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**Diversity of medium and large-sized mammals across habitats and seasons in the Faragosa-Fura landscape, Gamo Zone, Southern Ethiopia**

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**1│INTRODUCTION**

Mammals act as umbrella species of terrestrial ecosystems because of their large area home range requirements and contribute to the conservation of other species (Bene et al., 2013; Udy et al., 2021). Medium and large-sized mammals, play key roles throughout many of the world’s ecosystems including grazing, predation and seed dispersal (Gebresenbet et al., 2018; IUCN, 2021; Reeder et al., 2019). Moreover, they provide important human benefits such as food, recreation, and income (Penjor et al., 2021; Wolf & Ripple, 2018). Conversely, mammals have been in extinction crisis globally and locally due to anthropogenic activities (Ripple et al., 2014; Worku & Girma, 2020). Habitat loss and degradation and harvesting (hunting/gathering for food, medicine, fuel and materials) are by far the main threats to mammals (Bakala & Mekonen, 2020; Kasso & Bekele, 2017; Mekonen, 2020; Qufa & Bekele, 2019; Wale, 2017).

Spatial and temporal environmental heterogeneity can determine the population trends of wild populations, either a population decrease or extinction, or the ability of some species to become overabundant. Hence, quantifying their diversity and distribution across habitats and seasons is pivotal for developing conservation strategies in order to avoid extermination and to secure the richness of mammalian biodiversity (Girma & Worku, 2020; Kasso & Bekele, 2017; Udy et al., 2021).

Worldwide, Class Mammalia is composed of 5487 species. Of these, more than 1150 species are found in Africa (Newbold et al., 2015). East Africa is rich in mammalian fauna (Diriba et al., 2020; Girma et al., 2012), which provide living space for more than 360 diverse species (Lavrenchenko & Bekele, 2017). Ethiopia is one of the top 25 biodiversity-rich countries in the world, and hosts two of the world’s 34 biodiversity hotspots, namely, the Eastern Afromontane and the Horn of Africa hotspots. It is one of the countries with the most diverse mammalian faunas in Africa (Amare, 2015; Tefera, 2011; Yalden et al., 1986).

Among identified 320 mammalian species of Ethiopia, 55 are endemic to the country, distributed in 14 orders and 39 families (Lavrenchenko & Bekele, 2017; Rabira et al., 2015). More than 60% of the mammalian species are medium and large-sized (Negeri et al., 2015). Topographic diversity and climate are the most significant predictors of mammalian species diversity in the country (Amare, 2015; Bakala & Mekonen, 2020; Belete & Melese, 2016; Tefera, 2011). However, the wildlife population has diminished over the past century both in abundance and distribution through the loss of habitat, hunting, and land clearance for farming; land degradation due to overgrazing (Gebresenbet et al., 2018; Girma & Worku, 2020; Lemma & Tekalign, 2020; Worku & Girma, 2020).

In Ethiopia, most of the studies on mammals were restricted to protected areas (Fetene et al., 2019; Wale, 2017) but the diversity and conservation status of mammalian species outside protected areas such as human-dominated landscape are poorly known (Gebresenbet et al., 2018). However, the study of mammals in communal areas is equally important (Girma & Worku, 2020; Lemma & Tekalign, 2020; Tamrat et al., 2020; Udy et al., 2021) even more because of the huge anthropogenic pressures (Burgin et al., 2018; Girma et al., 2012; Legese et al., 2019; Worku & Girma, 2020).  There are some documented information on mammals of human-dominated landscapes in the northern, southwestern, southeastern and central parts of Ethiopia (Bakala & Mekonen, 2020; Gebresenbet et al., 2018; Getachew & Mesele, 2018; Lavrenchenko & Bekele, 2017; Legese et al., 2019; Qufa & Bekele, 2019) and a few in Southern Ethiopia (Diriba et al., 2020; Girma et al., 2012; Lemma & Tekalign, 2020).  There are several intact forests in the Southern parts of Ethiopia. However, their fauna are still not well documented.

The present study was carried out in the Mirab Abaya district, Gamo Zone, Southern Ethiopia. The landscape is largely a forest habitat that harbors different mammal species. The study area is connected to Lake Abaya, the largest lake in the Ethiopian Rift Valley system, which is the main water source for the mammalian species and the Lake created wetland habitat. Despite this, the landscape has been under human interference (e.g., poaching, settlement, expansion of banana and vegetables plantations, fire wood collection, and logging for charcoal production) and livestock pressures. Such human-induced actions can adversely affecting wildlife of the landscape. Understanding of the status of prominent biological components such as mammals in the area is important to urgent management actions. Moreover, there is no ecological study on biodiversity undertaken in the area till now.

Therefore, to contribute towards closing these gaps and to provide the first basic quantitative insights, the present study examined the effects of habitats and seasons on mammals’ diversity, relative abundance and distribution using direct and indirect evidences (Figure 1). The research questions assessed were: i) Are there any differences of the mammalian species composition between habitats types and seasons? It predicted that more forested habitat and wet season would have more diverse mammal species composition compared to agricultural areas and dry season as more resources are available in the forested and wet season; ii) Do mammalian diversity vary among habitats and seasons? It predicted that mammalian species diversity vary in different habitats and between seasons as they have a wider ecological acceptance range; iii) what is the relative abundance of mammals in these habitat types and seasons? It predicted that mammal species richness (number of species) and abundance (number of records) vary between wet and dry seasons and among habitats due to resource differences. The findings of this study are crucial to justify the conservation status of mammalian species in different habitat types and seasons in the landscape.

**2│MATERIALS AND METHODS**

**2.1│Description of the study Area**

FFL is found in Mirab Abaya district in Gamo Zone, Southern Ethiopia and lies between 06°10'12" to 06°15'00" N latitude and 37°42'36" to 37°47'24" E longitude (Figure 1) with an elevation ranging from 1184 - 1795 m.a.s.l. and about 475 km away from Addis Ababa, the capital city of Ethiopia. The study area is located at 30 km North of Arba Minch town, the capital city of Gamo Zone. The total area of the FFL is around 100 km2. The FFL is bounded by Fura Kebele (the lowest administrative unit in Ethiopia) to the south, Faragosa Kebele to the north, and Lake Abaya to the west and southwest. Fura and Faragosa Kebeles are settlement areas in the study landscape (Figure 1). There is one main asphalted road from Addis Ababa to Arba Minch crosses the FFL makes it easily accessible.

The altitudinal range of the FFL is 1,182 - 1,505 m a.s.l. The study area has bimodal rain fall: June to September (heavy rains) and March to April (light rains), the remaining months of the year are fairly dry. The mean monthly rainfall and temperature in the area are 41.8 - 161.4 mm and 14.75 - 26.75°C, respectively (ENMSA, 2019). FFL is characterized by heterogeneous habitats. Thus, based on land-use types and water availability, the landscape was divided into four habitat types: forest (area = 36.04 km2), wet-land (area = 10.12 km2), grass-land (area = 17.74 km2), and cultivated-land (area = 24.19 km2) (Figure 1). The habitats were determined using degrees on Google Earth map, Arc GIS, reconnaissance and with the help of a GPS. Each habitat types were further divided into spatially isolated sites (wet-land = 5, forest = 14, grass-land = 9, cultivated-land = 10) where line transects lay. Based on transect reconnaissance the common flora of the area consists of *Terminalia brownie*, Acacia spp, *Dodonaea angustifolia*, *Acalypha fruticosa*, *Maytenus arbutifolia*, *Olea europaea*, *Ximenia americana*, *Syzygium guineense,* *Prunus africana*, *Bridelia scleroneura*, *Maytenus undata*, *Vangueria apiculata*, *Rhus vulgaris* and *Ozoroa insigns*.

**2.2│Data collection**

Fixed-width line transect sampling method was used to collect mammalian data (Sutherland, 2006). Based on satellite images, GIS and preliminary survey, the study area was first stratified into the four habitat types described above: forest, wet-land, grass-land, and cultivated-land following Worku & Girma (2020). Each habitat types were further divided into spatially isolated sites as described above. This was delineated on a top map of the area, and transects were then established systematically in representative (homogenous vegetation) areas of each habitat type in spatially isolated sites. The distance between adjacent transects and from habitat edges to a transect was limited to a minimum of 0.5 km, to avoid double counting and to avoid edge effects, respectively (Sutherland, 2006). A total of 36 line transects were established across the four major habitat types. Number of transects varied among habitats depending on the isolated sites: 14 in the forest, 5 in the wet-land, and 9 in the grass-land and 10 in the cultivated-land habitats. The length of each transect line was two km and a fixed-sighting distance of 100 m on both sides of transects was used in the habitats. The starting and ending points of each transect were fed into a Garmin GPS unit and used for navigation during data collection.

August and September 2019 during the wet season and January and February 2020 during the dry season were used for data collection. Mammal surveys were carried for two days per season and two times per day (early in the morning between 6:00 and 10:00 hr and late in the afternoon between 15:00 and 18:00 hr; when most animals are thought to be more active)(Belete & Melese, 2016; Woldegeorgis & Wube, 2012). Therefore, each transect line was surveyed eight times in the course of the study period.

During transect visits, a researcher and five trained data collectors traversed the line transects. The data collectors were walking quietly and gently and at a constant speed along each transects against the direction of the wind to minimize disturbances of mammals. During data collection, a researcher and five trained field assistants traversed the transect lines. The observers were walking quietly and gently along each transect and at a constant speed along each transects against the direction of the wind to minimize disturbances of mammals.

Data was collected by recording animal observations and signs (fecal droppings, feed marks, tracks, burrows, territorial markings, spine, sound, and other evidences) (Kingdong, 2015; Rabira et al., 2015). To avoid recounting of the same sign during subsequent monthly sampling periods, only counted sign by data collectors and the researcher was marked at a place. Data collectors shifted in transects to minimize bias. Data recorded whenever an individual animal or group or signs of animals sighted were as follows: date, time, habitat type, species name, individual number of each species, and GPS location (Diriba et al., 2020; Girma et al., 2012; Rabira et al., 2015). Animal counting was made by naked eye and using Bushnell laser rangefinder binocular. Whenever deemed necessary, field guide book was used for identification of mammals (Kingdong, 2015). Only unambiguous signs were recorded. Data from the two replicate surveys each season were pooled together for each transect and used for analysis (Diriba et al., 2020; Girma & Worku, 2020).

**2.3│Data analysis**

Based on records of direct and indirect sign surveys along transects, a presence/absence data matrix was generated and processed for the study habitats and seasons. All the recorded evidences of mammals were classified to their respective orders, families, species level and IUCN red list categories. The conservation status of each species was also identified based on the IUCN Red List (IUCN, 2021). Species diversity was computed in four ways using encounters recorded: species richness (number of species found at a habitat types during a given time period), species diversity (combination of species richness and evenness), species composition (the similarity in species composition between two treatment categories- habitat types, or seasons)(Girma & Worku, 2020; Rabira et al., 2015), and species relative abundance (a measure of frequency of records of mammalian species in habitat types and seasons). An individual-based rarefaction method was used to estimate species richness and abundance in habitat types and seasons (Legese et al., 2019; Qufa & Bekele, 2019). Similarities in species composition among habitats were presented using Venn-diagram. The summed abundance of the number of encounters of each species recorded along each transect for each habitat type in each season was used as the input for the individual-based richness computation. Species richness and diversity of mammals in the study area was analyzed by Shannon-Weaver diversity Index and Simpson’s diversity Index (Sutherland, 2006) calculated as: ( and (2) respectively. The evenness of mammalian species was calculated as . Where, H′ = Shannon-Weaver diversity Index, 1-D = Simpson diversity index, D = dominance, S = the number of species, Pi = the proportion of sampled species expressed as proportion of total sample, ln = logbasen.

Then, variations in number of species belonging to each relative abundance category among habitats were tested using chi-square test. To examine species composition of habitat types, Bray–Curtis similarity analysis was conducted between each pair of habitats (Sutherland, 2006). Habitat analysis was performed using Arc GIS and all data analysis was performed using PAST 4.03.

**3│RESULTS**

**3.1│Mammalian taxonomic composition**

A total of 21 mammalian species belong to six orders and thirteen families were identified in the FFL (Figure 2, Table 1). Order Carnivora was the first and the second most abundant order in terms of number of families (5 families) and species (6 species), respectively. Order Artiodactyla was the second and the first most abundant in terms of number of families (3 families) and species (7 species), respectively. Four mammalian orders were represented each by a single species. At family level, Bovidae (4 species) and Canidae (3 species) were the dominant families. The families Suidae, Felidae and Sciuridae were represented each by two species, but eight families were represented each by a single species (Table 1).

Base on IUCN red list categories three species such as *Hippopotamus amphibius, Panthera leo and Panthera pardus* were vulnerable species found in the study area. *Tragelaphus imberbis, Redunca redunca* and *Ourebia ourebi* were categorized as lower risk/conservation dependent IUCN category (Table 1).

Out of a total of 21 species recorded, 20 species recorded during wet and dry seasons, while *Panthera pardus* recorded only in the wet season (Figure 6). At habitat level, mammal species richness and assemblage were varied among the four habitat types, in increasing order of: wet-land < cultivated-land < forest < grass-land (Figure). *Redunca redunca, Ourebia ourebi, Phacochoerus aethiopicus, Hystrix cristata, Papio anubis* and *Chlorocebus pygerythrus* were the six (23.81%) species shared all habitat types in common (habitat generalists), while *Lepus habessinicus, Panthera pardus* and *Panthera leo* were habitat specialists recorded only in grass-land, forest and wet-land, respectively (Figure 3). Except *Panthera leo*, *Panthera pardus, and Colobus guereza* all the species encountered in the three habitats are subsets of the species recorded in the grass-land habitat (Figure 3).

**3.2│Relative abundance of mammals**

A total of 685 evidences of mammalian species were recorded in the FFL. The number of records varied among orders and families. The abundant order by the number of records from the study area was order Primates which include 290 followed by order Artiodactyla include 194. The least abundant order was Tubulidentata which composes only 8 records. The most abundant family by number of records was Cercopithecidae (290) whereas the least was Viverridae comprises only three records. Based on frequency of records, *Papio anubis* (20.15%) was the most abundant in the study area followed by *Chlorocebus aethiops* (19.27%). Based on IUCN red list category, the vulnerable species such as *Panthera pardus* and *Panthera leo* each contributed less than 0.29%, whereas, *Hippopotamus amphibius* contributed 4.09% of the total records.

The results of the present study showed that of the 685 total records, 30.80% (N = 211) was recorded in the natural forest, 20% (N = 137) in the wet-land, 29.64% (N = 203) in the grass-land and 19.56% (N = 134) in the cultivated-land habitats (Figure 4). The number of records of mammalian species was varied significantly among habitats (KW𝜒2 = 6.03; 𝑃 > 0.05).

In terms of frequency of records, *Chlorocebus pygerythrus was* most abundant species in forest habitat (33.18%, n = 70) and wet-land (32.11%, n = 44)followed by *Papio anubis* (26.54%, n = 56) and *Hippopotamus amphibius* (20.43%, n = 28), respectively. *Papio anubis* (23.49%, n = 47) was also the most abundant in grass-landfollowed by *Phacochoerus aethiopicus* (13.30%, n = 27) while, in cultivated land the most abundant was *Xerus rutilus* (29.14%, n = 39) followed by *Crocuta crocuta* (22.39%, n = 30). *Panthera pardus* and *Panthera leo* were only recorded in forest and wet-land habitats, respectively. Mammalian species frequency of records among four habitat types is described in figure 5 below.

The number of records of mammals was higher in dry season (n = 377, 55.04%) than in wet seasons (n = 308, 44.96%). The abundance of mammals varied significantly between seasons (𝜒2 = 40.783; df = 20; 𝑃 < 0.05; Figure 6). Two species (*Papio anubis* and *Chlorocebus pygerythrus)* were relatively the most abundant in both seasons (Figure 6). These two species contributed 37.99% and 40.58% of the total records of the wet and dry season survey, respectively. The remaining mammalian records contributed between 0.32 and 7.79% in the wet season and 0.53 and 6.90% during the dry season survey. Frequency of records across habitat types was significantly different (𝜒2 = 43.147; df = 20; 𝑃 < 0.05) between seasons.

**3.3│Diversity and similarity indices of mammals**

The Shannon diversity of mammal species was higher in the grass-land (H = 2.543) than other habitats. But, there was no significant difference in Shannon– Wiener Index values between the four habitat types. The higher and lower evenness of the mammalian species was recorded in grass-land (E = 0.7064) and natural forest (E = 0.4761). The dominance of mammalian species was recorded from the highest to the lowest in the natural forest (D = 0.1983) and grass-land (D = 0.1051), respectively. Shannon diversity index and dominance of mammalian species was similar during the dry and the wet seasons. The overall species richness of FFL was 21 and Shannon–Wiener Index values (H) was 2.56 and Simpson's index of diversity showed the highest species diversity (0.8968) in the study area. The diversity indices of mammalian species across habitats and in the study landscape are described in the figure 7 below.

Among the four habitats, more similarity of mammalian species was observed between forest and grass-land. The similarity index between pairs of habitats in decreasing order was forest vs. grassland (0.609) > forest vs. wet-land (0.517) > cultivated-land vs. grass-land (0.433) > grass-land vs. wet-land (0.353) > cultivated-land vs. forest (0.313) > wet-land vs. cultivated-land (0.273).

**4│DISCUSSION**

**4.1│Mammals' taxonomic composition**

The orders and families of mammals recorded in the present study were higher than with the study conducted on medium and large-sized mammal’s indifferent localities. For instance, Legese et al. (2019) identified five orders and seven families in Wabe forest, Ethiopia. Also, Qufa & Bekele (2019) identified seven orders and 11 families from Lebu Natural Protected Forest, Southwest Showa, Ethiopia; Lemma & Tekalign (2020) recorded four orders and five families in Humbo Community-Based Forest Area, Southern Ethiopia; herein FFL 6 orders and 13 families were recorded. In contrary, Girma & Worku (2020) identified nine families and five orders in Nensebo Forest, Southern Ethiopia, which is higher than the present study.

The Primates were the most abundant orders recorded and all belongs to a family Cercopithecidae*.* Similarly, several studies have also reported a higher relative abundance of Primates than other orders from different parts of Ethiopia (Bakala & Mekonen, 2020; Belete & Melese, 2016; Rabira et al., 2015; Worku & Girma, 2020). This is could be due to the high reproductive successes, their more adaptive nature to different habitats, diversified foraging behavior and high tolerance level of Primates to human disturbances (Lemma & Tekalign, 2020; Negeri et al., 2015). Order Carnivora contained the highest number of family (4) among other orders. The result is consistence with the different studies elsewhere in Ethiopia (Bakala & Mekonen, 2020; Girma & Worku, 2020; Lemma & Tekalign, 2020; Rabira et al., 2015). Order Artiodactyla has the highest species richness and the second abundant order recorded. This in agreement with the study in Nensebo forest in Southern Ethiopian where Artiodactyla was the most abundant order containing more species (Girma & Worku, 2020; Lemma & Tekalign, 2020). Orders such as Rodentia, Tubulidentata, and Lagomorpha were recorded as less in the number of individuals. This in line with other studies in different localities in Ethiopia (Fetene et al., 2019; Getachew & Mesele, 2018; Girma & Worku, 2020; Rabira et al., 2015; Worku & Girma, 2020).

**4.2│Mammalian species richness**

The present survey revealed 21 different large and medium-sized mammalian species from the FFL. Some studies that have used similar transect line techniques and to areas of different protection levels across the country and elsewhere revealed that the mammalian species recorded were lower than the result obtained from the present study. For example, Lemma & Tekalign (2020) recorded a total of eight large and medium mammalian species in Humbo Community-Based Forest Area, Southern Ethiopia; Woldegeorgis & Wube (2012) recorded 14 mammal species from Yayu forest in southwest Ethiopia; Getachew & Mesele (2018) recorded even lower (12) mammal species in the Mengaza communal forest, East Gojjam, Ethiopia. This variation might account for variation in mammals' group composition, variation in vegetation structure and human influence and livestock grazing. Findings of the present study therefore highlight that FFL has a valuable importance for the conservation of Ethiopia's mammal species. In addition, the number of mammalian species recorded during the present study was also comparable to several other studies conducted in Ethiopia and elsewhere. For instance, Njoroge et al. (2009) recorded 23 species in Arawale National Reserve, Kenya; Bene et al. (2013) recorded 23 species in Sime Darby, Liberia; Girma et al. (2012) recorded 19 species in Wendo Genet, Ethiopia. The relative abundance of food sources, dense green vegetation cover, and availability of water (Lake Abaya) were might be the major factors governing their abundance and species richness in the present study area.

The present study showed that globally vulnerable species such as *Panthera leo, Panthera pardus* and *Hippopotamus amphibius* were recorded in the area, indicating the area is potential for mammalian biodiversity conservation. *Panthera pardus and panthera leo are* the most widely distributed cats in the world, where food and cover is available (Burgin et al., 2018; Wolf & Ripple, 2018), however, they are vulnerable and at risk of local extinction (IUCN, 2021; Lavrenchenko & Bekele, 2017; Ripple et al., 2014; Tefera, 2011). Also in the present study area, they were restricted to wet-land and forest habitat, respectively. This might be due to the conflict with the local people due to predation for domestic animals (Tefera, 2011). This might contribute for the rareness of these species. In the present study *Hippopotamus amphibius* is distributed in three habitat types and the most abundant in wet-land habitat. This might be because of their ecological preference and adaptation of the mammalian species play a role in their distribution in different habitat types (Penjor et al., 2021; Tamrat et al., 2020; Udy et al., 2021; Wolf & Ripple, 2018). The presence of these conservation concern species demonstrates the effectiveness of wildlife conservation in the study landscape (Lavrenchenko & Bekele, 2017; Tefera, 2011).

**4.3│Mammals' diversity and abundance across habitats and seasons**

*Papio anubis* and *C. aethiops* were the most abundant and *Civettictis civetta, Panthera leo* and *Panthera pardus* were least abundant mammal species in the study area. The low abundance of carnivores might be associated with a minimal number of herbivores and their nocturnal behavior. As described by Wolf & Ripple (2018), Gebresenbet et al. (2018), Lemma & Tekalign (2020) and Worku & Girma (2020), most carnivore species are solitary, nocturnal and crepuscular so that their presence could not be easily documented.

The number of records of mammals recorded during the dry season (377) surpassed the number of recorded during the wet season (308). This in line with the work of Kasso & Bekele (2017) in Assela fragmented forest, Ethiopia, but disagrees with the work of Worku & Girma (2020) in Geremba forest of Southern Ethiopia where more mammals were observed during wet season than dry season. This seasonal abundance difference contradicts the more expected trend of higher abundance during the wet season because of resource availability. The possible explanation for this could be the high number of people and livestock were encroaching more during the wet season than the dry season (Diriba et al., 2020; Worku & Girma, 2020), leading animals to hide or move to other sites. Growth of herbaceous and ground vegetation might have provided thick cover for the mammals, which makes the sighting of them difficult (Diriba et al., 2020; Girma et al., 2012; Girma & Worku, 2020; Qufa & Bekele, 2019). Future researches should focus on examining the factors for seasonal difference in abundance.

In agreement of this hypothesis, most of the species of the FFL, such as *Lepus habessinicus, Mellivora capensis, Crocuta crocuta, Chlorocebus pygerythrus, Colobus guereza, Papio anubis, Orycteropus afer, Hippopotamus amphibius, Phacochoerus aethiopicus* and *Ourebia ourebi* were recorded relatively in lower abundances during the wet season compared with the dry season, which could be attributed to this supposed effect of encroachment on the probability of observing them during field surveys (Girma & Worku, 2020).

The results of the present study showed that of the 685 total records, the abundance was higher in the forest (30.80%) followed by wet-land. The result agrees with other studies (Bakala & Mekonen, 2020; Rabira et al., 2015). All the species encountered in the forest, wet-land, and cultivated-land (except *Panthera leo*, *Colobus guereza* and *Panthera pardus*) habitats are subsets of the species recorded in the grass-land habitat. Given the small size of the grassland habitat compared with the forest, these results are surprising and disagree with the well-established area-species relationships; which states that habitats with greater area tend to contain higher number of species compared with habitats with smaller area (Bakala & Mekonen, 2020; Diriba et al., 2020; Udy et al., 2021; Worku & Girma, 2020). Specifically, presence of large number of order Artiodactyla (herbivores species) guild found in the grassland, as a result of higher habitat quality, might have also attracted a high number of order Carnivora species and resulting to increased diversity (Diriba et al., 2020; Fetene et al., 2019; Girma & Worku, 2020). Therefore, the different habitat should be given equivalent conservation attention. Further focused studies are needed on prey–predator relationships for effective management planning in the FFL.

Species assemblage of the wet-land habitat was nine and dominated by *Hippopotamus amphibius* and *Chlorocebus pygerythrus*. This indicates that, despite hosting the lowest number of species, the wetland habitat supports species that are unique to that habitat type, specifically the vulnerable *Hippopotamus amphibius*. Thus, the wetland habitat plays a complementary role in increasing mammal diversity and water source for mammals of the FFL. Similar results have been demonstrated by a number of studies (Bakala & Mekonen, 2020; Fetene et al., 2019; Rabira et al., 2015; Udy et al., 2021; Worku & Girma, 2020), suggesting that a combination of the wetland and the other habitats is crucial to the long-term maintenance of viable populations of some species.

The species index of the diversity of the study area showed higher species richness (*H* = 2.56; 1-D = 0.8968) than to study conducted by Qufa & Bekele (2019) in Lebu natural protected forest, Ethiopia (H = 2.119; 1-D = 0.8167). The grassland habitat is characterized by greater species richness and Shannon diversity index, and vice versa for wetland habitat. The present study was also comparable to the species diversity index (D = 7.142) recorded in Geremba forest by Worku & Girma (2020). Different possible factors like availability of food sources, dense forest cover, and water might be contributed to higher species richness.

**5│CONCLUSIONS**

The findings of the study reveal that FFL supports a considerable number of medium and large mammalian species, including three globally threatened species: the vulnerable *Panthera pardus, Panthera leo* and *Hippopotamus amphibius* (IUCN, 2021). This is the first ecological information on the diversity of mammals of the FFL, which would serve as valuable baseline information for stakeholders to make effective conservation decisions and for researchers wishing to conduct related ecological studies. Also, least conservation concern species such as *Papio anubis*, *Chlorocebus pygerythrus and Phacochoerus aethiopicus* are highly recorded in the study area across habitat types and seasons. The Simpson index showed the area harbors diverse mammalian species. The number of medium and large-sized mammalian species recorded in the study area is higher and comparable to other localities in Ethiopia and elsewhere using similar transect line technique sampling and direct and indirect field methods.

Despite the importance of FFL as the home for 21 mammalian species belongs to six orders and 13 families, it is not legalized as a wildlife refuge area. Therefore, to ensure the long-term conservation of the mammal of the forest, the following recommendations are suggested: The federal and regional governments should legalize as a wildlife refuge area to conserve mammals of the area. Clear demarcation of the area is also essential. Local community and knowledge-based conservation and management initiatives must be implemented in the area. 

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DATA ACCESSIBILITY STATEMENT

All data used in this study will be archived in the Dryad data repository upon acceptance.

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