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Research Article

Large Mammal Diversity and Endemism at Geremba Mountain Fragment, Southern Ethiopia

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Outside protected areas in Ethiopia, there is a lack of information concerning mammalian diversity and ecology. Consequently, the findings of the research on large mammals at Geremba Mountain constitute one of the steps towards a continuing effort to document the diversity and distribution of Ethiopian mammals. The survey was conducted to investigate the species composition, relative abundance, and population structure of large mammals at Geremba Mountain fragment from August 2017 to February 2018, covering both dry and wet seasons. Direct (sighting) and indirect (scat) survey techniques were employed using systematically established transect lines and sampling plots, respectively. Transects and plots were established across three dominant habitat types (modified dry ever green Afromontane forest, alpine bamboo forest, and Erica scrubland). A total of 10 large mammal species were recorded including two endemic mammals, namely, *Chlorocebus* djamdjamensis and *Tragelaphus scriptus* meneliki. There was a statistically significant difference in the abundance of species among habitat types at Geremba Mountain. The highest diversity index was recorded in the alpine bamboo forest habitat ($D = 7.142$, $H' = 2.052$), and the Erica scrubland had the lowest. *Papio anubis* was the most abundant species while *Felis serval* was the least abundant species. The populations of most of the species were characterized by more adult and more female individuals. However, promising young individuals of the endemic mammals (*C. djamdjamensis* and *T. s. meneliki*) and *Papio anubis* were recorded. The mountain fragment is an isolated island that is totally disconnected with other fragments in the region, so attempts should be made to connect the fragment with other fragments using wildlife corridors.

1. Introduction

Mammals render ecosystem services, economic, cultural, educational, and scientific values. Mammals regulate vegetation dynamics, are involved in a seed dispersal and pollination, regulate prey populations, and are important in nutrient cycling [1]. Large mammals hold a central role in wildlife based tourism that generates billions of dollars and significantly contributes to the gross domestic product (GDP) of many African countries such as South Africa, Tanzania, and Kenya [2]. Large mammals are important in many cultures and beliefs. For example, monkeys are considered holy in Hindu religion [3]. Mammals provide educational and scientific values for teaching students about mammals life history, ecology, and conservation, in addition to serving as experimental animals in testing newly discovered drugs [4].

Mammals are among the most widely distributed organisms in the world. Mammals occur from the Antarctic to desert ecosystems [5]. They can successfully colonize diverse habitat types due to diversity in size and morphological, physiological, and behavioral adaptation [6]. Mammals range from the smallest Kitti's Hog-Nosed Bat (*Craseonycteris thonglongyai*) (2 g) to the giant blue whale (*Balaenoptera musculus*) (140000 kg) [7]. Large mammals are defined as mammals weighing above 7 kg [8]. There have been discoveries of new taxa over the past decades; as a result, the number of mammalian species has been

continuously being updated. To date there are 5416 species of mammals, out of which 2277 (42%) rodents (Rodentia), 1116 (20.6%) bats (Chiroptera), and 428 (7.9%) shrews and allies (Soricomorpha) comprise the largest species [7].

Ethiopia is among the biodiversity rich countries in Africa. The species of mammals are estimated to be around 320 species including 39 endemics (both small and large mammals), distributed in 14 orders and 39 families [9], which ranks the country among the most diverse mammalian faunas in Africa [10]. It has been indicated that large mammals were once widely distributed in most parts of the country and were fairly abundant [11], when the forest cover of the country was estimated to be 60% [12]. However, the majority of the large mammals are now confined to isolated protected areas and mountain fragments, mostly found in southern and southeastern part of the country [10].

Wildlife habitat degradation, fragmentation, and loss are common threats to mammals in Ethiopia, have remained as the most important challenges of wildlife conservation in Ethiopia [13], and have been escalating in the recent decades [14]. Expansions of agriculture, human settlement, fire wood collection, wood extraction, livestock encroachment, and anthropogenic fire have been the major drivers for wildlife habitat degradation, fragmentation, and loss [14–16]. These threats have led to loss of vast areas of wildlife habitat and have been degrading factors in Ethiopia including in protected areas [17–19]. Most fragments are montane fragments that are inaccessible for agricultural and human settlements [14]. Mountain fragments are common throughout the densely populated highlands of Ethiopia and have been recently known for their enormous potential for conservation of biodiversity [14, 20, 21]. These mountain fragments have been serving as last refugees for diverse large mammals including endangered and endemic species [20, 22, 23]. However, most of these mountain fragments are not protected legally and have been disconnected ecologically from other fragments in the surroundings [24]. Although, it is believed that habitats outside protected areas have an enormous role in supporting diverse wildlife species, there have been few surveys of these sites and comprehensive scientific baseline information is lacking [25].

Mount Geremba is fragmented mountain (12.5 km^2) in the southern highlands of Ethiopia [25]. The mountain is predominantly covered by alpine bamboo and with spare Erica scrubland vegetation at the summit of the mountain. Despite its small size, it is known as home for diverse wildlife species including endemic and vulnerable large mammals [25]. The fragment is totally disconnected from similar fragments in the locality and has been often challenged by the human dominated landscape surrounding the mountain. Despite the fact that the mountain fragment harbors diverse large mammal species in increasingly distributed environment, little is known about the large mammal diversity and ecology. Furthermore, how these mammals survive in the presence of continuing disturbance is unknown to the scientific community. Comprehensive information on faunal resources and their specific habitat association should be made available for sustainable wildlife conservation. In particular, this study attempted to answer research questions such as the following: What is the large mammals species composition in the fragment? What is the relative abundance of each species? What is the population structure nexus to further demographic stochastic? Therefore, the study is aimed at investigating large mammals species composition, relative abundance, and population structure.

2. Materials and Methods

2.1. Study Area. Mount Geremba is located in Arbegona woreda (district) administered under Sidama zone of the Southern Nations, Nationalities, and Peoples' Region State (SNNPRS) of Ethiopia (Figure 1). Arbegona is bordered by Bona Zuria woreda to the south, Bursa to the southwest, Gorche to the northwest, and Bensa woreda of the Sidama zone of SNNPRS to the east, whereas in north it is boarded by Kokosa woreda of the West Arsi zone of Oromia Regional State (Figure 1). It is located about 361 km to the south of the capital, Addis Ababa. Geographically it is situated between 6°38′ to 6°49′ N and 38°34′ to 38°49′ E, covering a total area of 12.5 km^2 (1250 ha) (Figure 1).

Arbegona is characterized by a hilly and mountainous landscape with an altitude range from 2000 to 3336 m a.s.l. [25]. There are various mountain fragments in the woreda covered by sparse vegetation and highly encroached by human activities. Mountain fragments in the woreda include Geremba, Yerke, Idoro, Udume, Werbadule, and Hafursa. Perennial rivers of Arbegona include Gange, Gabata, Cheleleka, Tare, Gorenti, Bulichana, and Malawe [25]. The woreda exhibits a bimodal rainfall pattern, with a minor rainy season between the months of February and April and major rainfall between the months of July and October. The annual rainfall ranges from 1250 to 1300 mm [25]. The mean monthly temperature ranges from a minimum of 14°C to a maximum of 18°C [25].

2.2. Reconnaissance Survey. A reconnaissance survey was carried out to get basic information on accessibility, topography, and infrastructures [26]. The reconnaissance survey was carried out during the second week of May 2017 for five days. During the survey all the dominant habitat types were transverse on foot, visual estimation of the area of each habitat type was made, and 20 ground truth points (geographical coordinates) representing all the dominant habitat types were taken using global positioning system (GPS) as an input for estimating the total area of each habitat type using geographic information system (GIS) and remote sensing technologies.

2.3. Sampling Design. Based on direct observation made during the reconnaissance survey and land cover information obtained from satellite images using geographic information system (GIS) and remote sensing, the Geremba Mountain was stratified into three dominant habitat types, namely, subalpine (Erica scrubland), alpine bamboo forest, and modified dry ever green Afromontane forest habitats. The sub-Afroalpine habitat (Erica scrubland) covered the upland areas with rugged topography (3291–3305 m a.s.l.)

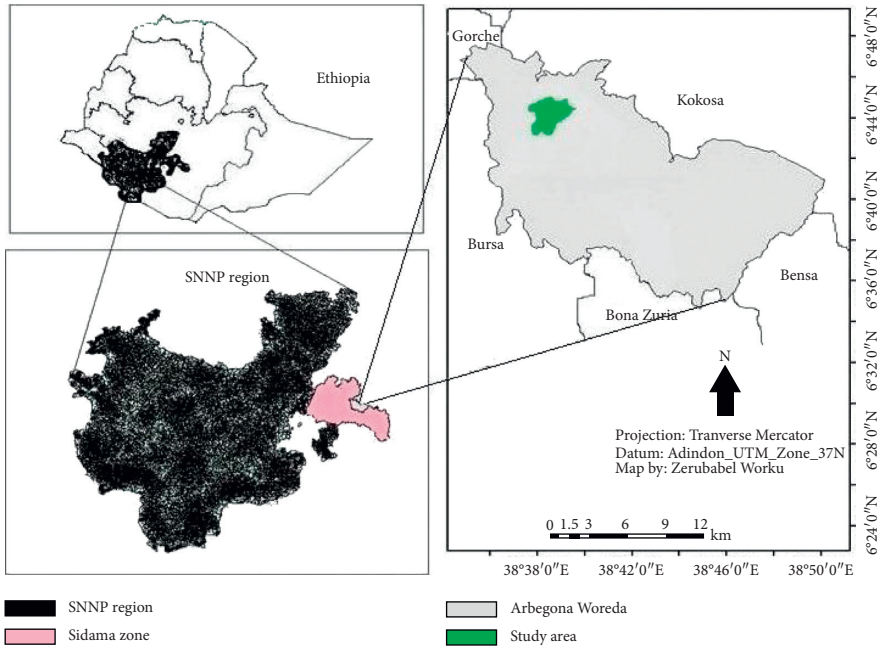

Figure 1: Location map of Geremba Mountain, southern Ethiopia.

and was dominated by remnants of *Erica arborea* interspersed with *Hypericum revolutum* and scattered stands of the endemic giant lobelia (*Lobelia rhynchopetalum*) (Figure 2). The alpine bamboo habitat occurred in valleys and middle altitude areas between 3189 and 3229 m a.s.l. and was dominated by highland bamboo (*Arundinaria alpina*) (Figure 3). It comprised the highest proportion of the mountain fragment. Modified dry evergreen Afromontane forest habitat occurred in areas with an altitude range 3075–3165 m a.s.l. and encompassed buffer areas with 0-1 km distance from the edge of the alpine bamboo forest. This habitat was characterized by modified forest habitat (a remnant dry evergreen Afromontane forest with human interventions, severely encroached by human settlement and agriculture) (Figure 4) [27].

To effectively survey the species diversity of large mammals, two standardized survey techniques, namely, direct (sighting) and indirect (scat) census, were employed [28].

2.3.1. Direct Survey. A total of ten (T_1–T_{10}) transect lines were systematically generated with the help of GIS [29] using QGIS v. 2.18 software (Figure 5(a)). Stratified systematic sampling design was employed to establish transects among the three dominant habitat types. From field observation and land cover analysis, the approximate area of each habitat type was determined in order to estimate the proportion of sample transects needed to represent each habitat type. Accordingly, five transect lines (T_1, T_2, T_3, T_4, and T_5) were laid representing the modified dry evergreen Afromontane forest habitat, four transect lines (T_6, T_7, T_8, and T_9) in the alpine bamboo forest habitat and one transect line (T_{10}) in sub-Afroalpine (Erica scrubland) habitat.

From a total area of 12.5 km^2 (1250 ha), 3.75 km^2 (375 ha) (30% of the area) was sampled. The length of each transect line was 750 m and the distance between two adjacent transects was 500 m to avoid double counting. The variable transect width method, ranging from 20 m in the alpine bamboo habitat to 150 m in the modified dry evergreen Afromontane habitat, was employed (Figure 5(a)). To avoid edge effects, transects were spaced 250 m from the edge of the forests/habitat type. The transect lines were laid 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 were also considered during the transect line setup.

2.3.2. Indirect Survey. As a double confirmation and to account for the difficult topography and effectively census elusive and nocturnal large mammals, indirect survey technique was also employed. Indirect survey plots were systematically generated with the help of geographic information system [29] using QGIS v. 2.18 software. Accordingly, a total of 20 plots (P_1–P_{20}) spaced 750 m apart were established (Figure 5(b)). The size of each plot was 100 m^2 (20 × 5 m). To avoid edge effects, plots were established 250 m from the edge of the forest. Plots were established following the slope of the ground. Ecological or density gradients including aspect, accessibility, terrain, long roads, streams, and contour of hills were considered during the plots layout.

2.4. Data Collection. The study was conducted for one year between the months of August 2017 and February 2018 covering both dry and wet seasons. Data were collected in four sessions (Wet I, Wet II, Dry I, and Dry II). Each transect line was visited six times per season. Besides fixed line

Figure 2: The sub-Afroalpine (Erica scrubland) habitat at Geremba Mountain (photo: Zerubabel Worku, 2018).

Figure 3: Alpine bamboo forest habitat at Geremba Mountain (photo: Zerubabel Worku, 2018).

Figure 4: Modified dry evergreen Afromontane forest habitat at Geremba Mountain (photo: Zerubabel Worku, 2018).

transects surveys, random search was conducted to record the occurrence of mammalian species in the study areas for a complete species list, as applied by [30].

Data on large mammal species richness and abundance were recorded along the established transect lines, during morning hours (6:00 to 10:00 am) and late afternoon (3:00 to 5:00 pm) following [31, 32]. Each line transect was navigated by using Garmin 60/78 global positioning system (GPS) and Handheld bearing compass Suunto KB-14/360R *G* by walking at a constant speed of ~1 km/h [33–35]. During the study periods, a silent detection method (suitable clothing for camouflage, moving against the direction of wind, and keeping quite) was practiced to minimize disturbance and increase of animals detectability. Observations were made with naked eyes and Nikon action 10×50 binoculars.

During the study, body weight was the parameter used to categorize mammals as large-sized; accordingly, mammals weighing above 7 kg were considered as large mammals as applied by [8]. The number of individuals of each species, approximate perpendicular distance, sex, age, group size, and activity of the animals were recorded using pre-prepared data sheet. Morphological developments (horn ridges, horn size, and body size), growth and maturation, changes in pelage color or patterns, sexual maturity (bacula, testes length, condition of mammary glands, and behavior during breeding) were used to determine the approximate age (adult, subadult, and young) [36].

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

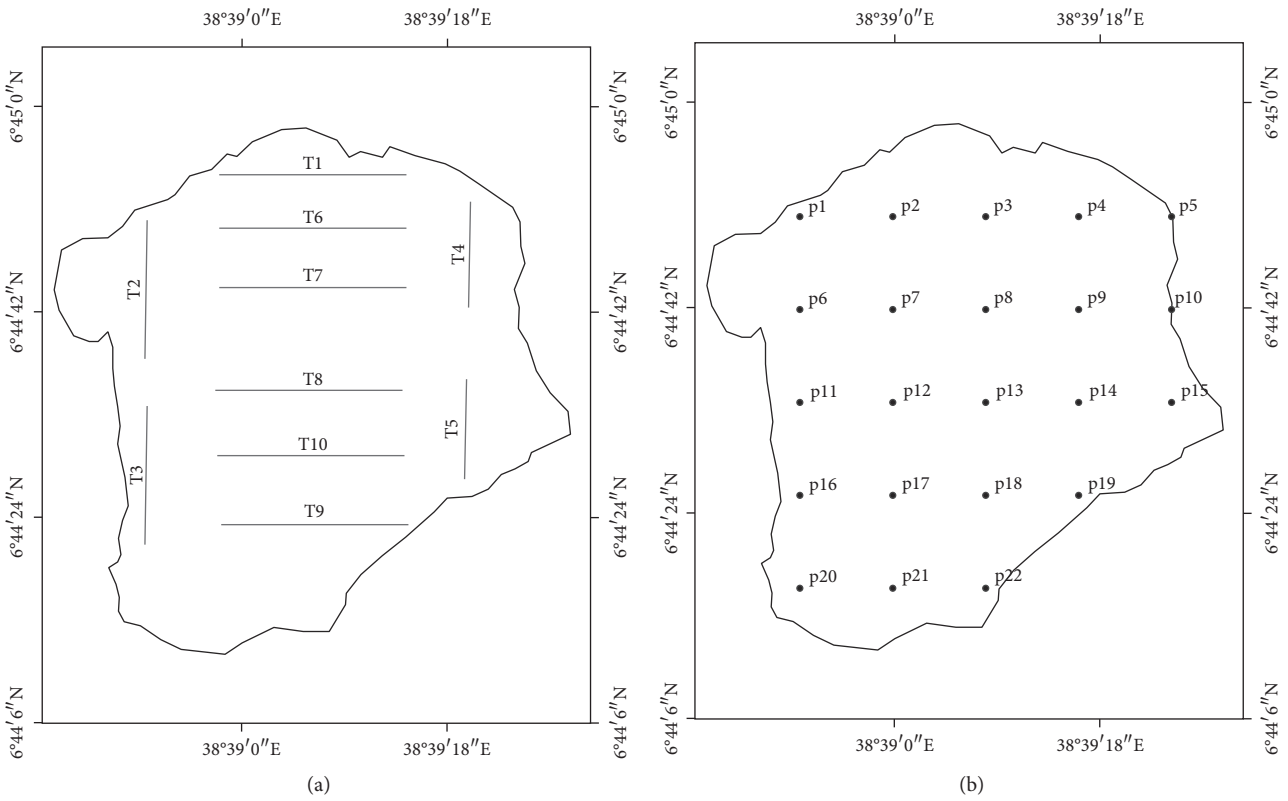

Figure 5: Transects (a) and plots (b) layout at Geremba Mountain, southern Ethiopia.

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 as a means to avoid double counting [37]. Double counting of the same individual or herd was avoided using easily recognizable features of individuals, herd size, and composition [38].

2.4.1. Indirect Survey. Each field plot was scanned carefully, and all fresh scats of large mammals were counted and recorded. Identification of scats obtained was attempted in the field by using specialized field guides for the identification of scats of mammals [39–41]. Scats were distinguished by different 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. Each species of large mammals encountered was identified in the field based on the Kingdon Field Guide to African Mammals [42] and "Atibiwoch" [43].

The taxonomic treatment was based on the Mammals of the World 3rd Edition [7]. The conservation status of each species was also identified based on the IUCN Red List [44] and the CITES Appendices.

The species similarity among the habitat types was computed using Sorenson's coefficient (CC):

$$(CC) = \frac{2C}{S1 + S2}, \tag{1}$$

where C is the number of species the two habitats have in common, S1 is the total number of species found in habitat 1, and S2 is the total number of species found in habitat 2.

Species diversity among habitat types was calculated using the Shannon-Weiner index of diversity:

$$(H\prime) = \sum Pi \ln \mathrm{P}isi = 1, \tag{2}$$

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

Simpson's diversity index among habitat types was calculated as follows:

$$(D) = \frac{1}{\Sigma Pi2si = 1}, \tag{3}$$

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

The evenness of mammalian species among habitat types was also calculated as

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

where H′ max = ln(s) and s is the number of species in the particular habitat type. Evenness ranges between 1 (complete evenness) and 0 (complete unevenness).

The relative abundance of particular large mammals was determined using the following expression:

$$\text{percent relative abundance } (\%) = \frac{n}{N} \times 100, \quad (5)$$

where n is the number of individuals of a particular recorded species and N is the total number of individuals of all recorded species in the study site.

The results and findings of the research were presented by simple descriptive statistical tools. Following [45] and the computation of relative abundance, the identified mammals were grouped as common (if probability of observing the individuals of the species is 100% in every session of the field work), uncommon (if probability of observing is more than 50%), and rare (if probability of observing is less than 50%) according to [37]. Records of the number of individuals of mammals in the line transect that fall in the same habitats were summed together and treated as a record in one habitat, and mean records of the survey were considered. Each species was classified into different group size-class, age-sex categories, and ratios, i.e., percentages of adults and young ones, male per female, and young ones per female. A Kruskal-Wallis test was used to compare differences in mammal species abundance among habitats. The effect of the season on species abundance between dry and wet season was analyzed and compared using Chi-square test, and the seasonal difference in sex ratio was evaluated by t-test. For all statistical tests, p value of 0.05 was considered significant. Minitab version 17 was used for all statistical test analyses.

3. Results

3.1. Species Diversity. A total of 10 species of large wild mammals distributed in 5 orders and 7 families were identified and recorded after a total effort of 30 km walked distance at Geremba Mountain fragment (Table 1). Two endemic species (Bale monkey, *Chlorocebus djamdjamensis*, and Menelik's bushbuck, *Tragelaphus scriptus meneliki*) and two vulnerable species (Bale monkey and leopard, *Panthera pardus*) were recorded from the mountain (Table 1). Seven species, *C. djamdjamensis*, *Canis aureus*, *Crocuta crocuta*, *Felis serval*, *Papio anubis*, *Sylvicapra grimmia*, and *T. s. meneli*ki, were recorded through direct observation, whereas three nocturnal and elusive species, *Hystrix cristata*, *Orycteropus afer*, and *P. pardus*, were revealed using indirect evidence (scat survey) (Figure 6).

Seasonal variation in species richness of large wild mammals was observed among different habitat types. The highest species richness ($n = 9$) was recorded in the alpine bamboo forest habitat during the wet season (Table 2). There was a significant difference in species abundance among the three habitat types ($H = 20$, df = 2, $p < 0.05$). The overall Sorensen species similarity index (CC) of large wild mammal species among three habitat types of Geremba Mountain was 0.714 (Table 3). The highest (0.875) similarity index was recorded between modified dry evergreen Afromontane forest and alpine bamboo forest (Table 3). The highest large mammals Simpson's index (1-D) of diversity was obtained from the alpine bamboo forest habitat ($D = 7.142$), and the Erica scrubland habitat had the lowest diversity ($D = 3.802$).

3.2. Relative Abundance. *Papio anubis* was the most abundant species comprising (21%, $n = 48$) the recorded individuals, followed by *S. grimmia* (17%, $n = 39$) and *T. s. meneliki* (14%, $n = 32$) (Table 4). On the other hand, *F. serval* was the least abundant species (0.8%, $n = 2$) (Table 4). Both of the endemics *C. djamdjamensis* and *T. s. meneliki* were the most abundant in the alpine bamboo habitat type during both seasons, and *C. djamdjamensis* was closely associated with the alpine bamboo stands. Seasonal variation in species abundance was observed, and *P. anubis* was the most abundant during both dry and wet seasons (Figure 7). A total of 227 ± 9 individuals were recorded, out of which 114 ± 5 (50.2%) individuals were observed during the wet season and 113 ± 6 (49.7%) individuals during the dry season, but the seasonal species abundance of large wild mammals was not significantly different ($\chi 2 = 0.004$, df = 1, $p > 0.05$).

3.3. Population Structure. Out of the total recorded 10 species of large wild mammals during the present study period, the populations of four species, *C. djamdjamensis*, *S. grimmia*, *P. anubis*, and *T. s. meneliki*, were characterized by more adult and more female individuals during both wet and dry seasons. Generally, the number of adult females was relatively higher than that of any other age/sex group during both seasons, the pooled sex ratio of adult animals of all species was biased towards females, and the difference was significant ($t = 29.259$, df = 41, $p < 0.05$; $t = 31.440$, df = 41, $p < 0.05$) during wet and dry seasons, respectively. For the count of both seasons, the number of young individuals of all species was disproportionately low relative to the number of adult females. However, promising young individuals of the endemic mammals (*C. djamdjamensis* and *T. s. meneliki*) and *P. anubis* were recorded (Table 5).

4. Discussion

4.1. Species Diversity. The recorded relatively large number of mammals indicated the potential of the mountain fragment as a home for diverse large mammal species, despite its small size. Furthermore, despite the fact that the area is surrounded by human dominated landscape that often challenged the survival of the mammals, the mountain fragment harbored diverse large mammals including some endemic species. Scholars have revealed the importance of mountain fragments as last refuges for large mammals, especially in areas where there is intense human encroachment and expansion of agriculture [20, 46]. Moreover, the fact that the mountain is home for the endemic *T. s. meneliki* and *C. djamdjamensis* makes it critical for wildlife conservation. *T. s. meneliki* has been reported to inhabit the northern, central, and southeastern highlands of Ethiopia ranging from 1800 m to 3200 m a.s.l. [11, 24, 47]. Typically, the species is reported to inhabit dry evergreen Afromontane forest and alpine bamboo habitats [11, 47]. Furthermore, it was reported to be among the most abundant large mammal species in Bale Mountains National Park (BMNP) [22, 47], once known to be connected with the Geremba Mountain, before habitat fragmentation caused by anthropogenic

Table 1: Checklist of large wild mammals registered in Geremba Mountain, southern Ethiopia.

Taxon scientific name	Common name	IUCN status	CITES status	Current/Local status
Artiodactyla				
Bovidae				
Tragelaphus scriptus meneliki	Menelik's bushbuck[E]	LC	—	Un-co
Sylvicapra grimmia	Common duiker	LC	—	Un-co
Carnivora				
Canidae				
Canis aureus				
Hyaenidae	Common jackal	LC	—	Un-co
Crocuta crocuta	Spotted hyena	LC	—	Co
Felidae	Leopard	VU	App. I	Ra
Panthera pardus	Serval cat	LC	App. II	Ra
Felis serval				
Primates				
Cercopithecidae				
Chlorocebus djamdjamensis	Bale monkey[E]	VU	App. II	Ra
Papio anubis	Olive baboon	LC	App. II	Un-co
Rodentia				
Hystricidae	Crested porcupine	LC	—	Un-co
Hystrix cristata				
Tubulidentata				
Orycteropodidae	Aardvark	LC	—	Un-co
Orycteropus afer				

IUCN status: EN: endangered, VU: vulnerable, NT: near threatened, LC: least concern; CITES status: App. I/II: appendix I/II; current/local status: Co: common, Un-co: uncommon, Ra: rare; [E] endemic.

Figure 6: Scats of large mammals recorded at Arbegona, southern Ethiopia: (a) *Panthera pardus*; (b) *Crocuta crocuta*; (c) *Hystrix cristata*; (d) *Papio anubis* (photo: Zerubabel Worku, 2018).

factors disconnected the continuous forest. Bale monkey is a typical species found in alpine bamboo forest that uses the habitat as source of food, cover, and other habitat requirements [48]. Studies have pointed out that *C. djamdjamensis* is fairly common in the Bale, west Arsi, and Sidama highlands including mountain fragments in close association with alpine bamboo forest [48, 49].

The insignificant seasonal variation in the species richness of mammals could be explained by the isolated nature of the mountain, where movements to and from the patch/fragment do not occur. This could imply a poor genetic makeup that could lead to inbreeding effects on the metapopulations of large mammals over long period of time [50], unless the fragment is connected by wildlife corridors with other similar fragments in the surrounding area or extensive forest in the adjacent BMNP.

The highest record of the species in the alpine bamboo dominated forest could be due to the relatively dense and vast nature of the habitat type as compared to other habitat types providing a better space, cover, and food satisfying diverse niche requirements of mammals. The possible reasons for the distribution and diversity of large-sized mammal species might be due to the habitat types and quality (presence of food and water) and stability of the area from disturbances. Disturbance is also a key factor that determines the habitat use of large mammals [19, 22, 51, 52].

4.2. Relative Abundance. The relatively higher abundance of olive baboon in the area could be attributed to the feeding behavior as the species is adapted to feed on variety of food items and survive different climatic and topographic

Table 2: Diversity indices of large wild mammal's indifferent habitat types of Geremba Mountain, southern Ethiopia.

Study site habitat types	Species/habitat	Individuals/habitat	H′	D	H_{max}	E
Arbegona (30 km walked)	10	227 ± 9				
Modified forest (15 km walked)	7	87 ± 3	1.679	4.629	1.945	0.863
Alpine bamboo forest (12 km walked)	9	105 ± 3	2.052	7.142	2.197	0.934
Erica scrubland (3 km walked)	5	35 ± 2	1.412	3.802	1.609	0.877

E: Pielou evenness, H′: calculated Shannon-Weiner diversity, H_{max}: ln(s) [species diversity under maximum equitability conditions], D: Simpson Index.

Table 3: Sorensen species similarity index for the large wild mammals among different habitat types of Geremba Mountain, southern Ethiopia.

Study site habitat types	No. of species per habitat	Sorenson's species similarity index
Arbegona (30 km walked)	10	0.714
Modified forest vs. alpine bamboo forest (15 km vs. 12 km walked)	7 vs. 9	0.875
Modified forest vs. Erica scrubland (15 km vs. 3 km walked)	7 vs. 5	0.833
Alpine bamboo forest vs. Erica scrubland (12 km vs. 3 km walked)	9 vs.5	0.714

Table 4: Relative abundance of large wild mammals among different habitat types of Geremba Mountain, southern Ethiopia.

Species	No. of animals observed in different habitat types						Total animals observed	Relative abundance (%)
	Modified forest		Alpine bamboo forest		Erica scrubland			
	Wet	Dry	Wet	Dry	Wet	Dry		
P. anubis	11	20	5	3	7	2	48 ± 4	21
S. grimmia	8	9	8	7	4	3	39 ± 2	17
T. s. meneliki	5	6	12	9	0	0	32 ± 2	14
C. crocuta	1	0	6	9	8	5	29 ± 1	12.7
C. djamdjamensis	2	0	6	17	0	0	25 ± 2	11
C. aureus	3	5	4	2	3	2	19 ± 1	8.4
H. cristata	7	8	4	1	0	0	20 ± 3	8.8
O. afer	1	1	4	4	0	0	10 ± 1	4.4
P. pardus	0	0	2	0	1	0	3 ± 1	1.3
L. serval	0	0	2	0	0	0	2 ± 0	0.8
Area total	38 ± 3	49 ± 4	53 ± 3	52±4	23 ± 2	12±1	227 ± 9	100%

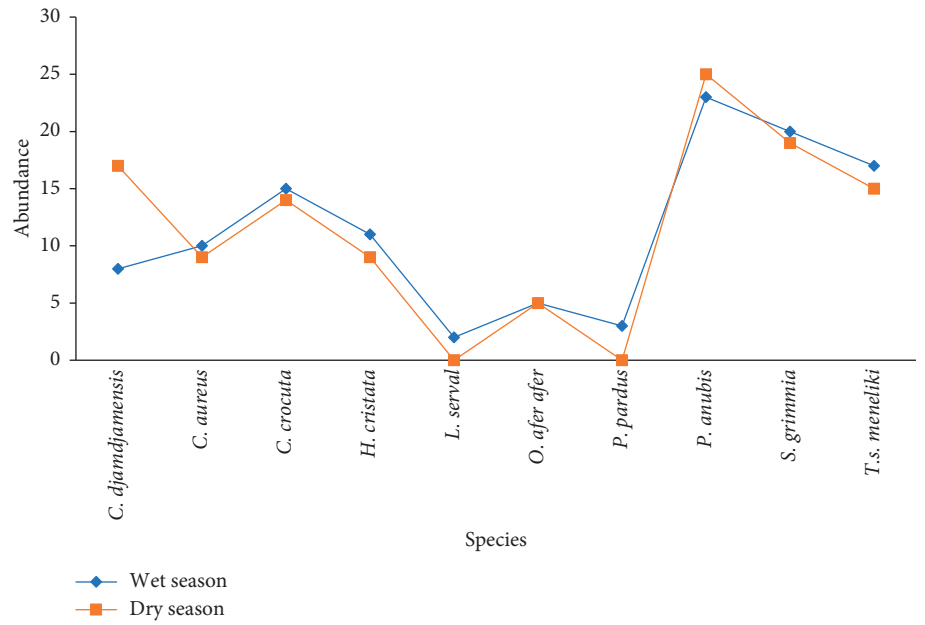

Figure 7: Seasonal variation in species composition and abundance of large wild mammals at Geremba Mountain, southern Ethiopia.

Table 5: Populations structure and ratio of large wild mammals at Geremba Mountain, southern Ethiopia.

Arbegona species	Total individuals		Classified individuals (%)		% young		Ratio			
							Wet season		Dry season	
	Wet	Dry	Wet	Dry	Wet	Dry	M/F	Y/F	M/F	Y/F
C. djamdjamensis	8	17	62	64	12	17.6	1 : 2	1 : 0.3	1 : 1.7	1 : 0.4
C. aureus	10	9	40	44	—	—	1 : 1	—	1 : 1.5	—
C. crocuta	15	14	0	0	—	—	—	—	—	—
H. cristata	11	9	0	0	—	—	—	—	—	—
L. serval	2	0	0	0	—	—	—	—	—	—
O. afer	5	5	0	0	—	—	—	—	—	—
P. pardus	5	1	0	0	—	—	—	—	—	—
P. anubis	23	25	56	64	22	16	1 : 1.3	1 : 0.6	1 : 1.7	1 : 0.3
S. grimmia	20	19	40	68	5	21	1 : 1.6	1 : 0.2	1 : 2.6	1 : 0.5
T. s. meneliki	17	15	71	47	—	6.7	1 : 2.6	—	1 : 1.6	1 : 0.4

F: female, M: male, Y: young.

variations. Olive baboon is known to be widely distributed in Africa in a wide variety of habitats ranging from savanna grass lands up to Afromontane forest [53]. Similarly, [54] noted wide distribution of olive baboon in an altitude range of 1700 m a.s.l. to 2300 m a.s.l. Different types of food items are targeted by olive baboon from cereals to fruits and from vegetables to trees [55]. Olive baboon is also disturbance tolerant species that can survive in areas where there are severe human encroachments and poor cover [55]. It is also among the top crop raider species in Ethiopia that are attracted to inhabit fragmented mountain cliffs surrounded by agriculture [56].

The relatively higher abundance of *T. s. meneliki* in the alpine bamboo forest could be due to its preferences for dense vegetation cover with abundant cover from predators and other threats and better foraging opportunities as compared to the other two habitat types [11, 19, 24]. Similarly, the *C. djamdjamensis* diet is predominantly alpine bamboo shoot that gives it an obligatory association with alpine bamboo forest. Various studies have indicated that alpine bamboo is the ideal habitat for Bale monkey, and its diet mainly comprises alpine bamboo [49, 57, 58]. The significant seasonal variation in the abundance of Bale monkey could be attributed to higher availability of its favorite alpine bamboo shoots during the dry season compared to wet season [57, 58]. It is reported that alpine bamboo flushes fresh shoots during dry season in the months of February and March [58], synchronized with the dry season data collection period of the study. As a result, the higher availability of the bamboo shoots could concentrate the populations of the Bale monkey during dry season in the alpine bamboo forest.

4.3. Population Structure. The relatively higher population of females and good proportion of young individuals indicate a healthy population showing potential of population growth in the future. This is supported by [59], which stated that sex and age structure of a population at any given point of time is also an indicator of the status of the population. This is supported by different studies in different areas [59–61]. The endemic *T. s. meneliki* and *C. djamdjamensis* had considerable good number of young individuals that one expects from a growing population [24, 57]. Therefore, the study revealed that the endemic species populations can be sustained at least for some time, despite the overwhelming threats. However, the long-term viability of the species populations in the area remains uncertain due to the isolated nature and small size of the fragment [58].

5. Conclusion and Recommendations

Despite the fact that Geremba Mountain fragment is a small isolated patch of alpine bamboo dominated forest, surrounded by human dominated landscape, it supported a considerably large number of large mammals. Furthermore, it is home for some endemic (Menelik's bushbuck and Bale monkey) and vulnerable (Bale monkey and leopard) large mammals. The large mammal species richness and abundance varied among habitat types. The study revealed that seasonality and habitat types were important factors in determining the species abundance and distribution in the area indicating specific habitat use by some of the species in response to ecological factors such as altitudes and vegetation. The alpine bamboo forest was the richest in large mammal diversity, with *P. Anubis* being the most abundant species, and the endemic and vulnerable Bale monkey is closely associated with the alpine bamboo.

However, the anthropogenic activities in and around the remnant forest and the isolated nature of the fragment can shrink the available habitats to wild mammals and block gene flow with metapopulations in nearby fragments ultimately affecting the abundance and survival of the large mammals. As a result, there is a need for full protection of the area from the surrounding threats, through making efforts like proclaiming the area as a protected area, and continuous effort should be made to ecologically integrate the fragment with other fragments in the localities through wildlife corridors. Furthermore, special consideration should be made to protect the vulnerable endemic Bale monkey and its unique habitat, alpine bamboo. Further research should also be made to investigate the habitat association of Bale monkey and alpine bamboo in terms of cover and food sources and genetic variations among metapopulations found in other fragments in the localities.

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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