Terrestrial Medium and Large-Sized Mammalian Species Diversity in Michole Community Protected Forest, Southern Ethiopia

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Abstract

Study on medium and large size mammalian species diversity and distribution is important for conservation efforts in the different protected areas of Ethiopia. The study aimed to assess the species diversity of medium and large-sized mammalian fauna between October 2019 and July 2020 in Michole Community Protected Forest, southern Ethiopia. The study was conducted by stratification of the study area into three habitat types riverine forest (3.37 km²), woodland (4.14 km²), and grassland with scattered trees (2.33 km²) based on the vegetation cover. A diurnal transect survey method was implemented to record the mammalian species diversity. A total of 18 representative sample transect lines (six in riverine forest, four in grassland with scattered trees, and eight in the woodland habitats) which varied in length and width were used. A total of 17 species of medium and large-sized mammalian species were identified and recorded in the study area. Accordingly, order Carnivora and Primates constitutes a large proportion of abundance, while order Lagomorpha was the least. Anubis baboon (*Papio anubis*) was the most abundant species (15.14%) followed by Spotted hyena (12.98%), Porcupine (12.51%), Vervet monkey (10.35%), Common duiker (8.80%), and Giant root-rat (8.65%). The distributions of mammals among the three habitat types were comparable. Riverine forest harbored the highest mammalian diversity index ($H'=2.35$) followed by the woodland ($H'=2.32$), and the grassland with scattered trees ($H'=2.30$), respectively. The greatest species similarity was recorded in woodland (0.902). The study area harbors considerable mammalian species that are threatened by interacting anthropogenic factors. So, urgent conservation measures by concerned sectors are needed to safeguard these animals and their habitat.

Introduction

Africa is rich in mammalian fauna (Girma et al., 2012). According to Blake et al. (2008), 15% of the mammalian species distribution and abundance is in the African forests. Topographic diversity and climate are the most significant predictors of mammalian species diversity in Africa (Tefera, 2011) in which heterogeneous habitats support different species of mammals (Vaughan et al., 2000). In the Horn of Africa, Ethiopia, the profound geological history, broad latitudinal spread, and diverse altitudinal ranges provide high mammalian diversity (Tefera, 2011). Currently, 320 of the mammalian species have been recorded and 55 of them are considered to be endemic to the country (Lavrenchenko and Bekele, 2017). The large extent of highlands, the variations in temperature, and rainfall contributed to the countries highest mammalian species level of endemicity (Yalden and Largen, 1992).

Mammalian diversity is considered a species-based indicator of terrestrial ecosystem health, which has been a key feature in forest management (Jorgensen et al., 2005). Unfortunately, African mammalian communities currently face extreme threats and declining rapidly due to several factors, such as increased hunting rates, habitat loss, habitat degradation, and habitat fragmentation, increased human settlement, and urbanization (Kingdon et al., 2003). Due to subsistence livelihood, many of the people of Africa are exerting pressure on the wildlife, especially the mammalian species (Njoroge et al., 2009). At

the moment, many of the protected areas and/or forests of Ethiopia facing many challenges, mainly due to the growing human populations, border conflicts, and recurring drought.

Michole Forest is one of the few forests found in the Wolaita zone, southern Ethiopia where there was no study carried out on the wildlife species. The local inhabitants of the present study area stated as there has been human encroachment and dependence of the residents to the forest area for their subsistence life for the past several years for the pastureland, collection of firewood, charcoal production, and settlement where such activities are disturbing the mammalian species. This study is, therefore, carried out to assess the terrestrial mammalian diversity and major threats facing their conservation in Michole Community Protected Forest, southern Ethiopia.

Materials And Methods

The study area

Offa district is one of the 12 districts in Wolaita Zone, southern Ethiopia. It is located 406 km south of Addis Ababa and 183 km far away from Hawssa town and located 29 km away from Wolaita Sodo town, in the southern direction along Goffa-Sawla road. Offa is bordered in the northwest by Kindo Koysha, in the northeast by Sodo Zuriya, in the south by Gamo and Gofa zones, in the west by Kindo Didaye, and in the east Humbo districts. The administrative town of Offa district is Gesuba. Currently, the area of the district covers 374.74 km². Among it, 18,313 hectare of land is under cultivation, 7,216 hectare serves for grazing and 2,278 hectares is covered by forests and bushes. Currently, the district is divided into 22 rural and two urban kebeles (the smallest administrative unit).

The study area, Michole Community Forest is located between 6°39'0"–6°45'0"N Latitude and 37°27'30"–37° 33'30" E Longitudes with altitudinal ranges from 1200 to 2028 m a.s.l. It is found in Wolaita Zone at 432km from Addis Ababa, the capital city of the country, and 47km southwest of Wolaita Sodo town, zone administration seat (Fig. 1). The total area of the forest is 983.7 hectares. The rainfall pattern is bimodal type.

The district consists of three agro-climatic zones and elevation ranges between 1,100 and 2,800 m asl. The mean annual rainfall is ranging between 800 mm and 1400 mm. The mean annual temperature ranges between 14°C and 34°C. Approximately, 2,278 hectares of the total land area are covered by forest. There are five major rivers and four streams that flow west to east direction and all of them are Omo tributaries. Insufficient and irregular rain causes uncertainty in agricultural activity. The period of the rain season is from the month of June to August, and the remaining months are dry. The range of habitats in Michole Community Forest is diverse in altitude and vegetation cover. These are woodland (414.1 hectares) which is the largest part of the forest area and dominated by *Acacia abyssinica* and *Cordia africana* trees, grassland with scattered trees (232.7 hectares), which is dominated by the grass *Chrysopogan auycheri*, and the main sources of food for grazing animals, and the riverine forest (336.9 hectares) covered by the large trees that grow all the years and dominated by *Podocarpus flacatus* and

Juniperus procera. Once the wild animal species have existed in the area; however, currently some of them including the known big mammals in the world like elephants and buffalos had gone out of the district, due to the traditional killing and hunting of the wild animals. Such types of cultural practices were common in the Offa district.

According to the 2007 Central Statistics Agency (CSA) Report, the total population of the district is 120,548. Out of these numbers, 66,747 are males and 53,801 are females. Of the total 9,299 urban dwellers, 4971 are males and 4328 are females. On the basis of this data, males' outnumbered females in urban and rural areas. The combined numbers of males exceeded the population of the district. The population density of the district is 359 km².

A preliminary survey was carried out during October 2019 in the study area. During this period, essential information such as accessibility, climatic conditions, vegetation type, fauna, topography, infrastructure, and anthropogenic activities in the area was gathered. Detailed studies were carried out from November 2019- August 2020. Quantitative data were obtained on the diversity; distribution and relative abundance of the medium and large mammalian species during both dry (December-February) and wet (May-July) seasons.

The study area was stratified into three main study blocks using aerial photography (scale 1:30,000), satellite imagery, and area topography maps (scale 1:50,000 and 1:250,000) (Kingdon, 2003). The boundaries of each study unit were traced and followed based on the main vegetation types of the study area. These include grassland, woodland, and riverine forest. A modification of the unequally sized sample unit ratio method of Norton-Griffiths (1978) was adopted for sampling.

Out of the total blocks of the study area, a number of representative sample blocks were randomly selected. The sampling blocks selected from each habitat type represent 20–25% of each of the surveyed areas. Randomly selected transects were then established in each block. Data on the diversity, distribution and abundance of medium and large-sized mammals in Michole Community Forest was collected through a randomly selected line transect survey. A total of 18 representative samples of transect lines (six in riverine forest, four in grassland, and eight in the woodland habitats) which varied in length and width were used.

In the woodland, transect length of 1.5 km and width of 100 m, in riverine forest transect length of 3 km and width of 50 m and in grassland with scattered trees transect length of 2 km and width of 200 m was used, and the distance between each transect was 1 to 2 km to avoid double counting. Variation in length and width of transect line was determined by the type of vegetation cover and topography of the area (Table 1).

Table 1
Length and width for randomly selected transects

Habitats	Number of potential transects	Number of sample transects	Length and width of transect (km)
Riverine forest	26	6	3km x 0.5km
Grassland	14	4	2km x 0.2km
Woodland	32	8	1.5km x 0.1km
Total	72	18	

Methods

Direct and indirect observations of medium and large mammals were conducted along randomly selected transect lines (trails, footpaths, and other access routes). The data was collected with the help of 18 well-experienced local people during the wet and dry seasons at a constant speed to maximize the probability of seeing all individuals on the transect (Norton-Griffiths, 1978). Transect counts were carried out twice a day for three days in each month (survey period) during both dry and wet seasons from 06:00 to 10:00h in the morning and 16:00 to 18:00h in the late afternoon, when the animals were active and when visibility was good. The study area was surveyed about 36 times during both dry and wet seasons. During counting careful descriptions of the observed group/individuals were made based on natural markings of individuals for future identification and avoiding double-counting. The individuals observed per transect were pooled together and extrapolated to estimate the population for the whole study area.

The numbers of individuals of each species observed time and habitat type were recorded during the survey (Appendix I). Observations were made with the naked eye or aided by binocular (7 x 50 mm), while evidence of tracks, scats, dung, dens, burrows, carcasses, feeding remains, scratches, feeds, and beds, calls were considered as indirect observation (Wilson et al., 1996; Sutherland, 1996).

Indirect pieces of evidence are very useful when surveying animals that are naturally rare, elusive, and found at low densities. Mammalian species identification was made by using standardized field guides (Kingdon, 1997). During this study, estimating body weight as a basic feature to categorized mammals into medium-sized (those between 2 and 7 kg) and large-sized (those over 7 kg body mass) mammals.

Data analysis

Diversity measures take into account both the number of species and how evenly distributed individuals in those species are across the whole community (Vaughan et al., 2000). Thus, such measures as the number of species, the relative abundance of individuals, and diversity (a combination of richness and evenness) were taken into account during data analyses.

Data were analyzed using SPSS version 20 computer software programs and Microsoft Excel-2010. Appropriate statistical methods such as the Chi-square test and descriptive analysis were used to

compute differences in the abundance of mammal species among habitats and the seasonal variations in species compositions in the study area. The species diversity and evenness of mammals of each area and season were determined by using Shannon–Wiener entropy index (H') and Simpson's diversity index. Shannon-Wiener diversity index (H), Simpson diversity index ($1-D$), and evenness (J): Shannon–Wiener diversity index assumes that all species are represented in a sample species and calculated by its formula:

$$H = - \sum P_i \ln P_i$$

Where,

H = Shannon-Wiener diversity index

P_i = Fractional of individuals belonging to i^{th} species

$\ln$ = Natural logarithm

Simpson's diversity index was issued to assess the diversity of any population in which each number belongs to unique species and calculated by the formula:

$$D = 1 - \left(\sum \frac{n(n-1)}{N(N-1)} \right)$$

$$N(N-1)$$

Where D = Simpson's diversity index, n = Number of individual species, N = Total number of organisms, $\sum$ = Summation, Evenness is a measure of relative abundance of different species making up the richness of an area by the formula: $E = H/H_{\text{max}}$, $H_{\text{max}} = \ln S$, S = Number of species. The relative abundance of each species (observed medium and large mammals) in the three habitat types were computed using the formula; Abundance = total number of individual of a species/total number of individual species in the sampled habitat $\times 100$.

The observed mammalian species were categorized as common if they were realized during the whole study period, uncommon if they were seen in more than half of the surveys, and rare if seen in less than half of the surveys. Simpson similarity index (SI) was also computed to assess the similarity between the three habitats with reference to the composition of species.

$$SI = \frac{3C}{I + II + III}$$

Where: SI = Simpson's similarity index; C = the number of common species to all tree habitats; I = the number of species in habitat one (riverine forest), II = the number of species in habitat two (woodland), and III = the number of species in habitat three (grassland).

Results

Diversity of medium and large-sized mammals

During this study, 647 observational records of medium and large-sized mammals, belonging to 17 species, and grouped into 11 families and five orders; such as Primates, Artiodactyla, Rodentia, Carnivora, and Lagomorpha were documented. The species include Anubis baboon (*Papio anubis*), Vervet monkey (*Cercopithecus aethiopus*), Colobus monkey (*Colobus guereza*), Common duiker (*Sylvicapra grimmia*), Bushbuck (*Tragelaphus sylvaticus*), Bushpig (*Potamochoerus larvatus*), Giant root-rat (*Tachyoryctes macrocephalus*), Porcupine (*Hystrix cristata*), Common jackal (*Canis aureus*), Spotted hyena (*Crocuta crocuta*), African civet (*Civettictis civetta*), Common genet (*Genetta abyssinica*), White-tailed mongoose (*Ichneumia albicauda*), African wild cat (*Felis lybica*), Serval cat (*Felis serval*), Lion (*Panthera leo*), Abyssinian hare (*Lepus habessinicus*) (Table 3).

Most of Porcupine (*Hystrix cristata*), colobus monkey (*Colobus guereza*), Anubis baboon (*Papio anubis*), Abyssinian hare (*Lepus habessinicus*), Vervet monkey (*Cercopithecus aethiopus*), Common genet (*Genetta abyssinica*), African wild cat (*Felis lybica*), common jackal (*Canis aureus*), Giant root-rat (*Tachyoryctes macrocephalus*), White-tailed mongoose (*Ichneumia albicauda*) and African civet (*Civettictis civetta*) were medium-sized mammals and spotted hyena (*Crocuta crocuta*), Serval cat (*Felis serval*), Bush pig (*Potamochoerus larvatus*), Bushbuck (*Tragelaphus scriptus*), Lion (*Panthera Leo*), and common duiker (*Sylvicapra grimmia*) were the large mammals of the study area.

Based on the species composition in the three habitat types Anubis baboon (*Papio anubis*), Porcupine (*Hystrix cristata*), and Spotted hyena (*Crocuta crocuta*) were the most common mammals which were recorded in all the habitat types, while Lion (*Panthera leo*) were recorded only in one of the habitat types (Grassland habitat). At the family level, Cercopithecidae, Felidae, Bovidae, and Viverridae were the dominant families: while Suidae, Spalacidae, Hystricidae, Canidae, Hyaenidae, Herpestidae, and Leporidae were the less represented families in the study area.

Among the five orders identified; order Rodentia and order Artiodactyla were represented each by two families, while the other orders Primates and Lagomorpha by one species, and the order Carnivora represented by five families. Based on the species, the order Carnivora was represented by the highest number of species ($N=8$) followed by the Primates and Artiodactyla ($N=3$) each. The rest orders Rodentia and Lagomorpha were represented by two and one species, respectively (Table 3).

The researcher classified the recorded mammals as directly observed and indirect pieces of evidence and among them nine of the recorded mammal species such as *Papio anubis*, *Cercopithecus aethiopus*, *Colobus guereza*, *Canis aureus*, *Crocuta crocuta*, *Sylvicapra grimmia*, *Ichneumia albicauda*, *Lepus habessinicus*, *Tragelaphus sylvaticus* were directly observed inside the forest. Three indirectly recorded mammal species such as *Potamochoerus larvatus*, *Tachyoryctes macrocephalus*, *Genetta abyssinica* were identified through patterns of tracks they left behind. Besides these, *Hystrix cristata* and *Civettictis civetta* were identified by the evidence of scats. While Serval cat (*Felis serval*) and African wild cat (*Felis*

lybica) were recorded by the identification of dungs. However, species *Panthera leo* was assured of its presence by the local villager's informed witness.

Table 3
Diversity of medium and large size mammalian species in Michole Community Forest

Order	Family	Species	Common name	Season		Total
				Dry	Wet	
Primates	Cercopithecidae	<i>Papio anubis</i>	Anubis baboon	45	53	98
		<i>Cercopithecus aethiopus</i>	Vervet monkey	31	36	67
		<i>Colobus guereza</i>	Colobus monkey	8	13	21
Artiodactyla	Bovidae	<i>Sylvicapra girmma</i>	Common duiker	26	31	57
		<i>Tragelaphus sylvaticus</i>	Bush buck	5	11	16
	Suidae	<i>Potamochoerus larvatus</i>	Bush pig	11	17	28
Rodentia	Spaclacidae	<i>Tachyoryctes macrocephalus</i>	Giant root-rat	30	26	56
	Hystriidae	<i>Hystrix Cristatea</i>	Porcupine	37	44	81
Carnivora	Canidae	<i>Canis aureus</i>	Common jackal	17	22	39
	Hyaenidae	<i>Corcuta corcuta</i>	Spotted hyena	51	33	84
	Viverridae	<i>Civettictis civetta</i>	African civet	7	10	17
		<i>Genetta abyssinica</i>	Common genet	8	4	12
	Herpestidae	<i>Ichneumia albicauda</i>	White tailed mongoose	16	10	26
	Felidae	<i>Felis lybica</i>	African wild cat	4	6	10
		<i>Felis serval</i>	Serval Cat	4	3	7
		<i>Panthera leo</i>	Lion	2	4	6
Lagomorpha	Leporidae	<i>Lepus habessinicus</i>	Abyssinian hare	8	14	22

The number of individual observations recorded, and the relative frequency of each mammalian species were presented in Table 4 below. During the dry season, the Spotted hyena (*Crocuta crocuta*) has the highest relative frequency of 16.45% ($N= 51$), and the least relative frequency of 0.65% ($N= 2$) was for the Lion (*Panthera leo*). During the wet season, the Anubis baboon (*Papio anubis*) was with the highest frequency of 15.73% ($N= 53$), and the Serval cat (*Felis serval*) with the lowest frequency of 0.89% ($N= 3$).

Table 4
Relative abundance of medium and large-sized mammalian species in Michole Forest

Common Name	Dry Season		Wet Season	
	Number of Mammals	Relative abundance	Number of mammals	Relative abundance
Anubis baboon	45	14.51	53	15.73
Vervet monkey	31	10.00	36	10.68
Colobus monkey	8	2.58	13	3.86
Common duiker	26	8.39	31	9.20
Bushbuck	5	1.61	11	3.26
Bushpig	11	3.55	17	5.04
Giant root-rat	30	9.68	26	7.72
Porcupine	37	11.94	44	13.05
Common jackal	17	5.48	22	6.53
Spotted hyena	51	16.45	33	9.79
African civet	7	2.26	10	2.97
Common genet	8	2.58	4	1.19
White-tailed mongoose	16	5.16	10	2.97
African wild cat	4	1.29	6	1.78
Serval Cat	4	1.29	3	0.89
Lion	2	0.65	4	1.19
Abyssinian hare	8	2.58	14	4.15
Total	310	100	337	100

On the other hand, the study also revealed that the relative abundance of the different species varied between 0-18.84% in the dry season and 0-21.54% in the wet season in the riverine forest habitat, while in the woodland habitat the relative abundance was between 0-15.89% in the dry season, and between 0 and 17.92% during the wet season. The relative abundance of the species in the grassland habitat was varied from 0 to 26.32% during the dry season and from 0 to 17.1% during the wet season (Table 5 and Table 6).

Table 5
Relative abundance of species in the three habitat types during the dry and wet seasons

Common name	Relative abundance of species in the three habitat types					
	Riverine Forest		Woodland		Grassland	
	Dry	Wet	Dry	Wet	Dry	Wet
Anubis baboon	16.67	21.54	12.15	17.92	13.85	5.94
Vervet monkey	13.77	15.38	11.21	15.09	0.00	0.00
Colobus monkey	2.17	10.00	4.67	0.00	0.00	0.00
Common duiker	6.52	2.31	9.35	15.09	10.77	11.88
Bushbuck	3.62	0.00	0.00	4.72	0.00	5.94
Bushpig	7.25	7.69	0.00	0.94	1.54	5.94
Giant root-rat	2.90	1.54	9.35	9.43	24.62	13.86
Porcupine	12.32	18.46	13.08	0.00	9.23	19.80
Common jackal	5.80	7.69	8.41	11.32	0.00	0.00
Spotted hyena	18.84	10.77	15.89	5.66	12.31	12.87
African civet	0.00	0.00	1.87	9.43	7.69	0.00
Common genet	3.62	0.00	2.80	0.00	0.00	3.96
White-tailed mongoose	0.00	0.00	9.35	0.00	9.23	9.90
African wild cat	2.90	0.77	0.00	1.89	0.00	2.97
Serval Cat	1.45	0.00	1.87	0.00	0.00	2.97
Lion	0.00	0.00	0.00	0.00	3.08	3.96
Abyssinian hare	2.17	3.85	0.00	8.49	7.69	0.00

In this study, the highest species richness was recorded in the riverine forest habitat ($N=25$), and the least was recorded in the grassland habitat ($N=22$). The species richness in various habitats was 25, 23, and 22 for the riverine forest, woodland, and grassland, respectively. The total number of observations for mammalian species in the riverine forest was 268, woodland ($N=213$), and grassland ($N=166$).

Table 6
Individual observations counted and seasonal variation of medium and large-sized mammalian species among the three habitats

Common name	Species abundance in three habitat types					
	Riverine Forest		Woodland		Grassland	
	Dry	Wet	Dry	Wet	Dry	Wet
Anubis baboon	23	28	13	19	9	6
Vervet monkey	19	20	12	16	0	0
Colobus monkey	3	13	5	0	0	0
Common duiker	9	3	10	16	7	12
Bushbuck	5	0	0	5	0	6
Bushpig	10	10	0	1	1	6
Giant root-rat	4	2	10	10	16	14
Porcupine	17	24	14	0	6	20
Common jackal	8	10	9	12	0	0
Spotted hyena	26	14	17	6	8	13
African civet	0	0	2	10	5	0
Common genet	5	0	3	0	0	4
White-tailed mongoose	0	0	10	0	6	10
African wild cat	4	1	0	2	0	3
Serval Cat	2	0	2	0	0	3
Lion	0	0	0	0	2	4
Abyssinian hare	3	5	0	9	5	0
Total	138	130	107	106	65	101

Habitat association and seasonal variation of mammalian species

The study revealed that there was no difference ($\chi^2 = 0.52$, $df = 1$, $p > 0.05$) in species composition and richness between the different habitats during both the dry and wet seasons in the study area. Habitat selection of the mammalian species varied seasonally in the study area. The riverine forest had the highest number of species ($N = 14$ and $N = 11$) followed by the woodland ($N = 12$ and $N = 11$), and the grassland habitat ($N = 10$ and $N = 12$) during the dry and wet seasons, respectively (Table 7).

The highest number of species ($N = 14$) was recorded in the riverine forest during the dry season, and the least was from the grassland ($N = 10$) species during the dry season. A total of 268 individuals mammals were recorded in riverine forest habitat, in which 138 individuals were, recorded during the dry season and 130 of them during the wet season. Small numbers of individuals ($N = 166$) were recorded from the grassland habitat. Among the 166 individuals, 65 were recorded during the dry season, and the rest 101 during the wet season. The seasonal abundance of mammals was significantly vary for the three habitats ($\chi^2 = 0.52$, $df = 1$, $p > 0.05$): riverine forest ($\chi^2 = 0.36$, $df = 1$, $p > 0.05$); woodland ($\chi^2 = 0.52$, $df = 1$, $p > 0.05$), and grassland with scattered tree ($\chi^2 = 0.027$, $df = 1$, $p > 0.05$).

Table 7
Species richness in different habitat types

Season	Habitats		
	Riverine Forest	Woodland	Grassland
Dry	14	12	10
Wet	11	11	12

Differences in species evenness, richness, and diversity between seasons on the stratified vegetation types were higher in the forest area. Application of the Shannon-Wiener information theory revealed that diversity index and evenness of the mammalian species in the different habitat types of the area were: 0.867 and 0.880 for (riverine forest habitat), 0.887 and 0.920 for (woodland habitat), 0.894 and 0.929 for (grassland habitat) respectively during the wet season (Table 8). While during the dry season, the diversity index and evenness of the mammalian species were 0.891 and 0.891 for the (riverine forest habitat), 0.902 and 0.936 for the (woodland habitat), and 0.877 and 0.922 for the (grassland habitat), respectively (Table 8).

Table 8

The diversity indices of the medium and large mammalian species in the three habitats of the study area during the dry and wet seasons

Habitat	Season	Number of species	Number of individuals	H	H _{max}	Evenness	1-D
Riverine Forest	Dry	14	138	2.351	2.639	0.891	0.891
	Wet	11	130	2.109	2.398	0.880	0.867
Woodland	Dry	12	107	2.325	2.485	0.936	0.902
	Wet	11	106	2.206	2.398	0.920	0.887
Grassland	Dry	10	65	2.122	2.303	0.922	0.877
	Wet	12	101	2.308	2.485	0.929	0.894

Discussions

A total of 17 species of medium and large-sized wild mammals were identified in the three major vegetation types of Michole Forest. The order Carnivora was recorded by the highest number of families and species during the study period, followed by order Artiodactyla and order Rodentia. Similar results were recorded in some parts of Africa including Ethiopia by using similar line transect techniques. Girma et al. (2012) recorded 18 species of medium and large mammalian species in Kaka and Hunkolo Fragments, Meseret and Solomon (2014) recorded 23 medium and large mammalian species from Borena-Sayint Park, south Wollo, Ethiopia, and Kasso et al. (2010) identified 21 species in Chilalo-Glama Forest Priority Area. The mammalian diversity of the current study area is very low compared to areas of different protection levels across the country and elsewhere. The low species richness of mammals in the present study area might be associated with the low quality and fragmented habitat of the area.

Meseret and Solomon (2014) also showed a positive correlation between habitat heterogeneity and animal species diversity. Among the three habitats in the study area, the heterogeneous plant species assemblage available in the woodland and riverine forest contributed to the highest diversity of mammals. The ecological preference and evolutionary adaptation of mammalian species play a role in their occurrence and abundance in different habitat types (Dawd and Solomon, 2013; Rabira et al., 2015).

The medium and large-sized mammals prefer certain habitat types and consequently, are not uniformly distributed while foraging. These preferences and the availability of optimal habitat will affect lifetime reproductive success. For African mammals, day-to-day movement between habitats is determined by diverse factors including forage composition, availability, and quality, water availability, topography, soil types (Grand, 2002; O'Kane and Macdonald, 2018). The high abundance of mammalian species in the riverine forest, in this study, might be due to these factors. The distributions and abundance of medium and large-sized mammal species of the present study area were not uniform. Riverine forest supported the highest diversity of medium and large-sized mammal species followed by woodland forest. Open grassland has supported the lowest diversity. Moreover, woodland and riverine forest habitats held a more stable community than open grassland habitats. In this study, woodland and riverine forest habitats have more or less similar distribution and abundance of mammals due to the similarity of vegetation cover, food, and water availability.

The nine medium-sized mammals, Anubis baboon, Crested porcupine, Vervet monkey, Common jackal, Common duiker, White-tailed mongoose, African civet, Spotted hyena, Bush pig and Abyssinian hare were the most abundant species in the present study area in both wet and dry seasons. But Serval cat and Lion were the least abundant species in the present study area. This might be related to the diet and habitat requirements of the animals as identified by Gonfa et al. (2015).

This is perhaps due to the high reproductive successes, diversified foraging behaviour, and high tolerance level of primates to human disturbances. Anubis baboon was the most abundant mammal in the area. High species richness of the primates may be associated with the wide distributional range of the species and their more adaptive nature to different habitats. In many areas, this monkey frequents human

settlements and feeds extensively on cultivated plants. Several studies have also reported a similar abundance of primates from different parts of Ethiopia (Mekonnen et al., 2012; Gonfa et al., 2015).

The species is known to be widely distributed in Africa in a wide variety of habitats from savannah grassland to Afromontane forest. Johnson et al. (2012) mentioned that baboons consume a huge variety of items including roots, tubers, corms, fruits, leaves, flowers, buds, seeds, bark, exudates, cacti, and grasses. *P. anubis* and *C. guereza* has known to prefer habitats in an altitudinal range between 1200 and 2028 m a.s.l., which is the altitude range of the study area. A similar observation was made by UNESCO (2008) that *P. anubis* and *C. guereza* distribution, were ranging from 1800 and 2600 m a.s.l. This high abundance of the species in the study area might be correlated with vegetation cover, altitude, and availability of food.

Spotted hyena were the most abundant carnivore species recorded in the riverine and woodland habitat of the study area. The serval cat and Lion were the least abundant species of family Felidae in the present study area. The average number of individuals recorded per habitat was relatively the same in the three habitats, however, significantly less in woodland and grassland habitat in the dry season. Habitat use and dietary attributes such as composition and quality have a significant effect on animal distribution. As reported by Brnesh et al. (2015), the habitat might have limited food and cover to be utilized by the animals.

Conclusion

The result of the present study provided information on some aspects of diversity, distribution, and habitat association of medium and large mammalian species in the Michole forest. It gives baseline information for further studies on mammalian species in the area. Seventeen mammalian species were identified from the study area. Order Carnivora and Primates constitutes a large proportion of abundance, while order Lagomorpha was the least. The species such as Spotted hyena, Anubis baboon, Porcupine, and Vervet monkey were the most abundant, while Serval cats and Lion were the least abundant species in the study area. The distribution and abundance of mammal species in forests varied due to the vegetation types and altitudinal differences. Riverine forest had the highest number of species and followed by the woodland and grassland. The distribution and utilization of different vegetation communities by the mammal species could be explained in terms of seasonal changes. Seasonal variation in the quality and abundance of forage affected the habitat preference of the medium and large-size mammalian species. It is possible to conclude that the food, water, and protection were decisive to determine the distribution of the mammal species in the present study area. Based on the results of the present study, continuous long-term studies of the ecological aspects of medium and large-sized mammalian species are needed for future conservation measures, and also regular assessment and monitoring of the wildlife species are essential in Michole Forest.

Declarations

Ethics approval and consent to participate

This study conducted in accordance with the declaration of Helsinki that provides guidance for the researcher to protect research subjects. The study was approved by the Institutional Research Review Board (IRB) of Wolaita Sodo University. The consent to participate is not applicable to this research.

Consent for publication

This manuscript doesn't contain any person's data, and further consent for publication isn't required.

Availability of data and materials

The data generated and analyzed during the current study are included in the body of this paper.

Competing interests

There is no conflict of interest between the authors regarding this paper.

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Authors' contributions

Amanuel Agebo: Designed the research, collected data, organized the data on the computer, did the analysis, interpretation, and identification, and wrote the draft manuscript.

Wondimagegnehu Tekalign: Proposed the research conception, read the draft, review, and edit, supervised; and validated the final manuscript.

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Appendix

Appendix I is not available with this version.

Figures

Figure 1

Map of the study area