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Research Article

Diversity, Abundance, and Habitat Association of Medium and Large-Sized Mammals in Tiski Waterfall, Awi Zone, Ethiopia

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The reliable data on faunal diversity, abundance, and habitat preference are essential for proposing and establishing relevant conservation interventions. A survey was done from September 2019 to March 2021 to investigate the diversity, relative abundance, and habitat association of large and medium mammals in Tiski Waterfall, Ethiopia. Data were collected using the line transect survey method in both habitat types. In cliff sites, the point transect was also used. The habitats were populated by large and medium animal species that favor dense forest and shrubland habitats near water sources. During the research, three different habitat categories were evaluated (dense forest, shrubland, and cliff sites). Ten mammalian species were discovered. During the wet season, there were 243 ± 6.6 populations recorded, while during the dry season, there were 204 ± 6.8. Seasonal differences in species abundance were statistically significant ($p \leq 0.001$). The total populations of the three habitat types were 198.2 ± 7.39, 135 ± 5.35, and 114 ± 5.16 for dense forest, shrubland, and cliff site, respectively. All three habitat categories had a great difference in species abundance ($p \leq 0.001$). The olive baboon (*Papio anubis*) was the most common, accounting for 38 percent of the population, followed by the vervet monkey (*Cercopithecus aethiops*), which accounted for 23 percent. Leopard (*Panthera pardus*) and common bushbuck (*Tragelaphus scriptus*) contributed the least to the total, accounting for only 2% each of the total. The highest diversity of mammalian species was found in dense forest ($H' = 0.98$), followed by shrubland ($H' = 0.90$), and the cliff location has the lowest diversity ($H' = 0.57$). The maximum uniformity of the species was found in dense forests ($J = 0.51$), followed by a shrub region ($J = 0.43$), and the remaining of the habitat ($J = 0.35$). Dense forest and shrubland had the highest species similarity (Sl = 0.67), followed by shrubland and cliff site (SI = 0.61). In dense forests with cliff sites, the similarity was lowest (SI = 0.31) in each. To limit the impact of agricultural growth on big and medium mammals, good habitat management is required.

1. Introduction

Mammalian species are one of the greatest resources found on the Earth [1]. In terrestrial ecosystems, mammals provide a variety of roles; ecological benefits, economic, cultural, educational, and scientific qualities are all provided by mammals [2, 3]. Large- and medium-sized mammals play a fundamental role in ecosystems functions [4]. Prey population management and seed dissemination are some important functions of large- and medium-sized mammals in forest ecosystems [4]. “Large-sized mammals weigh more than 7 kg and medium-sized mammals weigh between 2 and 7 kg” [5]. Even though large- and medium-sized mammals have different functions, they are threatened by various factors induced by human beings [1]. One of the driving factors of biodiversity loss is the shift from natural habitat to agricultural land usage [6]. In reality, losses in habitat diversity (e.g., degradation of microhabitats) may have an even higher impact on assemblages of diversity [7]. Forests provide a variety of habitats for animals, which is one of the most significant ecosystem functions [8]. To fulfill their foraging, housing, and escape needs, various mammals seek different settings [9]. Large, endangered species were hurt by human development and activity, while smaller, commensal species were not unaffected or even benefited [10]. Forest overuse for commercial agriculture has hurt wildlife species all over the world [11]. Hunting is another crucial element to consider, as it has the potential to affect the elimination of local animal species, particularly large ones [12]. Human-modified environments will play a big role in tropical forest

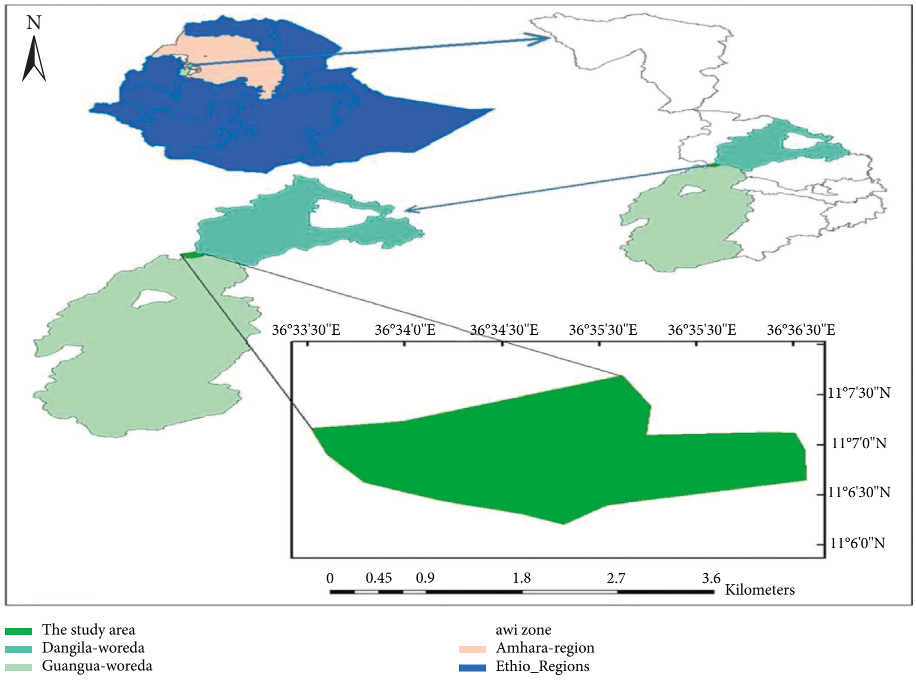

Figure 1: Map of the study area.

biodiversity's fate [13]. Many additional causes of global change, such as the conversion of forests to farming, have the potential to drastically diminish or alter the number of mammal species that live in a given area [14]. "There is a lack of information on mammalian faunal resources of remote forests in Ethiopia" [3]. Tiski Waterfall features a one-of-a-kind ecology. The location is surrounded by cliffs and vegetation. This distinctive habitat attracts a variety of wild creatures and is also a popular tourist destination. However, anthropogenic causes like crop production and grazing have a significant impact. As a result, the findings of the study on the diversity, abundance, and habitat association of medium and large animals in Tiski Waterfall are one step in a larger effort to document Ethiopian mammals in less accessible places. As mammal inventories are key instruments for directing conservation efforts and management activities successfully, identifying the status and knowledge about faunal variety, abundance, and habitat preference are vital for the application of relevant conservation strategies [15]. To strengthen management measures and integrate sustainable protection of the wildlife resource in Tiski Waterfall, information on the species diversity of large and medium animal populations and baseline data for better large and medium animal management are also needed.

2. Materials and Methods

2.1. Study Area Description. Awi is one of the zones in the Amhara Region of Ethiopia. The administrative center of the Awi Zone is Injibara town. It is named for the Awi subgroup of the Agaw people, some of whom live in this zone. Agew Awi Zone is bordered on the west by Benishangul-Gumuz Region, on the north by the Semien Gondar Zone, and on the east by the Mirab Gojjam Zone. Tiski Waterfall is found between Dangila and Guangua woredas in the Awi Zone. The study area is found in the Awi Zone, the Amhara Region of Ethiopia. It is geographically located between 11°6′0″ N to 11°7′ 30″ N to 36° 33′ 30″E to 36° 36′ 0″E (Figure 1).

2.2. Methodology

2.2.1. Study Design and Data Collection Method. Before the actual study, a pilot survey was undertaken to acquire basic information on the vegetation cover, accessibility, and animal type found in the study site via direct observation and interview. Knowing a species′ range, abundance, and habitat needs is essential for creating a baseline for long-term monitoring at a given location [16]. Data were collected from September 2019 to March 2021, covering both the wet and dry seasons. According to the rainfall distribution in the area, the dry season is from December to April, and the wet season is from May to November. The study area is very attractive and the waterfall is one of the attractions that attract tourists to the Awi Zone (Figure 2).

Based on land cover features, satellite pictures, and a preliminary assessment, the area was divided into homogeneous habitat types. Dense forests, shrubland, and cliff areas were the habitat types studied. In each habitat category, line transects were created consistently in typical (uniform vegetation) sites except cliffs. The length of the transect varied depending on the habitat type and the landscapes, the longest transect was in shrublands, which was 5 km in length, and the shortest one was in the dense forest, which accounts for 0.1 km in length. Similarly, the line transect survey method was used for large and medium mammal studies to collect data in the four sampled habitat types [15]. On both sides of the line transect, observations were

Figure 2: Partial view of Tiski Waterfall.

performed gently up to a distance of 100 m (in the dense forest) to 400 m (in shrublands). Depending on the coverage of the habitats, the side observations of line transect varied. The variation of transect width was determined based on the type of vegetation cover of each of the census zones [17, 18]. To reduce animal distraction from odors, the transect was run in the opposite direction of the wind. In this study, twenty-two transected and one hundred five points were taken. Of the total transects, 16 transects were in the dense forest and 6 transects were in the shrubland, depending on the area coverage and landscape types. The number of points on the transects varies based on the habitat size and types: 69 points in dense forest and 36 points in shrubs. At the cliff site, there is no line transect, but a point count was applied in caves under the cliff. Depending on the vegetation type and geography of the area, different lengths of transect lines were used [19]. Similarly, in [15], "forty-three transect lines were established, being 18 for wetland, 12 for woodland, 7 for the riverine, and 6 for grassland habitats depending on the area cover of each habitat." GPS was used to record the starting and finishing sites of each transect. Direct observations with binoculars and mammal guide books were used to identify the animals and count the number of individuals [3, 18]. In addition to direct observation, indirect evidence such as feces, feed markings, tracks, calls, and other types of evidence was recorded [12]. Species discovered from indirect evidence, on the other hand, were subsets of the species observed during the regular survey and hence were not included in the data analysis [20].

Each point was counted six times, three times during wet seasons and three times during dry seasons. At the time of field observation, the creatures' English, local, and scientific names were recorded. The following information was recorded: date, time, habitat type, species name, species number, and GPS location. Two individuals were assigned to each transect, and the transect was visited twice a day. The surveys were conducted early in the morning, between 6:00 and 10:00 a.m., and late in the afternoon, between 3:00 and 6: 00 p.m., when most animals are assumed to be more active [15]. To minimize rivalry, the activity patterns indicate a temporal partition of species cohabiting in the same area [21]. On a prepared datasheet, all observed animal species were recorded. Field guide books and local people were used to identify the species of mammals. Simultaneous counting and thorough observation of animal eating and sleeping areas, particularly on the cliff, were used to prevent counting the same species or individual animals again. To acquire correct data, well-experienced researchers with wild animal expertise were involved. Bodyweight was utilized to categorize mammals into medium and large sizes during the research. Mammals weighing between 2 and 7 kg were classified as medium, while those weighing more than 7 kg were classified as large [15].

2.2.2. Calculation of Species Diversity. The Shannon–Wiener diversity index was calculated using the following formula:

$$(H') = -pi^{*} \ln(pi\prime), \tag{1}$$

where H' is the Shannon–Wiener index, pi is estimated as ni/N, where ni is the proportion of the total population of the ith species, and $N = -\sum ni$. This uses proportions rather than absolute abundance values to reduce the effects of order of magnitude difference in mammal numbers between species.

This index provides a measure of "evenness" in the proportion of each species occurring within squares:

$$J = \frac{H'}{H\max}, \tag{2}$$

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 similarity among and between the habitats concerning the composition of species was computed using Sorenson's similarity index (SI):

$$(\mathrm{SI}) = \frac{\mathrm{C2}}{\mathrm{S1} + \mathrm{S2}}, \tag{3}$$

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.

Table 1: Mammalian species identified in Tiski Waterfall in Awi Zone, Ethiopia.

Order	Family	Common name	Sc. name	Local name
Carnivora	Felidae	Leopard	*Panthera pardus*	Neber
		Serval cat	*Felis serval*	Awurie dimet
	Hyaenidae	Spotted hyena	*Crocuta crocuta*	Jib
		Comment jackal	*Canis aureus*	Qebero
Artiodactyla	Bovidae	Bush back	*Tragelaphus scriptus*	Dikula
	Suidae	Wild pig	*Sus scrofa*	Yedur asama
Primate	Cercopithecidae	Vervet monkey	*Cercopithecus aethiops*	Tota
		Colobus monkey	*Colobus guereza*	Gureza
		Olive baboon	*Papio anubis*	Jinjero
Rodentia	Hystricidae	Porcupine	*Cercopithecus*	Jart

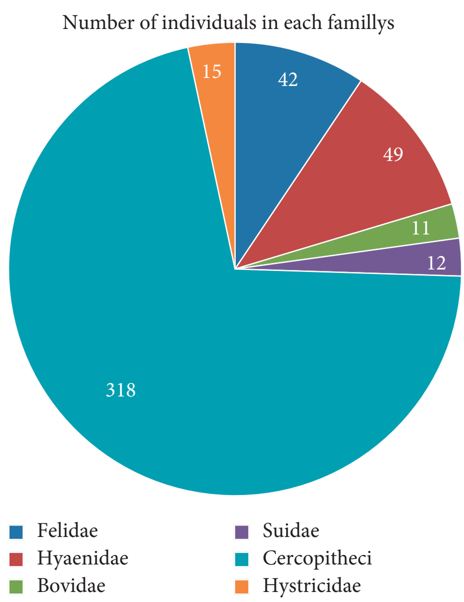

Figure 3: Number of individuals in each family.

Relative abundance (RA) (%) = $n/N \times 100$, where n is the number of individuals of particular species recorded and N is the total number of individuals of the species.

2.2.3. Data Analysis. All data collected during the study period were presented in a table by season and habitat type. The Shannon–Wiener Diversity Index was used to calculate the distribution, abundance, and evenness of species between the wet and dry seasons and within habitat types, and SPSS version 20 software was used to analyze the data. Excel version 2016 was also used to generate the relative abundance and species diversity indexes using formatted formulas.

3. Results

3.1. Species Composition. During the research, 447 individuals and 10 animal species were identified. There are four orders and six families of mammals in this group (Table 1). Carnivora and Artiodactyla both had two families, with four Carnivora species and two Artiodactyla species. *Cercopithecus* (three species, 318 individuals, which counts the highest population numbers among other families) had the most mammalian population, followed by Hyaenidae (two species, 49 individuals), Felidae (two species, 42 individuals), and Hystricidae (one species, 15 individuals) (Figure 3). The remaining families, Suidae (one species, 12 individuals) and Bovidae (one species, 11 individuals, the family with the fewest populations), were each represented by a single species. Mammalian species richness varied seasonally across different habitat types (Table 2). During the wet season, most mammalian species were more abundant than during the dry season (Figure 4). During the study, a total of 243 ± 6.6 populations were observed during the wet seasons and 204 ± 6.8 populations during the dry seasons. Seasonal differences in species abundance were statistically significant ($df = 1$, $p \leq 0.001$) (Table 3). Moreover, there was a statically significant difference among the mean number of mammalian populations ($df = 1$, $p \leq 0.001$) (Table 4). The average populations of the three habitat types were as follows:198.2 ± 7.39 for the dense forest, 135 ± 5.35 for shrubland, and 114 ± 5.16 for cliff sites. Between the three habitat categories, there was a significant difference in species abundance ($df = 2$, $p \leq 0.001$) (Table 5). In both seasons, the shrubland habitat had the highest number of species ($n = 8$), followed by the dense forest ($n = 7$). The cliff site ($n = 5$) contained a considerably smaller number of species during both the dry and wet seasons (Table 6). The total Sorensen species similarity index of mammalian species across three habitat categories was 1 (Table 7). The highest similarity index (SI = 0.67) was found between dense forests and shrubland (Table 7).

3.2. Relative Abundance of Species. The olive baboon (*Papio anubis*) was the most numerous of the ten mammals, accounting for 38% of the total with 168 individuals, followed by the vervet monkey (*Cercopithecus aethiops*), which accounted for 23% with 101 individuals, and the colobus monkey (*Colobus guereza*), which accounted for 11% with 49 individuals (Table 2). Spotted hyena (*Crocuta crocuta*) had 7% of the population with 33 individuals, and serval cat (*Felis serval*) had 7% of the population with 31 individuals. On the other hand, leopard (*Panthera pardus*) and common bushbuck (*Tragelaphus scriptus*) contributed the least of the total documented individuals, accounting for only 2% of the total with 11 individuals each (Table 4). During both the dry and wet seasons, *Papio anubis* was the most abundant,

TABLE 2: Mean abundance of wild mammals among different habitat types with seasons in Tiski waterfalls.

Species	Dense forest habitat		Shrubland habitat		Cliff site habitat		Total No.	RA (%)
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season		
Panthera pardus	2	2	0	0	3	4	11 ±2.28	2
Felis serval	0	0	12	13	3	3	31 ± 3.84	7
Crocuta crocuta	4	3	14	12	0	0	33 ± 4.24	7
Canis aureus	2	2	6	6	0	0	16 ± 3.79	4
Tragelaphus scriptus	2	4	2	3	0	0	11 ± 2.00	2
Sus scrofa	0	0	2	6	2	2	12 ± 2.82	3
Cercopithecus aethiops	38	53	4	6	0	0	101 ± 6.51	23
Colobus guereza	22	27	0	0	0	0	49 ± 6.51	11
Papio anubis	15	22	22	23	33	53	168 ± 8.10	38
Cercopithecus	0	0	2	2	4	7	15 ± 3.4	3
Total number	85 ±3	113 ±4	64 ±2	71 ±2.5	45 ±2.5	69 ±3	447 ± 49	100

RA = relative abundance.

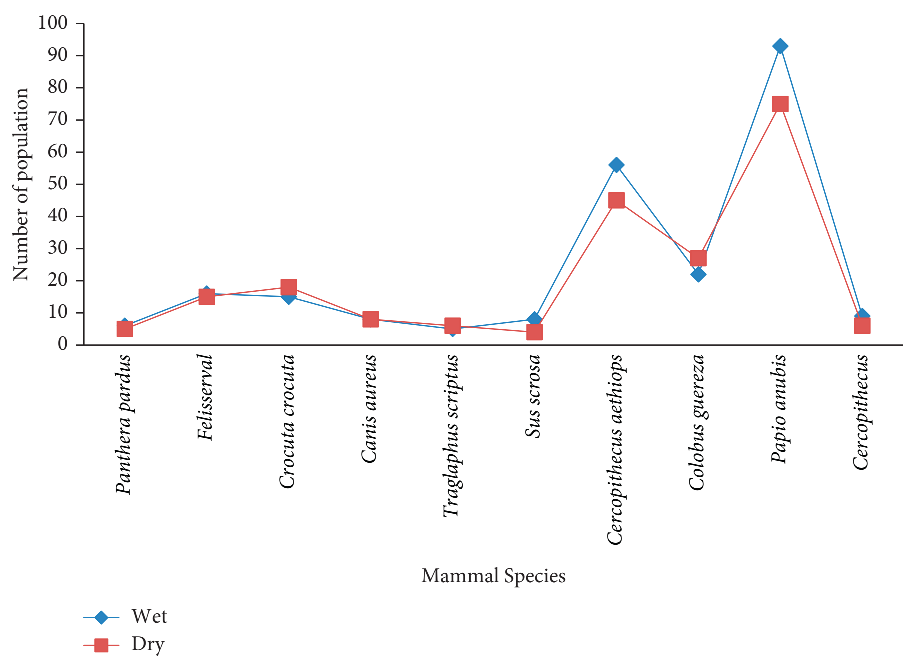

FIGURE 4: Seasonal variation in species composition and abundance of large and medium wild mammals in Tiski Waterfall, Ethiopia.

TABLE 3: The statistical analysis of wild mammals' population in the wet and dry season in Tisiki waterfall.

Seasons	Mean	Std. deviation	Std. error	Min	Max	df	*F*	Sig.
Wet	243.00	6.60	2.69	233.00	253.00			
Dry	204.00	6.81	2.78	194.00	214.00	1	101.4	0.000
Total	223.50	21.35	6.16	194.00	253.00			

followed by *Cercopithecus aethiops* (Figure 5). A total of 447 ± 49.35 individuals were observed, comprising 243 ± 6.6 (54%) during the wet season and 204 ± 6.8 (46%) during the dry season.

3.3. Diversity Indices of Mammals in the Three Habitat Types. The dense forest supports the largest diversity of mammalian species ($H' = 0.98$), followed by shrubland ($H' = 0.90$), while the cliff site was the least diversified ($H = 0.57$) among the three habitat types. Dense forest ($J = 0.51$) also had the highest species evenness, followed by shrubland ($J = 0.43$) and the remaining habitats ($J = 0.35$) (Table 6).

3.4. Species Similarity Index. Between the three habitat categories, dense forest and shrubland (Sl = 0.67) had the most mammalian species similarity (Sl = 0.67), followed by shrubland and cliff sites (SI = 0.61). In dense forests with cliff sites (SI = 0.31), the similarity was the lowest (Table 7).

Table 4: Population mean of each species.

Name of species	Mean	Std. D	Std. error	Mini	Max	df	F	Sig.
Panthera pardus	11.00	2.28	0.93	8.00	14.00			
Felis serval	31.00	3.85	1.57	25.00	37.00			
Crocuta crocuta	33.00	4.24	1.73	27.00	39.00			
Canis aureus	16.00	3.79	1.54	10.00	22.00			
Tragelaphus scriptus	11.00	2.00	0.81	8.00	14.00			
Sus scrofa	12.00	2.83	1.15	8.00	16.00	9	699.7	0.000
Cercopithecus aethiops	101.00	6.51	2.65	92.00	110.00			
Colobus guereza	49.00	6.51	2.65	40.00	58.00			
Papio anubis	168.00	8.10	3.30	158.00	178.00			
Cercopithecus	15.00	3.40	1.39	10.00	20.00			
Total	44.70	49.35	6.37	8.00	178.00			

Table 5: Number of mammalian populations among habitat types.

Habitat type	Population	Std. deviation	Std. error	Min	Max	df	F	Sig.
Dense forest	198.20	7.39	2.34	188.00	208.00			
Shrubland	135.00	5.35	1.69	125.00	145.00	2	524	0.000
Cliff site	114.00	5.16	1.63	104.00	124.00			
Total	147.2	36.86	6.73	104.00	208.00			

Table 6: The mammalian species diversity (H') and evenness (J) in different habitat types in Tiski waterfalls.

Habitat types	No. of species	Populations	Diversity (H')	H_{max}	Evenness (J)
Dense forest	7	198 ± 7.4	0.98	0.946	0.51
Shrubland	8	135 ± 5.3	0.90	2.08	0.43
Cliff site	5	114 ± 5.16	0.57	1.61	0.35

Table 7: Similarity index of wild mammals' species among the three habitat types of Tiski waterfalls.

Habitat types	No. of species per habitat	Species similarity index
Overall similarity	10	1
Dense forest vs. shrubland	7vs8	0.67
Dense forest vs. cliff site	7vs5	0.31
Shrubland vs. cliff site	8vs5	0.61

4. Discussion

Based on land coverage, the areas were divided into three habitat types (dense forest, shrubland, and cliff areas). A total of 11 large- and medium-sized animal species from four orders and six families were found throughout the research. When compared to other investigations, the number of species was rather low. In different parts of Ethiopia, there were mammalian studies with similar objectives and methodologies of this study; however, the mammalians in Tiski Waterfall were low in numbers. For instance, Adaba Community Forest, West Arsi Zone, Southeast Ethiopia, [19]; Wabe forest fragments, Gurage Zone, Ethiopia [5]; Dati Wolel National Park, Western Ethiopia [15]; Loka Abaya National Park, Ethiopia [18]; Qinling Mountains, China [8]; the Karoo [22] had a relatively higher number of mammalians than that in this study. The mammalian diversity appears to be less likely because the list may not include all mammalian species, particularly medium-sized animals, which may be overlooked and for which no different technique is used to study [15]. On the other hand, several anthropogenic influences in the study area could explain why the number of species was so low. In the study areas, illegal tree cutting for fuel, building material harvesting, animal grazing, human encroachment, substantial agricultural expansion, poaching, and charcoal making were all observed [5, 10, 23, 24]. "Hunting affects many threatened mammal species" [25]. One of the main causes of habitat destruction is the change from natural setting to farmland use [6, 26, 27]. Logging licenses that are well-managed can sustain vital populations of large- and medium-sized animals [28]. An impoverished percentage of the original assemblage of medium and large mammals survived in areas controlled by intensive agricultural land use, like maize monoculture [29]. The location is bordered by a human-dominated landscape, which has caused a significant threat to the species' survival [1, 19, 30, 31]. A similar study in Wabe forest fragments, Gurage zone, Ethiopia, recorded the following both medium- and large-sized mammalian: "porcupine (*Hystrix cristata*), honey badger (*Mellivora capensis*), vervet monkey (*Chlorocebus aethiops*), olive baboon (*Papio anubis*), and colobus monkey (*Colobus guereza*)

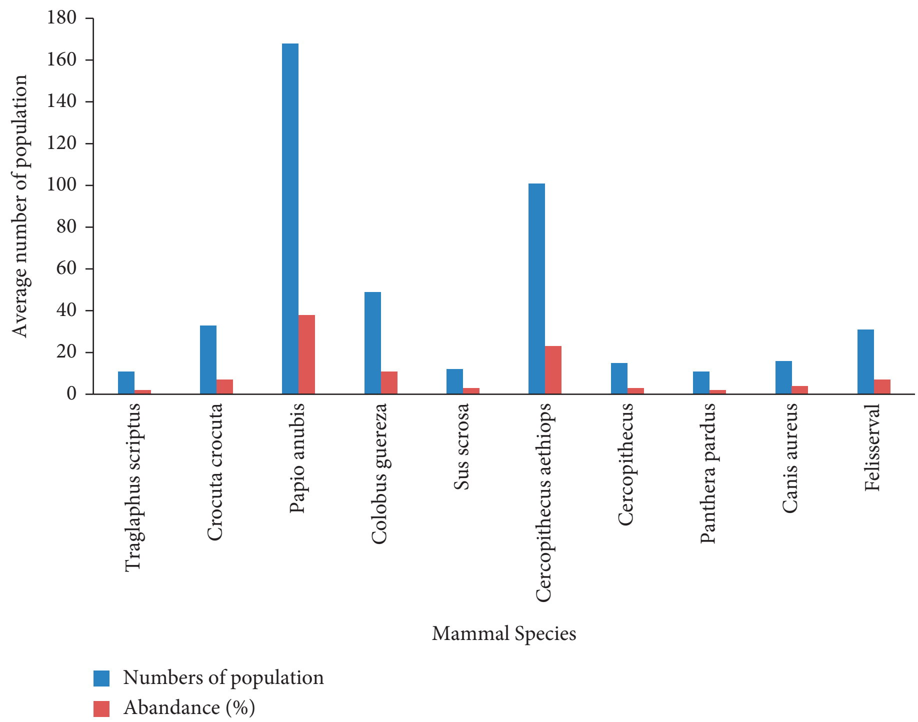

Figure 5: Number of population and relative abundance (%).

were among the medium-sized mammals and spotted hyena (*Crocuta crocuta*), aardvark (*Orycteropus afer*), bohor reedbuck (*Redunca redunca*), oribi (*Ourebia ourebi*), and common duiker (*Sylvicapra grimmia*) were the large mammals of the study area [5]." There was a seasonal change in the species composition of large and medium mammals. The wet season had a higher population density than the dry season. The possibility of a higher number of people being found during the rainy season might be attributed to various variables, such as the availability of food and other supplies following the rain. Seasonal differences in mammals due to the intensity of human interference and the complexity of vegetation structure were observed [18]. Seasonal fluctuation in vegetation structure could have a role in seasonal changes in biodiversity. The pattern of anthropogenic effects, like animal grazing and human settlements, may also have an impact on such variance [3, 32]. Species richness alterations through time and space provide a foundation for forecasting and analyzing community responses to management and natural disruptions [2]. Human and animal encroachment into the area, on the other hand, is higher during the wet season since the neighboring lands are filled with crops due to the limited availability of grazing. According to some researchers, habitat heterogeneity and animal species diversity have a favorable relationship [15]. The varied plant species assemblage accessible in the dense forest followed by shrubland in the study area led to the great diversity of animals recorded in these habitats. Mammalian distribution and habitat relationships are frequently linked to the availability of water, food, and cover [9, 15]. These variables may account for the increased abundance of mammalian species in dense forests observed in this study. The significant similarity of vegetation between dense forest and shrubland may explain the highest record of species similarity between the two habitats in the research area; moreover, livestock and human settlement hurt the dispersal of wild animals. There was a distraction that destroyed wild animal habitats, particularly in the shrubland. Many additional causes of global change, such as the conversion of forests to farming, have the potential to drastically reduce or alter the number of mammal species that live in a given area [23, 33]. The abundance of mammal species in the dense forests may be owing to the low impact of many animals moving from grazing areas to the dense forest's interior reaches in search of food, as this environment is the most inaccessible for human activities and cattle. The Tiski waterfalls should be considered in conservation initiatives at all scales. Mammalian diversity is dependent on both a local and regional pool of mammals to achieve significant biogeographic scales [2].

In the research locations, the olive baboon (*Papio anubis*) can be found in a variety of habitats. The olive baboon's significantly higher abundance in the area could be ascribed to their feeding behavior since the species is evolved to eat various foods and endure a variety of climatic and topographic differences [3, 15]. Similarly, in Loka Abayan National Park, Ethiopia, the olive baboon (*Papio anubis*) was the most abundant [18]. "The order primates had the highest relative abundance compared to other orders" [4]. Among other habitat types, the dense forest habitat type had the most diversity and evenness. "The preferences of large and medium mammals for forest habitat types were consistent throughout the day and night" [8]. Species richness increased as forest cover around forest remnants grew, and habitat types differed in their ability to support mammal species [11, 13]. "Mammal abundance was also affected by landscape, forest cover, and habitat type" [13]. Habitat usage patterns have a significant impact on interactions between wildlife species and ecological communities and the long-term viability of species and population stability [9]. Mammalian species were found to be more similar in dense forest and shrubland than in any of the other habitat groups. To suit their needs for food, shelter, and escape, various mammals chose diverse settings [9].

5. Conclusions and Recommendations

Mammal species were found to be more similar in dense forest and shrubland than in the other habitat groups. Diverse mammals select different habitats to satisfy their foraging, shelter, and escape demands. The maximum species diversity was found in the forest environment type. Because shrub habitat provided insufficient shelter or cover to protect mammals from predation or danger, animals exhibited a lower preference for shrub habitat than the forest. Further research should focus on the dynamics of vegetation biodiversity within the forest and shrubland, as these factors can influence animal food, shelter, and microclimate. Furthermore, because habitat conditions in those habitat categories may change in the future as a result of dynamic changes, habitat functions on animal conservation must be regularly monitored. To limit the impact of agricultural growth on large and medium mammals, appropriate habitat management is required.

Data Availability

The data are available from the first and second authors upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of Interest.

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