



JIMMA UNIVERSITY
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SCHOOL OF GRADUATE STUDIES
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Diversity, Relative abundance and Habitat preference of Medium and Large sized Mammals in Babiya Folla Montane Forest, Limmu Kossa District, Jimma Zone, South West, Ethiopia

By: Birhanu Takele

Advisor: Tadesse Habtamu (PhD)

Co advisor: Tsegaye Gadisa (PhD)

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Declarations

This is to certify that the thesis titled "Diversity, relative abundance, and habitat preference of medium and large-sized mammals in Babiya Folla montane Forest, Limmu Kossa District, Jimma Zone, South West Ethiopia" has been submitted in partial fulfillment of the requirements for the degree of Masters of Science in Ecology and Systematic Zoology. This work, conducted by Birhanu Takele Gebre, is an original piece that has not been previously submitted to any other university, college, or institution to obtain any other master's degree, bachelor's degree, or certificate. The assistance received during this investigation, the reference books, and journals used have been duly acknowledged.

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Acronyms/Abbreviations

ANOVA	Analysis of variance
BFMF	Babiya Folla montane Forest
CF	Coffee forest
EWCA	Ethiopian Wildlife Conservation Authority
GPS	Global position system
HWLC	Human wildlife conflict
IOBC	Institute of Biodiversity Conservation
IUCN	International Union for Conservation of Natures
NF	Natural forest
NP	National park
OFA	Oromia forest authority
SCF	Semi coffee forest

Abstract

Mammals are a diverse group of animals that hold ecological and economic significance, are impacted by various factors that affect their distribution and abundance. This study was conducted to assess the diversity, relative abundance, and habitat preference of medium and large-sized mammals in Babiya Folla montane forest southwestern Ethiopia from February to July 2023. The area was categorized into three habitats: Coffee forest, Semi coffee forest, and Natural forest. Data was collected using line transects, camera traps, and interview methods. The line transects were established and representative sample transects were randomly selected from each habitat for the survey. R statistics (R version 4.2.2) with a vegan package was used to analyze the diversity, richness and evenness of the species. The effect of habitat, season, and its combined effect on the diversity, richness, and evenness of the species were analyzed by ANOVA. Chi-square test was used to compute the difference in the abundance of species between seasons and among habitats. A total of 2803 individual mammals counted that distributed into 22 species belong to six orders and twelve families were recorded for the area. The highest diversity ($H=2.08 \pm 0.02$), (1.86 ± 0.029), and richness ($R=12.25 \pm 1.03$), (11.5 ± 0.29) was recorded in the natural forest during wet and dry seasons respectively. The impact of habitats and season on diversity and richness was significant ($F_{2,10}=7.461, p < 0.05$), ($F_{2,10}=29.29, p < 0.05$), and ($F_{2,10}=24, p < 0.05$), ($F_{2,10}=14.43, p < 0.05$) during dry and wet seasons, respectively. However, there was no significant effect on species evenness ($F_{2,10}=0.78, p > 0.05$) and ($F_{2,10}=3.16, p > 0.05$) during dry and wet seasons, respectively. The combined effect of habitat and season was significant ($F_{2,10}=6.751, p < 0.05$) on diversity. However, there was no significant combine effect on richness ($F_{2,10}=1.895, p > 0.05$) and evenness ($F_{2,10}=2.738, p > 0.05$). The olive baboon was the most abundant (31.46%) and the least were honey badger, leopard, serval cat, and spotted hyena (0.035%) each. There was no significant difference ($X^2=0, DF=1, p > 0.05$) in species abundance between seasons. However, there were significant differences in species abundance between CF and SCF ($X^2=421.003, DF=1, P < 0.05$), between CF and NF ($X^2=440, DF=1, P < 0.05$) and between SCF and NF habitats ($X^2=467.5, DF=1, P < 0.05$). The natural forest habitat was highly preferred by the mammals. From the camera trap data, the olive baboon (31.90%) was also the most abundant, and the white-tailed mongoose (0.48%) had the least. Settlement, habitat loss and modification as a result of encroachment for coffee plantation, deforestation, charcoaling and griddling were the main threats to mammals. Therefore, all concerned bodies should take immediate action to conserve the forest biodiversity including medium and large sized mammal species in the area.

Key words: Abundance, Babiya Folla, Distribution, Diversity, Mammals

1. INTRODUCTION

1.1. Background of the study

Mammals, which give live birth and nourish their young with milk from mammary glands (Macdonald, 2019), are classified into three groups based on their body weight. As per this classification, mammals weighing less than 2 kg are categorized as small, those weighing between two and seven kg are considered medium and all mammals weighing over seven kg are classified as large (Sutherland, 2006). They are a diverse group of animals that have adapted and are found in various regions around the world.

Mammals hold significance both ecologically and economically. They serve as vital elements of biodiversity worldwide (Kebede, 2018). Specifically, the presence of medium and large sized mammals greatly contributes to the effective operation of ecosystems (Kebede, 2018). They also play vital roles in ecosystems by performing essential services like regulating insect populations, dispersing seeds, and pollinating plants. Additionally, they serve as indicators of overall ecosystem health (Jones and Safi, 2011). Furthermore, mammals are sources of income and food for humans.

Ethiopia, a landlocked country in the horn of Africa, is renowned for its diverse ecosystems and varying altitudes (Wale and Yihune, 2021), which have significantly contributed to the extensive variety of animal species (Fetene et al., 2019). Consequently, Ethiopia is recognized as one of the most biodiverse countries in Africa (Wale and Yihune, 2021). Mammals are found in a wide range of ecosystems, from deserts to afro-alpine habitats (Ceballos and Ehrlich, 2002), and their diversity and distribution are closely tied to the presence of forest cover, which provides them with food and shelter. Various species of mammals inhabit different types of forests depending on their dietary preferences. Unfortunately, the resources of forests, particularly tropical rainforests and montane forests, are dwindling (Geeraert et al., 2019), including the montane forests in southwest Ethiopia (Sisay and Gitima, 2020).

Human activities are the primary causes of biodiversity loss, environmental degradation and the impoverishment of ecosystems (Wilson and Reeder, 2005). For example, the increasing demand for forest products and land for agriculture due to population growth has greatly affected the Afromontane rainforest reserve in southwestern Ethiopia (Feyera, 2006; Gole, 2003; Aerts *et al.*, 2011; Hundera *et al.*, 2013). Specifically, key forest areas in southwestern Ethiopia are being converted into commercial coffee plantations, posing a significant threat to the Afromontane rainforest (Hwang *et al.*, 2020). More

specifically, the Babiya Folla montane forest is among highly fragmented forest. Consequently, the decline of the Afromontane rainforest is likely to have a negative impact on the diversity of mammals in southwestern Ethiopia (Shanko *et al.*, 2021). Similarly, the reduction of forests for coffee plantations affects the diversity of mammal species in Babiya Folla natural montane forest (current study area).

After observing these conservation challenges, the federal and regional government designate forest priority areas and tried to preserve their status in order to overcome human activities and protect unique forest fragments (IOBC, 2005). The Babiya Folla forest priority area in Limmu Kossa District, northern central Jimma Zone is among such forest reserve areas still maintaining relatively large extent of moist evergreen montane vegetation (IOBC, 2005). This forest is continuation of the Kebena forest, which is highly used for coffee plantations to the south, and the fragmented chain of this forest connected to the Buno Bedele to the west. Even though, the forest covers large extent of area, the faunastical value of this unique forest has never been assessed. In view of the fast forest conversion to commercial farms, it is important to prioritize securing mammalian taxonomic records and other relevant information on mammals, especially from this unique, isolated, remote, and less accessible Afromontane rainforests.

Taxonomy and biodiversity conservation cannot be separated (Mace, 2004). This is because without knowledge of the mammal resources, conservation efforts cannot be effectively implemented. In this regards, the taxonomic record serves as the foundation for all other mammalian studies, including understanding its diversity, relative abundance, habitat preferences and detailed ecology of mammalian community. This information is key for development of appropriate conservation strategies. However, the current study area lacks scientific data on the diversity of medium and large mammals and other associated parameters. Therefore, this study aims to address this gap by assessing the diversity, relative abundance, and habitat preferences of medium and large sized mammals in the Babiya Folla natural montane forest.

1.2. Statements of the problem

Any floral area owns with faunal biodiversity. Specifically, natural forest areas provide a habitat for many medium and large sized mammals. These mammals rely on forests for their basic needs such as shelter, food, and protection. The type and nature of forests directly affects the diversity, abundance, and distribution of these mammal species. Sadly, human activities have degraded these forest areas worldwide, leading to a loss of biodiversity including medium and large sized mammals and their ecosystem services at large (Jacobson *et al.*, 2019). Similarly, the conversion of natural forests to other land use forms due to human activities has greatly affected the survival and abundance of wild medium and large mammals (Dirzo *et al.*, 2009). Medium and large sized mammals are particularly susceptible and at risk of local extinction due to forest conversion and habitat loss (Carballo *et al.*, 2014).

In Ethiopia, natural forests are often modified, deforested and destroyed for various agricultural activities, resulting in a loss of biodiversity, including medium and large mammalian species (Hussein, 2021). This is a common trend in the natural forest ecosystem in southwestern Ethiopia (Oostdijk, 2021). Until recently, this region had relatively well-preserved natural forests. However, in recent decades, these forest areas have been heavily targeted for large-scale commercial farming, especially for coffee and tea plantations (Hundera *et al.*, 2013). These activities have a significant impact on the Babiya Folla forest and surrounding areas, causing disruption to the forest ecosystem and posing a threat to the diverse wildlife, including vulnerable mammal species. The study area is one of the few remaining vulnerable forest ecosystems protected as a forest priority area (Megerssa, 2014). The area is likely supports many mammalian species. However, no formal study has been conducted to assess the medium and large mammalian species found in natural forests and the marginal forests managed for different purposes, particularly those partially converted to coffee forests.

1.3. The Research Questions

- ❖ What is the diversity and the regional and global status of medium and large mammals found in the Babiya Folla montane forest?
- ❖ What is the relative abundance of each in relation to the mammalian community of the area?
- ❖ How medium and large mammals are distributed in the area?
- ❖ Which habitat is more preferred by which medium and large sized mammals?
- ❖ What are the main threats that affect the diversity, richness and distribution of medium and large sized mammal species in the area?

1.4. Objectives of the Study

1.4.1. The General objective

The general objective of this study was to assess the diversity, relative abundance and habitat preference of medium and large sized mammals in Babiya Folla montane forest, Limmu Kossa district, Jimma Zone, South west Ethiopia.

1.4.2. The specific objectives

The specific objectives of this study were:

- ❖ To record the diversity of medium and large sized mammals in Babiya Folla montane forest per season and habitats
- ❖ Determine the status of medium and large sized mammals in Babiya Folla montane forest.
- ❖ To estimate the relative abundance of medium and large sized mammalian community per season in the area.
- ❖ To determine the distribution and habitat preference of the medium and large sized mammals per season and habitats in the study area.
- ❖ To record the main threats to medium and large sized mammal species in the area.

1.5. Significances of the Study

Studying on ecological parameters of mammal species is important for many things. Specifically, the findings of this study provide well-organized scientific documentation on the diversity, abundance, and habitat preferences of medium and large mammal species. This information is crucial for implementing appropriate conservation measures in the study area and ensuring that local communities benefit from the conservation and management of these mammalian species. Additionally, it enriches the list of known mammal species and extends the range of mammalian species in the country. Furthermore, it establishes a foundation of knowledge for future studies on mammals in this area. Conducting assessments and recording biodiversity in isolated and less accessible regions highlights the importance of these areas in supporting unique biodiversity and emphasizes the need for special conservation efforts.

1.6. The Scopes of the study

The Babiya Folla forest is found in three districts, namely mana, kersa, and limmu Kossa, and is managed by the Oromia forest and wildlife enterprise (the Babiya Folla district office). This research focuses solely on the forest located in the Limmu Kossa district. Additionally, the forest in this district can be categorized into two types: Kabana forest and dembi state forest. Specifically, this study was conducted in the dembi state forest, which is a part of the Babiya Folla forests. The study's scope is limited to determining the diversity, distribution, relative abundance, habitat preference and main threats to medium and large-sized mammals in the area.

1.7. Ethical considerations

The Babiya Folla Forest and Wildlife Enterprise Office prepared the ethical letter for the Limmu Kossa District administration Office in general, particularly, for the Forest and Environmental Protection bureau and Jimma university biology department wrote a letter for all concern bodies regarding this investigation to maintain legal bases. There in the study area, the researcher approached the community politely and showed a friendly relationship while working in the field, without ignoring the culture, lifestyle and religion of the people in the area throughout the survey periods.

2. LITERATURE REVIEW

2.1. Taxonomic Records of Mammals

The study of biodiversity relies on recognizing variations in taxonomy to identify areas of significant evolutionary and conservation importance. The number of species documented in a particular region is closely related to the number of taxonomists studying that region (Raczkowski & Wenzel, 2007). Consequently, taxonomy has always been considered a peripheral field, even during the early stages of ecological research (Giangrande, 2003). Therefore, taxonomic knowledge remains crucial for conducting credible biological studies and is urgently needed due to the biodiversity crisis (Wheeler, 2014). Moreover, this knowledge serves as the foundation for scientifically documenting all forms of animal and plant diversity as taxonomy encompasses the naming, describing, and categorizing of every living organism on Earth.

It is crucial to provide taxonomic descriptions of mammals in order to implement appropriate conservation strategies. Field studies indicated that the rate of describing new mammal species is ten times higher than that of birds (Patterson, 2000). Most of these descriptions come from tropical forests and areas that have had limited access by taxonomists. Globally, the number of described mammal species is still increasing. In the past, there were approximately 5416 known mammalian species (Wilson and Reed, 2005; Kingdon *et al.*, 2013). However, currently, the number of known mammalian species has risen to 6495, with 96 of them recently becoming extinct and 6,399 still existing in the world (Burgin *et al.*, 2018). Africa, in particular, boasts the highest diversity and abundance of mammal species in the world (Kingdon *et al.*, 2013). This can be attributed to land bridges that have periodically allowed mammalian herbivores and predators to migrate between continents (Tillman and Borer, 2015). In Africa, there are more than 1160 recognized mammal species, distributed across 16 orders (Kingdon *et al.*, 2013). It is also crucial to document and understand the range of already described mammal species in new areas.

2.2. Importance of medium and large mammals

2.2.1. Ecological values of medium and large mammals

Mammalian species make significant ecological contributions to the environment. Specifically, large-sized mammal species can serve as keystones that determine the diversity of an ecosystem (Sinclair,

2003). Mammals fulfill various roles, including providing ecological benefits (Graipel *et al.*, 2017; Berebe *et al.*, 2022). They also act as environmental engineers (Gebo and Takele, 2020), shaping ecosystem balance (Gebo *et al.*, 2021) and playing a crucial role in the proper functioning of ecosystems (Geleta and Bekele, 2018). Terrestrial mammals, especially those of medium and large sizes, play important roles in maintaining ecosystems (Carvalho, 2014; Botelho *et al.*, 2012). They are essential for forest ecosystems as they regulate prey populations, disperse seeds, control plant diversity and structure, and manage potential pest species through herbivory (Botelho *et al.*, 2012; Legese *et al.*, 2019). Additionally, they contribute to plant productivity and nutrient cycling (Pastor *et al.*, 1993), regulate insect populations, and contribute to ecosystem health (Jones & Safi, 2011). Consequently, the loss and rarity of mammals in a given ecosystem have severe consequences for the structure, composition, and diversity of forests (Geleta and Bekele, 2018). Therefore, conserving mammal species, particularly in forests, also means conserving the forest ecosystem in that area.

2.2.2. Economic importance of medium and large mammals

In addition to providing ecological services, mammalian species are also economically important for humans. Throughout history, wild mammals have been a valuable resource for humankind (Boesch *et al.*, 2017). For example, humans consume wild mammal meat as a source of food and to gain economic value (Boesch *et al.*, 2017; Ripple *et al.*, 2016). Mammals also have commercial value for humans, such as using elephant teeth or ivory for ornaments and jewelry, and using their skin and hide for clothing and shoes. Additionally, mammals contribute significantly to the rural economy by creating jobs, income, and profits through businesses in the food and sporting industries (Macmillan & Phillip, 2008). The recreational use of wildlife also has attractive value, attracting more people and generating economic benefits from tourism (Duffus and Dearden, 1990). Specifically, endemic mammals are utilized as a source of income due to their appeal to tourists. People from various parts of the world travel to see certain medium- and large-sized animal species in specific geographic areas, and are even willing to pay for this experience. Consequently, this can contribute to the economic growth of a nation.

2.3. Diversity of medium and large mammals

Mammalian species are a valuable resource that can be found on planet Earth (Qufa and Bekele, 2019). Ethiopia is known for its rich diversity of fauna (Chane & Yirga, 2014) and is particularly renowned for its variety of mammalian species, many of which are unique to the country compared to other African nations (Yalden & Largen, 1992; Wale and Yihune, 2021). However, most of these mammal species are

found in the highland regions of Ethiopia, specifically in the montane forests. The presence of diverse habitats, ecosystems, variable topography, and climate conditions in the country, along with other environmental factors, has created favorable conditions for the evolution and survival of these species (Yalden & Largen, 1992; Hillman, 1993a).

Habitat heterogeneity and geographical barriers play a role in shaping mammalian diversity patterns (Bradfield *et al.*, 2022). However, mammal diversity is significantly reduced in areas with higher mean annual temperature and precipitation (Feng *et al.*, 2019). Mammal species exhibit greater diversity in forest habitats compared to other types of habitats (Qufa and Bekele, 2019; Shanko *et al.*, 2021). This could be attributed to the favorable conditions provided by forests, such as cover, food, and suitable habitats. In Ethiopia, most studies on this aspect of mammals have been conducted in protected areas. However, there is limited research on natural montane forest areas in the country, including the current study area.

2.4. Mammalian records in Ethiopia

In recent years, the number of identified mammal taxa in Ethiopia has been increasing (Lavrenchenko & Bekele, 2017). For example, as of 2011, there were 280 described mammal species in Ethiopia (Tefera, 2011). Currently, the mammal fauna resource in Ethiopia consists of 326 species, distributed among 144 genera, 43 families, and 14 orders (Chankallo, 2023). This suggests that as more areas are surveyed, new mammal species are being discovered and researched taxonomically in the country. Among these described mammals, 17.7% of the species are considered endemic (Gonfa *et al.*, 2015; Lavrenchenko & Bekele, 2017; Chankallo, 2023). This indicates that the numbers of mammalian species in the country, especially for smaller and medium sized mammals are expected to increase as more areas of the country are explored taxonomically. Ethiopia is internationally recognized for its rich diversity of mammalian species and their unique presence (Lavrenchenko and Bekele, 2017; Fashing, 2022). This can be attributed to the country's diverse topography and climate, which play a significant role in predicting the presence of mammalian species (Tefera, 2011). Although most of the recorded mammal species in Ethiopia were found in protected areas, the number of mammal records outside these areas is comparatively lower. This is due to a lack of available data on mammalian species from outside-protected areas in the country (Agebo and Tekalign, 2022).

2.5. Distribution and habitat requirements of medium and large mammals

Mammals can be found in nearly all habitats and regions of the world, with the exception of Antarctica (Buckland *et al.*, 1993; Jenkins *et al.*, 2013; Worku and Girma, 2020). The reason for this widespread distribution of mammals is due to their varying sizes, shapes, physiological characteristics, and behavioral adaptations (Ceballos and Ehrlich, 2006). In Ethiopia, medium and large-sized mammals are found in a wide range of ecosystems, from deserts to afro alpine ecosystems (Ceballos and Ehrlich, 2002). The distribution of individuals within suitable habitats can be determined by their home ranges, territories, and microhabitats (Smith, 1992).

The distribution and abundance of large mammals are influenced by both the abiotic and biotic components of their environment (Timer, 2005). For example, access to crucial resources like food, living space, and mates plays a significant role in determining where mammals are found in a particular area (Yimer and Yirga, 2013). The distribution is also influenced by factors such as habitat, weather conditions, and water resources. This means that mammal populations are found in areas where their essential needs for survival and reproduction are readily available. As resources are distributed evenly throughout an area, mammal species are also distributed there in a regular pattern. In fact, the structure and composition of vegetation is one of the important environmental factors that determine the distribution, abundance, and diversity of mammalian communities that live within it (Timer, 2005). Furthermore, mammals can be found in both lowland and highland areas of the country, and their ability to survive and reproduce is closely linked to the availability and quantity of their essential needs within their environment.

2.6. Endemic mammals in Ethiopia

An endemic mammal species refers to a species of mammal that is native and restricted to a specific geographic region or habitat and is not naturally found anywhere else in the world, hold great importance for the country. This is because the presence of species that are unique to a single nation adds a special interest to its wildlife and requires specific conservation efforts (Yalden and Largen, 1992). Ethiopia is recognized as one of the world's centers of endemism due to its geographical position and topography shaped by high mountains and deep valleys (Yimer and Yirga, 2013). Additionally, it serves as the habitat for numerous mammalian species native to African savannahs (Yimer and Yirga,

2013). Ethiopia is home to over 55 mammalian species that are considered endemic (Lavrenchenko and Bekele, 2017). Out of these, 36 are rodents, 10 are shrews, 3 are bats, 2 are primates, 2 are artiodactyls, 1 is a carnivore, and 1 is a hare (Lavrenchenko and Bekele, 2017). However, the number of endemic species has increased to 63 currently (Tesema and Delelegn, 2022). Furthermore, the level of mammalian endemism in Ethiopia is significant compared to other African countries (Yalden, 1983; Yalden and Largen, 1992; Lavrenchenko and Bekele, 2017). This indicates that Ethiopia has extensive highland areas that are isolated from the rest of Africa and experiences variations in temperature and rainfall across different habitats (Yalden, 1983; Yalden and Largen, 1992).

2.7. Threats to the medium and large mammals

Despite the presence of parks and protected areas, wildlife populations in Ethiopia face continuous threats (Tefera, 2011). The size of wildlife habitats in Ethiopia has significantly decreased due to human activities. As a result, many mammal species, particularly large mammals, are at risk of population reduction especially in areas with intensified land use where species can only survive in small fragments of habitat (Gebremedhin *et al.*, 2021) due to their size and dependence on forests for shelter.

In Ethiopia, there are 32 threatened mammal species categorized as Critically Endangered, Endangered, and Vulnerable, with 19 being large-sized mammals and only 13 being small mammals (chankallo, 2023). Some of the large-sized mammal species facing threats include the Black Rhinoceros (*Diceros bicornis*), Grevy's Zebra (*Equugrevyi*), Wild Ass (*Equus africanus*), Walia Ibex (*Capra walie*), and Ethiopian Wolf (*Canis simensis*) (Chakallo, 2023). Other threatened mammal species include Swayne's hartebeest (*Alcelaphus buselaphus swaynei*), Menelik's bushbuck (*Tragelaphus scriptus meneliki*), African elephant (*Loxodonta africana*), Ethiopian lion (*Panthera leo*), Dibatag (*Ammodorcas clarkei*), African wild dog (*Lycaon pictus*), and Leopard (*phantara pardus*), mountain nyala (*Tragelaphus buxtoni*) (Tefera, 2011; IUCN, 2022). Many of these species are unique to Ethiopia.

Human activities are the primary factors contributing to the decline of biodiversity globally. It plays a significant role in the ongoing biodiversity crisis and had far-reaching effects on the functioning of ecosystems and the rate at which species become extinct for thousands of years (Pineda-Munoz *et al.*, 2021). The reasons behind the loss of biodiversity include human settlements, pollution, habitat destruction, hunting, the introduction of invasive species, the overexploitation of favored species, and climate change (Wale *et al.*, 2018; Singh *et al.*, 2021). It has a significant impact on mammals Qufa and Bekele (2019). This impact is particularly evident in the rainforest, where both protected and

unprotected areas are affected, leading to a decrease in the abundance and diversity of medium and large-sized mammals (Porrás *et al.*, 2016). The survival of these mammal species is threatened by factors including agricultural land expansion, illegal logging, overgrazing, quarry operations, charcoal production, and illegal hunting (Dirzo *et al.*, 2009; Wale and Yihune, 2021; Tefera and Gutema, 2022). The protected areas and forests of Ethiopia currently face numerous challenges, such as a growing human population, border conflicts, recurring drought, and economic needs, all of which impact these areas (Gonfa, 2019; Agebo and Tekalign, 2022). National parks, in particular, are greatly influenced by human activities (Gonfa, 2019). As a result, medium and large mammal species within and outside of protected areas in the country are at risk, leading to a significant decline in their populations.

2.7.1. Hunting

Hunting defined as the collection of any wildlife from their natural habitat by any means and for any purpose (Fa & Brown, 2009). Examples of hunting activities include hunting for food, collecting trophies (such as skins, teeth, antlers, and horns), obtaining medicinal resources and other traditional uses (body parts), and keeping animals as pets (Fa & Brown, 2009; Corlett, 2007). As a result, the populations of various mammalian species that disperse seeds and browse on vegetation have suffered significant depletion or even extinction (Corlett, 2007). It is one of the main factors influencing the distribution of large mammals in various regions of the world (Murai *et al.*, 2013). This factor has a significant negative impact on mammals that are hunted for food (Melo *et al.*, 2015). Moreover, it is a major contributor to biodiversity decline in tropical areas and has resulted in decrease in the distribution of large mammals (Gallego-Zamorano *et al.*, 2020). Unsustainable hunting practices for wild animals, specifically bush meat, serve as the primary source of protein and income for many rural communities in northeastern Gabon (MacCarthy, 2018). Similarly, the extraction of bush meat mainly comes from mammals, with ungulates and rodents comprising the largest portion of biomass extracted (Fa & Brown 2009).

2.7.2. Impact of Habitats loss, destruction and fragmentation on mammals

Habitat loss is the term used when natural environments vanish, while habitat destruction refers to the damaging or complete destruction of natural habitats (Klappenbach, 2021). Habitat fragmentation is the process in which large habitats become divided into smaller and isolated patches of habitats (Fahrig, 2019). Anthropogenic activities are the primary reason for the loss, degradation, and fragmentation of habitats (Scanlon, 2018). Mammals and their habitats face different threats (Kasso & Bekele, 2014). Habitat transformation is the main factor directly contributing to the decline of biodiversity (Drouilly *et*

al., 2018; Banks-Leite *et al.*, 2020). This occurs through the conversion of habitats into agricultural land, overexploitation, the introduction of invasive species, and climate change (Drouilly *et al.*, 2018; Banks-Leite *et al.*, 2020). Tropical regions are home to more than 75% of scientifically described species (Banks-Leite *et al.*, 2020). However, tropical forests are experiencing a higher rate of conversion into agricultural land compared to any other ecosystem. Consequently, the transformation and destruction of habitats are the leading causes of global biodiversity loss (Montoya, 2008; Banks-Leite *et al.*, 2020).

The extinction of endangered species and the consequent loss of biodiversity are the most challenging consequences of human-induced habitat destruction (Bascompte & Sole, 1996). Mining activities and the infrastructure associated with them result in habitat loss and fragmentation in natural habitats where mammals reside (Sonter *et al.*, 2017; Martins-Oliveira *et al.*, 2021). This has negative effects on wildlife, including soil and water contamination, suppression of vegetation, and changes in the landscape (Martins-Oliveira *et al.*, 2021). These alterations in the landscape frequently impact medium and large-sized mammals that rely on forests, as they require expansive areas to meet their ecological needs (Martins-Oliveira *et al.*, 2021). Urbanization is another factor contributing to the decrease in habitat and the increase in habitat fragmentation over time (Liu *et al.*, 2016; Scanes, 2018). Habitat destruction and overexploitation are the primary drivers of the current biodiversity crisis (Romero-munoz *et al.*, 2021). The reduction and fragmentation of habitats can lead to various losses for fauna, such as decreased shelter, food availability, and reproduction locations (Martins-Oliveira *et al.*, 2021), ultimately increasing the risk of species extinction (Kafle *et al.*, 2020). Ethiopia is also facing similar challenges, resulting in the loss of biodiversity, including medium and large mammal species.

2.7.3. Human Wildlife Conflicts

The interaction between human beings and nature began millions of years ago with the creation of human beings (Amare, 2015). HWC is the conflict that occurs between humans and wild animals (Hussein and Negese, 2021; Ia, 2021). This interaction can have positive or negative effects. People and wildlife compete for food and resources (Yihune *et al.*, 2009). Unfortunately, most of these interactions are negative and result in harm to both people and wildlife (Hussein and Negese, 2021). The conflict arises when the needs and behavior of wildlife negatively impact humans or when humans negatively impact the needs of wildlife (Yihune *et al.*, 2009; Gameda and Meles, 2018; Mekonen, 2020). The conflicts are widespread and diverse, involving categories such as livestock predation, disease, and crop raiding (Yihune *et al.*, 2009) and pose a significant problem worldwide (Ayechev & Tolcha, 2020; Ia, 2021). Particularly, developing countries are more susceptible (Amaja *et al.*, 2016). This concern is

particularly prominent among individuals residing near protected areas (Teshome & Girmay, 2017; Hussein and Negese, 2021). An example of this conflict occurs in the Gera districts, where modern coffee production is a prevalent activity (Amaja *et al.*, 2016).

In Ethiopia, the majority of the surrounding protected areas are occupied by agricultural landscapes, resulting in direct interaction between wildlife species and people (Kumsa, 2006). The primary causes of conflicts include land use changes, proximity to protected areas, illegal resource exploitation, settlement, habitat loss due to agricultural expansion and deforestation, lack of public understanding, and negative perceptions of the local community towards wildlife (Teshome & Girmay, 2017; Gameda and Meles, 2018; Hussein & Negese, 2021; Derebe *et al.*, 2022; Shanko and Tona, 2022; Temesgen *et al.*, 2022).

The consequences of conflict have led to the entrance of certain predatory mammal species into urban areas, posing risks to both humans and themselves. For example, mountain lions in the Jasper Ridge Bio Reserve in California have been involved in similar conflicts (Dirzo *et al.*, 2009). This is why mammals are at the highest risk of local extinctions due to loss of habitat or hunting (Carvalho *et al.*, 2014). Similarly, in developing countries, the conflict involves crop damage, livestock attacks, predation on managed wild animal species, or even human fatalities (Gameda and Meles, 2018). Crop damage is particularly common across Africa, with baboons, rodents, grivet monkeys, squirrels, porcupines, pigs, deer, and elephants being the mammal species that negatively impact community livelihoods (Gameda and Meles, 2018).

3. MATERIALS AND METHODS

3.1. Description of the study Area

The study was carried out in the Babiya Folla Montane forest, which is located in the Limmu Kossa District, Jimma Zone, Oromia National Regional State, Southwestern Ethiopia. The district is situated between the coordinate points 07°57'32"N & 8°15'17"N and between 36°53'11"E & 37°16'55"E. The altitude within district ranges from 1200 to 3020 meters above sea level (Getaneh, 2022). The district consists of 44 kebeles, and its administrative center, Limmu Genet, is located 75 kilometers northwest of Jimma town. The district is bordered by Chora Botor district to the northeast, Mana district to the southwest, Tiro Afeta district to the southeast, Gomma to the southwest, and Limmu Seka district to the northwest (Fig1).

The total land size of the district is 1316 square kilometers or 131,600 hectares (Getaneh, 2022). The fragmented forest within the Babiya Folla forest cluster is spread across three districts of the Jimma Zonal administration (Birechis, 2017). The largest portion of this forest is located in the Limmu Kossa District, and some areas of the natural forest have been encroached for coffee plantations (Tegegn, 2022). The total forest size of the study area is approximately 14,128.47 hectares. The population of Limmu Kossa district is 228,054, with 47,511 households, including 112,887 males and 115,167 females (Limmu Kossa district forest and environmental protection office, 2023) (Fig1).

The climate condition of the district is considered moderate and highland. The annual rainfall of the Limmu Kossa district ranges from a minimum of 500mm to a maximum of 1800mm and the temperature of the district varies between minimum temperature 20°C and maximum temperature 32°C (Limmu Kossa District Forest and Environmental Protection Office, 2023).

Vegetation of the Babiya Folla forest is characterized as moist evergreen montane rainy forest (IOBC, 2005), dominated by *Ficus sycomorus*, *Croton macrostachyu*, *Pouteria altissima*, *Aningeria altissima*, *Vernonia amygdalina*, *Podocarpus falcatus* (*P. gracilior*), *Strychnos spinose*, *Apodytes dimidiata*, *Millettia ferruginea*, *Albizia gummifera*, *Ficus sycomorus*, *Coffe arabica* and *Cordia africana*. Most forest areas have different canopy strata with diverse undergrowth, the typical character of the montane forest in the southwest Ethiopia.

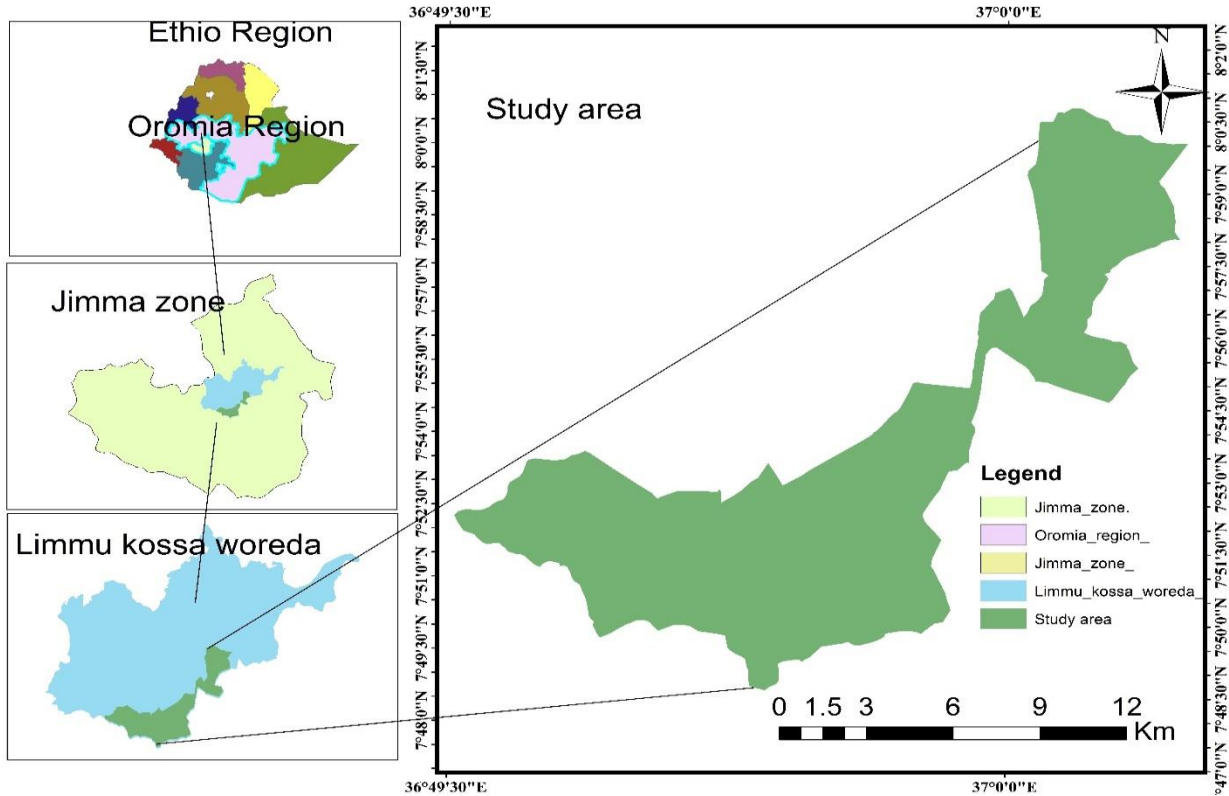


Figure 1: Map of the study area (Birhanu Takele, 2023)

3.2. Habitat categorization and descriptions

The vegetation cover, structure, composition and intensive forest management were used to classify habitats in the study area. Therefore, the study area has been divided into three habitat categories including coffee forest, semi coffee forest, and natural forest.

Coffee Forest: is the forest, which contains dominantly coffee forest under the shade of sparsely populated natural trees. The estimated size of this habitat is 5,624.16 hectares. In addition, human beings frequently manage it, as it is primarily economic sources for local inhabitants in the area.

Semi coffee forest: is the coffee forest shaded under relatively denser natural tree than that of coffee forest. The estimated size of this habitat is 4,934.34 hectares. Nevertheless; management action is prohibited in the area. Due to this reason, the forest and its cover are recovering itself.

Natural forest: is the intact natural forest, which the area is dominated by natural canopy forming indigenous trees species. The estimated size of this habitat is 3,570.07 hectares. In this forest, no

anthropogenic activities are permitted and the forest maintains its canopy and different layered vegetation's.

3.3. Materials

The materials used for this study were GPS, pencil/pen, metric tape, bag to hold materials, notebook, wildlife sensor camera traps, binocular, phone camera to capture photos of mammals, field guidebook such as field guide for African mammals (Kindon, 2013; Bekele, 2013) and data sheet form.

3.4. Methods

3.4.1. Preliminary Survey

The preliminary survey was conducted in February 2023 in the Limmu Kossa district for seven days before the actual data collection. During this survey, basic information such as climatic data and topography information was collected to classify the area into habitats and determine the size of each habitat. The relevant information about the study area was obtained from site visits, governmental bodies (agricultural experts and development workers) and local inhabitants. The study area was categorized into three habitat types. To assist with the data collection, field assistants and local guides including professionals in animal science, forest keepers of Babiya Folla were purposefully chosen and trained.

3.4.2. Research Design

To conduct this research Line transects survey and Wildlife camera trap method were implemented. Line transect is appropriate for species relatively medium and large (conspicuous) and one of the best method for estimating abundances of mammal species (Abera, 2019) Wildlife camera trap is best and simple method to gather data of nocturnal and cryptic mammal species (Perera *et al.*, 2022). Indirect evidence such as pug tracks, burrows, calls, dead body and quill foot marks would be used as it is an appropriate method for presence, absence of naturally scarce, elusive mammals with low densities (Atnafu, 2018; Gebo & Takele, 2020). In addition, interview survey was used to gather additional information on occurrence history of mammal and threats.

3.4.3. Sampling design and transect line establishment

During this survey, mammalian sampling sites were determined and line transects were established in each habitat. A total of 50 line transects (20 in Coffee forest, 16 in Semi forest and 14 in natural forest) were laid. The number of transect line per habitat was determined by the size of the habitat. The length and width of the each transect line was determined by type of vegetation cover and size of the habitats (Kebede, 2018). Accordingly, the length of transect line ranged from 5km to 8kms in Coffee forest, in Semi coffee forest it ranged from 6.4 to 8.8kms, and in natural forest it ranged from 4.5 to 6.7kms. The distance between consecutive transect lines and from the edge of the habitat to the transect line was fixed at 500m to 1km in order to avoid double counting and edge effects (Krebs, 1989; Diriba *et al.*, 2020; Worku and Girma, 2020). However, the width between consecutive transect lines within each habitat varied based on visibility and vegetation cover (500m in Coffee forest, 400m in Semi coffee forest, and 300m in natural forest). The established transect lines were marked by GPS and permanently used for two seasons. The sampling area was required to cover at least 20% to 25% of the study area (Agebo and Tekalign, 2022).

3.4.4. Data collection Method

Data collection involves both dry and wet seasons, with February to March and June to July considered as the dry and wet seasons respectively. The body weight of mammals was used as a fundamental characteristic to classify them into medium and large-sized categories. According to this classification, mammals weighing between 2 and 7 kg are considered medium sized, while those weighing over 7 kg are classified as large-sized (Sutherland, 2006; Agebo & Tekalign, 2022). In this study, the same classification system was used to categorize mammals in the survey area as either medium or large-sized. As per this classification, animals such as small carnivores and primates, large rodents, hyraxes, and pangolins fall under the medium-sized category, while most diurnal primates, carnivores larger than a fox or house cat, and all perissodactyla and artiodactyls are classified as large-sized mammals (Negeri *et al.*, 2015).

3.4.4.1. Line transect survey

A line transect survey was used to gather data on the diversity, relative abundance, and habitat preference of medium and large-sized mammals (Plumptre, 2000; Krebs, 2006; Qufa & Bekele, 2019) in three different habitats (Coffee forest, Semi coffee forest, and natural forest) for two seasons. From the total line transects, 13 representative samples were chosen randomly for the survey, with 5 from the

Coffee forest, 4 from the Semi coffee forest, and 4 from the natural forest. These samples were used for both dry and wet seasons (Chane & Yirga, 2014).

Once the transect lines were established, the sites were left undisturbed for a period of seven consecutive days before the actual survey took place. The survey team consisted of an investigator, a field assistant, local guidance. The survey was conducted twice a day, in the morning from 06:00-10:00 am and in the late afternoon from 16:00-18:00 pm when most mammalian species are active and easily visible (Rabira *et al.*, 2015; Agebo & Tekalign, 2022). The recording of mammal species was done on foot by walking along the selected line transects (Chane & Yirga, 2014). The observers recorded any observed mammals within their visual range on either side of the transect line. The data was collected by directly observing medium and large mammal species, using either the naked eye or binoculars (7x50), while moving on the transect lines.

Numbers of individual in the group were carefully counted. The recorded mammalian species was described up to species level by consulting local guides at least for vernacular name of the observed mammals and Field guidebook such as Kingdon field guide to African Mammals (Kingdon, 2013; Bekele and Yalden, 2013) were used to confirm the identification. while walking along the transect line, any observed indirect signs of mammals such as tracks, scat, dung, calls, burrows, quills, scratches and kill remains were recorded (Chame, 2003; Sutherland, 2006; Klare *et al.*, 2011; Gebo & Takele, 2020). For this study, the recorded indirect evidences were only used to indicate presence or absence of the species. The indirect signs were identified by consulting local guides and zoological experts from Jimma University. For the determination of the status of medium and large sized mammalian species, the updated IUCN Red List (IUCN, 2022-2 (<https://www.iucnredlist.org/>)) was used.

3.4.4.2. Camera trap survey

Five camera traps were set along the selected transect lines and some selected sites such as wildlife paths, fresh pasture, mineral lick, water points and burrow sites were considered to enhance the chance of mammalian capture. Local guides were consulted to identify such sites in the study area. The wildlife camera traps (1280 x 720 video resolution, motion sensor up to 10 m, 32 IR LED); Bushnell Trophy Cam 2014, model 119537c were used. The cameras were programmed to record videos for 35 seconds in a trigger with one-second delay before the second trigger (one after the other). During setting, the cameras were fixed on appropriate sized tree trunk about 1m off the ground, facing towards the clearing. The camera made active only for 48 hrs in one site and relocated to other site to cover more survey areas. Undifferentiated Blurred picture of mammals and incomplete captures of mammals (e.g. tail ends

hind legs) were not be considered (Lim and Ng, 2008; Perera *et al.*, 2022). For this particular study, a single capture event of an individual mammal species would be defined based on a time range (Perera *et al.*, 2022). Therefore, consecutive trapping records of individuals of the same species within 2 hours interval were considered as different. Furthermore, physically undifferentiated, repeatedly captured individuals of the same species were being considered the same individual (Hossain *et al.*, 2016). Safety and functionality of the camera were visited every 24 hours and data from camera trap was recorded at the end of survey.

3.4.4.3. Interview Survey

The history of mammals and the main threats to mammals were addressed by key informants' interviews and direct observation in the field (Gelanew and Tolla, 2022). Local elder people, development agents, and district forest professionals were purposefully selected based on their indigenous knowledge about the forest and its fauna, their resided in the area for over ten years, their experiences, and their ability to respond (Legese *et al.*, 2019). The interview consisted of 23 respondents including 3 district officials, 15 local community elders in and around the forest area, and 5 development agents. All of them were male and interviewed using open-ended questions (appendix 2).

The purpose of this interview was to gather information about mammal species that are found in the area, mammals that had not been detected or captured during the field survey and to identify the main threats to mammals. The selected individuals were directly contacted and shown reference pictures of the mammals to trace the occurrence history of rare species and identify potential threats to mammal species in the area. The data obtained from these interviews were then used to determine whether the mammals were present or absent and recommend appropriate conservation measures.

3.5. Data analysis

The mammalian data was summarized using Microsoft excel 2010 per transect code/number and habitats. The diversity of medium and large mammalian species was calculated by using the Shannon-Weaver index of diversity of the following formula as cited in Agebo and Tekalign, 2022).

$H' = - \sum P_i \ln P_i$ Where H' = Shannon-Weaver index of diversity, P_i = the proportion of the i^{th} species in the habitat and \ln is the natural logarithm. H' = influenced both by number of species as well as by the evenness of species.

Evenness index (J) of species in each habitat per season was calculated by $J = H'/H'_{\text{max}}$ where, J = Evenness Index, H' = Shannon-Weaver diversity Index, $H'_{\text{max}} = \ln S$ = natural logarithm of the total number of species (S) in each site.

The relative abundance of medium and large mammal species in study area was calculated by dividing the number of each species by the total number of individuals in all species (Legese *et al.*, 2019).

$$\text{Relative abundance} = \frac{\text{number of individuals of each species}}{\text{total number of individuals in all species}} \times 100\%$$

Habitat preferences of medium and large sized mammals were determined by observing their frequency of occurrence in different habitats and seasons. The abundance of observed mammals was categorized as common if they were seen during all of the surveys, uncommon if they were seen in more than half of the surveys, and rare if seen less than half of the survey periods (legese *et al.*, 2019).

Simpson Similarity Index (SI) was used to assess the similarity of species composition in three different habitats in the study area using the following formula:

$SI = \frac{2C}{I+II}$, where, SI = Simpson's similarity index, I = number of species in habitat one, II = number of species in habitat two, C = the number of common species in each habitats (legese *et al.*, 2019). The overall similarity of the species in the area was calculated using the formula: $SI = \frac{3C}{I+II+III}$, where III = number of species in habitat three following (Agebo and Tegegn, 2022). The relative abundance index of camera trapped medium and large sized mammals was calculated by relative abundance index formula: $RAI_{\text{spa}} = \text{events} \times 100 / \text{camera trap nights} / \text{sampling effort}$.

Where RAI_{spa} =relative abundance index for species 'a'; events=number of independent records per species; 100 camera trap nights=unit of standardization to compare data with other studies; sampling effort=total amount of nights that the camera trap stations were working (Arroyo-Arce *et al.*, 2017).

R statistics (R version 4.2.2) with vegan package was used to analyze diversity, richness and evenness of the species. In this calculation transect number/code was used as replication. Homogeneity of the variance of the data for normality was checked by using Bartlett's test. The effect of habitat and season on diversity, richness and evenness of the species were analyzed by one way ANOVA (Asmare *et al.*, 2023). The combine effect of habitat and season on mammalian parameters was analyzed by two way ANOVA (Scrosati and Heaven, 2007). Chi-square test(X^2) was used to analyze variations in the abundance of species between seasons and habitats (Atnafu and Yihune, 2018). The interview survey and direct observation on the main threats of mammals presented in percent and descriptively (Gelanew and Tolla, 2022).

4. RESULTS

4.1. Mammal Species composition in Babiya Folla montane Forest

A total of 2803 individuals (1339 during dry and 1464 wet season) distributed in 22 mammal species under six orders and twelve families were recorded for Babiya Folla montane forest. The highest species were recorded in order carnivore (9 species), followed by order primate (5 species) and Artiodactyla (5 species) whereas, the least species number recorded in orders Hyracoidea, Lagomorpha and Rodentia each represented by only one species (Table1). Seasonally, 18 species were recorded during the dry season, whereas 21 species were recorded during the wet season in the study area. Nine of the recorded species were medium-sized, while thirteen of them were large-sized (table 9).

Among recorded species, nine species were recorded by direct observation in the field. Two of the species were recorded through their indirect evidences that indicate their presence in the area. Likewise, the other two species were recorded only from camera traps. Only one species was recorded through both direct and indirect evidence. Similarly, two species were also recorded through both direct observation and camera traps. The remaining six species were identified using direct, indirect, and camera trap methods (Table1).

Table 1: Medium and large sized mammal species identified from the study area

Order	Family	Scientific name	Common name	Local name	Method of identification
Primates	Cercopithecidae	<i>Cercopithecus mitis</i>	Blue monkey	Cano	Visual
		<i>Cercopithecus negletus</i>	De Brazzas monkey	Dalecha cano	Visual
		<i>Colobus guereza</i>	Colobus monkey	Weenni	Visual
		<i>Papio anubis</i>	Olive baboon	Jaldeessa	Visual/CT
		<i>Chlorocebus aethiops</i>	Griquet monkey	Qamale	Visual
Carnivora	Viverridae	<i>Genetta tigrina</i>	Blotched genet	-	CT
		<i>Civettictis civetta</i>	African civet	Xiriigni	Visual/DB/CT
		<i>Mellivora capensis</i>	Honey badger	Hama	Visual/digging hole
	Herpestidae	<i>Mungos mungo</i>	Banded mongoose	Dhudhugi	Visual
		<i>Ichneumia albicauda</i>	White tailed mongose	Dhudhugi	CT
	Canidae	<i>Canis aureus</i>	Common jackal	Gedela	Calling
	Haenidae	<i>Crocuta crocuta</i>	Spotted hyena	Worabesa	Visual, PM/calling/CT
	Felidae	<i>Phantera pardus</i>	Leopard	Qerrensa	Visual
		<i>Felis serval</i>	Serval cat	Iyya	Visual
	Artiodactyla	Bovidae	<i>Sylvicapra grimmia</i>	Common Duiker	Quruphe
<i>tragelaphus scriptus</i>			Bush buck	Bosonu	Visual and PM/CT
Suidae		<i>Hylochoeru meinertzhageni</i>	Giant forest hog	Areya	Visual, PM, FD and CT
		<i>Phacochoerus africanus</i>	Common warthog	Karkaro	Visual
		<i>Potamochoerus larvatus</i>	Bush pig	Boyye	Visual, PM, FD and CT
Lagomorpha	Leporidae	<i>Lepus habessinicus</i>	Abyssinian hare	Illeeti	Visual and CT
Hyracoidea	Procaviidae	<i>Procavia capensis</i>	Rock hyraxes	Osole	Visual
Rodentia	Hystricidae	<i>Hystrix cristata</i>	Crested porcupine	Xaddee	Quill/spine

Note: BD dead body, CT camera trap, PM pugmark, FD fecal drop

4.2. Diversity and richness of medium and large sized mammals in the area

Diversity index (H') for medium and large-sized mammal species in the area for the three habitats were ($H'=1.64 \pm 0.036$), ($H'=1.63 \pm 0.072$) and ($H'=1.86 \pm 0.029$) in coffee forest, semi coffee forest and natural forest respectively during the dry season. The highest species richness was recorded (11.5 ± 0.29) for the natural forest habitat, while the least was recorded for the semi coffee forest (7.75 ± 0.25) during the dry season. The diversity index of medium and large-sized mammal species was ($H'=1.54 \pm 0.07$), ($H'=1.86 \pm 0.06$), and ($H'=2.08 \pm 0.02$) for the three habitats respectively during the wet season (table 2). The natural forest habitats had the highest species richness (12.25 ± 1.03), while the coffee forest habitat had the least (7.2 ± 0.2) during the wet season (Table 2).

Table 2: Mean diversity, richness and evenness of medium and large mammals in dry and wet seasons.

Habitats	Mean of H' and SE		Mean of R and SE		Mean of J and SE	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet sea son
CF	1.64 ± 0.036^a	1.54 ± 0.07^a	7.8 ± 0.49^a	7.2 ± 0.2^a	0.80 ± 0.014^a	0.78 ± 0.027^a
SCF	1.63 ± 0.072^{ab}	1.86 ± 0.06^b	7.75 ± 0.25^{ab}	9 ± 0.71^{ab}	0.79 ± 0.039^a	0.85 ± 0.004^a
NF	1.86 ± 0.029^c	2.08 ± 0.02^c	11.5 ± 0.29^c	12.25 ± 1.03^c	0.76 ± 0.015^a	0.84 ± 0.023^a

Note: CF coffee forest, SCF semi coffee forest, NF natural forest, different superscript (a, ab, c) indicated significant difference at 95% confidence level, H' =diversity index, SE=standard error and R=species richness, J= species evenness

Table 3 below indicates the significant difference on diversity and richness between habitats during the dry season. Accordingly, the species diversity between habitats was significantly different during the dry season ($F_{2,10}=7.461$, $p < 0.05$).

Table3: One-way ANOVA results for diversity, richness and evenness of medium and large sized mammals in dry season.

Parameters		DF	Sum of square	Mean square	F value	P value
Diversity	Habitats	2	0.1445 1	0.07226	7.461	0.0104
	Residuals	10	0.09684	0.00968		
Richness	Habitats	2	38.37	19.187	29.29	0.00065
	Residuals	10	6.55	0.655		
Evenness	Habitats	2	0.003841	0.001920	0.78	0.484
	Residuals	10	0.024622	0.002462		

DF= degree of freedom

There was also a significant difference in species richness between habitats during the dry season ($F_{2, 10}=29.29$, $p < 0.05$). The one-way ANOVA results showed that there was a significant difference in species diversity ($F_{2, 10}=24$, $p < 0.05$) in three habitats during the wet season. The species richness between habitats was also significant ($F_{2, 10}=14.43$, $p < 0.05$) during this season (Table 4).

Table 4: One way ANOVA results for diversity, richness and evenness of medium and large sized mammals in wet season

Parameters		DF	Sum of square	Mean square	F value	P value
Diversity	Habitats	2	0.6782	0.3391	24	0.000152
	Residuals	10	0.1413	0.0141		
Richness	Habitats	2	57.22	28.610	14.63	0.00107
	Residuals	10	19.55	1.955		
Evenness	Habitats	2	0.01288	0.006438	3.16	0.0864
	Residuals	10	0.02037	0.002037		

The diversity index values between habitats indicated that the species diversity was highest in the natural forest (2.06 ± 0.035) and the least species diversity was in the coffee forest (1.7 ± 0.023). Similarly, the species richness was highest in the natural forest (14.25 ± 0.75) and the least was in the coffee forest (8.6 ± 0.24) between habitats in the area (table 5).

Table 5: Mean diversity, richness and evenness of medium and large mammals between habitats in the area.

Habitats	Mean of H' and SE	Mean of R and SE	Mean of J and SE
CF	1.7 ± 0.023^a	8.6 ± 0.24^a	0.79 ± 0.014^a
SCF	1.87 ± 0.039^b	9.5 ± 0.64^{ab}	0.84 ± 0.022^a
NF	2.06 ± 0.035^c	14.25 ± 0.75^c	0.78 ± 0.012^a

Note: Different superscript (a, ab, c) indicated significant variation at 95% confidence level

The results showed that there was difference in species diversity between habitats ($F_{2,10}=32.58$, $p < 0.05$) in the area. Similarly, there was also a significant difference in species richness ($F_{2, 10} = 30.16$, $p < 0.05$) between habitats (Table 6).

Table 6: One way ANOVA results for diversity richness and evenness of species between habitats in the area

Parameters		DF	Sum of square	Mean square	F value	P value
Diversity	Habitats	2	0.28515	0.14257	32.58	0.0004
	Residuals	10	0.04376	0.00438		
Richness	Habitats	2	78.13	39.06	30.16	0.00058
	Residuals	10	12.95	1.29		
Evenness	Habitats	2	0.008252	0.004126	3.541	0.0687
	Residuals	10	0.011652	0.001165		

The natural forest had the highest species diversity (1.97 ± 0.046) and richness (11.875 ± 0.44). In contrast, the coffee forest had the least species diversity (1.58 ± 0.041) and richness (7.5 ± 0.26) during the combined season (Table 7).

Table 7: Mean diversity, richness and evenness of species for combined seasons.

	Habitats	Mean of H ⁺ and SE	Mean of R and SE	Mean of J and SE
Combined season	CF	1.58 ± 0.041	7.5 ± 0.26	0.79 ± 0.015
	SCF	1.74 ± 0.06	8.375 ± 0.42	0.82 ± 0.021
	NF	1.97 ± 0.046	11.875 ± 0.44	0.80 ± 0.018

The results of the two-way ANOVA revealed, there was a significant combined effect on diversity ($F_{2, 10} = 6.751$, $p < 0.05$). However, the combined effect was not significant on species richness ($F_{2, 10} = 1.895$, $p > 0.05$) and species evenness ($F_{2, 10} = 2.738$, $p > 0.05$) for the combined season (Table 8).

Table 8: Two way ANOVA results for diversity, richness and evenness of species for combined seasons

Parameters		DF	Sum of square	Mean square	F value	P value
Diversity	Hab: seasons	2	0.1625	0.0813	6.751	0.00575
	Residuals	20	0.2408	0.0120		
Richness	Hab: seasons	2	4.19	2.09	1.895	0.176
	Residuals	20	22.10	1.10		
Evenness	Hab:seasons	2	0.01184	0.005920	2.738	0.0889
	Residuals	20	0.04325	0.002162		

4.3. The status of medium and large sized mammal species

According to the IUCN, (2022-2), the global status of mammals in the area was assessed. Accordingly, of the 22 total species recorded for the area, only Leopard was categorized as vulnerable and all others were categorized as least concern.

Table 9: The status of mammal species and their Occurrence

Common name	IUCN status	Body size	Occurrence
African civet	Least concern	Large	Single
Banded mongoose	Least concern	Medium	Single
blotched genet	Least concern	Medium	Single
Blue monkey	Least concern	Medium	In group
Bush buck	Least concern	Large	Single/in pair
Bush pig	Least concern	Large	In group
Abyssinian hare	Least concern	Medium	Single
Colobus monkey	Least concern	Medium	In group
Common Duiker	Least concern	Large	Single/in pair
Common jackal	Least concern	Large	-
Common warthog	Least concern	Large	In group
Crested porcupine	Least concern	Large	-
De Brazzas monkey	Least concern	Medium	In group
Giant forest hog	Least concern	Large	In group
Grivet monkey	Least concern	Medium	In group
Honey badger	Least concern	Large	Single
Leopard	Vulnerable	Large	Single
Olive baboon	Least concern	Large	In group
Rock hyraxes	Least concern	Medium	In group
Serval cat	Least concern	Large	Single
Spotted hyena	Least concern	Large	Single
Whitetailed mongoose	Least concern	Medium	Single

C. status, conservation status

4.4. Relative abundance of medium and large sized mammals

During this study, the seasonal relative abundance of medium and large-sized mammal species of the area was computed. Accordingly, the Olive baboon (*Papio anubis*) was the highest abundant species 462 (34.5%) followed by the colobus monkey (*colobus gureza*) 212 (15.83%) while the least abundant species was the Honey badger (*Mellivora capensis*) 1 (0.074%) during the dry season. Similarly, during the wet season, the Olive baboon (*Papio anubis*) was the highest abundant species 420 (28.68%) followed by Colobus monkey (*Colobus gureza*) 314 (21.45%) while the least abundant species were the Banded mongoose (*Mungo mungo*), Leopard (*phantara pardus*), Serval cat (*Felis serval*), and Spotted hyena (*Crocuta crocuta*) 1 (0.035%) for each. The relative abundance value indicated that the Olive

baboon (*Papio anubis*) was the most abundant species in both seasons with 882(31.1%) individuals. However, honey badger (*Mellivora caensis*), leopard (*panthera pardus*), serval cat (*Felis serval*), and spotted hyena (*Crocuta crocuta*) were the least abundant species 1 (0.035%) individuals for each (Fig 2).

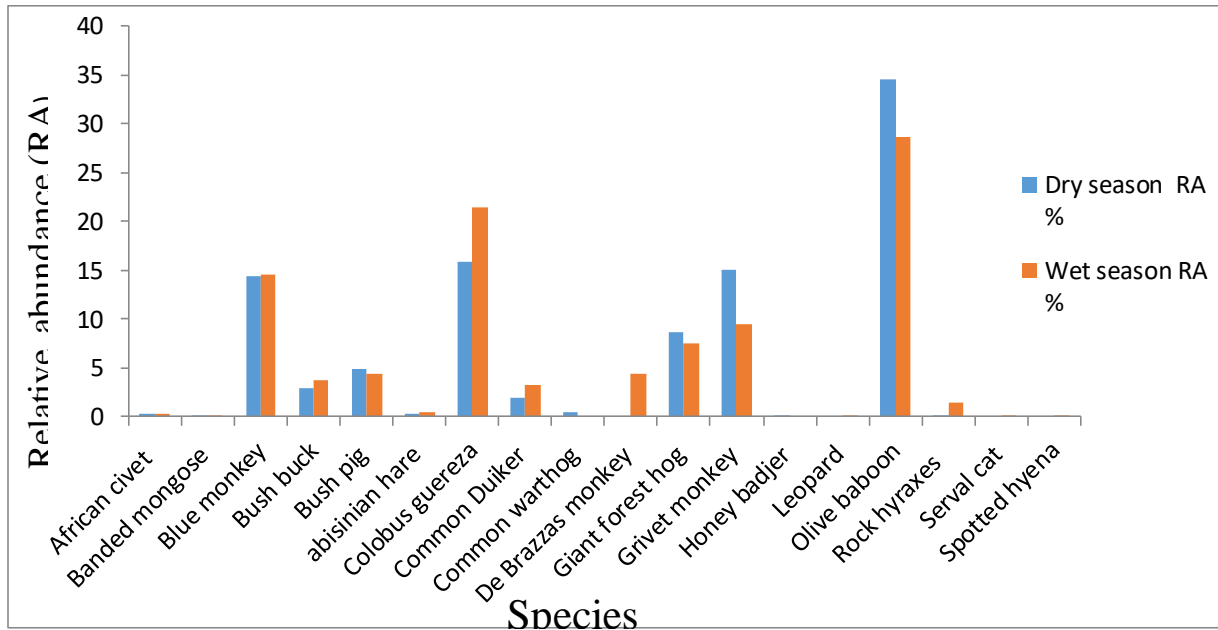


Figure 2: Relative abundance of medium and large sized mammals per seasons

The figure 2 displayed below illustrates the overall abundance of medium and large sized mammals in different seasons and habitats. The natural forest had the highest abundance of individuals, with 530 individuals (39.58%), while the semi coffee forest had the least abundance, with 362 individuals (27.04%), during the dry season. Similarly, during the wet season, the natural forest had the highest abundance, with 614 individuals (41.94%), while the coffee forest had the least abundance, with 354 individuals (24.18%), in the study area. There was no significant variation in species abundance between seasons ($\chi^2=0$, $DF=1$, $p > 0.05$). However, there was a significant variation in species abundance between coffee forest and semi coffee forest, coffee forest and natural forest as well as semi coffee forest and natural forest ($\chi^2=421.003$, $DF=1$, $P < 0.05$, $\chi^2=440$, $DF=1$, $P < 0.05$, $\chi^2=467.5$, $DF=1$, $P < 0.05$) respectively.

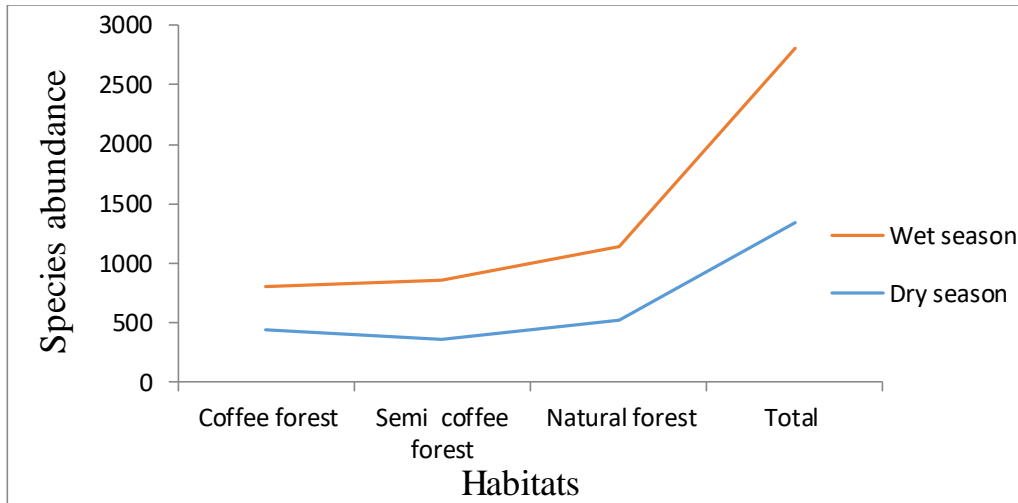


Figure 3: Total abundance of medium and large sized mammals in each habitat per season.

4.5. Distribution of medium and large sized species in the area

The distribution of medium and large sized mammals in the area has shown that only 9 species were commonly and widely distributed in all habitats during both the dry and wet seasons, three of the species were distributed in two habitats and the rest only distributed in single habitats in single season (Table 11). The evenness index value of medium and large sized mammal species was highest in coffee forest and the least was in natural forest during the dry season. However, during wet season, semi coffee forest was highest and the least was in coffee forest (Table 2). The results of the one-way ANOVA showed that there was no significant difference in species evenness in between habitats during the dry (Table 3) and wet (Table 4) seasons, respectively. Similarly, the combine effect was not significant on species evenness between habitats for combined season (Table 8).

Table 10: Distribution and abundance of medium and large sized mammals

Common name Species	Dry season			Wet season		
	CF	SCF	NF	CF	SCF	NF
African civet	-	-	4	-	1	4
Banded mongoose	-	-	3	-	-	1
Blue monkey	75	35	82	16	98	100
Bush buck	7	12	21	10	14	30
Bush pig	14	22	29	16	20	29
Abyssinian hare	1	1	3	3	1	3
Colobus monkey	88	27	97	99	109	106
Common Duiker	8	8	11	9	14	24
Common warthog	-	-	7	-	-	-
De brazzas monkey	-	-	-	-	22	43
Giant forest hog	18	47	52	37	30	42
Grivet monkey	97	60	44	30	44	65
Honey badger	-	-	1	-	-	-
Leopard	-	-	-	-	-	1
Olive baboon	139	150	173	134	136	150
Rock hyraxes	-	-	3	-	7	14
Serval cat	-	-	-	-	-	1
Spotted_hyena	-	-	-	-	-	1

CF= coffee forest, SCF= semi coffee forest, NF= natural forest

4.6. Habitat preference of medium and large sized species in the area

The habitat preferences of medium and large-sized mammal species show that about half of the recorded species prefer and commonly used three habitats. These species were frequently seen throughout the entire survey period, both in the morning and at night, during both the dry and wet seasons. Only (16.66%) of the species were used both Semi coffee forests and natural forests and (33.33%) of the species were preferred only natural forests. However, dominantly all the species were preferred natural forests (Table 11). Nine of the recorded medium and large sized mammal species were considered as common, only one of them was considered as uncommon and eight of them considered as rare in the area (Table 11).

Table 11: Frequency occurrence of medium and large mammals

Species name	Frequency	Dry season			Wet season		
		CF	SCF	NF	CF	SCF	NF
African civet	Rare	-	-	*	-	*	*
Banded mongoose	Rare	-	-	*	-	-	*
Blue monkey	Common	*	*	*	*	*	*
Bush buck	Common	*	*	*	*	*	*
Bush pig	Common	*	*	*	*	*	*
Abyssinian hare	Common	*	*	*	*	*	*
Colobus monkey	Common	*	*	*	*	*	*
Common Duiker	Common	*	*	*	*	*	*
Common warthog	Rare	-	-	*	-	-	-
De brazzas monkey	Rare	-	-	-	-	*	*
Giant forest hog	Common	*	*	*	*	*	*
Grivet monkey	Common	*	*	*	*	*	*
Honey badger	Rare	-	-	*	-	-	-
Leopard	Rare	-	-	-	-	-	*
Olive baboon	Common	*	*	*	*	*	*
Rock hyraxes	Uncommon	-	-	*	-	*	*
Serval cat	Rare	-	-	-	-	-	*
Spotted_hyena	Rare	-	-	-	-	-	*

Note: - Not sighted * sighted

4.7. Similarity of medium and large sized mammals between habitats and seasons

The Simpson similarity index value showed that the Coffee forest and Semi coffee forest had the highest similarity (SI=1) during the dry season, compared to the similarity between Coffee forest and natural forest (SI=0.783), as well as between Semi coffee forest and natural forest (SI=0.783) during the dry season. However, during the wet season, the lowest similarity (SI=0.72) or 72% was observed between the Coffee forest and natural forest, in contrast to the similarity between the Coffee forest and Semi coffee forest, and the Semi coffee forest and natural forest (SI=0.857), where 85.7% of the species were similar among these habitats. The overall similarity of the species was approximately 69.23% across the three habitats in the area (Table12).

Table 12: The similarity of medium and large sized mammals between habitats and season.

Habitats	Simpson similarity index	
	Dry season	Wet season
Coffee forest and Semi coffee forest	1	0.857
Coffee forest and Natural forest	0.783	0.72
Semi coffee forest and natural forest	0.783	0.857
Overall similarity		0.692

4.8. Relative abundance index of medium and large sized mammals from camera traps

From a total of 210 sampling efforts, ten species were identified from camera traps in the study area during both the dry and wet seasons (appendix 4). According to the relative abundance index value, the giant forest hog was found to be the most abundant (22.85%) while the Blotched genet and Abyssinian hare were the least abundant (0.95%) each during the dry season. During the wet season, the Olive baboon was the most abundant (42.86%) while the white-tailed mongoose (0.95%) was the least abundant species. In general, the Olive baboon was the most abundant (31.90%), while the white-tailed mongoose was the least abundant (0.48%) in the area (Table 13).

Table 13: Relative abundance index of medium and large sized mammals from camera traps

Species	Dry Season		Wet Season		Combined season	
	Individual	RAI	Individual	RAI	Sum	RAI
African civet	0	0	3	2.86	3	1.43
Blotched genet	1	0.95	9	8.57	10	4.76
Bush buck	5	4.76	11	10.48	16	7.62
Bush pig	4	3.81	5	4.76	9	4.29
Common duiker	1	0.95	7	6.67	8	3.81
Giant forest hog	24	22.85	8	7.62	32	15.24
Olive baboon	22	20.95	45	42.86	67	31.90
Spotted hyena	0	0	2	1.90	2	0.95
Abyssinian hare	1	0.95	2	1.90	3	1.43
White tailed mongoose	0	0	1	0.95	1	0.48
Total	58		93		151	

4.9. Interview survey results

All of the interviewed respondents reported that there were a higher number of medium and large mammal species compared to observed and camera trapped including the Aardvark and Brown Hyena species in the area. Lion, Buffalo, and wild dog mammal species were present in the area before ten years ago, according to their reports, the modification of the area for coffee plantations resulted in the disappearance of these mammal species. Majority of the respondents mentioned that these mammal species might be migrated to neighboring districts. Only a few of them were unaware of where the species had migrated from the area. As the respondents stated that habitat restoration, controlling illegal activities and removing human settlements from the forest area were possible solutions to bring back the mammals to their habitat (Table 14).

Table 14: Mammalian occurrence history from local community

Interview questions	Response	No. Respondents	Percent
What medium and large sized mammal species are found in the Babia Folla montane forest?	All observed species including brown hyena and Aardvark	23	100%
What medium and large sized mammal species were once present in this forest but are now absent from the area?	Lion, Buffalo, and wild dog	23	100%
Where did you think the lost mammals migrated	They migrated to neighboring districts	20	86.66%
	Unaware of where the species had migrated	3	13.04%
What are the reasons behind the absence of those mammals that were present in the region?	Modification of the area for coffee plantation	23	100%
What do you suggest to bring back those mammal species to their habitats?	Habitat restoration	12	52.17%
	Controlling illegal activities	6	26.08%
	Removing settlement	5	21.74%

Out of the interviewed respondents, majority of the respondents stated that human disturbance, habitat modification, encroachment for coffee plantations, settlement, charcoal production, deforestation, and griddling to kill trees and reduce forest shade were the main threats to mammal species. Similarly, personal observation was conducted during survey time and confirmed these threats in the area (Appendix 6). In addition, some of them reported that activities such as collecting firewood, the presence of roads that cut through the forest, and snaring were some of the threats in the area. According to the respondents, the reasons for people being forced to degrade the natural forest were the need for

coffee plantation as it serves as the primary source of income, lack of alternative land for agriculture and the need to fulfill basic needs. Finally, the participants suggested that the government should enhance its ongoing efforts to restore the forest and actively involve the local community in wildlife conservation to revive these mammal species and safeguard their natural habitats. They were also reported that all local communities should respect the rules and protect themselves against illegal activities and disturbances in the forest (Table 15).

Table 15: Threats to medium and large sized mammal species in the area

Interview questions	Response	No. Respondents	Percent
What are the main threats to medium and large-sized mammal species and natural forest decline of Babiya Folla Montane Forest?	Human disturbance, habitat loss and modification, encroachment for coffee plantations, settlement, charcoal production, deforestation, and griddling	18	78.26%
	Collecting firewood, the presence of roads that cut through the forest, and snaring	5	21.74%
Why people forced to these actions in the forest?	The need for coffee plantation	16	69.56%
	Lack of alternative land for agriculture	3	13.04%
	The need to fulfill basic needs	4	17.39%
What do you suggest to protect forest reduction and conserve these wildlife resources in their natural habitats?	The government should enhance its ongoing efforts to restore the forest and actively involve the local community in wildlife conservation	13	56.52%
	All local communities should respect the rules and protect themselves against illegal activities and disturbances in the forest	10	43.48%

5. DISCUSSIONS

During the entire survey period, 22 mammal species were recorded in the Babbiya Folla montane forest. This portrays a diverse range of medium and large mammal species found in the area. This result is comparable to results with similar studies in different parts of Ethiopia. For instance, 22 medium and large-sized mammal species were documented in Fragmented Remnant Forests near Asella Town, Ethiopia (Kasso and Bekele, 2017), 23 mammals were recorded in the Jorgo-Wato Protected Forest in Western Ethiopia (Erena, 2021), and 24 mammal species were documented in the Dodola Community Conservation Area, Ethiopia (Mekonin and Girma, 2022).

The number of medium and large sized mammal species observed in the study area is higher compared to the number recorded in a certain parts of southwestern Ethiopia. For example, researchers documented 13 medium and large mammals in the Guda forest, southwestern Ethiopia (Shanko *et al.*, 2021), 14 mammal species were recorded in the Yayu forest in southwest Ethiopia (Woldegeorgis and Wube, 2012). Additionally, the current findings are also higher compared to other comparable protected areas. For instance, in the GuraLopho Protected Area in Ethiopia, a researcher documented 10 mammal species (Merga, 2020), 11 medium and large mammals were observed in Tirba Lake Awi Zone, Ethiopia (Derebe *et al.*, 2023). However, the species composition observed in the present study is lower compared to the medium and large-sized mammal species recorded in other Ethiopian national parks. For instance, 25 species were documented in Gambella National Park (Reat, 2021), and 28 species were recorded in Chilalo-Galema NP (Lema and Admasu, 2020).

The diversity and richness of medium and large-sized mammal species in coffee forests and semi coffee forests were almost similar during the dry season. This is due to habitat homogeneity and the similarity of tree species that the species used its fruits as food. However, significant difference on diversity and richness was observed during this season. The possible reason for this difference is due to variations of habitat components in natural forests than other habitats. Similarly, Tukey-HSD test at 95% confidence level indicates that the difference is because of natural forest.

There is a positive correlation between habitat heterogeneity and species diversity of mammals (Chane and Yirga, 2014). The variation in the number and abundance of mammal species in different habitat is influenced by the habitat's quality and the species' preferences (Kasso and Bekele, 2017). For this study, during the wet season, significant variation was observed in species diversity and richness in three

habitats. This might be because of habitat variability and vegetation structure during this season. The diversity and species richness were higher in natural forest habitat. This might be because of vegetation structure, cover, shelter, and absence of the human disturbance in this habitat.

Similar studies in different parts of Ethiopia showed that the natural forest harbored more diversity of medium and large-sized mammal species (Geleta and Bekele, 2016; Atnafu and Yihune, 2018; Serbessa, 2020). However, the diversity of medium and large-sized mammal species was less in the Coffee forest followed by Semi coffee forest. This might be because of the presence of different anthropogenic activities, human disturbance and habitat unsuitability especially, for shy medium and large-sized mammal species. The study revealed that habitat and season have an important impact on species diversity and richness (Gebo *et al.*, 2021). For this study, habitat and season had a significant effect on the diversity and richness of medium and large-sized mammal species. Similarly, the combine of habitat and season had an effect on mammalian diversity rather than the richness and evenness of the species in the area. This also suggests that different species face varying rates of threats in habitats during different seasons.

Seasonal variation in species was observed in the present study area. More number of medium and large-sized mammal species was recorded during the wet season than the dry season. This difference in species richness might be because of the availability of diverse vegetation, which serves as a food and water source for the mammals in the area during the wet season (Atnafu and Yihune, 2018). Additionally, the level of human disturbances and the complexity of vegetation structure vary with the seasons (Desalegn, 2023). Throughout the study period, the highest species richness was recorded from natural forest habitat. This is because; comparatively the natural forest has enough food, water sources, and covers for the survival of the species and protects them from predatory attack than other habitats in the area. However, the least species richness was recorded from coffee forests. This is because of various anthropogenic activities in this habitat of the area.

The abundance of mammal species was higher during the wet season compared to the dry season. This could be ground vegetation regeneration, the availability of sufficient grasses, fruits, and water sources during the wet season, and the scarcity of these resources during the dry season. This is in line with the findings that were reported in various parts of Ethiopia such as in the Tiski Waterfall Awi Zone (Deribe *et al.*, 2022), Michole Community Protected Forest in southern Ethiopia (Agebo and Tekalign, 2022), Faragosa-Fura landscape in the Gamo Zone of Southern Ethiopia (Gebo *et al.*, 2021). This might be habitat similarity provide favorable conditions to support a relatively consistent abundance of medium

and large-sized mammal species across different regions. Nevertheless, the abundance record contradicted the abundance findings in the Chilimo forest (Desalegn, 2023) and Loka Abaya NP (Diriba *et al.*, 2020). Although there was a slight variation in species abundance between seasons, the variation was not significant. However, there were significant variations in species abundance between habitats. This might be due to the characteristics and heterogeneity of habitats.

The order primate was the most abundant accounting for 2219 (79.17%) of the total records followed by order artiodactyl accounting for 531(18.94%) of the total. This high abundance of primate might be because of their reproduction success, variable diet behavior and high survival level of primate to human disturbances (Agebo and Tegegn, 2022), wide distribution range of the species (Bobo *et al.*, 2014) and adaptive nature in different habitats (Gonfa *et al.*, 2015). However, the least abundant was order lagomorpha accounting for 12(0.43%) of the total records in the present study area. This might be due to their nocturnal and shy behaviors. In species level, Olive baboon (*Papio anubis*) was the most abundant species accounting for 882(31.46%) in the area. This is due to its feeding habits (generalist feeder) (Mullu & Solomon, 2016), reproduction success, ability to resist the human disturbance and wide distribution ranges of the species from savanna grassland up to land afro montane forest (Girima *et al.*, 2012; Bobo *et al.*, 2014). Similar with this study, several studies from different parts of country reported as the Olive baboon was the most abundant (Kabie *et al.*, 2021; Dansa and Tekalign, 2022; Agebo and Tekalign, 2022). However, the least abundant species were honey badger (*Mellivora capensis*), leopard (*Panthera pardus*), serval cat (*Felis serval*) and spotted hyena (*Crocuta crocuta*). The possible reason of their rarity might be their activity patterns, shy behavior and ability of hiding them self under cover and cave (Girima *et al.*, 2012).

The results of this study also, indicated that the olive baboon (*Papio anubis*) was the most abundant species from camera trapped data. This finding is consistent with the study conducted in Jorgo-Wato Protected Forest, Western Ethiopia with a similar method (Erena, 2022). The second most abundant species was the giant forest hog (*Hylochoerus meinertzhageni*). According to Hundera *et al.* (2021), the Olive baboon and giant forest hog were the most abundant species in Belete-Gera National Forest Priority Area. The least abundant was white-tailed mongoose (*Ichneumia albicauda*) in the study area. The camera traps being in the field for a short period may cause this.

The way mammals use their habitat, the type and quality of their diet greatly influence their distribution (Agebo and Tekalign, 2022). The seasonal distribution of medium and large-sized mammal species in

BFMF indicated that during the wet season, the species were widely distributed compared to their distribution in the dry season. This might depend on the presence of enough cover, shelter, and different fruits and grasses used as sources of food during this season in the area. There was a slight difference in species evenness between habitats. However, the difference was not significant. Comparatively, Semi coffee forest was evenly distributed than other two habitats in the area. This could be because of a relatively fair distribution of food and water accessibility. The distribution and abundance of the primate order were highest in the study area. This is in line with the research conducted in Wabe forest fragments, Gurage zone, Ethiopia (Legese *et al.*, 2019). The order primate is more highly adaptable in human-dominated areas than other orders. Particularly, the olive Baboon was widely and abundantly distributed species in three habitats in the area.

The most commonly distributed medium and large-sized mammal species in all habitats were Olive baboon (*Papio anubis*), colobus monkey(*Colobus guereza*), Blue monkey (*Cercopithecus mitis*), Grivet monkey(*Chlorocebus aethiops*), Giant forest hog (*Hylochoerus meinertzhageni*), common duiker (*Sylvicapra grimmia*), Bushbuck(*Tragelaphus scriptus*) and Bushbig(*Potamochoerus larvatus*) in the study area. The mammal distribution is limited by different factors like food sources, habitats, climate and geographical barriers of an area. The sufficient resource and species distributions are positively correlated, which means that they are evenly distributed as the resource is fairly distributed. However, some other species distributions in the area were limited in natural forests. This is due to their shy behavior and sensitivity to human disturbance.

Medium and large-sized mammals exhibit a preference for specific habitat types, leading to uneven distribution during foraging activities (Agebo and Tekalign, 2022). The composition, availability, and quality of forage, water, topography, and soil types influence mammals' movement between habitats (Grand, 2002). The present study found that approximately half of the observed mammal species commonly preferred all habitats in the study area. However, the natural forest was the most widely and abundantly preferred habitat for all species. This is due to the presence of diverse fruits for frugivorous mammals, ample water availability, suitable cover for shy mammals, and suitability of the habitat (Kabie *et al.*, 2021). The habitat association of mammals are often influenced by the availability of water, food, and cover. Certain species such as the Banded mongoose, Leopard, Serval cat, spotted hyena, and common warthog were rarely observed in the study area and exclusively preferred the natural forest. This may be attributed to their need for cover and protection against human disturbance. On the

other hand, the Blue monkey and De Brazzas monkey preferred areas with tall trees and along riverbanks due to their need for a variety of fruit types and secure environments, as they are shy mammals (Girima *et al.*, 2012). However, other primate species like the Olive baboon, Grivet monkey, and colobus monkey were often found close to human-inhabited areas in search of garden fruits in the early morning but would retreat to the forest for recreation and rest in the area.

The medium and large-sized mammal species in the area exhibited similarities in their habitats. Consequently, the recorded species in coffee forests and Semi coffee forests were similar during the dry season. This might be a similarity in vegetation structure. However, there was a low similarity in the species recorded between coffee forests and natural forests, as well as semi coffee forests and natural forests during the same season. Similarly, during the wet season, the highest similarity of species was recorded between coffee forests and Semi coffee forests, Conversely, the lowest similarity was observed between coffee forests and natural forests during this season. This might be due to the dissimilarity of habitats.

The local communities hold positive perceptions and attitudes towards the forest and wildlife in the area. They are willing to participate in biodiversity conservation efforts if the government is involved in conservation actions in the area. This aligns with the findings of a study conducted by Legese *et al.* (2019). The local community reported that lion, buffalo and wild dog might have migrated to neighboring districts with dense forests in search of suitable areas and food sources. This is because the forests in those districts have not been encroached upon for coffee plantations, unlike the forest in Limmu Kossa district. This might negatively impact the diversity and richness of mammal species. They also mentioned that the forest had not experienced significant disturbance or encroachment for coffee plantations until the last ten years. Aardvark and brown Hyena species were not sighted during this survey period. This may be due to their nocturnal behavior and the limited duration of the survey.

Habitat loss and modification are the most serious threats to mammal species distributions in the study area. The forest is continuously being encroached upon for coffee plantations. Other significant threats include human disturbance, settlement, deforestation, and charcoal production in the area. These factors have limited the distributions of some medium and large-sized mammal species in natural forests. Similar threats have been reported from different areas in the country, such as Wacha Protected Forest in Western Ethiopia (Geleta and Bekele, 2026), Wabe forest fragments in the Gurage zone, Ethiopia (Legese *et al.*, 2019), and Gibe Sheleko National Park in Southern Ethiopia (Abie *et al.*, 2020).

6. CONCLUSIONS

The present study assessed the diversity, relative abundance, distribution, and habitat preference of medium and large-sized mammals in the Babiya Folla montane forest. The findings of this study highlight the remarkable diversity and richness of mammal species in the area, with total of 22 identified species including the vulnerable leopard. The majority numbers of species were recorded from the natural forest habitat due to its favorability than the other two habitats. The natural forest habitat also had the highest diversity and species richness followed by Semi coffee forest. Whereas, the least diversity and species richness were recorded in Coffee forest due to different anthropogenic activities in the area. The Olive baboon was the most abundant species in the area. About half of the recorded species were commonly distributed and preferred all the habitats. However, almost all of the species widely and abundantly preferred the natural forest. The study also revealed a range of threats that pose significant challenges to the stability of the ecosystem, survival and well-being of mammal species in the area. The main threats to mammal species were settlement, human disturbance, habitat modification/coffee plantation, deforestation, charcoal production, and girdling/ring barking. Despite these threats, the area still maintains a significant and diverse number of mammal species, comparable to less disturbed forests in the country. This indicates that the area has a rich mammal biodiversity, even though it has been fragmented and modified for coffee plantations. Therefore, it is crucial for all concerned organizations to take immediate action to sustain the area and preserve its biodiversity, including its medium and large-sized mammal species.

7. RECOMMENDATIONS

The present findings have led to the following recommendations being made for the conservation and preservation of biodiversity, specifically medium and large sized mammal species in the Babiya Folla montane forest. The following recommendations are forwarded to Babiya Folla forest and wildlife enterprises, as well as Limmu Kossa district forest and environmental protection office and all other relevant bodies.

1. Some of the absented mammal species from the area indicates that the BFMF is fragmented and the amount of intact natural forest is decreasing at alarm rate, all the concern bodies should take immediate actions to protect and restore this unique ecosystem to ensure the long-term survival of the mammal species.
2. Although the efforts made by the district government to protect the existence of the forest and the biodiversity therein are commendable, much more needs to be done in coordination with the local community for the sustainability of the area. It is crucial to interact with local communities in order to tackle the problem of human disturbance, by creating awareness about the significance of conserving biodiversity and the ecological services offered by mammals.
3. To combat the issue of anthropogenic activities strict enforcement of existing laws and regulations is necessary. Collaborating with law enforcement agencies and implementing regular patrols in the area can deter illegal activities.
4. Conducting scientific research further y is needed in detail of threats and interaction of wildlife with human beings and other ecological parameters of some mammal species that were not sighted during this survey.
5. Forming partnerships with local and international conservation organizations, research institutions, and government agencies is crucial for the success of conservation initiatives and collaborative efforts can pool resources, expertise and funding to implement comprehensive and sustainable conservation strategies in the area.

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Appendix 2: Interview Questions

My name is **Birhanu Takele Gebre**, my field of study is M.Sc. in ecology and systematic Zoology at Jimma University, college of Natural sciences and department of biology. I am the owner of this interview questions to assess diversity, relative abundance and habitat preferences of medium and large sized mammal species in Babiya Folla montane forest.

The primary objectives of these nine open-ended interview questions are to determine the types of medium and large sized mammal species present in the Babiya Folla montane forest and identify their main threats. The aim of this interview is to gather valuable information from respondents and assess the reasons behind the absence of certain mammal species that were once present, as well as identify the current mammal species assumed present and the main threats they face. Additionally, recommend appropriate conservation measures to reduce habitat loss, which negatively affects species diversity, richness, and abundance in the Babiya Folla montane forest.

1. Respondent's full name _____ Address _____ Occupation _____ sex _____ Age _____
2. . How long have you been in the area? _____years
3. What medium and large sized mammal species are found in the Babia Fola montane forest?
4. What medium and large sized mammal species were once present in this forest but are now absent from the area?
5. Where did you think the lost mammals migrated?
6. What are the reasons behind the absence of those mammals that were present in the region?
7. What you suggest to bring back those mammal species to their habitats?
8. What are the main threats to medium and large-sized mammal species and natural forest decline of Babiya Folla Montane Forest?
9. Why people forced to these actions in the forest?
10. What do you suggest to protect forest reduction and conserve these wildlife resources in their natural habitats?

Appendix 3: Data collection format

Study area _____ Study site _____ Transect no. _____ Observer _____ season _____

Date ____/____/____

N o.	com mon name	Local name	Age			Number of individual	Hab itat type	Time of observation	GPS Location		Elevat ion	Method of identification	Remark
			Y	S/ A	A				Long itude	Lati tude			
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													

Appendix 4: Mammal species trapped by camera from study area



Giant forest hog



Bush pig



Abyssinian hare



Spotted hyena



Olive baboon



Blotched genet



Common duiker



White tailed mongoose



African civet



Bush buck

Appendix 5: Observed indirect evidences of mammals in the area



Fecal matter of bush pig



Bead African civet



quill/spine of crested porcupine



Foot print of bushbuck



fecal drop of bush buck



fecal drop of African civet

Appendix 6 : Observed threats to mammals in the area



Girdling/ring-barking



Deforestation



Fresh charcoaling



Captured person with charcoaling



Fixing camera in the field



recording data in the field



Some of the interviewed participants

