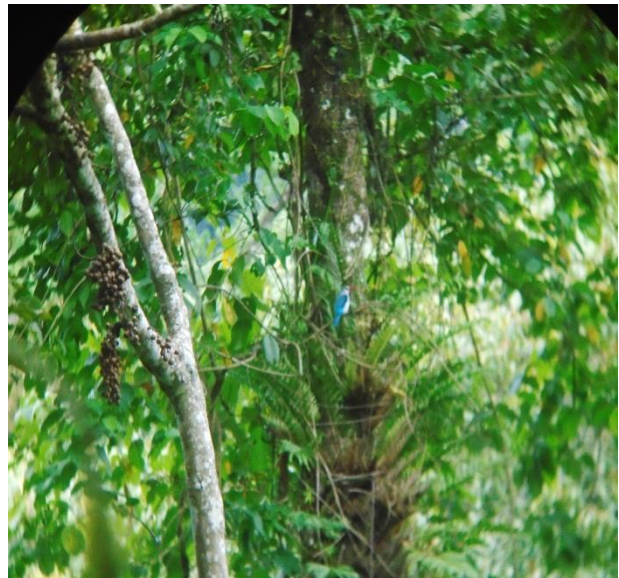
(Fig 5)



(Fig 6)



(Fig 7)



(Fig 8)

Figure 5, 6, 7, & 8 Silvery cheeked hornbill(*Bycanistes brevets*) in shade coffee, African boubou (*Laniarius Ethiopicus*) in farmland, Little bee-eater (*Eurystomus glaucurus*) & woodland kingfisher(*Halcyons senegalensis*) in natural forest was recorded among the habitats respectively.



Fig 9 : African paradise flycatcher (*Terpsiphoneviridis*).