A Preliminary Survey of Medium and Large-Sized Mammals in Amoro Forest, West Gojjam Zone, Amhara, Ethiopia

Dagnachew Lakew[1] and Belayneh Ayichew[2]

[1]Wollo University
[2]Arba Minch University

July 22, 2021

Abstract

Aim: The objective of this study was to survey the species composition, relative abundance and to determine major threats of medium and large-sized mammals in Amoro Forest. Method: Linetransects surveying and indirect surveys method (including fresh tracks, scats, hair, spines and burrows) were used to survey mammalian diversity. A survey was conducted in the early morning from 6:00 to 10:00 and late afternoon from 16:00 to 19:00. Key interview and direct site observationswere carried out to assess the major threat of mammals in the study area. Results: A total of 12 species of medium and large sized mammals belonging to sex orders and eight families were recorded. Porcupine (Hystrix cristata), Vervet monkey (Chlorocebus aethiops) and Olive baboon (Papio anubis) were among the medium-sized mammals while, Spotted hyena (Crocuta crocuta),Leopard (Panthera pardus) and Common duiker (Sylvicapra grimmia) were among the large sized mammals observed in the study area. Shannon–Wiener Index values were low (H' = 1.666) whereas, the Simpson's index (1-D) of diversity showed the highest species diversity (0.761) in the study area. Illegal logging of trees; overgrazing, agricultural activities and human-wildlife conflicts were the foremost threats in the area. Conclusion: Species richness and evenness were varied from habitat to habitat in Amoro forest. Land degradation anddifferent anthropogenicactivities were common threats for the mammals in the study area. Community participation and awareness creation is very important to limit the impact of anthropogenic activities threatening wildlife. Key words: Anthropogenic activity, Conservation, Diversity, Mammalssurvey

A Preliminary Survey of Medium and Large-Sized Mammals in Amoro Forest, West Gojjam Zone, Amhara, Ethiopia

Belayneh Ayechew[1] Dagnachew Mullu[2*]

[1]Department of Biology, Arba Minch University, P. O. Box 21, Arba Minch, Ethiopia

E-mail; belaynehayechw@gmail.com

[2]Department of Biology, Wollo University, P. O. Box, 1145, Dessie, Ethiopia

[*]Correspondence: dagnachew.mullu@yahoo.com

Abstract

Aim : The objective of this study was to survey the species composition, relative abundance and to determine major threats of medium and large-sized mammals in Amoro Forest.

Method : Linetransects surveying and indirect surveys method (including fresh tracks, scats, hair, spines and burrows) were used to survey mammalian diversity. A survey was conducted in the early morning from 6:00 to 10:00 and late afternoon from 16:00 to 19:00. Key interview and direct site observationswere carried out to assess the major threat of mammals in the study area.

Results : A total of 12 species of medium and large sized mammals belonging to sex orders and eight families were recorded. Porcupine (*Hystrix cristata*), Vervet monkey (*Chlorocebus aethiops*) and Olive baboon (*Papioanubis*) were among the medium-sized mammals while, Spotted hyena (*Crocuta crocuta*),Leopard (*Pantherapardus*) and Common duiker (*Sylvicapra grimmia*) were among the large sized mammals observed in the study area. Shannon–Wiener Index values were low (H' = 1.666) whereas, the Simpson's index (1-D) of diversity showed the highest species diversity (0.761) in the study area. Illegal logging of trees; overgrazing, agricultural activities and human-wildlife conflicts were the foremost threats in the area.

Conclusion : Species richness and evenness were varied from habitat to habitat in Amoro forest. Land degradation anddifferent anthropogenicactivities were common threats for the mammals in the study area. Community participation and awareness creation is very important to limit the impact of anthropogenic activities threatening wildlife.

Key words : Anthropogenic activity, Conservation, Diversity, Mammalssurvey

1 | INTRODUCTION

Mammals are among the most widely distributed organisms in the world and occur from the antarctic to desert ecosystems (Jenkinsa*et al* ., 2013).Mammals are biologically the most successful groups of animals with the possible exception of arthropods (Stanbury, 1972). Due to diversity in size and morphological, physiological, and behavioral adaptation, mammals colonize diverse habitat types(Ceballos and Ehrlich, 2006). Mammals haveapproximately5,416 numbers of extant species on the globe (Geleta andBekele, 2016), out of which 2277 (42%) rodents (Rodentia), 1116 (20.6%) bats (Chiroptera), and 428 (7.9%) shrews and allies (Soricomorpha) comprise the largest species (Wilsonand and Reeder, 2005).Ethiopia possesses wide geographic, topographic, and climatic variations, which, serves as home to a large number of endemic mammalian species (Bantihunand Bekele, 2015). Around 320 species, of 55 are endemic, including 39 endemics (both small and large mammals), which ranks the country among the most diverse mammalian faunas in Africa (World Conservation Monitoring Centre (WCMC), 2013; Lavrenchenko and Bekele, 2017).

Mammals are the most important components of terrestrial ecosystems (Bogonia*et al* ., 2017) and provide vital ecological functions such as pollination and seed dispersal (Alves - Costa and Eterovick, 2007; Botelho*et al* ., 2012), keeping ecological stability via predator-prey interaction(Herrerias-Diego *et al* ., 2008; Botelho*et al* ., 2012) and source of food and income generation like tusks, horns, and ivory (Boesch*etal* ., 2017).However, mammals are experiencing greater population declines because of various reasons (IUCN, 1996). These include low reproductive rates, large body size, habitat fragmentation, over-exploitation, and low rate of body growth, low generation time and requirement of large area (Vaughan, 2000; Cardillo*et al* ., 2005). Among the known species of mammals, 25% are threatened, 11% are endangered, 4% are critically endangered and approximately 2% of the known modern day mammals have gone extinct in the last 400 years (IUCN, 1996).

Surveying is an important requirement to know the status of mammal's species (Keeping andPelletier, 2014).Mammal inventories are essential tools for the proper conservation strategies and management practices (Legese, *et al* ., 2019). There are several previous studies conducted in protected area of Ethiopia(e.g. Yalden, 1988; Bekele, 1998;Woldegeorgis andWube, 2012, Kasso and Bekele, 2014;Geleta and Bekele, 2016; Wale *et al* ., 2017; Kasso and Bekele, 2017; Atnafu and Yihune, 2018).Even though, studies conducted on mammals mainly targetedNational Parks and sanctuaries (Kassoand Bekele, 2014), the survey outside those area like protected forest and other fragmented areais still finger counted. Vast area remains biologically unexplored due to a major habitat block within the country. A complete inventory of mammals on different ecosystem types of Ethiopia does not exist and is not well documented (Tefera, 2011).Extensive study is needed to document the diversity of mammals which have ecological and ecotourism value and isalso important to design future conservation policies on the biodiversity of the region. Therefore, the aim of this study was to survey and document the species composition of medium andlarge sized mammals and their major threats in Amoro protected forest.

2 | MATERIALS AND METHODS

2.1 | Description of the study area

The study was conducted in AmoroForest, located in Dega Damot District, Amhara Regional State, Northwestern Ethiopia (Figure 1). It is located between 10°50'06.53" latitude 37°35'51.94" longitudes. The major town nearby is Feresbet and is far from 3 km from the forest. The district is also characterized by good climate for most of the year with annual rainfall between 900 and 1200 ml. Topographically it consists of 35% mountainous, 30% ups and downs, 20% valleys and 15% plains (Dega Damot Woreda Agricultural Office (DWAO), 2017).

Fndika River cross the forest from the north side and goes to the south east of the area. The area also has many small rivers that follows from eastern and northern parts and enters in the main river. The area is divided into six land use types such as farm land, grazing land, shrub land, settlement, forest and bare land. Different types of crops cultivate in the study area, including barley (*Hordeumvulgare*), wheat (*Triticum spp* .), faba bean (*Vicia faba*), teff (*Eragrostis teff*), maize (*Zea mays*) and potato (*Solanumtuberosum*) (DWAO, 2017).*Juniperusprocera,Oleaeuropaeasubsp. cuspidata, Allophylusabyssincus,* are the dominate tree, while *Carissa spinarum, Discopodiumpenninervium, Dombeyatorrida, Lobelia giberroa, Myrsineafricana and Pittosporumviridiflorum* are the dominate shrub and short trees (Liyew*et al* ., 2018).

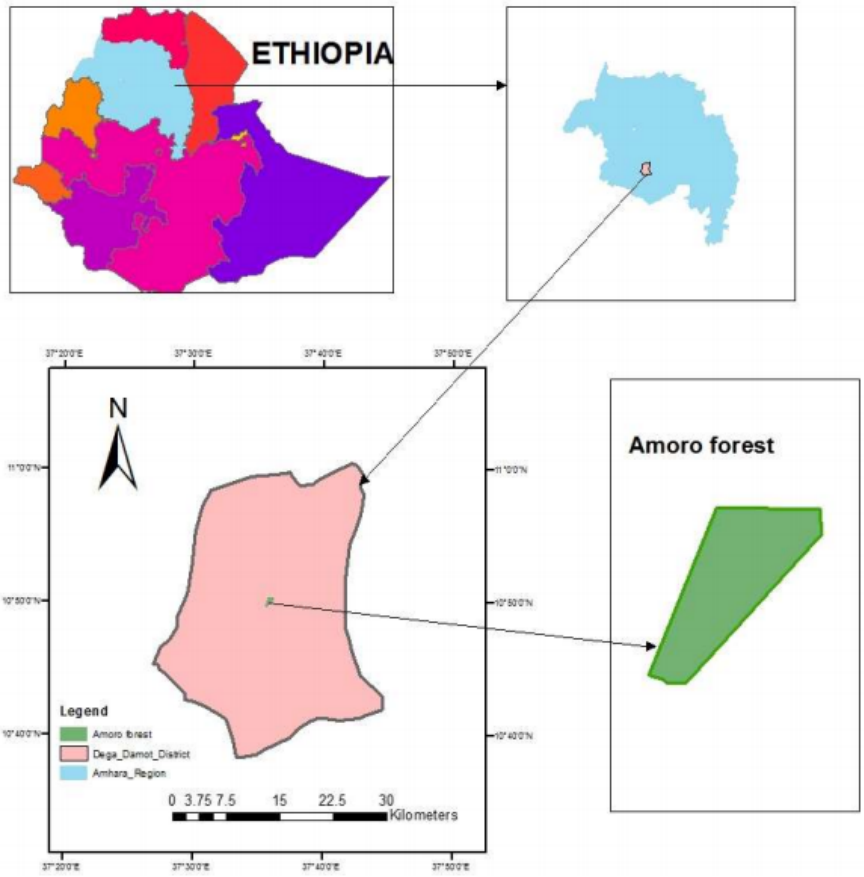

Figure 1 Map of the study area (source and credit: Liyew*et al* ., 2018)

2.2 |Reconnaissance Survey

A reconnaissance was carried out during the first week of March 2020 for two days in order to get basic information on accessibility, topography, and infrastructures of the study area.

2.3 | Sampling Design

For this study, the study area was stratified into three patches of habitats (bar lands, scrubland and natural forest)based on the vegetation structures and topography of the landscapes. In order to, effectively survey the species diversity of medium and large sized mammals, two standardized survey techniques, namely direct and indirect evidence was employed (Legese *et al.,* 2019).

2.4 | Data collection

Diurnal linetransect is costeffective method for surveying medium and large vertebrates (Legese *et al* ., 2019).Indirect survey technique was also employedfor the difficult topography and effectively census elusive and nocturnal large mammals (ZerubabelandZerihun, 2020). So, combining diurnal linetransect with indirect surveys (including fresh tracks, scats, hair, horns, spines, burrows and digging) can enhance the detectability of themammalian and maximize species lists (Larsen, 2016). A survey was conducted for 18 days /126 hours, when the activities of mammals are more active; in the early morning (06:30 to 10:30) and late afternoon (Legese *et al.,* 2019; Tilahun and Merewa, 2020).

During data collection, the researchers were walking on foot along the pre-established line transect and directly count all the individuals sighted with their respective species using unaided eyes and/or binocular. To minimize disturbance during counting, silent movement followed by 3 to 5 minutes waiting period was allowed.Each encountered species of large and medium sized mammals was identified in the field using Kingdon Field Guide to African Mammals (Kingdon, 1996) and "Atibiwoch" (Yirga, 2008).Mammals weighting between 2 and 7 Kg were considered as a medium sized while, weighing above 7 kg were considered as large mammals as applied by (Sutherland, 2006). A total of 8 randomly laid transect line were established to count the sighted mammals and to recorded indirect evidence of the animal signs in the area. This study was also increased with key interview and direct site observation to assess the major threat ofmammals in the area (Abu, 2011).

2.5 | Data analysis

Collected data were organized and entered into a worksheet for the analysis.Species diversity of mammals was analyzedfollowing Shannon and Weiner (1949) as cited in Legese *et al* . (2019).Shannon-Weiner diversity index was computed by the formula $(\mathbf{H}^{'}) = [?]\mathbf{PilnPi}$, Where,Pi is the proportion of each species in the sample: lnPi is natural logarithm of this proportion.

Species evenness was evaluated using Shannon-Weiner evenness index (E).$\mathbf{E = H'/Hmax}$ Where, H' is Shannon-Weiner diversity index and Hmax=lns, is natural logarithm of total number of species in each habitat. Simpson similarity index (SI) was also computed to assess the similarity mammalian species composition between the study habitats.$\mathbf{SI = 2C/I + II}$ = Where: C= the number of common species to the habitats, I= the number of species in habitat one, II= the number of species in habitat two.The relative abundance of each species was calculated by dividing the number of records of each species by the total number of records of all species in the study area. The abundance of observed mammals were categorized as "common" if they were seen during all of the surveys, "uncommon" ifthey were seen in more than half of the surveys, and "rare"if seen less than half of the surveys following Legese *et al* . (2019). Interview surveys and direct filed observations on the threats of mammals were presented descriptively.

3 | RESULTS

3.1 | Species composition

A total of 152 observations of 12 species of medium and large sized mammals belonging to sex orders and seven families were recorded within a total time of 126 hours survey. 9 (58.4%) species were obtained by direct sighted, evidence of body parts andvocalization whereas, 3 species (25%) were recorded through evidences gets from interviewing of local peoples. Order Primates was the most abundant order followed by Hyracoidea, whereas order Lagomorpha was theleast recorded in the study area. Cercopithecidae and Procaviidaewere the dominant families, while Hyeniadea was the least represented family in the study area(Table 1).

Table 1:Medium and large sizedmammalspecies composition in Amoro Forest

Order	Family	Scientific name	Common name	Local name	ID Evidences
Artiodactyla	Bovidae	*Sylvicapra grimmia*	Common duiker	Midako	Visual
Hyracoidea	Procaviidae	*Procavia capensis*	Ethiopian Rock Hyrax	Eshekoko	Visual
Lagomorpha	Leporidae	*Lopusstarkii*	Rabbit	Tenchel	Visual
Primates	Cercopithecidae	*Papio Anubis*	Olive baboon	Zingero	Visual
		Colobus guereza	Guereza	Gureza	Visual
		Chlorocebus aethiops	Vervet monkey	Tota	Visual
Carnivora	Hyeaniadea	*Crocuta crocuta*	Spotted hyena	Jib	Scat/ vocalization
	Felidae	*Pantherapardus*	Leopard	Nebre	Personal information
		Felis Serval	Serval cat	Aner	Personal information
	Canidae	*Canis aureus*	Common jackal	Kebero	Visual
		Otocyon megalotis	Bat-eared fox	Afine	Personal information
Rodentia	Hystricidae	*Hystrix cristata*	Porcupine	Jart	Scat/Spines

3.2 | Distributional patterns and abundance

The distributional patterns of mammals were varied across the study habitats. High number of species was observed in the scrub lands (7 species) followed by natural forest (6 species). However, a single species was recorded in bar land habitats. Of the total species 5 (55.6%) species were observed in two of the three habitats, while 4 (44.4%) species were limited to specific habitat type. Specifically, Ethiopian rock hyrax and Rabbit were only recorded from scrubland. Similarly, Guereza and Spotted hyenawere exclusive to scrublands (Table 2). Among the 12 species of mammals, Guereza was the dominant mammalian species followed by Vervet monkey, Olive baboon, and Ethiopian rock hyrax, while, Common duiker, Rabbit, and Common jackal were the less common species in the study area. Spotted hyena and Porcupine were exclusively identified from indirect evidences (scat, spines, footprint and vocalization) but the presence of Leopard, Serval cat and Bat-eared fox ('afene) were guaranteed by villagers. Regarding to the occurrence of mammals based on their encounter rate/frequency of observation through the study interval, Guereza and Vervet monkey were common. Only Olive baboon was considered uncommon, while all the remaining observed mammals were rare.

Table 2 Medium and large sized mammal species distribution, occurrence and relative frequency observations during the survey period(**Key** : * there presence is assured by the villagers',**-** no direct observed)

Scientific name	Common name	Occurrence	Habitat types	Habitat types	Habitat types	Total obser
			Bar lands	Scrubland	Natural forest	
Sylvicapra grimmia	Common duiker	Rare	3	1		4
Procavia capensis	Ethiopian Rock Hyrax	Rare		14		14
Lopusstarkii	Rabbit	Rare		3		3
Papio Anubis	Olive baboon	Uncommon		3	18	21
Colobus guereza	Guereza	Common			53	53
Chlorocebus aethiops	Vervet monkey	Common		7	39	46
Crocuta crocuta	Spotted hyena	Rare			2	2
Pantherapardus	Leopard	*	-	-	-	-
Felis Serval	Serval cat	*	-	-		-
Canis aureus	Common jackal	Rare		2	1	3
Otocyon megalotis	Bat-eared fox	*	-	-	-	-
Hystrix cristata	Porcupine	Rare		5	1	6

3.3| Species diversity and evenness

The highest diversity of mammals was recorded from scrublands followed by natural forests in the area. But, only a single species was seen in the bar land habitat, as a result no species diversity here. Medium and large sized mammalian similarity was high between scrublands and natural forests (SI=0.62), followed by scrubland and bar land habitats (SI=0.25). But, there was no mammalian species similarity between natural forests and bar land (SI=0.00). On the other hand,the higher and lower evenness of the mammalian species was recorded in scrublands(E = 0.826) and natural forest (E = 0.636). The highest Simpson's index (1-D) of mammalian species was recorded from the scrublands (0.803) and the natural forests habitat had a lower diversity (0.647).The overall species richness of Amoro forest was 12, and Shannon–Wiener Index values were low (H' = 1.666) whereas the Simpson's index of diversity showed the highest species diversity (0.761) in the study area (Table 3).

Table 3 Medium and large mammal richness and diversity indicesduring the survey period

Variables	Habitats	Habitats	Habitats	Overall diversity indices
	Bar lands	Scrubland	Natural forest	
No. of species	1	7	6	12
No. individuals	3	35	114	152
SWI(H')	-	1.606	1.149	1.666
H_{max}	-	1.946	1.792	0.670
Simpson's index of diversity (1-D)	0.00	0.803	0.647	0.761

3.4| Major threats to mammals of Amoro forest

Field observations have showed that anthropogenicactivities and land degradation have greatly influenced the diversity and abundance of mammals in the study area. Those observed activities were agricultural land expansion, timber production, illegal logging for fuel wood and grazingby livestock (figure 2). Moreover, a particular/small respondent, claimed illegal hunting (especially for leopards and olive baboon) are common. According to their response, leopard is the known livestock predator in and around the Amoro forest. In addition to this, clearing forest from adjacent crop lands to avoid mammal pests (especially for; Olive baboon and Vervet monkey) is another threats for mammals in the area.

Figure 2 Major threats to mammals of Amoro protected forest. logging for fuel wood and timber (A) and (B), land degradation (C), agricultural land expansion near to the forest (D); (Photo by: Belayneh Ayechw)

4 | DISCUSSION

During the present preliminary survey of medium and large-sized mammals from Amoro forest, a total of 12 species were identified using direct and indirect evidences. Similarly, Legese *et al* . (2019) recorded 12 mammal species in Wabe forest fragments, Gurage zone, Ethiopia within a similar survey period. Atnafu and Yihune (2018) also noted similar results from communal forest of northern Ethiopia. In contrast, research

carried out inTululujia Wildlife Reserve, Southwestern Ethiopia showed a total of 19 mammalian species (Belete and Melese, 2016). Alves*et al* . (2014) also recorded 18 medium and large-sized mammals in a fragment of Cerrado in the TriânguloMineiro region, southeastern Brazil.

Limited survey period, size of the study areas, and changes of habitats by various anthropogenic pressures (Legese *et al.,* 2019), variation in sample sites, sampling effort spent, season considered, and variation in vegetation physiognomy (Qufa and Bekele, 2019), size of the area, habitat fragmentation and destruction (Cardillo*et al* ., 2005; Link *et al* ., 2010)have a significant effect on species presence, abundance and distribution. In Amoro forest this might be due to, a limited survey period, an agricultural land expansion, illegal logging for fuel wood, grazingby livestock, illegal hunting and clearing forest and its small size of the study area. Moreover, Qufa and Bekele (2019) explained that, due to the presence of top predators, Lebu Natural Protected Forest accommodates the less number of mammals. Top predators are available in the current study area too. Olive baboons have killed along the journey when it migrates to the near forest, FelatiteSelasa Protected forest, during shortage of food in the area.

Like most mammalian studies, Alves*et al* . (2014); Carvalho*et al* . (2014);Gonfa*et al* . (2015);Belete and Melese, (2016);Geleta and Bekele (2016); Atnafu and Yihune (2018) and Qufa and Bekele (2019), the current studyshowed inclination of mammals to favor one habitat over the other resulting the availability and quality of resources. In the current study, scrublands have high species diversity of medium and large sized mammals. This result fits with the outcomes of Legese*et al* . (2019). Nevertheless, most studies showed that high species diversity of mammals recorded either in woodlands and/or forest habitats (Bobo*et al* ., 2014; Belete and Melese, 2016;Geleta andBekele, 2016; Qufa and Bekele, 2019; Tilahun and Merewa, 2020). This might be due to the existence of higher disturbance rate in the forest habitat of Amoro forest than scrub lands. Most mammal specieswere recorded by direct observations. Legese *et al* . (2019) reported as mammals can be easy exposure due to the openness of the habitat might resulted from habitat loss and fragmentation. The same is true for the current study.

The most frequently sighted species were Guereza, Vervet monkey and Olive baboon in descending order. Several studies have reported, primates are the most abundance order in different study sites (e.g. Geleta andBekele, 2016; Atnafu and Yihune, 2018; Legese *et al* , 2019). Bobo *et al* . (2014) clarified that, primates'high reproductive successes; diversified foraging behavior and their more adaptive nature to different habitats and human disturbances is a reason beyond their abundance in different areas.

The distribution and abundance of the order Hyracoidea were ranked next to primates. This finding contrasts with the finding of Geleta andBekele, (2016), and Qufa and Bekele, (2019). This might be due to the difference in the habitat characteristics of the study areas. In the current study area,have different degraded land with caves which is suitable habitat for Ethiopian rock hyrax(Table 2).The distribution and abundance of order Carnivorewere minimal in the study area. This might be, in fact their nocturnal and cryptic behavior and the respondents informed, as there is illegal hunting due to the presence of high depredations of livestock's by carnivores (especially, Leopard and Bat eared-fox) in and around the study area.Due to human interferences of the area and their nocturnal and cryptic behavior their presence could not be easily documented (Gonfa*et al* ., 2015). Tilahun and Merewa(2020) also reported as Felisserval was observed at low density at Geremba Mountain Fragment. The distribution and abundance of order Atriodictayla was a least in Amoro forest. A single species, Common duiker, was represented in this order. This might be due to in the presence of excess numbers of top predators, the number and presence of herbivores in the area will decrease. In addition to this, the respondents decided as common duiker hunted for meat and it is a common crop raider next to Olive baboon and Vervet monkey. Due to this conflict their number became decreasing from time to time. Land degradation and different anthropogenicactivities such as, agricultural land expansion, timber production, illegal logging for fuel wood and grazingby livestock were the major identified threats of mammals in the study area.Besides, small respondent claimed that as there is a human wildlife conflict especially, with primates and carnivores. Poaching, agricultural encroachments especially by investor, deforestation, illegal settlement and human wildlife conflict are the main threats of mammals (Tilahun and Merewa, 2016).Likewise, Legese et al.(2019) reported, extensive habitat fragmentation, deforestation, expansion of roads and human settlements

and infrastructure developments like roads are the chief pressures in Wabe forest fragments.Moreover, other researchers are reported similar trend (e.g. Geleta and Bekele, 2016; Qufa and Bekele, 2019; Worku and Girma. 2020) in different study area.

5 | CONCLUSIONS

The number of medium and large mammal species recorded from Amoroprotected forest was small. However, the result of this study will serve as a signal for further study on the biodiversity of the area and management actions to be applied in the future. Land degradation anddifferent anthropogenicactivities such as, agricultural land expansion, timber production, illegal logging for fuel wood, grazingby livestock were a common threats for the mammals in the study area. Human wild animals' conflict was also recorded frequently with mammals such as Olive baboon and Vervet monkey because of crop damage such as barley, maize and pea bean. Similarly, Leopard and Bat eared–fox was a common livestock predators in the area. In order to, minimize such conflict and anthropogenic activities on wildlife of the study area, community participation, enforcement of law and rehabilitating the degraded area play paramount significance for sustainability of wildlife in Amoro protected forest is recommended.

ACKNOWLEDGEMENTS

We are grateful to all respondents for providing us with genuine information and their time. Additionally, we thank also goes to Dega Damot District agricultural office in West Gojjam Zone, Amhara Region, for giving the necessarily data and permitting to do this research in the Amoro protected forest and finally we thank the department of Biology, School of Bio-Science and Technology, College of Natural Science, Wollo University for provision offield materials.

Conflicts of Interest: We haven't any conflicts of interest.

Data Accessibility Statement: All data used in this study present along the authors. If the data is required by the journal we will attach it. The authors have chosen Dryad data repository to be accessible to the scholars.

References

Abu, K., (2011). Population census and ecology of a rare gelada population (*Thereopithecs gelada* unnamed sub-sp.) in Indato, eastern Arsi, Ethiopia.

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

Alves-Costa, C. P., andEterovick, P. C. (2007). Seed dispersal services by coatis (Nasuanasua, Procyonidae) and their redundancy with other frugivores in southeastern Brazilian. *ActaOecologica* ,**32** : 77–92.

Atnafu, G., andYihune, 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.

Bekele, A. (1998). A census of large mammals in the Harena forest Ethiopia.*SINET Ethiop. J. Sci* . **11** :27-39.

Belete, T., andMelese, M. (2016). Assessment of large mammalspotential in Tululujia Wildlife Reserve, Southwestern Ethiopia.*International Journal of Agricultural and Life Sciences* ,**2** (4), 80-86.

Bobo, S., Kamgaing,L.,andNtumwel, C.(2014). Species richness, spatial distributions, and densities of large- and medium-sized mammals in the northern periphery of Boumbabek National Park, southeastern Cameroon.*African Study Monographs* , **49** :91–114.

Boesch, L., Mundry, R., Kuhl, S. H., and Berger, R. (2017). Wild mammals as economic goods and implications for their conservation, *Ecology and Society,* **22** (4): 36.

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

Botelho, L. M. A., Calouro, M. A., Borges, H. M. L., & Chaves, A. W. (2012).Large and medium-sized mammals of the Humaita Forest Reserve, Southwestern Amazonia, State of Acre, Brazil.*Check List* ,**8** (6): 1190–1195.

Cardillo, M., Mace, G.M., Jones, K.E., Bielby, J., Bininda-Emonds, O.R.P., Sechrest, W., Orme, C.D.L. and Purvis, A. (2005).Multiple Causes of High Extinction Risk in Large Mammal Species.Science press.

Ceballos, G. and Ehrlich, P.R. (2006). "Globalmammaldistributions, biodiversity hotspots, and conservation," Proceeding of the National Academy of Science USA, **103** (51): 19374–19379.

Geleta, M., and 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.

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

Herrerias-Diego, I., Quesada, M., Stoner, K. E., Lobo, J. A., HernandezFlores, Y., and Montoya, G. S. (2008).Effect of forest fragmentation on fruit and seed predation of the tropical dry forest tree Ceibaaesculifolia.*Biological Conservation,* **141** : 241–248.

Jenkinsa, C. N., Pimmb S. L., and Joppac, L., N. (2013), "Global patterns of terrestrial vertebrate diversity and conservation," in Proceedings of the National Academy of Sciences of the United States of America, New York, NY, USA.

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

Kasso, M., and 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.

Keeping, D., and Pelletier, R. (2014). Animal density and track counts: Understanding the nature of observations based on animal movements,*PLoS ONE* , **9** (5): 1–11.

Kingdon, J., (1997). TheKingdon Field Guide to African Mammals, Academic Press, London, UK.

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

Lavrenchenko, A. L., and Bekele, A. (2017). Diversity and conservation of Ethiopian mammals: What have we learned in 30 years? Ethiopian Journal of Biological Science, **16** : 1–20

Link A, Luna A, and Alfonso F, (2010).Initial effects of fragmentation on the density of three Neotropical primate species in two lowland forests of Colombia.*Endangered Spp Res* . **13** :41–50.

Qufa, C., A, and Bekele, A. (2019).A preliminary survey of medium and large-sized mammals from Lebu Natural Protected Forest, Southwest Showa, Ethiopia.*EcolEvol* . **9** :12322–12331.

Shannon, G. E., and Weaver, W. (1949).The mathematical theory of communication. Chicago, IL: University of Illinois Press

Stanbury, P. (1972). Looking at Mammals.Heinemann. Books Ltd, London

SutherlandJ. W. (2006). Ecological Census Techniques, University of East Anglia, Norwich, UK, 2nd edition.

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

Vaughan, A.T., Ryan, M.J. and Czaplewaki, N. (2000).Mammalogy, 4th Edn. Saunders College Publishing, New York.

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

Wilsonand, D.E. andReeder D.M., (2005).MammalSpeciesoftheWorld, Johns Hopkins University Press, Baltimore, MD, USA.

Woldegeorgis, G., andWube, T. (2012).A survey on mammals of the Yayu forest in Southwest Ethiopia.*Ethiopian Journal of Science* ,**35** : 135–138.

Tilahun, Z. and Merewa, Z. (2020).Large Mammal Diversity and Endemism at Geremba Mountain Fragment, Southern Ethiopia.*Hindawi, International Journal of Ecology* . https://doi.org/10.1155/2020/3840594

World Conservation Monitoring Centre (WCMC, 2013), Biodiversity Data Sourcebook, World Conservation Monitoring Centre, Cambridge, UK.

Yalden, D., W. (1988). Small mammals of the Bale Mountains, Ethiopia.*African Journal of Ecology* , **26** , 282–294.

Yirga, S., (2008).Atibiwoch, Ethiopian Wildlife and Natural History Society, Addis Ababa, Ethiopia.