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FACULTY OF LIFE SCIENCE

POPULATION STATUS AND FEEDING ECOLOGY OF THE ETHIOPIAN WOLF (*Canis simensis*) IN AND AROUND BORENA - SAYINT NATIONAL PARK, SOUTH WOLLO, ETHIOPIA

A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Biology (Zoological Sciences)

By

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ABBREVATION AND ACRONOMY

BSNP - Borena-Sayint National Park

CBD- Convention of Biodiversity Conservation

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

PaDPA- Amhara Regional State Park Development and Protective Authority

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ABSTRACT

A study on the population status, distribution and feeding ecology of the Ethiopian wolf (*Canis simensis*) was carried out in the Borena-Sayint National Park, Southern Ethiopia during October, 2010 – March, 2011 including wet and dry seasons. Distance sampling line-transect count method was used to estimate the population of Ethiopian wolf. A total of 29 and 34 wolves were counted during wet and dry seasons, respectively. The sex ratio of adult male to adult female was 2.5:1.00. Pack size changed seasonally. The sex structure of Ethiopian wolf was adult male 34.48%, adult female 13.79%, sub-adult males 27.59%, sub-adult females 13.79 % and young 10.34%. The age ratio of adult to young was 1:4.67 both during dry and wet seasons. There was no significant difference among the total population number, age and sex categories, and the pack size during dry and wet seasons ($P > 0.05$). The mean pack size was 3 ± 0.25. The pack composition varied with season, forming larger packs during the dry season. The occurrence of food items in the scats significantly differed ($P < 0.01$). Rodents were the principal prey items with 69.2% frequency of occurrence. Grass blades and bird feathers also formed the diet components. Among livestock, remains of sheep were identified in few scats. Distribution and vegetation utilization of the Ethiopian wolf showed a marked preference for *Lobelia-Hypericum* habitats. However, there was a seasonal change in the preference of habitat. The main threats of the Ethiopian wolves in the study area were grass collection, livestock grazing, encroachment and related environmental problems. It is necessary to educate the local people and conservation issues of the Ethiopian wolf to enhance the coexistence of the Ethiopian wolf with human beings.

Keywords: Ethiopian wolf, feeding ecology, habitat preference, population status, threat.

1. INTRODUCTION AND LITERATURE REVIEW

1.1. Background of the study

Ethiopia is one of the most physically and biologically diverse countries in the world with sizeable endemism (Leykun Abune, 2000). It comprises highland massives surrounded by arid lowlands, which contain various wildlife habitats ranging from alpine moorlands to lowland savannas and arid lands, and extensive wetlands (Yalden, 1983). The past geological history, unique topography and wide ranging climate of Ethiopia have contributed to diverse biological resources and numerous endemic species of flora and fauna (Hillman, 1993; Yalden and Largen, 1992).

There are over 861 species of birds, 284 species of mammals, 201 species of reptiles, 63 species of amphibians and 150 species of fish in Ethiopia (Yalden and Largen, 1992). Among these, 31 species of mammals, 16 birds, 24 amphibians, 9 reptiles and 40 fish are believed to be endemic (Hillman, 1993). However, these vary from place to place and season to season due to climatic and environmental factors. Therefore, accurate population estimate of these diverse wildlife forms is an essential requirement for conservation efforts.

Using vegetation as the main distinguishing factor, there are 10 broadly recognized ecosystems in Ethiopia. These are Afro-alpine and sub afro-alpine ecosystems (3200 – 4620 m asl), montane grassland ecosystems (1500 – 3200 m asl), dry evergreen montane forest and evergreen scrub ecosystems (1500 – 3200 m asl), moist montane forest ecosystems (800 – 2500 m asl), *Acacia - Commiphora* woodland ecosystem (900 – 1900 m asl), *Combretum – Terminalia* woodland ecosystem (500 – 1900 m asl), lowland tropical forest ecosystem (450 – 800 m asl), desert and semi-desert scrubland ecosystems (>500 m asl), wetland ecosystems and aquatic ecosystems (Zerihun Woldu, 1999).

Ethiopia has the largest extent of afro-alpine and sub-afro-alpine habitats in Africa. These ecosystems are characterized by the giant herb, lobelia (*Lobelia rhynchopetalum*), the evergreen tree heather (*Erica arborea*) and shrubby and herbaceous everlasting flowers (*Helichrysum* spp.).

The endemic wild mammals in this ecosystem include the walia ibex (*Capra ibex walia*), mountain nyala (*Tragelaphus buxtoni*), Starck's hare (*Lupus starcki*), Ethiopian wolf (*Canis simensis*), and the gelada baboon (*Theropithecus gelada*). The giant mole rat (*Tachyoryctes macrocephalus*) is also a characteristic species of this ecosystem. Endemic birds found in these ecosystems include spot-breasted plover (*Vannellus melocephalus)*, Ankober serin (*Serinus ankoberensis)* and chough (*Pyrrhocorax graculus*), lammergeyer (*Gypaetus barbatus*) and golden eagle (*Aquila chrysaetos*) (CBD, 2007).

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. This 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 of 4-5 months (June to October) and a dry season of 6-7 months (November to May). The southern and central parts of the region receive about 1000 mm of annual rainfall. The amount of rainfall reaches its lowest in the northwestern and northeastern parts of the region along the boundary with Sudan, Tigray and Afar regions, where it amounts to < 700 mm (PaDPA, 2006). BSNP (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 of highly, degraded, eroded and isolated in South Wollo Zone of Amhara Regional State in northern Ethiopia. This area has attracted the interest of the National and Regional Governments.

According to Boddicker *et al*. (2002), many mammalian species, especially those indigenous to tropical forests are cryptic, discrete and inhabit areas that are not easily accessible. During the last glacial age, afro-alpine habitats were widespread across the highlands of the country. A wolf like *Canid* ancestor is thought to have colonized this expanding habitat and given rise to a new species, remarkably well adapted to the afro-alpine environment. This endemic species is described as the Ethiopian wolf (*Canis simensis,* Rϋppell, 1835) (Gottelli *et al*., 2004). This wolf used to occur at lower elevations before becoming subject to severe human persecution (Nowak, 1999). It is an afro-alpine specialist with a restricted distribution in the high elevations (Zelealem

Tefera and Sillero-Zubiri, 2007). It is also considered as the world's rarest *Canid* and qualified as a "Critically Endangered" species in the Red Data Book of IUCN (Sillero-Zubiri, 1996). This species is endemic to Ethiopia.

1.2 Statement of the problem and Justification

For effective research and management of wildlife species, reliable estimate of population and information on feeding habits are essential (Putman, 1984; Matrai *et al*., 1998). Ethiopian wolf is one of the endemic mammals of Ethiopia (Sillero-Zubiri and Gottelli, 1995a) and it is also one of the most important flagship species of the country. Marino *et al*. (1999) studied the distribution range and population status of the Ethiopian wolf in all the seven isolated pockets of afro-alpine ecosystem including in the South Wollo and Denkoro State Forest. However, detailed studies on the population status and feeding ecology of Ethiopian wolf in some of these sites of its distribution are yet to be available.

1.3. Literature Review

Canis simensis is the only true wolf species in Africa. It is also known as the Simien fox, Simien jackal or the Abyssinian wolf. Locally, the Ethiopian wolf is called by different names. In Amharic speaking areas of the South Mountains and Menz, it is called Key Kebero; in the Wollo area, it is called Seren; in Gojjam, it is called Walge; in the southeast of the country in Arsi and Bale mountains, among the Oromifa speakers, it is usually called Jedella Ferda, but in few localities in the same area, it is also called Arouaye.

The Ethiopian wolf crossed over from Asia during the Pleistocene period less than 1 million years ago, when the sea level was lower, and Africa and the Middle East were connected. During the Pleistocene, the highlands of Ethiopia were predominantly afro-alpine moorland (Bonnefile *et al*., 1990), and these habitats were the ideal habitat for a variety of small mammals, particularly grass rats (Muridae). This afro-alpine environment must have morphologically shaped the Ethiopian wolf as a specialized rodent hunter (Gottelli and Sillero- Zubiri, 1992). The afro-alpine habitat, characteristically represented by few mountain tops in the Ethiopian highlands was widespread during the Pleistocene. During the last glacial period, the African tropics were generally colder and drier than at present. Consequently, the moorlands of East African Mountains were about 1000 m lower than they are now (Bonnefile *et al*., 1990). Extrapolation of the present distribution of afro-alpine habitat in Ethiopia suggests that up to 100,000 km^2 of afro-alpine habitat may have been available for the Ethiopian wolf and for its prey during the last glaciations (Gottelli and Sillero- Zubiri, 1992). The end of the Pleistocene brought climatic changes and forced the extensive Ethiopian afro-alpine moorlands to shrink to their present size, reducing the habitat available for the Ethiopian wolf by an order of magnitude. Only about 2% (22, 750 km^2) of the total land area of Ethiopia is above 3000 m. Of this, less than 10% at present consists of afro-alpine steppes or mountain grasslands suitable for the Ethiopian wolf, which is found only in a few localized mountain pockets (Yalden and Largen, 1992; Gottelli and Sillero- Zubiri, 1992; Malcolm, 1997; Marino *et al*., 1999).

The Ethiopian wolf is one of the four canid species in Africa; the others being *C. aureus, C. mesomelas, C. audustus* and *Lycaon pictus* (Zelealem Tefera, 2001). Systematics of the Ethiopian wolf was confusing due to lack of material on which to base its classification. Different travellers at different times have given the species different names such as *Canis sinus gervais; Canis* or *Vulpes walge heuplin*; and *Simenia simensis* (Yalden *et al*., 1980). More recent studies have categorized it as a member of the genus *Canis* (Clutton-Brock *et al*., 1976). The phylogenetic analysis using mt DNA sequences suggested that *Canis simensis* is a distinct species, with closer relationship to the grey wolf (*C. lupus*) and the coyote (*C. latrans*) than to any of the African *Canid* species (Gottelli *et al*., 1994) (Fig. 1).

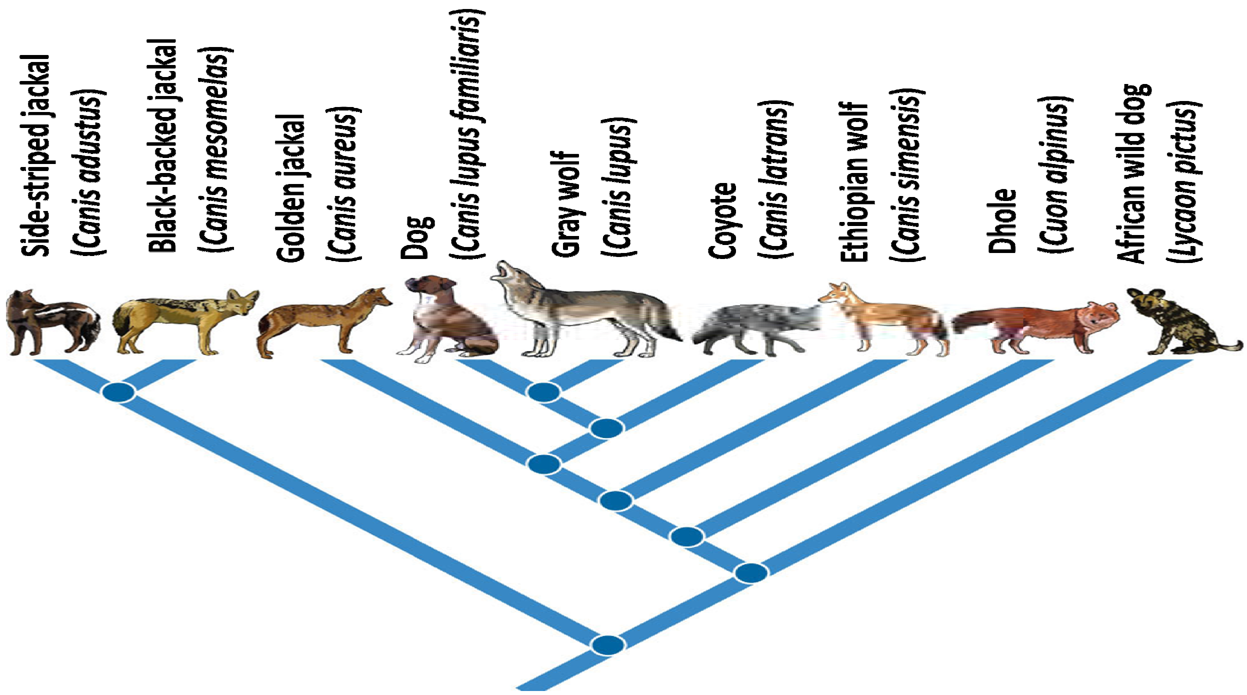

Figure 1. Phylogenetic tree of *Canis simensis* and other *Canids* generated from 372 bp sequence of cytochrome b mt DNA (Source: Chen *et al.,* 2000).

This species may have evolved from a gray wolf-like ancestor around 100,000 years ago (Gottelli *et al*., 2004). *Canis simensis* is closely related with the side-stripped jackal (*C. adustus)* and *Dusicyon* spp (Clutton-Brock *et al*., 1976). The Ethiopian wolf may be an evolutionary relict of a gray wolf-like ancestor, which invaded northern Africa from Eurasia, where fossils of wolf-like *Canids* are known from the late Pleistocene (Clutton-Brock *et al*., 1976). Two species have been recognized as taxonomically distinct from the opposite side of the Great Rift Valley. The northwestern highland and central highland populations have been described as *C. s. simensis* and the southeastern highland population as *C. s. ceternii*, based on brighter red coat colour of some specimens from northwestern highlands, and consistently longer nasal bones in those from southeastern highlands (Yalden *et al*., 1980). A recent study has indicated that the two possible sub-species are genetically identical at the level of mt DNA analysis (Gottelli *et al*., 1994). However, studies on the microsatellite DNA have indicated some differences (Gottelli *et al*., 1994).

The family *Canidae* is one of the most widely distributed families of the Order *Carnivora*. Members of this family occur in many places of all continents except Australia and Antarctica (Eisenberg, 1989). The rich diversity of this family reflects the success of its evolution (Hunt, 1996). Canids exhibit strong flexibility to environmental constraints. This makes them potentially strong competitors with a number of species (Johnson *et al*., 1996).

Ethiopian wolf populations occur north of the Rift Valley in the Simien Mountains, Mount Guna, North Wollo, South Wollo, Guassa-Menz and southeast of the Rift Valley in the Arsi and Bale Mountains. The Ethiopian wolf was first recorded in the Simien Mountain ranges in northwestern highlands of Ethiopia (Marino, 2003). According to Marino (2003), populations still occur in the Simien Mountains including the Ras Dejen, which is the highest peak in Ethiopia (4533 m asl).

In this area, suitable wolf habitat is confined to the altitudes of 3700 m and 4400 m asl and distributed in four main areas interconnected by narrow corridors. The Geech plateau of the Simien Mountains National Park accounts for only a small extent of available wolf habitat, and most of the suitable habitat, therefore, lies outside the Park. On Mount Guna near Debre Tabor, a small wolf population occurs. The Ethiopian wolf is locally extinct in Mount Choke in the southwest of Gojjam (EWNHS, 1996; Marino *et al*., 1999).

The North and South Wollo highlands in the northeast of the country have been reported to have a population of Ethiopian Wolf. In the North Wollo area, Mount Abune Yoseph (4,190 m asl) has a total area of 140 km^2 of important wolf habitat. The nearby areas of Abuye Gara (3,500-3,700 m asl) and the Delanta ranges (3550-3750 m asl) also have small populations of the Ethiopian wolf. In the South Wollo area with a total area of 243 km^2, the Amba Ferit range is the most important range for the distribution of the Ethiopian wolf. It is in this range, Denkoro-State Forest (Borena-Sayint National Park) is located. Guguftu and Kewa Mountain ranges are habitats of Ethiopian wolf populations (Marino *et al*., 1999). The North Shoa areas of Goshe-Meda Ankober (3700 m asl) and Kundi (3900 m asl) used to have small Ethiopian wolf population until recently. Guassa area of Menz in North Shoa is one of the smallest units of afro-alpine area where a continuous area of suitable wolf habitat lies at 3200- 3700 m asl.

Guassa area is defined as a North-South extension of afro-alpine range, bounded by a steep escarpment of the Rift Valley in the east and by low-lying agricultural areas of Menz in the West (Tefera Tenagashaw, 1998). The Arsi Mountains form the second largest available habitat in the country, with 870 km^2 of suitable wolf range. Which lies between 3200 m and 4100 m asl. The Galama range connected to the West to Chilalo Mountain forms a suitable habitat at 3300-3400 m asl. The isolated mountain peaks of Mount Kaka and Mount Inkolo provide extra patches of suitable habitat of lesser importance in the Arsi Mountain range (Marino *et al*., 1999). With more than 1000 km^2 of suitable wolf habitat, the Bale Mountains comprises the largest area of afro-alpine range in Ethiopia as well as in Africa. This mountain complex has Tullu Deemitu (3900 to 4377 m asl); Sanneti plateau (3800- 4000 m asl); Web-Valley (3400 to 3500 m asl) and the lowest wolf range of Gaysay Valley (3,000 m asl) comprising a montane grassland ecosystem.

The Bale Mountain is the largest area of Ethiopian wolf habitats, which holds about half of the global population of the species. Arsi, Guassa - Menz, Wollo, and Simien Mountains provide refugia for further smaller populations that made up the remainder of the global population (Deresse Dejene, 2003). The estimated population of the Ethiopian wolf was 250, 80, 50, 35, 40, and 25 individuals in the Bale Mountains, Arsi, Simien Mountains, North Wollo, South Wollo and Guassa-Menz, respectively (Marino *et al*., 1999).

The Ethiopian wolf feeds almost exclusively on diurnal small mammals of the high altitude afro-alpine grassland community (Sillero-Zubiri, 1994; Sillero-Zubiri and Gottelli, 1995a, b). Unlike many other carnivores, pack members feed alone on small rodent prey. In the Bale Mountains, diurnal rodents accounted for 96% of all prey occurrences in faeces, with 87% belonging to three Bale endemic species, the giant mole rat (300–930g), Blick's grass rat (*Arvicanthis blicki*), and the black-clawed brush-furred rat (*Lophuromys melanonyx*) (Sillero-Zubiri and Gottelli, 1995b). Other prey species include typical grooved toothed rat (*Otomys typus*), rock hyrax （*Procavia capensis*）, yellow spotted brush-furred rat (*Lophuromys flavopunctatus*), Starck's hare (*Lepus starcki*), young of common duiker （*Sylvicapra grimmia*）, reedbuck （*Redunca redunca*）, mountain nyala (*Tragelaphus buxtoni*), young antelopes, lamb, and goslings and eggs. Leaves of sedge (*Carex monostachya*) are occasionally ingested, probably to assist digestion or to control parasites (Sillero-Zubiri and Gottelli, 1995b; Malcolm, 1997). Where the giant mole rat is absent, it is replaced in the wolf diet by the smaller East African mole rat, *Tachyoryctes splendens* (i.e., *Gaysay* montane grassland in Bale and Menz) (Malcolm, 1997; Zelealem Tefera, 2001). In the Simein Mountains, wolves feed on *Arvicanthis abyssinicus* (Müller, 1977). The most favoured technique to catch giant mole rats is by digging the prey. Although the Ethiopian wolf is a pre-eminent, solitary rodent hunter, it is also a facultative, cooperative hunter to take feed on large carcasses (Morris and Malcolm, 1977). Ethiopian wolves will take carrion or feed on carcasses. Sheep carcass is the most successful bait for attracting wolves (Sillero-Zubiri, 1996). The density of Ethiopian wolf is positively correlated with density of rodent prey and negatively with vegetation height (Sillero-Zubiri and Gottelli, 1995a).

Rüppell originally described the Ethiopian wolf in the Simien Mountains as hunting in small packs and killing sheep and small game animals (Harper, 1945). However, Brown (1964) noted that small rodents were the main food of the wolves, and that they foraged mostly alone. Morris and Malcolm (1977) analyzed a small number of droppings from the Bale Mountains and concluded that mole rats (*Tachyoryctes*) were the most important food source, followed by Starck's hare (*L. starcki*), grass rats (*A. blicki*), and swamp rats (*O. typus*). In areas of grazing, wolves often were observed foraging among herds of cattle, a tactic that may aid in ambushing rodents out of their holes, by using cattle as a mobile hide (Morris and Malcolm, 1977).

There is little nocturnal activity, with wolves seldom moving far from their evening resting site. They may become more crepuscular and nocturnal where human interference is severe (e.g., Simien: Brown, 1964 and Somkaro and Kaka Mountains: Sillero-Zubiri, 1995). Rich food patches are carefully explored by wolves, which walk slowly, pausing frequently to investigate holes or to localize rodents by means of their good hearing potential. Once the prey is located, the wolf moves stealthily towards it, taking short steps, and freezing, sometimes with its belly pressed flat on the ground. The prey is catched with the mouth after a short dash. Occasionally, wolves run in zigzag across rat colonies picking up the rodents (Marino *et al*., 2003).

They live in separate and cohesive packs, and communally share and defend an exclusive territory. In optimal habitat, packs consist of 3-13 adults, containing 3-8 related adult males, 1-3 adult females, 1-6 yearlings and 1-6 pups (Sillero-Zubiri and Gottelli, 1995b).

Ethiopian wolves come together for social greetings and border patrols at dawn, noon and evenings and rest together at night (Fig. 2).

Figure 2. A pack of the Ethiopian wolves (Source: William, 2001)

The Ethiopian wolf is restricted to the high montane ecosystem. The species occurs in two main ecological zones in Ethiopia (Hurni, 1986). The afro-alpine (approx. 3,700- 4,400 m asl) and the subalpine (approx. 3,000- 3,700 m). Suitable habitats extend from 3,200m up to 4,500m, with some wolves present in montane grasslands at 3,000 m. However, as subsistence agriculture is extended up to 3,500–3,800 m in many areas, restricting wolves to higher ranges (Marino, 2003). Rainfall at high altitude varies between 1,000 and 2,000 mm/year, with one pronounced dry period from December to February/March. Wolves utilize all Afro-alpine habitats, but prefer open areas with short herbaceous and grassland communities, where rodents are most abundant, along the flat or gently sloping areas with deep soils and poor drainage. Prime habitats in the Bale Mountains are characterized by short herbs (*Alchemilla* spp.) and grasses and low vegetation cover, a community maintained in continuous succession as a result of mole rat burrowing activity. Other good habitats include tussock grasslands (*Festuca* spp., *Agrostis* spp.), high-altitude scrubs dominated by *Helichrysum* spp. and short grasslands in shallow soils. In northern parts of the range, plant communities characterized by a matrix of *Festuca* spp., *Euryops pinifolius* and *Lobelia rhynchopetalum* sustain high rodent abundance, and are preferred by wolves. Below 3, 300 m, trees mainly *Hypericum revolutum* and *Hagenia abyssinica* occur in increasing numbers in heather. Ericaceous moorlands (*Erica* and *Phillipia* spp.) at 3,200–3,600 m are of marginal value, with open moorlands having patches of herbs and grasses, which are relatively good habitats for the Ethiopian wolf.

The Ethiopian wolf is classified by the World Conservation Union (IUCN) in its Red List as Endangered, and is considered to be the rarest canid in Africa (IUCN, 1997; Sillero-Zubiri and Marino, 2008). Fewer than 500 Ethiopian wolves persist, patchily distributed among seven fragmented regions from the northern highlands of the Simien Mountains to the south-central highlands of the Bale Mountains (Marino, 2003).

Disease is a specific threat to small, fragmented or threatened populations, with viral diseases in particular responsible for high mortality and local extinction of several such populations (Murray *et al*., 1999; Dobson and Foufopoulos, 2001). These populations are vulnerable to pathogens that can infect multiple host species and are transmitted from more abundant reservoir host populations (Murray *et al.,* 1999; de Castro and Bolker, 2005). The largest population of BMNP has suffered several dramatic declines as a result of mortality induced by epidemics of rabies (Sillero- Zubiri, King and Macdonald, 1996b; Randall *et al*., 2004) and canine distemper and canine parvovirus (Laurenson *et al*., 1998).

Infectious diseases can dramatically influence the dynamics of endangered species and populations, but until recently, disease has been a relatively neglected issue in conservation biology (Scott, 1988). Perhaps the most immediate threat to the Ethiopian wolf is from diseases, which are known to devastate populations of rare and endangered species (Thorne and Williams, 1988; Alexander and Appel, 1994). Since intensive scrutiny of Ethiopian wolves began in the 1980s, the impacts from rabies have been well-documented in the BMNP. The first significant outbreak recorded occurred in 1990 on the Sanetti Plateau (Sillero-Zubiri *et al*., 1996), killing 54% of the wolf population. In 1992, a second rabies epidemic swept through the Web Valley, killing 77% of the wolves. In 2003 and 2004, another rabies outbreak occurred in BMNP, when over two-third of the 95 wolves in the Web Valley were found dead or disappeared (Randall *et al.,* 2004). The devastating impacts of infectious diseases, and the rapid rate of spread among gregarious species, continue to threaten the survival of Ethiopian wolves.

On islands or in isolated landscapes like that of relict mountain tops, the restricted resource base and small population sizes often lead to specialized species that are vulnerable to extinction through interspecific competition (Rosenzweig, 2000). However, human and, by extension, dog populations have rapidly increased over the past few decades in all the Ethiopian wolf ranges, as they seek agricultural land or pasture for their domestic livestock. In BMNP, domestic dogs compete with wolves for resources. Scat analysis of domestic dogs carried out in BMNP, revealed that among the nineteen rodents identified, five were *Arvicanthis blicki*, seven were *Otomys typus*, three were *Tachyoryctes splendens* and two were *Tachyoryctes macrocephalus*. The finding of this study has revealed the potential threat of the domestic dogs on the endemic and endangered Ethiopian wolves in BMNP though interspecific competition (Anagaw Atickem *et al*., 2009). Over the course of the above study, a total of 36 dog–wolf interactions were observed. In the interactions, if there was more than one dog, the dogs chased the wolf (n = 21). When there were more wolves than dogs, the wolves dominated the interaction and they chased dogs away (n = 9). Dogs that were not roaming entered the wolf range occasionally following their owners and met wolf. Roaming dogs, which were observed hunting rodents in the Ethiopian wolf range during the study period were observed greeting with the Ethiopian wolves (n = 3). As most settlements were established near the Ethiopian wolf habitat, 92% of the occasions when wolves were chased by dogs happened when a wolf approached the settlements (Anagaw Atickem *et al*., 2009).

The existence of high altitude subsistence agriculture and overgrazing of habitat, loss of genetic variability, predation, domestic dogs hybridization and disease transmission like rabies; increased road kills and shooting are major threats for the Ethiopian wolf distribution in afro-alpine grasslands and heathlands. At present, the species is already extinct from various parts of Ethiopia. These include, Mount Choke of Gojjam (Marino, 2003; Gottelli *et al*., 2004), Gosh-meda and Ankober of Shoa, Mount Guge (Gamogofa) and Harerge (Malcolm and Sillero-Zubiri, 1997).

1.4. OBJECTIVES

1.4.1. General Objective

- The general objectives of the proposed project were to study the population status, distribution pattern and feeding habits of the Ethiopian wolf in Borena-Sayint National Park (BSNP), Ethiopia.

1.4.2. Specific Objectives

- To determine the current population and structure of Ethiopian wolf in BSNP.
- To identify altitudinal gradient as a factor responsible for distribution pattern of the Ethiopian wolf in BSNP
- To study the feeding habits of the Ethiopian wolf in BSNP.

1 .4.3. Research questions

This project tries to answer the following questions:

- What is the population size of the Ethiopian wolf in Borena-Sayint National Park and surrounding areas and how does it vary between seasons?
- What are the feeding activities displayed by the Ethiopian wolf at different times of the day and in different seasons?
- Is there any variation in the pack size and social activities of the Ethiopian wolf from season to season?

1.4.4. Significance of the Study

Findings of this study are expected to show the current status of Ethiopian wolf in Borena-Sayint National Park and give an insight into the conservation of the Park in particular.

2. THE STUDY AREA AND METHODS

2.1. The Study area

Borena-Sayint National Park (BSNP) 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.3). The Park is located in the northeastern part of Ethiopia about 600 km by road from Addis Ababa, 205 km from Dessie and 16 km from Mekane Selam, the capital of Borena Woreda. The Park is situated among three Woredas, namely, Borena in the south, Sayint in the north and Mehal Sayint (a newly established Woreda) in the east. Borena Woreda on the south (with its seven Kebeles) and southwest (with 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.

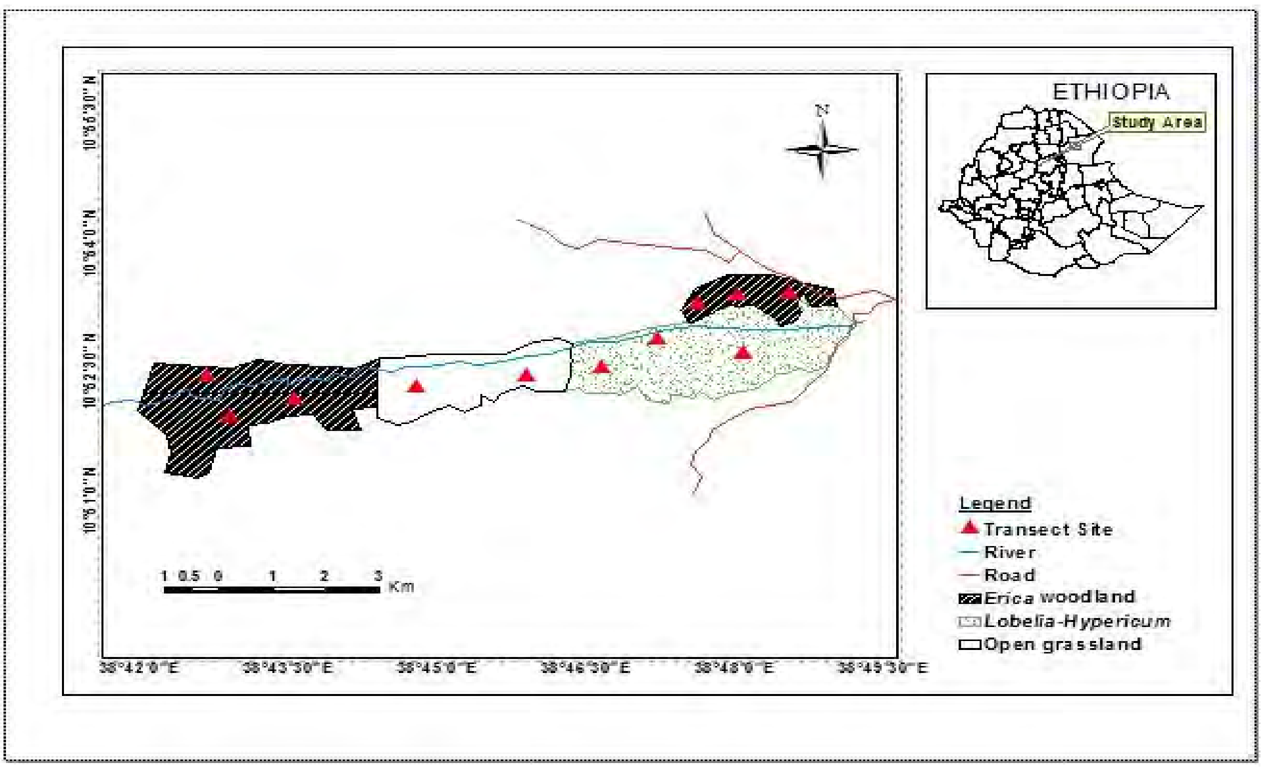

Figure 3. Location map of the study area

Rainfall and temperature data were recorded for seventeen years (1993-2010) from Mekane Selam Meteorological Station of the Ethiopian National Meteorology Service Agency (ENMSA, 2010), 16 km away from the study area. The mean monthly maximum temperature ranged between 17.8^{O}C (August) and 24.4^{O}C (March); whereas the mean monthly minimum temperature ranged between 9.5^{O}C (November) and 11.8^{O}C (May) as shown in the Fig. 4.

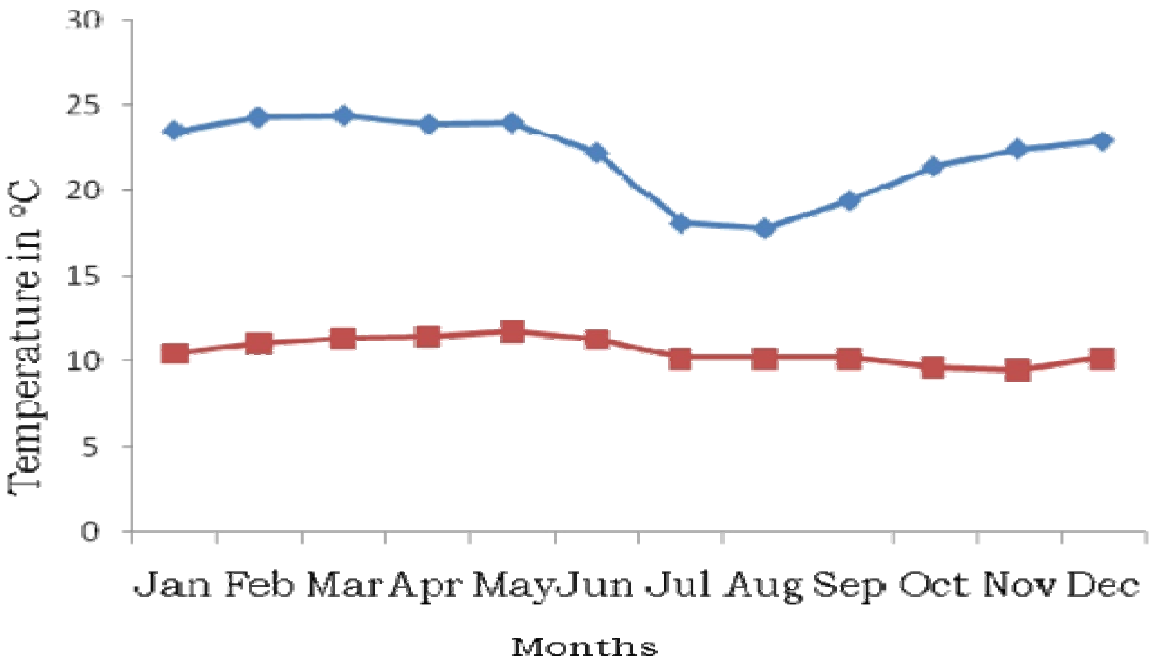

Figure 4. Average maximum and minimum temperatures of the study area from 1993 to 2010 G. C (ENMSA, 2010).

According to the seventeen years rainfall data the area has a bimodal rainfall distribution, characterized by prolonged wet season from June to September (long rains), locally known as "Kiremt" and a short wet season between March and April, locally known as "Belg" (Fig. 5). The mean monthly rainfall of the area varies between 9.5 mm (December) and 235.7 mm (July).

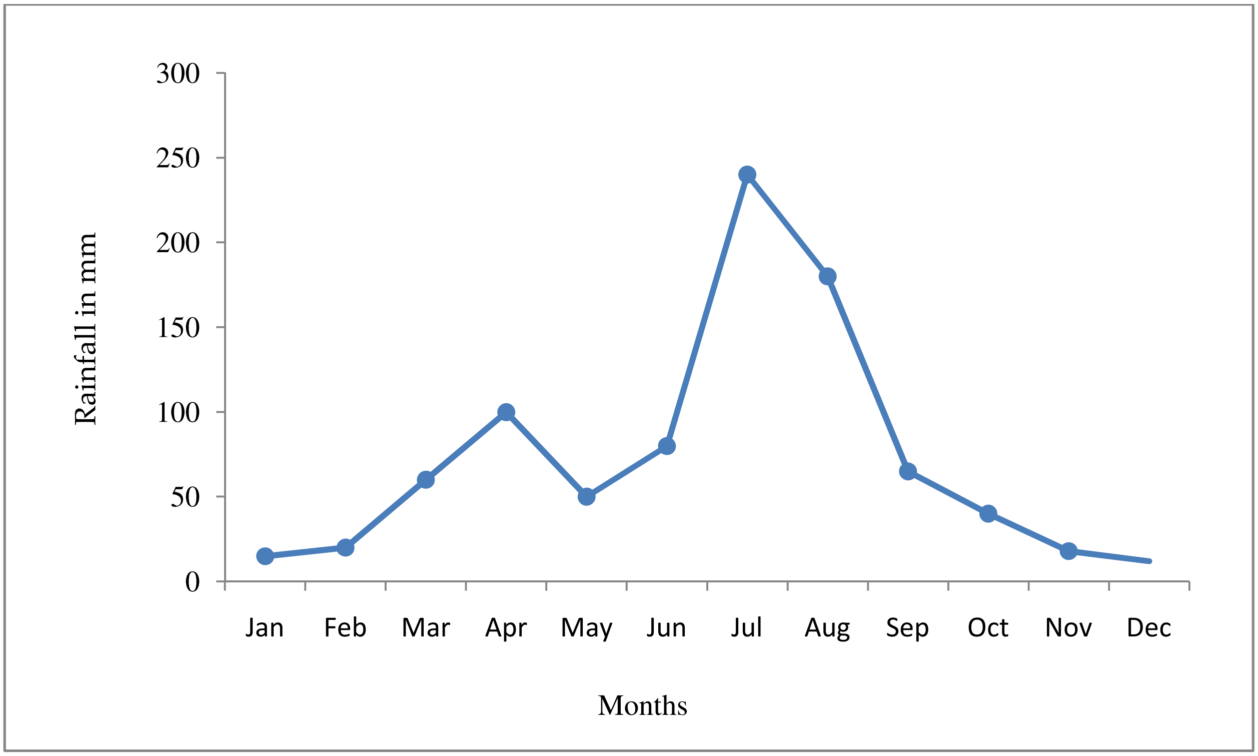

Figure 5. Average monthly rainfall of the study area from 1993 to 2010 G.C (ENMSA, 2010).

The Park has different topographical features ranging from lowland to highland mountains. The altitude ranges between 1900 – 3699 m asl. The park is generally characterized by rough topography with mountains, deep incised valleys, escarpments and plateaus. Most part of South Wollo is covered by volcanic rocks mainly basalt of Tertiary age (McGinley, 2007, 2008). According to EFAP (1994), the area of Denkoro forest (now Borena-Sayint National Park) was 80 km^2. Currently, it covers only an area of only 43 km^2, which makes it the smallest Park among the National Parks of Ethiopia. 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 20 cm due to excessive erosion, with 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.

One of the most attractive features of Ethiopia is the diversity of its vegetation. Various parts of the country with varied topography, altitude and rainfall distribution have resulted in unique vegetation formation (Leykun Abune, 2000). The abundance and distribution of mammals depend mainly upon the nature, structure and density of vegetation (Taylor and Green, 1976). BSNP has a rich biodiversity with high number of endemic species and attractive bio-physical features (Keiner, 2002). Eventhough the Park is small in size, it has higher species diversity due to the characteristics of moist evergreen forest (Abate Ayalew *et al.,* 2006). The study area encompasses three vegetation zones: afro-alpine belt, sub-afro-alpine belt and afro-montane belt.

The Afro-Alpine Belt (□ 3200 m) consists of an area at altitude □ 3,200 m asl. These form the slopes and top of the highest mountains. The rocks are volcanic, mostly basalts and trachytes. The mountains attract rain and the basaltic and trachytic bed-rock precludes excessive internal drainage. High on the mountain, in the afro-alpine belt, the soil temperature is very low, near freezing (Tewolde Berhan Gebre- egziabher, 1988).

The vegetation in the area includes *Kniphofia foliosa, Crassula connata, Helichrysum citruspinum, Alchemilla abyssinica, Lobelia rhynchopetallum, Agrostis quinquesta, Festuca abyssinica, Trifolium accaule* and *Erica arborea.* In the crevices, various herbs, mosses and lichens are present.

The Sub-Afroalpine Belt (3000- 3200 m) consists of mostly by ericaceous scrub: *Erica arborea*, *Hypericum revolutum* interspersed with tussock grass (*Festuca abyssinica*), and *Lobelia rhynchopetallum.*

Lobelia rhynchopetallum - Hypericum revolutum habitat type

Is found around the area, locally called "Lemeske" and at altitude of around 3450 m asl and at coordinates of 10^{0}52.082" latitude and 038^{0}48.625" longitude. The characteristic plant species in this site are *Lobelia rhynchopetallum*, *Hypericum revolutum* associated with *Festuca abyssinica* (Fig. 6).

Figure 6. *Lobelia* with *Hypericum* habitat type (Photo: Yigrem Kebede, November, 2010)

Erica arborea - *Festuca abyssinica* habitat type

Is found in the areas locally called" Bizu Gemera" and "Keta Chilaga". At an altitude of 3300 m and 3631 m asl, respectively. Bizu Gemera is a site found inside the Park while Keta Chilaga is located outside the Park at coordinates of 10^0 51.003" latitude and 038^0 47.576" longitude and 10^0 54.515” latitude and 038^0 58.753” longitude, respectively. The characterstic species in this site are *Erica arborea* with *Festuca abyssinica* (Fig. 7).

Figure 7. *Erica* with *Festuca* habitat type (Photo: Mulugeta Belay, December, 2010)

Open grassland (*Festuca abyssinica)* habitat type

This habitat type is found around the area, locally called "Mentaw Gora" at an altitude 3400 m asl and at coordinates 10^0 51.889" latitude and 038^0 47.789" longitude. The characterstic plant species in this site are *Festuca abyssinica* with sparsely associated *Hypericum revolutum* and red-hot pokers (*Kniphofia foliosa*) (Fig. 8).

Figure 8. Open grassland *(Festuca abyssinica*) habitat type (Photo: Yigrem Kebede, December, 2010)

BSNP is a central highland area rich in biodiversity. It harbours various species of wild animals including mammals, birds, invertebrates and amphibians. According to the inventory made by the South Wollo Department of Agriculture, the area harbours 44 species of mammals and 232 species of birds (Marino, 2003).

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, which are used by wildlife, humans and livestock. Local farmers use these water sources for irrigation to cultivate potato, maize, onion and chilly during the dry season. The area is wet all round the year because of the forest cover and topography that increase precipitation.

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 206 km. In addition to this, a new alternative gravel road is built from Kombolcha district to Merto Lemariam district crossing Nile River at Mekane Selam to join South Wollo Zone and Gojjam. This new road gives great opportunity for the visitors of 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 (Figure 9). However, trekking on animals and on foot are the principal means of transport to BSNP.

Figure 9. Dry season Mekane Selam road to the camp site (Photo: Yigrem Kebede, December, 2010).

The area is highly populated by livestock, which 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 fodder for their cattle (Fig. 10), illegally in the absence of scouts, who patrol the area. Moreover, they cut *Fistuca* grass (*Festuca abyssinica*) to thatch their houses and earn some money by selling in the market.

Figure 10. Illegal collection of grass by a local farmer in Borena-Sayint National Park (Photo: Meseret Chane, December, 2009).

2.2. METHODS

Reconnaissance observations was made before the actual data collection to have basic information on accessibility, climate, vegetation cover, topography, infrastructure, fauna and launching sampling plans in this study area. A research design was established depending on this initial observation. The actual data were collected by dividing the study period in to dry and wet seasons. Detailed data collection was carried out from October to November 2010 to accommodate the wet season and from December 2010 to March 2011 to accommodate dry season with additional short term stay in the study area. Quantitative data were collected on the population size, age and sex categories, and habitat preference and habitat utilization, distribution and feeding ecology of the Ethiopian wolf during the dry and wet seasons.

The study area was heterogeneous in vegetation type and topography. It is classified into three Vegetation Zones. These include Vegetation Zone 1/Open grassland (OGL), Vegetation Zone 2/ *Erica* woodland (EWL) and Vegetation Zone 3/. *Lobelia- Hypericum* (LH). 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 the three vegetation types.

Line-transect sampling technique was used to assess the population status of Ethiopian wolf as adopted by Sillero-Zubiri and Macdonald (1997). Eleven transect lines; each of 1.5 to 3 km long were located randomly in the study area using Global Positioning System (GPS). Among these, two were in the open grassland (Bizu Gemera) habitat, three were in the *Erica* woodland (Keta Chilaga), three were in *Lobelia- Hypericum* (Lemesk) and three were in *Erica* woodland (Mentaw Gora) habitats. Transects were placed by stratified random sampling approach in which transect placement was proportional to the area of the habitat type. Adjacent transects were at least 300 m apart. All transects were roughly parallel to each other. Silent detection method was followed to minimize disturbances (Wilson *et al*., 1996). During transect walking, the observer recorded the start and end time, start and end GPS locations, and GPS ID. Whenever an Ethiopian wolf was encountered, the observer recorded the time, GPS location, pack size, distance from the observer, transect – animal distance or perpendicular distance (PD) and habitat type where the animal was located. Censuses were conducted once per month on foot by the researcher and a well trained field assistant of the Park and two trained scouts who were familiar with the area. In the beginning of the study, the field assistant was trained to estimate animal - observer distance, and perpendicular distances. Surveys were conducted during 6:00- 10:00 h in the morning and 16:00 to 18:00 h in the afternoon, at an average speed of 1 km/hr in the *Erica* woodland and *Lobelia- Hypericum* or 2 km/hr in the open grassland habitats. GPS co-ordinates of census transects were predetermined and setup prior to starting the census. On census days, transects were walked from North to East. A GPS was used while walking along transects, the coordinates were captured and the GPS coordinates with mean distances of each transect were recorded (Table 1).

Table 1. Census transects for BSNP with co-ordinates and length of transects.

Transects	**Area size (km^2)**	**Transect length (km)**	**Co-ordinate (x, y)**
T1	1.5	1.5	10^{0} 52.082" - N 038^{0} 48.625"- E
T2	1.5	1.5	
T3	3	3	
T4	1.5	1.5	10^{0} 54.515"- N 038^{0} 58.753"- E
T5	1.5	1.5	
T6	3	3	
T7	3	3	10^{0} 51.003"- N 038^{0} 47.576"- E
T8	3	3	
T9	1.5	1.5	10^{0} 51.889"- N 038^{0} 47.789"- E
T10	1.5	1.5	
T11	3	3	
Total	**24**	**24**	_

Transects were covered systematically with a constant speed to maximize the probability of seeing all animals around the transect. A global positioning system (GPS) was used to follow straight-line by sighting land markers on the line of travel as well as taking bearings to the objects relative to the transect line. Animals observed at a distance of □300 m from the center line showed little reaction, whereas animals observed at <300 m showed variable responses, but were easily observed. Perpendicular distance was measured accurately by using GPS. Censuses were conducted for both seasons (wet and dry) in order to achieve representative estimates. Any change in the population size between dry and wet seasons was noted. The number of animals in the pack, the sighting distance and perpendicular distance of the animal from the observer were recorded each time an animal or a pack was spotted and the following estimation was made (Buckland *et al*., 1993).

D = ns/2LW

Where

D = estimated density of animals (or animal packs)

n = number of animals (or animal packs) seen

s = mean pack size

L = length of transect line(s)

W = mean perpendicular distance of animals (or packs) seen

The population size of Ethiopian wolf was estimated by multiplying the population density (D) with total extent of habitat of the present study (A = 24 km^2), following the method of Buckland *et al*. (1993), Sutherland (1996) and Yisehak Doku *et al*. (2007).

N= D x A

Where, N= Total Population Size

D= Population Density (individual per km^2)

A= Total extent of habitat (in km^2)

Each individual in the pack was identified into respective age and sex category during counting. Adult male, adult female, sub-adult male, sub-adult females and young were identified. Identification of sex and age category were carried out in the field by using relative body size, colour, raised-leg urination and external genitalia (Sillero–Zubiri and Gottelli, 1995a).

During the observation, size of each pack of Ethiopian wolf was recorded before further subdividing into the respective sex and age categories. When the distance between individuals was <50 m, they were considered as members of the same pack (Lewis and Wilson, 1979;

Hillman, 1987; Borkowski and Furubayshi, 1998). Single animals were included within the term 'group' for the purposes of analysis (Arcese *et al*., 1995). All counts were considered to be fully representative as no additional animals were flushed from cover during observation.

The location of each pack and individuals at each vegetation type was recorded. The method of Larson *et al*. (1978) and Norton-Griffiths (1978) was used to describe the dry and wet season distribution and the vegetation type utilization of the animal. By taking each pack or individual sighting as scores with respect to habitat types and comparing their frequencies to the relative availability of vegetation type, it was possible to detect the utilization of vegetation type and distribution of the wolf. Intensive ground surveys were carried out along the eleven transects in each of the monthly surveys in order to determine the distribution of Ethiopian wolf. This was carried out during the morning 06:00-10:00 h and afternoon hour 16:00h-18:00 h, three times per month during the wet and the dry seasons.

Habitat preference of Ethiopian wolf was assessed via a combination of transect sampling in the three different habitat types and scan sampling on the selected study packs. During transect walking, when Ethiopian wolf was encountered, the habitat type was recorded on the basis of the dominant habitat of the area. In addition, habitat types were recorded during scan sampling or activity time budget study, every 10 minutes.

During the time of faecal collection, the age of the sample was categorized into fresh, recent and old (Breuer, 2005). Area, location, date of collection, age of faeces, time of collection, altitude of the collection site and position were also recorded. Faecal droppings were checked regularly for hairs, feather and bones of the animal matters that were consumed by wolves (Breuer, 2005). Identification of carnivore faeces was carried out based on shape, colour, ingested hair, diameter and odour (Fig. 11).

The faecal samples of the Ethiopian wolf were sun dried and grounded in a mortar, and then washed in a sieve (1 mm) using hot water to separate hairs, bones, teeth and other prey components from other organic materials. Then the separated hairs were washed in acetone, dehydrated by 100% ethanol and dried on filter paper. Finally, it was observed under a stereo microscope by considering form, length, colour and diameter (Breuer, 2005).

Figure 11. Droppings of the Ethiopian wolf (Photo: Yigrem Kebede, December, 2010)

All data collected were analyzed using SPSS version 16 computer software programme.
Descriptive statistics, t-test, chi-square test and one-way ANOVA were used for analysis. Differences in seasonal and hourly time budget among adult, sub-adult and yearlings were tested using one way ANOVA. Paired t- test was used to compare the wet and dry season population status of the Ethiopian wolf. Chi-square test was used to analyze the faecal dropping samples.

3. Results

3.1. Population number

A total of 200 faecal dropping samples of the Ethiopian wolf were collected. Out of them, 100 samples were collected from in and around BSNP and 25 faecal samples were collected from each of the four different sites namely, Lemesk, Keta Chilaga, Bizu Gemera and Mentaw Gora. The results of transect counts for both wet and dry seasons are given in Table 2. Among the 22 packs observed in BSNP, 11 each were recorded during the wet season (October and November) and during the dry season (December to March) counts. A total of 29 (5.8 ± 1.50 individuals /km^2 (obtained from 11 packs) were counted during the wet season and 34 (6.8 ± 1.8 individuals /km^2) individuals were obtained during the dry season. Counts during the dry season were not significantly higher than that during the wet season (t= -5.000, df = 3, p □ 0.05) (Table 2). Number of individuals per pack counted in each of the transects is given in Figure 12.

Table 2. Pack (**Si**) and individuals of the Ethiopian wolf counted (**Xi**) in sampled transect in BSNP.

Sites	**Transects**	**No. of wolves**					
		Wet season		Dry season		Mean	
		Si	Xi	Si	Xi	Si	Xi
Lemesk	T1	1	3	1	4	1	3.5
	T2	1	3	1	4	1	3.5
	T3	1	3	1	3	1	3
Keta Chilaga	T4	1	2	1	3	1	2.5
	T5	1	3	1	3	1	3
	T6	1	3	1	3	1	3
Bizu Gemera	T7	1	2	1	3	1	2.5
	T8	1	3	1	3	1	3
Mentaw Gora	T9	1	2	1	2	1	2
	T10	1	3	1	3	1	3
	T11	1	2	1	3	1	2.5
Total		**11**	**29**	**11**	**34**	**11**	**31.5**

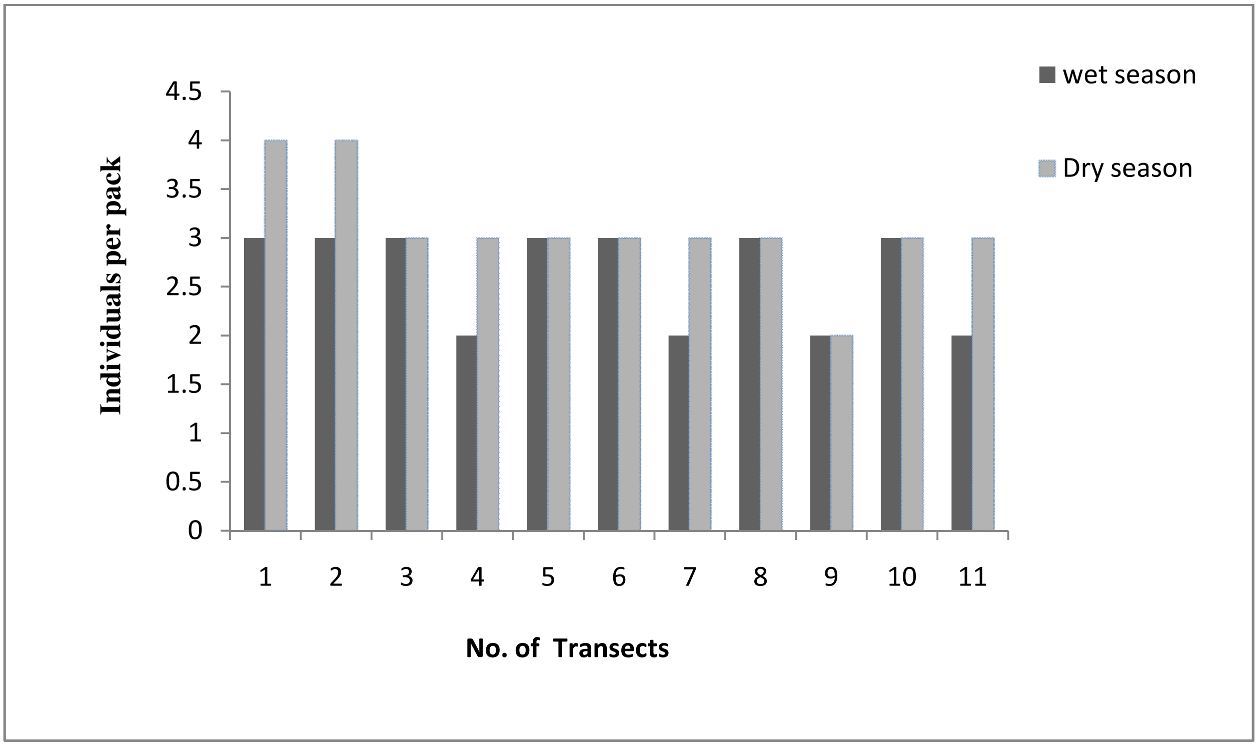

Figure 12. Total individuals per pack counted in each of the transects.

During the wet season, a total of 29 wolves were observed. Their population was composed of 10 (34.48%) adult males, 4 (13.79 %) adult females, 8 (27.59%) sub-adult males, 4 (13.79 %) sub adult females and 3 (10.34%) young. There was no significant difference among the different age groups during the wet season ($F_{4\ 15}$ = 1.28, P □ 0.05). The number of adult males was significantly higher than adult females, sub-adult females and young (df = 4, $p < 0.05$) during wet season. Adult males were also significantly more than young (t=7.00, df = 3, $p < 0.05$), adult females (t=5.196, df = 3, $p < 0.05$) and sub-adult females (t=5.196, df = 3, $p < 0.05$). There was significant difference between sub-adult males and young (t=5.000, df = 3, $p < 0.05$). Next to adult males, the largest proportion was of sub-adult males. Adult males were not significantly different from sub-adult males (t= 1.732, df = 3, p □ 0.05). There was no significant difference among sub-adult females and young (t = 1.00, df = 3, p □ 0.05), adult female and sub-adult male (t = -2.449, df = 3, p □ 0.05), sub-adult male and sub-adult female (t = 2.449, df = 3, p □ 0.05) and adult female and young (t = 1.000, df = 3, p □ 0.05) (Table 3).

Out of the total population counted during the wet season, 31.03% was from Lemesk, 27.59% was from Keta chilaga, 24.14% was from Mentaw Gora and 17.24% was from Bizu Gemera. The average population density of Ethiopian wolf counted during the wet season was 1.8 ± 0.49/km^2 at Lemesk, 1.4±0.245/km^2 in Keta Chilaga, 1.00±0.316/km^2 in Bizu Gemera and 1.6±0.40/km^2 in Mentaw Gora. The overall density was 5.8 ± 1.50 individuals /km^2 for the study area.

The total population counted at Lemesk was significantly higher than Bizu Gemera (t = 4.000, df = 3, $p < 0.05$). There was no significant difference among the total population counted at Lemesk and Keta Chilaga (t = 0.500, df = 3, p □ 0.05), Lemesk and Mentaw Gora (t = 1.633, df=3, p □ 0.05), Keta Chilaga and Bizu Gemera (t = 2.449, df = 3, p □ 0.05), Mentaw Gora and Keta Chilaga (t = 0.500, df = 3, p □ 0.05) and Mentaw Gora and Bizu Gemera (t =1.633, df=3, p □ 0.05) (Table 3).

Table 3. Population structure of the Ethiopian wolf during the wet season

Study sites	Adult male	Adult female	Sub-adult male	Sub-adult female	Young	Mean (±SE)
Lemesk	3	1	3	1	1	1.8 ± 0.49
Keta chilaga	3	1	2	1	1	1.6 ± 0.24
Bizu Gemera	2	1	1	1	0	1.00 ± 0.316
Mentaw Gora	2	1	2	1	1	1.4 ± 0.245
Total	**10**	**4**	**8**	**4**	**3**	**5.8 ± 1.50**

During the dry season, a total of 34 wolves were counted. Among these, 29.41% were adult males, 11.76% adult females, 38.24% sub-adult males, 11.76% sub-adult females and 8.82% young (Table 4). There was no significant difference in the number of different age groups during the dry season ($F4\ 15 = 2.74$, p □ 0.05). However, sub-adult males were higher in number than other age and sex structure groups. Adult males were significantly more than young (t=

3.656, df =3, p < 0.05), adult females (t= 3.000, df =3, p < 0.05) and sub-adult females (t= 3.000, df =3, p < 0.05). There was significant difference between sub-adult males and sub-adult females (t=4.700, df =3, p < 0.05) and young (t= 8.660, df =3, p < 0.05). There was significant difference between adult females and sub-adult males (t=4.700, df =3, p < 0.05). There was no difference among adult males and sub-adult males (df =3, t= 1.732, p 0.05), adult females and young (df =3, t= 1.000, p 0.05) and sub-adult females and young (df =3, t= 1.000, p 0.05).

Table 4. Population structure of the Ethiopian wolf during the dry season

Study sites	Adult male	Adult female	Sub-adult male	Sub-adult female	Young	Mean (±SE)
Lemesk	4	1	4	1	1	2.2 ± 0.735
Keta chilaga	2	1	4	1	1	1.8 ± 0.49
Bizu Gemera	2	1	2	1	0	1.20 ± 0.374
Mentaw Gora	2	1	3	1	1	1.6 ± 0.245
Total	**10**	**4**	**13**	**4**	**3**	**6.8 ± 1.8**

Out of the total population counted during the dry season, 32.35% from Lemesk, 26.47% from Keta chilaga, 23.53% from Mentaw gora and 17.65% from Bizu gemera. The overall mean density of Ethiopian wolf counted during the dry season was 2.20 ± 0.735/km^2 at Lemesk site, 1.8±0.49/km^2 in Keta Chilaga, 1.20±0.374/km^2 in Bizu Gemera and 1.6±0.245/km^2 in Mentaw Gora. The overall density was 6.8 ± 1.8 individuals /km^2 for the study area.

The total population counted at Lemesk was significantly more than that of Bizu Gemera (t = 3.162, df = 3, p < 0.05). There was no significant difference among the total population counted at Lemesk and Keta Chilaga (t = 1.633, df = 3, p 0.05), Lemesk and Mentaw Gora (t = 2.449, df=3, p 0.05), Keta Chilaga and Bizu Gemera (t = 2.449, df = 3, p 0.05), Mentaw Gora and Keta Chilaga (t = 0.535, df = 3, p 0.05) and Mentaw Gora and Bizu Gemera (t = 1.633, df=3,p 0.05) (Table 4).

The population structure and the proportion of various age-sex categories of the observed Ethiopian wolf in the BSNP are given in Figure 13. The age ratio of young to adult was 1:4.67 both during wet and dry seasons (Table 5). Sub-adults to adults was 1:1.167 and 1:1.21, sub-adult males to sub-adult females was 1:2 and 1:3.25, sub-adult male to adult males was 1:1.25 and 1.13 during wet and dry seasons, respectively. Adult female to sub-adult female was 1:1 and young to sub-adult was 1:4 and 1:5.67 during wet and dry seasons, respectively.

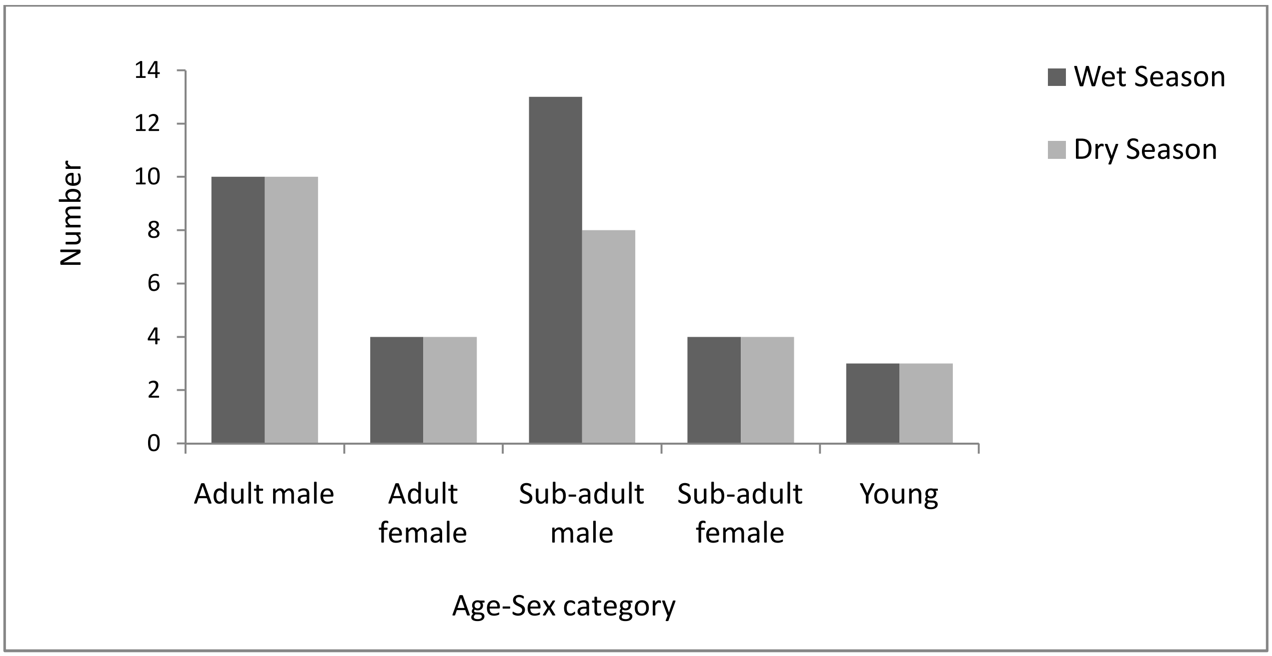

Figure 13. Age and Sex categories of the Ethiopian wolves observed during dry and wet seasons.

Table 5. Proportions of different age and sex categories of the Ethiopian wolf recorded during the dry and wet seasons (AM = Adult male, AF = Adult female, SAM = Sub-adult male, SAF = Sub-adult female, Y = Young)

Season	Sex and Age categories					Ratio			
	Sex		Age			Sex	Age		
	AM	AF	SAM	SAF	Y	AM : AF	Mean (±SE)	Yg :Ad	Mean (±SE)
Wet	10	4	8	4	3	1.00:2.5	1.25±0.25	1:4.67	2.750 ± 0.25
Dry	10	4	13	4	3	1.00:2.5	1.50±0.50	1:467	2.750 ± 0.957
Mean	10	4	10.5	4	3	1.00:2.5	1.38±0.38	1:4.67	2.750 ±0.60

A total of 200 faecal droppings were collected. Five categories of distinguishable items were found in the faeces of the Ethiopian wolf from the four study sites. These were: hair or bone, bird feather, sheep wool, grass and plastic materials. The occurrences of food items in the scats significantly differed ($\chi 2 = 199.59$, df = 4, $P < 0.01$). Rodents were the principal food type (Table 6).

Table 6**.** Prey and other food items of Ethiopian wolves recorded from faecal samples (n=100) collected in and around Borena**-**Sayint National Park.

Food items	Frequency in scats observed	Percentage (%)
Rodents	92	69.2
Sheep	4	3.01
Grass blades	25	18.8
Birds	7	5.26
Plastic materials	5	3.76
Total	**133**	**100**

Bones and teeth of rodents were the most frequently observed (69.2%) food remains observed in the scats of the Ethiopian wolf in the study area. The second most common food item was grass blades (18.8%). Bird feathers constituted 5.26% of occurrence. The occurrence of sheep wool was low (3.01%). Plastic material commonly used for packing goods was found in 5 of the 133 scats, with frequency of occurrence 3.76%. More than one rodent remains were found in several scats. Remains of single rodent were found in 38 scats (41.3%), two in 33 scats (35.87%) and three in 21 scats (22.83%).

Five items (rodent, bird feather, sheep wool, grass and plastic materials) were found in wolf faeces from Lemesk site (Table 7). There were significant variations in the proportion of various food items of Ethiopian wolf during wet and dry seasons. During the wet season, the prominent food items in this site were bones and teeth of small mammals (39.47%). Grass blades were the second most prominent food item, which constituted for 34.21% of the total prey items. The occurrence of feather, plastic and wool were 13.16%, 7.89% and 5.26%, respectively. During the dry season, the percentage of bones and teeth of small mammals was more (62.16%) than those observed during the wet season. There was significant difference between rodent and grass remains in the faecal matter ($\chi 2=8.54$, df = 1, $P < 0.05$). The second most common food item was grass blades (18.92%), followed by feathers (8.11%). Plastic and sheep wool accounted for 5.41%, each during the dry season.

Table 7. Percentage of food items recorded from faecal samples (n= 25) of the Ethiopian wolf collected from Lemesk site during wet and dry seasons.

Food items	**Wet season**		**Dry season**	
	No. of observations	%	No. of observations	%
Rodent	15	39.47	23	62.16
Grass blades	13	34.21	7	18.92
Birds	5	13.16	3	8.11
Sheep	2	5.26	2	5.41
Plastics	3	7.89	2	5.41
Total	**38**	**100**	**37**	**100**

Five categories of food were found in the wolf faeces collected from Keta Chilaga site. These were rodents, grass blades, bird feather, sheep wool and plastic materials (Table 8). There were significant variations in the proportion of various food items recorded during wet and dry seasons. During the wet season, the prominent food items were bones and teeth of small mammals (34.15%). Grass blades were the second most prominent food item, which constituted for 29.27% of the prey items. The occurrence of feather, plastic and wool were 14.63%, 12.19% and 9.76%, respectively. The percentage of bones and teeth of small mammals (59.46%) were different from those recorded during wet season. During the dry season, there was significant differences in the occurrence of rodent and grass blades in the scat ($\chi 2=9.14$, df = 1, $P < 0.05$). The second most common food item was grass blades (19.22%), followed by plastic (10.81%). Feather and sheep wool accounted for 8.11 and 5.41%, respectively.

Table 8. Percentage of food items recorded in faecal samples (n= 25) of Ethiopian wolf in Keta Chilaga site during wet and dry seasons.

Food items	**Wet season**		**Dry season**	
	No. of observations	%	No. of observations	%
Rodent	14	34.15	22	59.46
Grass blades	12	29.27	6	16.22
Birds	6	14.63	3	8.11
Sheep	4	9.76	2	5.41
Plastics	5	12.19	4	10.81
Total	**41**	**100**	**37**	**100**

Five categories of food items were found in wolf faeces collected from Bizu Gemera site. These were rodents, grass blades, bird feather, sheep wool and plastic materials (Table 9). There were significant variations in the proportion of various food items of Ethiopian wolf during wet and dry seasons. During the wet season, the prominent food items in this site were bones and teeth of small mammals (38.64%). Grass blades were the second most prominent food item, which constituted for 29.55% of the prey items. The occurrences of feather, plastic and wool were 15.91%, 11.36% and 4.55%, respectively. During the dry season, there was significant difference in the occurrence of rodent and grass remains in the droppings ($\chi2$=31.70, df = 1, P < 0.05). The percentage of bones and teeth of small mammals (58.14%) were different from those recorded during the wet season. The second most common food item was grass blades (18.6%), followed by feather (11.63%). Plastic and sheep wool accounted for 6.98% and 4.65%, respectively.

Table 9. Percentage of food items recorded from faecal samples (n= 25) of Ethiopian wolf collected from Bizu Gemera site during wet and dry seasons.

Food items	**Wet season**		**Dry season**	
	No. of observations	%	No. of observations	%
Rodent	17	38.64	25	58.14
Grass blades	13	29.55	8	18.6
Birds	7	15.91	5	11.63
Sheep	2	4.55	2	4.65
Plastics	5	11.36	3	6.98
Total	**44**	**100**	**43**	**100**

Five categories of food items were found in wolf faeces collected from Mentaw Gora site. These were rodents, grass blades, bird feather, sheep wool and plastic materials (Table 10). There were significant variations in the proportion of various food items of Ethiopian wolf during wet and dry seasons. During the wet season, the prominent food items in this site were bones and teeth of small mammals (39.02%). Grass blades were the second most prominent food item, which constituted for 31.7% of the prey items occurred. The occurrence of feather, plastic and sheep wool were 14.63%, 9.76% and 4.89%, respectively. During the dry season, there was significant difference in the occurrence of rodent remains and grass blades in the droppings ($\chi2$=9.32, df = 1, P < 0.05). The percentage of bones and teeth of small mammals (60%) was different from those recorded during the wet season. The second most common food item during the dry season was grass blades (17.5%), followed by feather 10%. Plastic and sheep wool accounted for 7.5% and 5%, respectively.

Table 10. Percentage of food items recorded from faecal samples (n= 25) of Ethiopian wolf collected from Mentaw Gora site during wet and dry seasons.

Food items	**Wet season**		**Dry season**	
	No. of observations	%	No. of observations	%
Rodent	16	39.02	24	60
Grass blades	13	31.7	7	17.5
Birds	6	14.63	4	10
Sheep	2	4.89	2	5
Plastics	4	9.76	3	7.5
Total	**41**	**100**	**40**	**100**

Out of the 11 packs of Ethiopian wolf observed during the wet season, two were in open grassland, six were in *Erica* woodland and three were in *Lobelia- hypericum* habitats. There was also true during the dry season. The Ethiopian wolf preferred *Erica* woodland habitats during both wet and dry seasons (Figure 14).

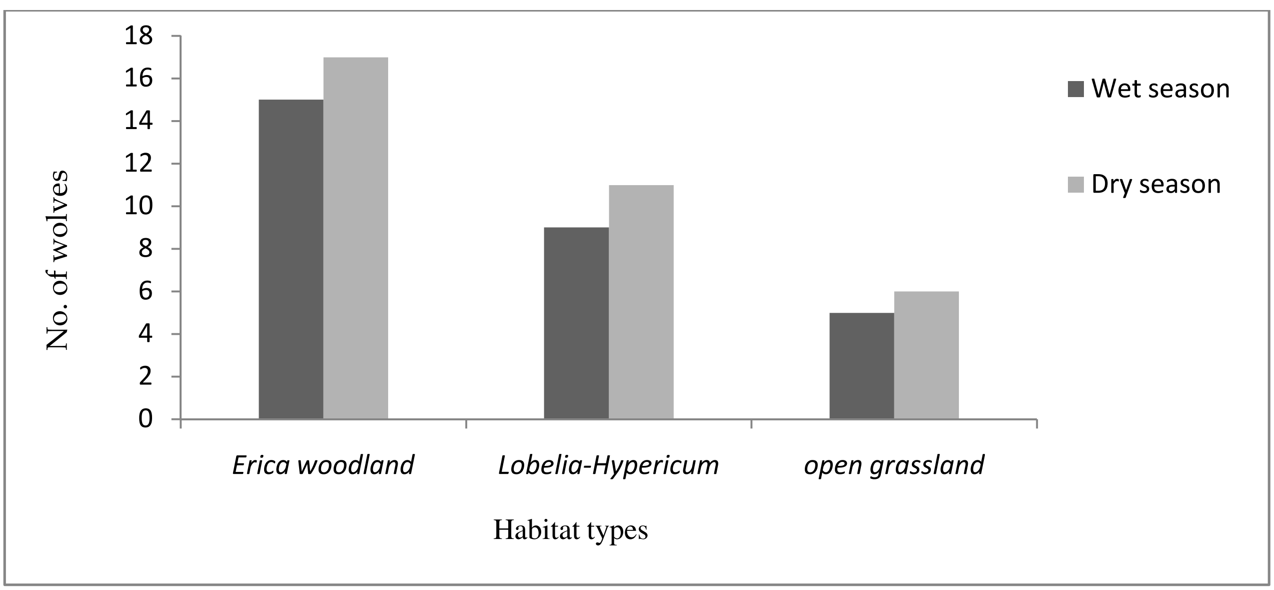

Figure 14. Abundance of the Ethiopian wolf in different habitat types during the wet and dry seasons.

They preferred habitats with tall vegetation to take rest. Resting locations were characterized by tall vegetation with thick cover. Wolves in the BSNP preferred habitats with sufficient cover and at the same time high rodent prey. Table 11 shows the number of Ethiopian wolf seen in different vegetation types during dry and wet seasons.

Table 11. Abundance of Ethiopian wolf packs in different habitat types during the wet and dry seasons.

Sites	**Habitats**	**Numbers of Ethiopian wolf observed**					
		Wet season		Dry season		Mean	
		Pack No.	Ind. No.	Pack No.	Ind. No.	Pack No.	Ind. No.
Keta Chilaga	*Erica* woodland	3	8	3	9	3	8.5
Lemesk	*Lobelia-Hypericum*	3	9	3	11	3	10
Mentaw Gora	*Erica* woodland	3	7	3	8	3	7.5
Bizu Gemera	Open grassland	2	5	2	6	2	5.5

The mean pack size of the Ethiopian wolf observed during the wet and dry seasons are given in Table 12. Pack size, composition and structure changed with the season. Adults were more than young. Small packs containing 2 - 3 individuals were common throughout the study period. During wet season, the overall mean pack size was 2.75± 0.25. The mean pack sizes in Lemesk, Keta Chilaga, Mentaw Gora and Bizu Gemera sites during the wet season were 3, 3, 2 and 3, respectively. The mean pack sizes in Lemesk, Keta Chilaga, Mentaw Gora and Bizu Gemera sites during the dry season were 4, 3, 3 and 3. During the dry season, the overall mean pack size was 3.25± 0.25. During October and November, up to three wolves were seen in packs. During December, January and February, a maximum of five wolves were seen in different packs. The most frequently observed pack size was three individual during the wet season and four individuals during the dry season. There was no difference in the pack size during wet and dry seasons (P□ 0.05). During the dry season, the number of packs observed was high with a mean pack size of 3.3. The largest pack was observed in *Lobelia- Hypericum* and *Erica* woodland and the smallest was in open grassland.

Table 12. Pack size of the Ethiopian wolf during the wet and dry seasons in different study sites.

Sites	Season	Total packs	Total No.	Range of pack size	Mean pack size
Lemesk	Wet	3	9	3	3
	Dry	3	11	3-4	4
Keta Chilaga	Wet	3	8	2-3	3
	Dry	3	9	3	3
Bizu Gemera	Wet	2	5	2-3	3
	Dry	2	6	2-3	3
Mentaw Gora	Wet	3	7	2-3	2
	Dry	3	8	2-3	3

The number of sheep was the highest followed by cattle, horse and goat, which constituted for 79, 53, 37 and 24 individuals, respectively (Table 13). Overgrazing increased competition for pastures especially during dry seasons. During the present study, 30 local farmers were observed collecting grass from BSNP.

Table 13. Livestock observed in BSNP.

Species	Total
Sheep	79
Cattle	53
Horse	37
Goat	24
Total	**193**

4. Discussion

The main significant decline of Ethiopian wolf in Borena-Sayint National Park is due to human induced impact through cutting of trees (grass collection), and subsistence agriculture and Livestock grazing. So, in order to manage the populations and to effectively conserve wildlife, regular population estimates are essential (Sillero- Zubiri, 2004). Separation of the study period into dry and wet seasons was important in order to observe the influence of seasons on the vegetation and on the distribution of animals. More wolves were observed during the dry season. The dry season coincides with the availability of more food and shelter in the present study area. The afro-alpine climate is very cold and hence rodents are intolerant to such adverse weather condition. As a result, they avoid extreme cold by going underground. This reduced the forage efficiency of the wolf and the wolves hide themselves during cold weather in the denning sites and under thick vegetation covers (Marino *et al*., 2003). However, the population counts were not significantly different between wet and dry seasons and also there was no significant variation ($p > 0.05$) on the counts in all transects between the two seasons. This indicates that there was no significant temporal and spatial variation between the different habitats types, even if the relative abundance of animals is naturally associated with preference towards a given habitat. This could depend on what the habitat provides in terms of food, breeding site, protection from predators, cover from overheating and cold and free space for essential activities.

However, the tolerance against adverse environmental situation varies among different groups of organisms. Small mammals give priority to cover as protection from predators than food. Usually, they avoid predators by hiding as, there is only little chance to escape if spotted. Large mammals, on the other hand, emphasize the importance of food in their habitat. Most of them run to avoid predators rather than try to hide. They can use any standing tree or some behavioural strategies to avoid hot sun during hot hours of the day. Differences in the counts of Ethiopian wolf in some of the transects have most likely resulted in the tendency of wolf to seek habitats with good supply of food.

In the present study, the total number of Ethiopian wolves counted in the entire area of 24 km^2 of BSNP was 29. The number of wolves counted during the dry season increased by five individuals when compared to that of the wet season. This difference might be due to the fact that during the wet season, the weather in the study area was cloudy, which could reduce the detectability of individuals while counting. According to Marino *et al.* (1999), the population estimate of the Ethiopian wolf in Bale Mountains was higher than the total population counted for other regions. So, conservation measures should be taken for other regions in a very good manner to manage the rest wolf population for the long run.

Compared to Lemesk and Keta Chilaga, which accounted 58.82% of the total population, the wolf population was less (41.2%) in Mentaw Gora and Bizu Gemera. Lemesk and Keta Chilaga are more ecologically intact than Mentaw Gora and Bizu Gemera. Mentaw Gora and Bizu Gemera sites are highly affected by habitat changes and fragementation as a result of illegal extraction of trees and grasses by the local communities and relatively poor habitat quality because of intense livestock grazing. Thus, wolves shift or extend their home range and they may also be pushed towards the edges.

Distribution and habitat association of large mammals are determined in terms of their ecological requirements. Water and pasture conditions or the combinations of both are 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 an outcome 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 essential ecological requirements are met. The distribution of medium and large-sized mammals and their diversity in BSNP was highly associated with habitat types (Meseret Chane, 2010). *Erica* woodland has supported the highest number of mammalian species (20), followed by open grassland habitat, which supported 12 medium and large-sized mammalian species. The possible reason for this distribution and diversity of medium and large-sized mammal species might be due to the presence of food and water and stability of the area from disturbances. Moreover, *Erica* woodland is a more stable area than open grassland habitat in BSNP (Meseret Chane, 2010). Hence *Erica* woodlands have abundance of mammals due to high vegetation cover, food and water availability.

Earlier, Sillero-Zubiri and Gottelli (1995) have reported that the Ethiopian wolves were abundant in open grassland habitats in Bale Mountain National Park. In the present study area, the open grassland habitat is degraded by livestock grazing and human induced impacts through illegal cutting of grasses leading to few numbers of animals. However, the present investigation is in agreement with what was reported by Sillero-Zubiri and Gottelli (1995) that the Ethiopian wolves were abundant in *Lobelia* with *Hypericum* habitat. Eshetu Moges (2008) stated that, the habitat is very suitable for the availability of rodent diversity that are useful for the diet of wolves such as *Stenocephalomys griseicauda, Lophoromys flavopunctatus* and *Otymus typus.* The highest count recorded in transect 1 and 2 was in accordance with the preference of the *Lobelia* with *Hypericum*. In the present study area, the wolf preferred *Lobelia* with *Hypericum* most to *Erica* woodland habitat and least in open grassland both during wet and dry seasons. They preferred *Erica* woodland for shelter to prevent the cold climate during wet season and to avoid predators by hiding inside of the thick woody vegetation cover during dry season. High small mammal diversity was recorded in *Erica* woodland (Eshetu Moges, 2008). This might be due to the difference in the vegetation cover, foliage and availability of food in this habitat type (Mugatha Mebratu, 2002).

According to Morris (1987), distribution of small mammals over an area is not uniform and species are more abundant in some habitats than in other habitat types. This could be due to the abundance and distribution of small mammals depending mainly on the nature and density of vegetation, food and shelter (Happold, 1974). The distribution of rodents is not uniform in BSNP (Meseret Chane, 2010). Some species are widely distributed and others are restricted only to two or one habitats. For instance, *S. griseicauda, L. flavopunctatus* and *O. typus* were recorded in all three habitats whereas *A.dembeensis* was recorded in a single open grassland habitat in BSNP (Eshetu Moges, 2008). This species was reported in open grassland habitats of other geographic ranges, and was one of the diets of wolves in Arsi (Chilalo- Galama) and Simien Mountain National Park (Geech, Bwahit, Ras Dejen, Silki) (Sillero-Zubiri and Gottelli, 1995a).

Sillero-Zubiri and Gottelli (1995a) have reported the different rodent species such as *T. Macrocephalus*, *A. blicki, L. melanonyx, O. typus* and *S. griseicauda* that were preyed by the Ethiopian wolf through direct observation and scat analysis in Bale Mountain National Park.

Even if there was high rodent diversity in Mentaw Gora and Bizu Gemera and the habitat was very suitable for different rodent types, these were not positively correlated with the wolves abundance. This might be due to human-wildlife conflict and livestock grazing prevailing in this area. The Ethiopian wolf population has declined during the last few decades as a result of habitat destruction, particularly in northern Ethiopia. Heather and grasslands have been cleared and ploughed to grow cereal crops and for grazing (Sillero-Zubiri and Macdonald, 1997). The immediate consequences of these have diminished rodent populations due to human - wildlife conflict in the area. At least two wolf populations in Gojjam and Shoa have been extirpated due to habitat degradation, and the ranges of other wolf populations have been reduced (Marino *et al*., 2003).

The knowledge of sex ratio and age distribution among the mammalian populations is vital for evaluating the viability of the species as these variables reflect the structure and the dynamics of population (Wilson *et al*., 1996). Sex and age structure of a population at any given point of time are also indicators of the status of the population (Woolf and Harder, 1979). The result of the present study showed more than 50% of the population is composed of males. So, such increment of male individuals is one of the main reasons to jeopardize the criteria of the minimum population size of Ethiopian wolf since the density was below 50 individuals. In addition to this, the high number of male individuals was one of the means to decrease the average heterozyogsity of wolves and to minimize the low fecundity rate efficiency of the wolves.

Ethiopian wolves live in separate and cohesive social packs communally sharing and defending an exclusive territory. In optimal habitat, packs consisted of 3-13 adults, containing 3-8 related adult males, 1-3 adult females, 1-6 yearlings and 1-6 pups in BMNP (Sillero-Zubiri and Gottelli, 1995b). In the present study the mean percentage composition of adult males (29.41%), adult females (11.76%), sub-adult males (38.24%), sub-adult females (11.76%), and young (8.82%) during the dry season, the adult sex ratio of male to female was 2.5:1 and the pack size of Ethiopian wolf was 11 packs both during wet and dry seasons. From this packs, the highest number of males in the packs was recorded. This could be due to migration of females during agonistic interaction of male to females and hence the male individuals is dominant over the females as a result the male individuals will recruited in to multi- male philopatric packs and the females removed out from their own territories and goes through the other territories and forms interspecific competiton among the other family packs and they carry out disease and attacks with other predators when they went to the other territory.

There are two main hypotheses regarding the behaviour of packs of the wild animals. The first suggests that when in packs, animals can prevent or avoid predation pressure better than when live alone (Hamilton, 1971; Giest, 1974; Eisenburg, 1981). This could be done by a variety of methods including improved predator detection, active group defense and predator confusion. The other hypothesis links with the social organization of the species with the distribution and availability of its food supply (Jarman, 1974). So, group organization is the preventive solution for the stability of the habitat and helps to minimize both internal and external exposures through active group defense or active socialization.

Larger species can afford to be less selective, and can therefore live in larger groups (Mishra, 1982). Species, which exhibit flexible social system will form large groups when there is abundance of high quality forage but will be forced to form smaller groups when food supply is less abundant or when food is dispersed widely. The pattern of pack size in the different habitat types in both seasons was similar except in Bizu Gemera. Range of pack size in Lemesk site (*Lobelia-Hypericum*) and Bizu Gemera (open grassland) are entirely different from Keta Chilaga (*Erica* woodland) and Mentaw Gora (*Erica* woodland), and differences were detected when adults, sub-adults and yearlings were observed. Pack size of the wolf varied in relation to environmental conditions. Data on pack size of carnivores may be indicative of the effects of a changing environment (Leuthold and Leuthlod, 1975), reproductive behaviour (Jarman and Jarman, 1973) and environmental disturbances resulting from heavy grazing, fire and other factors. Differences in pack size were found in all three habitat types and such differences persisted in relation with structure of the population.

In the present study, the overall mean pack size was 3.25± 0.25 during the dry season. In the BMNP populations in Sanetti, Tullu Deemtu and Web Valley, the mean pack size of Ethiopian wolf was 4.9 ± 0.3, 2.6 ± 0.4 and 6.7± 0.7, respectively (Sillero-Zubiri and Gottelli, 1995a). This might reflect on the difference in the habitat types of the present study area with that of the BMNP. This could indicate that spatial variation is a major factor for the differences of the demographic structure of wolves. The least number of wolf packs in Tullu Deemtu than Sanetti and Web Valley indicated that it is a poor habitat or delimited the giant mole rat abundance. In Tullu Deemtu, an increment in territory size will clearly not ensure the same rate of acquisition of key resources. However, wolves in larger packs in the more productive areas benefited from expansion by acquiring a greater area of territory than was available to wolves in smaller packs (Marino *et al*., 2003). So, in the present study area it is a more productive area so that the wolves do not much extended out from their own territories. The average home range of Ethiopian wolf in Borena-Sayint National Park (n=3 packs) was averaged 6.0 km^2, with some overlap in home ranges. Therefore, the prey biomass was not positively correlated with the density of Ethiopian wolf.

The Ethiopian wolf is a specialist rodent eater, adapted to prey on the dense population of diurnal rodents present in the Afro-alpine grasslands (Sillero- Zubiri and Gottelli, 1995a). Rodents are more consumed by wolf during the dry season than during the wet season in BSNP. Rodent eating canids of the temperate zones have strong influences on food availability (Sillero-Zubiri and Gottelli, 1995a; Malcolm, 1997). The frequency of remains of rodent prey was high in the scats of the Ethiopian wolf. This was an indication that rodents were the preferred food items of wolves in BSNP. Rodents are widely available small mammals in the *Erica* woodland, open grassland and *Lobelia- Hypericum* habitats of BSNP. In a similar study in Guassa (Menz), rodents constituted for 96% of all prey occurrences in droppings (Zelealem Tefera, 2004). The frequency of occurrence of rodent remains in the droppings of wolves in BMNP was also not much different (Sillero-Zubiri and Gottelli, 1995a). Rodents were the most abundant, easiest prey for the Ethiopian wolf to catch. Their availability was more predictable, as their abundance was closely associated with different habitat types (Sillero- Zubiri *et al*., 1995a). The predictability of the rodent prey may explain the territoriality of wolf packs as a food resource defense strategy and as optimization of its feeding efficiency (Sillero-Zubiri, 1994).

Plant materials like blades of grass were also located in scats of the Ethiopian wolf. Plant materials were the second prominent food item in the diet of the wolves next to rodents. This finding is also in consistent with a study in BMNP (Sillero-Zubiri and Gottelli, 1995a), where the frequency of occurrence of plant materials was found next to that of small mammals. In Guassa (Menz), the percentage occurrence of grass was 2.01% (n=7) (Zelealem Tefera, 2004). Plastic packing materials were also found in the scats of wolves. Other food items of wolves including plastics in Menz and Arsi were 12%, 5% and in Bale and Simien Mountains, it was 4%, each (Sillero-Zubiri and Gottelli, 1995a; Malcolm, 1997). Bird feather and sheep wool were also the food items of wolves in BSNP. In a similar study in Guassa (Menz), bird feather and sheep wool were reported as food items (Zelealem Tefera, 2004). Similarly, in BMNP such as Sanetti, Tullu Deemtu and Web Valley, grass was the second prey item of the Ethiopian wolf. Birds accounted for 1.1%, 0.0% and 2.2% in Sanetti, Tullu Deemtu and Web Valley, respectively. The occurrence of remains of domestic livestock in scats was low.

The presence of the Ethiopian wolf in the study area could be accounted with the availability of rodents. The occurrence of remains of domestic livestock in scats was low in the present study area. Among the livestock population in BSNP, sheep was identified in few scats as prey of wolves.

BSNP lacks a buffer zone, high number of cattle and other domestic animals graze on the edges of the Park (Figure 15). There has been deterioration of vegetation close to the edges that might influence the destruction of wildlife of the Park.

Figure 15. Livestock grazing in the Borena-Sayint National Park (Photo: Yigrem Kebede, December, 2010).

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 for thatching houses. This might cause scarcity of grass for herbivores and disturb the natural behaviour of wildlife in the Park. Like any other Park in Ethiopia, local people exploit the resource from BSNP as well. Forest exploitation inside the Park and traditional farming activities close to the Park might cause strong impacts on the wildlife. Wild animals are highly restricted in some parts of the Park because of human and livestock encroachment.

5. CONCLUSION AND RECOMMENDATIONS

One of the objectives of this study was to see the distribution, population status and feeding ecology of the Ethiopian wolf in BSNP. The population of the wolf in the present study area is greater than reported earlier (Marino *et al*., 1999). So, the overall status of the current population does not appear to be in immediate danger. Eventhough, wolves do not appear to be in immediate threat in the study area, there are many conservation problems that could affect the species in the future. These threats are the results of increased human population in the adjacent areas of BSNP. The threats in the study area include human-induced habitat loss and degradation through grass collection, livestock grazing, encroachment and environmental degradation. As a result, the quality of the wolf habitat is deteriorating. The scarcity of food in the degraded habitat will have profound negative effect on different aspects of the ecology of the species.

The population structure and pack size of the Ethiopian wolf were adult male and sub-adult male biased. The high percentages of males showed that Ethiopian wolf population might decrease in BSNP in the near future. Data related to the habitat preferences show that the Ethiopian wolf mostly preferred *Lobelia-Hypericum* and *Erica* woodland in the study area. This study also revealed that rodents are the principal diet of the Ethiopian wolf. Among livestock, sheep was identified as a prey of the Ethiopian wolf.

The following recommendations are suggested to mitigate the threats that could be faced by the Ethiopian wolf in BSNP:

- Local people should minimize grass collection, livestock grazing and encroachment to redevelop the degraded areas in BSNP.

- Changing personal attitude and practice through environmental education focusing on the effects of grass collection, livestock grazing and encroachment is important to increase the awareness of the local people about the resources of BSNP.

- Stakeholders should be encouraged to reduce human settlements encroaching into wildlife habitats and need to relocate agricultural activities out of wildlife ranges.

- Sharing of benefits with the communities living inside and adjacent to the Park will help to reduce conflicts between wildlife managers and local communities. There should be close link between the Park authority and the local communities living around. Local communities should also have a role in designing, planning, implementation and evaluation of wildlife conservation programmes.

- There are many roads crossing the BSNP with primary objective of connecting the nearby Woredas. This might influence destruction process of the Park unless properly managed and controlled.
- Clear demarcation and formation of buffer zones are essential to avoid cattle in the area.

- Enhance the competency of scouts and their effectiveness significantly through training and patrol equipment.
- Farmers have to carefully guard their livestock during day time.

- Land-use system authorities should work with the local people in guiding the people to use land resource sustainably in harmony with wildlife.

- The Park authority should provide compensation to the loss of livestock outside the Park area. This could help the people in providing local support.

- More efforts should be carried out to encompass additional areas and focus to incorporate the area outside the Park like Belechuma, Aksta and Kewa, which are habitats of the Ethiopia wolf.

- Conservation measures will not be successful without the active participation of the local people. So community based conservation system (co-management) should be an integral component for the conservation of the Ethiopian wolves.

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Appendix-1. List of large Mammals of Borena-Sayint National Park

Order/Family/Species name	Common name	Amharic name
Carnivora/Canidae		
Canis aureus	Common jackal	Tera-kebero
Canis mesomelas	Black-backed jackal	Tikur- jerba Kebro
Canis simensis	Ethiopian wolf	Key-kebero
Hyaenidae		
Crocuta crocuta	Spotted Hyaena	Jib
Felidea		
Files carcal	Caracal	Dalga- Anbesa
Files serval	Serval	Anner
Panthera pardus	Leopard	Nebir
Herpestidae		
Ichneunia albicauda	White-tailed mongoose	Faro
Genetta abyssinica	Abyssinian Genet	Shelmtsematse
Mustelidae		
Mellivora capensis	Ratel (Honey badger)	Kefo-defi
Ictonyx striatus	Zorilla (Striped polecat)	Fadet
Artiodactyla/ Bovidae		
Tragelaphus scriptus Meniliki	Menelik bushbuck	Menelik dekulla
Tragelaphus scriptus	Common bushbuck	dekulla
Silvicapra grimmia	Bush duiker	Medakoa
Oreotragus oreotragus	Klipspringer	Ses
Madoqua salitiana	Salt's Dik-Dik	Inshu
Leporidae		
Lepus strarckii	Starck's hare	Tinchel
Suidae		
Phacochoerus aethiopicus	Common warthog	Kerkero

Hyracoidae/ Procaviidae		
Procavia capensis	Rock hyrax	Shekoko
Hetrohyrax brucei	Bush hyrax	Shekoko
Primate/ Cercopithecidae		
Theropithecus gelada	Gelada Baboon	Gelada zengero
Papio anubis	Anubis Baboon	Tera zengero
Papio hamadryas	Hamadryas Baboon	Nech zengero
Cercopethicus aethiops	Grivet Monkey	Tera- tota
Colobidae		
Colobus guereza	Colobus Monkey	Guereza

Appendix-2. Data collection sheet used for line transects.

Place____________________ Date__________________

Transect number___________ Start time__________ End time________

Name of data collector__________________ Target species________

Transect direction____________ Transect length______________ Season_________

observation	Date	Species	No. seen	Sex		Age						
				M	F	AM	AF	SAM	SAF	Y	Habitat	Remarks

AM= adult male AF= adult female. SAM= sub –adult male. SAF= sub –adult female Y=Young,

*Open grassland, *Erica* woodland, *Lobelia-Hypericum*

Appendix-3. Data Collection Sheet for Ethiopian Wolf faecal dropping analysis

Area	Locality	Altitude	Position	Date of collecion	Time of collection	Age of Faeces	Component of prey eaten	Type of Prey eaten

Declaration

This is to certify that this thesis entitled "population status and Feeding ecology of Ethiopian wolf in Borena-Sayint National Park, South Wollo." Submitted to the School of Graduate Studies, Department of Biology, and Science faculty of Addis Ababa University in partial fulfillment for the requirements of degree of M. Sc. in Dryland biodiversity, done by Yigrem Kebede (ID.No.GSR/ 0737/01) is an authentic work carried out by him under my guidance. The matter embodied in this work has not been submitted earlier for award of any degree or diploma to the best of my knowledge and belief. All the sources of materials used have been duly acknowledged.

Yigrem Kebde Deneke	________________	______________
Name of Student	Signature	Date
Prof. M. Balakrishnan	_______________	________________
Name of Advisor	Signature	Date