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Mammalian Diversity in Borena-Sayint National Park, South Wollo, Ethiopia

By

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ABBREVATION AND ACRONOMY

BSNP	Borena-Sayint National Park
EFAP	Ethiopian Forest Action Programme
ENMSA	Ethiopian National Meteorological Service Agency
EWHNS	Ethiopian Wildlife and Natural History Society.
FDRECSA	Federal Democratic Republic of Ethiopia Central Statistics Agency
GPS	Geographic Positioning System
MoPED	Ministry of Planning and Development
NLFC	Newhall Land and Farming Company
PaDPA	Amhara Regional State Park Development and Protective Authority
ZNHM	Zoological Natural History Museum, Addis Ababa University

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ABSTRACT

The study on the diversity of mammalian fauna in Borena-Sayint National Park (BSNP), South Wollo Zone, Ethiopia was conducted from December, 2009 to April, 2010. The study area was divided into riverine forest, erica woodland and open grassland habitats based on topography during the preliminary survey. The altitude of the area ranges from 1900m to 3699m asl. Representative sample sites were taken from each habitat type and surveyed using random linetransect method. Twenty three species of medium to largesized, five species of rodents and two species of shrews were identified and recorded from BSNP. Small and largesized Sherman traps and snaptraps were used to trap small mammals and morphometric measurement was taken for the species. From a total of 88 small mammals trapped caught, *L.flavopunctatus* had the highest relative abundance (37.7%), followed by *P.harringtoni* and *O.typus* with 17% each. *S.albipes, A.dembeensis* and *C. flavescens* had 12.5%, 8% and 5.7% of abundance, respectively. *C.fumosa* had the lowest relative abundance (2.3%). Mammals of the study area were classified in to common (33.4%), uncommon (23.3%), occasional (16.7%) and rare (26.7%) based on how often they were sighted or evidences recorded. They were also categorized into meat eaters (33.3%), small gleaners (16.7%), fruit and leaf eaters (13.3%) and others (36.7%). For large mammal survey, indirect methods such as feaces, hairs, spines, puge marks, sound and carcass were used in addition to the direct observations. Major threats of the Park identified during the study period were grass collection, livestock grazing and encroachment.

Key words/ Phrases: Borena-Sayint National Park, conservation diversity, mammals

1. INTRODUCTION AND LITERATURE REVIEW

1.1. Introduction

Ethiopia is a country of geographical diversity with high and rugged mountains, flat-topped plateaus and deep gorges, incised river valley and rolling plains. It is often known as “the roof of Africa” due to its mountainous nature (Nievergelt, 1981). The Ethiopian relief includes a range of altitudes from bsl to 4620m asl, and the country consists of many peaks above 2500m asl. These extensive plateaus are bisected by the central rift valley (Afework and Corti, 1997). Yalden (1983) stated that Ethiopia is a mountainous country unique by extent of its highland and over 80% of African highland areas above 3000m altitude are located in Ethiopia. Approximately 15% of Ethiopian highlands are above 3,000m. The afro-tropical region covers more than 300,000km^2 of land 2000m asl, 50.4% of which is in Ethiopia and more than 25,000km^2 of land is above 3000m (Yalden and Largen, 1992).

The altitudinal variations within Ethiopia produce a range of climate, which affect every aspect of life in the country; plant and animal distribution and the concentration of people and the types of agriculture, while temperature, rainfall and vegetation play major roles in determining the distribution of fauna including that of endemic mammals (Yalden and Largen, 1992). The flora of Ethiopia is very diverse with an estimated number between 6,500 and 7000 species of higher plants, of which 15 percent is endemic.

Ethiopia is also rich in its faunistic diversity. There are 284 species of mammals of which rodents and shrews account for 39.4% (Yalden and largen, 1992). There are 861 species of birds, 201 species of reptiles, 145 species of fresh water fish, 63 species of amphibians and 324 species of butterflies known from Ethiopia. A total of 31 species of endemic mammals are found in Ethiopia. Among these, five are large and the rest are small mammals. The highest level of endemicity in the fauna of Ethiopia appears to be related with highlands (above 3000m) in the country (Yalden, 1983).

To protect and conserve these diverse and important biological resources such as endemic animals, 12 National Parks, 11 Wildlife Reserves, 3 Sanctuaries, 18 Controlled Hunting Areas and 69 Important Bird Areas have been established as refuge in Ethiopia (Zewdu Belete and Yemesrach Assefa, 2005).

The Amhara region is located in the north western part of Ethiopia between 9^{o} 20' and 14^{o}20' north, and 36^{o}20' and 40^{o}20' east. It covers about 170,152km^2 area. The region shares boundaries with Tigray region in the north, Afar region in the east, Oromia region in the south, Benishangul-Gumiz region in the south west, and Sudan in the west, and is administratively divided into 11 zones and 140 Woredas (PaDPA, 2006).

This region has wide geographic variations, which includes rugged mountains, deep gorges, and chains of plateau, river valleys and lakes. The altitude of the region varies from 100m to 4620m asl. This wide geographical variation resulted in diverse climate, vegetation,

soil, topography and drainage patterns. The wildlife of the region is mainly restricted in the protected areas and National Parks, one of which is Borena-Sayint National Park in the South Wollo Zonal Administration. The region falls in different agro-ecological zones, Kolla, Weina Dega, Dega and Wurch (PaDPA, 2006). The annual mean temperature for most parts of the region is between 15-21^{O}C. Relatively high temperature is observed at some valleys and marginal areas exhibiting arid climates. There are two distinct seasons, a rainy season lasting three to four months and a dry season of eight to nine months. The southern and central parts of the region receive about 1000mm of annual rainfall. The amount of rainfall reaches its lowest in north western and north eastern parts of the region along the boundary with Sudan, Tigray and Afar regions, where it amounts to less than 700mm (PaDPA, 2006).

Borena-Sayint National Park, the former Denkoro Forest is one of the recently declared National Parks of the country. It has relic biodiversity with significant natural forest and high altitude grassland flora and fauna. It is restricted to a mountain ridge top in highly degraded, eroded and isolated ecosystem in South Wollo Zone of Amhara Regional State in northern Ethiopia and the area has attracted the interest of the National and Regional Government, but with limited biological information. The major objective of this study is therefore, to assess the diversity of mammalian species in Borena-Sayint National Park and to recommend the conservation measures for fauna distribution of the study area.

1. 2. Literature review

The first step in biological resource surveys, an assessment of biodiversity, is estimation of diversity, with respect to species richness at one time and location and this step frequently lead to a second stage of monitoring of biodiversity, which refers to estimation of diversity at the same location for more than one time and to draw inference about changes. Investigating biodiversity continue to be a central theme of ecological, systematic, and evolutionary biology. It is also absolutely critical to the fields of conservation biology and resource management (Wilson *et al.*, 1996).

Monitoring highlights the need of conservation actions and species recovery and protection, management, creation and restoration of habitats and management action to be effective (Campbel *et al.*, 2002). Monitoring is also important in order to manage species for conservation and landscape conservation decisions. This requires species- specific knowledge of its biology, ecology, range, taxonomy, population and habitat status (Baillie *et al.*, 2004). Information regarding biological system is also important for biodiversity, for the maintenance of genetic diversity and to identify threats to species and systems and the best way to mitigate against these, hopefully before they have significant impact on the system. It is also essential to monitor factors such as habitat destruction, fragmentation and degradation and to avoid the degradation or ecosystem services provided by the natural ecosystem (Baillie *et al.*, 2004).

Africa is well endowed with both varieties and abundance of biological organisms. Biodiversity is the total variety of life on earth. It includes all genes, populations, species and ecosystems and ecological processes of which they are part. At ecosystem level, biodiversity underpins the ecological processes which are vital to human life, for example, in influencing global climate patterns, in mediating carbon cycle, in safeguarding watersheds, and in stabilizing soils to prevent desertification. At species level, components of biodiversity in the form of domesticated and wild animals, plants and microorganisms provide a vast array of goods and services, which are essential for the survival of humanity, as well as having of enormous economic value (Stattersfield *et al.*, 1998).

Villagra *et al.* (2009) stated that the diversity of organisms in an ecosystem provides essential food, medicine, industrial and household materials for the nation. Almost 40% of the modern drugs in the developed world are derived from plant and animal products (McGeocha *et al.,* 2008). In addition to food, medicine, fuelwood and construction materials, biological resources, especially forests provide wildlife habitat and recreational opportunities, prevent soil erosion and flooding and help to provide clean air and water. They also act as important biotic checks to pests, and serve to act against global climate change (Scholes *et al.,* 2006).

According to Stattersfield *et al.* (1998), one of the most important attributes of biodiversity is that it is not evenly distributed. Ultimately this is because each species has its own unique range, largely a product of the interaction between existing ecological conditions and

the species' evolutionary history. However, many species share broadly similar (but usually not identical) distribution patterns.

The distribution of species is determined by climate, availability of suitable resource, barriers of dispersal and interspecific interaction with those organisms sharing the same area. Distribution of mammals occurs in two levels namely geographical distribution and the local distribution. The distribution of species represents the sum of many local populations and the distribution of a particular species or group of populations (Vaughan *et al.,* 2000). Structurally complex habitats may provide more niches and divers ways of exploiting environmental resources and thus increase species diversity (Bazzaz, 1975). In most habitats, plant communities determine the physical structure of environment and therefore have a considerable influence on the distribution and interactions of animal species (McCoy and Bell, 1991).

Among mammals living today, 0.1% of them are egg laying and 99% are placental. They live on land, water bodies and air (Solomon Yirga, 2008). Species of mammals are found on all continents, occurring from the arctic in the north hemisphere to the southern tips of the continents and large islands in the southern hemisphere (Nowak, 1991; Vaughan, 1978).

Since the first edition of *Mammalian Species of the World* was published in 1882, nearly 500 new mammals' species have been described as the result of the recent explorations in remote parts of the world and taxonomic revisions of problematic groups. Indeed the cumulative number of new mammal species is still on the rise. Bat and rodent new species are discovered each year (Corbet and Hill, 1991). Recently discovered fossils continue to change the land escape

of mammalian evolution. In addition, new tools from the field of molecular biology are helping to address questions in animal behaviour and mammalian physiology (Vaughan *et al.*, 2000).

Ojeda *et al.* (2000) indicated that mammals are one of the most important components of biodiversity in the world. Functional structures of mammals are determined by the composition of functional traits (feeding type, body mass, activity patterns and gregariousness). Such structures often vary along environmental gradients such as disturbance and resource availability (Hashim and Mahgoub, 2007). They range in size from African pigmy mice (*Mus minutoides*) to whales (Mugatha, 2002).

According to Delnay and Happold (1979), one of the most fascinating features of tropical Africa is the wealth and diversity of its mammalian fauna. This fauna embraces species as varied as gigantic elephants, tiny pygmy mice, scaly pangolins, amphibious hippopotamuses, flying squirrels, naked burrowing rodents, and termite-eating aardvarks. Africa hosts the highest number and diversity of mammalian species in the world. Over 1,150 species of mammals are recorded from Africa, belonging to 13 Orders and 50 Families. Among them, small mammals are the most ubiquitous and numerous, both in species and individual members (Kingdon, 1974).

Large mammals have long been recognized as animals that interact in particularly complex and powerful fashions with their habitat (Laws, 1970). They are also fundamental elements in many ecosystems. Large carnivores frequently shape the number, distribution, and

behavior of prey animals (Berger *et al.*, 2001; Terborgh, 1988). Large herbivores function as ecological engineers by changing the structure and species composition of the surrounding vegetation (Dinerstein, 2003; Owen-Smith, 1988). Furthermore, both set of mammals profoundly influence the environment beyond direct species interaction such as through cascading trophic effects (Berger *et al.*, 2001; Crooks and Soule, 1999). Large mammals perform important ecological functions and are good indicators of the habitat value because they do not typically rely on specific single habitat as many small mammals do (NLFC, 2005).

According to Kingdom (1997), large mammals, particularly those in well-protected National Parks are generally easy to observe, sometimes on foot, but usually from a vehicle or hide. Outside protected areas, they can only be seen at some distance. Many mammals are encountered indirectly, most commonly by their tracks, diggings, excreta and feeding site.

Small mammals are categorized based upon such criteria as body size and home range size. Those included in the small mammal category are species such as rodents (i.e. mice, rats, ground squirrels). Many of these species are difficult to observe in the wild because of their size, their habit of moving only at night or because they live under ground or in other hide places (NLFC, 2005).

Small mammals are important components of biological diversity (Hashim and Mahgoub, 2007). They are known to have economical, ecological, social and cultural values (Afework Bekele and Leirs, 1997;

Martin, 2003). They also have an important role in natural communities to play and provide the main supply of live-food for many of the predatory mammals, birds and reptiles (Decher and Bahian, 1999; Granjon *et al.,* 2002). They make up a significant percentage of the diet of a variety of carnivores (Ray, 1998; Jorge, 2008). Small mammals consume invertebrates, vegetation, fruits and seeds, playing extremely important role as dispersal and pollination agents in different habitats. Thus, changes in their abundance and distribution can affect the dynamics of other species as well (Ray, 1998; Solari *et al.,* 2002).

Small mammals are considered to be good bio-indicators of habitats because of their short lifespan, rapid population dynamics and low level of pressure on their populations as result of hunting in comparison to large mammals (Shrews are never hunted because of the strong, unpleasant smell of their flank glands). They are also good bio-indicators because of the diversity, in tropical Africa, in terms of species and habitat preference (Barriere *et al.*, 2006).

Mammal species are relatively easy to identify and monitor, hence among the vertebrate groups, the taxonomy, behavior and biogeography of mammals are comparatively well known. Mammals are mobile and often select specific habitats and contribute to ecological processes such as seed dispersal, predation and pollination. Thus, the population densities of mammal communities and their responses to ecosystem processes potentially provide much valuable information to the promotion of conservation through increasing public interest and funding opportunities (Reid, 1997).

Mammals face numerous threats to their continued existence including habitat degradation and distraction, overexploitation, loss of genetic diversity, endangerment and extinction. The main problem confronting not only mammals but also the earth's biodiversity is human population explosion (Vaughan *et al.,* 2000).

The decline of mammals were dramatically accelerated by humans who shoot, trap, poison animals and burn forests. Four hundred years ago there was about 4200 species of mammals. However, since that period thirty-six species have become extinct and 120 are in immense danger extinction (Last, 1995).

The present study deals with an assessment of the mammalian fauna of Borena-Sayint National Park (BSNP), and the threats that they faced in this area.

1.3. Objectives of the study

1.3.1. General objective

- To assess the diversity of mammals in BSNP and add basic information on mammalian species in Ethiopia.

1.3.2. Specific objectives

The specific objectives of the study are:-

- To identify mammalian species of BSNP.
- To analyze habitat association of medium and large sized mammals in the study area
- To study the distribution and abundance of mammals in the study area
- To know the feeding habit and habitat interaction of mammals in BSNP
- To provide reliable biological and physical information of the Park
- To recommend the conservation of the study area.

1.3.3. Research Questions

- What kinds of mammals are there in BSNP?

- Which species of mammals are more frequently seen in the different vegetation types of area?

2. DESCRIPTION OF THE STUDY AREA

2.1. Geographic location

Borena-Sayint National Park is found in South Wollo Zone (Amhara Regional State) and lies between 10°50'45.4"-10°53'58.3" latitude and 38°40'28.4"-38°54'49" longitude (Fig.1). The Park is located in the north eastern part of Ethiopia about 600km by road from Addis Ababa, 205 km from Dessie and 16km from Mekane Selam, the capital of Borena Woreda. The park is situated among three Woredas namely Borena to the south, Sayint to the north and Mehal Sayint (a newly established Woreda) to the east. Borena Woreda on south (with its seven Kebeles) and southwest (with its two Kebeles), Sayint on the north (with one Kebele) and Mehal Sayint on the north (with its two Kebeles) and on the west with one Kebele). Legambo Woreda is located bordering the two Woreda Borena and Sayint. The largest portion of the Park is found in Borena Woreda.

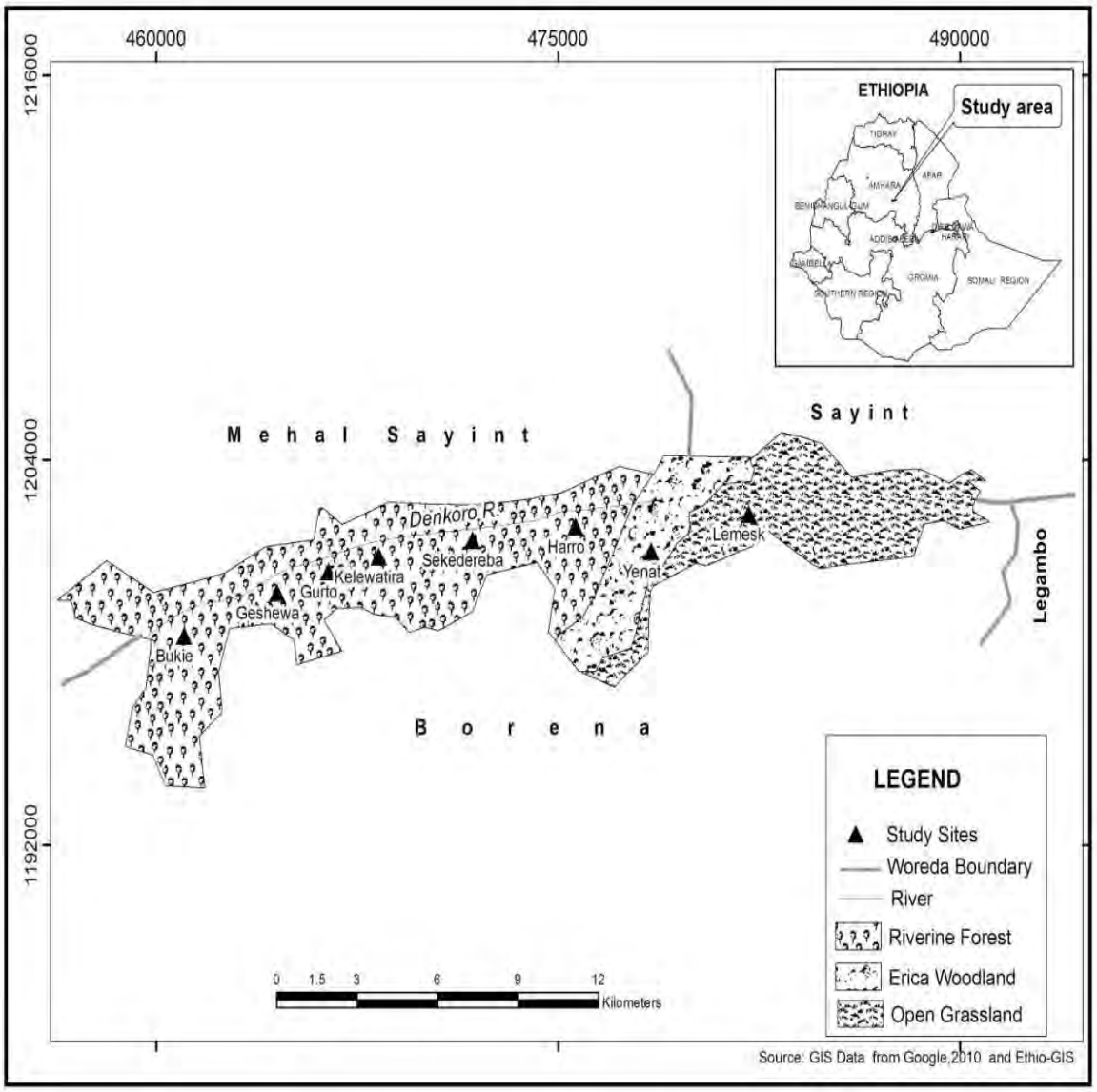


Figure 1. Location map of the study area

2.2. Climate

Rainfall and temperature data were recorded in Mekane Selam meteorological station, 16km away from the study area. This station is the closest of all other stations that record rainfall and temperature and has altitude and weather conditions close to the study area. These data were taken from the Ethiopian National Meteorology Service Agency (ENMSA, 2009).

2.2.1. Temperature

A seventeen years mean monthly maximum and minimum temperature of the area were summarized and showed that the mean monthly maximum temperature ranges between 17.8^{o}C (August) and 24.4^{o}C (March); whereas the mean monthly minimum temperature varies between 9.5^{o}C (November) and 11.8^{o}C (May) as shown in the Fig. 2.

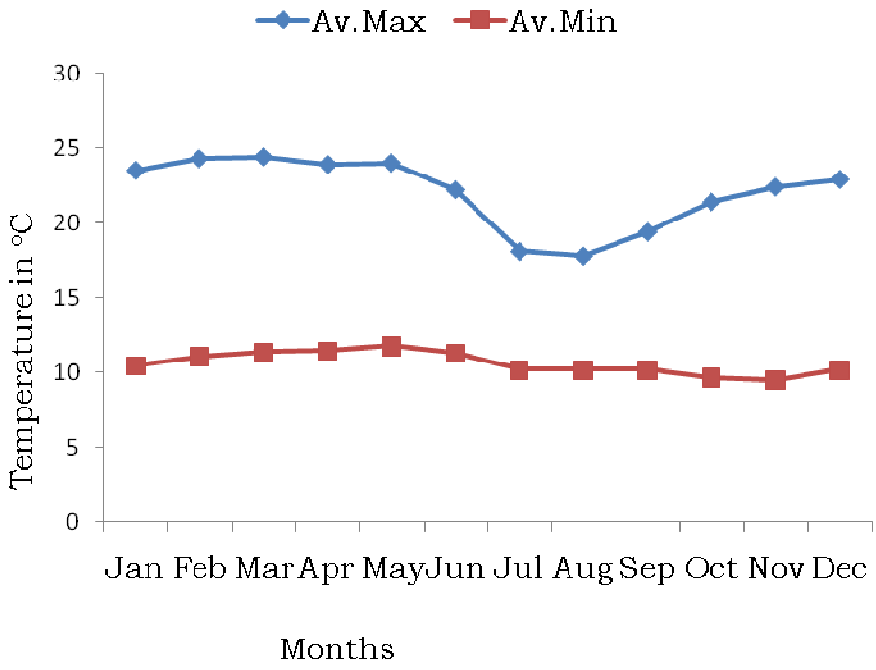


Figure 2. Average maximum (Av.Max) and minimum temperatures (Av.Min) of the study area from 1993 to 2009 G. C (ENMSA, 2009).

2.2.2. Rainfall

According to the seventeen years rainfall summarized data, the area has a bimodal rainfall distribution, characterized by prolonged wet season from June to September (longe rain), locally known as "Kiremt" and a short wet season between March and April locally known as "Belg" (Fig. 3).The mean monthly rainfall of the area varies between 9.5mm (December) and 235.7mm (July).

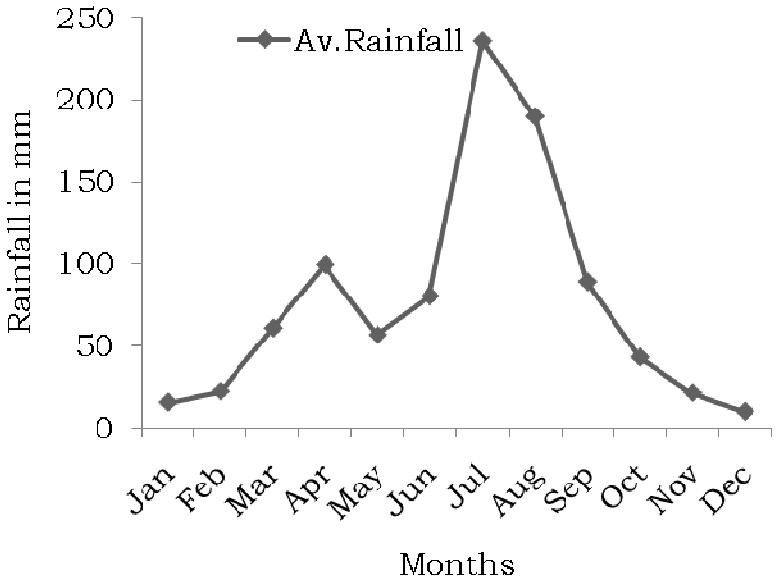


Figure 3. Average monthly rainfall (Av.Rainfall) of the study area from 1993 to 2009 G.C (ENMSA, 2009).

2.3. Topography

The Park has different topographical features ranging from low land to highland mountains. The altitude ranges between 1900m to 3699m asl. The park is generally characterized by rough topography with mountains, deep incised valleys, escarpments and plateaus. South Wollo is in most parts covered by volcanic rocks mainly basalt of tertiary age (Anonymous, 1988). According to EFAP (1994), the land area of Denkoro forest (now Borena-Sayint National Park) was 80km^2. Currently it covers only an area of only 43km^2, which makes it the smallest Park among the National Parks of Ethiopia.

2.4. Geology and soil

The major soil types in South Wollo are Cambisols, Arenosol, Lithosols and Vertisols (MoPED, 1993). Almost 80% of the area has a soil depth less than 20cm due to excessive erosion which brings about low soil productivity and low water holding capacity during periods of irregular rainfall (Henerickson *et al.*, 1983). BSNP lies on Tertiary volcanic deposits, which are extremely thick, and the soils are mainly Lithosoils (McGinley, 2008). Most parts of the area are covered by volcanic rocks mainly basalts of Tertiary age (Anonymous, 1988).

2.5. Vegetation cover

The floristic composition of the Park consists of 174 species of vascular plants representing 66 families classified as herbs, shrubs, trees/shrubs and trees. Among this 12 are endemic and 8 are indicator plant species (Abate Ayalew *et al.*, 2006). Based on the vegetation type, the study area can be classified in to three major habitat types as follows:-

1. Riverine forest
2. Erica woodland
3. Open grassland

2.5.1. Riverine forest

Riverine forests occur along the narrow stripe side of Denkoro river gorge that drains from east to the western part of the area. The area has thick forest (Figure 4) and lies between 2400 to 3000m asl. The lowest part is dominated by *Podocarpus flacatus*, with *Juniperus*

procera, *Olea europaea cuspidate* and *Olinia rochetiana* coming in as the altitude increases. Above this *Rapanea* and *Dembeya* begin to dominate along with *Hagenia abyssinica* (EWNHS, 1996).

Figure 4. The dense forest of BSNP at Bukie site (Photo: Meseret Chane, December, 2009).

2.5.2. Erica woodland

Erica woodlands in the adjacent area between riverine forest and grassland. *Erica arborea* and *Hypericum revolutum* cover the area at the edge of forest at an altitude of 3000m and in places there are closed stands of Erica woodland as shown (Plate 2).

Figure 5. *Erica* woodland of BSNP (Photo: Meseret Chane, December, 2009).

2.5.3. Open grassland

It is an afro-alpine habitat, high altitude grassland, which is dominated by *Festuca gelbertiana*, with scattered giant Lobelia *rhynchopetalum* and red-hot pokers (*Kniphofia foliosa*) (Plate 3)

Figure 6. *Festuca* dominated afro-alpine grassland of BSNP (Photo: Meseret Chane, December, 2009).

2.6. Water sources

There are many tributaries such as Gelgel Denkoro that drain into Denkoro River, which joins the Nile River in its western end after crossing the BSNP. In addition many ponds and water holes are found inside and surrounding the Park for wildlife, humans as well as livestock. Moreover, the local farmers use these water sources for small plots of land irrigation to cultivate potato, maize, onion and chilly in the dry season. The area is wet all round the year because of the forest cover and topography that increase precipitation and cause rain. Generally there is no scarcity for water for the wildlife and livestock in the area.

2.7. Accessibility

There is one main all weather gravel road from Dessie to western Woredas of South Wollo Zone that branches at different places until it reaches Mekane Selam which extends 206km from Dessie to Mekane Selam. In addition to this a new alternative gravel road is built by Federal Government from Kombolcha district to Merto Lemariam district crossing Nile River via Mekane Selam to join South Wollo Zone and Gojjam. This new road hopefully gives great opportunity to visit the park. There are dry season roads from Mekane Selam and other bordering Woredas to the newly built campsite which is built by Frankfurt Zoological Society (Plate 4). However, trekking on animals and on foot are the principal means of transport to BSNP.

Figure 7. Dry season road to the campsite (Photo: Meseret Chane, March, 2010).

2.8. Demography

Population pressure is the major threat of the development of the Park. There is high number of population in three bordering Woredas of the Park. According to Federal Republic of Ethiopia Central Statistic Agency (FDRECSA, 2007), the population of Borena, Sayint and Legmbo Woreda was 158,920, 144, 937 and164,964, respectively. three Wored

2.9. Landuse patterns and Human settlement

Abate Ayalew *et al.* (2006) stated that the broken and rugged nature of topography together with adverse inference of humans on the environment has brought about severe soil erosion in South Wollo

Zone. Human activities especially need for firewood and cultivation in this more lands in this Zone is speeding up the process of soil erosion.

The area surrounding the Park is characterized by mixed cereal and livestock agriculture as it is in the northern plateau of Ethiopia. The local farmers mainly cultivate wheat (*Triticum sativum*) and barley (*Hordeum vullgare*) for subsistence. They also cultivate maize (*Zea mays)* and potatoes using short rain and irrigation farming system. The same plots of lands are cultivated over and over again until they become less productive. Though the farmers very well know that the farmlands are over exhausted and need a period of rest or fallow, they cannot do it. However, the ecological consequence of landuse on a wide range of habitats has a direct influence on the diversity and distribution of vertebrate species such as reptiles (Kool, 1993), birds (Wiens and Rotenberry, 1985) and mammals (Harcourt, 1986).

The area is highly populated by livestock and creates pressure on the wildlife of the Park. The people use the livestock for farming, trekking and milk production. The local farmers predominantly cut grass as forage for their cattle as shown on Fig. 8 illegally in the absence of the scouts who patrol the area. Moreover, they cut *Fistuca* grass (*Festuca gelbertiana*) to thatch their houses and earn some money by selling in the market. Even though the local population earns their living directly from the land, mainly as subsistence farming, they also earn some income from collecting honey selling by installing beehives in the surrounding areas of the Park and selling it.

The population in the surrounding Kebeles of the Park is dense. They are all Amhara people. According to Derejje Yazezew (2009), the number of people in the surrounding four Farmers Association in the

southern border of the Park was estimated to be 1398 in 2007, which is increased by about 27.4% compared to that of 2001 data (1097). This clearly shows that the pressure on wildlife of the Park, since most of the people are engaged in rain fed agriculture and animal husbandry.

Figure 8. Illegal collection of grass by the local farmer (Photo: Meseret Chane, December, 2009).

3. MATERIALS AND METHODS

3.1. Duration of the study

Faunal survey was conducted from December, 2009 to April, 2010 in BSNP. During this period random transectlines were established randomly and the locations were marked using Global Positioning System (GPS.) Study area was classified in to three major vegetation zones based on vegetation types and altitude. A total of 40 days of fieldwork was done. Random study sites were taken to trap small mammals and both snap traps and live traps were used. Specimens were collected and identified. Other valuable data such as climate and human population in the study area were gathered from the concerned organizations. Access to the park was on foot.

3.2. Study area sub division

Preliminary study was conducted in the first field work. This showed that the study area was heterogeneous in vegetation type and topography and classified in to three Vegetation Zones. These include Vegetation Zone 1/Riverine forest (RF), Vegetation Zone 2/Erica woodland (EWL) and Vegetation Zone 3/Open grassland (OGL). Classification of the study area was based on the map of Denkoro Chaka sketched by Park Development and Protection Authority in December, 2006. Each vegetation zone has distinguishing features in vegetation type and topography. Censes zones were established in all three vegetations.

3.3. Small mammal trapping

Even though, the term "small mammal" is commonly used in biology, there is no clear cut demarcation for the use of the term, and researchers determine it differently. For instance, the International Biological Program (IBP) Small Mammals Working Group decided that mammals weighting up to 5kg are to be classified as small (Boulier, 1965). On the other hand some define mammals of less than10kg body mass as "small" (Ojeda *et al.*, 2000; Glennon and Porter, 2007). Recent studies define small mammals as those of less than 200gm body mass, but the threshold is still debatable (Juokaitis and Baranauskas, 2001; Hashim and Mahgoub, 2007). For this study mammal with body weight less than 200g was taken as small.

Trap type is a very important variable affecting the result of population studies on small mammals (Wiener and Smith, 1972). According to Ling-Ling Lee (1997), live trapping was selected as the primary protocol for small mammals because it is an effective, efficient, and benign technique for detecting the presence and estimating the abundance of most small mammal species. Therefore, this study used more number of live traps than snap traps.

Both live and snap trapping were used in randomly selected transects at different habitats of the study area to represent all the vegetation types. The length of line transect varied from 400m to 500m. A total of twenty small and large sized (13x 13x 38cm and 7.5x 9x22 cm), Sherman traps and five snap traps were placed 20m apart along the

transect. Traps were set for three consecutive days along transect of each habitat types so as to cover different habitat types.

Trapping was conducted from December 15, 2009 to January 5, 2010 during the first data collection period and from March 19, 2010 to April 9, 2010 during the second data collection period. The total trap nights during the survey period were 720.

Each trap was baited with peanut butter and covered with foliage and hays to camouflage and avoid excess heat during day time. This also protected the local people from being attracted by these shiny and glittering objects from far. The traps were checked twice a day, early in the morning hours (07:00-08:00) and late in the afternoon hours (17:00-18:00). The trapped specimens were removed from the trap and kept in polyethylene bags. Livetrapped animals were weighted, sex identified, and released at the place of capture after being marked appropriately.

Snaptrapped specimens were used for standard morphological measurement such as head to body length (HB), tail length (TL), hind leg length (HL), front leg length (FL) and bodyweight (W). Some specimens were skinned and dried and identified at species level in Zoological Natural History Museum (ZNHM) of Addis Ababa University, Ethiopia.

3. 4. Medium and largesized mammal survey

Survey of medium and large mammals in the study area was on foot along a randomly selected transectlines. There were a total of fifteen transect lines, which varied in length from 1.5km to 4km established

to observe large mammal species. Transect width ranged from 50m to 400m depending on vegetation cover and topography of the study site. Ten transect lines were established for riverine forest habitat in different study sites. These were three transect lines for Bukie, one for each Geshewa, Guruto and Kelawatira, two for each Sekedereba and Harro. The remaining two were for *Erica* woodland and three for open grassland.

Two rounds of observations of large mammals were carried out during filed study period from December 15, 2009 to April 11, 2010. When mammals were sighted, the number and GPS location were recorded at each transect line and species identification of large mammals was based on *The kingdom Field Guide to African Mammals* (Kingdon, 1997) and "*Atibiwochu*" (Solomon Yirga, 2008).

Observation of large mammals was done early in the moring during 06:00 to 08:00 h and late in the afternoon during 17:00 to 19:00 h, when most mammals were active in the study area. Indirect detection indices such as scats, hair samples, tracks, dense or burrows and scratches are very use full when surveying animals such as carnivores that are naturally rare, elusive, found at low densities and difficult to capture repeatedly (Erb, 2005). Direct observation was using binocular and naked eyes and indirect observation was using indirect evidences.

According to Wemmer *et al.* (1996), mammals can be categorized as common (fairly well distributed and sighted and/ or evidence recorded once a day), uncommon (fairly well distributed and sighted and/or evidence recorded once a week), occasional (restricted distribution and sighted and/ or evidence recorded infrequently), and rare (very few evidences recorded and/or single recorded during the whole survey periods). In the present study mammals were categorized based on this criterion.

3.6. Data Analysis

Species diversity of small mammals and large mammals were calculated using the Shannon-Weaver index of diversity, $H' = -\sum P_i \ln P_i$ where P_i is the proportion of the i^{th} species in the habitat (Shannon and Weaver, 1949). H' is influenced both by number of species as well as by the evenness with which mammals are distributed with those species. Equal H values may thus be obtained if one habitat contains fewer and evenly distributed species of mammals. The evenness of mammalian species was calculated as $J = H'/H'_{max}$ where $H'_{max} = \ln(s)$ and s is the number of species. This measure varies between 1(complete evenness) and 0(complete unevenness). Chi-square (χ^2) was used to compare differences in abundance of mammal species between habitats and the overall significant difference in abundance of mammal species in the study area. SPSS computer Programme was used for Chi- square analysis to test the association of medium and large mammal species and their habitats (Flower and Cohen, 1990).

Simpson similarity index (SI) was also computed to assess the similarity among and between three habitats with reference to the composition of species.

SI= 3C/I+II+III

Where: SI= Simpson's similarity index,

C= the number of common species to all three habitats

I= the number of species in habitat one

II= the number of species in habitat two

III = the number of species in habitat three

4. RESULTS

4.1. Mammalian species Identification

A total 30 mammalian species were identified and recorded in BSNP by direct and indirect methods (Table 1).

Table 1. Mammalian species identified in BSNP.

No	Common name	Scientific name
I	Order Rodentia	
1	Grass Rat	*Arvicanthis dembeensis*
2	Harsh furred rat	*Lophuromys flavopunctatus*
3	Harrington's rat	*Pelomys harringtoni*
4	White footed Stenocephalemys	*Stenocephalemys albipes*
5	Typical veli Rat	*Otomys typus*
6	Crested Porcupine	*Histrix cristata*
7	Common Mole Rat	*Cryptomys hottentotus*
II	Order Insectivora	
8	Smoky white-toothed shrew	*Crocidura fumosa*
9	Great red musk shrew	*Crocidura flavessens*
III	Order Hyracoidea	
10	Rock Hyrax	*Procavia capensis*
11	Bush Hyrax	*Hetrohyrax brucei*
IV	Order Lagomorpha	
12	Stark's Hare	*Lepus starcki*
V	Order Primates	
13	Vervet Monkey	*Chlorocebus aethiops*
14	Scaered Baboon	*Papio hamadryas*
15	Gelada Baboon	*Theropithecus gelada*
16	Guereza	*Colobus abyssinicus*
VI	Order Artiodactyla	
17	Menelik bush buck	*Traglaphus scriptus meneliki*

18	Common bush buck	*Traglaphus scriptus scriptus*
19	Klipspringer	*Oreotagus oreotagus*
20	Common duiker	*Sylvicapra grimmia*
VII	Order Carnivora	
21	Leopard	*Panthera pardus*
22	Serval Cat	*Felis serval*
23	Caracal	*Caracal caracal*
24	Spotted hyena	*Corcuta corcuta*
25	Common Jackal	*Canis aureus*
26	Ethiopian Wolf	*Canis simensis*
27	Black-backed Jackal	*Canis mesomelas*
28	White tailed Mongoose	*Ichneumia albicauda*
29	Abyssinian Genet	*Genneta abyssinica*
30	Honey Badger	*Mellivora capensis*

4.2. Distribution of small mammals and their relative abundance in different habitats

Seven species of small mammals, *Arvicanthis dembeensis* (Grass rat), *Lophuromys flavopunctatus* (Harsh furred rat), *Pelomys harringtoni*, *Stenocephalemys albipes* (White footed Stenocephalemys), *Otomys typus* (Typical veli rat), *Crocidura fumosa* (Smoky white-toothed shrew) and *Crocidura flavessens* (Great red musk shrew) were trapped (Table 2). From a total of seven species recorded in the study area, open grassland contained six species, while erica woodland and riverine forest contained five and four species respectively. A total of 88 individuals belonging to family Muridae (five species) and Soricidea (two species) were encountered. Of the seven species, *Lophuromys flavopunctatus* was with 33 individuals 37.7% of a total. This was

followed by *Pelomys harringtoni* and *Otomys typus* with 17% each. *Stenocephalemys albipes*, *Arvicanthis dembeensis* and *Crocidura flavescens* had 12.5%, 8% and 5.7%, respectively. *Crocidura fumosa* had the lowest frequency (2.3%) as shown in Fig. 9.

L.flavopunctatus and *O.typus* were the most widely dispersed species, occurring in all three habitat types but *L. flavopunctatus* had relatively high numbers compared to other species in all habitat types. *A.dembeensis*, *P.harringtoni*, *S.albipes* and *C.flavescens* were present in two of the three habitats. *C.fumosa* was found only in riverine forest habitat.

Table 2. Small mammals caught and their relative abundance (in brackets) at three habitats of the study area.

	Number of caught at each habitat type				
Species	RF	EWL	OPG	Total	% of Occurrence
Arvicanthis dembeensis	3 (3.4)	-	4 (4.6)	7	8
Lophuromys flavopunctatus	9(10.2)	12 (13.6)	12 (13.6)	33	37.5
Pelomys harringtoni	-	8 (9)	7 (8)	15	17
Stenocephalemys albipes	-	8 (9)	3 (3.4)	11	12.5
Otomys typus	4 (4.6)	5 (5.7)	6 (6.8)	15	17
Crocidura fumosa	2 (2.3)	-	-	2	2.3
Crocidura flavescens	-	3 (3.4)	2 (2.3)	5	5.7
Total	18 (20.4)	36 (41)	34(38.6)	88	100

RF= Riverine forest, EWL= *Erica* woodland, OPG= open grassland

N.B. Blank (-) indicates the absence of species in the habitat

Morphometric measurements of small mammals in the study area were taken (Table 3).

Table 3.Morphometric measurements of small mammals in the study area.

Species	HBL, cm	TL, cm	HLL, cm	FLL, cm	BW, g	Habit
A.dembeensis	8	10	3.8	2.9	78	Diurnal
L.flavopunctatus	9.5	5.5	4.5	3	48	Nocturnal/ Diurnal
P.harringtoni	12	11.5	4.6	3	74	Nocturnal/ Diurnal
S.albipes	12	11.5	4.9	3.2	85	Nocturnal
O.typus	8	17	4.6	2.5	64	Diurnal
C.fumosa	7	5	2.5	2.1	15	Nocturnal
C.flavescens	6	4.5	1.6	1.4	11	Nocturnal

N.B: HBL=Head body length, TL= Tail length, HLL=Hind leg length FLL=Front leg length, BW=Body weight.

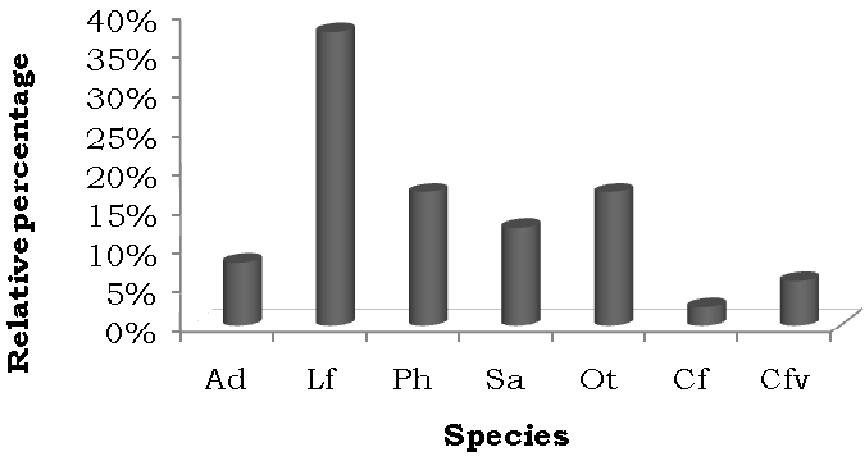
The difference in abundance of small mammals is given Table 4.

Table 4. Comparison abundance of small mammal between habitats of the study area. Figures in the table represent χ^2 values.

Species	Abundance different habitats RF vs. EWL	RF vs. OGL	EWL vs. OGL
A.dembeensis	3	0.14	4*
L.flavopunctatus	0.43	0.43	0
P.harringtoni	8***	7**	0.067
S.albipes	8***	3	2.27
O. types	0.11	0.4	0.09
C.fumosa	2	2	2
C.flavescens	3	2	0.2

N.B: RF= Riverine forest, EWL= Erica woodland, OGL= open grassland

Where * significance at $p< 0.05$; **= $p<0.01$; ***= $p<0.005$; df=1



Figurer 9. Relative abundance of small mammal species of the study area. (Ad= A.dembeensis, Lf= L.flavopunctatus, Ph= P.harringtoni, Sa= S. albipes, Ot= O.typus, Cf= C. fumosa, Cfv= C. flavescens.

4.3. Large and mediumsized mammals observed and identified

A total of 23 large and medium sized mammals were observed in BSNP through direct and indirect observations. Distribution and their common name and methods of identification are given in Table 5. *Erica* woodland contained 20 species and Riverine forest and open grassland contained 19 and 12 species respectively (Fig. 10).

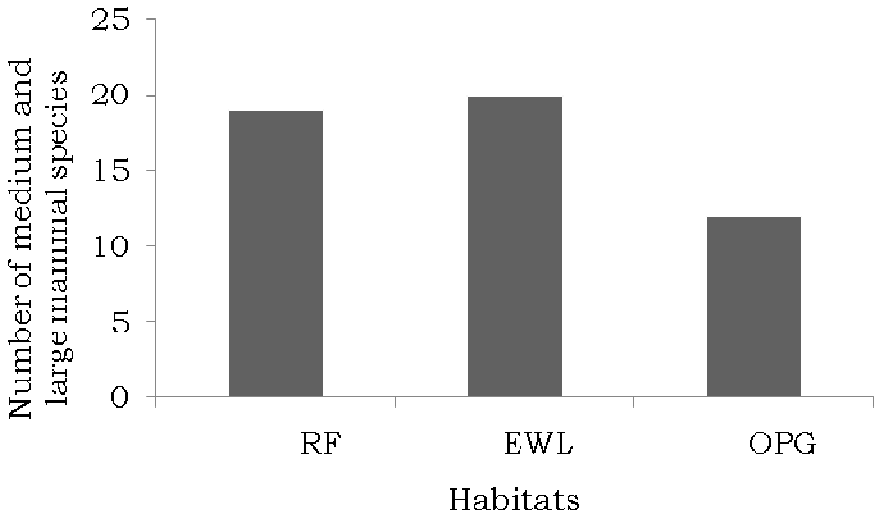


Figure 10. Number of medium and large sized mammal species in different habitats of the study area.

Table 5. Distribution of mammalian species in each habitat type.

No	Common name	Methods of identification	Habitat types			
			RF	EWL	OPG	Total
1	Crested porcupine	Faeces/spine	20	8	5	32
2	Rock hyrax	Visual/faeces	30	7	-	37
3	Bush hyrax	Visual/faeces	15	4	-	19
4	Stark's hare	Faeces	8	10	12	30
5	Vervet monkey	Visual	20	-	-	20
6	Sacred baboon	Visual	34	15	10	59
7	Gelada baboon	Visual	22	27	33	82
8	Guereza	Visual	87	21	-	109
9	Menelik bush buck	Visual	8	3	-	11
10	Common bush buck	Visual	12	4	-	16
11	Klipspringer	Visual	2	7	5	14
12	Common duiker	Visual	-	11	7	18
13	Leopard	Faeces/carcass	2	1	-	3
14	Serval cat	Faeces	1	1	-	2
15	Caracal	Vision	1	1	-	2
16	Spotted hyaena	Sound/Faeces	5	3	4	12
17	Common Jackal	Vision/faeces	-	1	2	3
18	Ethiopian Wolf	Faeces	-	-	1	1
19	Black-backed Jackal	Vision/Faeces	-	1	2	3
20	White tailed Mongoose	Vision	1	-	-	1
21	Abyssinian Genet	Vision	1	1	-	2
22	Honey Badger	Faeces	2	1	1	4
23	Common mole rat	Digging	14	20	25	59

Some directly and indirectly observed mammals of the study area during the study period were as follows;

HERBIVORES

Eight species of herbivores were recorded in the study area. The most common herbivores of the area were bush bucks, hyraxes, common duiker, klipspringer and crested porcupine.

Bushbucks

Two subspecies of bushbucks, Menelik bushbuck (*Traglaphus scriptus menelikі*) and common bushbuck *(Traglaphus scriptus scriptus*) were seen during the study period. Both subspecies were mostly seen in the riverine forest and *Erica* woodlands. They feed on small shrubs and grasses and usually occur near water source. Common predator of bushbuck in the study area was leopard. Carcass of a bush buck killed by predators is shown in Fig. 11.

Figure 11. Abush buck killed by predators (December, 2009).

Hyraxes

Rock hyrax (*Procavia capensis*) and Bush hyrax (*Hetrohyrax brucei*) were seen through riverine forest and *Erica* woodlands. They are predated by small carnivores and vultures (Figure 12). They were frequently observed during the day on rocks and bush especially in the morning (Figure 12).

a

b

Figure 12. Bush hyrax killed by vultures in the riverine habitat (a) and Bush hyrax observed (b), respectively (March, 2010).

Crested Porcupine

Crest porcupine (*Histrix cristata*) was not observed directly in the study area. But Faeces and spines were seen in all types of habitats. It was fairly distributed in all habitat types. It damaged the crops near the boundary of the study area.

Klipspringer

They were observed in pairs early in the morning from distance in *Erica* woodland and in open grassland and hide themselves in the

bush. They were unstable and moved away in each approach. They feed up on *Festuca* grass and other small bushes

Common duiker

The common Duiker, *Sylvicapra grimmia* also known as the Gray or Bush Duiker, is a small antelope this group was observed in *Erica* woodland and open grassland. It feed on small bushes and grass and also it is the major crop pests of the surrounding area.

PRIMATES

Four species of primates were recorded from the study area. These were Colobus monkey (Guereza), Vervet monkey, Gelada baboon and Sacred baboon. They occurred in the riverine forest and *Erica* woodland. The occurrence of Gelada baboon and Sacred baboon were extended to the open grassland.

Colobus monkey (Guereza)

This species was the most predominant primate in the riverine forest. They occurred in groups of more than ten individuals. This species was identified by the black and white body color and special calling sounds.

They were seen feeding on fruits and leaves of large vascular plants such as *Ficus sur*, *Allophylus abyssinica* and *Carissa edulis*.

Vervet monkey

They were seen in a group of more than six individuals only in the riverine forest and feed on ripen fruits of *Ficus sur*. Their distribution was restricted to the riverine forest.

Gelada baboon

Gelada baboon was the second most predominant primate in the study area (Figure 13). Many groups of gelada baboons were seen at all habitat types of the study area. There was conflict between the species and the local farmers as it damage crops.

Figure 13. Gelada baboon in the study area (March, 2010)

Sacred baboon

The species was seen in the riverine forest and *Erica* woodland. Their number was less in the area than gelada baboon. They preferred low altitude and found feeding mostly on pods of different plants.

CARNIVORA

Ten species of carnivores were recorded in the study area. Most of them were identified by indirect evidences. Faeces, puge mark and

carcass were located from the study area. The common jackal, black-backed jackal, caracal and Abyssinian genet were seen directly. The faecal signs of Ethiopian wolf (*Canis simensis*) were recorded in open grassland habitat. This species was rare.

Leopard

This species was identified through indirect methods by collecting, faeces and puck mark from the study area. The local scouts mentioned its presence in the area. The major prey of leopard in the area was bushbuck. It also hunted domestic animals like sheep and goats so that the local people also restricted its presence at certain locality of the park

4.4. Categories of mammals

Recorded medium and large mammals in the study area were categorized based on their feeding habits.

4.4.1. Occurrences of mammals

Mammals of the study area were categorized based on these criteria given (Table 6). From a total 30 species of mammals recorded in BSNP 10 species (33.4%) were common, 8 species (26.7%) were rare, 7 species (23.3%) were uncommon and 5 species (16.7%) were occasional (Fig. 14)

Table 6. Occurrence of mammals in the study area.

No	Common name	Category
1	Crested porcupine	Common
2	Rock hyrax	Common
3	Bush hyrax	Common
4	Stark's hare	Occasional
5	Vervet monkey	Uncommon
6	Scared baboon	Common
7	Gelada baboon	Common
8	Guereza	Common
9	Menelik bush buck	Uncommon
10	Common bush buck	Uncommon
11	Klipspringer	Uncommon
12	Common duiker	Uncommon
13	Leopard	Rare
14	Serval cat	Rare
15	Caracal	Rare
16	Spotted hyaena	Occasional
17	Common Jackal	Occasional
18	Ethiopian wolf	Rare
19	Black-backed Jackal	Occasional
20	White tailed Mongoose	Rare
21	Abyssinian Genet	Rare
22	Honey Badger	Rare
23	Common mole rat	Common
24	Grass Rat	Uncommon
25	Harsh Furred rat	Common
26	Harrington’s rat	Common
27	White footed Stenocephalemys	Uncommon
28	Typical veli rat	Common
29	Smoky white-toothed shrew	Rare
30	Great red musk shrew	Occasional

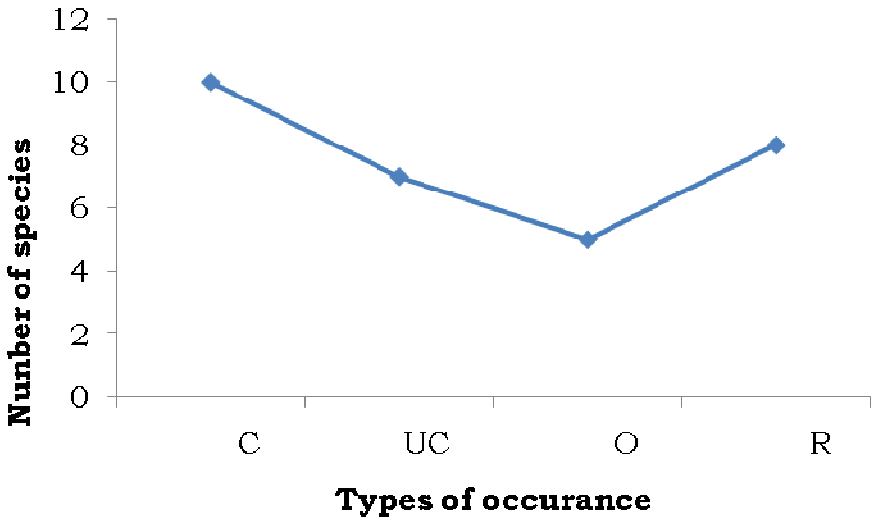


Figure 14. Types of occurrence of mammal species in the study area.

N.B: C= common, UC= uncommon, O=occasional, R= rare

4.4.2. Feeding habits of mammals in the study area

Mammamals of the study area are classified into four based on feeding habits as shown in the Table 7.

Of the total 30 mammal species recorded in BSNP, 11 species (36.7%) are small groups (others), 10 species (33.3%) are meat eaters, 5 species (16.7%) are gleaners and 4 species (13.3%) are fruit and leaf eater (Fig. 15)

Table 7. Categories of mammals based on feeding habits.

Categories	Example of mammals in the categories
Meat eaters	leopard, Jackals, Mongoose, Caracal, Hyaena Genet, Honey badger
Fruit and leaf eaters	Baboons, Guereza, Vervet
Small Gleaners	Klipspringer, Duiker, Bush buck, Hare
Others (Small groups) .	Small mammals, Porcupine, Shrew, Hyrax, Mole rat

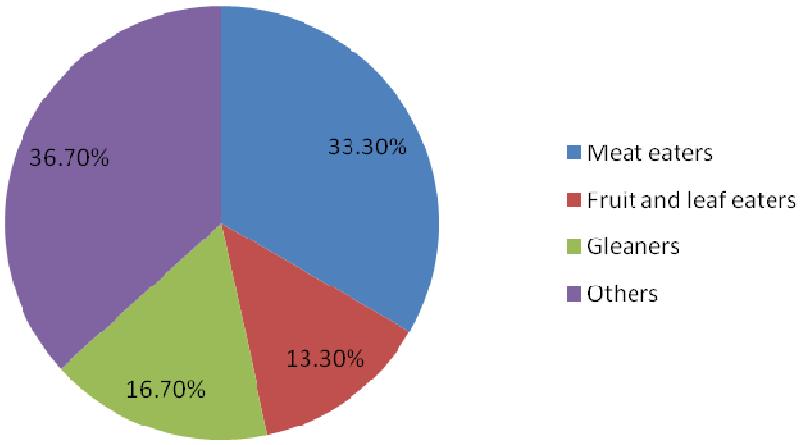


Figure 15. Percentage categories of mammals based on feeding habits.

4.5. Diversity indices for Small mammals

Diversity index (H') and evenness (J) of small mammals varied among different habitats (Table 10). The highest diversity index was recorded

in open grassland habitat, but the highest evenness was recorded in *Erica* woodland habitat. Riverine forest had the lowest diversity index and evenness.

Table 8. Diversity indices (H') and evenness (J) for small mammal species in different habitat types of the study area.

Habitat	Number of species	Abundance	H'	J
Riverine forest	4	18	1.224	0.883
Erica woodland	5	36	1.515	0.942
Open grassland	6	34	1.633	0.911

The Simpson similarity index (SI) for small mammals showed that the similarity of species composition of small mammals among three habitats of the study area was 0.4 (Table 9). This means that 40% of the species were common for all three habitats.

The overall difference in abundance of small mammals among the three habitats of the study area was significant at (χ^2=6.72, df= 2, $p<0.05$).

Table 9. Simpsons' similarity index (SI) for small mammals caught among the three habitats. Formula for SI for three habitats, SI= 3C/I+II+II

Species in habitat I	Species in habitat II	Species in habitat III	Species common to habitat I, II and III	Similarity index SI=3C/I+II+III
Ad	Lf	Ad	Lf	
Lf	Ph	Lf	Ot	
Ot	Sa	Ph		
Cf	Ot	Sa		
	Cfv	Ot		
		Cfv		
∑S=4	∑S=5	∑S=6	∑S=2	SI= 0.4

Habitat I= Riverine forest, Habitat II= Erica woodland,

Habitat III= Open grassland.

Ad= *Arvicanthis dembeensis*, Lf= *Lophuromys flavopunctatus,*

Ph= *Pelomys harringtoni*, Ot= *Otomys typus*, Sa= *Stenocephalemys albipes,* Cf= *Crocidura fumosa*, Cfv= *Crocidura flavessens*.

4.6. Diversity indices for medium and largesized mammals

A total of twenty three medium and largesized mammals species were identified and recorded. *Erica* woodland was represented by 20 species while riverine forest and open grassland were represented by 19 and 12 species, respectively.

Diversity indices (H') and evenness (J) of medium and large mammal species along the three habitat types are shown in Table 10. *Erica* woodland had the highest diversity index and evenness, whereas the lowest diversity index and evenness were recorded in open grassland and riverine forest habitat, respectively.

Table 10. Diversity indices (H') and evenness (J) of medium and largesized mammalian species.

Habitat	Number of species	Abundance	H'	J
Riverine forest	19	285	2.315	0.786
Erica woodland	20	147	2.511	0.834
Open grassland	12	107	2.015	0.811

Simpson similarity index (SI) of medium and large mammal species among three habitats in the study area was 0.407. This indicated that 40.7% of the species were common for all three habitats (Table 11).

Medium and largesized mammals showed the highest similarity occurrence between the riverine forest and *Erica* woodland, followed by *Erica* woodland and open grassland, whereas the lowest similarity occurrence was between riverine forest and open grassland (Table 12).

Table11. Simpson's similarity index (SI) for medium and large sized mammals among the three habitats.

Species in Habitat I	Species in habitat II	Species in habitat III	Species common to habitat I, II and III	Similarity index SI=3C/I+II+III
Cp	Cp	CP	Cp	
Rh	Rh	Sh	Sh	
Bh	Bh	Sb	Sb	
Sh	Sh	Gb	Gb	
Vm	Sb	K	K	
Sb	Gb	Cd	Sph	
Gb	Cg	Sph	Hb	
Cg	Mb	Ew	Cm	
Mb	Cb	Cj		
Cb	K	Bj		
K	Cd	Hb		
L	L	Cm		
Sc	Sc			
C	C			
Sph	Sph			
Wm	Cj			
Ag	Bj			
Hb	Ag			
Cm	Hb			
	Cm			
∑S= 19	∑S= 20	∑S=12	∑S= 8	SI= 0.471

Habitat I= Riverine forest, Habitat II= Erica woodlands, habitat III= Open grassland. Cp= Crested porcupine, Gb=Gelada baboon, Sc=Serval cat Rh=Rock hyrax, Gg=Colobus guereza, C= Caracal, Bh=Bush hyrax Mb=Menelik's bush buck, Sph=spotted hyaena, Sh=Stark's hare Cb=Common bushbuck, Wm=White tailed Mongoose, Vm=Vervet monkey, K= Klipspringer, Ag= Abssinian genet, Hb=honey badger, Sb= Scared baboon L= Leopard, Gb=Gelada baboon, Cm= Common mole rat, Ew= Ethiopian wolf, Cj=common Jackal, Bj= Black-backed Jackal

Table 12. Similarity in distribution of medium and largesized mammal species between habitats.

Habitats	Simpson similarity index (SI)
RF vs. EWL	0.694
vs. OPG	0.516
EWL vs. OPG	0.688

The abundance of medium and large mammal species varied between habitats of the study area (Table 13). The overall difference in abundance of medium and large mammal species among three habitats was significant at (χ^2=97, df=2, p<0.001).

Table 13. Comparison of medium and largesized mammalian species abundance between habitats.

Habitats	Chi-square (χ^2)
RF vs. EWL	44.08**
vs. OPG	80.8**
EWL vs. OPG	6.30*

Where * = Significance at p < 0.05; ** = p < 0.001; df = 1.

Habitat association of medium and large mammalsized of the study area was not significant (χ^2 = 63.8, df=44, p>0.05). The mammals in the [present study area, use all habitats independent of any variables (Table 14).

Table 14. Habitat association of medium and large mammals

	RF	EW	OPG
Chi-Square	9.217	17.174	37.435
df	12	11	9
Asymp. Sig.	.684	.103	.000

N.B: RF= Reverine forest, EW= Erica woodland, OPG= Open grassland

5. DISCUSSION

5.1. Small mammal distribution and diversity

This study has recorded seven small mammal species. Five of them were rodents and two of them were insectivores. This may not represent all the species present in the study area, but it gives update accounts of some of the small mammal species present in the study sites. According to Demeke Datiko *et al.* (2007), the species composition and abundance in natural habitats (ground water forest and riverine forest) were very poor. This might be due to the homogeneous vegetation that is dominated by few species of trees. In addition, the underground habitat is open or has less cover resulting in shortage of cover, food and diversity of microhabitats. Likewise, in this study, the lowest composition and abundance of small mammals was recorded in riverine forest. On the other hand, high small mammal diversity was recorded in *Erica* woodland and open grassland. This might be due to the difference in vegetation cover, foliage and availability of food in these habitat types (Mgatha, 2002).

According to Morris (1987), distribution of small mammals over an area is not uniform and species are more abundant in some habitats than others. This is due to the abundance and distribution of small mammals depending mainly on the nature and density of vegetation for food and shelter (Happold, 1974). In the present study area the distribution of rodents and insectivores were not uniform. Some species were widely distributed and others were restricted only to two or one habitat. For instance, *L.flavopunctatus* and *O.typus* were recorded in all three habitats. *A.dembeensis* was recorded from riverine forest and open grassland, whereas *P.harringtoni*, *S.albipes*

and *C.flavessens* were recorded from *Erica* woodland and open grassland. On the other hand, *C.fumosa* was recorded only from riverine forest.

L. flavopunctatus is one of the most widespread and numerous rodents in the moister areas of East Africa, inhabiting a range of different habitats with a preference for montane habitats (Clausnitzer *et al.*, 2003). Misonne (1969) stated that this species occurred from lowland forests at about 500m asl to afro-alpine, reaching well above 4200m and extending into ericaceous habitats and montane moorlands. Yalden (1988) reported that this species was also the most abundant, ranging from near the lower tree line at 1550m, right up through the forested zones and on to the Afro-alpine moorland at 3900m in the Bale Mountains. Likewise, this species was the most abundant and widely distributed in all three habitats of the present study area. It occurred in riverine forest, erica woodland and open grassland habitats and accounted for 37.5 % of the total catches.

P. harringtoni was recorded in *Erica* woodland and open grassland habitats at an altitude of more than 3200m asl in the present study and this second most abundant species accounted for 17% of the total catches. Yalden *et al.* (1976a) indicated that this species was widespread on Ethiopian plateau, on both sides of the Rift Valley, at altitudes of 1800-2800m asl,.Serekebirhan Tekele (2006) also recorded this species from Wonji sugarcane plantation area and indicated that it was one of the Ethiopian endemic rodent species. This shift in habitat by the species in the present study area might be due to the scarcity of food and cover at lower altitude habitat in the present study area.

According to Delany and Happold (1979), *O.typus* had been recorded from different mountains in Kenya, Uganda, Zambia and Tanzania in addition to Ethiopia. This species somewhat resembles *Dasymys incomtus* but differ in its shorter tail and agouti-brown fur. The species has a distribution of altitudinal range 1800-4000m asl (Yalden *et al.*, 1976a). In the present study this species was recorded from riverine forest, *Erica* woodland and open grassland. It was the second most abundant species comprising 17% of the total catches.

A.dembeensis is common between sea level and 2200m asl and considered to be a lowland species (Afework Bekele, 1996). Capula *et al.* (1997) reported that this species is the third endemic species of the genus in Ethiopia. Yalden *et al.* (1976a) also indicated that the species is widely distributed in Ethiopia including Awash National Park, Holeta, Akordat, Arbaminch, Koffole, Koka, Shore of Lake Zeway, Shore of Lake Tana and Awash River basin and feeds mainly on leaves, seeds and shoot of grass. This species is reported as agricultural pest in Ethiopia (Afework Bekele *et al.*, 1993). Dawud Yimer (2008) also recorded this species from Mazie National Park. The present study showed that this species was recorded in riverine forest and open grassland and accounted for 8% of the total catches. The presence of this species in these two habitats might be due to closeness to agricultural fields.

S.albipes is an endemic rodent of Ethiopia species inhabiting varied habitats from forest to scrubs in altitudes between 1500-3300m asl (Afework Bekele and Corti, 1997). According to Yaleden *et al.* (1976a), this species has been recorded from various parts of Ethiopia including Bahir-Dar, Lake Zeway, Alemaya, Debre Markos, Dembecha, Mendi, Nijabara, Goba, Kebre Mengist and Bako.

However, in the present study, this species was recorded in *Erica* woodland and open grassland at an altitude of 3100m asl and never in riverine forest. This might be due to the feeding behavior of the species AS it feeds mainly on grass, leaves and animal matters. The species was the third most abundant and comprised 12.5 % of the total number of rodent species in the present study area.

C.flavescens is a very large shrew with flat brain case and likely to be confused with *Suncus murinus*. It is, however, a very variable species in both size and color, and there are some suggestions that both characters are influenced by altitude. This shrew is one of the most common and widespread in Ethiopia, where it ranges from approximately 1000-3000m asl. It was recorded in different parts of Ethiopia including Addis Ababa, Chilalo Mountains, Debre Markos and west shore of Lake Tana. It was thought to be a typical forest species (Yalden *et al.*, 1976a). Yalden (1988) also observed the species in Bale Mountains National Park, below the tree line, and in association with clearings and within the forest. However, in the present study it was not trapped in the riverine forest. Instead, it was trapped in *Erica* woodland and open grassland habitats. This species was not abundant in the present study area. It was accounted for only 5.7% from the total catches.

C.fumosa is essentially a montane shrew with thick fur usually showing little contrast between the grey brown dorsum and silivery-grey venter. It has been recorded in Ethiopia at an altitude of 1750-3900m and is also known from mountains in Kenya, Uganda and Malawi (Yalden *et al.*, 1976a). This species was trapped only in the riverine habitats of the study area. The species was poorly distributed

and the least abundant of small mammals species that comprised 2.3% of the total number.

5.2. Medium and largesized mammals distribution and diversity

The present study area comprised twenty three medium and largesized mammalian species including the critically endangered Ethiopian wolf (*Canis semensis*) and the very common Gelada baboon (*T.gelada*) which are endemic to Ethiopia.

Distribution and habitat association of large mammals are determined in terms of their water and food requirements. Water and pasture conditions or the combinations of both are the major factors determining the distribution of wildlife populations in their natural habitats (Balakrishinan and Easa, 1986). According to Joubert (1976), habitats in terms of large mammals refer to the vegetation composition, floristic and structural, 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 largesized mammal distribution and diversity in the present study area was highly associated with habitat types. *Erica* woodland has supported the highest number of mammalian species (20), followed by riverine forest having nineteen species from a total of twenty three species. Open grassland habitat has supported twelve medium and largesized mammalian species. The possible reason for this distribution and diversity of medium and largesized mammal species might be due to the presence of food and water and stability of the area from disturbances.

The distribution of species is not uniform throughout its geographical ranges. Rather, it is a mosaic of the distribution of the local populations, nor are individuals in the population equally abundant in all regions. The natural world is heterogeneous, resulting in a patchwork distribution of habitats of varying quality (Vaughan *et al.*, 2000). Likewise, the distribution and abundance of medium and largesized mammal species of the present study area was not uniform. *Erica* woodland supported the highest diversity of medium and largesized mammal species followed by riverine forest. Open grassland has supported the lowest diversity. Moreover, *Erica* woodland and riverine forest habitats held a more stable community than open grassland habitat. Goodman (1975) has discussed the positive relationship between species diversity and community stability. The greater the species diversity among both plants and animals and the greater the number of energy pathways, the more resistant the community is to such changes as strong shifts in the density of common species. Therefore, in this study, *Erica* woodland and riverine forest habitats have similar distribution and abundance of mammals due to the similarity of vegetation cover, food and water availability and barriers to dispersal.

Consistency of herbivores to specific habitat is connected with availability of preferred food sources, of the required growth stage, for instance leaves or grasses, short or tall grass, fruits, new growth; minimum living space for the daily and seasonal movements; competition from associated species; adequate shelter from climatic elements and predators; availability of surface water; compliance to requirements of reproduction, for instance tall grass to hide calves (Pienaar, 1974). Herbivores, that need large home range and large area for seasonal movements were not recorded in the present study area. This might be due to small size and isolated island like nature of

the Park. On the other hand, herbivores that required only small home range and small area for seasonal movements were recorded. Herbivores accounted for the large proportion of mammalian species that supported small proportion of carnivores in the study area. Most of herbivore species occurred in riverine forest and *Erica* woodland habitats than open grassland habitat.

The Bushbuck was the most abundant species of family Bovidea in the present study area. This species appeared to be more concentrated in the riverine forest, but it was also recorded from *Erica* woodland and never in open grassland habitat. The species was more frequently seen in the center of riverine forest during the day and near to the periphery at night. This might prevent the species from nocturnal predators.

Pairs of klipspringers were seen frequently in the hilly and rocky part of the Park. Common duiker was seen in the *Erica* woodland and open grassland habitats. Its small size helped to obtain cover in small bush and long grasses.

Large rock outcrops allow for a suitable temperature (17-25C^{o}) and low humidity for hyraxes to survive (Grizemek, 2004). In the present study, direct observation and signs of bush and rock hyrax have been recorded in the riverine forest and erica woodland habitats more frequently. Hyraxes tend to eat mostly leaves, twigs, fruits, barks and grass. They are able to eat the bark and twigs because of the design of their gut and their relationships with symbiotic bacteria, which allow them to digest tough fibers (Rubsamen *et al*, 1981). This physiological adaptation made them abundant in the present study area.

Spines and faeces of crest porcupine have been collected throughout the study period from all habitat types of the study area. Therefore, it was relatively common species in BSNP. In addition, hair and faeces of stark's hare, which is a common species in BSNP were collected.

C. guereza is remarkably adapted species, in Ethiopia, and is found at altitudes between approximately 400m and 3300m asl, and occupies a wide variety of habitats ranging through tropical deciduous forest, montane *Juniperus* and *Hagenia* forest and riverine forest. In some areas the species survives in relatively small patches of remnant forest and it is, in general, tolerant of the presence of man (Yalden *et al.*, 1976b). This species was the most dominant primate in the present study area. This high abundance of the species in the study area might correlate with vegetation cover, altitude and availability of water.

The second most dominant of primate species in the study area was gelada baboon. According to Mori and Belay (1990), gelada baboon occurs in the highlands of Ethiopia, particularly in northern parts of Rift Valley including Shoa, Gonder, Wollo and Gojjam Provinces and southern parts of Rift Valley in Arsi region. In the present study the species has been observed in all three habitat types with uniform distribution. Geladas are mainly vegetarian, feed upon herbs, grasses (most of the time) and roots but they also seldom eat insects (Last, 1982). They were observed eating grasses in BSNP.

P.hamadryas is particularly associated with rocky habitats in desert and semi-desert regions and is now confined to the Arabian Peninsula, northern Somalia, eastern Ethiopia and Red sea Hills of Sudan. Although this form is, to considerable extent geographically

and ecologically isolated from both *Papio anubis* and *Theropithecus gelada*, there is a limited degree of overlap between the ranges of all three species and such areas of contiguity, hybridization may be anticipated (Yalden *et al.*, 1976b). Likewise, in the present study area *P.hamadryas* range overlap in all three habitats with *T. gelada* but its abundance was decreased from riverine habitat to open grassland habitat. This might show the species preference to semi-desert habitat.

C.aethiops is widely distributed and often a common species in northern and central Ethiopia, occupying a wide variety of habitats ranging from riverine, tropical deciduous or montane forest to comparatively open *Acacia* woodland. In many areas, this monkey frequents human settlements and feeds extensively on cultivated plants. The species has been recorded near sea level and extends to an altitude of at least 3000m asl (Yalden *et al.*, 1976b). In contrast, in this study the species was observed in riverine forest habitat and it is the least abundant of all primates observed in BSNP. This association of species to riverine forest might be due to the availability of fruit tree species such as *Ficus sur* and *Carissa edulis*.

Distribution and abundance of large carnivores in the present study area were minimal. These species were rare and difficult to see in the study area.

P. pardus is the most widely distributed of all the wild cats in the world. It is found almost in every kind of habitats ranging from the rain forest to tropics to desert and temperate regions, where food and cover is available (Kitchener, 1991). But in the present study area, it was restricted in a certain locality because the local people kill it as

this animal preys on domestic animals (Marker *et al.*, 2003). This might contribute for the rareness of the species. Signs of spotted hyaena like sound, Pug mark and faeces have been recorded in all three habitats of the study area. The sound was heard at night and hunted domestic animals like dogs, sheep and goats.

According to Sillero-Zubri and Gottelii (1995), Ethiopian wolf *(C. simensis*) occurs in a few mountain ranges of Ethiopian highlands. It occurs in Simien Mountains, Mountain tops of Wollo highlands around Abune Yoseph, Amba Ferit, Donkoro Chacka and other high altitude areas of the Wollo region and in Northern Shoa area of Menz (Guassa). It also occurs in Arsi and Bale mountains of and other high altitude areas (Marino, 2003). In this study the presence of Ethiopian wolf was confirmed through indirect evidences such as, signs and interviewing the local people. The people who were interviewed in the area had seen wolves rarely, and the species distribution was highly restricted in Afro-alpine parts and never in other parts of the Park.

5.3. Threats of Borena-Sayint National Park

During the present study periods, the major threats observed in the Park were grass collection, livestock grazing, encroachment and environmental degradation.

5.3.1. Grass collection

Grass collection is one of the serious threats of wildlife in the Park. The local people cut grass to feed their cattle, sell in the market and thatching houses. This might cause scarcity of grass for herbivores and disturb the natural behavior of wildlife in the Park.

5.3.2. Livestock grazing

Since the park lacks natural buffer zone, high number of grazing cattle and other domestic animals make a devastating effect on the edges of the Park. During over grazing, there has been deterioration of vegetation close to the edge that might influence the wildlife of the Park.

5.3.3. Encroachment

Like any other Parks in Ethiopia, the local community exploits the resource from the Park. Forest exploitation inside the Park and traditional farming activities close to the Park might cause strong impacts on the wildlife of the area. Wild animals were highly restricted in some parts of the Park because of human and livestock encroachment.

5.3.4. Environmental degradation

BSNP is like an island in highly degraded northern highland of Ethiopia and environmental degradation is common phenomena in the region that might cause a strong impact on future existence of the Park.

5.4. Tourist potential of Borena-Sayint National Park

The Park comprises of outstanding landscapes, several unique biological diversity and scenic features that attract visitors. Although endemic wildlife that occur in the area constitute the highest share, the landscape, natural forest and caves will incredibly attract.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

The present study identified and documented mammalian species of BSNP and gave base line information about their presence. The distribution and abundance of mammal species in Park varied because of vegetation types and altitudinal differences. For example, guereza, gelada baboon, sacred baboon and bushbuck were frequently seen in the Park.

BSNP contains significant populations of mammalian species such as rodents, insectivores, carnivorous and herbivores. Among herbivores, order primate constitutes the large proportion in abundance than other orders.

The number of large mammal species occurred in the present study area is comparable to other National Parks of the Amhara region such as Alatish National Park. More ever, BSNP has a scenic topographic features and harbored endemic fauna like, gelada baboon, critically endangered Ethiopian wolf and Menilk's bushbuck. So, the Park needs strong attention from Federal and regional government to implement proper wildlife management.

BSNP is the most threatened Park of the country because of its size, shape and location. To conserve the wildlife in the Park, threats such as encroachment, livestock grazing, grass cutting, environmental degradation, poaching and deforestation should be minimized.

6.2. Recommendation

BSNP is like an island in the middle of highly modified environment thus its presence is crucial. Therefore, to ensure the long-term conservation of wildlife of the Park, the following recommendations are suggested:

- The National and Regional government should introduce appropriate strategies to conserve wildlife of the Park.
- Involvement of various stakeholders through community based observation is essential.
- There are many roads crossing the Park with primary objective of connecting the nearby Woredas but might influence the conservation activities of the Park unless properly managed and controlled to suite the Park needs.
- Regular assessment and monitoring of fauna and flora of the Park is essential.
- The Park workers might work to benefit the local community and to increase their awareness.
- Development of infra structures to attract tourists is crucial.
- Clear demarcations and natural buffer zones are essential to minimize the exploration of wildlife of the area.
- Enhance the competency of scouts and their effectiveness significantly through training and patrol equipment.
- Meteorological station should set up at in or around the Park to obtain accurate meteorological data of the Park.
- Illegal activities of the local community in the Park should be controlled.
- Implementation of rural development program might be designed to move the local people from the Park proximity.

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