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Population Status and Diurnal Activity Patterns of the Rock Hyrax (*Procavia capensis*) in Dinsho, in and Around Bale Mountains National Park, Ethiopia

By
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DEDICATION

This work is dedicated to my parents.

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ABSTRACT

The rock hyrax (Procavia capensis Pallas, 1766) was studied from September 2003 to February 2004 in Dinsho area, in and around Bale Mountains National Park (BMNP). Data on the population, age and sex category, group size, diurnal activity pattern, food habits, habitat utilization and impact of the local people on their population were studied. Total count was employed to determine the population size. The total population recorded in wet season was 368 whereas it was 332 in the dry seasons. Out of the total population, 40.3% were adults, 34.8% were sub-adults and 24.9% were juveniles. The sex of only 157 rock hyraxes was confirmed. Adult sex ratio was biased towards females but it was nearly 1:1 in the juveniles. Out of the sexed hyraxes, 55.7% were females and 44.3% were males. Relatively higher percentage of breeding females (over 42%) out of the sexed ones in the polygamous rock hyrax colony shows sustainability of the hyrax population.

The major activity of the dominant territorial male was watching. Feeding took place for brief intervals. The rock hyraxes were more active during early in the morning and late in the afternoon. During the noon hours, they were not mostly seen outside the shelter. The rock hyraxes intensively feed in groups during early morning and late afternoon hours. The diet of rock hyraxes constituted a wide variety of plants around the vicinity of their shelter. There was significant difference between grazing and browsing during the wet and dry seasons. More rock hyraxes were engaged in browsing during the dry season than during the wet season. In the dry season, there were local migrations from areas with less vegetation cover and no water, to bushy areas where water was available. It was revealed that habitat destruction, hunting and

disturbances in and around the areas of their shelter affect the behaviour and threaten the survival of rock hyraxes.

Key words: *Rock hyrax (Procavia capensis), population status, diurnal activity, Dinsho.*

1. INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

1.1.1 Dwindling wildlife of Ethiopia

Due to the long evolutionary history associated with the African savannas and the large extent of natural habitats available, compared to other continents, Africa has the most diverse and numerous mammals (Balakrishnan, 1994). However, due to various socio-economic factors in the continent, much of the original habitats have been already lost or degraded. Drastic changes in natural landscapes associated with habitat loss and habitat fragmentation are the main processes contributing to the decline of biodiversity in the African continent and elsewhere (Lindenmayer *et al.*, 2000).

Ethiopia supports diverse wildlife forms in its unique habitats and rugged topography ranging from 110 meters below sea level to 4,620 meters above sea level, associated with varied climatic conditions. Much of the diversity of Ethiopian wildlife occurs at high altitudes (Stephens *et al.*, 2001). According to Hillman (1993a), 277 species of mammals, 861 species of birds, 201 species of reptiles, 63 species of amphibians, 150 species of fresh water fish, and 324 species of butterflies have so far been identified from Ethiopia. Among these, 31 species of mammals, 16 species of birds, 6 species of reptiles, 30 species of amphibians and 4 species of fish are endemic to the nation (Leykun Abunie, 2000).

However, due to human pressure on natural habitats and related effects many of these wild animals are at present confined within limits of protected areas. Protected areas of the nation

include nine national parks, eight wildlife reserves, three sanctuaries and eighteen controlled hunting areas. However, only the Awash National Park and Simien Mountains National Park are so far legally gazetted (Hillman, 1993a). The conservation areas in Ethiopia cover a total of 5.5 million hectares, which is only about 5 per`cent of the total area of the country (Tadesse Hailu, 1998).

1.1.2 Distribution, taxonomy and status of hyraxes

Hyraxes, commonly known as dassies, are small, non-ruminant and rodent-like creatures. They are the smallest ungulates, which appeared first in lower Eocene beds of Egypt and presently are found almost all over Africa, except in the arid northwestern part, and parts of the Middle East (Macdonald, 1985; Vaughan *et al.*, 2000; Hoeck, 2003).

Hyraxes are members of the order Hyracoidea; which belong to one extinct family, Pliohyracidae and one extant family Procaviidae. There are three genera in the family Procaviidae: *Procavia* (rock hyrax), *Heterohyrax* (bush hyrax) and *Dendrohyrax* (tree hyrax) with a total of six species (Vaughan *et al.,* 2000). *Procavia* is the only extant genus in the order Hyracoidea which is considered to have evolved in Africa before the Oligocene, some 40 million years ago (Walker, 1975). This genus is thought to retain the most primitive features and the tree hyrax probably evolved last from the same line as *Heterohyrax*, which is intermediate (Estes, 1991).

According to Kingdon (1997), there were at least 11 genera of hyracoides 30-20 million years ago in Africa, some of which were the dominant herbivores of that time. But due to their poor ability to regulate body temperature, short legs, slow breeding and the cumbersome way of cropping, they have been almost totally replaced by modern ruminants during the Miocene,

around 25 million years ago. It is only the three genera, fast enough to climb rocky slopes, cliffs and mountain ranges that are too steep for other ungulates and those able to feed on trees and areas beyond the reach of hoofed ungulates or ruminants which survived.

1.1.3 Behavior and habitat of hyraxes

Procavia and *Heterohyrax* are diurnal and gregarious, which occupy rocky areas, arid scrub and open grasslands while *Dendrohyrax* is usually nocturnal solitary and arboreal, and are found in forested areas, though in eastern Africa they inhabit lava flows ranging from sea level to 4,500 meters above sea level (Nowak, 1991; Vaughan *et al.*, 2000). However, Lavrenchenko (2000) noted that *Heterohyrax* is found in the Harenna Forests in Bale Mountains National Park. He has also noted that it is arboreal and occupies the ecological niche of *Dendrohyax*.

Procavia is the most widespread in distribution ranging from "Cape to Cairo" through the Horn and the Sahara with isolated populations in the mountain ranges of the Sahara, while *Heterohyrax* occurs throughout the Horn of Africa, East Africa and marginally in South Africa, with an isolated population in Angola (Stuart and Stuart, 1997).

Drastic reduction of the formerly abundant populations of *Procavia* has resulted in Egypt because of killing them for food, and as a result of destruction of natural vegetation. People suspected that the hyraxes may compete with sheep for forage in South Africa, developed antagonism towards them and have eliminated them from many of their former ranges (Nowak, 1991).

Procavia capensis and *Heterohyax brucei* are found in Ethiopia. These are the main hosts of a protozoan blood parasite (leishmania) for which the vectors are sand flies of the genus *Phlebotamus (*Ashford et *al.*, 1973 cited by Yalden *et al.*, 1986). The genera *Procavia* and *Heterohyrax* occur in Bale Mountains National Park (BMNP) in Ethiopia. The former is found at altitudes between 2800-3500 meters above sea level (Yalden *et al.*, 1986; Hillman, 1993b).

There has been minimal study about hyraxes in Ethiopia, and as a result their ecology and behaviour are not known. The present investigation was undertaken to evaluate the current population status and the diurnal activity pattern of the rock hyrax in Dinsho area, Ethiopia.

1.2 Literature review

1.2.1 Phylogeny of hyraxes

Hyraxes are small, wooly animals with 'hoofed' digits. They have no visible tail. Due to their superficial resemblance, they were once grouped with rodents and then with elephants and rhinoceroses (Bere, 1962). It is Thomas Huxley who for the first time put them into their own order, Hyracoidea (Kingdon, 1997). Fossil and morphological evidences show that hyraxes share many features with elephants and sirenians or sea cows which together are called paenungulates (Springer *et al.*, 1997). Recent investigations have shown that the antibodies, placenta, mammae and genitalia of hyraxes have common features with those of the odd-toed ungulates and those of the aardvark (Macdonald, 1985; Kingdon, 1997; Vaughan *et al.*, 2000).

Hyraxes have acute sense of touch, vision and hearing. They are both grazers and browsers. Generally, these animals are not limited in their distribution by lack of water (Estes, 1991;

Nowak, 1991). *Procavia* has hypsodont (high-crowned) dentition, whereas the other two genera have brachydont (low-crowned) dentition. Female hyraxes have six teats, two pectoral and four inguinal (Hoeck, 1982).

1.2.2 History and distribution of *Procavia capensis* Pallas, 1766

Rock hyrax, *Procavia capensis*, though known since long time ago, was first described by Pallas when he saw one for the first time in a tavern in Cape Town, where it was kept as a pet (Smithers, 1983). This species has the widest geographical and altitudinal distribution. Most authorities have recognized its occurrence in Syria, Lebanon, Israel, Jordan, Sinai, the Southern Arabian Peninsula, and almost all over Africa (Corbet, 1979; Olds and Shoshani, 1982; Macdonald, 1985; Hoeck, 1990; Stuart and Stuart, 1997). A distribution map of the rock hyrax is given in Figure 1.

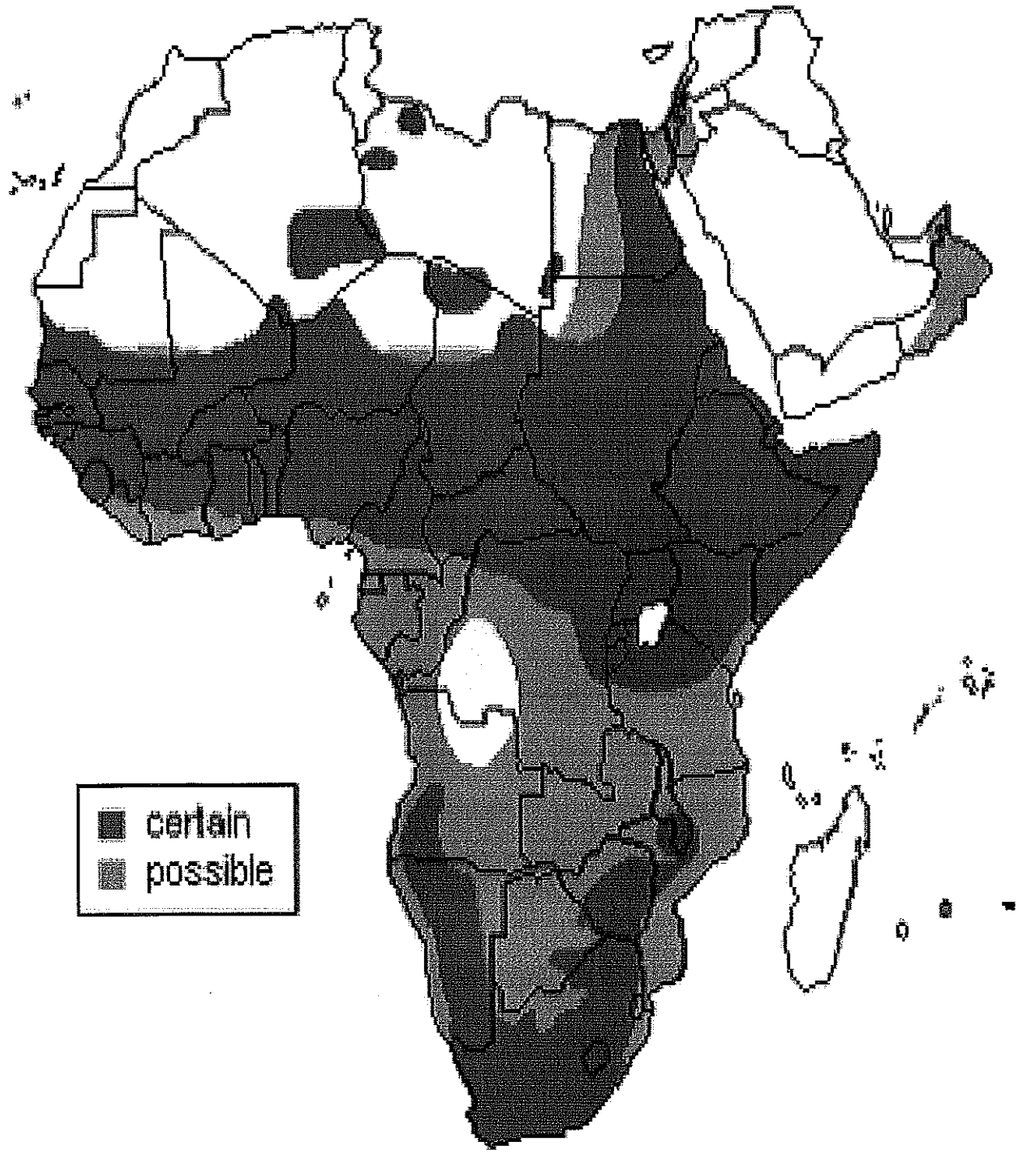

Figure 1. The distribution (range) map of rock hyrax (Hoeck, 1990).

1.2.3 *Procavia* and its taxonomy

The number of recognized species of rock hyraxes varies from taxonomist to taxonomist, with up to five separate species being distinguished (Wilson and Reeder, 1993). According to Olds and Shoshani (1982), some authors consider the rock hyrax to be monospecific with 17 subspecies. However, Kingdon (1997) noted that even though *Procavia* is sometimes treated as a single species, they are more usually divided into five species (Table 1), most of which are divided into subspecies.

Table 1. The different species of *Procavia* and their distribution.

Species	**Distribution**
Procavia *capensis*	South, East and southwest Africa
Procavia habessinica	Northeast Africa and Arabia
Procavia johnstoni	Central and East Africa
Procavia welwitchii	Kaokoveld (north-western Namibia)
Procavia ruficeps	South Sahara

The genera *Procavia* and *Heterohyrax* are represented by *P. capensis* and *H. brucei* in Ethiopia and comprise allopatric forms, due to the high degree of variations resulting from the isolation of habitats within Africa, which posed considerable taxonomic problems (Corbet, 1979). For instance, *P. habessinica* was considered to comprise more than one species (Ashfored, 1977). However, Corbet (1979) named *P. habessinica* as *P. capensis* and Ashford and Smith (1985) accepted this nomenclature. *P. capensis* and *H. brucei* are recorded in Bale Mountains National Park (BMNP) (Hillman, 1993b).

The subspecies, *Procavia capensis capillosa,* found in the Bale Mountains is confined to high altitudes (2800-3500 m) and is isolated from the more northerly population by the Wabi Shebele. They are distinguished from other *Procavia* and the other hyracoids by dental characters. The upper incisors are convergent with flat anterior surfaces, and hence they closely resemble those of a rodent, while the lower incisors are parallel, not divergent as in other *Procavia* (Yalden *et al.,* 1986). Corbet (1979) also noted that the rock hyrax, *Procavia capensis capillosa* Brauer, of BMNP as an endemic subspecies, with considerably different fur and incisor teeth from other hyraxes of nearby areas.

Rock hyraxes are the smallest among ungulates with the approximate size of a large rabbit or marmot. The mouth of the species is exceptionally large in order to facilitate quick eating to avoid predators in their foraging grounds (Olds and Shoshani, 1982). They have a short brown or gray bristly coat with a characteristic large dorsal gland in the mid-back. This gland is surrounded by specialized glandular hair known as osmetrichia (Balakrishnan, 1987) and secretes a clear, scented fluid that is important in species specific signaling. They are tail-less or the tail is rudimentary. The ears are short and almost round. There are four functional digits on the forefeet and three on the hind feet (Weisz, 1973; Olds and Shoshani, 1982; Smithers, 1983; Estes, 1991). The external morphology of a dominant territorial male rock hyrax while watching is shown in Figure 2.

The premolar series of teeth is much shorter than the molar series in *Procavia* but the two series are about equal in length in *Heterohyrax* and the premolar series longer than the molar series in *Dendrohyrax* (Nowak, 1991).

Figure 2. External morphology of a dominant male rock hyrax.

1.2.4 Ecology of rock hyrax

Rock hyraxes are found where there are rocky outcrops, known as "kopjes". They prefer to live in "kopjes" found within savanna zones, semi-desert vegetation and mountains. They avoid "kopjes" within forest. The rocky outcrops provide them the necessary shelter from predators and harsh weather condition (Fourie and Perrin, 1987; Estes, 1991; Kingdon, 1997). Rock hyraxes prevent physical harm from predators only by hiding in their rocky shelter. The "kopjes" must have crevices large enough for the hyraxes to enter, but are certainly small for the predators to enter (Sale, 1966).

In several parts of Africa, like the Serengeti in Tanzania and Matobos in Zimbabwe, the rock hyraxes occur together with the bush hyraxes and live in close association on rock outcrops

(Hoeck, 1982; Barry and Mundy, 1998). Such associations, which increase in the presence of dependent offspring in nurseries, enhance the ability to detect predators (Barry and Mundy, 2002). However, the rock hyraxes and the bush hyraxes do not interbreed as the positioning of the penis and mating behavior differ (Gerlach and Hoeck, 2001). They are herbivorous and feed mainly on grass, which is fairly abundant throughout the year and easily accessible around their shelter (Fourie and Perrin 1989; Hoeck, 1989; Kingdon, 1997). The rock hyrax also eats tree leaves, fruits, flowers, shrubs and barks. It feeds on any plant including some that are poisonous to most other animals (Nowak, 1991). *Procavia* may be found feeding at any time of the day, provided it is warm and sunny, with peaks of activities in the early morning and late afternoon for short times in order to avoid confrontations with predators (Nowak, 1991; Stuart and Stuart, 1997; Kingdon, 1997).

1.2.5 Social system and behavior of rock hyrax

Rock hyraxes are diurnal and live clumped together in colonies on "kopjes". A colony consists of up to 80 individuals or more inhabiting in the "kopjes" depending mainly on the size of the "kopje" and availability of food. The dominant male may mark his territory with urine and faeces (Hoeck, 1982). It also defends the area from other males by means of territorial calls from other males in order to have exclusive access to the females living there. The females are not territorial. They allow females from other kopjes to enter ones territory (Hoeck, 1982; Fourie and Perrin, 1987; Estes, 1991; Kingdon, 1997, Kotler *et al.*, 1999). There are four types of males in a colony: territorial males, peripheral males, early dispersing males and late dispersing males. A territorial male is the dominant male who protects his harem of females as well as the "kopje" from peripheral males. Peripheral males are those males that have dispersed from other nearby

"kopjes". Early dispersing males leave their natal "kopje" before they reach sexual maturation in order to establish themselves as a peripheral male at another "kopje". Late dispersing males, on the other hand, leave their natal "kopje" after they have reached sexual maturity. Males always disperse from their natal "kopjes" (Hoeck *et al.*, 1982).

They have communal urination and defecation sites preferably on a flat or nearly flat surface. These latrines are thought to have scenting role, where all members of the group share a common smell that scents their feet and fur (Spinage, 1971; Kingdon, 1997; Chame, 2003).

Predation pressure on rock hyraxes is extremely high. Predators include leopard, Egyptian cobra, puff adder, wild dog, spotted hyena, civet, jackal, eagle, raptors and the Ethiopian wolf (Olds and Shoshani, 1982; Gargett, 1990; Kingdon, 1997; Barry *et al.*, 2003; Online, 2003). External parasites such as ticks, lice, mites and fleas, and internal parasites such as nematods and cestodes also probably play an important role in the hyrax mortality (Macdonald, 1985).

1.2.6 Sexual behavior and physiology of rock hyrax

Adult female rock hyraxes come into estrus during the breeding season, which peaks in April and become receptive once a year (Macdonald, 1985; Fourine and Perrin, 1987). However, Haltenorth and Diller (1988), Estes (1991) and Kingdon (1997) have stated that mating season differs from locality to locality and can even differ from top to the bottom of an escarpment. In East Africa, mating season and birth seem to coincide with the rainy season. Gestation period is 7.5-8 months. The long gestational period of the hyraxes is thought to be related to having had much larger ancestors (Kingdon, 1971). There may be 1-6 litters, but usually the litter size

consists of 2-3. The young are born fully developed, seen active immediately after birth and soon start to eat plants. They mature at around 16 months and are known to live for up to 12 years. Females live significantly longer than males. Sex ratio up to 2 years is 1:1. Later, females are seen in excess as males are driven out from the group upon sexual maturity, between 16 and 24 months (Fourie and Perrin, 1987; Estes, 1991; Barry and Mundy, 1998). But Gerlach and Hoeck (2001) noted that there is no significant skew in the sex ratio of hyraxes.

Like the other species of hyraxes, rock hyraxes have poor ability to regulate their body temperature. Their metabolic rate is low. Body temperature is maintained mainly by gregarious huddling, long periods of inactivity and basking. Although their physiological status allows them to exist in dry areas and use food of relatively poor quality, they are dependent on shelters that provide relatively constant temperature and humidity (Bartholomew and Rainy, 1971; Rübsamen *et al.*, 1982).

1.2.7 Justifications

The rock hyraxes are faced with heavy predation. The threats also include human use for food and fur, periodic epidemics and localized depletion as a result of habitat loss (Kingdon, 1997). Although, they have a low breeding rate, they are seen distributed widely (Nowak, 1991; Stuart and Stuart, 1997) and none of the species of *Procavia* is listed under any of the threatened categories of animals (Kingdon, 1997). There is no information on ecological aspects of this species in Ethiopia as well as in many of the areas of their distribution. Hillman (1986) noted that measurements that enable accurate estimation of the population of rock hyrax are not made and there are probably thousands of them in BMNP. There is no quantitative data on its activity

patterns and the factors affecting them in the Park. The present study is the first of its kind in the country. It is expected that results of the present investigation will provide preliminary information on the current population status, diurnal activity patterns and other related aspects of the species in Dinsho area in and around the BMNP. This information is expected to be of help for further studies and conservation of the species. The present investigation is restricted to Dinsho area based on accessibility of the area for census work and for follow-up of the activity patterns. Further, the presence of a relatively high population of rock hyraxes in the area also prompted to concentrate the observations in Dinsho area, in and around the BMNP.

1.2.8 Objectives

The objectives of the present investigation are the following:

General objective

- ❖ To compile data on the current population status, diurnal activity patterns and other related aspects of the rock hyrax (*Procavia capensis*) in Dinsho area, in and around the BMNP.

Specific objectives

- To determine the current population status of the rock hyrax in the study area.
- To examine the relative proportion of sex and age category of the rock hyrax.
- To describe the diurnal activity patterns of this animal.
- To assess the impact of the local people on the rock hyrax, and
- To suggest measures for conservation of the species.

2. STUDY AREA AND METHODS

2.1 The study area

2.1.1 Location and topography

The Bale Mountains National Park (BMNP), is located between 6^0 29' and 7^0 10' N and between 39^0 28' and 39^0 58' E in the southeastern part of Ethiopia. The Park was designated in 1974, with an area of 2200 km^2, varying in altitude from 1500 m to 4377 above sea level (Stephens *et al.*, 2001). The Park was created primarily for the conservation of the endemic Mountain nyala and the Ethiopian wolf and also as part of the largest tract of the Afro-alpine habitats in Africa (Hillman, 1993b). The Park's Headquarter is located at the northern tip of the Park in Dinsho, which is 400 km by road from Addis Ababa.

2.1.2 Ecology and Vegetation

The BMNP contains the following five ecological zones: the northern grassland, the northern woodlands and heather moorlands forming a mosaic between 3100-3400 m a.s.l., the treeless Afro-alpine habitat and moorland above 3400 m, and the southern Harenna forests between 1500-3200 m. Each of these vegetation zones harbours specialized flora and fauna, some of which are endemic to Ethiopia. Records show that the Park contains over 900 plant species more than 17 of which are endemic to the country and two to the Park (Woldegebriel Gebrekidan, 1996). The Gaysay area is the northern limit of the Park, and the main site of the present investigation, at Gaysay (3000-3400 m a.s.l.) consists of flat plains dominated by open grassland, swamps and bushes. The most important plants include *Helichrysum splendidum, Artemisia afra* and

Hypericum revolutum. Common grasses of the area are the genera *Andropogon, Bromus, Festuca* and *Poa*. The mountains on either side of the plain are covered by *Juniperus procera, Hagenia abyssinica* and *Hypericum revolutum* forests, which have grass and herbs underneath (Woldegebriel Gebrekidan, 1996). The summary of plant species composition suggests that the greatest diversity is found in the northern woodlands (61.6% of all species recorded) followed by the northern grasslands (36.7%) (Hillman, 1986).

2.1.3 Fauna

Due to a broad range of habitats between 1500 and 4377 m altitude, the BMNP harbours a variety of diversified fauna. A large proportion of these species are endemic to the Park. Out of the 67 species of mammals, 256 species of birds recorded for BMNP, 5 species of mammals and 6 species of birds are endemic to the Park (Befekadu Refera and Afework Bekele, 2001; Stephens *et al.*, 2001).

Mountain nyala, Menelik's bushbuck, rock hyrax, reedbuck, warthog, serval cat, caracal, common jackal, baboons, grey duiker, spotted hyena, Ethiopian wolf and rodents, including the endemic giant mole-rat, are some of the mammals found in the Gaysay area. Aves such as the Abyssinian long claw, the marsh harrier and the winding cistocola are commonly found in the area

2.1.4 Division of the study area

The present investigation was confined to the northern tip of the Park at the Dinsho area, mainly in the Gaysay-Adelay part. This area of broad valleys and high ridges lies between altitudes of

3000 and 3500 m. The investigation was centered on six study sites (S-1 to S-6). These are Site 1 (Upper Danka or Derbo), Site 2 (Lower Danka or Shenteme), Site 3 (Hora Soba), Site 4 (Adelay Ridges), Site 5 (Gasuray Area) and Site 6 (Tingo) (Fig. 3).

2.1.4.1 Site 1

This site ($07^0$04.948' N, $039^0$46.272' E) is in Gojera settlement area, where rock piles shelter the hyraxes in a valley at an altitude of 3140 m. Lower to the hyraxes' shelter the River Danka flows. One colony of rock hyraxes inhabit in this site. The area is dominated by *Juniperus procera, Hagenia abyssinica* and *Discopodium penninervium* trees. *Hypericum revolutum*, scattered *Erica arborea* and *Euphorbia dumalis* are the predominant shrubs in the site. Herbs of *Knophofia foliosa, Arisaema eneaphyllum, Helichrysium citrispinum* and *Urtica simensis* and grass of the genera *Andropogon*, *Festuca* and *Carex* are common in the areas around.

2.1.4.2 Site 2

This site ($07^0$07.198' N, $039^0$46.272' E) is located at the Gaysay plains on the boundary of the Park around the junction of Weyib and Danka Rivers. It is a grassy plain at an altitude of 3064 m where 15-25 m deep gorge with rock piles is found. Hyraxes of this site live in one colony. They share the rock piles shelter with lizards and birds like Wattled ibis. Vegetation types of this area consists of few *Juniperus procera*, *Hagenia abyssinica* and *Discopodium penninervium* trees, *Hypericum revolutum*, *Myrsine Africana, Helichrysum splendidum* and *Phytolacca dodecandra* shrubs, *Arisaema eneaphyllum, Kniphofia foliosa* and *Artemisia afra* herbs and abundant grasses of the genera *Andropogon, Carex* and *Festuca*.

2.1.4.3 Site 3

Hora Soba site ($07^0$06.233' N, $039^0$41.405' E) is located at a distance of about 15 km from the BMNP Headquarter on the way to Addis Ababa. This site is situated at an altitude of 3229 m closer to the main highway and human settlement areas. The hyraxes live in four colonies, sheltered in small cliffs and in between rock piles found around the settlements. Vegetation of the area include scattered *Hagenia abyssinica, Juniperus procera, Discopodium penninervium* and *Olea* sp. trees, shrubs of *Phytolacca dodecandra, Euphorbia dumalis* and *Hypericum revolutum*, herbs, *Urtica simensis* and *Kniphofia foliosa* and grasses of the genera *Festuca*, *Carex* and *Agrostis.*

2.1.4.4 Site 4

Adelay ridge ($07^0$05.442' N, $039^0$44.271' E) is an area found at an altitude of 3450 m. This site is in the northern woodland area of the northern Gaysay. The area consists of rock piles at the base of the cliffs, which is the shelter of rock hyraxes. There are three colonies of them in this site. Rock hyraxes found in this site share the cliffs with baboons and lizards for shelter. The plant species that dominate the area are *Hagenia abyssinica, Juniperus procera and Rappanea simensis* trees. *Hypericum revolutum* and *Erica arborea* give a dense bush growth at the upper part of the cliffs and rock piles. In between the trees and bushes is an open area of extensive grass growth of the genera *Poa*, *Agrostis* and *Koleria*.

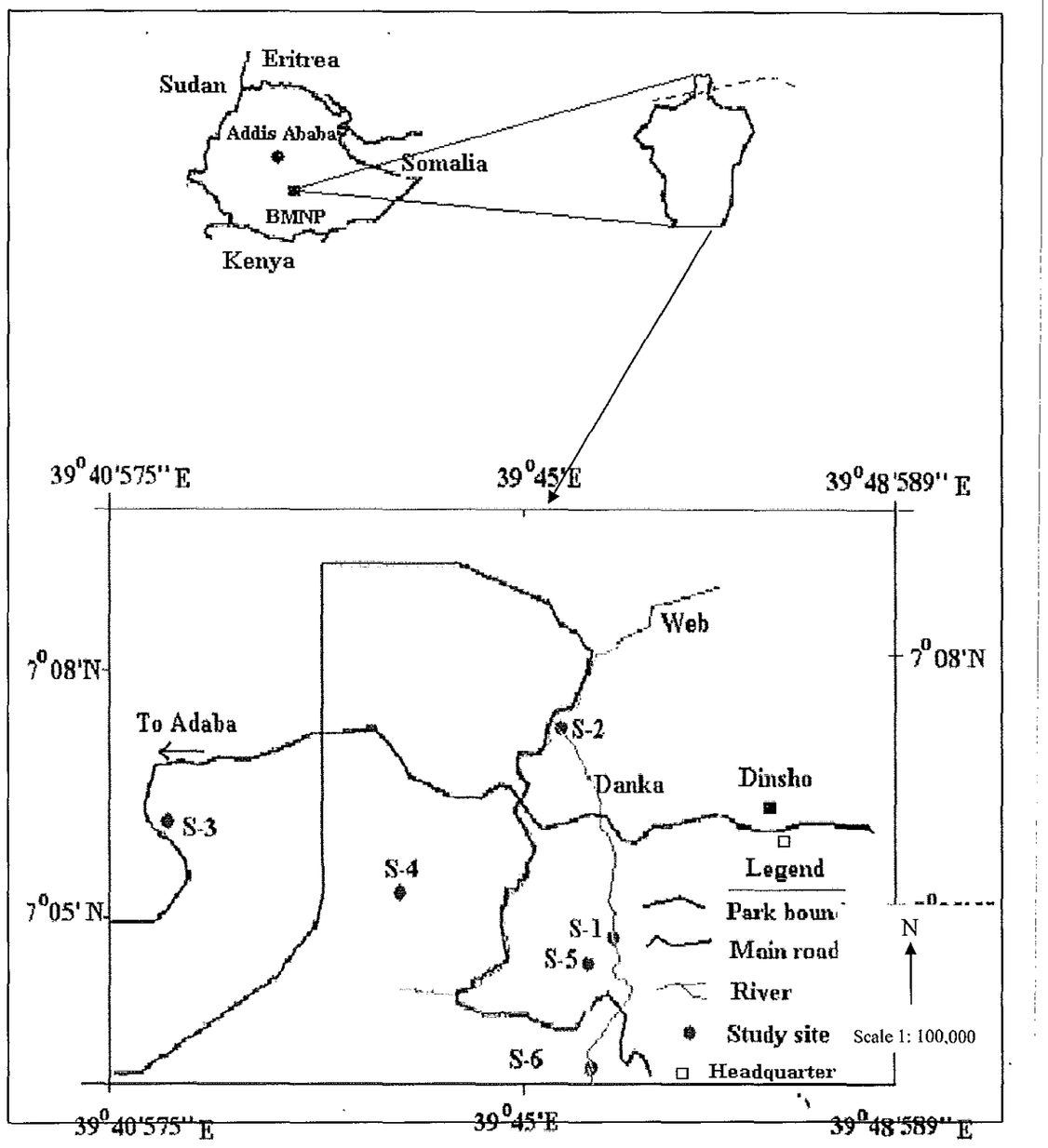

Figure 3. Map of the study sites.

2.1.4.5 Site 5

This site ($07^0$04.669' N, $039^0$45.319' E) is situated at the base of Gasuray peak; at an altitude of 3185 m. Hyraxes of this area live in two colonies. The dominant vegetation in the area is *Juniperus procera* tree. Some *Hagenia abyssinica* and *Discopodium penninervium* trees, shrubs of *Hypericum revolutum* and *Euphorbia dumalis*, herbs like *Urtica simensis* and grasses of the genera *Andropogon* and *Carex* are found in the area.

2.1.4.6 Site 6

This site ($07^0$03.356' N, $039^0$46.567' E) is about 7 km from the BMNP Headquarter towards the South. It is a valley at an altitude of 3276 m with cliffs on two sides. Within the valley is a rock pile, which is the shelter of the hyraxes, beneath which the River Danka flows. Rock hyraxes in this area are found in three colonies. One of them has territory away from the river. Shrubs of *Erica arborea* dominate the area. Some scattered *Juniperus procera*, *Hagenia abyssinica* and *Discopodium penninervium* trees and herbs of *Urtica simensis* and *Helichrysium citrispinum* and grasses mainly of *Agrostis* and *Festuca* spp. also grow in the area.

2.1.5 Geology and soil

The Bale Mountains area was formed from lava outpourings during the Miocene and Oligocene periods, between 38 and 7 million years ago, which covered the Mesozoic marine sediments and underlying Precambrian rocks after the Eocene uplifting of the Ethiopian highlands. The rocks of the volcanic outpourings are more of trachytes, but also include rhyolites, basalts and associated agglomerates and tuffs (Morton, 1978; Miehe and Miehe, 1994; Williams, 2002). The soils,

mainly derived from the basaltic and trachytic parent rocks, are fairly silty loams of reddish-brown to black colour (Miehe and Miehe, 1994).

2.1.6 Climate

Because of the great variation in altitude and by the bulk of the massif, which attract orographic rainfall, the Bale Mountains experiences major seasonal variations in climate over its area (Williams, 2002).

2.1.6.1 Rainfall

Rainfall of the BMNP is characterized by eight months rainy season ranging from March to October, with greater bulk of the rainfall in April and August to October followed by a four months dry season from November to February (Daniel Gemechu, 1977; Sillero-Zubiri *et al.*, 1998; Williams, 2002). The lower altitudes of the area receive annual rainfall between 600-1,000 mm, whereas the higher altitudes receive up to 1,200 mm. The Park receives rainfall from the equatorial westerlies and the Indian Ocean air Steam (Williams, 2002). The mean monthly rainfall of the Dinsho area during 1994-2003 is presented in Figure 4.

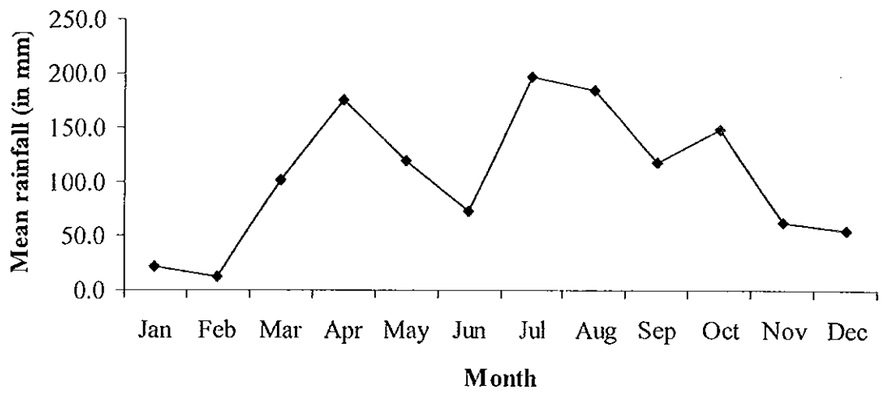

Figure 4. Mean monthly rainfall of Dinsho area (1994-2003).

2.1.6.2 Temperature

Generally, the temperature of the BMNP is characterized by hot days and cold nights (Stephens *et al.*, 2001). The temperature falls with increasing altitude of the area. The maximum and minimum temperatures during the dry season showed high fluctuations. The lowest temperature recorded was -15 ^{0}C at night whereas the highest recorded temperature the next day was 26 ^{0}C (Williams, 2002). The rainy season, on the other hand, is warmer and the temperature shows less daily fluctuation (Miehe and Miehe, 1994; Williams, 2002). Frost was prevalent in Dinsho area at night, particularly in the dry season during the study period. The mean monthly maximum and minimum temperature of the Dinsho area during 1995-2002 is given in Figure 5.

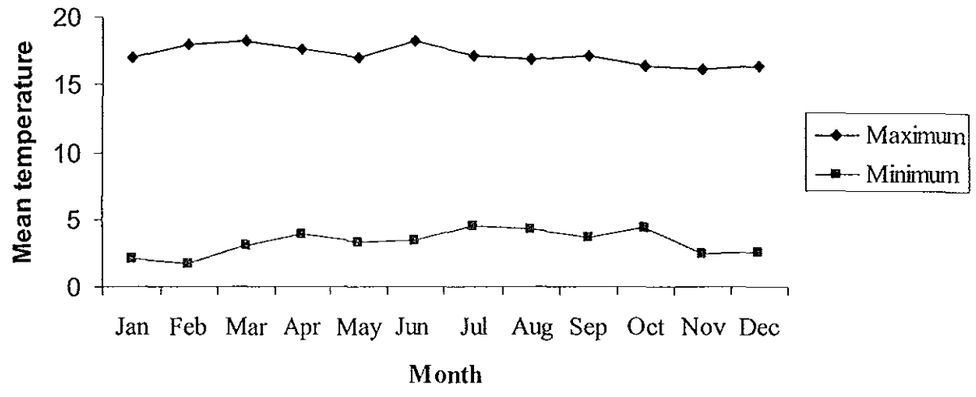

Figure 5. Mean monthly maximum and minimum temperature (°C) of Dinsho area (1995-2002).

2.1.6.3 Humidity

Humidity varies with season of the study area. Relative humidity is highest in the wet season and lowest in the dry season. Goba exhibits a higher average value than Dinsho. However, the seasonal values are extreme in Dinsho, with higher wet season and lower dry season values (Hillman, 1986).

2.1.7 Human settlements and land use patterns

Prior to the establishment of the Park, the BMNP area was largely uninhabited. During 1974-1991 periods, due to the investments in mechanized state farms in the lowlands, little room was left for pastoralists, except at higher altitudes (Stephens *et al.,* 2001). Since then, BMNP area has been under increasing pressure from an ever-growing human population. The estimated human population in the Park in 1984 was 2,500 people (Hillman, 1986). During the change of government in 1991 firearms became readily available and as a result, direct persecution of

wildlife and resettlement of previously cleared areas became common, resulting in considerable destruction of habitat (Shibru Tedla, 1995; Stephens *et al.*, 2001).

At present, the settlers use the Park area for permanent settlement and crop cultivation. Further, they also use this area as a source of timber and fuel wood and for temporary use of the area for cattle grazing and the "horas" (mineral springs).

The Gojera area, surrounding the Park in three directions, is settlement site with many houses mainly concentrated at lower altitudes below the peak of Gasuray and the Park's Headquarter (Hillman, 1986; investigator's observation). Between 1986 and 1991, the Park area was extended northward, but was rapidly resettled following the change of government in 1991 (Stephens *et al.*, 2001).

For utilizing the "horas", large numbers of livestock enter the Park at Hora Soba, Worgona, Wasama and Upper Weyib Valleys. People construct houses for temporary use at high altitudes near the "horas" as well as they use caves for sheltering their cattle. Livestock kept around the "horas" for several days, severely affect the habitat (Hillman, 1986).

2.2 Methods

2.2.1 Duration of the study

The present investigation was made from September 2003 to February 2004. The investigation sessions were from September to October 2003 (September, wet season I and October, wet season II) and from January to February 2004 (January, dry season I and February, dry season II).

2.2.2 Data collection

A preliminary survey was made in the area during early September 2003, prior to the actual data collection so as to assess and compile information on distribution of rock hyraxes and vegetation type in Dinsho area. After this survey, six study sites were selected based on the animal concentration and the presence of abundant fresh dung piles as adopted by Sutherland (1996) and Chame (2003). Observation points were selected based on accessibility and view of the shelter of hyraxes. All observations were simultaneously recorded in an observation chart. The data recording sheets and points of discussion with local people were prepared prior to the commencement of the actual data collection period.

Data on the population size, age and sex category, diurnal activity pattern and food habits of rock hyraxes were collected and compared on seasonal level. To address some of the study objectives, discussions were held with park officials, scouts, biologists, selected elders, students and herd's boys, and their views on various aspects concerned with the rock hyrax and related issues were recorded in a questionnaire.

2.2.3 Population census

Prior to estimating the population size of rock hyraxes, a reconnaissance survey count was made in each of the study sites. As the rock hyraxes live in aggregation in small colony units and as their density is relatively low, total count method was used for population count.

2.2.3.1 Total count

Based on the information obtained during the reconnaissance survey, total counts were made in the six study sites using direct count method as adopted by Norton-Griffiths (1978); Western and Grimsdell (1979); Melton (1983); Wilson (1989); Sutherland (1996) and Wilson *et al.* (1996).

Population census data were collected by direct observation of free-ranging animals with unaided eye and by using 8x30 binoculars as adopted by Baba *et al.* (1983) and Barry and Mundy (1998). All census works were made on foot. Counts were made twice during the wet season (September and October) and twice during the dry season (January and February) for five consecutive days in each month. Population census were made while the rock hyraxes were basking on exposed areas of the kopjes and actively feeding during 07:00h to 09:30h in the morning and during 16:30h to 18:00h in the afternoon. One scout of the park was involved in counting them during their peak of activities. The data record sheet used for the census is presented in Appendix 1.

2.2.4 Sex ratio and age category

The age group of rock hyraxes and sex of some individuals were identified and noted while making the population census in the field. They were categorized as juveniles, sub-adults and

adults. They were distinguished by comparative body size and grouped among their respective age category as adopted by Barry (1994) and Barry and Mundy (1998, 2002) for the hyraxes. Juveniles were also distinguished by their dark pelages. Some adult males were distinguished by their relatively large body size (Morris, 1965; Olds and Shoshani, 1982; Gerlach and Hoeck, 2001) and thick necks, blunt features and sharp tusks (Estes, 1991) from adult females in the field. The tusks were visible or exposed while the hyraxes were calling, grooming, basking and watching. In addition to these, adult males were distinguished by their ridged or triangular upper incisors from that of the rounded faces in females (Hahn, 1935). Some adult females were identified while lactating and/or being continuously followed by juveniles. But this could not be a fool proof method to identify the sex category of the adults. It was unable to categorize the juveniles and sub-adults into their respective sex category in the field. Hence, hyraxes were live trapped as adopted by Barry and Mundy (1998) and Gerlach and Hoeck (2001), so as to categorize them into specific sex category.

2.2.4.1 Trapping

Locally made string traps with a slip loop knot at one end were used to live trap rock hyraxes as adopted by Asrat Hailu(1987). Prior to setting the traps, the sites where the traps were to be placed were pre-baited by maize seeds, peanuts and/or banana as adopted by (Barry and Mundy, 1998; Kotler *et al.*, 1999; Gerlach and Hoeck, 2001). Double strings were used for the traps so as to minimize damage of the trap and to avoid escape of the trapped rock hyraxes. The traps were set around active or occupied holes and at the entrance of caves or rock holes at dawn. The loop of the trap was carefully placed and held in position by gently attaching with leaves or herbs so that the loop can easily tighten when the hyraxes come out or enter the holes. The other end of

the string loop was tied at the base of plant stem or any firm object around so that the trapped hyraxes could not escape. Following the principle of saturation trapping adopted by Rogers *et al.* (1997), more tarps were placed to trap maximum number of hyraxes. Averages of 20 traps were set at each kopje or colony. The traps were checked frequently during day time. The trapped rock hyraxes were then sexed based on their genitalia (Macdonald, 1985) and the presence of six mammae in the females (Nowak, 1991). Each of the individual hyraxes trapped was marked at its first capture by cutting hair from a distinct spot as adopted by Gerlach and Hoeck (2001) so as to identify whether the hyrax was trapped earlier or not, and for identification in the field, with large painted marks on both sides of the body as described by Michell *et al.* (1996). Sex ratio of the rock hyrax populations in the study area was computed by considering only the sexed individuals.

2.2.5 Group size

The group size of rock hyraxes was recorded while conducting total counts. Following the method adopted by Barry and Mundy (2002) for *Procavia capensis* and *Heterohyrax brucei*, groups are defined as aggregations of two or more spatially associated individuals in obvious visual, auditory and/or olfactory communication with each other, basking on the same kopje; in which such individuals are in close proximity on the same outcrop. Mean group size of the hyraxes was quantified by season and study sites.

2.2.6 Diurnal activity patterns

Data on the diurnal activity pattern of the rock hyrax were collected by direct observation using unaided eye and by using 8x30 binoculars as adopted by Milner and Harris (1999). Observations

were made from a distance of 30-60 m according to the accessibility of the site, by selecting suitable vantage points, mostly hilltops or elevated areas by being hidden under some cover. Lower Danka (Shenteme) and Upper Danka (Derbo) were selected to follow the activity of a dominant territorial male and that of a colony of rock hyraxes, respectively for this study due to the relatively accessible and open nature of the areas. It was also possible to recognize the dominant male during the initial study period in the field at Lower Danka. In the Upper Danka, the colony size was 10 individuals and it was manageable to make observations. In the colony the activities of all individuals other than the dominant male were observed.

The activities of a dominant male and a colony of rock hyraxes were recorded in the respective study sites every 5 minutes from 06:00h to 18:00h for four consecutive days every month following the method used by Clough and Hassam (1970), Waser (1975), Leuthold and Leuthold (1978) and Doi *et al.* (1983). A total of 16 days was used and 192h of observation and 2304 units of activities were recorded for the whole study period. Data were collected by focusing observations at the dominant male and the colony in a given sample period (Instantaneous Sampling Method) as described by Altman (1974), Altman and Altman(1977), Doi *et al.* (1983), Murphy and Curatolo (1987), Dwiyahreni *et al.*(1999) and Ermias Deribe (2001). Data on the time spent in performing particular activities by the dominant male and the number of hyraxes engaged in different activities for the hyrax colony were recorded and analyzed by expressing the percentage of time spent in each activity for the dominant male and percentage of the number of rock hyraxes engaged in different activities in the five minutes period.

Activity patterns were categorized into feeding (grazing and/or browsing), watching, basking, inside shelter and others (grooming, scratching, sniffing, playing, suckling, resting under shade,

chasing and drinking) and recorded in an observation sheet presented in Appendix 2 which is prepared following the methods of Spinage (1968), Clough and Hassam (1970) and Mitchell (1977).

2.2.6.1 Watching

Rock hyraxes were recorded as watching when they continuously and cautiously watch in their surroundings for a predator or other intruders. When the presence of a strange animal or an intruder was noticed, they stared at it in an alert position for a long duration.

2.2.6.2 Basking

When the rock hyraxes exposed their flanks and abdominal area to the radiation of sun, laying or sitting on rocky outcrops by stretching their limbs and body, it was recorded as basking. During this behavior, they were seen huddled in a group of 3-6, especially in the early morning hours.

2.2.6.3 Feeding

Rock hyraxes were recorded as feeding when they were engaged in grazing, browsing or consuming fallen leaves of trees without being interrupted by other activities.

2.2.6.4 Inside shelter

When rock hyraxes were totally out of view and were not observed watching, basking, and foraging or were absent from their resting shade, it was recorded as inside shelter. Rock hyraxes stayed inside rocky caves during night and start coming out early in the morning.

2.2.6.5 Other activities

They were recorded as involved in other activities when they groom and scratch their own body, sniff and chase others, play one another, suckle, drink and rest under shade. Playing and suckling were common activities among the juveniles. Grooming and scratching were pronounced in rock hyraxes when the sun light gets brighter. Chasing was a common activity of the dominant male, but not of the other colony members.

The appropriate activity was recorded every 5 minutes. When the focal animal(s) is/ are hidden out of view, it was considered as missing and excluded from the data.

2.2.7 Food habits

Data on the food habits of the rock hyraxes were collected throughout the study period by direct observation on animals in the field with the help of unaided eye and by using 8x30 binoculars. All plant species eaten were recorded as adopted by Sale (1965), Turner and Watson (1965) and Millner and Harris (1999) for hyraxes. Initial collection of plants was made for identification by the BMNP experts/biologistsSome of the plants which were known to the investigator were identified in the field itself. All vegetation materials found in the hyrax shelter as leftovers were collected and identified using the sample vegetation around the colony site as adopted by Sale (1965). The data obtained in this way were included with sight records as adopted by Leuthold (1971). Observations on the food habits of the rock hyraxes were made in all the study sites.

While following the activity patterns of the rock hyraxes colony, particularly feeding, the number of animals engaged in grazing and/or browsing was recorded separately during the study period.

Average percentage of hyraxes engaged in grazing and/or browsing was compared both during the wet and dry seasons.

2.2.8 Assessment of the impact of local people

In addition to observations made during the study period, discussions were held with the local people, Park officials, game scouts, field guides, biologists, selected elders, students and herders. Direct discussions were held based on a questionnaire given in Appendix 3 and the views of them were recorded.

2.2.9 Data analyses

Data recorded during the study period were analyzed by SPSS computer software package. Rock hyraxes counted in each study site was compared using one-way ANOVA ($p=0.05$). Population size during the wet and dry seasons, age and sex category of rock hyraxes were compared using student's t-test for independent sample of groups ($p=0.05$). Difference in the amount of time spent in various activities by the dominant male and the number of hyraxes engaged in various activities in the rock hyrax colony were also analyzed using one-way ANOVA. One-way ANOVA was used to test the level of significance among each activity. The number of hyraxes engaged in grazing and browsing during the wet and dry seasons was analyzed using student's t-test. Student's t-test was used to test seasonal difference in mean group size of rock hyraxes. Tukey-type post hock test was also used to compare the difference in mean group size of rock hyraxes among the study sites during the wet and also the dry seasons.

3. RESULTS

3.1 Population size

A result of the total counts of rock hyraxes is given in Table 2. During the study period, the highest average population size was 134 during the wet season in site 3 and the lowest size was 10 in site 1 in both the wet and dry seasons. Site 3 had the highest population (37.5%) and site 1 had the lowest (2.9%) population among all the study sites.

Table 2. Population size of rock hyraxes in the study sites (Mean ± SE).

Season	Population size in different sites						Total
	S-1	S-2	S-3	S-4	S-5	S-6	
Wet	10±0	33±3.5	134±11.5	62±3.5	51±4	78±7.5	368
Dry	10±0	30±3	129±6	46.5±3.5	44±2.5	73±6.5	332.5
Average	10±0	31.5±2.02	131.5±5.53	54.3±4.78	47.5±2.89	75.5±4.3	350.3
%	2.9	9.0	37.7	15.4	13.5	21.5	100

S-1= Site 1, S-2= Site 2, S-3= Site 3, S-4= Site 4, S-5= Site 5 and S-6= Site 6.

Although there was some increase in the average number of rock hyraxes counted during the wet season (368 ± 30) than during the dry season (332.5 ± 21.5), the difference was not significant ($t=0.962$, $p>0.05$). On average, 350 rock hyraxes were counted during the study period. A

comparative picture of the rock hyraxes counted in the six study sites during the wet and dry seasons given in Figure 6.

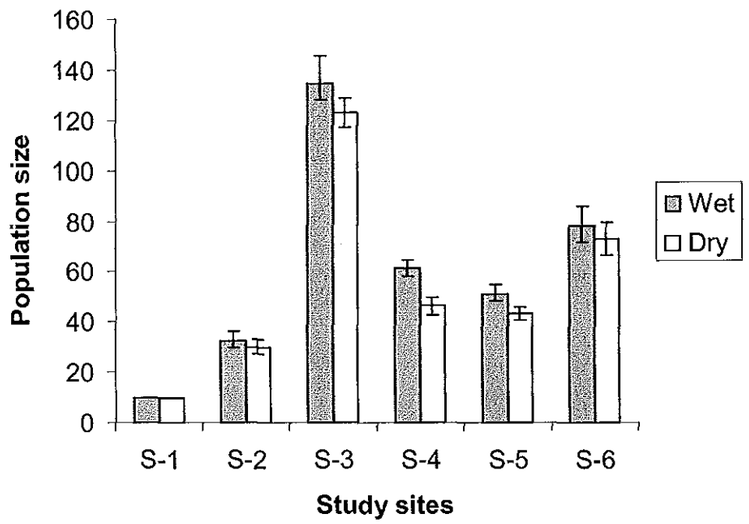

Figure 6. Population size of rock hyraxes in the study sites(S-1 to S-6) during wet and dry seasons (Mean ± SE).

3.2 Age distribution

The mean age categories of rock hyraxes observed during the study period are given in Figure 7. There were more adults (40.3%) than sub-adults (34.8%) and juveniles (24.9%) among the hyrax colonies. The ratio of sub- adults to adults was 1:1.2, juveniles to adults 1:1.6 and juveniles to sub-adults 1:1.4 during the study period. There were less number of juveniles than the adults and sub-adults. As compared to the dry season, there were relatively more juveniles during the wet season. Even though there was some differences in the number of individuals of the different age

classes, there was not significant difference among each category ($p>0.05$) at 5% confidence level.

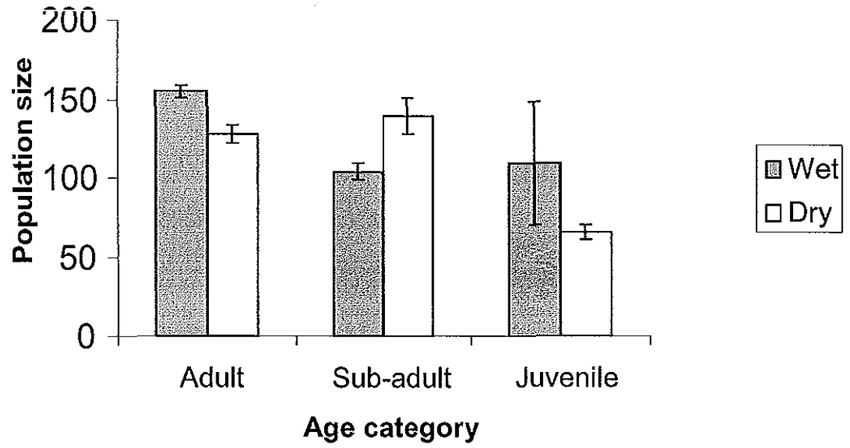

Figure 7. Age group of rock hyraxes during wet and dry seasons (Mean ± SE).

3.3 Sex ratio

The sex of most of the rock hyraxes was indeterminate due to the lack of visible external morphological features that enables to distinguish sex in the field. It was more difficult in case of juveniles and the sub-adults.

Averages of 23 rock hyraxes were trapped in each site seasonally. During the trapping period, one sub-adult hyrax was found dead and two others (one adult and one juvenile) were injured. Relatively more rock hyraxes were trapped in unbaited sites than baited ones. The details of rock hyraxes trapped in the study sites during the wet and dry seasons are given in Table 3.

On the basis of careful observations in the field and trapping, it was possible to identify the sex of 18 and 139 rock hyraxes, respectively out of the total population in the six study sites.

Table 3. Number and sex of rock hyraxes that were trapped in the study sites during the study period.

	Sex		
Site	Male	Female	Total
1	3	3	6
2	4	6	10
3	19	24	43
4	12	20	32
5	8	9	17
6	13	18	31
Total	59	80	139

Large numbers of females than males were trapped during the study period. A total of 157 rock hyraxes were sexed through trapping and observation in the field during the study period. The number of sexed rock hyraxes both during the wet and dry seasons is given in Table 4.

Table 4. Number and sex of rock hyraxes that were trapped and observed during the wet and dry seasons.

Season	Adult		Sub-adult		Juvenile		**Total**
	M	F	M	F	M	F	
Wet	26(6*)	38(14*)	20	24	25	29	162
Dry	24(8*)	32(8*)	28	34	16	18	152
Average	25.0(7*)	35.0(11*)	24.0	29.0	20.5	23.5	157.0
%	15.9(4.5*)	22.3(7*)	15.3	18.5	13.1	14.9	100.0

M= Male, F= Female

* Rock hyraxes sexed in the field

During the wet season the ratio of adult males to adult females was 1:1.46, sub-adult males to sub-adult females 1:1.20 and juvenile males to juvenile females 1:1.16. On the other hand, the dry season's ratio of adult males to adult females was 1:1.33, sub-adult males to sub-adult females 1:1.21 and juvenile males to juvenile females 1:1.3. The sex ratio of adults was biased towards females whereas; juveniles' sex ratio was nearly the same. Out of the sexed rock hyraxes, males constituted 44.3% and females occupied 55.7%. But the difference was not statistically significant ($p>0.05$). Fifteen out of the adult females were observed lactating (11) and being continuously followed by juveniles (4).

3.4 Group size

The colony of rock hyraxes consists of a dominant territorial male, several adult females and sub-adults and juveniles of both sexes. One to several adult males were also seen inhabiting the periphery of the group attempting to join the colony. During the wet season and dry season I,

rock hyraxes aggregated in large groups, however, it was not the case during the dry season II. Rock hyraxes of group sizes 10-24 were frequently seen during the study period. The mean group size of rock hyraxes was 26.3 ± 1.64 and 23.7 ± 1.88 during the wet and dry seasons, respectively. There was no significant difference ($t= 1.013$, $p> 0.05$) in the mean group size of the hyraxes between the wet and dry seasons.

But comparison of group sizes among the study sites shows significant difference ($p<0.05$) during the wet and dry seasons. Mean group size of rock hyraxes among study sites during the wet and dry seasons is given in Table 5.

Table 5. Group size of rock hyraxes in the study sites during the wet and dry seasons (Mean ± SE).

	Group size of Site					
Season	1	2	3	4	5	6
Wet	10±0.0b	32.5±3.50a	33.6±2.87a	20.5±1.65ab	25.5±1.55a	26.17 ± 2.63a
Dry	10±0.0b	30 ± 3.0a	32.5±3.64a	15.5±1.26ab	21.7 ±1.71ab	24.17±3.54ab

Means with in the same row followed by same letters (a and a, b and b or ab and ab) are not significantly different and those with different letters (a with b) are different among each other at 5% level of significance.

3.5 Diurnal activity pattern

Based on the observations on behavioural patterns of the rock hyraxes five major activity states such as watching, basking, feeding (grazing and/or browsing), inside shelter and other activities were revealed.

3.5.1 Activity patterns of a dominant male

Average percentage of time spent by the dominant male during the wet season in watching, basking, feeding, inside shelter and "other activities" were 49.7, 16.4, 9.6, 17.8 and 6.4, respectively. In the dry season the average percentage for watching, basking, feeding, inside shelter and "other activities" were 50.2, 13.9, 11.5, 17.5 and 6.9, respectively.

Although there were some variations in the percentage of time spent in the various activities during the wet and dry seasons, it was not statistically significant ($p>0.05$). Therefore, the data on the mean percentage of time spent in various activities, both during the wet and dry seasons, were lumped together. Summary of the mean percentage of time spent in various activities by the dominant male is given in Table 6.

Fifty percent of the day time of the dominant territorial male rock hyrax was devoted for watching, which was the major activity during daytime. It started watching early in the morning and reached its peak at 06:00-07:00h and late afternoons (16:00-17:00h) while the other colony members were feeding or basking. Average percentage of time spent for watching during the daytime hours ranged from 32.5% to 69% (50.0 ± 2.57).

The dominant male basks after watching for a long duration in the morning before and after feeding. Then the frequency of basking diminished towards noon up to early afternoon. Basking was more during 15:00-16:00h. Over 15% of the day time was spent in basking. It ranged from 1.4 to 32.2%.

Only 10.5% of the day time was spent by the dominant male in feeding. Feeding behavior was initiated in the early morning and reached its peak during 07:00-10:00h. Feeding activities were of brief periods and less during noon. Feeding activity increased in the afternoon and reached its peak during 17:00-18:00h just before dusk. Remaining inside shelter was the most frequent activity, next to watching. The dominant male rock hyrax stayed inside shelter during night until it came out for watching around 06:00h, during noon and during rainfall. Over 17% of the total day time was spent inside shelter and it ranged from 0.0% to 53.1%.

Table 6. Hourly data on the percentage of time spent by the dominant male during the study period in each activity during 06:00-18:00 (Mean ± SE).

	% of time involved in each activity				
Time, h	**Watching**	**Basking**	**Feeding**	**Inside shelter**	**Other activities**
06:00-07:00	63.8	1.4	1.9	32.2	0.7
07:00-08:00	48.2	18.7	25.9	4.8	2.4
08:00-09:00	55.7	21.0	15.5	0.0	7.8
09:00-10:00	42.5	18.9	25.3	7.4	5.9
10:00-11:00	48.1	32.2	4.7	8.9	6.1
11:00-12:00	45.8	17.1	3.6	10.6	22.9
12:00-13:00	32.5	6.3	0.2	53.1	7.9
13:00-14:00	40.8	13.5	1.3	34.8	9.6
14:00-15:00	43.2	15.6	6.2	27.1	7.9
15:00-16:00	52.4	24.2	0.0	18.7	4.7
16:00-17:00	69.0	10.1	9.2	9.1	2.6
17:00-18:00	57.5	2.9	32.7	5.6	1.3
Average	50.0±2.57	15.2±1.96	10.5±2.57	17.7±3.49	6.7±1.56

The dominant male spent the least daytime hours (6.7%) in performing other activities. Chasing other adult males in the periphery of the group, sniffing, resting under shade, grooming and scratching were more common during dry season than during the wet season. However, comparison of the mean percentage of activities indicate that there is no significant difference in the time spent in the activities between the wet and dry seasons ($p>0.05$). Other activities were least common during the early morning hours and during late afternoon hours but highest towards the end of forenoon (11:00-12:00h). The time spent in performing other activities ranged from 0.7 to 22.9%. During the present survey, the dominant male spent about 82% of the daytime outside its shelter.

3.5.2 Activity patterns of a rock hyrax colony

The mean percentages of rock hyraxes engaged in watching, basking, feeding, inside shelter and "other activities" during the wet season were 15.8 ± 1.54, 22.0 ± 4.51, 31.2 ± 6.27, 28.9 ± 7.13 and 2.1 ± 0.42, respectively. In the dry season, watching, basking, feeding, inside shelter and "other activities" constituted the mean percentages 12.6 ± 1.13, 21.5 ± 3.79, 36.6 ± 7.77, 23.1 ± 5.54 and 6.3 ± 1.45, respectively. There were variations among the various diurnal activities of the colony in the wet and dry seasons. But comparison of the various activities between the wet and dry seasons indicate that there is no significant difference ($p>0.05$) except "other activities" ($p<0.012$). Therefore, the mean percentage of individuals engaged in various activities in wet and dry seasons were lumped together. Data recorded on the diurnal activity pattern of a rock hyrax colony during the study period is given in Figure 8.

The colony members were engaged in feeding related activities more often than other activities. This constituted an average of 33.9 ± 4.91% and ranged from 5.8 to 76%. Rock hyraxes commence feeding early in the morning and reached its peak at 08:00-09:00h. The activity declined gradually since then and diminished during noon (12:00-13:00h). Feeding activity was interrupted by drizzling during the wet season. Average percentage of animals engaged in feeding ranged from 4.9% to 63% during the wet season and up to 84.3% during the dry season. The other frequent activity, next to feeding was remaining inside shelter with a mean percentage of 26 ± 4.46. Seventy four percent of the members of the hyrax colony were seen outside their shelter during the daytime. On average, 14.2% ± 0.99, 21.7% ± 2.88 and 4.2% ± 0.85 of the rock hyraxes were engaged in watching, basking and in other activities, respectively, during the diurnal activity period. The least frequent activity of the rock hyrax colony was "other activities".

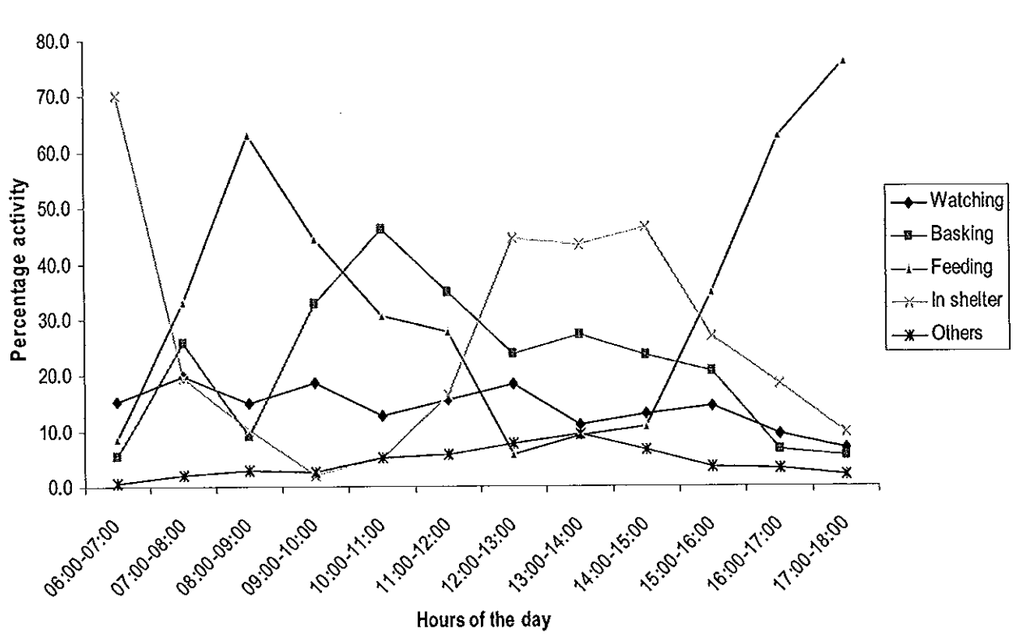

Figure 8. Diurnal activity patterns of a colony of rock hyrax during the study period.

3.6 Feeding habit and habitat utilization

Rock hyraxes were mainly grazers but they were also seen browsing. The most important food plants of rock hyraxes during the study period were grasses such as *Carex*, *Festuca*, *Agrostis*, *Poa* and *Koleria* sp. and *Andropogon abyssinica*. They also consumed mosses grown on surface of rocks. In the wet season, they regularly feed on leaves of *Knophofia foliosa*. They rarely feed on *Arisaema eneaphyllum*. Leaves of *Myrsine africana*, *Juniperus procera*, *Hypericum revolutum*, *Phytolacca dodecandra* and *Euphorbia dumalis* were food of the rock hyraxes more commonly during the dry season. Fallen leaves of *Hagenia abyssinica*, the thorny leaves of *Helichrysium citrispinum* (Figure 9) and *Urtica simensis* that has leaves with stinging hairs were also consumed during the dry season. *Discopodium penninervium*, a medicinal plant, was also eaten by the rock hyraxes (Figure 10). Discussions held with the local elders and farmers have revealed that the rock hyraxes residing around farmlands consume barley seedlings and potatoes during the harvest season.

During the study period, the distribution of rock hyraxes was more or less homogenous. In the wet season, rock hyrax colony was observed foraging in particular foraging ground in the morning and then shift to another area of the same site during the afternoon. This was common in Sites 2 and 3. During the dry season, there was temporary and local migration from grassy, open and drier areas to bushy and areas with source of water within the same site as witnessed in the colonies in sites 2, 3 and 6. Mixing up of individuals among some of the four colonies in Site 3 was also observed during the dry season in the same site.

Figure 9. *Helichrysium citrispinum*, which is thorny, is one of the food items of the rock hyraxes.

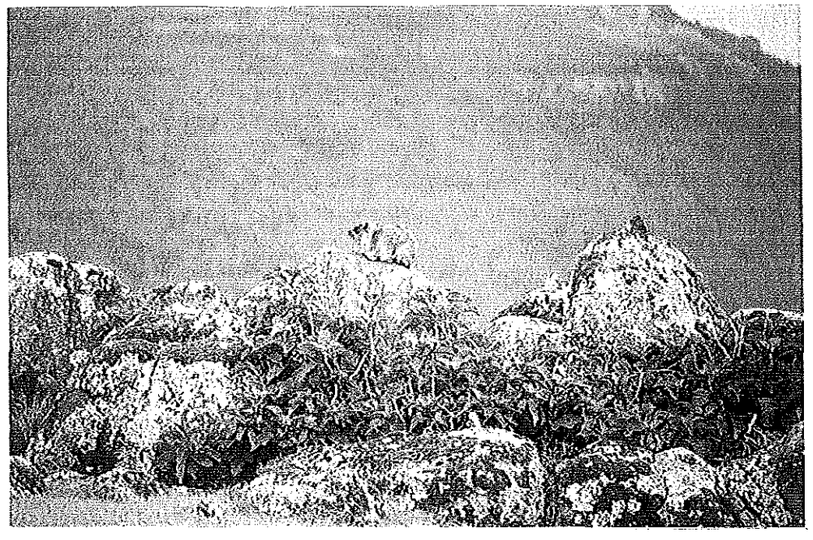

Figure 10. *Discopodium penninervium*, which is a medicinal plant, is also a food item of the rock hyraxes.

As compared to the wet season, rock hyraxes engaged in relatively more time in feeding and also move relatively longer distance away from their shelter for foraging during the dry season. The mean percentage of rock hyraxes engaged in grazing and browsing during the wet and dry seasons were compared. On average, 98.3 ± 0.15 and 92.1 ± 0.8 individuals were engaged in grazing during wet and dry seasons, respectively, and 1.7 ± 0.15 and 7.9 ± 0.8 individuals in browsing during wet and dry seasons, respectively. There was significant difference in the percentage of individuals engaged in grazing ($t = -7.556$, $p = 0.017$) and browsing ($t = 7.556$, $p = 0.017$) in the wet and dry seasons. Seasonal percentage of rock hyraxes engaged in grazing and browsing is given in Figure 11.

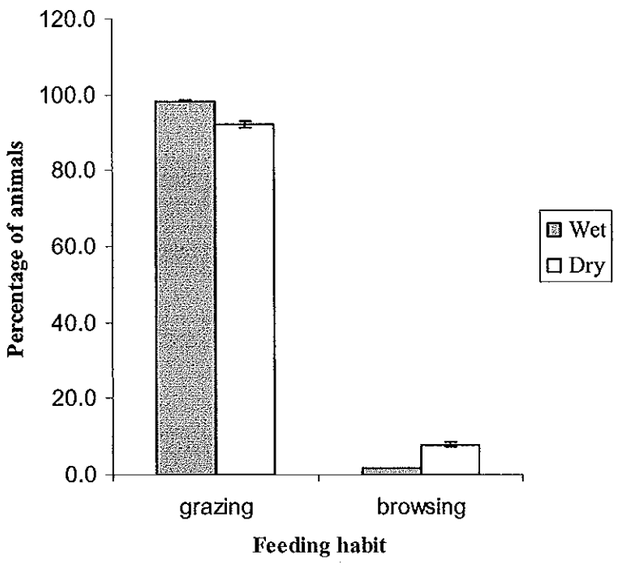

Figure 11. Seasonal difference in the feeding habits of rock hyraxes (Percentage ± SE).

3.7 Assessment of the impact of local people

From personal observations as well as from discussions made with local people and of various agencies during the study period, it was possible to understand attitude of the local people towards the park and its wildlife and threats to the rock hyraxes. From the discussions made with 50 individuals, 36 (72%) of the respondents had good awareness on the Park and the benefit of wildlife conservation. They had also positive attitude towards conservation of the Park and its wildlife. Eleven (22%) of the respondents had no idea about the Park and its wildlife. While three (6%) of them had negative attitude towards wildlife of the Park and its conservation. The following are some of the factors affecting the status of rock hyraxes in the study area.

3.7.1 Habitat destruction

The Dinsho area is inhabited by a large number of human populations. Such high population explosion has resulted in encroachment into the natural habitats of the rock hyraxes. This is highly pronounced in Sites 1, 2, 3 and 6. People use these habitats for grazing (as in Site 1, 2, 3 and 6), agricultural purposes (as in Site 3), cutting trees and collecting fire wood (as in Site 1 and 6), sheltering (as in Site 3) and watering their cattle (as in Site 5). Continuous cutting and burning of shrubs of *Erica arborea* for the purpose of fencing farmland and expanding areas for foraging cattle was common in Site 6 and nearby areas. From personal observations on some whitish crystalline marks and droppings left on natural habitats and communications held with the local people rock hyraxes were wide spread in many areas and also abundant. Due to the increasing human pressure on their natural habitat, rock hyraxes are currently missing from many

of their former ranges, especially from around Site 1 and 3. Presently, these areas are almost fully occupied by settlers and the original natural habitats are being used for different purposes.

3.7.2 Predation

Common jackal and domestic dogs were commonly observed around the shelter of hyraxes and chasing them. Domestic dogs were present around the hyrax shelter in Site 1, 2, 3 and 6 repeatedly coming from nearby settlements. One rock hyrax was killed and eaten by domestic dogs during the study period in Site 2 and other two hyraxes were killed by domestic dogs in Site 3.

3.7.3 Hunting

The BMNP as a whole has few scouts to protect the 2,200 km^2 Park areas. Moreover, only less priority is given for conservation of the rock hyraxes as compared to the antelopes in the area. During the study period, it was a common phenomenon to see rock hyraxes escaped from hunters and having rope on their neck. Locally made rope snare traps were seen repeatedly being placed at entrances of the rock hyrax shelter as in Sites 1, 2 and 3. From discussions held with the local elders, herders and park staff members, it is understood that the local people trap rock hyraxes for medicinal purposes. The local people believe that rock hyraxes are important in treating gastric and asthmatic patients and healing fire burn wounds.

3.7.4 Disturbance

During the study period, it was common to observe people passing through the rock hyraxes habitats. Site 1, 2 and 3 are cases in point. People settling around the hyrax shelter also chase the

hyrax from farmlands with the help of domestic dogs. The local people were also observed disturbing the hyraxes while collecting honey from wild honey bee colonies found around the rock hyrax shelter as has been witnessed in Site 2 and 4. Herders were also observed disturbing the hyraxes by shouting and throwing stone on them.

4. DISCUSSION

4.1 Population size

Effective management measures for conservation of species depend up on accurate records of their distribution and population trend (Newman *et al.*, 2003). For proper management and conservation of rock hyraxes, knowledge about their population status, ecology and behavior are vital. In the present study, average of over 350 rock hyraxes was counted in the six study sites during both the wet and dry seasons.

Relatively large number of rock hyraxes was counted during the wet season than during the dry season, although the difference was not significant. This is primarily due to the birth of young individuals during the wet season. Food was available in plenty during the wet season. They have seasonality in breeding activities and peak birth coincides with the rainy season (Hoeck, 1977, Macdonald, 1985).

The highest count of rock hyraxes was in study Site 3 and the least was in Site 1. The large population count in Site 3 could be due to the presence of enough shelter (rock outcrops) and as this site is situated in an open plain, which is away from forest areas harbouring predators of the hyraxes. Rock hyraxes prefer to live in kopjes found within savanna zones, semi-desert vegetation and mountains avoiding kopjes with in forests (Estes, 1991). In the present study, it is revealed that the rock hyraxes also inhabit in rocky gorges as in Sites 1, 2 and 6. Sites 1, 4, and 5 harbour a relatively less population. This is due to the lack of enough space for sheltering the

hyraxes in Site 1 and high predation pressure in Sites 4 and 5 as the latter are located within and around the thick forests of the Adelay Area.

Long-term observations in Serengeti and in Matobos show that hyrax populations fluctuate highly, and small colonies are prone to extinction (Hoeck, 1989; Barry and Mundy, 1998). On the other hand, increased group size has been shown to effect a more efficient system of predator detection and avoidance because large groups provide more eyes for detecting predators (Barry and Mundy, 2002), which is one of the major advantages of group living animals.

There was significant difference in the rock hyrax counts among some of the Sites. This could be due to the differences in food availability, enough space for shelter and protection and predation pressure. There was no significant difference in the rock hyraxes counts among the study Sites between the wet and dry seasons. This could probably be due to difficulty in counting as the rock hyraxes graze in between the rock outcrops and do not mostly move long distances to graze in the open. They avoid drizzling and spend much time inside shelter during the wet season. This made counting them difficult. They spend most of their daytime either with in the shelter of the kopje or basking on the kopje's flat surfaces (Hoeck *et al.*, 1982; Fourie and Perrin, 1987; Estes, 1991).

4.2 Age structure

The age structure of animal populations gives an understanding about the population growth, status and stability. Age of individuals give an idea about the life span, age at puberty. Age-

specific reproductive potential and a schedule of mortality with age (Steyn and Hanks, 1983). These are important parameters in wildlife management practices.

In the present study, the adults constituted highest proportion of the rock hyrax population, while juveniles occupied the least. When it comes to the discussion on growth ratio, more adults in the population shows less reproductive potentiality and growth, whereas, if juveniles are more, it shows high level of reproduction and better growth rate. Comparatively, large number of juveniles was counted during the wet season. However, the number of juveniles was less in dry season. The least count of juveniles during the dry season is partly due to the growth of the juveniles during the period and transfer to sub-adults. It could also be due to juvenile mortality as a result of physiological stress and predation. Juveniles are highly susceptible to predation in natural populations (Barry and Mundy, 1998, 2002). Further, as the juvenile rock hyraxes do not move far from their shelter and may not have been counted, the number of juveniles may be underestimated in the population count.

Hillman (1986) noted the presence of rock hyraxes in the BMNP commonly in suitable rocky escarpment and estimated to be several thousands in the park area. But, a detailed population census of them has not yet been conducted in the Park area. Hence, at this stage it is difficult to draw general conclusions on the population trend of rock hyraxes in the BMNP in general, and the study sites in particular. But the data revealed on different age structure of the rock hyraxes in the present study might be an indication of the decreasing number of them in the present study sites.

4.3 Sex structure

Identification of sex of rock hyraxes by observing external morphology from a distance is difficult. Hence, sex of most rock hyraxes in the study sites was not confirmed. From the total population size (over 350), the sex of only 157 could be identified, specifically mainly being by trapping. Relatively, more hyraxes were trapped in unbaited than baited sites. This could probably be the sensitive and vigilant behaviour of the hyraxes to alien materials. Asrat Hailu (1987) also obtained similar results while trapping rock hyraxes. Sex ratio disparity was higher in adults than in the sub-adults and juveniles. Sex ratio among juveniles was nearly 1:1. Primary sex ratio in the rock hyraxes is about 1:1, but secondary sex ratio skewed in favor of females, with males suffering from higher rate of mortality. This may be due to the fact that the young males would disperse from the parent colony (Hoeck, 1982; Barry and Mundy, 1998), while juvenile females would remain within the colony, maintaining the family bond (Hoeck *et al.*, 1982; Macdonald, 1985; Fourier and Perrin, 1987; Estes, 1991). Out of the sexed rock hyraxes, males constituted 44.3% while females occupied 55.7%. The smaller population size of males than that of the females might be due to the high juvenile male mortality. High predation pressure on males is also possible as they mostly remain outside the shelter on watching and protecting the colony members, hence they are subjected to predation. In many species of polygynous ungulates, adult males suffer greater mortality than females and this asymmetry has been attributed to costs associated with the evolution of male reproductive competitions (Berger, 1983).

In the present study, it is difficult to give a conclusive sex ratio of the whole rock hyrax population counted in the study sites. This is due to the fact that the sex of most rock hyraxes was

not determined, and secondly, there may be bias towards male or female trapping. However, based on the trapped rock hyraxes the sex ratio was 1:1.26, which is female biased. Female biased populations may have better reproductive potentiality and hence the present sex ratio of the hyrax populations in the Dinsho area is expected to sustain.

4.4 Group size

Rock hyraxes are social animals living in colonies that can number from some to several tens in a given colony. In the present survey, group size of the rock hyraxes ranged from 10-24 individuals. Grouping of the hyraxes in specific age or sex was not evident during the study period. Large group sizes of rock hyraxes were observed in study sites having enough rock outcrops for sheltering them. The habitat in which the shelter is situated also influence the group size of the hyraxes. Group size of 10 and 22 were frequently observed during the study period. Macdonald (1985) also noted that group size of rock hyraxes varies between 2 and 26. Study sites situated in open and less vegetation cover had large groups of rock hyraxes, as in Site 3, than those located at forested areas.

Group size during the wet season was relatively larger than that during the dry season, even though the difference was not significant. The difference could be due to the availability of enough resources such as food and water in the vicinity of the shelter during the wet season, which is scarce during the dry season.

Group size of the rock hyraxes in the study sites was larger during the wet season than during the dry season and it was significantly different. This could be attributed to the large population size and the availability of enough foliage and water around the hyraxes' shelter during the wet

season. Even though splitting of the rock hyrax colony was not common during the study period, it was observed in study Site 3 that some members of a colony split and joined another colony inhabiting in a rock outcrop having water and some vegetation cover during the dry season II. Such partial shifting could be associated with the need for vegetation cover and water. Data on grouping patterns of herbivores may be indicative of the effects of a changing environment (Leuthold and Leuthold, 1975). But this demands longer time of observation to give a conclusive idea on whether such behaviour is common in the rock hyraxes or not.

4.5 Diurnal activity pattern

The present study has revealed that the dominant male rock hyrax and the hyrax colony devoted the daylight hours to perform various activities. The daily activity patterns of wild ungulates play an important role in the animals' energy relations, particularly their feeding, thermoregulation and anti-predatory strategies (Leuthold and Leuthold, 1978).

There were variations among the different activities, both diurnally and seasonally. Such variations were mostly due to differences in environmental factors such as temperature and rainfall, in addition to availability of food. Seasonal and daily activity patterns of animals represent adaptations to variations of environmental conditions such as photoperiod, temperature and precipitation. Activity patterns may also vary with socio-ecological constraints such as competition for food, space and mate, foraging efficiency, predation, resource availability, quality of resources and prey vulnerability. Reproductive status may also affect the activity pattern of individuals at any time (Lariviere and Messier, 1997).

The dominant territorial male spent much of the day time hours in watching (50%). It was the most watchful member of the colony. It comes out from its shelter early in the morning prior to other members and sits on the rock escarpment, watching the surroundings. After sun basking for sometime, it starts feeding. Time spent in feeding was very short (10.5%). The dominant male might probably feed on nutritious food items within such short period of time to maintain its dominance status. While feeding, it grazes or browses very quickly and after taking some bouts, it watches its surrounding and then starts feeding again.

After a while, it returns to its watching site and basks for some time until it enters the shelter during the hot hours of the day or during rainfall. In the afternoon hours, it comes out first from its shelter and watch around for a long duration. Such a time budget of the dominant male for watching could be to protect the colony from predators. Adult rock hyraxes allocate much of their surface activity to being vigilant against vertebrate predators (Barry and Mundy, 2002). It may also prevent the adult females making contact with other adult males attempting to join the group and mate. During the study period, an adult male residing in the peripheral area of the colony in Site 2 tried to join the colony, but chased away by the dominant male. Related females live in a kopje with a territorial male that defends the kopje by chasing, biting, teeth gnashing and by territorial calls in order to have exclusive access to the females who live there in a home range (Fourie and Perrin, 1987; Estes, 1991).

Although there is no significant difference ($p>0.05$), " other activities" were more common during the dry season than during the wet season. This could be due to repeated chasing of the adult males by the dominant male and sniffing adult females around the tail base, more frequently during the dry season II. In Site 3, one adult rock hyrax was observed heavily wounded on its back region. Even though there was no direct observation of mating, repeated sniffing and

chasing of the dominant male might be an indication of the onset of breeding season of the species. The dominant territorial male is particularly aggressive during the breeding season (Sale, 1965; Hoeck *et al.*, 1982). Grooming, scratching and resting under shade were also common during the hot hours of the day and during the dry season. Such repeated grooming and scratching, when the radiation of sun gets stronger could be in response to external parasites which might play an important role in the mortality of hyraxes (Macdonald, 1985).

The members of the rock hyrax colony other than the dominant male start emerging out of their shelter at about 06:15h. Usually adults emerge followed by sub-adults and juveniles. Then they huddle together on the top of rocks in several groups, facing different directions. To avoid confrontations with predators, feeding or huddling hyraxes face slightly away in the pattern of a fan (Estes, 1991). While huddling, all of them watch their surroundings but mostly the adult ones were the most watchful ones. The young ones often climb up on the back of adults and burrow into the fur. Such huddling pattern and body contact may have the function of warming up the body. After sun-rise, they bask on rock surfaces for long durations. This was followed by intensive feeding. Feeding activity was at the peak levels early in the morning and late in the afternoon. In most cases of such active hours of the day, the rock hyraxes were observed feeding in groups, once initiated by an adult. Communal feeding is common in highly sociable animals such as ungulates and has survival advantage especially when foraging at a distance from shelter (Sale, 1965). The rock hyrax colony was observed feeding for longer duration in the afternoon hours than in the morning session, feeding activity till dusk (18:45h) and moving few meters away from their shelter. During this time, the hyraxes including the dominant male were foraging more intensively. Towards the midday, the activities decreased gradually because most hyraxes retired to their shelter probably to avoid the hot sun. The general observation that most wild

ungulates are active in the early mornings and late afternoons with long period of inactivity during the noon (Leuthold, 1977) holds true for the rock hyraxes in Dinsho. There was difference in the number of rock hyraxes engaged in the various activities during the wet and dry seasons. But, except "other activities" the differences were not significant. Feeding activity was minimal in the wet season than in the dry season. This could be attributed to the availability of high quality food during the wet season. Larger number of the colony members remained inside shelter during the wet season than during the dry season. This was primarily due to rainfall, common during the wet season. Rock hyraxes avoid even drizzling. This could be associated with their poor thermoregulatory ability (Olds and Shoshani, 1982; Hoeck, 2003).

"Other activities" were pronounced during the dry season as compared to the wet season. Resting under shade was common in response to strong radiation of sun during the dry season. During the wet season, they were not encountered drinking. But in the dry season, they drink water several times a day. This can be related with the lack of succulent forages during the dry season than during the wet season. Sale (1965) also observed in Mount Kenya that hyraxes drink water during the times they ate plants with less moisture content like tussock grass and lichens.

Grooming and scratching were also relatively common during the dry season although the rock hyraxes also do so during hot hours in the wet season. During the study period, allogrooming was not encountered. Rock hyraxes do not show any sign of allogrooming or caring for their mates. The only social interaction that takes place between rock hyraxes is their huddling and stacking together in order to warm themselves (Fourie and Perrin, 1987).

4.6 Feeding habit and habitat utilization

In the present survey, it was observed that the rock hyraxes depend mainly on grasses. Grasses of the genera such as Andropogon, *Carex*, *Festuca*, *Poa*, and *Agrostis* constituted the main diet, especially during the wet season. The availability of these grasses in the vicinity of the shelter of the hyrax in abundance may be one of the reasons for their choice. Availability of the grasses nearby the shelter might minimize predation risk up on foraging. Rock hyraxes food is mainly grasses and herbs grazed within easy reach of shelter (Kingdon, 1997). A forager should forage more thoroughly and demands a lower minimum harvest rate from patches nearer the central place than farther away, provided both near and far patches are simultaneously present. Many animals must retreat to a refuge, nest, or colony to successfully escape an attacking predator (Kotler *et al.*, 1999). In addition to grasses, the hyraxes consume barley seedlings and potatoes during the harvest season as these resources were available around their shelter. Herbs and leaves of shrubs and some trees including some thorny and medicinal plants and leaves with stinging hairs were also food components of the rock hyraxes. From the results of the present survey, one can explain that rock hyraxes have a wide variety of choice and high adaptation to different foods. *Procavia* feed on any plant, including some that are poisonous to most other animals, such as plants of the families Solanaceae and Euphorbiaceae (Nowak, 1991).

The wide distribution of the rock hyrax and their localized settlement could be associated with such wide variety and great adaptability to various food materials. But with a short period of time it is difficult to give a complete quantitative data on the food habits of the rock hyraxes.

Although the rock hyraxes were seen to graze and browse during the wet and dry seasons, browsing was more frequent in the dry than the wet season. The significant difference between grazing (t= - 7.556, p= 0.017) and browsing (t= 7.556, p= 0.0.17) in the wet and dry seasons and the engagement of more hyraxes in browsing during the dry than the wet season during the study period could probably suggest that rock hyraxes change their feeding habit in accordance with seasonal variations. The more frequent browsing of the hyraxes during the dry season could be associated with the lack of fresh and good quality grasses during the dry season and hence to compensate they have to consume more leaves. Olds and Shoshani (1982) and Fourie and Perrin (1989) have described that the diet of rock hyrax varies in accordance with seasonal vegetation. Rock hyrax is a facultative grazer that switches to browsing in the dry season (Hoeck, 1975; Barry and Mundy, 2002).

The shifting of foraging ground between the morning and afternoon sessions observed in some study sites could probably be associated with the availability of food and to conceal themselves from predators. Temporary and local migration from a grassy and open area in Site 2 and rock escarpment with less vegetation cover in Site 3 to bushy and water available areas witnessed during the dry season was probably to get shade to avoid the striking radiation of the sun during the dry season. It will also help to get drinking water which was lacking in the former area. *Procavia* escape midday heat and desiccation by seeking shade (Estes, 1991).

Rock hyraxes were also observed to move relatively longer distances from their shelter during the dry season than during the wet season to forage. This could be to get more food which was in short supply around the hyraxes' shelter. Similar observation was also made by Sale (1965).

4.7 Impact of the local people

Increased human population in Dinsho area has been adversely affecting wildlife of the area through encroachment into natural habitats and by use of these habitats for different economically important practices. Such increasing human population is encroaching to these habitats at the expense of rock hyraxes and other wildlife of the Dinsho area. Although protected areas are one of the oldest devices of conservation, and remain a corner stone of conservation policy, such areas are continually under threat from growing human populations (Stephens *et al.*, 2001). The extreme northern part of the BMNP is one of the regions of the park with highest concentrations of human population (Woldegebriel Gebrekidan, 1996).

From personal observations and discussions held with different bodies and individuals, habitat of the hyrax is shrinking alarmingly due to the continuous expansion of human activities into the habitats. Rock hyrax habitat has been used for agriculture and grazing. Human persecution by hunting and disturbance is another problem posed on the rock hyraxes. From the discussions held with the local people, although most of them have positive attitude towards the Park and its wildlife, they have less concern about the wildlife of the area, particularly the rock hyrax. In addition to the wild natural predators, domestic and feral dogs coming from nearby settlements and Dinsho town disturb and hunt the hyrax.

Less attention is given by the Park officials to the conservation of the rock hyrax population in Dinsho area as compared to the other wild ungulates.

5. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The present survey provides information on some of the ecological aspects of the rock hyrax (*Procavia capensis* Pallas, 1766) in Dinsho area of BMNP, Ethiopia. It is expected that the data gathered and presented can be used for further detailed studies on the species and for their conservation.

Even though an average of over 350 rock hyraxes were counted in the study sites during the present survey, a conclusive idea on population status and population trend can not be arrived at as detailed and continuous census are required on a long term basis. Out of the total counted population, 40.3% were adults, 34.8% were sub-adults and 24.9% were juveniles. The relatively less number of juveniles in the study sites could probably indicate the dwindling status of the rock hyrax population in this area. On the other hand, out of the sexed rock hyraxes, 55.7% were females. The relatively high number of breeding females (more than 42%) in the sexed hyraxes might show the sustainability of the species.

Rock hyraxes live in stable colony units. They were observed in a mean group size of 26.3 and 23.7 during the wet and dry seasons, respectively. Group size does not differ significantly in the wet and dry seasons. However, rock hyraxes of group size 10 and 22 were frequently seen during the study period. Based on the availability of resources such as water and food, rock hyraxes would undergo temporary and local migrations.

Rock hyraxes were more active during the morning and late afternoon hours. The main activity of the dominant male was watching (50% of the daytime hours) while that of the colony was feeding (33.9%), followed by inside shelter (26%). Various diurnal activities of the rock hyraxes could be influenced by daytime climatic conditions and some ecological factors such as availability of food and water. Except "other activities", activities of the rock hyrax colony were not significantly different during the wet and dry seasons.

They mainly prefer and inhabit rocky outcrops situated in open plains and gorges than "kopjes" in forest regions. The species depend on several species of plants found in the vicinity of the shelter as food materials, including some thorny and medicinal ones. They are mainly grazers. But seasonal changes influence their feeding habit.

Human interactions in the habitat of rock hyraxes in Dinsho area is threatening the existence of them and hence effective conservation measures must be taken to protect them from vanishing from the area.

5.2 RECOMMENDATIONS

Based on the results of the present survey, the following recommendations are suggested:

- To determine the population status and population trend of rock hyraxes, detailed and continuous surveys are to be made covering all habitats of them in the BMNP.

- A long-term study on the behavioural adaptations of the rock hyraxes is necessary for

better understanding of this species and to suggest effective conservation and management programmes.

- Habitat destruction and alteration for agricultural and grazing activities have to be controlled in the habitat of rock hyrax.

- Appropriate awareness programmes involving the local people are to be arranged so as to make them aware of the benefits of conservation of natural habitats and wildlife of the area.

- Few of the local people may be incorporated into the conservation programmes of the rock hyrax for which they should be rewarded with incentives.

- To minimize the overall human effects on the rock hyrax and other wildlife, the BMNP has to be legally gazetted at the earliest opportunity.

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APPENDICES

Appendix 1. Data sheet for recording population census

Name of collector _____

Date _____ Site _____

Name of the place _____ Weather condition _____

No.of Obsn.	Total No. Seen	Adult			Sub - adult			Juvenile			Habitat type	Remark
		M	F	UD	M	F	UD	M	F	UD		

Key:

M - Male
F - Female
UD- Unidentified

Appendix 2. Data sheet for recording diurnal activity pattern of rock hyraxes.

Date _____ Site _____ Focal animal _____

Time of observation	Weather condition	Activity				
		Watching	Basking	Feeding a, Grazing b, Browsing	Inside shelter	Others*

* Grooming, Scratching, Sniffing, Chasing, Resting under shade, Drinking, suckling.

Appendix 3. Questionnaire (points of discussion)

Sex _____ Age_____

Occupation _____

Educational background _____ Date _____

1. How long have you lived in Dinsho? _____

2. What was the condition of the area in earlier times?

_____

3. What changes did you observe in the Dinsho area and rock hyraxes in it?

_____

4. What do you feel regarding the presence of Rock hyraxes in the Dinsho area?

_____

5. What do Rock hyraxes eat? _____

6. Have you faced serious problems because of the presence of Rock hyraxes in this area? If so, how did you overcome these problems?

_____

7. Do people trap Rock hyraxes? If so, for what purpose?

_____

8. Do you want Rock hyraxes to live around?

_____

9. What is your opinion on the Bale Mountains National Park and Wildlife in it?

_____

10. What should be done for the conservation of Rock hyrax and the Park as a whole?

_____