

## Research Article

# A Preliminary Survey of Medium- and Large-Sized Mammals and Their Conservation Status in the Asimba Forest Priority Area, Semiarid Highlands of Northern Ethiopia

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Mammal species provide vital environmental and economic functions although they globally face numerous threats. Knowledge of the composition and diversity of mammal species provide information for appropriate management interventions. We conducted this study from July 2019 to February 2020 to assess the species composition, diversity, and conservation of mediumand large-sized mammals in the Asimba Forest Priority Area, northern Ethiopia. Data were collected through direct and indirect evidence from three habitat types, namely, natural forest, bushland, and plantation forest. We analyzed the data using descriptive statistics and the Species Diversity Index. We also used  $\chi^2$  to compare differences in the number of observations and species richness of the mammal species in different habitats between the dry and wet seasons. A total of 263 observations were compiled, and 15 medium- and large-sized mammalian species were recorded in the Asimba Forest Priority Area. The Species Diversity Index and Evenness of the area were H' = 2.436 and J = 0.899, respectively. Hamadryas baboon (*Papio hamadryas*) was the most commonly observed species, with 20.7 and 19.2 relative frequencies in the dry and wet seasons, respectively, whereas striped polecat (*Ictonyx striatus*) was the rarest species, with 3.0 and 0.0 relative frequencies during the dry and wet seasons, respectively. The number of observations ( $\chi^2 = 2.298$ , df = 2, and p = 0.316) and species richness ( $\chi^2 = 0.115$ , df = 2, and p = 0.943) did not differ significantly in the three habitats. Anthropogenic factors, mainly habitat destruction and overgrazing, were widely observed in the Asimba forest as conservation threats to the mammal species. The current study helps to increase knowledge about the mammal species of the area and is essential for their future conservation strategies.

## 1. Introduction

Ethiopia is one of the world's richest biodiversity countries due to the altitudinal variations within the country that produce a range of climates that affect plant and animal distribution [1]. Ethiopia has high mammal species diversity and endemism [2]. It is believed that there are about 311 mammalian species in the country. Of these total mammal species, 55 are endemic [3].

Mammals in general and large-sized mammals (weighing >7 kg) and medium-sized mammals (weighing 2–7 kg) [4] in particular have ecological, economical, and recreational values [5]. The functional significance of mammal species lies in their ecological roles, including seed

dispersal and predation on numerous plant species that change the structure and composition of the world's ecosystems [6, 7]. Medium- and large-sized mammals are key components of forest and savanna communities and are, therefore, considered good indicators of ecosystem health and integrity [4, 8]. Due to their regulatory roles as prey and predators, they influence the community structure and complexity of the trophic levels in which they are involved [9, 10]. Terrestrial mammal communities are fundamental to the functioning of ecosystems, as they play a major role in nutrient cycling [11]. Mammal species also provide important human benefits such as food, recreation, tourism, and income [12, 13]. However, this will become a reality only with the presence of documented information on the diversity, species composition, and relative abundance of mammal species. Even though mammal species provide ecological and economic functions, they face numerous threats globally, such as habitat loss, degradation, and harvesting (hunting and gathering for food, medicine, and materials) [4]. Correspondingly, many mammal species in Ethiopia are threatened due to the ever-increasing human population, habitat loss, and degradation [14, 15]. As a result, many mammal populations around the globe have gone extinct and many others are declining [8].

Knowledge of the species composition and diversity of large- and medium-sized mammals in particular ecosystems is the first step for conservation action, which provides information for the implementation of management plans [6], and is essential in preventing species extinctions [16]. Hence, a number of studies have been carried out in different parts of the world related to the assessment of medium- and large-sized mammals in protected areas such as national parks, sanctuaries, and national priority forests [16-19]. Similarly, several surveys were conducted focusing on the assessment of mammal species in different parts of Ethiopia [15, 20-22]. Although medium- and large-sized mammal fauna represents one of the best-studied groups in the world, for many species, there are still knowledge gaps about distribution, habitat use, and persistence after habitat destruction in the Asimba Forest Priority Area [23].

Asimba Forest Priority Area is one of the oldest protected forests in Tigray National Regional State, northern Ethiopia and established as a national forest priority area in 2012. Six state forest priority areas are found in the region. These include Wujig-Mahgo-Waren, Hugumburda-Gratkahassu, Hirmi, Waldiba, Asimba, and Desea. Thus, the Asimba Forest Priority Area is one of the six state forest priority areas in the Tigray region [24]. It has old biodiversity and a significant natural forest. It is believed that the natural forest also harbors high faunal diversity. However, Asimba forest has never been studied for its medium- and large-sized mammal species. The aim of this study was, therefore, to provide baseline data on diversity, species composition, relative abundance of medium- and large-sized mammals, and anthropogenic impacts that are essential for conservation measures and building a management model of the mammal species.

## 2. Materials and Methods

2.1. Study Site. The Asimba Forest Priority Area is located in Tigray National Regional State, northern Ethiopia, particularly in Irob Woreda (Figure 1). It is located between 14°26′45″ N and 39°36′46″ E. The study area is found in the semiarid eastern highlands of Tigray. The forest is among the 58 national forest priority areas in Ethiopia. The Asimba Forest Priority Area covers an area of about 5,000 hectares. The forest is found in one of the seven Tabias (kebeles) of Irob Woreda, called Arae. The study area accounts for 75% midland, 15% highland, and 10% lowland agroecological zones. Rainfall is marked by a weakly bimodal pattern, with small showers of rain during the months of March–May and a long rainy season in summer during the months of June-August. The mean annual rainfall and mean annual temperature of the area are about 470 mm and 20°C, respectively.

2.2. Preliminary Surveys. A preliminary survey was done in June 2019 in order to have basic information on the forest. We also communicated with the Irob Woreda Natural Resource Conservation Office and the local communities to obtain information about the forest. The vegetation structure and topography of the study area were observed and identified. Accordingly, the study area was stratified into three habitat types. These habitats include natural forests, bushland, and plantation forests. The forest is dominated by plant species such as Juniperus procera, Olea europea, and Dodonea angustifolia. Furthermore, Combretum aculeatum, Carissa edulis, Calpurnia aurea, Acacia abyssinica, Maytenus obscura, and Acacia mellifera are plant species located in the Asimba Priority Forest Area.

2.3. Data Collection. Data collection was conducted for 8 months, from July to October 2019 (the wet season) and from November 2019 to February 2020 (the dry season). We used direct sighting methods, indirect evidence, and interviews to collect the data. A combination of methods in a single study produces information at a faster rate and results in a more complete mammal survey than any single method [25]. The medium- and large-sized mammal species were surveyed using a diurnal line transect by walking at a constant speed following the work of Benchimol [8]. The diurnal line transect is a well-recognized and cost-effective methodology for surveying medium- and large-sized vertebrates [26–30].

The survey of medium- and large-sized mammals was carried out on foot by walking along the transect lines [20] for 8 days per month. The transect length was measured and located in the study area with the help of GPS. The mammalian species were counted by surveying along the transect, following the direct sighting method [31]. The observed mammals were counted, GPS locations were recorded at each transect line, and species were identified based on the Kingdon Field Guide to African Mammals [32], "Atibiwochu" [33], and Mammals of Eritrea and Ethiopia [34]. Observation of medium- and large-sized mammals was done early in the morning during 06:00–08:00 hrs and late in the afternoon during 17:00-19:00 hrs, when most mammals were active. The counting was done using binoculars and the naked eye, depending on the distance of the mammal species from the observers. A total of 40 (17 bushlands, 13 natural forests, and 10 plantations) randomly laid transect lines were established to count the observed mammal species. An average of 6 km was walked each day at a mean speed of 1 km/h. Each transect line was set at a distance of 0.5 km from other transects to avoid double counting. Upon a visual detection event, observers recorded the following: time, species name, and number of individuals.

We also walked along the established transect lines to document the composition and diversity of mammal species through indirect evidence. Indirect surveys, including fresh



FIGURE 1: Location map of the Asimba Forest Priority Area.

tracks, fecal drops, vocalization, and scratches, were used as they are very useful for recording when animals are naturally rare, nocturnal, cryptic, elusive, found at low densities, and difficult to capture repeatedly [35].

Threats to mammalian species that affect their distribution and abundance in the study area were observed and recorded during the transect walk. Questionnaire surveys were also conducted with communities living adjacent to the forest for many years and local administrative offices to obtain information about the presence of medium- and large-sized mammals in the study area. A semistructured questionnaire was used to generate information on mammal presence, human-mammal interaction, and associated impacts [15, 35]. A total of 70 (47 male and 23 female) respondents living adjacent to the forest were interviewed. Interviews were mainly focused on the types of mammal species existing in the forest, human-wildlife conflicts in the area, and the conservation status of the forest ecosystem.

2.4. Data Analysis. We analyzed the data using descriptive statistics and the Species Diversity Index. The mammalian species diversity of the study area was analyzed using the Shannon Diversity Index as follows:  $H' = -\sum PilnPi$ , where H' = the Shannon Diversity Index,  $P_{i=a}$  fraction of the entire population made up of species *i*, and ln = natural logarithm [36]. The species richness (S) of the mammalian

species was calculated using the equation  $S = \sum n$ , where *n* is the number of species in a community. Species evenness, which measures the pattern of distribution of the mammalian species present in the area, was evaluated using the Shannon-Wiener Evenness Index as follows:  $J = H'/H_{max}$ , where J = Shannon–Wiener Evenness Index; H' = Shannon-Wiener Diversity Index;  $H_{max} = \ln$ ; and S = natural logarithm of the total number of species (S). The Simpson Diversity Index of mammals in the current study area was calculated as follows:  $D = 1 - \sum (pi)$ , where D = Simpson Diversity Index and  $P_i =$  fraction of the entire population made up of species *i*. The relative frequency (RF) was calculated by dividing the number of records for each species by the total number of records for all species. Chisquare  $(\chi^2)$  was also used to compare differences in the number of observations and species richness of the mediumand large-sized mammalian species in the three habitats.

#### 3. Results

A total of 263 observations were conducted and 15 mammal species were identified in the Asimba Priority Forest Area. Of these total recorded mammal species in the Asimba Priority Forest Area, 66.7% (n = 10) were observed from direct observations, while 33.3% (n = 5) were recorded from indirect evidence. The identified medium- and large-sized mammals were distributed in six orders and 11 families.

Among the identified orders, nine species were from the order Carnivora, two species were from order Primate, and the other four orders were represented by one species each (Table 1). Of the total mammal species recorded in the current study area, 73.3% (n = 11) of them were mediumsized mammals, while 26.7% (n = 4) of them were large-sized mammals. The mammal species observed in the current study area were distributed in the natural forest, bushland, and plantation forest (Table 1). At the current study site, we recorded one species leopard (Panthera pardus) vulnerable to extinction. Even though the remaining mammal species (14) observed in the Asimba Priority Forest were listed as Least Concern in the IUCN Red List of Threatened Species, we observed that they were under threat as a result of anthropogenic factors such as habitat loss, killing, and humanwildlife conflicts.

Out of the total observations recorded in the current study area, 62.4% (n = 164) were recorded during the dry season, while 37.6% (n = 99) were recorded during the wet season. *Papio hamadryas* had the highest frequency of 20.2% (n = 53), and *Ictonyx striatus* had the lowest frequency of 1.9% (n = 5) (Table 2).

The highest mammal species diversity (H' = 2.07) was recorded in bushland during the dry season, while the highest mammal species diversity (H' = 2.14) was recorded in natural forests during the wet season (Table 3). The results of the current study indicated that of the total observations; 39.2% (n = 103), 35% (n = 92), and 25.9% (n = 68) were recorded in bushland, natural forest, and plantation forest, respectively. The highest species richness, (S = 10) and (S = 9), was found in bushland and natural forests during the dry and wet seasons, respectively (Table 3). The number of observations ( $\chi^2 = 2.298$ , df = 2, and p = 0.316) and species richness ( $\chi^2 = 0.115$ , df = 2, and p = 0.943) did not differ significantly in the three habitats.

The respondents interviewed for the purpose of this study revealed that agricultural expansion towards the forest, cutting of trees for firewood and home construction, drought, and human-wildlife conflict (as a result of crop raiding and livestock depredation) were the main threats to mammals in the current study area. According to the majority of the respondents, i.e., 62.9% (n = 44), habitat destruction is the main threat to medium- and large-sized mammals in Asimba forest. Of the total interviewees, 7.1% (n = 5) mentioned that drought is challenging for mammals found in the forest (Figure 2). Our field observations also confirmed that human activities have greatly affected and disturbed the species composition and diversity of the mammals found in the Asimba forest. The local people living in the vicinity of the Asimba forest were destroying trees for firewood and construction. Although Asimba forest is a protected area, it is subjected to grazing, resulting in biodiversity loss.

#### 4. Discussion

In the current survey, a total of 15 medium- and large-sized mammal species were recorded in the Asimba Protected Forest in northern Ethiopia. This indicates that the study area could have a crucial role to play in the conservation of mammals, including vulnerable species. The number of mammal species detected (i.e., 15) in the Asimba forest can be considered low when compared to the number of species recorded in the Municipality of Jaú, São Paulo, Brazil [37], Borena Sayint National Park, Ethiopia [20], Juchitan, Isthmus of Tehuantepec, Mexico [18], and Arawale National Reserve, Kenya [19]. Fifteen medium- and large-sized mammal species were recorded in Lebu Natural Protected Forest, Ethiopia [22], and Wacha Protected Forest, Ethiopia [15], similar to the number of mammal species observed in Asimba forest. However, the number of mammals recorded in the Asimba forest was higher when compared with the number of species recorded in Mengaza communal forest, Ethiopia [38] (Table 4).

The variation in the number of medium- and large-sized mammal species in the Asimba Priority Forest Area from mammal species recorded in another area might be due to environmental factors. The distribution of species and biodiversity is determined by a large number of abiotic and biotic factors [40]. Qufa and Bekele [22] pointed out that the variation might also be due to the difference in sample sites, sampling effort spent, season considered, and variation in vegetation physiognomy. The reason for recording lower number of mammal species in the current study area may also be due to the impact of anthropogenic factors observed in and around the forest. The presence of human activities around the habitat of mammals influences the dispersal of the species [18, 37]. The low number of small- and medium-sized mammals in the Asimba Priority Forest might also be related to climatic conditions. Climate change poses a long-term threat to mammal species. Mammal species severely affected by drought in different parts of the Tigray region.

The highest mammal species diversity was recorded in bushland during the dry season, while the highest mammal species diversity was recorded in natural forests during the wet season. A survey of medium- and large-sized mammals in Lebu Natural Protected Forest, Ethiopia [22], and Wacha Protected Forest, Ethiopia [15], found the highest Shannon mammal species diversity in bushland, which is consistent with the current finding. The highest species richness in the Asimba forest was recorded in bushland and natural forest in the dry and wet seasons, respectively. This might be associated with a good source of quality food in these habitats. The distribution of mammals in a given habitat may be associated with vegetation cover and food availability in the area.

Anthropogenic activities that negatively affect the species composition and diversity of medium- and large-sized mammals in the current study area were revealed at the study site. We confirmed the anthropogenic factors both through direct observations and interviews. These human activities in the present study absolutely had an impact on the habitat and resources of the wild mammals. Conservation challenges for the mammals in the Asimba forest were critical. This results in the loss of the territory and living range of medium- and large-sized mammals. According to [41], the population of large mammals is continuously

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Order	Family	Common name	Scientific name	Habitat type	Method of detection
Artiodactyla	Bovidea	Klipspringer	Oreotragus oreotragus	NF, BL	VI
	Canidae	Common jackal	Canis aureus	NF, BL	VI
		Caracal caracal	Caracal caracal	NF, BL	VI
	Felidae	Leopard	Panthera pardus	NF	VO, I
		Serval cat	Leptailurus serval	NF, PL	VI
Carnivora Herpes Hyaen Mustel Viverr	Herpestidae	Slender mongoose	Galerella sanguinea	BL	VI
	Hyaenidae	Spotted hyena	Crocuta crocuta	NF, PL	VO, FP
	Mustalidaa	Striped polecat	Ictonyx striatus	BL, PL	FP
	Mustelldae	Honey badger	Mellivora capensis	BL, PL	VI
	Viverridae	African civet	Civettictis civetta	NF	FP
Hyracoidea	Procaviidae	Rock hyrax	Procavia capensis	NF, BL	VI
Lagomorpha	Leporidae	Cape hare	Lepus capensis	PL	VI, F
Primates (		Hamadryas baboon	Papio hamadryas	NF, BL	VI, FP
	Cercopithecidae	Vervet monkey	Chlorocebus aethiops	BL, PL	VI, FP
Rodentia	Hysticide	Crested porcupine	Hystrix cristata	BL, PL	Quill, FP

TABLE 1: List of mammal species, habitat types, and methods of detection in the Asimba forest.

*Note.* Forms of record: I = interviews; VI = visualization; VO = vocalizations; FP = fecal-pellet count; F = footprint count; NF = natural forest; BL = bushland; PL = plantation forest.

TABLE 2: Mammal species recorded and their relative frequency observed during the survey period in Asimba forest.

Species name	NR	RF (%)	NRD	RFD (%)	NRW	RFW (%)
Oreotragus oreotragus	15	5.7	6	3.7	9	9.1
Canis aureus	19	7.2	14	8.5	5	5.1
Caracal caracal	9	3.4	7	4.3	2	2
Panthera pardus	13	4.9	8	4.9	5	5.1
Leptailurus serval	16	6.1	9	5.5	7	7.1
Galerella sanguinea	6	2.3	6	3.7	_	_
Crocuta crocuta	21	8	14	8.5	7	7.1
Ictonyx striatus	5	1.9	5	3	_	_
Mellivora capensis	6	2.3	5	3	1	1
Civettictis civetta	9	3.4	3	1.8	6	6.1
Procavia capensis	14	5.3	11	6.8	3	3
Lepus capensis	14	5.3	12	7.3	2	2
Papio hamadryas	53	20.2	34	20.7	19	19.2
Chlorocebus aethiops	51	19.4	21	12.8	30	30.2
Hystrix cristata	12	4.6	9	5.5	3	3
Total	263		164		99	

*Note.* NR = number of records; RF = relative frequency; NRD = number of records in the dry season; RFD = relative frequency in the dry season; NRW = number of records in the wet season; and RFW = relative frequency in the wet season.

TABLE 3: Species diversity indices in dry and wet seasons during the survey period in the natural forest (NF), bushland (BL), and plantation forest (PL).

Maniah la a		Dry			Wet		Orverall
variables	NF	BL	PL	NF	BL	PL	Overall
Number of records	52	69	43	40	34	25	263
Number of species (S)	9	10	7	9	8	6	15
Η'	1.99	2.07	1.66	2.14	1.91	1.48	2.436
J	0.9	0.9	0.85	0.97	0.92	0.82	0.899
Simpson's diversity index	0.85	0.94	0.81	0.88	0.86	0.71	0.889

declining in number due to the shrinkage of their natural habitats. The presence of human activities threatens the existence of terrestrial mammals in any protected area [42]. Human activities such as deforestation for agricultural expansion, charcoal production, fuel wood collection, and grazing by livestock resulted in the alteration of the natural forest [22], which is the habitat of mammal species. Reference [4] also noted that high anthropogenic pressure and human population growth are major drivers of biodiversity loss. Other studies also confirmed that human disturbances have serious negative consequences for populations of mammal species [18, 39].



FIGURE 2: Responses of the respondents towards the threats of the medium- and large-sized mammals in the Asimba Forest Priority Area.

TABLE 4: Comparison of the number of medium- and large-sized mammal species recorded in the Asimba Priority Forest with mammals in other different study sites.

Study sites	Methods used	No. of spp.	References
Asimba Protected Forest (Ethiopia)	Line transect, indirect survey, and questioners	15	This study
Mengaza Communal Forest (Ethiopia)	Line transect and indirect survey	12	[38]
Ingwezi Game Management Project (Zimbabwe)	Camera trap	27	[39]
Lebu Natural Protected Forest (Ethiopia)	Line transect, indirect survey, and questioners	15	[22]
Natural heritage in Sao Paulo (Brazil)	Transects and camera traps	26	[37]
Borena-Sayint National Park (Ethiopia)	Line transect and indirect survey	23	[20]
Varzea and Terra Firme forests (Brazil)	Camera trap	21	[17]
Juchitan, Isthmus of Tehuantepec, Oaxaca (Mexico)	Indirect surveys only	18	[18]
Wacha Protected Forest (Ethiopia)	Line transect and indirect survey	15	[15]
Arawale National Reserve (Kenya)	Line transect only	23	[19]

## 5. Conclusion

The current study identified medium- and large-sized mammal species existing in the Asimba Protected Forest, which provides baseline information for future conservation and management plans for the species. This study is the first ecological research ever carried out in the Asimba Protected Forest. A total of 15 medium- and large-sized mammal species were recorded in the forest. Human activities that affect the survival of the mammal species in the Asimba forest were also noted. Even though the numbers of medium- and large-sized mammal species recorded in the Asimba Priority Forest Area are considered low when compared with mammals recorded in other sites, this study, in conclusion, suggests that it will contribute to the management and conservation of mammal species in particular and protected areas in general. In relation to this, it can also be concluded that Asimba forest is one of the wildlife zones in northern Ethiopia. According to the findings of this study, we suggest that urgent management and conservation practices for mammal species in particular and the natural ecosystem, in general, should be initiated through the active and positive participation of the local people in and around the Asimba Priority Forest Area.

## **Data Availability**

The data used to support the findings of this study are included within the article.

## Disclosure

The funder had no role in the study design, data analysis, data interpretation, or writing up the manuscript.

## **Conflicts of Interest**

The authors declare that they have no conflicts of interest.

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