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Distribution And Conservation Challenges Of Diurnal Large Mammals In Bayo Community Managed Forest, Salamago Woreda, South Omo Zone, Southern Ethiopia

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Abstract

An ecological study on diurnal mammals was carried out in Bayo Community Managed Forest located in Salamago Woreda, South Omo Zone. The objective of the study was to investigate the distribution and conservation challenges of diurnal large mammals in the study area. Based on the habitat type and topography of the study area, total of 11 transect, i.e 7 in forestland, and 4 in Wooded Grassland were laid to collect the data. Besides direct methods, indirect methods such as faecal droppings, fresh tracks, carcass or shell count, den (burrow), hair, and digging were used. Questionnaire and focus group discussions were also used to assess anthropogenic threats in the study area. Data were analyzed using descriptive statistics, SPSS and QGIS software. A total of 20 species of diurnal large mammals belonging to six orders and eight families were identified. The species identified were Cercopithecus pygerythrus, Cercopithecus aethiops, Papio anubis, Erytherocebus patas, Cercopitheus neglectus, Colobus guereza, Equus quagga, Traglaphus strepsiceros, Traglaphus imberbis, Traglaphus scriptus, Medagua guentheri, Sylvicapra grimma, Kobus ellipsiprymnus defessa, Syncerrus caffer, Potamochoerus larvatus, Phacochoerus africanus, Hylochoerus meinertzhageni, Hystrix cristata, Orycteropus afer, and Phataginus temminckii smutus. Seasonal variation in the between habitat types ($\chi 2 = 4.849$, df= 1, $p<0.05$). Totally, 685 and 600 mammals were counted during wet and dry seasons, respectively. On habitat basis, 683 and 602 animals were recorded in forestland and wooded grassland habitats, respectively. Major threats in the study area include poaching, fire, grazing, fuelwood extraction, population growth, habitat modification, overharvesting of resources,and invasive species. About 98.44% of respondents had a positive attitude towards Bayo Community Managed Forest. The interference of local community has had the impact on mammals species. Habitat based mammals management involving participation of Woreda and Zonal Government is recommended for sustainable. The local government should promote the study area and provide appropriate support for its conservation.

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Introduction

Tropical Africa has greater mammalian diversity than any other area of the world [1]. This region supports most of the mammalian fauna [2] [3]. Fifteen per cent of

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large mammalian species distribution and abundance are found in most forest and savannah regions in Africa and it is of the utmost importance to protect them for the role they play in the ecosystem [4].

Ethiopia is one of the countries found in the eastern horn of Africa[5]. which is endowed with spectacular landscape and topography from which diverse habitats and associated flora and fauna are found [6] [7]. Unique resources of wildlife, scenic beauties and diverse culture immersed in a long history have been visited since long ago [7]. Geographically, stratified into several ecological units, the associated diversity in climate and the varieties of ecosystems have rendered the country has a diverse, rare, unique and endemic species of wildlife [8]. In the near past, these wild animals (mammals, birds, amphibians, reptiles and fish) were abundant in a bewildering variety, but currently in a declining state due to anthropogenic pressures [6] [7] [9]. The country is also rich in its faunal diversity [10]. The Ethiopian mammal fauna consists of 326 species, under 144 genera, 43 families and 14 orders [10] [11]. The number of mammals in Ethiopia is much higher than in other African countries [12].

Mammals are mainly concentrated in the southern parts and southwest border and adjacent areas of the country [12]. The mountain massifs in the north and centre parts are also home to many endemic species of mammals, particularly the Ethiopia wolf (Canis simensis), Gelada baboon (Theropithecus gelada), Menelik's bushbuck (Tragelaphus scripus Meneliki), Mountain Nyala (Tragelaphus buxtoni), Starch's hare (Lepus Starcki) ,Swayne's, hartebeest (Alcelaphus buselaphus), Bale monkey (Chlorocebus djamdjamensis) and Waliai Ibex (Capra walie) [11] [12] [13]. Evan et al., 2020). The Ethiopian wild fauna are comprised of 326 mammals, 918 birds, 240 reptiles, 200 fish, 71 amphibians and 1,225 arthropods (324 butterflies) (EWCA, 2020). Of these; 177 (57 small to large mammals, 19 birds, 25 reptiles, 30 amphibians, 41 fresh-water fishes, and 7 arthropod species) are endemic species, which results in the countries' status as a global biodiversity hotspot [7] [10] [11].

The main challenges of mammals in the protected areas of the country include overgrazing and encroachment from pastoral people, shifting cultivation and permanent agriculture, human settlements, increased demand and extraction of fuelwood, wood logging, construction materials, uncontrolled fires, illegal poaching and hunting, charcoal burning, illegal fishing and extraction of other natural resources [7] [14] [15] The invasive plant species and native plant species encroachment are also new agenda threat to extinction of mammalian specie and their habitat [16] . The loss of forests and protected areas are underpinned by population growth, unsustainable natural resource management, poor enforcement of existing legislation, uncertain land tenure, the impact of climate change and very low public awareness of the importance of biodiversity [17] [18]. The objectives of the study are therefore as follows; develop distribution map of diurnal large mammals and identify major threats to diurnal large mammals in the study area. Therefore, the present study would have highly valuable to provide the baseline information about the current status and effective conservation approaches.

Description of the Study Area

Salamago Woreda is found in South Omo Zone, southern Ethiopia. It is located between 5021' -6027'N and 36021'-37057'E. The elevation is ranging between 383m and 2543m asl. It is about 800 and 530 km southwest of Addis Ababa and Hawassa, respectively, and 374kms far from Arba Minch and 123 km from Jinka (capital city of South Omo) (Fig 1). The word "Salamago" named after the name of two streams-" Sala " and " Mago".Bayo community-managed natural forest is located in Salamago Woreda. Bayo or "Kub Gasho" named closed and no human interface forest in Dime ethnic group language (Biyo is the Amharic name of forest). It is located between 6014'30"- 6015'0"N and 36013'30-36019'30"E . The

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elevation is ranging between 900m and 2543masl. It is about 24 km from Salamago Woreda (Hana city). The forest area coverage is 109.81km2 (10,981ha). Boundary designated and the forest was established in 2009. However, the boundary was redemarcated and being legalized by SNNPRS in 2019. It is the community managed forest which is bordered by three kebeles namely: Dime Woyde, Dime Erqa, and Dime Garfa kebele. The forest is currently supported by the REDD+ project.

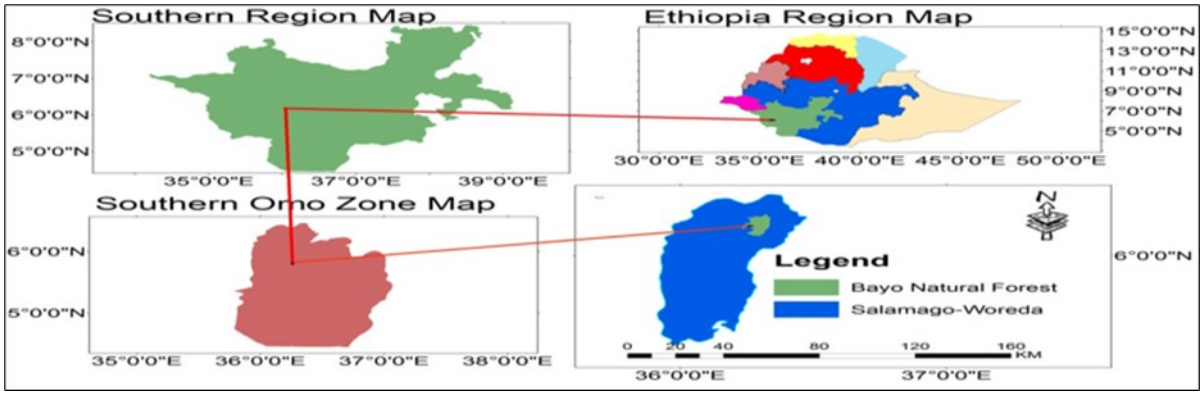

Figure 1. Map of the study area

Climate

The rainfall in the region is bi-modal. Main rainy season is from March to July and short rainy season is from August to September. The mean monthly maximum and minimum temperatures are 41.140C and 200C, respectively.

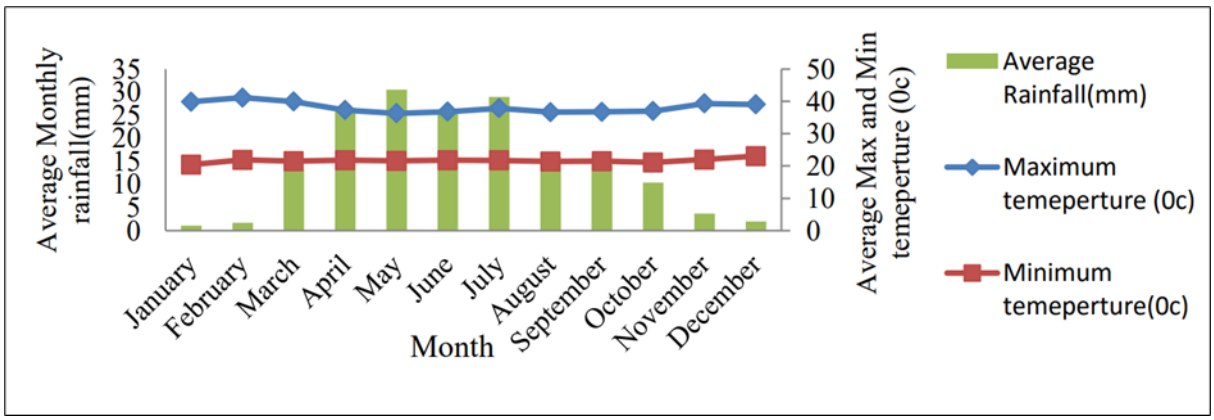

Figure 2. Average monthly rainfall and temperature of salamgo

Landscape

Bayo community forest surroundings have unique natural, features such as, mountain chains at Jemesho, Jemesho water, Jemsho river fall, Bezi water, and Hot spring water. Both Jemesho water and Hot spring water is endowed with scenic beauty to attract many international and local tourists. The local community belived the water has therapeutic use as well as spiritual Power. Jemesho Mountain is the biggest

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mountain in Salamago Woreda, which is found inside Bayo community forest. Jemesho Mountain is the water tower to Salamago Woreda, particularily to Muri, Bodi, Banchi, Konso and Dime community.

Vegetation types and habitat classification

The major vegetation types of the Bayo community-managed forest area are characterized by Moist Evergreen Montane Forest Ecosystem to Combretum-Terminalia woodland Ecosystem. The area coverage of each vegetation type is calculated using Landsat images are obtained from NASA and United States Geological Survey (USGS) Global Land Survey (GLS) program.

Table 1. Land covers type in the study area

Land cover type	Area (km^2)	Perecentage
Bayo Wooded Grassland	34.58	31.49
Bayo forestland	75.23	68.51
Total	109.81	100

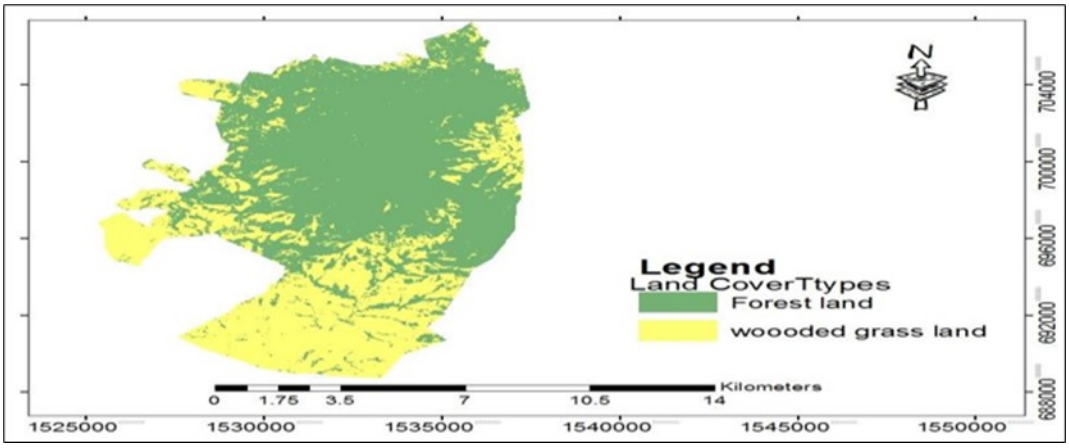

Figure 3. Land cover of Bayo community managed forest in February, 2021.

The most dominant ground cover herbs in the forestland are Ethiopian cardamom, Ginger, some Acanthaceae family Justicia herbs and climber species. Some trees, shrub and herbs species in the forestland are : Flacourtia indica, Podocarpus falcatus, Asparagus africanus, Vernonia species, Olea africana, Croton macrostachyus, Syzygium guineense, Euphorbia ampliphyla, Maesa lanceolata, Ficus thonningii, Ficus elastica, Ficus vasta, Carissa edulis, Hagenia abyssinica, Embelia schimperi, Dombeya torrida, Terminalia schimperi, Coffee arabica, Erythrina burana, Celtis Africana.

The plant species in the wooded grassland are Cordia africana, Croton macrostachyus, Terminalia schimperi, Ximenia americana, Ficus spp, Ficus thonningii, Acacia spp., Cordia spp, Dobera glabra, Ximenia Americana, Combretum aculeatum, Salvarora persica, Combretum molle, Combretum aculeatum, Dichrostachys cinerea, Commiphora abyssinica, Terminalia browni, Terminalia mantaly, Sclerocarya birrea, Ziziphus mucronata, Vernonia spp., Syzigum guineese, Acacia abyssinica.

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Figure 4: The Forestland at Bayo community managed forest, Southern Ethiopia (Photo: Tamirat Haile, 2021).

Figure 5: The Wooded grassland at Bayo community managed forest, Southern Ethiopia

(photo: Tamirat Haile, 2021).

Materials and Methods

Materials

Material used for this study include: Binocular, Telescope, Digital camera, Field data sheet, Global positioning system, satelite map, compass, Kingdon Field guide of mammals, Data Sheet, Notebook, and Questionnaire.

Research approach

Based on habitat type and topography, the study area stratified into two-forestland and wooded grassland. Then transect were laid in each habitat type. On these transects direct survey methods were used to collect data on distribution of diurnal mammals in the study area. Besides, indirect survey methods such as fecal droppings, fresh tracks, Carcass or shell count, Den (burrow), hair, and digging were used. Questionnaire and focus group discussions were used to investigate anthropogenic threats in the study area.

Research Sampling Techniques

Sampling Techniques for mammal's survey

Line transect sampling method was used to study distribution of diurnal large mammals in the forest following

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[19] [20] [21]. Starting and end points of each transect line was delineated by GPS and permanent natural signs. The total area coverage of the Bayo community managed forest is 109.81km2, of which 42.34% (46.5km2) of the study area was sampled. With respective to habitat types 31.86km2 and 14.64km2 forestland and wooded grassland, respectively. The number potential transects were 64 in both habitat types considering the steep flates and clip area. Depending on the sampled area, a total of 11 actual transect lines were randomly established, 7 in forestland, and 4 in the wooded grassland. The length of transect line was varied from 3.5 to 5km depending on the habitat and topography. For selected and surveyed transect lines, the total length was 46.5km; of which 29.5km was in forestland and 17km was in wooded grassland. The gap between consecutive transects was maintained at 0.5km to avoid any double counting of animals in the study area. To avoid edge effects, steep flates and clip area, transects were spaced 0.2km from the edge of the each habitat types, steep flates and clip.

Table 2. Sampled line transects in the study area

Number	Length (km)	Habitat	Area (Length and width)
Transect1	5km	Forestland	5km*1km = 5 km^2
Transect2	4.5km	Forestland	4.5km*1km = 4.5km^2
Transect3	4km	Forestland	4km*1km = 4km^2
Transect4	4km	Forestland	4km*1km = 4km^2
Transect5	4km	Forestland	4km*1 km = 4km^2
Transect6	3.5km	Forestland	3.5km*1 km = 3.5 km^2
Transect7	4.5km	Forestland	4.5km*1 km = 4.5 km^2
Transect8	5km	wooded grassland	5km*1km = 5km^2
Transect9	5km	wooded grassland	5km*1km = 5 km^2
Transect10	3.5km	wooded grassland	3.5km*1km = 3.5 km^2
Transect11	3.5km	wooded grassland	3.5km*1km = 3.5 km^2

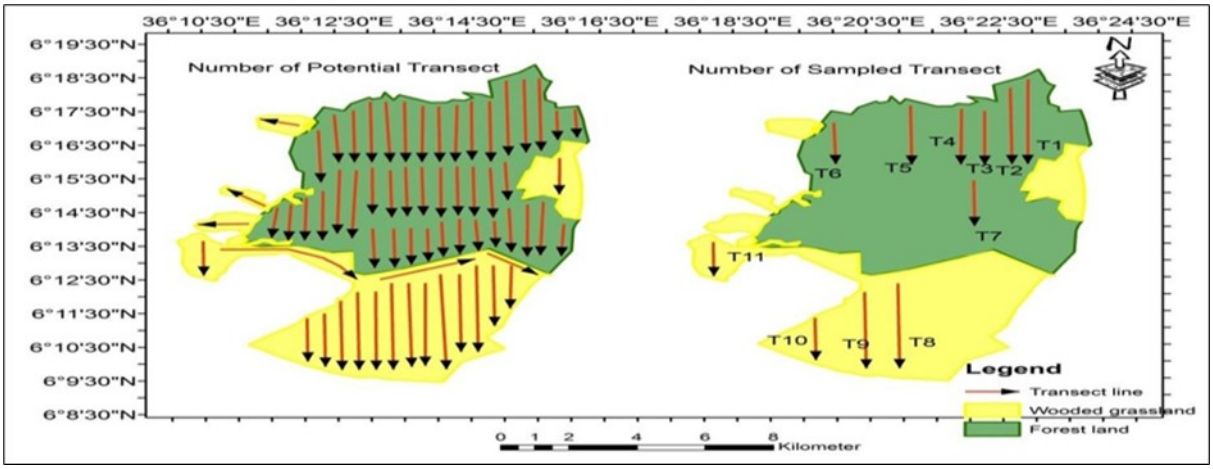

Figure 6. The number of potential and sampled transects in the study area

Questionnaire survey and focus group discussion for conservation challenges

Salamago Woreda consists of 22 kebeles.Thus, based on proximity to the forest, three kebeles namely: Dime Woyde, Dime Erqa and Dime Garfa kebeles were selected purposively. The number of households in each kebele was, 283, 194, and 168 for Dime Woyde, Dime Erqa and Dime Garfa, respectively. Following [22], 10% of the total population (n=64) was used as sample population. Accordingly, the sample

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size distribution in each kebele was 28, 19 and 17 for Dime Woyde, Dime Erqa, and Dime Garfa, respectively. Sampling frame in order to identify householdes in each kebele was calculated using systematic random sampling technique.

$$K = \frac{N}{n}$$

where, K is the sampling frame (size of selection interval), N is the total number of households (HH) in the kebele and n is the sample size allocated in the kebele. Moreover, focus group discussions were conducted with kebele leaders (n= 12), local elders (3), agriculture development Agent experts (3), and 1 expert from REDD+ Project. Hence, the sample sizes for the study become 83.

Data Collection

Field Mammals Survey

Data were collected from Feburary to December 2021. Both wet and dry season months were included in the study. Thus, seasonal data were collected during May – July 2021 and October – December 2021 for wet and dry seasons, respectively. Transects were visited twice a month during the study period. Transects were traversed on foot with average speed of 2 - 2.5km/hr and the starting and ending points of each transect was marked using Garmin 64 GPS [23].To enhance sampling effort, in a single visit, each transect was walked twice morning hours 06:00–10:00 AM and afternoon from at 02:00–06:00 PM while many mammals are become active for feeding and maximum animal observation was possible [23] [24]. During direct observation both naked eye, telescope and binocular (10*42mm Resolution) were used to observe animals following the transect route. During transect visit, the researcher and three trained local field assistants were traversed the track lines. Each two were assigned to the left and right side of the transect line and scanned the route following [25]. [1]field guide of mammals were used for species identification. In order to determine the spatio-temporal distribution of mammals the ground truth points collected via GPS were transferred to computer database. All mammals encountered along line transects were recorded on data sheet prepared for this purpose [26]. At each observation event, species name, number of individuals and sighting distance were recorded on the data sheet.

Furthermore, indirect evidences of animals presence such as tracks/imprints, fecal/scat and den/burrow found along the transect line were also recorded [27] [28]. The local community of the study area were consulted for vernacular or local name of animals, call and sign identifications of the mammalian species.

Conservation challenges survey

In order to collect information about the anthropogenic threats to the forest in the study area, questionnaires and focus group discussions were used.

Household Survey

First, the questionnaires were prepared in English but later translated into local language that widely spoken in the area (Dime Ethnic group language) so as to obtain the required information without language barrier. The structured questionnaires contain both open and close ended questions to get information about anthropogenic activities in the study area. Questionnaire covered demographic information, such as age, sex, education level, village name, about forest, illegal Fire, livestock grazing invasive or climate changes, and attitudes of the community towards wildlife modified from [29].

Focus Group Discussion

Focus group discussions were conducted from three kebele so as to complement the information gathered through questionnaires. Focus group discussions (n=19) were conducted from three kebele, Dime

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Woyde, Dime Erqa, and Dime Gerfa community. To collect information about the forest in relation to its faunal composition. The nearby to forest community leaders focus group discussion with each kebele administrators was conducted. From different age group i.e. Kebele Leaders, Local Elders, community ,members and community rangers based focus group discussion with each kebele people were carried outed. Information obtained from group discussion were summarized used text analysis methods, and report as narrative form of note.

Data Analysis

The identified species were taxonomically grouped into their respective order, family, scientific species, common name was analysed by Microsoft EXCEL program. species richness computation, the minimum number of species identified were considered. Species richness was analysed by Microsoft EXCEL programs. The spatio-temporal distribution map was analyzed by QGIS software 3.4 version. Moreover, figures, tables, and charts were used to present the results of the study. The questionnaire survey data was analyzed and compared by computer program SPSS version 20.0, whereas FGD data were analyzed summarized used text analysis methods and report as narrative form of note.

Results

During the present investigation, a total of 20 diurnal large mammalian species were identified and recorded in the Bayo community managed forest in both the dry and wet seasons. In the survey, all of these species were recorded within the randomly selected sampling habitats of the two major habitat types.

Species composition was assessed based on season and habitat types. Accordingly, 19 and 20 species were recorded during wet and dry seasons, respectively. Hence, seasonal variation in the number of species of mammals was not statistically significant ($\chi 2 = 0.024$, df= 1, $p>0.05$) (Table 4). On a habitat basis, more number species (n= 17, wet season; n=18, dry season) was recorded in wooded grassland habitat than forestland (n= 10, wet season; n=14, dry season). DE Brazza's monkey and Giant forest Hog were recorded only from forestland whereas Patas monkey (Erytherocebus patas), Lesser kudu (Traglaphus imberbis), Guenther's Dik-dik (Medagua guentheri), Defassa waterbuck (Kobus ellipsiprymnus defessa), Aardvark (Orycteropus afer) and Ground pangolin (Phataginus temminckii smutus) were recorded only in wooded grassland habitat (Table 4 and Figure 8).

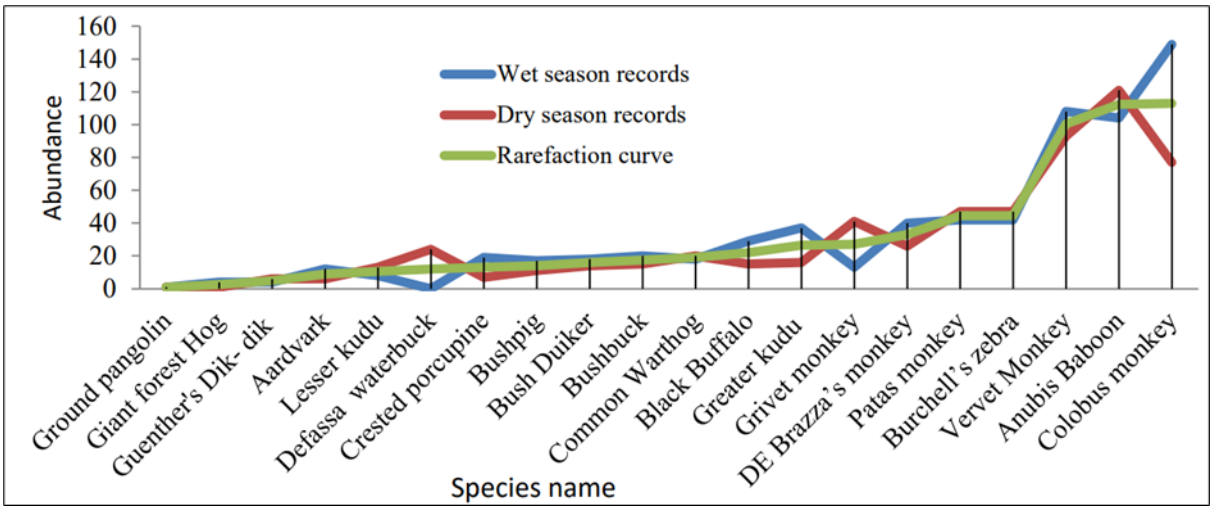

Figure 7. Mean number of species richness and frequency of records computed by rarefaction curve two seasons.

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Table 3. List of mammals recorded in Bayo community managed forest

ScientificName	Common Name	Local name	IUCN Category	CITES	BCMF status	Identification Methods
order Primates						
Family Cercopithecidae						
Cercopithecus pygerythrus	Vervet Monkey	Angum Kar	Least Concern	Appendix II	Common	Direct
Cercopithecus aethiops	Grivet monkey	Ftu Kar	Least Concern	Appendix II	Common	Direct
Papio Anubis	Anubis Baboon	Gydu	Least Concern	Appendix II	Common	Direct
Erytherocebus patas	Patas monkey	Alqum	Least Concern	Appendix II	Uncommon	Direct
Cercopitheus neglectus	DE-Brazza's monkey	Sudn	Least Concern	Appendix II	Common	Direct
Family colobidae						
Colobus guereza	Colobus monkey	Guru	Near- Threatened	Appendix II	Common	Direct
Order Perissodactyla						
Family Equidae						
Equus quagga	Burchell's zebra	Kubo yre	Near- Threatened	Appendix II	Common	Direct
Odrder Artiodactyla						
Family Bovidae						
Traglaphus strepsiceros	Greater kudu	Wugre	Near- Threatened	Appendix II	Common	Direct

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ScientificName	Common Name	Local name	IUCN Category	CITES	BCMF status	Identification Methods
Traglaphus imberbis	Lesser kudu	Marchne	Near Threatened	Appendix II	Uncommon	Direct
Traglaphus Scriptus	Bushbuck	Unibo	Least Concern	Appendix II	Uncommon	Direct
Medagua guentheri	Guenther's Dik- dik	Shuno	Least Concern	Appendix II	Uncommon	Direct
Sylvicapra grimma	Bush Duiker	Kolfi	Least Concern	Appendix II	Uncommon	Direct
Kobus ellipsiprymnus defessa	Defassa waterbuck	Kuku	Near-Threatened	Appendix II	Uncommon	Direct
Syncerrus caffer	Black Buffalo	Miku	Least Concern	Appendix II	Uncommon	Direct
Family Suidae						
Potamochoerus larvatus	Bushpig	Gudm	Least Concern	Appendix II	Common	Indirect (tracks,dropping and feeding tracks, carcass
Phacochoerus africanus	Common Warthog	Gashu	Least Concern	Appendix II	Common	Direct
Hylochoerus meinertzhageni	Giant Forest Hog	Kalakandi	Least Concern	Appendix II	Rare	Direct and Indirect (tracks)
Family Hystricidae						
Hystrix Cristata	Crested porcupine	Grish	Threatened	Appendix II	Rare	Indirect (tracks, carcass
Order Tubulidentata						
Family Orycteropodidae						
Orycteropus afer	Aardvark	Blikune	Threatened	Appendix II	Rare	Indirect (den or burrow),Holes
Order Pholidota						
Family Manidae						
Phataginus temminckii smutus	Ground pangolin	Kukuneche	Endangered	Appendix II	Rare	Indirect (shell,tracks)

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Table 4. Seasonal species composition and abundance of mammals among different habitats in BCMF

Species	Forestland		Wooded grassland		Total	
	Wet	dry	wet	dry	Wet	Dry
Vervet Monkey (*Cercopithecus pygerythrus)*	99	82	9	11	108	93
Grivet monkey (*Cercopithecus aethiops)*	-	8	13	33	13	41
Anubis Baboon (*Papio anubis)*	65	68	39	53	104	121
Patas monkey (*Erytherocebus patas)*	-	-	42	47	42	47
DE Brazza's monkey (Cercopitheus neglectus)	40	26	-	-	40	26
Colobus monkey (*Colobus guereza)*	131	63	18	14	149	77
Burchell's zebra (*Equus quagga)*	-	6	42	39	42	47
Greater kudu (*Traglaphus strepsiceros)*	-	5	37	11	37	16
Lesser kudu (*Traglaphus imberbis)*	-	-	8	13	8	13
Bushbuck (*Traglaphus scriptus)*	16	13	4	2	20	15
Guenther's Dik- dik (*Medagua guentheri)*	-	-	4	6	4	6
Bush Duiker (*Sylvicapra grimma)*	14	9	4	5	18	14
Defassa waterbuck (Kobus ellipsiprymnusdefessa)	-	-	-	24	-	24
Black Buffalo (*Syncerrus caffer)*	1	1	28	14	29	15
Bushpig (*Potamochoerus larvatus)*	8	7	9	4	17	11
Common Warthog (*Phacochoerus africanus)*	-	10	18	10	18	20
Giant forest Hog (*Hylochoerus meinertzhageni)*	4	1	-	-	4	1
Crested porcupine (*Hystrix cristata)*	3	2	16	5	19	7
Aardvark (*Orycteropus afer)*	-	-	12	6	12	6
Ground pangolin (*Phataginus temminckismutus)*	-	-	1	1	1	1
Total No. of individuals per habitat	381±7	302±5	304±3	298±3	685±7	600±6
Total No. of species per habitat	10	14	17	18	19	20

Distribution

Of the 1,285±20 individuals, 683 and 602 animals were recorded in forestland and wooded grassland habitats, respectively. Highest number of individuals recorded were during wet season in forestland (n=381); whereas the lowest record was during dry season in wooded grassland habitat (n=298). (Table 5). Seasonal variation in species richness was observed among the two different habitats. Accordingly, the highest species richness (n=18) was recorded in the wooded grassland habitat during the dry season and the lowest (n=10) was in forestland during wet season (Table 8). Hence, there was significant difference in species composition between habitat types ($\chi 2$ = 4.849, df= 1, $p<0.05$). Some species were recorded only in one season. For instance, Defassa waterbuck (Kobus ellipsiprymnus defessa) was recorded only during dry season in wooded grassland habitat. Grivet monkey (Cercopithecus aethiops), Burchell's zebra (Equus quagga), Greater kudu (Traglaphus strepsiceros) and Common Warthog (Phacochoerus africanus) were also recorded only during dry season in forestland habitat.

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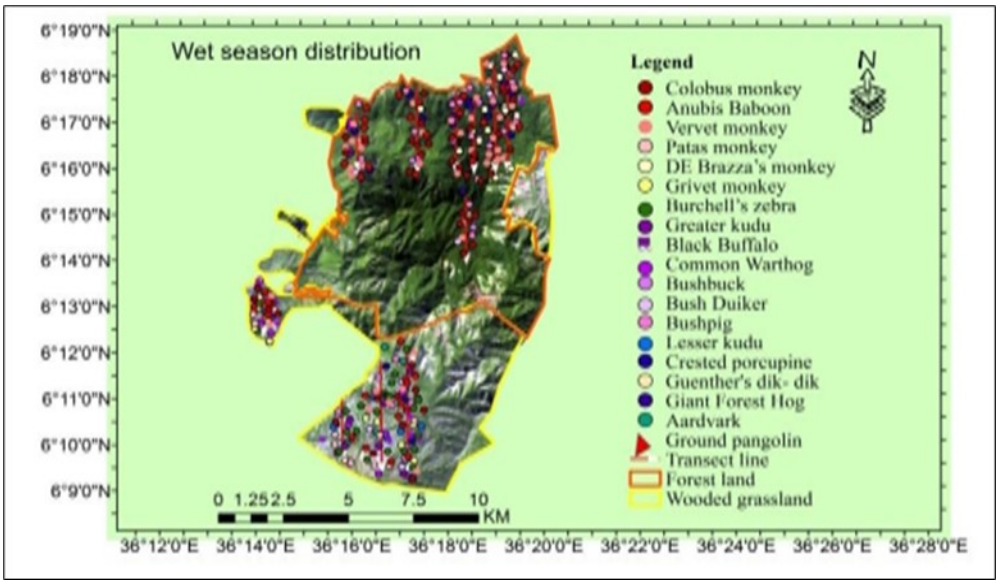

Figure 8. Wet season distribution mammals in BCMF

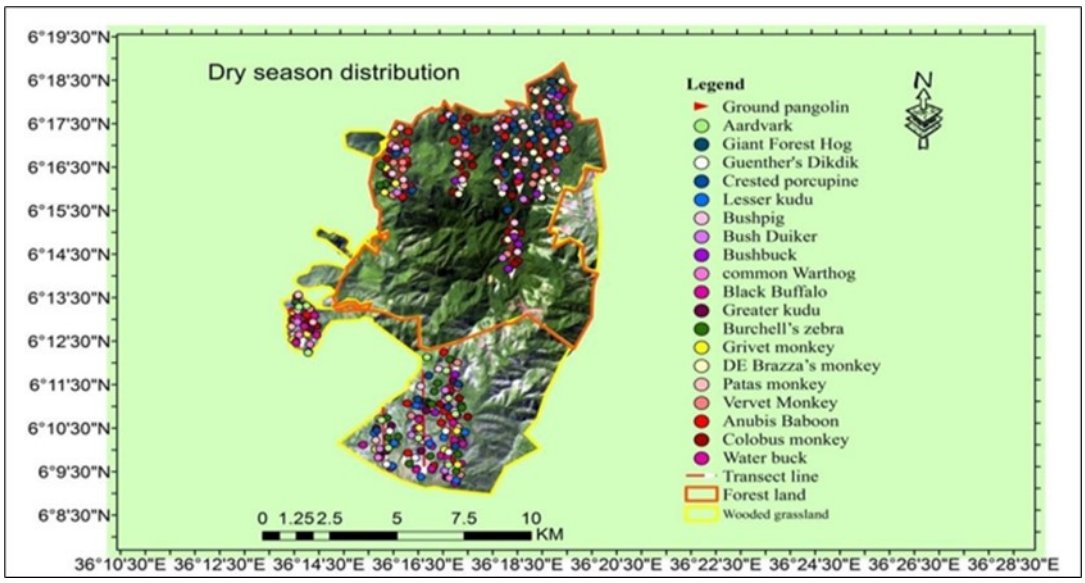

Figure 9. Dry season distribution of mammals in BCMF

The Colobus monkey (Colobus guereza) was the most observed species (28.45%) in forestland followed by Vervet Monkey (Cercopithecus pygerythrus) (26.54%), Anubis Baboon (Papio anubis) (19.50%), DE Brazza's monkey (Cercopitheus neglectus) (9.68%), Bushbuck (Traglaphus Scriptus) (4.25%), Bush Duiker (Sylvicapra grimma) (3.37%), Bushpig (Potamochoerus larvatus) (2.20%), Common Warthog (Phacochoerus africanus) (1.47%) and Grivet monkey (Cercopithecus aethiops) (1.17%). On the other hand, Anubis Baboon (Papio anubis) was the most observed (15.28%) in wooded grassland followed by Patas monkey (Erytherocebus patas) (14.78%), Burchell's zebra (Equus quagga) (13.46%), Grivet monkey (Cercopithecus aethiops) (7.64%), Greater kudu (Traglaphus strepsiceros) (7.97%), Black Buffalo (Syncerrus caffer) (6.98%), Colobus monkey (Colobus guereza) (5.32%), Common Warthog (Phacochoerus africanus) (2.29%), Defersa waterbuck (Kobus ellipsiprymnus defessa) (3.97%) and Crested porcupine (Hystrix cristata) (3.49%) (Table 8). Overall distribution of species in the study area was mapped based on the GPS coordinates of each observation event (Fig.8 and 9).

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Table 5. Distribution and abundance of mammals in the two habitat types of the study area based on season

English name	Forestland		Wooded grassland		Total	
	wet	dry	wet	dry	wet	dry
Vervet Monkey	99(25.98%)	82(27.15%)	9(2.96%)	11(3.69%)	108(15.77%)	93(15.50%)
Grivet monkey	-	8(2.65%)	13(4.28%)	33(11.07%)	13(1.90%)	41(6.83%)
Anubis Baboon	65(17.06)	68(22.52%)	39(12.83%)	53(17.79%)	104(15.18%)	121(20.17%)
Patas monkey	-	-	42(13.82%)	47(15.77%)	42(6.13%)	47(7.83%)
DE Brazza's monkey	40(10.53)	26(8.61%)	-	-	40(5.84%)	26(4.33%)
Colobus monkey	131(34.38)	63(20.86%)	18(5.92%)	14(4.70%)	149(21.75%)	77(12.83%)
Burchell's zebra	-	6(1.99%)	42(13.82%)	39(13.09%)	42(6.13%)	45 (7.5%)
Greater kudu	-	5(1.66%)	37(12.17%)	11(3.69%)	37(5.40%)	16(2.67%)
Lesser kudu	-	-	8(2.63%)	13(4.36%)	8(1.17%)	13(2.17%)
Bushbuck	16(4.20)	13(4.30%)	4(1.32%)	2(0.67%)	20(2.92%)	15((2.50%)
Guenther's Dikdik	-	-	4(1.32%)	6(2.01%)	4(0.58%)	6(1%)
Bush Duiker	14(3.67)	9(2.98%)	4(1.32%)	5(1.68%)	18(2.63%)	14(2.33%)
Defassa waterbuck	-	-	-	24(8.05%)	-	24(4%)
Black Buffalo	1(0.26)	1(0.33%)	28(9.21%)	14(4.70%)	29(4.23%)	15(2.50%)
Bushpig	8(2.10)	7(2.32%)	9(2.96%)	4(1.34%)	17(2.48%)	11(1.83%)
common Warthog	-	10(3.31%)	18(5.92%)	10(3.36%)	18(2.63%)	20(3.33%)
Giant Forest Hog	4(1.05)	1(0.33%)	-	-	4(0.58%)	1(0.17%)
Crested porcupine	3(0.79%)	2(0.66%)	16(5.26%)	5(1.68%)	19(2.77%)	7(1.17%)
Aardvark	-	-	12(3.95%)	6(2.01%)	12(1.75%)	6(1%)
Ground pangolin	-	-	1(0.33%)	1(0.34%)	1(0.15%)	1(0.17%)
Total(21)	381(100%)	302(100%)	304(100%)	298(100%)	685(100%)	600(100%)

Conservation Challenges

Socio-demographic profile of the respondents

Majority (81.25%) of the respondents were male household heads. Respondents with different age group were involved during the study. Hence, most respondents (90.62%) were found at age category between 26-55. Over half (57.81%) of the respondents had no formal education. However, 42.19% of respondents had formal education beginning from primary education up to college level. Almost all (98.44%) of the respondents were married. Farming (92.19%) was the major source of livelihood in the study area. With regard to occupation in the study area, 31.25% and 67.19% of the respondents lived 6-10 years and more than 10 years, respectively.

Threats to BCMF

In the present study many threats to BCMF were identified such as poaching, fire, grazing, fuelwood extraction, population growth, habitat modification, overharvesting of resources, invasives species .

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Poaching

Although majority age category (26-4) (53.13%) of the respondents denied the practice of poaching in the study area, (26->65) 31.25% of the respondents mentioned the occurrence of illegal hunting in the locality. As most respondents reflected, due to the control of the forest by the local government, there was less incidence of poaching. Animals that mostly being hunted in the study area include: Lesser kudu (Traglaphus imberbis), Buffalo (syncerrus caffer), Defassa waterbuck (Kobus ellipsiprymnus defessa), Greater kudu (Traglaphus strepsiceros), Bushback (Traglaphus Scriptus), Duicker (Sylvicapra grimma), Lion (Panthera leo) and Leopards (Panthera pardus).

Fire

All respondents category (18->65) (100%) confessed the occurrence of hunan-induced fire in the forest especially during dry season. The respondents mentioned many reasons why intentional fire set in the forest such as to avoid bush encrochment and obtain new grass growth, clearing the area for farmland (usually at the edge of the forest), and during honey collection. Muri, Bodi and Banchi ethnic groups annually burn large area in the forest.

Grazing

Respondents also mentioned practices of free grazing livestock in the forest, though it occurred less often. However, all repondents age category (18- >65) (100%) explained the existence of harvesting grass for livestock during a certain season while permitted by local community leader.

Fuelwood extraction

Majority age category (26-55) (92.21%) of the respondents mentioned that fuelwood collection inside the forest not allowed. Hence, fuelwoods usually being collected at the edge/outside of the core area of the forest. However, age category (18-25 and 56->65) 7.79% of the respondents informed the practice of fuelwood collection in the forest.

Other human impacts on Bayo community forest (population growth, habitat modification, overharvesting of resources, and invasives species) were also indicated by the respondent, despite not significant. The respondents mentioned these impacts were more pronounced before the forest was re-demarcated by SNNPRS and REDD+ in 2018. Particularily, according to age category (18->65) 99.44% of the respondents, the impact of population growth nearby the forest resulted serious problem on the forest before 2018. On the other hand, habitat modification, overharvesting, and invasive species were, low (26-45) (71.88%), moderate (18->65) (85.25), and (26-45) low (73.44), respectively. Invasive plant species occurred in the study area include: Parthenium weed (Parthenium hysterophorous), Mesquite trees (Prosopis juliflora), and Lantana weed (Lantana camara). Concerning the trends of the above mentioned factors, as per the respondents reflection, decreased for population growth (100%), habitat modification (18-65) (98.44%) and overharvesting (18-65) (98.44%) whereas increasing for invasive species category (26-35) (9.38%) (Table 7).

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Table 6. Socio-demographic characteristics of respondents

Variable	Response	Dime Woyde		Dime Erqa		Dime Garfa		Overall	
		Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Sex	Male	23	82.14	14	73.68	15	88.24	52	81.25
	Female	5	17.86	5	26.32	2	11.76	12	18.75
Age	18-25	-	-	-	-	1	5.88	1	1.56
	26-35	9	32.15	6	31.58	2	11.76	17	26.56
	36-45	14	50	9	47.37	10	58.83	33	51.56
	46-55	2	7.14	3	15.79	3	17.65	8	12.5
	56-65	2	7.14	-	-	-	-	2	3.13
	>65	1	3.57	1	5.26	1	5.88	3	4.69
Educational status	No formal education	15	53.58	12	63.16	10	58.82	37	57.81
	Primary school	10	35.71	5	26.32	4	23.53	19	29.69
	Secondary school	2	7.14	1	5.26	3	17.65	6	9.38
	College	1	3.57	1	5.26			2	3.13
Marital status	Married Single	28 -	100 -	18 -	94.74 -	17 -	100 -	63 -	98.44 -
	Divorced	-	-	1	5.26	-	-	1	1.56
Livelihood	Farming	26	92.86	17	89.47	16	94.12	59	92.19
	Government Employee	2	7.14	2	10.53	1	5.88	5	7.81
Duration	1-5 years	-	-	1	5.26	-	-	1	1.56
	6-10 years	8	28.57	5	26.32	7	41.18	20	31.25

Table 7. Human impacts on Bayo community managed forest

Impacts	Degree of impacts						Trends of impacts					
	Low		Moderate		High		Increasing		Decreasing		unchanged	
	Frequenc	Percen	Frequ e	Perc	Freq ue	Perc	Frequency	Perc	Freq ue	Perc e	Frequ en	Perc e
Population growth	-	-	1	1.56	63	98..44	-	-	64	100	-	-
Habitat changes	57	89.06	4	6.25	3	4.69	1	1.56	63	98.44	-	-
Over-harvesting	11	17.19	52	81.25	1	1.56	1	1.5	63	98.44	-	-
invasive species	59	92.19	5	7.81	-	-	9	14.09	-	-	55	85.94

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On the contrary, in the present study, respondents vehemently expressed the impact of wild animals in relation to crop damage, livestock depredation and being threats to human life. Accordingly, 70.32%, 20.32%, 9.38% of respondents confirmed the negative impacts of wildlife as crop damage, livestock depredation and threatning human life, respectively (Table 8). Hence, there was significant difference among the respondents in respect of types of impacts of wildlife in the study area ($\chi 2$ =6.77,df = 2,P<0.05). As per respondents, wild animals involved in the conflict include: Common warthog (Phacochoerus africanus), Anubis Baboon (Papio anubis), Patas monkey (Erytherocebus patas), Crested porcupine (Hystrix Cristata) as Crop raiders; Lion (Panthera leo) attacked both livestock and humans; Leopard (Panthera pardus) and Caracal (Felis caracal) attacked livestock especially goat and sheep; Honey badger (Mellivora capensis) destoryed beehives.

Table 8. Wild animals impacts on the local community

Types of problems	Dime Woyde		Dime Erqa		Dime Garfa		Overall	
	Frequency	%	Frequeny	%	Frequency	%	Frequency	%
Crop damaging	22	78.57	12	63.16	11	64.71	45	70.32
Predation	-	-	7	36.84	6	35.29	13	20.32
Threat on humans	6	21.43	-	-	-	-	6	9.38

Respondents attitude towards the forest was also assessed during the study. The forest existence as important source of livelihood realized by many (98.44%) respondents. However, 1.56% of the respondents had no information about the very existence of the forest at all. Respondents also ranked the degree of importance of the forest to their livelihood. Thus, 54.69% and 43.75% of the respondents mentioned BCMF as very important and important, respectively (Table 9). In general, there was significant difference among the respondents concerning their attitude towards BCMF ($\chi 2$ =30.219, df = 2, P<0.05).

Table 9. Perception of local community towards BCMF

Attitude towards BCMF	Name of Village										
	Dime Woyde		Dime Erqa		Dime Garfa		Overall		$\chi 2$	df	p values
	Frequency	%	Frequency	%	Frequency	%	Frequency	%			
Very important	19	67.86	8	42.11	8	47.06	35	54.69	6.392	2	0.011*
important	9	32.14	10	52.63	9	52.94	28	43.75	6.623	2	0.036*
I don't know	-	-	1	5.26	-	-	1	1.56	2.015	1	-
Total	28	100	19	100	17	100	64	100	15.426	2	0.00

*significant at 0.05

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Summary of Focus Group Discussion

A total of three focus group discussions were carried out at Dime-Woyde, Dime-Garfa, and Dime -Erqa kebeles (Figure 10). The discussants had better knowledge and understanding of the benefits of the forest. Thus, they had a strong positive attitude towards the forest. The discussion revealed that the local community has strong spiritual, cultural and economic nexus with the forest. The benefits obtained from the forest included honey collection, house construction materials, the seasonal harvesting of editable fruits and grass. Jemesho-water in the forest was also used as holy water and had cultural and medicinal values. The local community elders and community rangers look after any illegal activities in and around the forest. However, though the impacts are reduced due to the re-demarcation of the area by the government and REDD+, some threats such as poaching, fuelwood and fooder collection, human-induced fire are still viable. During the study period, the researcher had an opportunity to observe community members clothed wild animals products such as the skin of lion (Panthera leo), Leopards (Panthera pardus) and Cheetah (Acinonyx jubatus). Furthermore, during a household survey, the observed wild animals products collection in the house such as trophy or horns of Buffalos (syncerrus caffer) and Greater kudu (Traglaphus strepsiceros). The discussion also confirmed the occurrence of human-wildlife conflict in the area that is expressed by crop-raiding, livestock predation and threats on human life. The discussants also mentioned the effort of the REDD+ project in the study area in creating awareness about forest biodiversity. Thus, the project developed different alternatives of livelihood sources (such as nursery sites and honey beekeeping cooperative developments) that reduced anthropogenic influences on the forest.

Figure 10. Events of focus group discussions

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Other Observed Animals

Table 10: Other animals observed during the study

Species Name	Local name	Observation method
African civet (*Civetticitis civetta*)	Dugite	Indirect observation and interview
Cheetah (*Acinonyx jubatus)*	Kergine	interview
Spotted hyena (*Crocuta crocuta)*	Nayo	Indirect observation and interview
Caracal (*Felis caracal*)	Halute	Direct observation
Leopard (*Panthera pardus*)	Tolku	Direct observation and smell
Serval cat (*Felis serval*)	Alute	Indirect observation and interview
Lion (*Panthera leo*)	Beyo	Indirect observation and interview
Honey badger (*Mellivora capensis*)	-	Indirect observation and interview
Common jackal (*Canis aures*)	-	Observation, Indirect, and interview
Tortoise *(Testudo pardalis)*	Zahahami	Direct observation
Wild dog (*Lycaon pictus*)	Yayu	Indirect observation and interview

Discussion

In terms of number of mammalian species identified, the study area comprises relatively lower and higher number of species as compared to other similar studies in the country. For instance, lower records include 10 species in Geremba Mountain Fragments community-managed area, Southern Ethiopia [30]; 12 species in Mengaza communal forest, East Gojjam[31]; 19 species in Michole Community Protected Forest, Southern Ethiopia [4], and 19 species in Wondo Genet Forest Patches [23]. On the other hand, higher record include 27 species in Adaba Community Forest, West Arsi Zone, Southeast Ethiopia [32], and 22 species in Fragmented Remnant Forests around Asella Town, Ethiopia [33] In general, high reproductive success, adaptability to different habitats, diversified foraging behaviour, food source availability and high tolerance level to anthropogenic disturbances might attribute to high species richness in the study area[32] [34].

The present study show the highest number of mammals was recorded in forest than wooded grassland habitat in the study area. The species richness was highest in wooded grassland (17) compared to forestland (10) in the wet season, while as wooded grassland (18) compared to forestland (14) in dry season respectively. This study similar to Mammalian distribution was higher number in forestland than wooded grassland in Tululujia Wildlife Reserve, Southwestern Ethiopia [35], The distributed in the wooded grassland highest than forest land in the Nech Sar National Park, Ethiopia [36]. others hands different species distribution is higher in the natural moist Afro montane forest than Modified Afro montane forest and wooded grassland in Nensebo Forest, Southern Ethiopia [37]. The highest species number recorded in the natural forest habitat during the dry season than Wooded grassland and agro forestry land in Wondo Genet Forest Patches [23]. Different study Higher numbers of mammals distributed in the bushland area, followed by open grassland, riverine forest in Humbo Community-Based Forest Area, Southern Ethiopia [34].High numbers species in the wooded grassland might be due to relatively better vegetation diversity in the study area. [38]suggest that high numbers of species in vegetation supports a high numers of mammalian species

Poaching, grazing, human-induced fire, fuelwood extraction, population growth, habitat change, overharvesting, and invasive species were the major threats to BCMF. Although only 31.25% of respondents

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agreed on the occurrence of illegal hunting in the study area, the presence of animal products such as horns and skin in many houses of households might indicate a higher level of poaching in the area. According to some respondents the area used to host Elephants (Loxodonta African) six decades ago but now it locally disappeared. The FGD revealed that large antelopes are the most preferred targets of poaching. Similar results were reported from earlier studies such as n Echefa Forest and Wetland (Proposed In-situ Conservation Site) [39] [40], Wabe forest fragments, Gurage zone [41]; and in Harenna Forest, South East Ethiopia [42]. Human- induced fire is also commonly practised in the forest by Muri, Bodi, Banchi, Dime and Konso ethnic groups to get new fresh grass and reduce bush encroachment. The practice of human-induced fire in protected areas was also reported by [43] in and Around Jer Silase Monastry in Amhara Region. Although grazing in the forest is less frequent, local communities in the study area harvest grasses based on the consent of the local community leader. This similar in Mengaza communal forest, East Gojjam [31] and in Geremba Mountain Fragments, Southern Ethiopia [30]. This contradicts the finding of [43] around Jer Silase Monastry in Amhara Region, and Harenna Forest, South East Ethiopia [44] is highly practiced.

Invasive plant species encroachment is a major threat to the extinction of mammalian species, and very common agenda in worldwide [45][46]. In most of the Ethiopian protected areas invasiveness and encroachment of unpalatable plant species is increasing from time to time [16] [47]. Invasive plant species that occurred in the study area include parthenium weed (Parthenium hysterophorous), mesquite trees (Prosopis juliflora), lantana weed (Lantana Camara). These species are reported in different protected areas of the country [48] [49]

In the study area, there is the human-wildlife conflict that causes crop damage, livestock depredation and threatening to human life. However, crop damage was the most pronounced problem in the study area. Crop damage was reported as the most serious problem of human-wildlife conflict in many earlier studies [50] [51] [53] [54]

Respondents' positive attitude towards BCMF indicates the occurrence of better awareness about forest conservation as well as the proper realization of the benefits obtained from the forest. In general, due to the recent awareness creation made by REDD+, threats in BCMF is decreasing. Studies at Choke mountain forest [55], Harenna Forest [44], and in Menz-Gera Midir District, North Shewa Zone, Ethiopia [56] and [51] reported a similar result to the present finding.

Conclusion and recommendations

Conclusion

The occurrence of 20 mammalian species that belong to six orders and eight families indicates that BCMF is an important area that harbours diverse mammalian species. Thus, it is very important to sustain the existence of these species by strengthening the conservation approach practised in the area. Significant difference in species composition was observed between habitat types. Hence, the highest species richness was recorded in the wooded grassland whereas the lowest was in forestland. Therefore, this indicates habitat type determined the distribution of some species. On the other hand, seasonal variation in the number of mammals was not statistically significant. Thus, the season was not a factor to determine species richness in the study area.

In the study area, there are anthropogenic threats on wild animals such as poaching, human-induced fire, grazing, habitat modification, population growth and so on. On the other side, crop damage, livestock depredation and threatening to human life are the negative values of wildlife in the study area. However,

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due to the recent awareness creation made by REDD+, the local community has developed a positive attitude towards wild animals in the study area.

Recommendations

Based on the findings of the present study, the following recommendations are forwarded

• Illegal activities such as poaching, fuel wood collection and grass cutting in the Bayo community managed forest should be controlled, developing awareness of the community and respective role of them & other stakeholders ;

• Other ecological aspects such as feeding ecology, diurnal activity pattern and behavioral ecology should be studied in order to obtain better understanding about mammals in the study area;

• As BCMF is endowed with high biodiversity, survey on small mammals, avians, and carnivores species should also be encouraged;

• The local government should promote the study area and provide appropriate support towards it conservation.

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