Diversity and threats of medium and large-sized mammals in Faragosa Communal Forest, Gamo Zone, Southern Ethiopia

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Abstract

Abstract Mammals function as ecological engineers. The ecological relevance of mammals, shortage of data and increased human threats make the matter very essential and necessary to evaluate their diversity and current conservation status. Mammals' diversity and their threats in Faragosa Communal Forest (FCF) areas are poorly surveyed. The study aimed at assessing medium and large-sized mammals of the study area, and their major threats in FCF. Survey of mammals conducted from August to December 2019 in FCF, Gamo zone, Southern Ethiopia. Transect line method using direct and indirect field observations used to collect data on mammals and their threats. A total of 685 individuals were id belonging to twenty-one mammalian species, six orders and thirteen families were observed. Hystrix cristata, Xerus rutilus, Marmota monax, Mellivera capensis, Chlorocebus aethiops, Papio anubis, Colobus guereza, Civettictis civetta, and Lapus hassinicus were among the medium-sized mammals while Tragelaphus imberbis, Redunca redunca, Ourebia ourebi, Sylvicapra grimmia, Phacochoerus aethiopicus, Pontamochoreus larvatus, Hippopothamus amphibus, Orycteropus afer, Crocuta crocuta, Panthera leo, Panthera pardus, and Canis mesomelas were the large mammals of the study area. Papio anubis and Chlorocebus aethiops were the dominant species identified. The abundant order recorded by the number of observations was order Primates (284 individuals) followed by order Artiodactyla (201 individuals) while the least abundant order was Tubulidentata (8 individuals). Among observed 685 mammals, 371 (54.16%) individuals were recorded in dry season while 314 (45.84%) individuals were recorded in wet season and abundance significantly varied between seasons ($2 = 40.783$; df $= 20$; < 0.05). The prevailing threatening factors identified were logging of trees for fuelwood and house construction, overgrazing, deforestation, hunting, mining, and invasive alien plants. As the area is rich in mammals and threatened by different factors, urgent conservation action is highly recommended. K E Y W O R D S diversity, Ethiopia, Faragosa forest, mammals, threats

1—INTRODUCTION

Mammals are an extraordinary group, showing an amazing diversity of species, forms, ecologies, and behaviors (Wilson and Reeder, 2005; IUCN, 2019). Class Mammalia is composed of 5487 species and more than 1150 species of mammals are found in Africa (Borges et al., 2014). East Africa is rich in mammalian fauna (Girma et al., 2012a).

Mammalian species are one of the greatest resources found on the Earth (Qufa and Bekele, 2019). 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; Bogonia et al., 2017). Large-sized mammals (weigh more than 7kg) and medium-sized mammals (weigh between 2 and 7kg), in particular, have important ecosystem functions (Geleta and Bekele, 2016). Mammals play key roles throughout many of the world's ecosystems including grazing, predation and seed dispersal (Scholes et al., 2006). They also provide important human benefits such as food, recreation, and income (MEA, 2005).

Worldwide, medium and large-sized mammalian species face numerous threats (Kasso and Bekele, 2014;

Wale et al., 2017). Habitat loss and degradation and harvesting (hunting/gathering for food, medicine, fuel and materials) are by far the main threats to mammals (Ripple et al., 2016). Among land species, habitat loss is prevalent across the tropics, driven particularly by deforestation in Central and South America, West, East and Central Africa, Madagascar, and in South and Southeast Asia (Tabor et al., 2018).

The rate of species discovery among mammals is high in regions of high levels of endemism and threat (Reeder et al., 2007). Nonetheless, our understanding of conservation implications of mammals is surprisingly patchy. There is, therefore, an urgent need to secure and maintain sites containing assemblages of mammals (Negeri et al., 2015). For any comprehensible conservation and effective management action to be adopted for mammals, accurate knowledge of population composition, diversity, distribution, management and their threats have to be known and constantly monitored (Kasso and Bekele, 2014) in order to avoid extermination and to secure the richness of mammalian biodiversity (Laurindo et al., 2019).

Ethiopia is one of the world's rich biodiversity countries and it deserves attention regionally and globally (Yalden and Largen, 1992). Ethiopia's high faunal biodiversity reflects the existence of a large number of species of mammals and other higher vertebrates. Ethiopia is among the world leaders in terms of richness and endemism of mammalian species (Lavrenchenko and Bekele, 2017; Tefera, 2011). More than 60% of the mammal species in Ethiopia are medium and large-sized (Negeri et al., 2015). Topographic diversity and climate are the most significant predictors of mammalian species diversity in Ethiopia (Tefera, 2011).

Among identified 320 mammalian species of Ethiopia, 36 are endemic to the country (Gonfa et al., 2015). However, the wildlife population in Ethiopia has diminished over the past century both in amount and distribution through the loss of habitat, hunting, and land clearance for farming; land degradation due to overgrazing (Wale et al., 2017).

In Ethiopia, most of the studies on mammals were restricted to protected areas (Wale et al., 2017; Fetene et al., 2019; Takele and Solomon, 2011; Chane and Yirga, 2014) but the diversity and conservation status of mammalian species outside protected areas such as communal forest areas are poorly known. However, the study of mammals in communal areas is equally important (Tsegaye et al., 2009) even more because of the huge anthropogenic pressures (Legese et al., 2019; Kasso and Bekele, 2017; Girma et al., 2012b).

In Ethiopia, limited community-managed areas were surveyed for the diversity of mammals (Yalden and Largen, 1992). There are some documented information on mammals of community-managed areas in the northern, southwestern, southeastern and central parts of Ethiopia (Lavrenchenko and Bekele, 2017; Legesse et al., 2019; Qufa and Bekele, 2019) and a few in Southern Ethiopia (Girma et al., 2012b). There are several intact forests in the Southern parts of Ethiopia. However, these fauna are still not well documented.

FCF is one of these forests located in the Gamo zone, Southern region of Ethiopia. This forest seems a place where green economy strategy has come to be implemented. This ecosystem is hypothesized to contain some medium and large-sized mammal species in its forest, but the composition of mammalian species and their abundance, diversity, structure and threats in the area are not yet researched. Therefore, the present study was the first of its kind in the area and the main objective of the present study was to determine the species composition, diversity and relative abundance of medium and large-sized mammals and their threats from Faragosa Communal Forest, Southern Ethiopia.

2— MATERIALS AND METHODS

2.1— Description of the study Area

FCF is found in Mirab Abaya Wereda, Gamo Zone, SNNPR Regional State 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. It is located at 18 km south of Birbir town, the capital city Mirab Abaya Wereda, and 30 km North of Arba Minch town, the capital city of Gamo Zone (Figure 1). The total area of the natural forest is around 8880 hectares. The FCF is bounded by Fura Kebele to the south, Faragosa Kebele to the north, Done Kebele to the east, Ankober

Kebele to the northeast and Lake Abaya to the west and southwest. There is one main asphalted road from Addis Ababa to Arba Minch crosses the FCF makes it easily accessible.

Rainfall and temperature data were obtained from Mirab Abaya meteorological station. Ten years summarized the mean monthly maximum and minimum temperature of the area showed that the mean monthly maximum temperature was 26.75 °C while the mean monthly minimum temperature was 14.75 °C (ENMSA, 2018). According to the ten years rainfall summarized data, the area has a bimodal rainfall distribution, characterized by a prolonged wet season from June to September (long rain), locally known as "Balgo" and a short wet season between March and April locally known as "Asura". The mean monthly rainfall of the area varies between 41.8mm (January, dry season) and 161.4mm (may, wet season) (Figure 2).

2.2— Reconnaissance

Reconnaissance observations were made before data collection to provide information on accessibility, climate, vegetation cover, topography, infrastructure, fauna, and distribution of mammals and their threats and to launching sampling plans. Sampling designs and the number of sampling units were established based on these initial observations (Krebs, 2006).

2.3—Sampling design

Line transect sampling technique was used to estimate population abundance for a variety of mammalian species in the forests following Krebs (2006) and Laurindo et al.(2019). The systematic sampling design was employed to ensure the representativeness of the study population by sampling the total area of the forest. To do so, out of twenty potential transect lines of unequal size that run from North to South, the first transect was randomly selected and thereafter every fourth transect number (3, 7, 11, 15, 19) were systematically selected. The length of transects varied from 2.5 to 7.5 km. The length of the total transect line was 92.24 km. For selected and surveyed transect lines, the total length was 25.6 km. Consecutive transects were at a distance of 0.7 km to avoid double counting. Transect lines were delineated by GPS and/or natural signs.

The study was divided into dry and wet seasons to check variations on diversity and abundance between seasons (Laurindo et al., 2019). August and September for the wet season, and October and November for the dry season, a total of four months were assigned to collect data.

2.4— Methods of data collection

The standard field techniques including direct and indirect observations were employed from July to December 2019 in FCF to collect data. The survey was carried in the first two consecutive days every month and twice a day (early in the morning during 06:00 to 08:00 hour and late in the afternoon during 17:00 to 19:00 hour) following Legese et al. (2019).

Direct and indirect observations for medium and large-sized mammals surveys were started 200 meters inside from forest edge and were recorded at the maximum of 100-meter distance from both the left and right side during walking along the fixed-width transect line (Krebs, 2006).

Direct observation was made through binocular and naked eyes to assess mammalian species and threats and indirect observation was made based on indirect evidence of mammals such as carcass, footprint, holes, sound, and fecal-pellet (Larsen, 2016; Laurindo et al., 2019).

During transect visits, a researcher and five trained field assistants traversed the track lines. While the observer was walking quietly and gently along each transects against the direction of the wind to minimize disturbances of mammals, the data on any mammalian direct and indirect observation such as species, size, and threats were trapped by the camera and recorded on the datasheet. Body size, coloration, presence, and absence of horn, horn shape, genitalia, and dominant behavior were used to identify observed mammals following the Kingdom Field Guide to African Mammals (Kingdom, 2003).

2.5— Data analysis

All the observed (direct or indirect) mammals were identified to their respective orders, families and species level by using the taxonomic characters listed in Kingdom (2003), and Yalden and Largen (1992). The relative abundance of each species was computed using the percentage, from total number of each species observed per total individuals observed in the area.

Both qualitative and quantitative data were analyzed with descriptive statistics. SPSS Version 16.0 statistical program, PAST version 3.26b Statistical Package (Software) and appropriate statistical methods such as mean and percentage were used. Gini Simpson and Shannon-Wiener Diversity Index were computed by using PAST. A chi-square test was used to compare the seasonal variation in species abundance at 0.05 levels of significance. The threats were analyzed systematically by condensing and summarizing information.

3—RESULTS

3.1— Mammalian taxonomic composition

A total of twenty-one mammalian species belong to six orders and thirteen families were identified by direct and indirect field evidence in FCF. The species richness varied across orders and families. Order Carnivora represented by the largest number of families (five) followed by Artiodactyla (three) and Rodentia (two). Tubulidentata, Primates, and Lagomorpha each represented by single-family. Order Artiodactyla composes 33% of total species followed by Order Carnivora composes 29% of total species (Figure 3). More mammalian species were recorded for the family Bovidae (four species), followed by Cercopithecidae (three species). The families Suidae, Felidae and Sciuridae were represented by two species each. The remaining seven families Hippopotamidae, Orycteropodidae, Hystricidae, Hyeaniadae, Mustelidae, Viverridae, Canidae, Leporidae were represented by single species (Table 1).

Among identified mammals eleven (52.4%) species were large-sized and ten (47.6%) species were medium-sized (Table 1). Eight of the recorded mammal species observed using indirect evidence (Table 1) whereas the remaining thirteen records of observation for mammal species were through direct sighting (Table 1). Out of a total of 21 species recorded, 20 species occurred during wet and dry seasons. *Panthera pardus* recorded only in the wet season.

3.2— Abundance of mammals

A total of 685 medium and large-sized mammalian individuals belong to six orders, thirteen families and twenty-one species were identified in FCF. The number of individuals varied among orders and families (Figure 3) and among species (Figure 4). The abundant order by the number of observations from the study area was recorded by order Primates which include 284 individuals followed by order Artiodactyla include 201 individuals. The least abundant order was Tubulidentata which composes only 8 individuals. The most abundant family was Cercopithecidae (284 individuals) whereas the least was Viverridae comprises only two individuals. Among mammals, *Chlorocebus aethiops* (19.27%) and*Papio anubis* (19.27%) were the most abundant mammalian species in the study area followed by *Phacochoerus aethiopicus* (7.74%).*Panthera pardus* and *Civettictis civetta* each contributed only 0.29% of the total recorded individuals.

The abundance of mammals varied between seasons (Table 2). 371 (54.16%) individuals were recorded in dry season while 314 (45.84%) individuals were recorded in wet seasons. The variation of mammals between seasons was statistically significant (?2 = 40.783; df = 20; ? $<$ 0.05). The relative abundance of the different mammalian species varied from 0.32 to 20.38% in the wet season and from 0.27 to 21.56 % in the dry season. Two species*Papio anubis* , and *Chlorocebus aethiops* were relatively the most abundant in both seasons (Table 2). These two species contributed 36.94% and 39.89% of the total sample of the wet and dry season survey, respectively. The remaining mammalian species of individuals contributed between 0.23 and 8.28% in the wet season and 0.27 and 7.28% during the dry season survey. Mammals of individuals of*Pontamochoreus larvatus, Papio anubis* and *Chlorocebus aethiops* showed significant variation between wet and dry seasons and the other species significant level did not reveal variation between seasons.

3.3— Diversity indices of mammals

The overall species richness of FCF 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 (Table 3).

3.4— Threats to mammals in the study area

Human and non-human activities have threatened mammals and their habitats in the study area. During the present study periods, the major threats observed in the area were hunting, logging, deforestation, predation, invasive alien plants, overgrazing, and mining.

Hunting : The high rate of incidence of hunting was recorded for *Papio anubis* because its extent of damage was high to the local community and agricultural crops.*Chlorocebus aethiops* was also a pest on crops resulting in hunting. *Xerus rutilus* was hunted by young men also recorded in the area. During the fieldwork, the researcher had counted 8 carcasses of mammals of *Phacochoerus aethiopicus, Chlorocebus aethiops* , *Panthera pardus,* and *Papio anubis* .

Predation : *Papio anubis* killed and eat the young of*Redunca redunca* was recorded. Predation by dogs of animals like*Civettictis civetta* and *Orycteropus afer* were recorded.

Overgrazing : Locals regularly bring cattle to the forest mainly for drinking water in the Lake Abaya. Mammals Cattle overgrazing and competition for food resources were recorded. Even though cattle are prohibited, they cause severe overgrazing around the edge of the forest.

Deforestation : Deforestation for agricultural land expansion was observed at the edges of the forest. Clearing forest by humans from adjacent croplands to avoid large mammal pests was also recorded. *Papio anubis* damage to the natural forest through debarking and destroying the young and seedling plants was also recorded.

Logging : During the transect walk evidence of illegal logging such as the removal of trees for timber production, for fuelwood and construction materials and grass collection for cattle and thatching houses were observed.

Invasive alien species : The encountered invasive alien species during the transect survey were water hyacinth Parthenium weed (*Parthenium hysterophorus*) and Lantana weed (*Lantana camara*) at the edges of forests and roads. The invasive plant Parthenium weed (*Parthenium hysterophorus*) dominated the place at some edges of the forest and homogenized the place (see Appendix 3). Also, they reduced the grass species abundance for herbivores mammals.

Mining : Mining of stone for cobblestone by different enterprises in different parts of the forest was another challenge observed during the survey, and severely affecting forest habitat of mammals.

4— DISCUSSION

4.1— Mammals composition and abundance

The present survey revealed different large and medium-sized mammals from FCF and a total of 21 species were identified from 685 total observational records. These mammal species were grouped into six orders and thirteen families. Some studies that have used similar transect line techniques and to areas of different protection levels across the country and elsewhere revealed that the medium and large-sized mammals recorded were lower than the result obtained from the present study. For example, Geleta and Bekele (2016) recorded 15 mammal species in Wacha Protected Forest, Western Ethiopia by direct and indirect evidence. Also, Woldegeorgis and Wube (2012) recorded 14 mammal species from Yayu forest in southwest Ethiopia; Atnafu and Yihune (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.

The number of medium and large-sized mammals recorded during the present study was 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. (2012b) recorded 19 species in Wendo Genet, Ethiopia; and Ofori et al. (2012) recorded 23 species in the moist semi-deciduous forest of Ghana. The relative abundance of food sources, dense green vegetation cover, and high survey period, good management practice of local people and availability of water (Lake Abaya) were might be the major factors governing their abundance and species richness in the present study area.

Some studies conducted in different countries revealed that the medium and large-sized mammals recorded were higher than the result obtained from the present study. Some of the studies among others include Cortes-Marcial et al. (2014) recorded 35 mammals in Oaxaca, Mexico and Melo et al. (2015) recorded 33 mammals in northern Amazon, Brazil. This might account for variation in sample sites, season considered, and variation in vegetation cover.

Most mammals were recorded by direct observations during the present survey. This result disagreed with the result obtained by Alves et al. (2014) in which out of a total of 239 individuals 75% were obtained from indirect evidence, footprints but agrees with most studies in different localities (e.g. Legese et al., 2019; Gonfa et al., 2015)

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 and Bekele (2019) identified seven orders and 11 families from Lebu Natural Protected Forest, Southwest Showa, Ethiopia; Laurindo et al. (2019) found out six orders and 12 families, Cerrado remnants in south eastern Brazil; herein FCF 6 orders and 13 families were recorded.

The Primates were the most abundant orders recorded and all belongs to a family Cercopithecidae. *Pabio anubis* and *Chlorocebus aethiops* were the most abundant mammal species in the study area. Similarly, several studies have also reported a higher relative abundance of Primates than other orders from different parts of Ethiopia (e.g. Geleta and Bekele, 2016; Gonfa et al., 2015; Girma et al., 2012b). 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 (Negeri et al., 2015).

The abundance of carnivores was minimal; however, it contained the highest number of family (4) among other orders. Among the recorded carnivores, *Civettictis civetta, Panthera leo* and *Panthera pardus* were least abundant. This might be associated with a minimal number of herbivores and their nocturnal behavior. As described by Hunter and Yonzon (1993), most carnivore species are solitary, nocturnal and crepuscular so that their presence could not be easily documented.

Order Artiodactyla has the highest species richness and the second abundant order recorded. *Phacochoerus aethiopicus* was abundant and *Ourebia ourebi* was the least abundant species recorded in this order. The destruction of habitat is especially harmful to large mammals that require large home ranges to fulfill their nutritional requirement (Ripple et al., 2016).

Orders such as Rodentia, Tubulidentata, and Lagomorpha were recorded as less in the number of individuals. This inline with other studies in different localities in Ethiopia (e.g. Atnafu and Yihune, 2018; Geleta and Bekele, 2016; Gonfa et al., 2015).

The number of individuals of mammals recorded during the dry season (371) surpassed the number of recorded during the wet season (314). This inline with the work of Kasso and Bekele (2017) in Assela fragmented forest, Ethiopia. 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. Growth of herbaceous and ground vegetation might have provided thick cover for the mammals, which makes the sighting of them difficult (Gundogdu, 2011).

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 and Bekele, (2019) in Lebu natural protected forest, Ethiopia (H = 2.119;

1-D = 0.8167). Different possible factors contributed might be due to higher survey period and availability of food sources, dense forest cover, and water.

4.2— Threats to mammals

Mammals of FCF are affected by several human and non-human induced factors such as forest clearing for farming, fuelwood exploitation, and extraction of construction materials from the areas, mining, hunting, and predation by dogs and carnivores. This holds true in different localities (Woldegeorgis and Wube, 2012; Legese et al., 2019; Geleta and Bekele, 2016; Fetene et al., 2011). Anthropogenic activities affect the interactions, distribution, and diversity of species through habitat loss and modifications (Kasso & Bekele, 2014).

Fuelwood exploiters and local communities visit the forest accompanied by dogs. The presence of dogs in natural habitats affects wildlife. The interaction between wildlife and dogs include predation and disturbance (Doherty et al., 2017). Livestock was also seen in some parts of the forest for grazing. Geleta and Bekele (2016) also reported the adverse effects of livestock on mammals in Wacha Protected Forest, western Ethiopia.

Mining of stones for cobblestone was another challenge in the area. Similarly, Attuquayefio et al. (2017) showed mining poses serious risks to the continent's natural environment and exceptionally rich biodiversity and direct negative impacts include habitat loss and fragmentation, the killing of wildlife during land clearance.

6— CONCLUSIONS

The present study gave baseline information about the presence of medium and large-sized mammals identified and documented 21 medium and large-sized mammalian species of FCF. Among identified mammals, 10 were medium and 11 were large-sized mammals. Thirteen species of mammals identified through direct observations while eight were through indirect evidence. FCF contains significant mammalian orders such as Artiodactyla, Tubulidentata, Rodentia, Primates, Carnivora, and Lagomorpha. Among these, order primate constitutes a large proportion of the abundance of individuals than other orders. *Papio anubis* ,*Chlorocebus aethiops and Phacochoerus aethiopicus* are highly recorded in the study area. The relative abundance of mammalian species of individuals between wet and dry seasons varies significantly. The Simpson index showed the area is diverse. The number of medium and large-sized mammalian species recorded in the study area is comparable to other localities in Ethiopia and elsewhere and even higher than some studies using similar transect line technique sampling and direct and indirect field methods.

FCMF is threatened by human and non-human factors such as hunting, overgrazing, logging, mining, invasive alien species and deforestation by agricultural expansion. In general, if these threats continue, there might be reduced chance to see the present mammals of the study area.

Despite the importance of FCF as the home for mammals, 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 given in the area.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

AUTHOR CONTRIBUTIONS

Berhanu Gebo and Serekebirhan Takele conceived, designed the study data collection. Berhanu Gebo conducted fieldwork, analysis, write the manuscript and revised the whole document. Serekebirhan Takele designed the survey method, edited the manuscript and revised the final version of the main document for submission for potential review. All authors contributed to the writing of the manuscript and approved the submitted version.

DATA AVAILABILITY STATEMENT

The medium and large-sized mammals and threats data and photos used to support the findings of this study are included within the article.

REFERENCES

Alves, B. G., Junior, M. O., & Brites, V. C. (2014). Medium and large-sized mammals of a fragment of Cerrado in the Triangulo Mineiro region, Southeastern Brazil. *Bioscience Journal of Uberlandia* ,*30* (3), 863–873.

Atnafu, G., & Yihune, M. (2018). Species composition and relative abundance of medium and large mammals in Mengaza communal forest, East Gojjam, Ethiopia. *Journal of Ecology and the Natural Environment* ,*10* (2), 34–40. https ://doi.org/10.5897/JENE2 017.0667

Attuquayefio, D. K., Owusu, E. H., & Ofori, B. Y. (2017). Impact of mining and forest regeneration on small mammal biodiversity in the Western Region of Ghana. *Environ. Monit. Assess.,* 189 (5), 237–245.

Bene, J. K., Bitty, E. A., Bohoussou, K. H., Abedilartey, M., Gamys, J., & Soribah, P.A.J. (2013). Current conservation status of large mammals in Sime Darby oil palm concession in Liberia. *Global Institute Resear. Edu* . 2, 93–102.

Bogonia, J. A., Graipelb, M. E., Oliveira-Santosd, L. R., Cheremc, J. J., Giehla, H. E., & Peronia N. (2017). What would be the diversity patterns of medium to large bodied mammals if the fragmented Atlantic Forest was a large meta-community? *Biological Conservation* , 211, 85–94.

CBD. (2016). Conference of the parties to the convention on biological diversity (CBD). Thirteenth meeting. Cancum, Mexico, 4–17 December.

Chane, M., & Yirga, S. (2014). Diversity of Medium and Large-sized Mammals in Borena-Sayint National Park, South Wollo, Ethiopia.*International Journal of Sciences: Basic and Applied Research (IJSBAR),* 15(1), 95–106.

Cortes-Marcial, Y. M., Ayon, M., & Briones-Sala, M. (2014). Diversity of large and medium mammals in Juchitan, Isthmus of Tehuantepec, Oaxaca, Mexico. *Animal Biodiversity and Conservation* , 37(1), 1–12.

Doherty, T., Dickman, C., & Glen, A. (2017). The global impacts of domestic dogs on threatened vertebrates. *Biol Conserv* ., 210, 56–59.

ENMSA. (2018). Ethiopia National Meteorological Service Agency, Data base for metrological data source (2008-2017) of Mirab Abaya District, Ethiopia.

Fetene, A, Mengesha, G & Bekele, T. (2011). Spatial distribution and habitat preferences of selected large mammalian species in the Nechisar National Park (NSNP), Ethiopia. *Nature Sci* ., 9, 80-90.

Fetene, A, Yeshitela, K & Gebremariam, E. (2019). The effects of anthropogenic landscape change on the abundance and habitat use of terrestrial large mammals of Nech Sar National Park. *Environ Syst Res,* 8, 19.

Geleta, M., & Bekele, A. (2016). Survey of Medium and Large-sized Mammals in Wacha Protected Forest, Western Ethiopia. *Scholarly Journal of Agricultural Science,* 6(3), 71–79.

Girma, Z., Bekele, A., & Graham, H. (2012a). Large Mammals and Mountain Encroachments on mount Kaka and Hunkolo Fragments, South east Ethiopia.*Asian. J. Appl. Sci.* , 5(5), 279–289.

Girma, Z., Mamo, Y., & Ersado, M. (2012b). Species composition, distribution and relative abundance of large mammals in and around Wondo Genet forest patch, Southern Ethiopia. *Asian Journal of Applid Science,* 5(8), 538–551.

Gonfa, R., Gadisa, T., & Habtamu, T. (2015). The diversity, abundance and Habitat associations of medium and large-sized mammals in Dati Wolel National Park, western Ethiopia. *Intl J Biodiv Conserv.* , 7, 112-118.

Gundogdu, E. (2011). Population size, structure, and behaviours of wild goat in cehennemdere wildlife improvement area. *Asian J.Anim. Vet.Adv* ., 6, 55–563.

Hunter, M. L., & Yonzon, P. (1993). Altitudinal Distribution of Birds, Mammals, People, Forests and Parks in Nepal. *Conserv. Biol* ., 7, 420– 423.

IUCN. (2019). The IUCN Red List of Threatened Species: e.T41695A147992107. http://dx.doi.org/10.2305/IUCN.UK.2019-2.RLTS.T41695A147992107.en

Kasso, M., & Bekele, A. (2017). Diversity, Abundance and Distribution of Mammals in Fragmented Remnant Forests around Asella Town, Ethiopia.*MAYFEB Journal of Biology and Medicine* , 1, 1–12.

Kasso, M., and Bekele, A. (2014). Threats to mammals on fragmented habitats around Asella Town, Central Ethiopia. *International Journal of Biodiversity* , 1–7. http://dx.doi.org/10.1155/2014/903898

Kingdom, J. (2003). The Kingdon Field Guide to African Mammals. Christopher Helm A and C Black Publishers Ltd., London, 475.

Krebs, C. J. (2006). Mammals In: Ecological Census Techniques: a Hand book, (Sutherland W.J. ed). Cambridge University Press, Cambridge, 186–213.

Larsen, T. H. (2016). Core standardized methods for rapid biological field assessment. Arlington, VA: Conservation International.

Laurindo, R. S., Toledo, F. R. N., & Teixeira, E.M. (2019). Mammals of medium and large-size in Cerrado remnants in Southeastern Brazil.*Neotropical Biology and Conservation* , 14(2), 195–206.

Lavrenchenko, L. A., & Bekele, A. (2017). Diversity and conservation of Ethiopian mammals: what have we learned in 30 years?. *Ethiop. J. Biol. Sci.,* 16, 1–20.

Legese, K., Bekele, A., & Kiros, S. (2019). A Survey of large and medium sized mammals in Wabe forest fragments, Gurage zone, Ethiopia.*Int J Avian & Wildlife Biol* ., 4(2),32–38.

Magurran, A. E. (2004). Measuring biological diversity, 2nd ed. Blackwell Science Ltd, Oxford, U.K.

MEA. (2005). Millennium Ecosystem Assessment; Ecosystems and human well-being: synthesis. Island, Washington, D.C., USA.

Melo, A., Gadelha, R., Silva, D., Silva Junior, A., & Pontes, A. (2015). Diversity, abundance and the impact of hunting on large mammals in two contrasting forest sites in Northern Amazon. *Wildlife Biology* , 21(5), 234–245.

Negeri, N., Gadisa, T & Habtamu, T. (2015). The diversity, distribution and relative abundance of medium and large-sized mammals in Baroye controlled hunting area, Illubabor Zone, Southwest Ethiopia. *Intl J Mol Evol Biodiv* ., 5, 1-9.

Njoroge, P., Yego, R., & Muchane, M. (2009). A survey of the large and medium-sized mammals of Arawale National Reserve, Kenya. *J East African Natural Hist* ., 98, 119-128.

Ofori, B. Y., Attuquayefio, D. K., & Owusu, E. H. (2012). Ecological status of large mammals of a moist semi-deciduous forest of Ghana: implications for wildlife conservation. *J. Biodiver. Enviro. Sci* ., 2, 28–37.

Qufa, C. A., & Bekele, A. (2019). A preliminary survey of medium and large-sized mammals from Lebu Natural Protected Forest, Southwest Showa, Ethiopia. *Ecology and Evolution,* 00, 1–10.

Reeder, D. M., Helgen, K., & Wilson, D. E. (2007). Global trends and biases in new mammal species discoveries. Occasional Papers,*Museum of Texas Tech. Univ.,* 269, 1–36.

Ripple, W. J., Abernethy, K., Betts, M. G., Chapron, G., Dirzo, R., Galetti, M., Levi, T., Lindsey, P. A., Macdonald, D. W., Brian Machovina, B., Newsome, T. M., Peres, C. A., Wallach, A.D., Wolf, C., & Young, H. (2016). Bushmeat hunting and extinction risk to the world's mammals. *R. Soc. open sci.,* 3, 160–498.

Scholes, J., Kuper, W., & Biggs, R. (2006). Biodiversity. Africa Environment Outlook (Our Environment, Our Wealth). Report, Nairobi, 261.

Tabor, K., Hewson, J., Tien, H., Gonzalez-Roglich, M., Hole, D., & Williams, J. W. (2018). Tropical Protected Areas under Increasing Threats from Climate Change and Deforestation. *Land* , 7, 90.

Takele, S., & Solomon, J. R. A. *(2011). Diet composition of black-backed jackal. Journal for nature conservation, 23(2), 169 –181.*

Tefera, M. (2011). Wildlife in Ethiopia: Endemic Large Mammals. *World Journal of Zoology,* 6 (2), 108–116.

Tsegaye, G., Semeret, M., & Lemenih, M. (2009). Participatory forest management and its impacts on livelihoods and forest status: the case of Bonga forest in Ethiopia. *Int For Rev.,* 11, 346–358.

Wale, M., Kassie, A., Mulualem, G., Tesfahunegny, W., & Assefa, A. (2017). Wildlife threats and their relative severity of Eastern Ethiopia protected areas. *Ecology and Evolutionary Biology* , 2, 59–67.

Wilson, D. E., & Reeder, D. M. (2005). Mammal species of the world. A taxonomic and geographic reference. Baltimore, MD: Johns Hopkins University Press.

Woldegeorgis, G., & Wube, T. (2012). A survey on mammals of the Yayu forest in Southwest Ethiopia, *Ethiop. J. Sci* ., 35(2), 135–138.

Yalden, D. W., & Largen, M. J. (1992). The endemic mammals of Ethiopia.*Mammal Review,* 22(3-4), 115–150.

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