Research Article

Large Mammal Diversity in Nensebo Forest, Southern Ethiopia

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There is a lack of information on mammalian faunal resources of remote forests in Ethiopia; as a result, the findings of the research on large wild mammals at Nensebo forest is one of the steps in a continuing effort to document and describe the diversity and distribution of Ethiopian mammals in remote and less accessible forests. The survey was conducted to assess the species composition and relative abundance of large mammals. Two standardized survey techniques, direct (sighting/hearing) and indirect (scat/footprint), were employed using systematically established transect lines and field plots in two dominant habitat types (modified moist Afromontane forest and intact moist Afromontane natural forest) of the study area. A total of 16 species were recorded including two endemic mammals, namely, *Tragelaphus buxtoni* and *Tragelaphus scriptus meneliki*. Abundance of species among different habitat types was not significantly different ($\chi^2 = 0.125$, df = 1, $p > 0.05$), and *Colobus guereza* was the most abundant species. In contrast, *Felis serval*, *Panthera leo*, and *Tragelaphus buxtoni* were the least abundant species. The highest diversity index was recorded in the natural forest habitat ($H' = 2.188$), and the modified forest had the lowest diversity index ($H' = 1.373$). There is an urgent need to minimize threats and mitigate impacts.

1. Introduction

Mammals provide ecological, economic, sociocultural, and educational and scientific services in a particular ecosystem [1–6]. They are one of the most widely distributed organisms in the world. Mammals are successful in colonizing diverse habitat types due to diversity in morphological, physiological, and behavioral adaptations and hence exist from the Antarctic to desert regions [6, 7]. They exhibit great diversity in size and forms. Particularly, range from the smallest Kitti's Hog-Nosed Bat (*Craseonycteris thonglongyai*) (2 g) to the giant blue whale (*Balaenoptera musculus*) (140,000 kg) [1]. Those that weigh above 7 kg are called large mammals [1, 8]. There have been discoveries of new taxa over the past decades; as a result, the number of mammalian species has been continuously updated. According to the most recent (3rd) edition of the standard taxonomic reference work, Mammal Species of the World [1], the class Mammalia comprises 5416 species. The largest groups are rodents (Rodentia, 42%), bats (Chiroptera, 20.6%), and their Allies (Soricomorpha, 7.9%).

Ethiopia is one of the top 25 biodiversity-rich countries in the world, and hosts two of the world's 34 biodiverse hotspots, namely, the Eastern Afromontane and the Horn of Africa hotspots [9, 10]. It is one of the countries with the most diverse mammalian faunas in Africa [6, 7]. It is estimated that there are about 320 species, including 39 endemics (both small and large mammals), distributed in 14 orders and 39 families [11–13]. Furthermore, the country is known as "*Home of the Unique Seven*" which refers to seven distinctive and large endemic mammals found only in Ethiopia [14], namely, the Ethiopian wolf (*Canis simensis*), mountain nyala (*Tragelaphus buxtoni*), walia ibex (*Capra walle*), Menelik's bushbuck (*Tragelaphus scriptus meneliki*), Swayne's hartebeest (*Alcelaphus buselaphus swaynei*), gelada baboon (*Theropithecus gelada*), and bale monkey (*Chlorocebus djamdjamensis*) [13, 14].

A number of large mammal diversity studies have been carried out in various protected areas of Ethiopia [15–18]. However, the faunal records of the country are underestimated since most studies have focused on protected areas [15], where large mammals are mainly concentrated in the south and southwest border and adjacent area. Several reports have also emphasized the importance of habitats outside protected areas in supporting large mammal diversity, but there have been few surveys of these sites and comprehensive baseline information is lacking [13]. However, protected areas alone cannot sustain large mammals. First, only a small proportion (186,000 km^2, equivalent to 16.4% of Ethiopia's surface area) of Ethiopia's landmass is legally protected [13]. Second, large mammals often travel long distances outside of protected areas to fragmented forest patches due to seasonal variations of resources. As a result, wildlife depends on land adjacent to these protected areas for continued viability. They may use these adjacent lands as critical dispersal areas, calving grounds and/or for other seasonal movement between protected areas. However, there has been little understanding of how the ecosystems function and large mammals survive especially in human dominated landscapes.

Nensebo forest, a patch of moist Afromontane forest (MAF), is partly connected to the Bale Mountains National Park (BMNP). However, this corridor has continued human encroachment that often challenges wildlife movement between the two areas of habitat. Large mammals such as mountain nyala and lion (*Panthera leo*) may move seasonally between these two habitat areas. However, there is no scientifically documented information about which large mammal species are restricted to the forest area, which are the most abundant, or on population structure or habitat use of resident species. Likewise, there is a need of information on the species diversity for the large mammal population to underpin management actions and integrate sustainable conservation of the wildlife resource in BMNP and forest fragment.

The aim of the present study was therefore to describe the species composition, relative abundance, and population structure and habitat use of large mammals in Nensebo forest to underpin future management.

2. Materials and Methods

2.1. Study Area. Nensebo forest is found in Nensebo Woreda (district) in west Arsi Zone of Oromia Regional state of Ethiopia (Figure 1). The district is situated between 6°10′ and 6°40′N longitudes and 39°0′ and 39°40′E latitudes (Figure 1). It is located 407 km from Addis Ababa and 134.5 km from Shashemene, the capital city of West Arsi zone. Nensebo Woreda is bordered by eight districts (Kokosa, Dodola, Adaba, Bensa, Girja, Meda Welabu, Chire, and Harenna Buluk), administered under four administrative zones (West Arsi, Bale, Borena, and Sidama zones) and shared between two regional states (Oromia Regional State and South Nations and Nationalities People Regional State, SNNPRS) (Figure 1).

The district is characterized by mountainous landscape having an altitude range between 1500 m above sea level (a.s.l) and 3700 m a.s.l. The Woreda exhibits a bimodal rainfall pattern, with the annual rainfall range between 900 and 1100 mm and with a temperature that varies between a minimum of 15°C and a maximum of 22°C [19]. Nensebo forest is a moist Afromontane forest jointly managed by community and Oromia forest and Wildlife Enterprise. Nensebo forest is part of Bale Mountains Ecoregion known for its rich biodiversity and high level of endemism. The forest is one of remnant moist MAF in the southeastern part of Ethiopia that exists in a human dominated landscape [20]. The total area of Nensebo forest is 5199 ha, of which 3168 ha is relatively intact MAF and 2031 ha is modified MAF.

2.2. Reconnaissance Survey. A reconnaissance survey was carried out to obtain basic information on accessibility, topography, and dominant habitat types during the last week of April, 2017. Based on the land cover features, the study site was stratified in to two dominant habitat types, namely intact MAF (Figure 2) and modified MAF. MAF is characterized by dominant stands of the indigenous tree species such as *Croton macrostachys*, *Strychnos spinosa*, *Clematis longicauda*, *Prunus africana*, and *Millettia ferruginea* [20]. In the reconnaissance survey, sampling design, and data collection, we followed the method of [21]. The forest occurred over mountain slopes, valleys, and remote inaccessible areas. The level of disturbance was minimal, there were no settlements or cultivation, and hardly livestock grazed in the area (Figure 2). Modified moist MAF (habitat) occurred relatively at lower altitudes (1882–2153 m.a.s.l) in close proximity to human settlement and cultivation areas. Modified habitat is characterized by sparse stands of moist Afromontane characteristic tree species with low level crop cultivation (mainly "enset" and coffee), intense livestock grazing, and sparse human settlements (Figure 3) [22].

2.3. Sampling Design. To effectively survey the species diversity and abundance of large mammals, two standardized survey techniques, direct (line transect; sighting/hearing) and indirect (plots; scat) census were followed [8]. Both the transect lines and field plots were laid/set lengthwise, following the slope of the ground and oriented perpendicular to ecological or density gradients. Aspect, accessibility, terrain, long roads, streams, and contour of hills are also considered during the transect lines and plots setup. Both direct (transect lines) and indirect survey (plots) were systematically generated using geographic information system [23] with the help of QGIS V2.18 software.

2.3.1. Direct Survey. A total of 20 (T1–T20) fixed length and systematic parallel line transect lines were established (Figure 4(a)). Line transects were oriented in a parallel direction and pointed north to south direction against altitudinal gradient. The distance between two adjacent transects was 1000 m to avoid double-counting and edge effect; transects were spaced 500 m from the edge of the
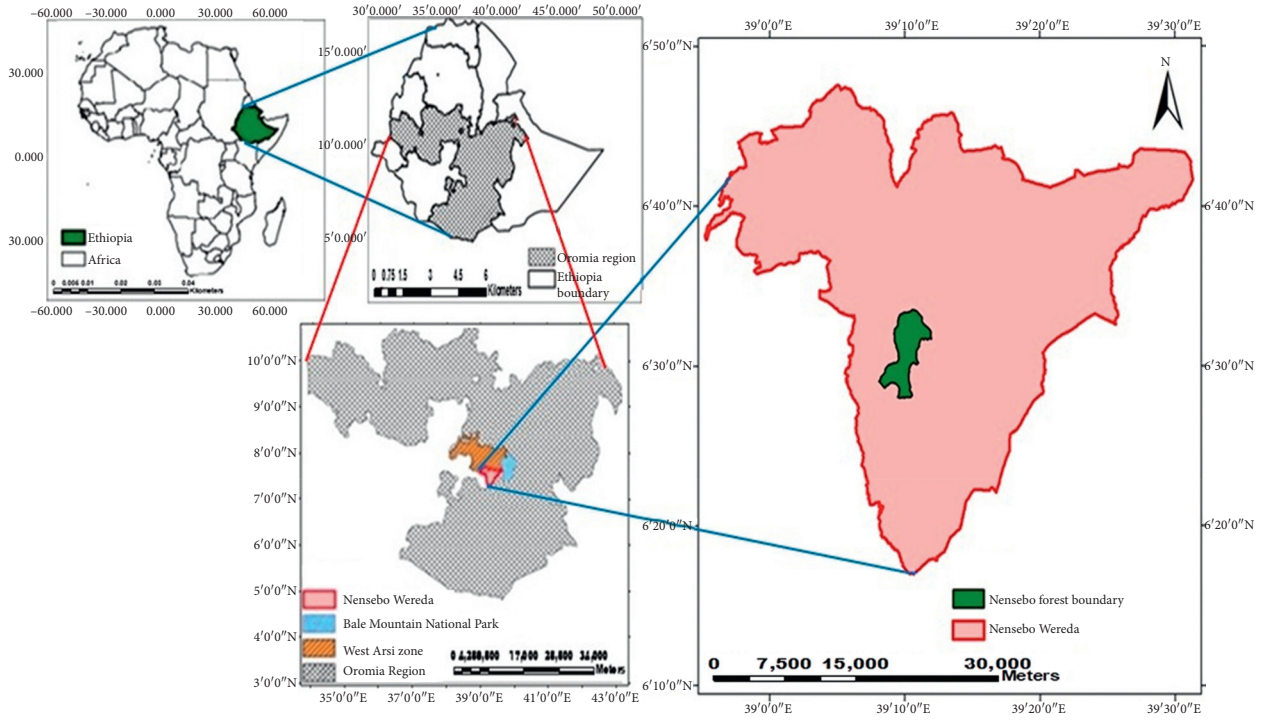
Figure 1: Location map of study area.

(a)

Figure 2: The intact moist Afromontane habitat at Nensebo forest, Southern Ethiopia (photo: Zerubabel Worku, 2018).

(a)

Figure 3: The modified MAF habitat at Nensebo forest, Southern Ethiopia (photo: Zerubabel Worku, 2018).
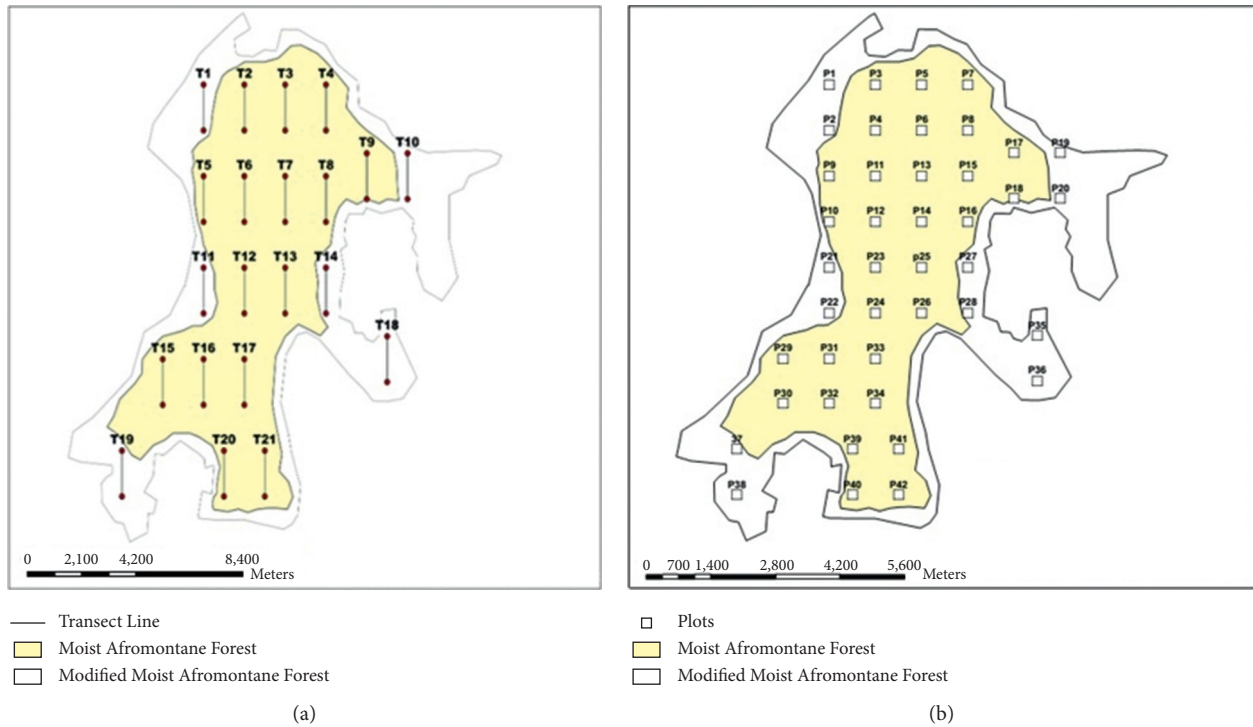
Figure 4: (a) Line transects layout and (b) plots layout at Nensebo forest, southern Ethiopia.

forests. Information from the pilot study, field observation, and land cover analysis and approximate area of each habitat type in the study areas were used to determine the proportion of sample transects needed to represent each habitat type. Accordingly, from the total of 21 transect lines, six transect lines were established in the modified MAF and 15 transect lines were established in the intact MAF (Figure 4(a)). The length of each transect was 1000 m, and sighting distance varied between 10 m in dense MAF and 100 m in the open modified MAF. Furthermore, to avoid double-counting natural barriers such as mountains, valleys and streams and other biophysical features were considered in establishing transects.

2.3.2. Indirect Survey. Due to the elusive nature of the mammals, difficult topography and relatively dense vegetation cover indirect survey was also employed to assess the presence of rare and nocturnal mammals. From the pilot study, field observation, and land cover analysis, the approximate area of each habitat type in the study area was determined and was used to determine the proportion of sample plots needed to represent each habitat type. Accordingly, a total of 42 plots (P1–P42) spaced 1000 m apart were established (Figure 4(b)). A total of 12 plots were established in the modified MAF, and 28 plots were established in the intact MAF (Figure 4(b)). The size of each plot was 100 m^2 (20 × 5 m). The plots were established following the transect lines established for the direct survey.

2.4. Data Collection. The study was conducted between the months of July 2017 to February 2018 covering both dry

(January to February 2018) and wet (July to August 2017) seasons. Each transect line/plot was visited six times per season.

2.4.1. Direct Survey. Mammalian populations were counted by direct observation along the established transect lines, during morning hours (6 : 00 to 10 : 00 am) and late afternoon (3 : 00 to 5 : 00 pm) according to [24, 25]. Each line transect was navigated by using a Garmin 60/78 Global Positioning System (GPS) and Handheld Bearing Compass Suun to KB-14/360R G by gently walking at a constant speed of ~1 km/h [25–27]. During the study periods, the silent detection method (suitable clothing for camouflage, moving opposite wind direction (from south to north), and avoiding loud voices) was practiced minimizing disturbance. Observations were made with naked eyes and Nikon action 10 × 50 binocular.

Body weight was the parameters used to categorize mammals as large-sized. Data collected for all individuals observed were approximate perpendicular distance, sex, age, group size, and activity of the animals. Morphological development (horn ridges, horn size, and body size), growth and maturation, changes in pelage color or patterns, and sexual maturity (bacula, testes length, condition of mammary glands, and behavior during breeding) were used to determine the approximate age (adult, subadult, and young/ calf) [28].

Secondary sexual characteristics, external genitalia and behavior (urination posture, vocalizations, nipples, presence and absence of bacula, and descended testes), and sexually dimorphic characteristics (such as absence/presence of

horn) were used to determine sex. Those individuals seen within a distance of <50 m from the nearby group were recorded as members of the same group [27, 28]. Double counting of the same individual or herd was avoided using easily recognizable features of individuals, herd size, and composition [15, 27, 28]. Furthermore, trained field assistants were employed to survey transects located at similar topographic landscape at the same time to minimize movements of animals between transects, hence avoiding double-counting.

For a more complete species list, in addition to fixed line transects surveys, random searches were held to record the occurrence of mammalian species in the study areas during both day and night time (using hand torch) for five days and nights in each season searching them in potential habitats and areas inaccessible with transect lines and plot survey methods [26]. Species identification of mammals was based on The Kingdon Field Guide to African Mammals [29] and "Atibiwoch" [30]. For taxonomic treatment of the results, Mammal Species of the World 3rd Edition [1] was adopted.

2.4.2. Indirect Survey. Each field plot was scanned carefully, and all fresh scats of wild animals were counted and recorded. Identification of scats obtained was attempted in the field by using specialized field guides for the identification of scats [8, 31–33]. Scats were distinguished for each species using parameters' size (measurement of length and diameter), shape, odor, color, and signs associated with feces, such as scrapes, feeding signs, and footprint.

2.5. Data Analysis. The conservation status of each species was also identified based on the IUCN Red List [34] and the CITES Appendices. Following [35], the identified mammals were grouped as common (if there was 100% chance of recording the species in all field trips), uncommon (recorded >50% of field trips), and rare (if probability of recording is less than 50%) [35].

The number of individual mammals recorded from a specific habitat type on the same line transect was recorded as a sample from one habitat. Each individual of a species was grouped in different group size-class and age-sex categories and ratios, that is, percentages of adults and young ones, male per female, and young ones per female. The effect of the season on species abundance and distribution among dry and wet season was also analyzed and compared using Chi-square test, and the seasonal difference in sex ratio was evaluated by *t*-test.

Species diversity among the two dominant habit types in the forest was calculated using the Shannon-Weiner index (H') of diversity [36]:

$$(H') = \sum_{i=1}^{s} P_i \ln P_i, \tag{1}$$

where P_i is the proportion of the ith species in the habitat.

In addition to the Shannon-Weiner index of diversity, Simpson's diversity index (D) was used to calculate the

species diversity among the two dominant habit types in the forest using [37]

$$(D) = \frac{1}{\sum_{i=1}^{s} P_{i_2}}, \tag{2}$$

where P_i is the proportion of the ith species, which will be used to analyze the data.

The similarity among and between the habitats with reference to the composition of species was computed using Sorenson's coefficient (CC) [38]:

$$(CC) = \frac{2C}{S_1 + S_2}, \tag{3}$$

where C is the number of species the two habitats have in common, S_1 is the total number of species found in habitat 1, and S_2 is the total number of species found in habitat 2.

The evenness of mammalian species was also calculated as [39]

$$J = \frac{H'}{H' \max}, \tag{4}$$

where $H' \max = \ln (s)$ and s is the number of species. This measure varies between 1 (complete evenness) and 0 (complete unevenness).

The relative abundance of the large mammals was determined by using [40]

$$\text{Relative abundance (\%)} = \frac{n}{N} \times 100, \tag{5}$$

where n is the number of individuals of a recorded species and N is the total number of individuals of recorded species. The results and findings of the research were presented by simple descriptive statistical tools.

3. Results

3.1. Species Composition. A total of 16 species of large mammals grouped into nine families and five orders were recorded after a total effort of 80 km walked. One endemic and endangered (mountain nyala) and another endemic subspecies Menelik's bushbuck were recorded from the fragmented forest (Table 1). The most abundant order was Artiodactyla (41%, 6 species), while Rodentia and Tubulidentata were the rarest, represented by single species each. Out of the total 16 species of large mammals recorded, 10 were recorded using both direct evidences (direct sighting or hearing) and indirect evidences (scat or foot print), two species with direct evidence only, and the rest four were recorded only through indirect evidences (scat or foot print) (Table 2; Figure 5).

Seasonal variation in species composition for some large wild mammals was observed (Figure 6). For instance, serval cat, lion, and mountain nyala were not recorded during dry season. However, the seasonal variation in the number of species of large wild mammals was not significantly different ($\chi^2 = 0.125$, df = 1, $p > 0.05$). Conversely, the abundance of mammals varied seasonally. A total of 920 ± 21 individuals of large mammals were recorded, from which 544 ± 16 (59.1%)

TABLE 1: Large mammal species composition and their conservation status at Nensebo forest, Southern Ethiopia.

Taxon (scientific name)	Common name	IUCN status	CITES status	Occurrence status	Local status
Order Artiodactyla					
Family Bovidae					
Tragelaphus buxtoni Lydekker, 1910	Mountain nyala	Endangered	—	Endemic	Rare
Tragelaphus scriptus meneliki Neumann 1902	Menelik's bushbuck	Least concern		Endemic	Rare
Sylvicapra grimmia Linnaeus, 1758	Common duiker	Least concern	—	Native	Uncommon
Family Suidae			—		
Phacochoerus africanus Gmelin, 1788	Common warthog	Least concern		Native	Common
Hylochoerus meinertzhageni Thomas, 1904	Giant forest hog	Least concern	—	Native	Uncommon
Potamochoerus larvatus F. Cuvier, 1822	bush pig	Least concern	—	Native	Uncommon
Order Carnivora			—		
Family Canidae					
Canis aureus Linnaeus, 1758	Common jackal	Least concern	—	Native	Uncommon
Family Haenidae					
Crocuta crocuta Erxleben, 1777	Spotted hyena	Least concern	—	Native	Common
Family Felidae					
Panthera pardus Linnaeus, 1758	Leopard	Vulnerable	Appendix I	Native	Rare
Panthera leo Linnaeus, 1758	Lion	Vulnerable	Appendix II	Native	Rare
Felis serval Schreber, 1776	Serval cat	Least concern	Appendix II	Native	Rare
Family Viverridae					
Civettictis civetta Schreber, 1776	African civet	Least concern	Appendix III	Native	Rare
Order Primates					
Family Cercopithecidae					
Papio anubis Lesson, 1827	Olive baboon	Least concern	Appendix. II	Native	Uncommon
Colobus guereza Rüppell, 1835	Colobus guereza	Least concern	Appendix II	Native	Common
Order Rodentia					
Family Hystricidae					
Hystrix cristata Linnaeus, 1758	Crested porcupine	Least concern	—	Native	Uncommon
Order Tubulidentata					
Family Orycteropodidae					
Orycteropus afer Pallas, 1766	Aardvark	Least concern	—	Native	Uncommon

TABLE 2: Large mammal species reordered with direct evidences and indirect evidences from Nensebo forest, Southern Ethiopia.

Species name	Recorded with direct evidences (sighting or hearing)	Recorded with indirect evidences (scat or foot print)
Canis aureus	Yes	Yes
Colobus guereza	Yes	Yes
Crocuta crocuta	Yes	Yes
Hylochoerus meinertzhageni	Yes	Yes
Felis serval	Yes	No
Panthera pardus	Yes	Yes
Papio anubis	Yes	Yes
Phacochoerus africanus	Yes	Yes
Potamochoerus larvatus	Yes	No
Sylvicapra grimmia	Yes	Yes
Tragelaphus scriptus meneliki	Yes	Yes
Civettictis civetta	No	Yes
Hystrix cristata	No	Yes
Orycteropus afer	No	Yes
Tragelaphus buxtoni	No	Yes

were observed during the wet season and 376 ± 11 (40.9%) during the dry season. The mean seasonal abundance of individuals was significant ($\chi^2 = 30.678$, df $= 1$, $p < 0.05$).

3.2. Relative Abundance. *Colobus guereza* was the most abundant (38%, $n = 330 \pm 7$) species, followed by olive baboon (24%, $n = 224 \pm 5$) and common warthog (12%, $n = 114 \pm 5$). Alternatively, serval cat, lion, and mountain nyala were the least abundant species (0.1%, $n_1 \pm 0$) (Table 3). Seasonal variation was observed in species composition of large mammals among habitat types. The highest numbers of species ($n = 16$) were recorded in the intact MAF habitat during the wet season. The modified MAF habitat ($n = 7$) contained a considerably less number of species during both dry and wet seasons (Table 3). Seasonal variation in mean number of individuals was observed between the habitat types. The seasonal variation in mean number of individuals

FIGURE 5: Scats and foot print of large mammals recorded at Nensebo forest, Southern Ethiopia. (a) Mountain nyala; (b) common jackal; (c) warthog; (d) giant forest hog; (e) leopard (photo: Zerubabel Worku, 2018).
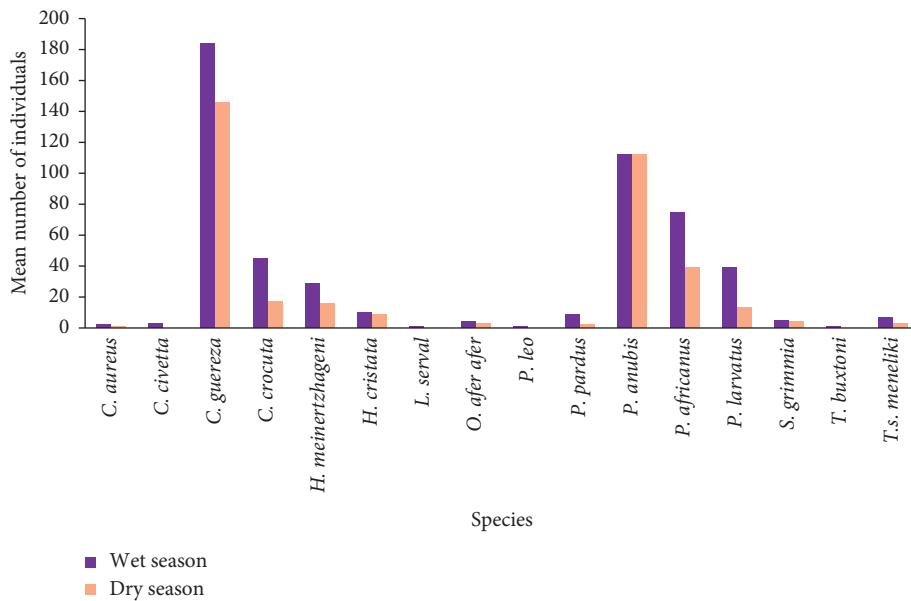

FIGURE 6: Seasonal variation in species composition and mean abundance of large wild mammals in Nensebo forest, Southern Ethiopia.

in intact MAF ($\chi^2 = 45.134$, $p < 0.05$; wet = 440 ± 13, dry = 262 ± 9) was significant, and it was not significant in modified moist Afromontane forest habitat ($\chi^2 = 0.459$, $p > 0.05$; wet = 104 ± 6, dry = 114 ± 4) (Table 3). The Sorensen species similarity index (CC) of large wild mammal species among the two habitat types was 0.64.

3.3. Population Structure.
The population structure of the most recorded species was characterized by more adult and few young individuals during both wet and dry seasons (Table 5). Alternatively, the number of adult females was relatively higher than adult males during both seasons. The pooled sex ratio of adult animals of all species was biased towards females, and the difference was significant, $t = 138.471$, df = 88, $p < 0.05$ and $t = 44.675$, df = 124, $p < 0.05$ during the wet and dry seasons, respectively.

4. Discussion

A total of 16 species of large mammals were identified during the study. This result can be compared with similar studies in different parts of Ethiopia that have similar ecology and have used similar techniques to census mammals. For example, previous research [41] identified 19 species of large wild mammals in and around Wondo Genet fragmented MAF. Reference [16] recorded 25 species of large- and medium-sized mammals in the Harenna MAF of Bale Mountains National Park (BMNP). The area is home to a diversity of wild mammals. Several other reports have also emphasized the importance of habitats outside of protected areas in supporting a diversity of wildlife species [12, 13]. The existence of relatively higher numbers of endemic, rare, and endangered species in the area indicates that the landscape of the fragment forest that spans over altitudinal difference is

TABLE 3: Relative abundance and mean abundance of large wild mammals among different habitat types of Nensebo forest, Southern Ethiopia.

| NENSEBO | Mean number of individuals observed in different habitat types | | | | Total animals observed | Relative abundance (in %) |
| | Moist Afromontane forest | | Modified moist Afromontane forest | | | |
Species	Wet	Dry	Wet	Dry		
C. guereza	141	87	43	59	330 ± 7	38
P. anubis	85	72	27	40	224 ± 5	24
P. africanus	64	30	11	9	114 ± 5	12
C. crocuta	40	16	5	1	62 ± 3	6.7
P. larvatus	31	10	8	3	52 ± 4	5
H. meinertzhageni	23	14	6	2	35 ± 4	3.8
H. cristata	10	9	0	0	19 ± 1	2
T. s. meneliki	6	3	1	0	10 ± 0	1
P. pardus	9	2	0	0	11 ± 1	1.1
S. grimmia	5	4	0	0	9 ± 1	0.9
O. afer	4	3	0	0	7 ± 0	0.7
C. civetta	3	0	0	0	3 ± 0	0.3
C. aureus	2	1	0	0	3 ± 1	0.3
F. serval	1	0	0	0	1 ± 0	0.1
P. leo	1	0	0	0	1 ± 0	0.1
T. buxtoni	1	0	0	0	1 ± 0	0.1
Total (16)	440 ± 13	262 ± 9	104 ± 6	114 ± 4	920 ± 21	100%

Diversity indices: the highest large mammals Simpson's (1-D) and Shannon-Weaver index of diversity was obtained in the intact moist Afromontane forest habitat ($D = 5.434$, $H' = 2.188$), and the modified moist Afromontane forest habitat had the lowest diversity ($D = 3.095$, $H' = 1.373$) (Table 4).

TABLE 4: Diversity indices of large wild mammals indifferent habitat types of Nensebo forest, Southern Ethiopia.

Habitat types effort	Number of species	Number of individuals	H'	D	H_{max}	E
Area total (80 km walked)	16	920 ± 21				
Modified moist Afromontane forest (20 km walked)	8	218 ± 5	1.373	3.095	2.079	0.660
Moist Afromontane forest (60 km walked)	16	702 ± 9	2.188	5.434	2.833	0.772

E = Pielou evenness; H' = calculated Shannon-Weiner diversity; $H_{max} = \ln(s)$ (species diversity under maximum equitability conditions); D = Simpson's index.

an important area to maintain endemism and therefore should be given high conservation priority. Seasonal variations were observed in species composition of large wild mammals among different habitat types. The variation is credited to the seasonal variations in availability of water, food, and cover.

The distribution and habitat association of mammals are often correlated mainly with the availability of habitat components [42]. Seasonal variation in habitat quality (variation in food, cover, and water sources) may also contribute to the seasonal variation in species composition.

Additionally, the pattern of anthropogenic effects, such as livestock grazing and human settlements, may also influence such variation. For instance, seasonal difference in the level disturbance (deforestation and livestock grazing) was observed, which was inversely related with wild animal's abundance and distribution. During the field data collection, increased presence of livestock and human settlements was observed in the wet season that could initiate human-wildlife conflict. Various studies elsewhere have frequently reported that the level of disturbance in large mammals' habitat determines habitat use, and large mammals have been reported to avoid habitats with a high level of disturbance [7, 14–18, 42–47]. Similar results were reported in the Alatish National Park, Ethiopia [28, 43].

Primates are widely distributed in Africa over diverse habitat types [48]. Many primates, including olive baboon and *Colobus guereza*, are known to commonly inhabit the attitudinal range, from 1500 to 3700 m a.s.l (current altitudinal range) [41, 48]. However, the distribution and abundance of primates are also highly influenced by the abundance, availability, and distribution of resources like sleeping cliffs/trees, food, and water [41, 48, 49]. During this study, some nocturnal and cryptic species may have been under reported. This is due to the behavior of the animals, rareness of the species, and poor visibility due to darkness and thick vegetation that could contribute to poor visibility and fewer sightings.

The heterogeneous plant species assemblage in the intact moist MAF could have contributed to the recorded highest diversity of mammals in the study area. Such habitat provides more extensive browsing and grazing opportunities, and the greater diversity of vegetation in such areas is likely

TABLE 5: Population structure of large wild mammals at Nensebo forest, Southern Ethiopia.

Species	Total Ind.		Classified Ind. (%)		% young		Ratio			
							Wet		Dry	
	Wet	Dry	Wet	Dry	Wet	Dry	M/F	Y/A	M/F	Y/A
C. aureus	2	1	0	100	—	—	—	—	—	—
C. civetta	3	—	0	0	—	—	—	—	—	—
C. guereza	184	146	55	55	8.7	12	1 : 1.4	1 : 0.04	1 : 1.6	1 : 0.08
C. crocuta	45	17	0	0	—	—	—	—	—	—
H. meinertzhageni	29	16	0	0	—	—	—	—	—	—
H. cristata	10	9	0	0	—	—	—	—	—	—
L. serval	1	0	0	0	—	—	—	—	—	—
O. afer	4	3	0	0	—	—	—	—	—	—
P. leo	1	0	0	0	—	—	—	—	—	—
P. pardus	9	2	0	0	—	—	—	—	—	—
P. anubis	112	112	94	67	25	20.5	1 : 1.4	1 : 0.2	1 : 2	1 : 0.2
P. africanus	75	39	12	7.7	—	—	1 : 2	—	1 : 2	—
P. larvatus	39	13	7.7	0	—	—	1 : 2	—	—	—
S. grimmia	5	4	60	50	—	—	1 : 2	—	1 : 1	—
T. buxtoni	1	0	0	0	—	—	—	—	—	—
T. s. meneliki	7	3	14	33	—	—	—	—	—	—

F = female; M = male; Ind. = individuals; Y = young.

to support larger numbers of prey species. Several scholars [43, 47, 50] have also previously reported a positive correlation between habitat heterogeneity and animal species diversity. As a result, large-sized mammal distribution and diversity in the present study areas were highly associated with habitat characteristics.

A previous report [17] reported a high diversity and evenness of medium- and large-sized mammals in Borena-Sayint National Park, South Wolo, Ethiopia, which has diversified habitat types. On the contrary, habitat homogeneity was reported to have lower diversity [43, 51, 52]. The knowledge of sex ratio and age distribution of individual mammals is vital for evaluating the viability of a species because these variables reflect the structure and the dynamics of populations. As a result, the higher proportion of females and young indicate a healthy, increasing population. Even though the total proportion of adults (male and female) was higher, the number of adult males was low. The cause for the low proportion of adult males in most of the species could be a natural distribution of sex ratios; in naturally growing population adult males proportion is lower than adult females, due to the fact that a single male and copulate with more than female, since most mammals are polygamous. It might be also related to poaching pressure, in which the adult males are mostly selected by poachers [53]. Culturally, the indigenous community prefers to hunt adult males for food, medicine, and cultural rituals over females and other age groups. Due to poor habitat, quality competition of males to mate and resources could also force the bachelor males to migrate to less suitable habitats that are poor in food quality and exposing them to predators and poachers [54], which could also be another reason for the lower record of adult males [54].

The results of the study on species diversity has revealed high species diversity and endemism over relatively small fragmented forest, and this is an important input to underpin sound wildlife conservation management options in the area. The results of the study also indicated high abundance of primates, which is important information for proposing primates management options in the area. The population structure study is also an important source of information for population management of the large mammals recorded in the forest fragment.

5. Conclusion

The results of the study indicated relatively high large mammals diversity in fragmented remote forest and calls for conservation attention. It can also be concluded that forest degradation (modified forest) leads to decline in large mammals abundance. Relatively primates are the most abundant in the fragment forest. The results of the study also indicated an increasing primates population in the future due to relatively higher young individuals, whereas the absence of young individuals in large carnivores and large herbivores could indicate population decline.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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