



DIVERSITY AND RELATIVE ABUNDANCE OF MEDIUM AND 11LARGE MAMMALS IN BIRBIR PROTECTED FOREST, WESTERN ETHIOPIA

¹Inderis Abdu, ²Gutema Jira and ¹Gatriay Tut,

¹Zoological Science, Mekdela Amba University, Tulawlia, P.O. Box 32, Ethiopia

²Zoological Science, Wollega University, Nekemte, P.O. Box 395, Ethiopia

Abstract: Investigation of diversity and relative abundance of medium to large-sized mammals was conducted in Birbir Protected Forest, western Ethiopia; between Augusts 2017 and February 2018. Three habitat types: Grassland, Woodland and Riverine forest were identified and sampled. Line transect method was implemented to record mammalian diversity. 30 lines transect, varying from 1.5 to 3km in length were spaced systematically throughout the forest. Among these, 14 transects: 6 from Grassland and 4 from each of woodland and riverine forest were randomly selected and permanently surveyed. For mammal survey, indirect methods such as faeces, hair, quill, sound and burrow were used in addition to direct observation. A total of 14 medium and large-sized mammal species were identified and recorded. Grassland supports highest species diversity both during wet ($H' = 1.804$) and dry ($H' = 2.113$) seasons. The least species diversity ($H' = 0.663$) during both wet and ($H' = 0.578$) dry season was recorded from Riverine forest. Woodland possessed the highest species evenness ($J = 0.815$) during wet season, followed by Grassland ($J = 0.783$), but during dry season, highest evenness ($J = 0.917$) was obtained from Grassland, followed by Woodland ($J = 0.663$). The least species evenness ($J = 0.417$) was recorded from Riverine forest during dry season. The highest mammalian species similarity was recorded between Grassland and Woodland during both seasons. The least species similarity was between Woodland and Riverine forest during wet season. Among species of mammals recorded, *H. amphibius*, 23.98% and *P. anubis*, 21.25% were relatively most abundant species, while *M. capensis* and *C. mitis* were represented with a few individuals. Habitat association of mammals revealed that most primate preferred woodland while, artiodactyls preferred Grassland. The lower mammalian diversity might be attributing to intense anthropogenic activities such as agricultural expansion, settlement, hunting and overgrazing.

Keywords: Phrases: Birbir, Diversity, Habitat association, Mammals, Relative Abundance.

1. INTRODUCTION

Mammals are the most successful groups of animals with the exception of arthropods (Kemp, 2005). They are quite diverse both in structure and function (Leykun, 2000) and are the most studied vertebrate taxa (Gerrit, 2010). More than 5000 extant mammalian species were

identified and recorded Worldwide (Vaughan et al., 2000). Among the total of 960 species of mammals occurring in sub-Sahara Africa, 320 species of them are found in Ethiopia where more than 60% of them are medium to large-sized (Afeework & Yalden, 2014).



Although mammals are widely studied organisms, still new species are being discovered at higher rates and estimated an additional 2,000 species have yet to be discovered (Reeder et al., 2007).

Ethiopia is a country with a unique varied topography and climate resulting in biological diversity and high endemism (Vreugdenhil et al., 2012). This variation affects every aspect of life while temperature, rainfall and vegetation play major roles in determining the distribution of fauna including that of endemic mammals (Freilich et al., 2014). Ethiopia is one of the biodiversity centers and among the most top 25 biodiversity rich countries in the World that harbors three of the world's 34 biodiversity hot spot regions; the Eastern Afromontane, Costal Forest of eastern Africa and the Horn of African hotspots (EBI, 2014).

The medium to large-sized mammals carry out a crucial role on their ecosystems (Simberloff, 1998); they are considered key species in structuring biological communities through pollinator, predation, seed dispersal and grazing (Gary et al., 2009). One of the issues of greatest interest in ecology is the relationship between habitat structure and the structure of animal communities (Galleti et al., 2009). Large to medium sized mammals are particularly sensitive to habitat changes and are a good indicator of the environmental health (Cortes et al., 2014). They are also commonly taken as umbrella species in most ecosystems (Williams et al., 2000; Davies et al., 2007) which have ability to shape the structure and function of the ecosystems in which they inhabit (Vaughan et al., 2000). Conservation activities of such species may automatically contribute to conservation of larger proportion of ecosystems (Andelman & Fagan, 2000).

Human activities have altered the patterns of landscape, habitat quality and distribution of species in many parts of the world (Olifiers & Fiszon, 2005). Wildlife populations have been declining throughout the world at alarming rate

(Boniface, 2001). Among the known species of mammals in the World, 25% are threatened, 11% are endangered, 4% are critically endangered and approximately 2% of the known modern day mammals have gone extinct in the last 400 years (Vaughan et al., 2000). Although Ethiopia is among few African countries with high mammalian diversity, they are highly deteriorating (Zarihun et al., 2012). Following the priority plan of Ethiopian government for poverty reduction and the fast growing economy of the country in recent decades, more national and international investors were attracted in agricultural sector (Dereje et al., 2015). As a result, wildlife habitats have been significantly degraded in many parts of the country just to achieve the policy. Beside this, in Ethiopia only limited areas were surveyed for biodiversity and unlike flora, fauna of the country is not well studied and documented (Vreugdenhil et al., 2012). Most of the large mammals inhabit the southern and western lowland ecosystems of the country (Blower, 1969; Melaku, 2011). Despite its mammal's abundance, little emphases have been given to the fauna in the western part of country (Gutema, 2015). Hence, there is scanty information on mammal diversity in this area hampering management actions to achieve conservation goals. The present study area is among less considered ecosystem with no scientific report on species composition and diversity of wildlife species. Therefore, the present study is aimed to investigate and provide baseline information on medium to large-sized mammal diversity and relative abundance.

2. MATERIALS AND METHOD

2.1. Description of the Study Area

Birbir Protected Forest is geographically located in Dale Sadi woreda of kellef Wollega Zone, Oromia regional state, western Ethiopia (Fig. 1). It is located 620 km West of Addis Ababa, the country's capital. The forest is located between 8°47'30"N - 8°52'30"E and 35°15'0"N-35°22'0"E and its altitude range between 1400 and 2000m above sea level (Kassaye & Tsegaye, 2016). The area



covers over 3600ha land area, which is demarcated and protected by Oromia Forest and Wildlife Enterprise, Wollega District in 2016 (OFWEWD, 2016).The agro-climate of the area alternates with long rainy season (June to September) and dry season (December to March), with annual rainfall ranging from 1300 to 1600 mm. Birbir forest is found in lowland area situated along the Birbir Valley system and shows hot desert agro ecological zone.

The area shows high variability in its temperature. The mean minimum and maximum temperature of the area is 13.25°C and 31.05°C, respectively and the Average annual temperature is 22.15°C. The maximum monthly temperature is 36°C recorded in March whereas, the minimum monthly temperature is 11.0°C recorded in August (Kassaye & Tsegaye, 2016).



Figure 1: Map of the study area.



2.2. Methodology

During Preliminary survey, the study area was classified in to three vegetation zones; Riverine Forest (RF), Woodland (WL) and Grassland (GL). In each habitat types, line transect were randomly drawn as a census zone. A total of 30 lines transects were systematically established (14 in the Grassland and 8 in both the Woodland and Riverine forests). The length of transect in each habitat type vary, with the maximum length of 3km laid in grassland and the minimum length of 1.5km in Riverine forest. The Transects were made at about 0.5 km far apart from each other to avoid double counting during data collection. In Riverine forest, line transects were laid out separately because of the inconvenience of the topography and dense vegetation structure. From 30 systematically established transects, 14 line transect were randomly selected for permanent survey; 6 from Grassland 4 from each of Woodland and Riverine forest.

The investigation of medium to large-sized mammals was done by direct observation on foot along a randomly spaced transects. During the transect's walk, the observer looked both on left and right side and recorded the species seen, number, habitat type, transect number, the time of the day and took the pictures of mammals seen. For nocturnal and naturally rare animals, indirect indicators such as animals' dropping, tracks, hair, vocal sound, quill, dead animal and other indicators along the transect lines were recorded. Indirect method is the only option available to study the distribution and number of nocturnal mammals and other inaccessible vertebrates (Cortes et al., 2014).

The data collection was done both in dry (January and February 2018) and wet (August and September 2017) seasons. All transects in each habitat type were visited twice during the survey; early morning and late afternoon. All transects in a habitat were surveyed at the same time between 06:00 and 10:00 am in the morning and between 16:00 and 18:00 in late afternoon, when most mammals

were active (Maira, 2016). The data collected from transects of similar habitat were pulled together for analysis.

The identification of species was done using the Kingdon Field Guide to African Mammals (Kingdon, 2003) and comparison with other digital sources. Local peoples were also consulted for species local name and for indirect signs. Bodyweight estimation was used as a basic feature to classify mammals in to medium-sized (those between 2 and 7 kg) and large-sized (those over 7 kg body mass) (Emmons & Feer, 1997).

Species identified were presented using frequency distribution table with their order, family, scientific and common names (both English common names and local names). Species Relative abundance (RA), the number of individuals of a particular species in a given community was computed using the formula below:

$$\text{Relative abundance} = \frac{\text{Number of individuals of a particular species}}{\text{Total number of individuals}} \times 100 \quad (1)$$

Species diversity of medium and large mammals was calculated using the Shannon-wiener index (H') by using the following formula (Elliott & Hewitt 1997):

$$H' = - \sum p_i \ln p_i \quad (2)$$

Where:

- p_i = proportion of individuals of a particular species
- n = number of individuals of a particular species found
- \ln = natural logarithm

The evenness of mammalian species was calculated by Shannon evenness as:

$$J' = \frac{H'}{\ln n} \quad (3)$$

Where:

- H' = Shannon- index of diversity,



- $H'_{max} = \ln(S)$ and S is the number of species in a community.

This measure varies between 1 (complete evenness) and 0 (complete unevenness).

Simpson similarity index (SI) was computed to assess the similarity between habitats with reference to the composition of species by using the formula:

$$SI = \frac{C}{A+B} \quad (4)$$

Where:

- SI = Simpson's similarity index
- C = the number of species common to both habitats
- A and B = the number of species in habitat A and B respectively

This index gives a value between 0 and 1. The closer the value to 1 is, the more the communities have in common and 1 completely similar community. Whereas, 0 values indicate there is no common species between communities.

hi-square (χ^2) test, at 0.05 level of significance was used to compare differences in abundance of mammal species between habitats and the overall seasonal difference in abundance of medium and large-sized mammal species in the study area. IBM SPSS version 20.0 computer software program was used to run Chi-square analysis.

4. RESULTS

4.1 Medium and Large-Sized Mammal Diversity

During the study a total of 367 individuals of medium and large-sized mammals were identified and recorded. Among these, 166 were recorded in wet season and 201 in dry season. The individuals recorded were identified into 14 species. Majority of these species, 57.1% (Eight species) were recorded through direct visualization and 35.7% (Five species) of them were recorded through both direct observation and indirect indicators. One species: spotted Hyena (*Crocuta crocuta*) was recorded indirectly through its faeces and vocalization. The mammals recorded in the current study are summarized in the table 1 below.

Table 1: Medium and large mammalian species identified and recorded from Birbir Protected Forest, western Ethiopia.

No.	Species scientific name	Common name	Local name (Afan Oromo)	Identification method
1	<i>Colobus guereza</i>	Colubos Monkey	Weni	Visual
2	<i>Papio Anubis</i>	Olive Baboon	Jaldesa	Visual
3	<i>Chlorocebus aethiops</i>	Vervet Monkey	Qalame	Visual
4	<i>Cercopithecus mitis</i>	Blue monkey	Qalame	Visual
5	<i>Syncerus caffer</i>	African Buffalo	Gafarsa	Visual/faeces
6	<i>Tragelaphus scriptus</i>	Bushbuck	Bosonu	Visual/ skin
7	<i>Sylvicapra grimmia</i>	Common duiker	Kuruphe	Visual
8	<i>Kobus ellipsiprymnus</i>	Waterbuck	Warabo	Visual/horn
9	<i>Hippopotamus amphibious</i>	Hippopotamus	Robi	Visual/ faeces
10	<i>Potamochoerus larvatus</i>	Bush Pig	Boye	Visual
11	<i>Phacochoerus africanus</i>	Warthog	Karkaro	Visual



12	<i>Crocuta crocuta</i>	Spotted Hyena	Warabesa	carcass/faeces
13	<i>Mellivora capensis</i>	Honey badger	Hama	Visual
14	<i>Hystrix cristata</i>	Crested Porcupine	Xade	Visual/spine

Among 14 species of medium and large-sized mammals recorded, only three species: crested porcupine (*Hystrix cristata*), Honey badger (*Mellivora capensis*) and Vervet Monkey (*Chlorocebus aethiops*) were medium-sized mammals; the remaining 11 species were large sized mammals.

Mammalian species recorded from Birbir Protected Forest were taxonomically identified into four orders eight families and fourteen species. Among the four orders, Artiodactyla was the most diversified order comprising three families and seven species, followed by order primate with two families and four species. The third diversified order was carnivora with two families and two

species. Rodentia was the least diversified order represented by a single family and one species.

Among Eight families of medium and large-sized mammals recorded, family Bovidae containing four species was the most diversified family. Family Colobinae, Hippopotamidae, Hynidae, Mustelidae and Hystricidae were the least diversified families, each represented by only one species. Majority of medium and large-sized mammal recorded in the present study were herbivores, accounting about 86% (12 species). The remaining 14% (two species) were carnivores. The taxonomical classification of the mammals observed in the present study is summarized in Table 2.

Table 2: Taxonomy of medium and large-sized-mammalian species recorded from Birbir Protected Forest, western Ethiopia

Order	Family	Species scientific name	Common name
Primate	Cercopithecidae	<i>Papio Anubis</i>	Olive Baboon
		<i>Chlorocebus aethiops</i>	Vervet Monkey
	Colobinae	<i>Cercopithecus mitis</i>	Blue monkey
		<i>Colobus guereza</i>	Colubos Monkey
Artiodactyla	Bovidae	<i>Syncerus caffer</i>	African Buffalo
		<i>Tragelaphus scriptus</i>	Bushbuck
		<i>Sylvicapra grimmia</i>	Common duiker
		<i>Kobus ellipsiprymnus</i>	Waterbuck
	Hippopotamidae	<i>Hippopotamus amphibius</i>	Hippopotamus
	Suidae	<i>Potamochoerus larvatus</i>	Bush Pig
		<i>Phacochoerus africanus</i>	Warthog
Carnivora	Hynidae	<i>Crocuta crocuta</i>	Spotted Hyena
	Mustelidae	<i>Mellivora capensis</i>	Honey badger



Rodentia Hystricidae *Hystrix cristata* Crested Porcupine

Besides the 14 (fourteen) species of medium and large-sized mammals identified and recorded, the presence of other unobserved 7 species of medium and large-sized mammals were reported by local community elders from the study area. Mammalian species recorded through community report were identified into three order (Carnivora, Tubulidentata and Lagomorpha) and five families (Felidae, Canidae, Viverridae, Orycteropodidae and Liporidae) (Table 3).

Table 3: Mammal species of Birbir Protected Forest reported by local communities

Order	Family	Species scientific name	common name	Local name (Afan Oromo)
Carnivora	Felidae	<i>Panthera leo</i>	African Lion	Lenca
		<i>Panthera pardus</i>	Leopard	Qeransa
		<i>Felis lybica</i>	African wild cat	Adala
	Canidae	<i>Canis aureus</i>	Common Jackal	Yedala
Tubulidentata	Viverridae	<i>Civettictis civetta</i>	African civet	Xirinyi
	Orycteropodidae	<i>Orycteropus afer</i>	Aardvark	Waldigesa
Lagomorpha	Liporidae	<i>Lepus habessinicus</i>	Abyssinian hare	Hileti

Habitat association and species richness of medium and large mammal in the present study revealed that grassland possessed the highest number of species (10 species) during both wet and dry seasons, followed by woodland having 5 and 8 species during wet and dry season, respectively. The least species richness 3 and 4 species was recorded from Riverine forest during wet and dry season, respectively (Fig. 2).

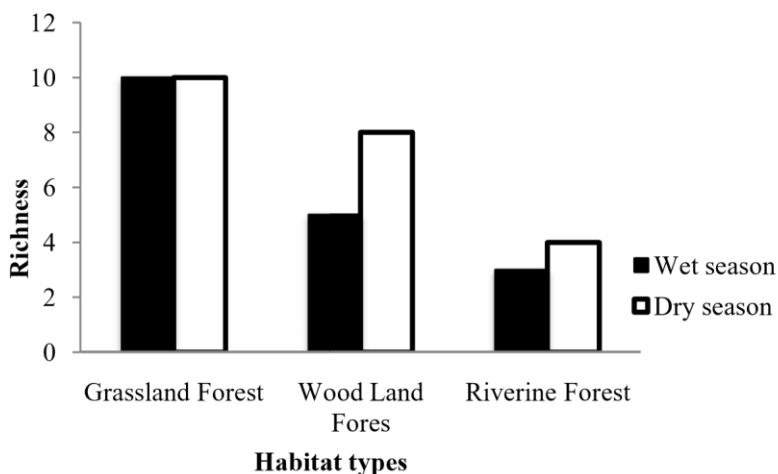




Figure 2: Medium and large-sized mammal species richness in different habitat of Birbir Protected Forest

The result of Shannon Winner Index of diversity showed that, grassland supports the highest species diversity among the three habitat types both during wet ($H' = 1.804$) and dry season ($H' = 2.113$), followed by Woodland habitat, with H' value of 1.311 and 1.378 during wet and dry seasons, respectively. The least species diversity ($H' = 0.663$) during wet and ($H' = 0.578$) dry season was recorded from Riverine forest. Seasonal variation was

observed in the evenness of mammalian species among the three habitat types. Accordingly, woodland exhibits the highest species evenness ($J' = 0.815$) during wet season and followed by grassland ($J' = 0.783$). In contrary, during dry season, the highest species evenness ($J' = 0.917$) was obtained from Grassland and followed by Woodland ($J' = 0.663$). The least species evenness during both wet ($J' = 0.663$) and dry ($J' = 0.417$) seasons was recorded from Riverine forest (Table 4).

Table 4: Diversity indices and evenness of medium and large-sized mammalian species in Birbir Protected Forest

Habitats	Seasons	Richness	Abundance	diversity index H' (H')	H' (lnS)	max Evenness (J')
	Wet	10	78	1.804	2.303	0.783
	Dry	10	49	2.113	2.303	0.917
Grassland	Wet	5	43	1.311	1.609	0.815
	Dry	8	91	1.378	2.079	0.663
Woodland	Wet	3	45	0.663	1.099	0.603
Riverine forest	Dry	4	61	0.578	1.386	0.417

Simpson similarity index of medium and large-sized mammals species among all of the three habitat types of the study area ($SI = 3C / I+II+III$) was least ($SI = 0.17$) during wet season. During dry season, species similarity among the three habitat type of the study area was zero. That means, no common species for the three habitats was recorded. Among the three habitat types, the highest mammalian species similarity index was recorded between Grassland and Woodland forest both during the

wet ($SI=0.54$) and dry ($SI = 0.44$) seasons and followed by the species between Grassland and Riverine forest during wet season ($SI = 0.37$) and species between Woodland and Riverine forest ($SI = 0.333$) during dry seasons. The least species similarity index was recorded between Grassland and Riverine Forest during dry season ($SI = 0.285$) and species between Woodland and Riverine Forest ($SI = 0.25$) during wet season (Table 5).



Table 5: Mammalian species similarity (SI) among the three habitat types in Birbir Protected Forest during different seasons

Habitat types	Survey season	Simpson’s similarity index (SI)
Grassland Vs Woodland	Wet	0.54
Grassland Vs Riverine Forest	Dry	0.44
Woodland Vs Riverine Forest	Wet	0.37
	Dry	0.285
	Wet	0.25
	Dry	0.33

Among 166 individuals recorded during wet season, Grassland habitat possessed the highest number of individuals (78), followed by Riverine forest (45 individuals). The least number of individuals (43) was recorded from Riverine habitat. However, among 201 individuals recorded during dry season, the highest number of individuals (91) was recorded from woodland habitat, followed by Riverine forest (61). The least number of individuals during dry season (49) was recorded from grassland forest (Fig. 3).

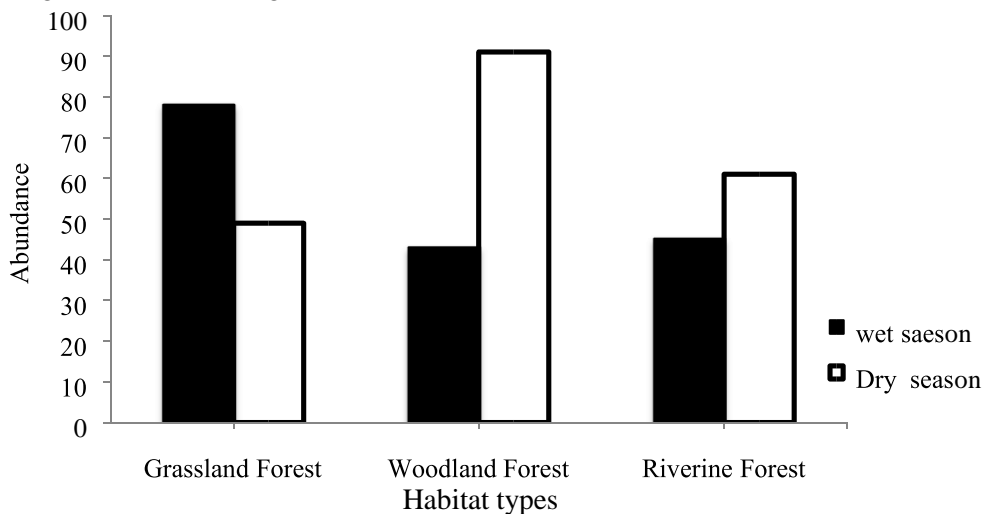


Figure 3: Abundance of mammals in different habitat type of the study area during both seasons of study period

The overall abundance of medium and large-sized mammals recorded during the present study was significantly different ($\chi^2 = 23$, $df = 2$, $P < 0.05$). Within a habitat, seasonal abundance of mammals (number of individuals) was significantly different for all the three habitats of the study area (Grassland: $\chi^2 = 127$, $df = 1$, P

$= 0.000$; Woodland; $\chi^2 = 134$, $df = 1$, $P = 0.000$ and Riverine forest: $\chi^2 = 106$, $df = 1$, $P = 0.000$).

4.2. Distribution and Habitat Association of Medium and Large-sized Mammals

Among medium and large-sized mammals recorded in the present study during wet season, *Papio anubis* was widely



distributed; it occurred in all of the three habitat types of the study area. *Colobus guereza*, *Crocuta crocuta*, *Hystrix cristata* and *Tragelaphus scriptus* occurred in two habitat types of the study area. *Chlorocebus aethiops*, *Syncerus caffer*, *Sylvicapra grimmia*, *Kobus ellipsiprymnus*, *Hippopotamus amphibious*, *Phacochoerus africanus* and *Potamochoerus larvatus* were least distributed during wet season, each occurred in one habitat type. During dry season, *C. guereza*, *C. aethiops*, *T. scriptus*, *S. grimmia*,

H. amphibious, *P. africanus*, *P. larvatus* and *H. cristata* were equally distributed in two habitats. Whereas, *P. anubis*, *C. mitis*, *S. caffer*, *K. ellipsiprymnus*, *C. crocuta* and *M. capensis* were recorded as least distributed species in the study area, each occurred in a single habitat type (Table 6).

Table 6: The distribution of medium and large-sized mammals of Birbir Protected Forest, Western Ethiopia

Species	Grassland		Woodland		Riverine forest	
	Wet	Dry	Wet	Dry	Wet	Dry
<i>Colobus guereza</i>	☐	-	☐	☐	-	☐
<i>Papio anubis</i>	☐	-	☐	☐	☐	-
<i>Chlorocebus aethiops</i>	-	☐	☐	☐	-	-
<i>Cercopithecus mitis</i>	-	-	-	☐	-	-
<i>Syncerus caffer</i>	☐	☐	-	-	-	-
<i>Tragelaphus scriptus</i>	☐	☐	-	☐	☐	-
<i>Sylvicapra grimmia</i>	☐	☐	-	☐	-	-
<i>Kobus ellipsiprymnus</i>	☐	☐	-	-	-	-
<i>Hippopotamus amphibius</i>	-	-	-	☐	☐	☐
<i>Potamochoerus larvatus</i>	☐	☐	-	-	-	☐
<i>Phacochoerus africanus</i>	☐	☐	-	-	-	☐
<i>Crocuta crocuta</i>	☐	☐	☐	-	-	-
<i>Mellivora capensis</i>	-	☐	-	-	-	-
<i>Hystrix cristata</i>	☐	☐	☐	☐	-	-

☐ =Species presence, - = Absence of species

In the present study area, most primate species preferred to use woodland, while majority of artiodactyls favored

grassland. Among medium and large-sized mammals recorded from the present study area, olive baboon (*P.*



anubis) was distributed in all habitats; grassland (16 individuals), woodland (16 individuals) and Riverine forest (7 individuals) during wet season, but during dry season it was confined to woodland habitat (39 individuals). There was significant variation in the number of individuals recorded in the three habitats during wet season ($\chi^2 = 39$, $df = 2$, $P < 0.05$) and the species was strongly associated to woodland habitat. Colobus monkey (*C. gureza*) was recorded from grassland (4 individuals) and woodland (12 individuals) during wet season. During dry season, it was recorded from woodland (33 individuals) and riverine forest (3 individuals). The variation in the number of individuals between grassland and woodland was significant during wet season ($\chi^2 = 16$, $df = 1$, $P = 0.000$) and in woodland and riverine forest during dry season ($\chi^2 = 36$, $df = 1$, $P = 0.000$) was statistically significant. This showed that *C. gureza* was strongly associated to woodland habitat during both season.

Vervet monkey (*C. aethiops*) was recorded only from woodland habitat (12 individuals) during wet season. But during dry season, it was distributed to grassland (6 individuals) and woodland (8 individuals). The variation in abundance of *C. aethiops* recorded in Woodland and Riverine Forest during dry season was statistically significant ($\chi^2 = 14$, $df = 1$, $P = 0.000$). Blue monkey (*C. mitis*) and *M. capensis* were recorded only from woodland

habitat (2 individuals and 3 individuals, respectively) during dry season. They were totally absent during wet season. Common duiker (*S. grimmia*) and waterbuck (*K. ellipsiprymnus*) occur only in grassland during both seasons. Bush pig (*P. larvatus*) and warthog (*P. africanus*) occur only in Grassland habitat during wet season and distributed in grassland and woodland during dry season. The variation in distribution of *P. larvatus* during dry season was slightly significant ($\chi^2 = 5$, $df = 1$, $P = 0.025$). However, the distribution is strongly significant for *P. africanus* ($\chi^2 = 14$, $df = 1$, $P = 0.000$) and the species is associated to grassland habitat. African buffalo (*S. caffer*) was recorded only from grassland during both wet (32 individuals) and dry (6 individuals) seasons, while hippopotamus (*H. amphibious*) confined to riverine forest during wet season.

During dry season, it was recorded from riverine forest (52 individuals) and woodland habitat (single individual). Hippopotamus was significantly associated to riverine forest ($\chi^2 = 53$, $df = 1$, $P = 0.000$). *Hystrix cristata* was recorded only from grassland and woodland habitat during both seasons. The variation in distribution of *H. cristata* during both wet season ($\chi^2 = 3$, $df = 1$, $P = 0.083$) and dry season ($\chi^2 = 5$, $df = 1$, $P = 0.025$) was slightly significant (Table 7).

Table 7: Habitat association of medium and large-sized mammals in Birbir Protected Forest

Species	Grassland		Woodland		Riverine forest	
	Wet	Dry	Wet	Dry	Wet	Dry
<i>C. guereza</i>	4	-	12	33	-	3
<i>P. anubis</i>	16	-	16	39	7	-
<i>C. aethiops</i>	-	6	12	8	-	-
<i>C. mitis</i>	-	-	-	2	-	-
<i>S. caffer</i>	32	6	-	-	-	-
<i>T. scriptus</i>	3	2	-	4	3	-



S. grimmia	2	7	-	1	-	-
K. ellipsiprymnus	4	8	-	-	-	-
H. amphibius	-	-	-	1	35	52
P. larvatus	8	2	-	-	-	3
P. africanus	5	11	-	-	-	3
C. crocuta	2	2	2	-	-	-
M. capensis	-	3	-	-	-	-
H. cristata	2	2	1	3	-	-
Total	78	49	43	91	45	61

4.3. Relative Abundance of Medium and Large-Sized Mammals

Seasonal variation was observed in the relative abundance of medium and large-sized mammalian species recorded from the study area. Accordingly during wet season, relatively the most abundant species recorded was Olive Baboon (*P. anubis*) which contributed about 23.5% (39 individuals) of the total number of individuals (166) recorded, followed by Hippopotamus amphibious, with 21.08% (35 individuals). Relatively the least abundance species during wet season were crested porcupine (*H. cristata*) with 1.807% (3 individuals) and common Duiker (*S. grimmia*), constituting only 1.2% (2 individuals).

During dry season, relatively the most abundant species recorded was Hippopotamus (*H. amphibious*) contributing 26.38% (53 individuals) of the total individuals (201) recorded, followed by Olive Baboon (*P. anubis*) with 19.4% (39 individuals). Colobus gureza with 17.91% (36 individuals) was the third abundant species. Blue monkey (*C. mitis*) and spotted Hyena (*C. crocuta*), each representing only 0.99% (2 individuals) were relatively the least abundant species recorded during dry season (Table 8).

Table 8: Seasonal relative abundance of medium and large-sized mammals recorded in Birbir Protected Forest, Western Ethiopia

No.	Species scientific name	Total number of individuals		Relative abundance (%)	
		Wet season	Dry season	Wet season	Dry season
1	<i>C. guereza</i>	16	36	9.639	17.91
2	<i>P. anubis</i>	39	39	23.493	19.4
3	<i>C. aethiops</i>	12	14	7.229	6.97
4	<i>C. mitis</i>	-	2	-	0.99
5	<i>S. caffer</i>	32	6	19.277	2.99
6	<i>T. scriptus</i>	6	6	3.614	2.99



7	<i>S. grimmia</i>	2	8	1.205	3.98
8	<i>K. ellipsiprymnus</i>	4	8	2.409	3.98
9	<i>H. amphibius</i>	35	53	21.084	26.38
10	<i>P. larvatus</i>	8	5	4.819	2.48
11	<i>P. africanus</i>	5	14	3.012	6.96
12	<i>C. crocuta</i>	4	2	2.409	0.99
13	<i>M. capensis</i>	-	3	-	1.49
14	<i>H. cristata</i>	3	5	1.807	2.48
Total		166	201	100	100

However, the mean value between wet and dry season indicates, Hippopotamus (*H.amphibius*) was the most abundant species contributing 23.98% and olive baboon (*P. anubis*) was the second most abundant species, with 21.25%. Whereas, colobus monkey (*C. gureza*), with 14.17% and African buffalo (*S. caffer*), with 10.35% were the third and fourth abundant species, respectively. Vervet

monkey (*C. aethiops*) was the fifth abundant species, with 7.08%. Honey badger (*M. capensis*) and blue monkey (*C. mitis*), contributed only 0.82% (3 individuals) and 0.55% (2 individuals), respectively and were the least abundant species recorded in the study area (Table 9).

Table 9: Relative abundance of medium and large-sized mammals recorded in Birbir Protected Forest, western Ethiopia

No.	Species scientific name	Number of individuals recorded			Relative Abundance (%)
		Season		Average	
		Wet	Dry		
1	<i>Colobus guereza</i>	16	36	26	14.17
2	<i>Papio anubis</i>	39	39	39	21.25
3	<i>Chlorocebus aethiops</i>	12	14	13	7.08
4	<i>Cercopithecus mitis</i>	-	2	1	0.55
5	<i>Syncerus caffer</i>	32	6	19	10.35
6	<i>Tragelaphus scriptus</i>	6	6	6	3.27
7	<i>Sylvicapra grimmia</i>	2	8	5	2.72
8	<i>Kobus ellipsiprymnus</i>	4	8	6	3.27
9	<i>Hippopotamus amphibius</i>	35	53	44	23.98



10	Potamochoerus larvatus	8	5	6.5	3.54
11	Phacochoenus africanus	5	14	9.5	5.18
12	Crocuta crocuta	4	2	3	1.63
13	Mellivora capensis	-	3	1.5	0.82
14	Histrix cristata	3	5	4	2.18
Total		166	201	183.5	100

5. DISCUSSIONS

The total number of medium and large-sized mammalian species (14) recorded during the present study was relatively low compared to other protected areas of the country. For instance, 28 species of medium and large mammals were recorded from Dharti wolel National Park (Rabira et al., 2015), 23 species from Baroye Control Hunting area (Dereje et al., 2015) and Borena Saint National Park (Meseret & Solomon, 2014), 20 species from Alatish national park (Girma & Afework, 2008) and 22 species from Fragmented Ruminant Forest around Asela town (Mohammed & Afework B, 2017).

The lower mammalian diversity recorded from the present study might be attributed to limited survey period, variation in the size of the area, severe habitat loss and fragmentation by various anthropogenic activities. There is a declining of large mammals due to habitat fragmentation, over exploitation and requirement of large area in several parts of Ethiopia (Vreugdenhil et al., 2012). Furthermore, the present study might not include all the lists of medium and large mammal's especially medium sized mammal as they can be over-locked and the absence of using special method separately. But the present result, 14 mammalian species recorded is a good picture for how the area is rich in biodiversity. In some instance, this study is comparable with the others finding in different locality of Ethiopia and Africa. For example, it is comparable with 15 medium and large mammals recorded from Wacha Protected Forest (Mosisa & Afework, 2016), 14 species from Yayu Biosphere Reserves (Gebrecherkos & Tilaye,

2012). In other parts of Africa, it is greater than 13 species of large mammals recorded from Ishaqibin Community Conservancy, Kenya (Muchai et al., 2008) and 10 species of medium and large mammals from Asubima Forest Reserve, Ghana (Quansah, 2010).

Beside 14 species of medium and large mammals recorded during this survey, the presence of 7 medium and large mammals was also reported by local community elders during oral interview. Majority of these species were nocturnal, carnivores, highly secretive and threatened species, including Lion (*Panthera leo*) and Leopard (*Panthera pardus*) which were listed as vulnerable in IUCN red list of threatened species. The possible reason for absence of these species in the present record might be due to their cryptic nature, requirement of large area or high sensitivity to human disturbance. Many carnivores are highly secretive and naturally occur at low to moderate densities, making it difficult to survey over large areas using traditional methods (Erb, 2005). In Ethiopia, quite least abundance records of these species were common in different localities (Meseret & Solomon, 2014; Rabira et al., 2015; Dereje et al., 2015). This indicate that, long-term study period, increasing sampling area and special survey design separately for medium sized mammals may identify additional medium and large-sized mammals from Birbir Protected Forest, Western Ethiopia.

From a total of 14 mammals recorded, one endemic primate species (*Cercopithecus mitis boutourlinii*) and artiodactyls species (*Hippopotamus amphibious*) were of conservation concern as per IUCN Red List of Threatened



Species criteria which were listed as vulnerable. The remaining twelve mammal species were at lower risks (Conservation dependent) which were listed as Least Concern in IUCN (2008) Red List of Threatened Species (IUCN, 2008).

According to Hawkins et al. (2003) and Kisel et al. (2011), the distribution of mammals is not in a smooth gradient. Distribution and habitat association of large mammals are determined in terms of water and food requirement (Balakrishnan & Easa, 1986). According to Joubert (1976), habitat in terms of mammals refers to the vegetation composition, floristic and structure of the area as a product of various factors such as climate, geology and soil. The habitat of the animals is therefore, the area where the animal preferably occurs and where all its life necessities are fulfilled. Consequently, medium and large-sized mammal diversity in the present study area was highly associated with habitat types. The highest species richness in grassland habitat of the study area during both seasons might be due to such factors. Similarly, highest species richness in grassland habitat was reported from Maze National Park (Dawud & Solomon, 2013). Moreover, the highest proportion of the present study area was covered by Grassland habitat with perennial streams and rivers such as Kuni and Merdafo River which pass through it. According to Bailey (1984), cover and large area or space are important factors because of large mammals depend on both food source and protection.

Regarding index of species diversity and evenness, the present study revealed the highest diversity index in Grassland habitat in both seasons and highest evenness during dry season. This result contradicts with studies conducted in different localities of Ethiopia. For instance, Dereje et al. (2015) reported the highest diversity index of mammals in riverine forest during dry season and in woodland during wet season from Barkoye Control Hunting Area. Highest species diversity was reported in woodland and the least diversity and evenness in open

grassland from Dhati Wolel National Park and Borena Saint National Park by Rabira et al. (2015) and Meseret & Solomon (2014), respectively. Primarily, the present highest species diversity and evenness in grassland might be affected by the largest proportion of grassland habitat besides the availability of sufficient water source such as perennial stream and rivers throughout the year. Similarly, the least diversity and evenness of mammalian species in Riverine forest might be due to its small size relative to the other habitats in the study area. Bailey (1984) reported that, space is the primary requirement especially for large mammals. In the present study, the diversity of the species was highly affected by size of the area. Moreover, high human encroachment around Riverine forest for mining activities during dry season and excessive flooding during wet season might have resulted in lower diversity and evenness in Riverine habitat.

The distribution of mammals in the different habitat types of the area might indicate habitat selection of the different species of mammals based on their ecological preferences as well as evolutionary adaptation (Bailey, 1984). Among the three habitat types in the study area, the highest relative species similarity of mammals was observed between Grassland and Woodland during both seasons. This result agrees with species similarity recorded in Dhati Wolel National Park (Rabira et al., 2015) and in Alatish national park (Girma & Afework, 2008). However, it contradicts with the highest similarity of mammal species between riverine forest and woodland forest in Borena Saint national park (Meseret & Solomon, 2014) and in Baroye Control Hunting Area (Dereje et al., 2015). The difference in species similarity between habitats of different study areas might be due to ecological variation and vegetation structure in those localities. The highest species similarity between Grassland and Woodland in the current study during both seasons might be because of resources and cover conditions of these two habitats relatively similar. Species similarity between Woodland and Riverine forest



during wet season in the present study area was relatively low. Similar result was reported from Dhati Wolel National Park (Rabira et al., 2015). The least species similarity between woodland and riverine forest in these area might be attributed from the difference in food resource and habitat conditions of these two habitats.

The distribution patterns of herbivores are believed to be determined by the operation of biotic mechanisms within the constraints set by a biotic factor (Bailey, 1984). In the present study area majority of primates were associated to woodland, while most artiodactyls were associated to grassland. This might be related with the quality of food item and foraging behavior or the physiological preference of the species. Availability of food, size of the area available for various activities, less competition from other large herbivores, escape cover from predators and climatic extremes, surface water availability and opportunity for reproduction determine the preference of herbivores for a specific habitat type (Funston, 1992; Lombardi et al., 2003). The association of primate species in woodland habitat of the present study area might be attributed to the availability of fruit trees with fresh leaves and suitability of the vegetation structure for various activities. Habitat selection in ungulates is influenced by spatial heterogeneity in their environments at scales ranging from feeding patch to biome (Owen-Smith, 2002; DuToit et al., 2003). Therefore, the association of most ungulate species to grassland habitat of the study area might be such factors.

A Significant variation was observed in the overall number of individuals of mammals recorded among habitats of the study area. During wet season, the highest number of individuals of mammals was recorded from grassland habitat. This might be attributed to availability of resources such as food, water and cover or hospitable environmental condition in the grassland habitat during wet season. During wet season, the highest rainfall boosts the over growth of ground vegetation in woodland and

over flooding of the main river along with thick vegetation undergrowth in Riverine forest habitats (Zerihun et al., 2012). This probably made Woodland and Riverine habitat less hospitable for mammals during wet season in the present study area.

However, during dry season, Woodland and Riverine forest possessed the highest number of individuals of mammals. The possible reason might be due to availability of fresh leaves and other fruits or dense and heterogeneous vegetation cover in woodland and riverine habitat during dry season than grassland habitat. Habitat heterogeneity and mammalian species diversity and abundance showed a positive correlation (Matias et al., 2011). During dry season, bush fire cleared dry grasses and other leaves, finding sufficient fresh grasses or cover for mammal was problem in grassland. Therefore, majority of mammals is forced to move to adjacent woodland and riverine habitat in search of food and cover. As reported by (Afolayan & Ajayi, 1980), water, food, cover, mineral requirement and burning practices are the major factors influencing the movement and distribution of wild mammals during dry season. Such seasonal movement of mammals in search of resource and cover is common (Zerihun et al., 2012). This condition attributed to lower number of individuals of mammals in grassland habitat of the present study during dry season.

Seasonal variation was observed in the number of individuals recorded in the present study. Accordingly, the total number of individual recorded during dry season outnumbers individuals recorded during wet season. Similar result is also reported by Zerihun et al. (2012) in Wondo Genet Forest Patch and (Belete & Melese, 2016) in Tululujia Wildlife Reserves. Number of individuals of mammal recorded during dry season in Woodland and Riverine forest was significantly greater than recorded during wet season. This might be because of lower degree of visibility during wet season resulted from thick vegetation cover. Excessive rain falls during wet season



boosts up regeneration and growth of herbaceous plants and ground vegetation. This provides thick cover and resulted in poor visibility of mammals. (Ajibade et al., 2011) showed that excessive rain during wet season can result to poor visibility of Grivate monkey due to outgrowth and thick vegetation at Kainji Lake National Park, Nigeria.

Furthermore, high number of livestock and people were encroaching during wet season than dry season in the present study. Livestock and human encroachment often reduce foraging opportunity of wild mammals which in turn reduce sighting of mammals (Gundogdu, 2011; Hassani et al., 2008). Several studies in different localities have revealed the adverse effect of livestock and pack animals encroachments and human settlement on the abundance and distribution of wild mammals, which in turn would reduce the sighting opportunities of the mammals (Zerihun et al., 2012; Subramanian et al., 2005; Dinakaran & Anbalagan, 2007; Dawud, 2008). All of these factors had contributed to lower number of individuals of mammals during wet season in Woodland and Riverine forest of the present study. In contrary, the number of individuals recorded during dry season in Grassland habitat was lower than the wet season. This might be due to the effect of bushfire on grassland habitat during dry season. Similarly, Afolayan (1976) indicated that seasonal influence on the distribution of large mammals at Yankari National Park, Nigeria as burning practice was a major factor, especially during dry season. Among 14 medium and large-sized mammals species recorded from the present study area, common hippopotamus (*H. amphibious*) was recorded as relatively the most abundant mammalian species comprising about 24% of the total individual recorded throughout the study. It was also had the highest species relative density with 2.56 individuals per square kilometer. The highest abundance of hippopotamus also reported from Dharti Wolel National Park (Rabira et al., 2015) and Boye

Wetland (Sefi and Birnesh, 2016). The distribution of this species in Ethiopia ranges from Djibouti boarder through highlands of south and southwest of the country distributed in rivers (Omo, Awash, Blue Nile and Gibe) and in rift valley lakes (IUCN, 2008). Population of hippopotamus in Ethiopia estimated about 25,000 and the Population size in Africa was estimated at 157,000 in 2004 (Lewison, 2007).

As mentioned by Lewison & Carter (2004), *H. amphibious* an amphibious creature; it has two main habitat requirements: water to rest in during the day and grass to graze on at night; said to be semi aquatic animal. It is found in all types of permanent freshwater habitats, including ponds, rivers, lakes and waterholes with gently sloping banks surrounded by grazing areas. In the present study, it is strongly associated to Riverine habitat. It has also been recorded from grassland habitat during dry season while grazing newly immersing grasses after burn periphery at night. The possible reason for the highest abundance of this species in the present study might be due to hospitable large water bodies and favorable environmental condition or due to availability of food pasture (grazing land) in Birbir protected forest.

Local peoples reported hippopotamus as a pest on agricultural crops such as rice, sorghum, ground nut, maize and sweat potato during wet season. Damage due to hippopotamus has been reported from different parts of Ethiopia, for example, in shoa-wanji sugarcane plantation as it caused severe damage on sugarcane by consuming the stem and shoot of the plant (Messele, 2007). There is evidences from the local people that hippopotamus attack people and it has killed two young individuals while swimming and fetching water from lower part of Birbir River. According to Kendall (2011) Hippopotamus has aggressive behavior toward people and is said to be the most dangerous of wild artiodactyls.

Olive baboon (*Papio anubis*) was the common and relatively the second most abundant species in the present



study area containing (21.25%) of the total individual of mammals recorded. It had the second highest species relative density constituting 2.27 individuals per square kilometer in the study area. Olive baboon was commonly recorded from all of the three habitat type during wet season. *P. anubis* was also among most blamed species of mammals by local community due to raiding of crop. Moreover, during wet season, it was recorded as the first most abundant mammalian species in Birbir Protected Forest. Several scholars have reported highest abundance and crop raiding activity of these primate mammals in Ethiopia and Africa. For example, Dereje et al. (2015) from Baroye Control Hunting area and Mosisa & Afework (2016) from wacha Protected Forest, Western Ethiopia, Dagnachew & Melese (2016) from Arba Minch Forest, Tegegn et al. (2017) from Trigni Forest of Gida-ayana district of Western Ethiopia.

The possible reason for abundance of *P. anubis* in the present study might be the result of its ability to adapt to wide range of ecological niche and feeding behavior on a variety of food items or due to less sensitive to anthropogenic impact. The main reason allowing *P. anubis* to adapt numerous habitats could be their flexibility in foraging strategy and ability to extract food and nutrients from almost all strata of the environment (Johnson et al., 2015).

During dry season, *P. anubis* was totally absent from Grassland and Riverine habitat of the present study area. It was frequently seen concentrated to woodland habitat. *P. anubis* is generalist feeder and Known to eat diverse food items (Whiten & Barton, 1994). Fruit was the major food item for extended time of olive baboon, but it can also feed on leaf, grasses, woody insects and roots (Dagnachew & Melese, 2016). The main reason for its restriction to woodland habitat in present study during dry season might be due to availability of fruits such as *Ficus sur*, *Carrisa edulis*, *Dovyalis abyssinica* and *Syzygium guineense*. Several studies from different localities in Ethiopia

reported the preference of this primate species in woodland and riverine habitat. For example, from Alatisch North Gonder (Girma & Afework, 2008), from Nechsar National park (Fetene et al., 2011), from Yayo Biosphere reserves Ilubabor (Gebrecherkos & Tilaye, 2012), and from Baroye Control Hunting Area, Ilubabor, Ethiopia (Dereje et al., 2015).

Colobus monkey (*C. gureza*) was relatively the third most abundant mammalian species recorded from Birbir protected forest. This species is known to have widely distributed across Africa continent ranging from Nigeria in the west to Ethiopia and Kenya in the east and from democratic republic of Congo in the south to Sudan in the north (Kingdon et al., 2008). In the present study it is frequently recorded from woodland during both seasons and also from grassland during wet season. The highest abundance of *C. gureza* was recorded during dry season in the present survey. This might be because low degree of visibility due to dense vegetation structure of the forest during wet season.

African buffalo (*Syncerius caffer*) is one of the largest herbivores of African savanna and endemic to the continent of Africa originating either from Ethiopian highlands or the great plains of West Africa (Furstenburg, 2003). According to Rayan (2006), African buffalo is among the most successful African mammals in terms of geographic distribution and abundance. They inhabit a wide range of habitats across Africa; from savanna grassland to thick forest (Sinclair, 1977). In the present study area it was relatively the fourth abundant species and distributed only in grassland habitat during both seasons. The abundance of this species in the present study area might be attributed to availability of large proportion of grassland habitat and palatable food, but during dry season it was rarely recorded from the edge of the grassland. This may be due to decrease in vegetation cover and availability of food during dry season.



Vervet monkey (*Chlorocebus aethiops*) is widely distributed and common species in northern, western and central Ethiopia occupying a wide variety of habitats ranging from riverine, tropical deciduous or montane forest comparatively open woodland. It frequents human settlement area and feeds extensively on cultivated plant (Meseret & Solomon, 2014). In the present study, Vervet monkey was common and fairly distributed in woodland habitat and always in conflict with local communities because of its crops raiding nature.

Blue monkey (*Cercopithecus mitis*) was the least common primate species recorded from the study area. It has recorded once in woodland habitat during the whole survey. This species is widely distributed in the Ethiopia and *C. mitis boutrlinii* is one of the sub species of *C. mitis* endemic to the country (Tesfaye, 2016). It is semi terrestrial primate inhabiting woodland habitat (Chapman 1984). It is highly sensitive to anthropogenic impact.

Interviews conducted with the local people revealed that the number of *C. mitis boutrlinii* was large before a decade. However, the number gradually declined due to habitat fragmentation, disease and human disturbance. As described by Chatelain et al. (1996) and Chapman et al. (2007), once forest fragmentation occurred, it continues with the formation of more fragmented habitats over time. This pattern gradually limits the size of the forest below which the species is no longer able to survive. This subspecies was listed as Vulnerable by International Union for Conservation of Nature (IUCN) because of extensive and uncontrolled destruction of forests (Kingdon, 2003).

Majority of medium and large-sized mammals recorded (86%) from Birbir Protected Forest during the present study were herbivores. The highest proportion of herbivores recorded in the present study area agrees with the finding of Rabira et al. (2015), Dereje et al. (2015) and Mosisa & Afework (2016). African savanna biome carries the earth's greatest diversity of ungulates and has

sustained multispecies animal production systems for millennia. The most evident of the biologically interesting features of African savanna ecosystems are high densities and diversities of large mammalian herbivores (Berger et al., 2001). The high diversity of herbivores species in the present study area was probably attributed to the large proportion of Grassland habitats and sufficient grass for grazing. Beside this, the grassland and some parts of woodland regularly burn during the dry season. This would allow regeneration of fresh grasses of high nutritive value that can support large diversity of grazers during the rainy season. Rainfall, fire and herbivores are the prime driving variables in African savanna ecosystems (Dutoit & Cumming, 1999).

Carnivores were rarely recorded in the present study. Only two species, spotted hyena and honey badger (14%) were carnivore among mammalian species recorded from the current study. The distribution and abundance of these species in the present study was least. Spotted hyena was recorded indirectly by its droppings, vocal call, foot print and underground hole in grassland and woodland habitat and honey badger was recorded directly once during the whole study period. The least abundance of these carnivorous species was also reported by Rabira et al. (2015) and Mosisa & Afework (2016). The possible reason for infrequency of these carnivores from the present study might be due to their nocturnal nature, solitary and naturally rare and secretive behavior. Hunter and Yonzo (1993) described that most carnivore species are solitary, nocturnal and crepuscular so that their presence could not be easily documented. Or the absence of carnivores such as lion and leopard might be due to high environmental pressure loss of habitat as these are requires large area.

6. CONCLUSIONS

The study surveyed medium and large-sized mammalian fauna of Birbir Protected Forest which is one of recently established protected area in western Ethiopia. The current study documented 14 species of medium to large sized



mammals. Even though the size of the area is small, the forest is a unique ecosystem being at western lowland edge of southwestern tropical forest of the country. The largest proportion of Grassland and Woodland associated with Riverine habitat form ideal habitat for conservation harboring large mammals such as African buffalo and Hippopotamus and globally threatened species such as Lion and Leopard. Although the number of species recorded in this study are relatively low, its provide baseline information about the medium to large size mammalian diversity of the study area.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest regarding the publication of this paper.

ACKNOWLEDGEMENTS

We are so thankful to Ethiopian Ministry of Education for financial assistance and Oromia Forest and Wildlife Enterprise of Wollega district for designing study area's map and other relevance information. Our heartfelt gratitude also goes to those who contribute directly or indirectly to the successful completion of this study.

REFERENCES

Afework, B. and Yalden, D. (2014). "Mammals of Ethiopia and Eritre," Addis Ababa University Press. Addis Ababa, Ethiopia, 391.

Afolayan, A.T. and Ajayi, S.S. (1980). "The influence of seasonality on the distribution of large mammals in the Yankari Game Reserve, Nigeria," African Journal of Ecology, 18, 87–96.

Afolayan, T.A. (1976). "The influence of seasonal on the distribution of large mammals in Yankari Game reserve, Nigerian," Proceeding of the 3rd Wildlife Symposium for Eastern Africa, Mweya, Uganda.

Ajibade, W., Adeyemo, A. and Agbelusi, E. A. (2011). "Population density and distribution of green monkey (*Cercopithecus aethiops* Linnus, 1758) at

Zugurma sector of Kainji lake national park, Nigeria," African Journal of Agricultural Resource, 6, 2456-2460.

Andelman, S. and Fagan, W. (2000). "Umbrellas and flagships," Efficient Conservation Surrogates or Expensive Mistakes. Preceding the National Academy Sciences, 97, 5954 –5959.

Bailey, J.A. (1984). "Principles of Wildlife Management," John Wiley, New York, USA, 373.

Balakrishnan, M. and Easa, P. S. (1986). "Habitat preference of large mammals in the Parambikulam Wildlife Sanctuary. Karala, India," Biol. Conserv., 37, 191–200.

Belete, T. and Mesele, M. (2016). "Assessment of large mammal's potential in Tulujuja Wildlife Reserve, Southwestern Ethiopia," International Journal of Agriculture and Life Science, 2, 80-86.

Berger, J., Stacey, P.B., Bellis, L. and Johnson, P. (2001). "A mammalian predator–prey imbalance," Grizzly bear and wolf extinction affect avian neotropical migrants. Ecological Application, 11, 947–960.

Blower, J. (1969). "The wildlife of Ethiopia," Oryx, 4, 45 – 57.

Boniface, O. (2001). "Spatial Patterns of Species diversity in Kenya," PhD. Dissertation, Wageningen University. Wageningen, Netherland, 157.

Chapman, C.A. (1984). "Speciation of tropical rainforest primates of Africa," Insular Biogeography. African Journal of Ecology, 21, 297-308.

Chapman, C.A., Naughton-Treves, L., Lawes, M.J., Wasserman, M.D. and Gillespie, T. R (2007). "Population declines of Colobus in western Uganda and conservation value of forest



- fragments,” *International Journal of primatologists*, 28, 513-528.
- Chatelain, C., Gautier L. and Spichiger, R. (1996). “A recent history of forest fragmentation in southwestern Ivory Coast,” *Biodiversity and Conservation*, 5, 37-53.
- Cortes, M., Martine, A. and Brones, M. (2014). “Diversity of medium and large mammals in Juchtan, Istmus of Tehuantepec, Oaxaca, Mexico,” *Animal Biodiversity and conservation*, 37, 1-12.
- Dagnachew, M. and Mesele, S. (2016). “Feeding Ecology of Olive Baboon (*Papio anubis*) in Arba Minch Forest, Arba Minch, Ethiopia,” *Journal of Natural Science Research*, 6, 21- 26.
- Davies, G., Storch, D. and Olson, V. (2007). “Topography, Energy and the Global Distribution of Bird Species Richness,” *Proc. R. Soc.*, 274, 1189 – 1197.
- Dawud, Y. (2008). “Mammalian diversity in Maze National Park, Ethiopia,” MSc. Thesis, Addis Ababa University, Addis Ababa.
- Dawud, Y. and Solomon, Y. (2013). “Mammals of Maze National Park, Southern Nations, Nationalities and Peoples Regional State, Ethiopia,” *SINET: Ethiopian Journal of Science*, 36, 55–61.
- Dereje, N., Gadisa, T. and Habtamu A. (2015). “The Diversity, Distribution and Relative Abundance of Medium and Large- sized Mammals in Baroye Controlled Hunting Area, Illubabor Zone Southwestern Ethiopia,” *International Journal of molecular and Biodiversity*. 5, 1-9.
- Dinakaran, S. and Anbalagan, S. (2007). “Effects of riparian vegetation on the functional organization of stream communities in southern Western Ghats,” *Journal of Aquatic Biology*, 22, 25-31.
- Du Toit, J.T., Rogers, K.H. and Biggs, H.C. (2003). “Surface water availability,” Implications for heterogeneity and ecosystem processes. In: *The Kruger Experience: Ecology and Management of Savanna Heterogeneity*. (Du Toit, J. T., Rogers, K. H., Biggs, H. C. eds.), Island Press, Washington D.C., 171 –188.
- Du toit, T. and Cumming, D.H. (1999). “Functional significance of ungulate diversity in African savannas and the ecological implications of the spread of pastoralist.” *Biodiversity Conservation*, 8, 1643 –1661.
- EBI- Ethiopian Biodiversity Institute (2014). “Ethiopia’s Fifth National Report to the Convention on Biological diversity”. Addis Ababa, Ethiopia.
- Elliott, K. and Hewitt, D. (1997). “Forest Species Diversity in Upper Elevation Hardwood Forests in the Southern Appalachian Mountains,” *Castanea*, 62, 32-42.
- Emmons, L. and Feer, F. (1997). “Neotropical Rain forest Mammals,” University of Chicago Press, USA, 380.
- Erb, J. (2005). “Predator scent post survey and winter track indices,” In *Status of Wildlife Populations*, ed, vol. M.H. Dexter, Ed. Minnesota: Division of Fish and Wildlife, Minnesota Department of Natural Resource, 47-60.
- Fetene, A., Mengesha, G. and Bekele, T. (2011). “Spatial distribution and habitat preferences of selected large mammalian species in the Nech Sar National Park (NSNP), Ethiopia,” *Nat. Sci.*, 9, 80-90.
- Freilich, X., Tollis, M. and Boissinot, S. (2014). “Hiding in the highlands,” Evolution of a frog species complex of the genus *Ptychadena* in the Ethiopian highlands. *Journal of Molecular and Phylogenetic Evolution*, 71, 157-169.



- Funston, P.J. (1992). "Movements, Habitat Selection and Population Structure of Buffalo (*Syncerus caffer caffer*) in the Sabi Sand Reserve," M.Sc. Thesis, University of Pretoria, South Africa.
- Furstenburg, D. (2003). "Kaapse buffel *Syncerus caffer caffer*," Suid Afrikaanse, Wilden Jag September, 8–11.
- Galleti, M., Giacomini, H. and Bueno, R. (2009). "Priority areas for conservation for Atlantic forest large mammals," *Journal of Biological Conservation*. (2009), 1229-1247.
- Gary, R., Matthew, G. and Blaire, V. (2009) "The Ecological Role of the Mammalian Meso-carnivore," *Biological Science*, 59, 165–173.
- Gebrecherkos, W. and Tilaye, W. (2012). "A survey on mammals of the Yayu forest in southwest, Ethiopia," *SINET: Ethiop. J. Sci.*, 35(2), 135-138.
- Gerrit, J. (2010). "Mammalian diversity threat and acknowledge across spacial scales," M. Sc. Thesis presented to collage of Natural Resource, University of Indaho, Indaho Moscow, 202.
- Girma, M. and Afework, B. (2008). "Diversity, distribution and habitat association of large mammals of Alatish, North Gonder, Ethiopia," *Acta Zoologica Sinica*, 54, 20-29.
- Gundogdu, E. (2011). "Population size, structure and behaviours of wildgoat in cehennemdere wildlife improvement area," *Asian Journal of Animal Veterinary Advantages*, 6, 555-563.
- Gutema, J. (2015). "Large Mammal Diversity and the Ecology of African Buffalo (*Syncerus caffer* Sparrman, 1779) in Dhati Wolel National Park, Western Ethiopia," Ph.D. dissertation submitted to department of Biology (Ecological and Systematic zoology stream), Addis Ababa University, Addis Ababa, Ethiopia. 137.
- Hassani, N., Asghari, H.R., Frid, A. S. and Nurberdief, M. (2008). "Impacts of overgrazing in a long term traditional grazing ecosystem on vegetation around watering points in a semi-arid rangeland of NorthEastern Iran, Pak," *Journal Biological Science*, 11, 1733-1737.
- Hawkins, B.A., Field, R. and Cornell H.V. (2003). "Energy, water, and broad-scale geographic patterns of species richness," *Ecology*, 84, 3105–3117.
- Hunter, M. L. and Yonzon, P. (1993). "Altitudinal Distribution of Birds, Mammals, People, Forests and Parks in Nepal," *Conservation Biology*, 7, 420- 423.
- IUCN (2008). "IUCN Red List of threatened animal species", IUCN. Barcelona.
- Johnson, C., Piel, A.K., Forman, D., Stewart, F.A. and King A.J. (2015). "Ecological determinants of baboon troop movements at local and continental scales," *Mov.Ecol.*, 3, 14 – 20.
- Joubert, C.J. (1976). "The Population Ecology of the Roan Antelope (*Hippotragus equinus equinus*, Desmera, 1804) in the Kruger National Park," Ph.D. Dissertation, University of Pretoria, Pretoria.
- Kassaye, B. and Tsegaye, D. (2016). "Prevalence of Bovine Trypanosomosis, Tsetse Density and Farmers Perceptions on the Impact of Control Program in KelleWollega Western Oromia, Ethiopia," *Journal of Veterinary Science and Technology*, 7, 295.
- Kemp (2005). "Origin and evolution of mammals," Oxford university press, New York, 342.
- Kendall, C.J. (2011). "The spatial and agricultural basis of crop raiding by the vulnerable common hippopotamus, *Hippopotamus amphibious* around



- Ruaha National Park, Tanzania,” *Oryx*, 45(1), 2834.
- Kingdon, J. (2003). “Kingdon Field Guide to African Mammals,” London: Academic Press, London.
- Kingdon, J., Gippoliti, S. and Butynski, T.M. (2008). “*Cercopithecus mitis*. In: IUCN 2012. IUCN Red List of Threatened Species.
- Kisel, Y., McInnes, L., Toomey, N.H. and Orme, C.D.L. (2011). “How diversification rates and diversity limits combine to create large-scale species–area relationships,” *Phil. Trans. R. Soc.B.*, 366, 2514–2525.
- Lewison, R. (2007). “Population responses to natural and human – mediated disturbances: assessing the vulnerability of the common hippopotamus (*Hippopotamus amphibius*),” *African Journal of Ecology*, 45, 407- 415.
- Lewison, R. and Carter, J. (2004). “Exploring behavior of an unusual megaherbivore,” A spatially explicit foraging model of the hippopotamus. *Ecological Modelling*, 171, 127–138.
- Leykun, A. (2000). “The Challenge of conserving Ethiopian Wildlife,” *Overview. Walia*, 31, 56-61.
- Lombardi, L., Fernandez, N., Moreno, S. and Villafuerte, R. (2003). “Habitat-related differences in rabbit (*Oryctolagus cuniculus*) abundance, distribution and activity,” *J. Mamm.*, 84, 26–36.
- Maira, B. (2016). “Medium and Large-sized Mammals,” Core Standardized Methods for Rapid Biological Field Assessment. (Larsen, T.H. eds). Conservation International, Arlington, VA.
- Matias, M.G., Underwood, A.J., Hochulo, D.F. and Coleman, R.A. (2011). “Habitat identity influences species-area relationships in heterogeneous habitats,” *J. Mar. Ecol. Prog. Ser.*, 437, 135-145.
- Melaku, T. (2011). “Wildlife in Ethiopia,” *Endemic large mammals. Journal of Zoology*, 6, 108-116.
- Meseret, C. and Solomon, Y. (2014). “Diversity of Medium and large-sized mammals in Borena sayint National park, South wollo, Ethiopia,” *International journal of sciences, Basic and applied research*, 15, 95-106.
- Messele, A. (2007). “Damage Caused by Large Mammals in Wonji-Shoa Sugarcane Plantation, Central Ethiopia,” MSc. Thesis. Addis Ababa University, Addis Ababa Ethiopia, 68.
- Mohammed, K. and Afework, B. (2017). “Diversity, Abundance and Distribution of Mammals in Fragmented Remnant Forests around Asella Town, Ethiopia,” *Journal of Biology and Medicine*, 1, 1-12.
- Mosisa, G. and Afework, B. (2016). “Survey of medium and large-sized mammals in Wacha Protected forest, Western Ethiopia,” *Journal of agricultural science*, 6, 71-79.
- Muchai, M., Yeg, F. and Kamau T. (2008). “Ishaqibin Conservancy,” Large Mammal Distribution, Abundance and Habitat Use, Report 02. National Museum of Kenya.
- OFWEWD- Oromia Forest and Wilife Enterprise Wollega District (2016). “Annual report,” Dembi dollo, Ethiopia, 22.
- Olifiers, R. and Fizon, T. (2005). “Relation between small-mammal species composition and anthropogenic variables in the Brazilian Atlantic Forest,” *Brazilian Journal of Biology*. 65, 495-501.



- Owen-Smith, N. (2002). “Adaptive Herbivore Ecology,” From Resources to Populations in Variable Environments. Cambridge University Press, Cambridge.
- Quansah, Y. (2010). “Survey of medium sized mammals in Asubima Forest Reserve,” MSc. Thesis Submitted to Department of Wildlife and Range Management, Kwame Nkrumah Science and Technology University, Ghana, 24.
- Rabira, G., Tsegaye, G. and Tadesse, H. (2015). “Diversity, abundance and Habitat association of medium and large-sized mammals of Dati Wolel National Park, Western Ethiopia,” International journal of biodiversity and conservation, 7, 112-118.
- Rayan, S.J. (2006) “Spatial Ecology of African Buffalo (*Syncerus caffer*) and Their Resources in a Savanna Landscape,” Ph.D. Dissertation, University of California, Berkeley.
- Reeder, D., Helgen, K. and Wilson, D. (2007). “Global trends and biases in new mammal species discoveries,” Occasional Papers, Museum of Texas Tech University, 269, 1-35.
- Sefi, M. and Birnesh, H. (2016). “Ecological behavior of common hippopotamus (*Hippopotamus amphibius*, Linnaeus, 1758) in Boye wetland, jimma, Ethiopia,” American Journal of Scientific and Industrial Research, 2, 41- 49.
- Simberloff, D. (1998). “Flagships, umbrellas, and keystones,” is single species management passé in the landscape era? *Biological Conservation*, 83, 247–257.
- Sinclair, A. E. (1977) “The African Buffalo,” A Study of Resource Limitation of Populations. University of Chicago Press, Chicago.
- Subramanian, K.A., Sivaramakrishnan, K.G. and Gadgil, M. (2005). “Impact of riparian land use on stream insects of Kudremukh National Park, Karnataka state,” *Indian Journal of Insect Science*, 5, 49 - 49.
- Tegegn, M., Abebe, A. and Tadesse, M. (2017). “Assessment of the abundance of Anubis baboons (*Papio anubis*) and conflict with humans in Tsirigni Forest of Gida Ayana District, Western Ethiopia,” *Journal of Ecology and the Natural Environment*, 9, 1-14.
- Tesfaye, D. (2016). “Ecology, Behaviour and Conservation of Boutourlini’s Blue Monkey (*Cercopithecus mitis boutourlinii*) in the Jibat Forest, Ethiopia,” MSc. Thesis, Department of Biology, Addis Ababa University, Addis Ababa, Ethiopia, 50.
- Vaughan, T., Ryan, J. and Czaplewski, M. (2000) “Mammalogy,” 4th ed. Saunders collage publishing, New York. USA.
- Vreugdenhil, D., Vreugdenhil, A. and Tamrat, T. (2012). “Gap Analysis of the Protected Areas System of Ethiopia,” with Technical Contributions from Nagelkerke, L., Gedeon, K., Spawls, S., Yalden, D., Lakew Berhanu and Siegel, L. World Institute for Conservation and Environment, USA, 188.
- Whiten, A. and Barton, R. (1994). “Reducing complex diets to simple rules: Food selection by Olive Baboon,” *Behav. Ecol. Sociobiol.*, 35, 283-293.
- Williams, P., Burgess, N. and Rahbek C. (2000). “Assessing large flagship species for representing the diversity of sub-Saharan mammals,” In: *Priorities for the Conservation of Mammalian Diversity: Has the Panda Had Its Day?* (Enwistle, A and Dunston, N. eds.), Cambridge University Press, Cambridge, USA, 85 –99.
- Zarihun, G., Yosef, M. and Mateos, E. (2012). “Species composition, distribution and Relative Abundance of Large Mammals in and around Wondo Genet



Forest Patch, Southern Ethiopia,” Asian Journal of applied science, 5, 538-551.