

ADDIS ABABA UNIVERSITY
COLLEGE OF NATURAL SCIENCE
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF ZOOLOGY



The Tree Hyrax (*Dendrohyrax arboreus*): Feeding Behaviour, Activity Patterns and Traditional Medicinal Use in Kafa Zone, Southwest Ethiopia

By: Asrat Aero Mamo

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Zoological Sciences (Ecological and Systematic Zoology)

Advisor: Professor M. Balakrishnan

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*A Thesis Submitted to the School of Graduate Studies of Addis Ababa University in Partial
Fulfillment of the Requirements for the Degree of Master of Science in Zoological Science
(Ecological and Systematic Zoology)*

Approved by the Examining Board

1. Prof. M. Balakrishnan	(Advisor)	_____		_____		_____		_____	
2. Dr. Tilaye Wube	(Examiner)	_____		_____		_____		_____	
3. Dr. Habte Jebessa	(Examiner)	_____		_____		_____		_____	
4. Prof. Abebe Getahun	(Chairperson)	_____		_____		_____		_____	

ABSTRACT

The Tree Hyrax (*Dendrohyrax arboreus*): Feeding Behaviour, Activity Patterns and Traditional Medicinal Use in Kafa Zone, Southwest Ethiopia

Asrat Aero Mamo

Addis Ababa University, 2016

Feeding behaviour, activity pattern and traditional medicinal use of the tree hyrax (*Dendrohyrax arboreus*) were investigated by direct observations and by questionnaire interview method between July – December 2015 in the Kafa Zone, Southwest Ethiopia. Transect method was used to observe feeding behavior and activity patterns and questionnaire interview was used to determine traditional medicinal use of tree hyrax. Tree hyrax shelters and trees with cavities were located. Activities of hyraxes were observed in the morning, midday and afternoon hours. Tree hyraxes showed a bimodal pattern of activity. Feeding was the dominant activity, which occupied 44.98% of day time activity time ($\chi^2 = 33.13$, d.f. = 9, $P < 0.001$). The most important dietary plant species of tree hyrax was *Ipomoea tenuirostris* (Yimbiroo, in the local language of kafegna). Travelling within and between trees occupied 39.68% of the daily time activity. There was difference in the activity levels in the morning, midday and afternoon hours ($\chi^2 = 9.4$, d.f. = 2, $P < 0.001$) of the day. There was no difference in their calling behaviour in relation to season in the study area. The stomach of the tree hyrax is important for local people in traditional medicinal use for cure of deep coughing and for fast growth of children. The local people prepare traditional medicine by drying and powdering stomach parts of tree hyrax and administered orally. The ecological strategy of tree hyrax in terms of slow food intake rate and energy conservation is discussed.

Key words: Activity patterns, *D. arboreus*, Feeding behaviour, Kafa Zone, Medicinal value

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1. Introduction

1.1. Background and Justification

Worldwide, 136 families, 1,135 genera and 4,700 species of mammals are recorded (McGinley and Hagon, 2009) and new species are being recorded during exploration (Larrenchenko *et al.*, 2016). According to Cole *et al.* (1994), 26 Orders of living mammals are found in the world. Among these, 97.5% occupy terrestrial habitats, while the other 2.5% inhabit aquatic environment. Of the world's 4,700 mammal species, a quarter (1,229 species) occurs in Africa (UNEP *et al.*, 2009). Large number of species of mammals including about 960 species and 137 species are found in the sub-Saharan Africa and Madagascar, respectively. The eastern and southern savannahs also contain large number of mammals (Cole *et al.*, 1994).

Ethiopia is stratified into a number of ecological units. The associated diversity in climate and the varieties of ecosystems have rendered the country to have a number of rare, unique and endemic species (Hillman, 1993; EWNHS, 1996). The Great Ethiopian Rift Valley cuts diagonally across the country from the northeast to south creating a vast depression. There is great variation in the altitude ranges from 120 m bsl to 4,620 m asl (Hillman, 1993). These factors strongly influence Ethiopia's extraordinary range of terrestrial and aquatic ecosystems which have contributed to have high diversity and rate of endemism (Tesfaye Awas, 2007).

Ethiopia is known for its topographical and related biological diversity in Africa. Ethiopia comprises the major part of Conservation International's Eastern Afromontane Hotspot (Brooks *et al.*, 2004). Ethiopia is endowed with diverse ecosystems and great varieties of habitats that support the occurrence of diverse fauna, flora and microbial organisms (Yalden, 1983).

The country is also rich in its faunal diversity. Ethiopia has high mammal species diversity (Yalden *et al.*, 1996). It possesses diverse mammalian fauna of over 320 species (Afwork Bekele and Yalden, 2013). In addition to the mammalian species, other fauna of Ethiopia are also highly diversified with 861 species of birds, 201 species of reptiles, 63 species of amphibians and 150 species of fishes (Hillman, 1993). Out of these, 31 species of mammals, 18 species of birds, 10 species of reptiles, 25 species of amphibians and 40 species of fishes are believed to be endemic to the Country (Redeat Habteselassie, 2012; Afework Bekele and Yalden, 2013).

Attention given for conservation and sustainable use of these biodiversity is too little (BIDNTF, 2010). Biodiversity of Ethiopia is under serious threat due to over exploitation, expansion of cultivation and settlements that are accompanied by excessive deforestation, over-grazing and pollution. As a result, distribution range and population of many mammals of the country have dramatically declined in the recent past (BIDNTF, 2010).

Small mammals are important ecological components of all terrestrial ecosystems and they are important indicators of ecosystem health and integrity (Dirzo *et al.*, 2009). However, because of lack of detailed information on most of such mammals in this sub-Saharan Africa, the current status, distribution and ecology of the small mammal species are only little known (Dirzo *et al.*, 2009).

Hyraxes are among the medium-sized mammalian groups thought to have originated from ungulates and are found only in Africa and the Middle East (Olds and Shoshani, 1982). Hyraxes are herbivorous terrestrial mammals, which belong to the order Hyracoidea, with short legs, a rudimentary tail and round ears (Kingdon, 1997). They are the smallest ungulate type mammals, alike in size and appearance to woodchuck (Estes, 1991). They are rabbit-sized animals with long bodies, blunt fingered hands, and feet, large mouthed, deep jawed and with long fur. They have long

tactile hairs on their muzzle, cheeks, throat, brows, rump and limb joints (Kingdon, 1997). They are compact bodied animals having short legs, small and round ears, cleft upper lip, a rudimentary tail and blunt hoofed digits (Olds and Shoshani, 1982; Kingdon, 2004) (Fig. 1).



Figure 1. The tree hyraxes in Kafa Zone, Southwest Ethiopia. (Photo: Asrat Aero, 2015).

Their forefeet have four digits, which are plantigrade, while the hindfeet have only three digits, which are semiplantigrade (Fig. 2). All digits have flat, hoof-like nails, except for the second digit of the hind feet, which have long, curved claws used for grooming and scratching (Vaughan *et al.*, 2000).

Hyraxes are browsing ungulates in Africa. Fossil beds in the Fayum, Egypt, indicate that during the Oligocene (about 40 million years ago), hyraxes of all sizes lived throughout the earth. They were the most important grazing and browsing ungulates ranging in size from that of the contemporary hyraxes (Hoeck, 1978). Before the Miocene (about 25 million years ago), there were 11 genera of hyraxes, which were among the most successful herbivores in Africa. During the Miocene, at the time of the first radiation of bovids, competition with the bovids (antelopes,

bison, sheep, goats and cattle) increased and hyraxes retreated to the more peripheral habitats with rocks and trees; habitats that were not invaded by bovids. Many of the hyraxes that could not find shelter or a specific niche died, and consequently, hyrax diversity was greatly reduced, and now only three genera remain (Hoeck, 2003). Hyraxes, elephants and sea cows (dugongs and manatees) had a common ancestor, during this Miocene, whose population diverged in habitat utilization in order to survive the radiation. This divergence caused new species of animals (hyraxes, elephants, sea cows) to evolve, each of which utilizes a different habitat (Hoeck, 2003). Despite their smaller size and absence of visible tail and trunk, hyraxes are the closest relatives of elephants and manatees. Some morphological similarities such as digits with short rounded nails, lack of a clavicle (collar bone), testicondy (presence of a permanent abdominal testes) (Olds and Shoshani, 1982), absence of a baculum (penis bone), position of teats in females (pectoral and ingunal), the serial arrangement of bones in the head of the astragalus (known as taxepody), similarities in hemoglobin and eye lens proteins among the extant taxa revealed the relationship of hyraxes, elephants and sea cows (Asher *et al.*, 2003; Rasmussen *et al.*, 1990).



(a)

(b)

Figure 2. Limbs of hyrax (a) Forefoot (plantigrade), (b) Hindfoot (semiplantigrade) (Photo: Gebremeskel Teklehaimanot, 2011).

Molecular studies have also shown that the three groups were derived from a common ancestor and were related to each other (Milstrey, 1985). Based on these morphological and molecular evidences, many authorities placed hyraxes in the Superorder Paenungulata (“near ungulates”) with Proboscidea (elephants) and Sirenians or sea cows (dugongs and manatee) (Springer *et al.*, 1997; Pardini *et al.*, 2007). The large size of prehistoric hyraxes can also indicate the fact that modern hyraxes may be the closest terrestrial relatives of the elephant. Together with the elephant shrews, aardvark, tenrecs and golden moles, the Paenungulates make up the group called Afrotheria (literally meaning ‘of African origin mammal’), a mammalian group whose radiation is rooted in Africa (Kleinschmidt *et al.*, 1986; Prinsloo, 1993; Prothero, 1993). Afrotheria are of African origin although some species have subsequently dispersed beyond Africa (e.g. Asian elephants and three species of sea cows) (Tabuce *et al.*, 2008).

There is only one extant family within Order *Hyracoidea* which is *Procaviidae*, distributed only in Africa and the Middle East with the following three recognized genera; the rock hyrax, *Procavia capensis*, the yellow spotted rock hyrax, *Heterohyrax brucei* and the tree hyrax, *Dendrohyrax arboreus* (Olds and Shoshani, 1982). Many of these hyraxes that could not find shelter or a specific niche died, and consequently, hyraxes diversity were greatly reduced and are considered highly endangered (Hoeck, 2003).

There are two species of rock hyraxes in Ethiopia *Procavia habessinica* and *Heterohyrax brucei*. The former is the larger of the two; its taxonomic position is at present confused (Corbet, 1979). Ashford (1977) considered that it includes more than one species. The genus *Heterohyrax* contains only one extant species, *H. brucei*, with 25 subspecies (Olds and Shoshani, 1982). The genus *Heterohyrax* was first described by Gray in 1868 using the yellow spotted hyraxes from central Ethiopia. There was a taxonomic confusion due to the association of the name yellow

spotted hyraxes only to *Heterohyrax* species. The yellow spotted *P. capensis* (*P. c. syriacus* and others) were grouped as *Heterohyrax* until separated yellow spotted hyraxes as yellow spotted dassie (*P.c. syriacus* in Lebanon, Isreal and Syria) and yellow spotted *H. brucei* for any *Heterohyrax* in Africa (Olds and Shoshani, 1982). *Heterohyrax brucei thomasi* is found in Ethiopia (Kaffa, Gimirra and Omo Basin in South and Southwest Ethiopia). *Hetrohyrax brucei rudolfi* is found in Borena (southern Ethiopia), *H. b. princes* in North of Abaya Lake (central Ethiopia) and *H. b. somalicus* in southeastern Ethiopia (Olds and Shoshani, 1982). The *H. b. pumilus* found in Somaliland may also occur in Ethiopia (Olds and Shoshani, 1982).

In Ethiopia, *Procavia* and *Heterohyrax* live in rock outcrops, piles of boulders and fractured cliff faces (Ashford *et al.*, 1973; Gebremeskel Teklehaimanot, 2015). *Heterohyrax brucei* also live in hollow *Ficus* and *Acacia* trees in different parts of Ethiopia. *Heterohyrax brucei* is found in the South, East and northeast Africa, *H. antinae* in Hoggar Massif (Algeria) and *H. chapini* in the mouth of the River Zaire (Kingdon, 2004). Other species, the western tree hyrax (*D. dorsalis*) is found in the West and central Africa and the eastern tree hyrax (*D. validus*) is distributed in the eastern African mountains, islands and coasts (Kundaeli, 1976; Kingdon, 2004). The tree hyrax inhabits mainly forest areas across mid-Africa extending from the eastern to the western coast. The biogeographic region of *D. arboreus* has not been described in Ethiopia and may be native in the country (Gaylard and Kerley, 1997).

1.2. Review of Literature

1.2.1. Body Characteristics

There are three species of tree hyraxes of the genus *Dendrohyrax*. These are Southern tree hyrax (*Dendrohyrax arboreus*), Western tree hyrax (*Dendrohyrax dorsalis*) and Eastern tree hyrax (*Dendrohyrax validus*) found in different parts of Africa (Kingdon, 1971). *Dendrohyrax arboreus* has long and soft fur; white spot absent under chin; nose covered with hair; dorsal spot creamy-white; naked patch in dorsal spots 23 to 30 mm long; one pair of inguinal mammae (infrequently a pectoral and an inguinal pair or a pectoral and two inguinal pairs); skull with postorbital bar eight complete or with narrow gap; basal length of skull 78.2 to 92.3 mm and mean length of upper diastema 15.8 mm in males and 15.2 in females (Gaylard and Kerley, 1997). *Dendrohyrax dorsalis* have short and coarse fur; white under chin present; nose hair naked; dorsal spot yellowish-white, conspicuous; naked patch in dorsal spots 42 to 72 mm long; one pair of inguinal mammae; skull with postorbital bar complete; basal length of skull 96.0 to 117.0 mm and mean of length of upper diastema 18.6 mm in males and 16.9 in females (Kundaeli, 1976). *Dendrohyrax validus* have thick and soft fur with gray-brown to black; dorsal spot yellow to russet-brown; naked patch in dorsal spot 20 to 40 mm long; one pair of inguinal mammae; skull with postorbital bar complete; basal length of skull 77.9 to 98.3 mm and mean length of upper diastema 15.2 mm in males and 16.1 in females (Jones, 1978).

Dendrohyrax arboreus was authorized by Smith in the 1827. The following four subspecies of tree hyraxes are recognized; *D. a. stuhlmanni*, *D. a. crawshayi*, *D. a. ruwenzorii* and *D. a. aldi-friederici* (Kingdon, 1971; Milner and Harris, 1999a).

1.2.2. Distribution and Habitat

Before the Miocene, hyraxes of all sizes were common and widely distributed in different continents (Hoeck, 2003). At present, they are restricted to Africa and the Middle East and found throughout the sub-Saharan and north-eastern Africa, discontinuously distributed from Senegal and southern Mauritania through southern Algeria, Libya and Egypt (east of the River Nile) to the central and southern Africa (excluding the Congo Basin forest and Madagascar). Hyraxes are endemic to Africa with the exception of bush hyrax found in Sinai and the rock hyrax in Lebanon to Saudi Arabia. Its range extends southward from Kenya and Uganda to South Africa and from eastern portions of Ethiopia to Democratic Republic of Congo and Zambia in the west to the eastern coast of the continent (Smithers, 1966; Kingdon, 1971). Tree hyraxes inhabit ranges from alpine, montane, highland, lowland, and riverine forests and from sea level to the alpine zone of Mt. Kenya (3200 – 4300 m) (Kingdon, 1971; Young and Evans, 1993). The eastern tree hyrax might be the earliest type of forest-living tree hyrax, a member of the primitive fauna of the islands of Zanzibar and Pemba in East Africa (Jones, 1978). As their name implies, they are typically associated with tree cavities, base of tree trunks that provide them shelter. Living in the cavity of trees help them avoid predators (Sale, 1966). The western tree hyrax is found in the West and Central Africa (Hoeck, 2001; Sale, 1966).

Tree hyrax spent the daytime on the trunk of trees around the shelter (Rudnai, 1984). They make use of cavity bearing trees because of their stable microclimate (Milner and Harris, 1999a) (Fig. 3). Climate and the availability of shelter were important factors limiting the distribution of hyrax population (Hoeck, 2001). Feeding is often in concentrated periods during the day, limiting their exposure to predators such as snakes, feral dogs, humans, eagles, hawks, leopards and jackals (Milner and Harris, 1999b; Hoeck, 2001).



(a)

(b)

Figure 3. Tree hyrax at Kafa Zone, Southwest Ethiopia (a) During sun bathing, (b) shelter of tree hyraxes (Photo: Asrat Aero, August, 2015).

Dendrohyrax arboreus is the only species of tree hyrax occurring in the southern African subregion (Skinner and Smithers, 1990). This species is also found in Ethiopia and may be a native. In South Africa, it inhabits the indigenous forests of southern KwaZulu-Natal and the Eastern Cape, (Milner and Harris, 1999a). It may be found in hollow trees or in dense foliage by day, and is an inefficient climber, as it has no specific morphological adaptations for arboreal life (Kingdon, 1971).

1.2.3. Behaviour

Tree hyraxes are active during the daylight hours (Milner and Harris, 1999a). Milner and Harris (1999a) were unable to determine the mating system but speculated that it may be facultative monogamy or polygyny. Female hyraxes give birth to up to four young after a gestation period of 7–8 months, depending on the species (Myers, 2000). At birth they are well developed and

weigh approximately 380 g. Young are weaned at 3–5 months, and reach sexual maturity by 16–17 months (Milner and Harris, 1999b). Arboreal hyraxes tend to be solitary, while those dwelling in rock outcrops tend to live in colonies (Myers, 2000). There are some exceptions of tree hyraxes where they live in small family groups (Kingdon, 1971). Hyraxes living in small family groups are dominated by a single male, who aggressively defends the territory from rivals. Where there is enough living space, the male may dominate multiple groups of females, each with their own range (Milner and Harris, 1999b). The remaining males lead solitary lives, often on the periphery of areas controlled by the dominant male, and mate only with younger females (Hoeck, 2001). The territorial male defends with chasing, biting, teeth gnashing and territorial calls in order to have exclusive access to the females. Females are usually philopatric and may associate with each other indefinitely (Hoeck, 1982).

Vocalization is a very important method of communication among tree hyraxes. They produce loud and distinct calls, characterized by long cries, at gradually increasing amplitude and intervals, reaching a loud crescendo at the end of calls (Lawes *et al.*, 2000). Tree hyraxes call throughout the daytime, but with marked peaks during evening and early morning hours corresponding with the activity patterns (Kingdon, 1971). They are also heard to call during the day, when disturbed. *Dendrohyrax arboreus* has a prominent scent-gland on the dorsal body, which may be used in marking territory, and in communication. The large latrines under their trees that they occupy clearly demarcate use of a home range (Milner and Harris, 1999b). As with the rock hyrax, tree hyraxes make use of latrines, which provide useful clues as to their whereabouts and is dominant individuals use latrines, defecating repeatedly at the bases of trees (Rudnai, 1984). Latrines are identified by piles of faeces found at the base on the ground, in the cavity of tree or in the hollows of a well-used tree (Kingdon, 1971) (Fig. 4).



Figure 4. Faeces of tree hyrax in the cavity of a tree at Kafa Zone, Southwest Ethiopia (Photo: Asrat Aero, August, 2015).

1.2.4. Ecological Importance

As part of the food chain, hyraxes consume parts of many trees, shrubs and grasses, and occasionally insects, while, they are being consumed by several predators such as feral dog, caracals, human, eagle and snake species (Hoeck, 2001). Hyraxes have been hunted by man for meat and fur, and their crystallized excrement has been used by African tribes to treat various illnesses (epilepsy, hysteria, convulsions) and as vitamin supplements (Hoeck, 2001). It is possible that *D. arboreus* may be a minor nuisance to farmers. There is also some chance that this species is a vector of some of the parasites capable of infecting humans (Myers, 2000). Hyraxes are known to harbor leishmaniasis causing parasites (Hoeck, 2001). In rituals, hyraxes also played a role. Some clans traditionally bless their newborn babies by wrapping them in

hyrax skin to ensure good health. Hyraxes are also regarded as an omen (Gaylard and Kerley, 1997).

1.2.5. Threats

Populations of tree hyraxes are regulated by predation, intra-specific competition, immigration, territorial fighting and dispersal (Hoeck, 1982). Hyraxes are subjected to threats of various avian and mammalian predators (Gebremeskel Teklehaimanot, 2015).

The most important avian predator of rock and bush hyraxes in certain parts of Africa is the eagle (*Aquila verreauxii*), which feeds almost exclusively on hyraxes (Milners and Harris, 1999b; Hoeck, 2001; Gebremeskel Teklehaimanot, 2015). This eagle preys on hyraxes despite low availability. Other predators are martial and tawny eagle, leopard, lion, jackal, spotted hyena and several snake species. In South Africa, the caracal is the second most important predator of hyrax, which can comprise more than 50% of its food (Hoeck, 2001).

Humans are also known to eat *D. arboreus* (Milners and Harris, 1999b). In the forest belt around Mt. Kilimanjaro, the eastern tree hyrax is heavily hunted for its skin (Gaylard and Kerley, 1997).

Other threats to tree hyraxes are forest loss, degradation, fragmentation (mainly due to logging and burning), and hunting. Hunting occurs in all areas where it is found apart from the most protected and remote forests. Many forest patches are too small to maintain viable populations of tree hyraxes (Lawes *et al.*, 2000). Although individual tree hyrax persist in closed-canopy forests logging, including selective logging of large trees, removes shelter trees, destroys arboreal pathways and makes the animals more vulnerable and prone to ground trapping (Kundaeli 1976).

External parasites such as ticks, lice, mites and fleas, and internal parasites such as nematodes, cestodes and anthrax play a role in hyrax mortality. In West Africa, tree hyraxes have nematode parasites such as *Crossophorus collaris*, *Libyostrogylus alberti*, *Hoplodontophorus flagellum* and *Theileriana brachylaima* (Kingdon, 1971).

Dendrohyrax arboreus populations have declined due habitat fragmentation and predation problems (Milner and Harris, 1999a). In fact, there have been recent studies documenting the habitat needs of *D. arboreus* in South Africa to curb its decline (Gaylard and Kerley, 1997; Lawes *et al.*, 2000). This species is listed as Least Concern in the IUCN's Red List of Threatened Species (IUCN, 2008) presumed to have large populations and local abundance. However, new molecular analysis of tree hyraxes shows that area of occupancy may be as low as 3,078 km² in the Eastern Arc mountain and coastal forest of Tanzania, viable habitat is severely fragmented and a population decline is inferred over the last 1–2 decades, due to hunting and habitat loss, degradation and fragmentation across a large portion of its area of occupancy. They are only locally abundant in small numbers of well protected sites, but sufficient data to quantify population size are currently unavailable (Smithers, 1986).

1.2.5. Traditional Medicinal Use

Traditional medicinal practice in Ethiopia is characterized by historical developments related to prolonged immigration from the southern Arabian Peninsula, the influence of Green culture, and the introduction of Christianity and Islam (Zein and Kloos, 2008). Ethiopian traditional medicinal practice is with ethnobotanical findings. The majority of the harvested medicinal plants were wild, which were reported in Bench ethnic group in Benchi Maji Zone, Southwest Ethiopia (Giday Mamo *et al.*, 2009). There are widespread systems of traditional and

complementary medicinal practices, which include Ayurvedic medicine in South Asia, especially in India (Unnikrishnan, 1998).

Many cultures employ traditional medicine incorporating animal-derived remedies (Ceriaco, 2012). Probably the most famous of these is the Chinese, who use animal products, to treat a variety of ailments. Although less known and less frequently studied, both Latin America and Africa have a long tradition of using their varied and rich fauna, including many endangered species, to treat various ailments. In traditional Chinese medicine, more than 1500 animal species have been recorded to have some medicinal use (Alves and Alves, 2011). In India, nearly 15–20% of Ayurvedic medicine is based on animal-derived substances (Unnikrishnan, 1998). In Latin America, at least 584 animal species have been used in traditional medicine (Alves and Alves, 2011). Zootherapeutic practices are also found in Europe (Quave *et al.*, 2010; Voultziadou, 2010; Ceriaco, 2012).

The three striped palm squirrel, *Funambulus palmarum* is being used as a traditional remedy for general poisoning by indigenous people in the Western Ghats of South India (Padmanabhan and Sajan, 2006). Similar practice of use of tree hyrax as traditional medicine in Nigeria and South Africa have been reported (Simelane and Kerley, 1998; Ngwenya, 2001).

In Ethiopia, the use of traditional medicine has a long history, and most of the rural people are well acquainted with this practice (Dereje Woldeyehanis and Messert Chane, 2014). Kore people use some bird species as traditional medicine in the Southern Nations Nationalities and Peoples Regional State (SNNPRS) of Ethiopia. Most of the medicinal animal species used by the Kore people are also serve as a source of food since ancient times, and hence local people are well acquainted with mammals than birds or reptiles in this region (Dereje Woldeyehanis and Messert

Chane, 2014). However, only little information is available on tree hyraxes in Ethiopia (Yirga Gidey, 2010). Like other animals, medicinal animal population share threats caused by habitat alteration, loss and fragmentation (Anvinam, 1995). Populations of hyraxes are reduced as a result of human activities including habitat degradation, hunting and killing for different purposes, such as medicine, food, skin and ritual (Rafai *et al.*, 2000; Topp-Jørgensen *et al.*, 2008). Besides, a given species of medicinal importance could also be exploited for another purpose, such as for food, cloth or ornament (Bennett *et al.*, 2002).

1.3. Justification of the study

The tree hyraxes have not been studied in Ethiopia. Their ecology is poorly understood in most parts of African. Most of the published information is from anecdotal accounts, although the distribution and factors controlling the population size of *D. validus* have been investigated in Mountain Kilimanjaro (Kundaeli, 1976) and resource selection has been studied using indirect methods such as radio-tracking in a population of *D. arboreus* in South Africa (Gaylard and Kerley, 1997).

From the limited information available, it is evident that the ecology of tree hyrax differs considerably from that of the closely related and better studied rock hyrax of the genera *Procavia* and *Heterohyrax* (Hoeck, 1982; Sale, 1965a). In contrast to the social and predominantly grazing rock hyrax of arid savannah areas, tree hyraxes are forest-dwelling, solitary, arboreal, folivorous and highly cryptic (Bothma, 1971; Kingdon, 1971; Jones, 1978). Daily activity patterns of tree hyraxes have been studied in captivity in Kenya (Rudnai, 1984). In addition, there are few anecdotal reports on aspects of vocalization, behaviour, territory size and breeding patterns of tree hyrax (Richard, 1964; Rahm, 1969; Kingdon, 1971).

There is no study on the feeding behaviour and activity patterns of the tree hyrax in Ethiopia. There is no quantitative and qualitative data available on the tree hyrax in Kafa, Southwest Ethiopia. Also no information is available on the traditional medicinal use of tree hyrax in Ethiopia. A lot of work has been done on ethnobotany and traditional medicine in the country, while information on ethnozoology is limited. It was in this context that the present research was initiated. Thus, the present study on the tree hyrax was made to address issues related to feeding behavior, activity patterns and the medicinal use tree hyrax by local people in Kafa Zone, Southwest Ethiopia.

1.4. Objectives of the Study

1.4.1. General Objective

The general objective of this study was to study feeding behaviour and activity patterns of tree hyrax (*Dendrohyrax arboreus*) and the traditional medicinal use in the Kafa Zone, Southwest Ethiopia.

1.4.2. Specific Objectives

- ◆ To study the feeding and foraging behavior of tree hyrax in Kafa Zone, Southwest Ethiopia.
- ◆ To study the activity patterns of tree hyrax in their habitat in Kafa Zone.
- ◆ To study traditional medicinal use of tree hyrax in the study area.

2. The Study Area and Methods

2.1. Location of the Study Area

The present study was carried out in the Kafa Zone, Southern Nations Nationalities and Peoples Regional State (SNNPRS) of Ethiopia located at a distance of 350 km from Addis Ababa to Jimma. Bonga, the capital city of Kafa is situated at 449 km Southwest of Addis Ababa. The study area was located between $7^{\circ}13'30''$ to $7^{\circ}19'30''$ N latitude and $36^{\circ} 9'00''$ to $36^{\circ} 18'00''$ E longitude (Fig. 5). Altitude ranges from 500 – 3500 m asl within the study area. Kafa is bounded by Oromiya Region on the northwest, north and northeast; Dawro Zone on the east and southeast; Benchi Maji Zone on the southwest and Sheka Zone on the west. Data for 2012–2015 were obtained from the National Meteorological Station located at Bonga.

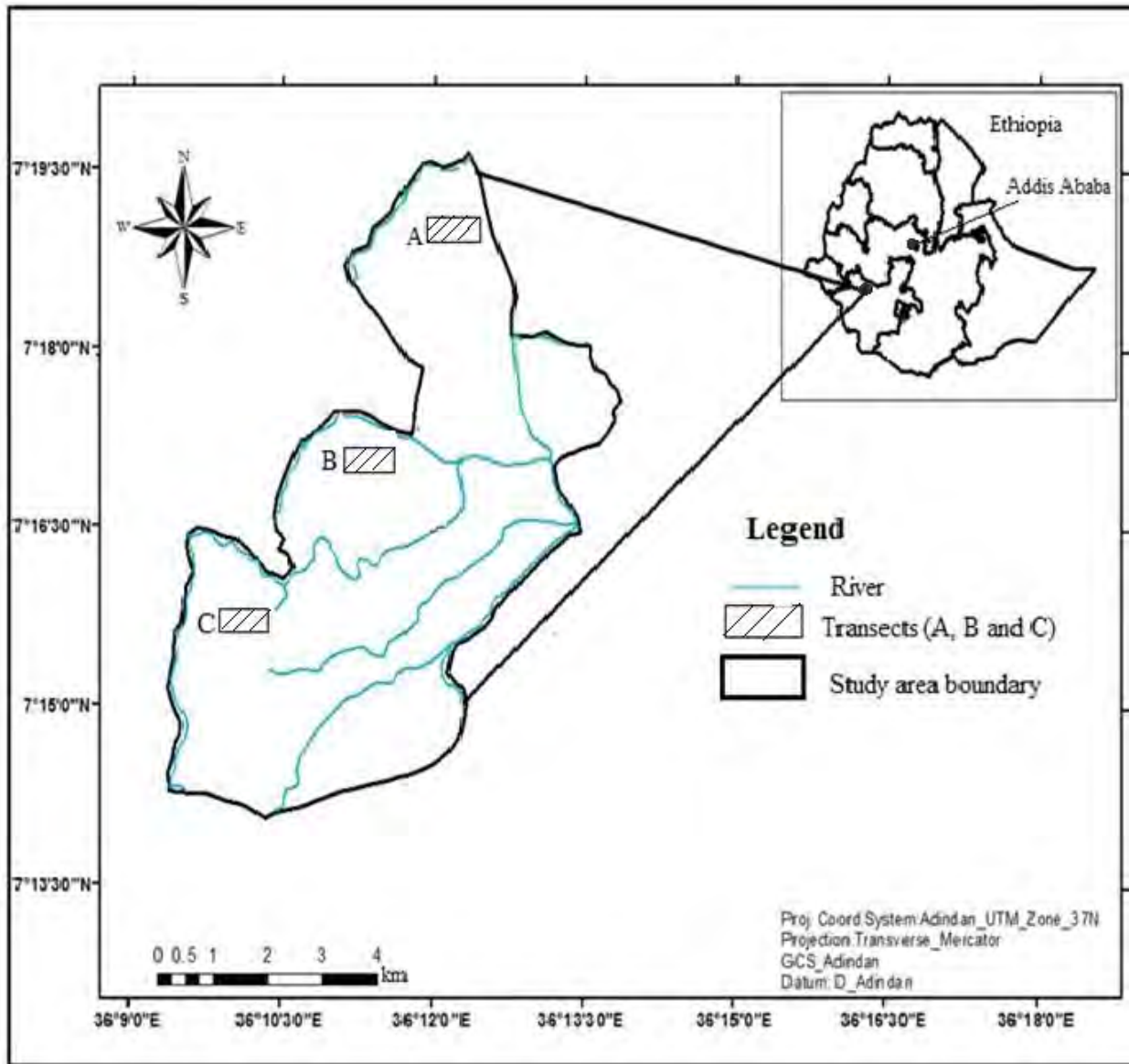


Figure 5. Map of the study area.

2.2. Climate

Kafa has conventional climatic zones based on altitude and temperature governed by the Inter-Tropical Convergence Zone (ITCZ), the humid southwestern monsoon and the dry northeastern trade winds. Intensities and frequencies of rain are highly variable throughout the Kafa Zone depending on altitude (Liljequist, 1986). The nearest station of the National Meteorological Agency is located at Bonga, from where climatic data were collected.

The study area is humid and has a warm tropical climate according to the Koeppen classification of climate (Liljequist, 1986). The mean monthly temperature at Kafa is 19.2 °C with a mean monthly minimum of 11.9 °C and a mean monthly maximum of 26.4 °C (Fig. 6). The coolest months are July and August, while the hottest months are January and February.

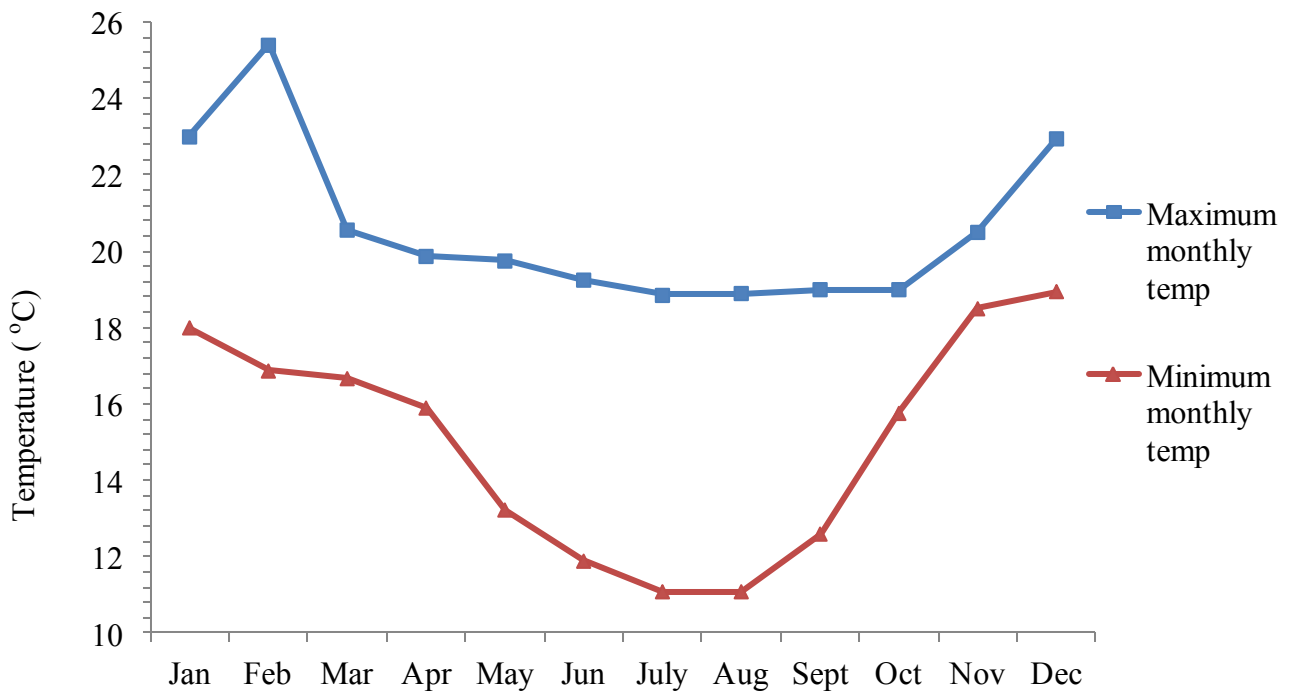


Figure 6. Maximum and minimum temperatures (°C) (mean for 2012–2015) at Kafa Zone, Southwest Ethiopia (Source: National Meteorological Service Agency located at Bonga).

The Kafa highlands are parts of the southwest Ethiopian highlands, which receive the highest amount of rainfall in Ethiopia (Liljequist, 1986). This is attributable to the presence of the afro-montane forest cover on top of the windward location to the moist monsoon winds. In the study area rainfall is bi-modal pattern where largest amount of rainfall occurs between May and September.

The mean monthly rainfall is 170 mm with high variations from year to year (120 – 250 mm) (Fig. 7).

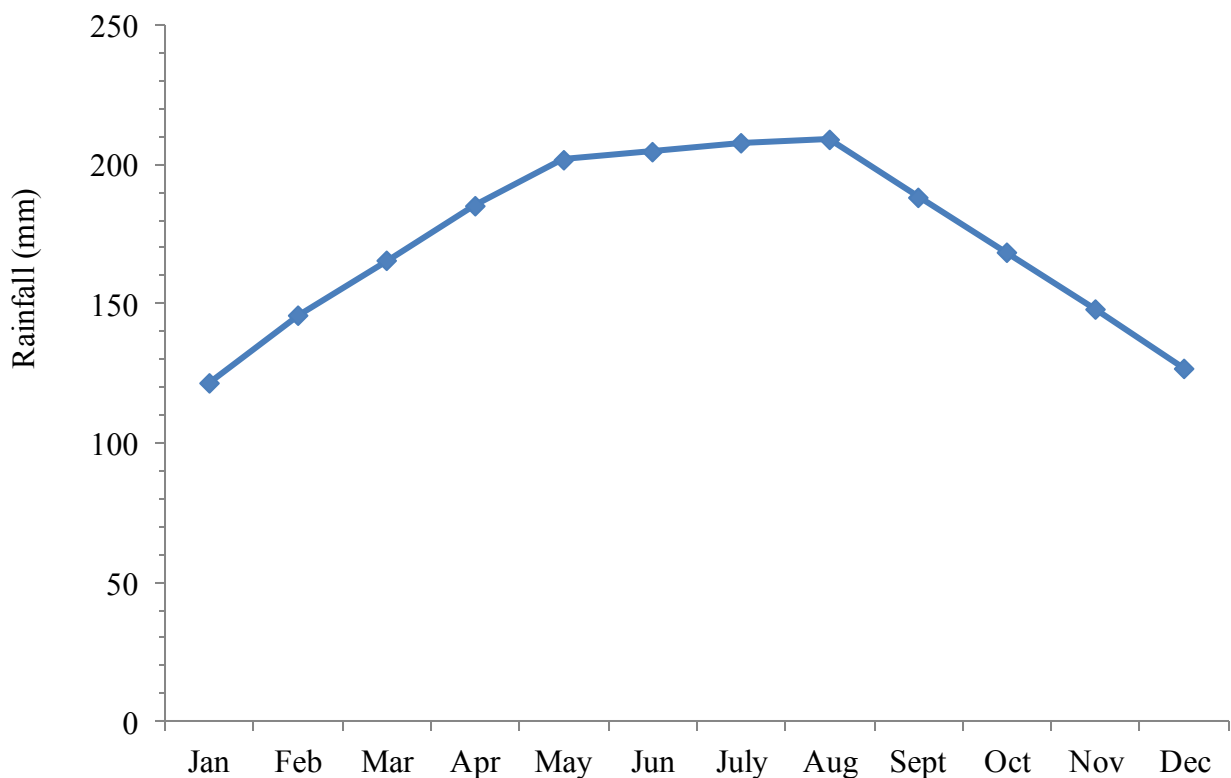


Figure 7. Monthly rainfall (mm) distribution (mean for 2012–2015) at Kafa Zone, Southwest Ethiopia (1,725m asl) (Source: Ethiopian Meteorological Service Agency, Bonga).

2.3. Vegetation Types

Kafa Zone has the following four major vegetation types: savanna grassland with scattered trees, woodland, riverine forest and afro-montane forest.

2.3.1. Savanna grassland

Savanna grassland with scattered trees covers a small part of the study area. Savanna is a mixed woodland and grassland ecosystem characterised by sufficiently widely spaced trees so that the canopy does not close (Schmitt, 2006). The open canopy allows sufficient light to reach the ground to support an unbroken herbaceous layer consisting primarily of grasses. Savannas maintain an open canopy despite a high tree density. It is often believed that savannas feature widely spaced, scattered trees (Friis *et al.*, 1982). The grass is usually tall up to 3 m, and the dominant grass species vary locally. *Panicum monticola* and the elephant grass (*Pennisetum* sp.) are common in the area. The tree species are predominantly deciduous, which are not more than 6 m height. The dominant tree species is *Combretum paniculatum* in association with *Terminalia albiza* (Schmitt, 2006).

2.3.2. Woodland

Woodland consists of areas of scattered trees than forests. Woodlands are the result of the fragmentation and clearing of forests to promote grass growth for grazing and firewood harvest (Friis *et al.*, 1982). There are different types of woodland habitats dominated by mixed species. Woodlands occur in the southern part, dominated by *Combretum paniculatum* in areas of altitude < 1100m. This type of woodland is a classic habitat with an even distribution of trees of uniform canopy and with no under story of bushes or shrubs, but typically with a well-developed grass cover (Friis, 1992).

2.3.3. Riverine Forest

One of the distinct vegetation types in the study area is the riverine forest. This is found on the lower flood plains along the rivers edges (White, 1981). Riverine forest is a type of ecosystem most found along waterways (Schmitt, 2006). Most tree species found in this habitat are; *Ficus sycomorus*, *Acacia polycantha*, *Celtis africana* and *Mimosops kummel*. These trees are able to tolerate flooding. They are distinguishable by their thick, larger and pointed leaves. Leaves of these trees have a distinct drip tip. The trees provide shelter for the many native species of fauna (Teketay Demel and Bekele Taye, 2002).

2.3.4. Afromontane Forest

White (1978) defined Afromontane vegetation as the vegetation of the lower slopes of the highest mountains and the upper slopes of the lesser mountains in tropical Africa that is totally different from the surrounding lowlands. Afromontane forest habitats are dominated by trees characterized by the crown cover (Friis, 1992). Although many Afromontane species are local endemics, the majorities, and especially the dominant species, are widely distributed within the Afromontane region (White, 1981).

Afromontane forest ecosystem of Kafa Zone is represented by characteristic species including *Phoenix reclinata*, *Podocarpus falcatus*, *Pouteria adolfi-friederici*, *Scheffleria abyssinica*, *Olea capensis*, *Prunus africana*, *Albizia schimperiana*, *Cordia africana*, *Ficus vasta*, *Millefria ferruginea*, *Wahlenbergia capensis*, *Ficus thonningi*, *Ilex mitis* and *Macaranga capensis* (Schmitt, 2006) (Fig. 8). *Olea welwitschii* is exceptional because this species is abundant in the canopy of natural forest, but regeneration seems to require forest gaps (Friis, 1992). Regarding occasional species such as *Pouteria adolfi-friederici*, *Sapium ellipticum*, *Polyscias fulva*, and *Prunus africana*, skewed population structures and relatively low abundances could be related to human impacts; or to natural gap dynamics. This vegetation type includes the largest and commercially

most important trees found in the Kafa Zone. The understory contains coffee (*Coffea arabica*), some of which are known to be wild populations (Teketay Demel and Bekele Taye, 2002).

Kafa Zone forests were dominated by afro-montane rainforest (Friis, 1992). The Kafa Zone contains large afro-montane forests in Ethiopia, and it is the center of origin and genetic diversity of *C. arabica* (Schmitt, 2006). Kafa Biosphere Reserve is one of the first two biosphere reserves established in Ethiopia, and aims to protect the natural environment and foster sustainable development in the region. The Kafa Biosphere is the birthplace of wild Arabic coffee and contains close to 5,000 wild varieties of the plant species in this biodiversity hotspot (Teketay Demel and Bekele Taye, 2002). Today, less than 3 percent remains forest, most of which is located in this region and includes large areas of mountainous afro-montane cloud forest. Afro-montane evergreen forest ecosystems contain the endemic and critically endangered wild *Coffea arabica* L. (Rubiaceae) (Schmitt, 2006). The afro-montane forests in the Biosphere Reserve are among the diverse ecosystems in Ethiopia with high numbers of endemic species and high floristic diversity (Schmitt, 2006).



Figure 8. Forest habitat in the study area at Kafa Zone, Southwest Ethiopia (Photo: Asrat Aero, 2015).

2.4. Materials and Methods

2.4.1. Preliminary Survey

Before starting the main research work, a preliminary survey was conducted in the study area during the last week of July, 2015 and relevant information about the study area (climatic condition, topography and approximate size of the area) were gathered. The location for detailed observations was also selected during this period.

2.4.2. Detailed Study

Data collection was conducted during July 2015 – October 2016, which is the wet season. Tree hyraxes were observed when they were active in the daytime and their behavioural activities were recorded. The sexes of individuals were difficult to identify due to their secretiveness and shyness. In addition, juveniles were spending most of the time in the hole or crevices and hence it was difficult to observe their activities. The individual activities of tree hyraxes were observed when moving around the home ranges, without making any disturbances. Representative sites were established randomly in the forest based upon possible access of shelters and trees with cavities. Three observation sites were selected and coded as A, B and C (Fig. 5).

In the study area, three transects, each of 140 paces long (roughly 100m) were established in areas where tree hyraxes were located. Data were collected during morning hours (07:30 – 11:30h), midday hours (11:40 – 13:40h) and afternoon hours (15:30 – 17:30h).

Feeding behaviour and activity patterns were scanned for four weeks each during wet and dry seasons, following focal animal sampling method (Altmann, 1974). In scan sampling, 10 minute unit observations were made for a maximum of 3 h/day at study site. In the study area, total of

168 hours of observations were made in 56 days including wet and dry seasons. Hyraxes involved in different activities were recorded during scan sampling. Activities such as feeding, moving, fighting and vocalizing were recorded in the morning, midday and afternoon hours.

At every transition between behaviors, the time and activity were recorded. During periods of feeding, plant species, parts and the number of bites of each of these items eaten were recorded (Litvaitis *et al.*, 1994). Bite counts are useful for identifying principal food items and the approximate proportion of each in the diet (Wallmo *et al.*, 1973). It was usually possible to identify forbs eaten.

A feeding bout was considered as the duration of continuous handling or eating one of the food items. Periods of feeding activity consisted of a number of bouts. Handling time was taken as the length of time taken to detach, chew and swallow an item. Samples of the identified food items were collected, pressed and taken to the National Herbarium, Addis Ababa University, Ethiopia, for identification using herbarium collections.

Tree hyraxes are particularly renowned for their loud diurnal screaming (Rahm, 1969), called loud calls. Whenever heard, the starting time, duration and intensity (scored subjectively as low, medium or high) were recorded. Other vocalizations when heard, the time, the individual responsible and any responses heard were recorded. The interaction of fights was also recorded as low, medium or high.

Sixty local people in the community around the study area were randomly selected and interviewed to find out the traditional medicinal uses of tree hyraxes. The local people were asked based on the age groups, but as women were not engaged in hunting of the tree hyraxes, they were not included in the interview. Local residents were interviewed for medicinal use of

the tree hyraxes, its body parts, mode of preparation of traditional medicine and methods of administration. Data on the use of tree hyraxes in the traditional medicinal use of local people were collected through semi-structured interview (Martin, 1995) (Appendix 3). Selection of months for data collection was based on the spare time of farmers during July – October 2015. Semi-structured questionnaires and in case where the respondents were uncomfortable with the questioning, discussions and informal interviews were made. During the discussion, information on different traditional medicinal uses were documented. Participants were interviewed in private from others in the community to satisfy the requirements of statistical independence (Hoffman and Gallaher, 2007).

2.5. Data analyses

Data on feeding behavior and activity patterns of tree hyraxes were analyzed by Chi-square test, using SPSS Version 20.0 statistical program. Chi-square test was also used to determine whether there was difference between the individuals displaying activity patterns during different time periods of the day.

Information on the medicinal use of tree hyraxes was analyzed using Fidelity Level (Friedman *et al.*, 1986). This factor quantifies the importance of a species for a given purpose. It is the percentage of informants claiming the use of a certain part of this species for a purpose, and calculated as:

$$FL = I_p / I_u \times 100\%$$

Where I_p is the number of informants claimed a use of the body parts of this species to treat a particular disease and I_u is the total number of informants use the species as a medicine to treat any given disease (Friedman *et al.*, 1986).

3. Results

3.1. Feeding Behaviour

Feeding accounted for 44.98% of the daily activities of tree hyraxes in the present study. In the morning, they spent 34.67% of their time feeding, in midday 13.33% and in the afternoon 52% of their active time in feeding. Distribution of feeding bouts throughout the observed 10 h of the day time was significantly different ($\chi^2 = 33.13$, d.f. = 9, $P < 0.001$). Major feeding peaks were during morning and afternoon hours.

During the focal animal sampling, 6 h were spent on feeding. During 168 h of observations 85 feeding bouts were counted from total 189 activities in wet and dry seasons. Leaves of *Ipomoea tenuirostris* were the principal food item consumed, accounting for over half of all feeding time (Table 1).

Table 1. Feeding records of tree hyraxes in the study area.

No	Food item	Parts of plant	No. bouts	Length(min)	Handling Times(s)	% feeding time
1	<i>Ipomoea tenuirostris</i>	Leaf, petiole, twings, shoot	33	5.9 (\pm 6.6)	37.3 (\pm 20.7)	55.8
2	Different forb species	Leaf	24	3.7 (\pm 4.2)	14.7 (\pm 5.1)	25.4
3	<i>Arthraxon micans</i>	Leaf	12	3.0 (\pm 2.2)	22.7 (\pm 4.7)	10.3
4	<i>Bersama abyssinnica</i>	Bark	4	4.0 (\pm 1.8)	7.5 (\pm 2.4)	4.6
5	Herbs (<i>Desmodium repandum</i> and <i>Tiumfetta rhomboidea</i>)	Leaf	5	1.7 (\pm 1.2)	25.3 (\pm 7.6)	2.4
6	<i>Commelina berghalensis</i>	Leaf	5	0.6 (\pm 0.5)	21.0 (\pm 3.2)	0.9
7	<i>Stephanica abyssinica</i>	Leaf	2	1.0	10	0.6

Mature leaves comprised major food of tree hyrax. More time was spent eating mature leaves than tender leaves. A remarkable amount of fibrous and dead matters were also consumed (Table 2). Hyrax spent longer time feeding on petioles than on tender leaves. In the present

investigation, tree hyraxes selected largest trees both in terms of height and diameter of principal stems in the Kafa Zone. The sheltering trees have had a number of cavity entrances and presence of moss balls. *Ipomoea tenuirostris* Choisy (Yimbiroo, Kafegna) was highly utilized by tree hyraxes for food in the present study area (Fig. 9).



(a)

(b)

Figure 9. (a) *Ipomoea tenuirostris* the principal food item and (b) a shelter of tree hyrax in the Kafa Zone (Photo: Asrat Aero, 2015).

Tips of branches, both of *Ipomoea tenuirostris* and of *Arthraxon micans* (Dooli mocoo, Kafegna) were regularly eaten by tree hyraxes. Leaves were normally consumed together with the last 15–20 cm of the branch.

Table 2. Proportion of time spent for feeding by tree hyraxes on specific parts of *Ipomoea tenuirostris*.

Parts	Proportion of time spent
Mature leaves	0.49
Petiole	0.29
Twigs	0.11
Young leaves	0.08
Shoots	0.03
Dry leaves	0.01

3.2. Activity pattern

The present investigation has revealed that the activity patterns of tree hyraxes differ from time to time, i.e. in the morning, noon and afternoon observation times of the present study. But activity patterns did not differ significantly between wet and dry seasons. The main behaviors observed during the study period were feeding, travelling, fighting and vocalization.

There were a total of 189 activities of observations in the tree hyraxes during the present study. They were more observed during morning and afternoon hours than in the noon hours (Table 3).

Table 3. Activities of tree hyrax recorded during different hours (07:30–11:30h, 11:40–13:40 h and 15:30 –17:30 h) in the study area.

Time	No. of Observation	Feeding bout %	Movement%	Fight%	Vocalization%
<u>Morning hours</u>					
Wet season	38	44.7	39.5	7.9	7.9
Dry season	42	42.85	39.09	9.53	9.53
<u>Midday hour</u>					
Wet season	12	41.67	58.33	0	0
Dry season	12	58.33	41.67	0	0
<u>After noon hours</u>					
Wet season	41	43.9	39.03	7.31	9.75
Dry season	44	45.45	36.37	9.09	9.09
Total	189	44.98	39.68	7.4	7.94

Tree hyrax activities were high in the morning and afternoon hours. In the morning and afternoon hours, hyraxes have performed almost similar activity patterns (Fig. 10). There was no significant difference between morning and afternoon activity patterns of tree hyraxes ($\chi^2 = 0.015$, d.f. = 1, $P > 0.05$). The distribution of daily activities was significantly different between the three time categories ($\chi^2 = 9.4$, d.f. = 2, $P < 0.001$).

They were more active in the afternoon (42.67%) and morning (41.33%) hours but less active in the midday (16%) hours.

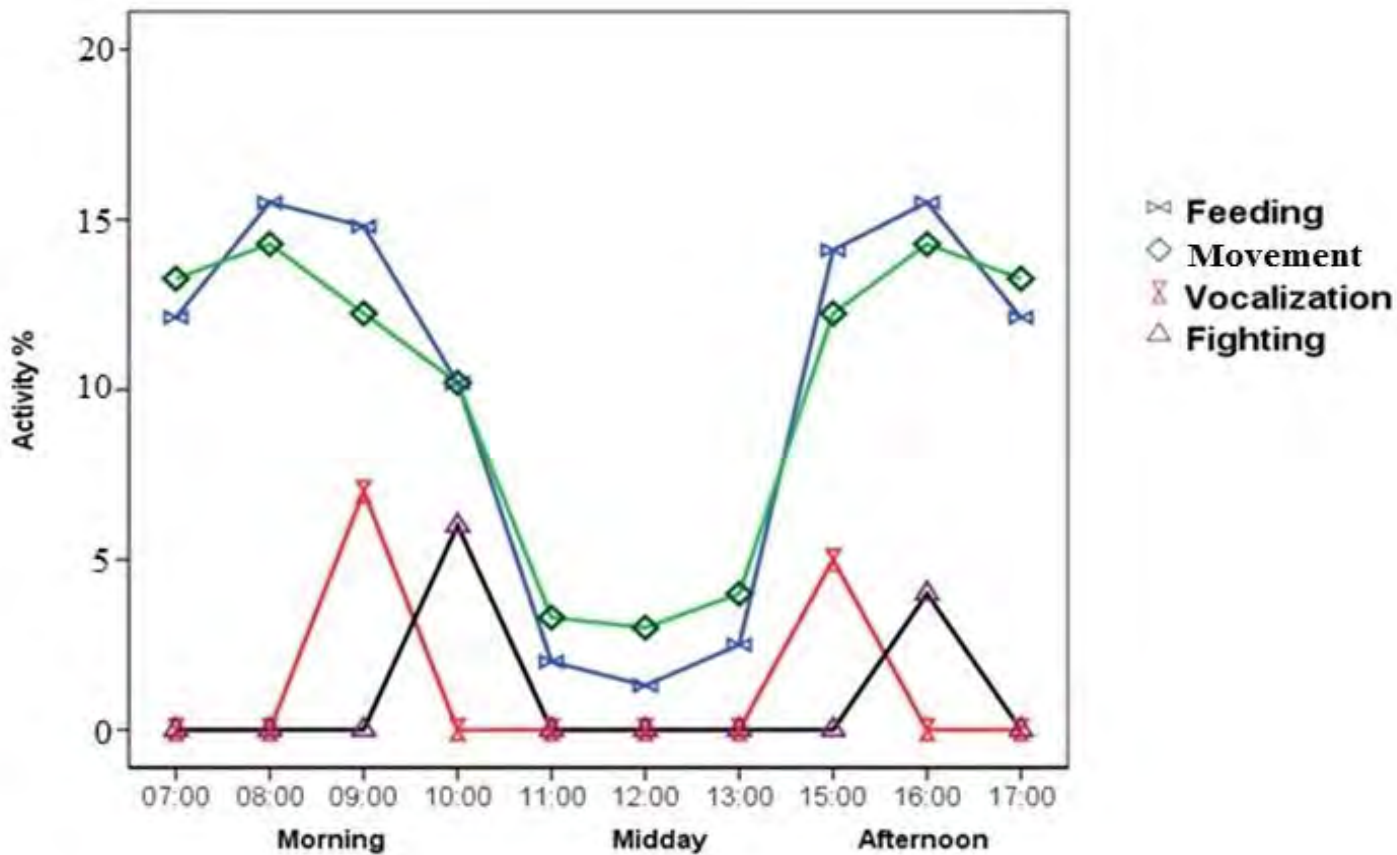


Figure 10. Patterns of activities for tree hyraxes. Percent of time spent feeding, movement, fight and vocalization are shown for each hour of the day from 07:00h to 17:30 h.

3.2.1. Vocalization

Only 15 vocalizations were recorded in the 10min unit of observations in the present study and the frequency of calls did not differ with seasons. Vocalization accounted for 7.94% of the daily activities of tree hyraxes in the present investigation. Among these calls 46.67% were in the morning and 53.33% in the afternoon. Calls were heard at 09:00h in the morning and at 15:00h in the afternoon. There was no vocalization recorded in the midday hours. Four loud calls were recorded during the present study. Eight medium calls were made by five individuals sitting in a

prominent position of tree branches. There were significant differences in the day time activities ($\chi^2 = 19.35$, d.f. = 9, $P < 0.001$) and the duration of the calling ($\chi^2 = 26.49$, d.f. = 14, $P < 0.001$).

Vocalisations were sometimes noisy (bleating calls).

3.2.2. Aggressive Behaviour

During the observations, fourteen fights were recorded. Seven fights each were seen in the morning and afternoon hours and there was no fight recorded in the midday hours. Tree hyrax fights were around 10:00 h in the morning and around 16:00h in the afternoon. Fighting accounted for 7.4% of the daily activities of tree hyraxes in the present study. There was no difference between the number of fights seen in the morning and afternoon hours. Of recognizable individuals, it was not possible to determine the motive for interaction. Many consisted solely of snarling between individuals and sometimes chasing off an intruder, but without physical contacts.

3.4. Traditional Medicinal Use

In the Kafa Zone of Ethiopia, the Manja Clan uses tree hyraxes for treating various ailments. They use different body parts, methods of preparation and methods of administration for different ailments (Table 4). The stomach was used in highest proportion to treat ailments. Use of tree hyrax in traditional medicinal practice was reported by local people both as a means of prevention and for cure for a number of ailments.

The principal medicinal use of tree hyrax body part was stomach to cure deep coughing, especially in children. Among the respondents, 43.3% responded that drinking broth of stomach and 26.67% stated that drinking broth of flesh were useful to cure deep cough. They were also used for fast growth of children. Local people call the stomachs and medicinal parts “uke

hashisho”. The undigested plant materials formed in the hyrax stomachs were used as herbal remedy, believed to ease aching of ribs. Ash of stomach contents of hyrax is applied for cure of different diseases. Among the respondents 16.67% remarked that fur of tree hyrax was used as a remedy to aching ribs while (13.33%) answered that the bones was used to treat burnt wound.

In the Kafa Zone, there was no any special religious consideration, taboo or other beliefs related to the use of tree hyraxes in the traditional medicinal practice using body parts of tree hyraxes.

Table 4. Responses of local people on the traditional medicinal use of tree hyrax in the Kafa Zone.

No.	Interview questions	Body parts used	No. of respondents	Percent of respondents	Types of disease
1	Body parts of tree hyrax used to treat different ailments	Stomach	26	43.3	Deep cough
		Flesh	16	26.67	Protein deficiency
		Fur	10	16.67	Aching ribs
		Bone	8	13.33	Burnt wound
2	Methods of preparation	Cooking	22	36.67	Deep cough
		Cooking and powdering	18	30	All disease
		Drying and powdering	12	20	All disease
		Fresh	8	13.33	Deep cough
3	Methods of administration	Oral	44	73.33	Deep cough
		Dermal	10	16.67	Aching ribs
		Nasal	4	6.67	Deep cough
		Ear canal	2	3.33	Deep cough

Among the respondents, 36% recommended that local traditional medicinal practitioners prepare the medicine by cooking of stomach and 30% of respondents replied by cooking and powdering of the tree hyrax flesh. But, 20% of the respondents reported that local traditional medicine was prepared by drying and powdering tree hyrax meat while 13.33% of the respondents that replied fresh meat of tree hyraxes were used. According to the local people response, tree hyrax medicine was more effective to the children than young people. Among the respondents, 73.33% replied that local medicines were administered orally, and 16.67% respond that it was applied on skin. Few respondents (6.67%) answered that traditional medicine of tree hyrax was administered nasally, while 3.33% responded as it is administered through the ear canal.

4. Discussion

4.1. Feeding Behaviour

Feeding of tree hyraxes took place for very short periods and fast in the present study area. Most feeding occurred in at morning and afternoon hours. Gaylard and Kerley (1997) reported that tree hyrax feeding were recorded between 07:30–11:00 h and 16:00–18:00 h, but occasionally up to 19:00h that individuals feed. Feeding is often in concentrated periods of time during the day, limiting their exposure to predators (Sale, 1966; Hoeck, 2001). During the present investigation, tree hyraxes were generally folivorous, and consumed only few plant species. Hoeck (1975) reported that tree hyraxes feed almost exclusively on leaves, and are obligate browsers. In the Serengeti National Park in West Tanzania, tree hyraxes were observed feeding on 64 plant species and they browsed leaves, flowers, fruits, bushes and herbs in the wet (81%) and dry (92%) seasons. Feeding was normally confined to areas very close to the shelter in which refuge can be taken. There was no evidence of fruits or insects in the diet of tree hyrax during the present observation period. Foraging for invertebrates, flowers, and sap by arboreal mammals is argued to be economical only for small mammals because of the small absolute size and low total biomass of the reward (Cork and Foley, 1991). In the study area, the principal dietary plants comprised of only few species such as *Bersama abyssinnica*, *Ipomoea tenuirostris*, *Arthraxon micans* and *Commelina berghalensis*. Gaylard and Kerley (1997) reported nearly 150 individual plant species from faecal remains of *D. arboreus*. The individual plant species such as *Hagenia abyssinnica*, *Hypericum revolutum*, *Ficus* spp. and *Podocarpus falcatus* were identified in the diet of tree hyraxes in South Africa (Smithers, 1966; Gaylard and Kerley, 1997; Milner and Harris, 1999a).

However, other plant parts also constitute a large proportion of the diet of tree hyrax in the Kafa regions. These include young leaves, petioles, twigs, shoots and dry leaves (Myers, 2000). Tree hyrax (*Dendrohyrax arboreus*) was observed feeding on coarse materials such as mature leaves, barks and twigs (Sale, 1965b). One of the adaptive strategies of the tree hyrax was selective browsing, eating a combination of foods to maintain its energy balance, not necessarily in proportion to the abundance of the food item (Milner and Harris, 1999a). This is contrary to the optimal feeding strategy of rock hyrax on energy and protein rich young leaves and shoots (Hoeck, 1975).

However, the rock hyrax (*P. habessinica*) is very efficient in protein utilization, and therefore able to cope with a low protein diet and has a low nitrogen requirement as a consequence of low metabolic rate (Ruhsamen *et al.*, 1982). The same may be true for the tree hyraxes as well, as they also have lower energy expenditure than predicted for their body size. In addition, selection of a common plant part as the major food source may be a strategy to maximize intake rate whilst minimizing search efforts (McNab, 1978).

4.2. Activities of Tree Hyrax

Tree hyraxes were observed occupying large trees bearing cavities or hollows. The present study revealed that the tree hyrax occupy only large trees which have cavity on the trunk. Rudnai (1984) also reported that tree hyraxes favoured trees with cavities or hollows.

During the present study, activities of tree hyraxes were observed in the day time. Rudnai (1984) reported that tree hyraxes are more active during the day time than during night. Studies of Richard (1964) also revealed that tree hyrax is most active during morning and afternoon hours. In the Virungas in Rwanda, tree hyrax is not nocturnal, but has a major feeding peak before dark;

whilst movement around the home ranges occurred predominantly during the daytime (Rudnai, 1984).

3.3. Vocalization

Tree hyraxes are almost impossible to observe in the wild but their presence is advertised by conspicuous loud calls. During the present study, tree hyrax calls were mostly heard in the morning and in the afternoon hours. Tree hyraxes were heard calling frequently during the early morning around the forest camps in the Arc Mountain of Tanzania (Roberts, 2001). According to Topp-Jørgensen *et al.* (2008), *D. validus* was frequently heard calling and observed basking on branches during day time. In disturbed forest habitat, individuals call less frequently and are rarely observed in the day as compared to undisturbed forest. This would agree with the findings of Kundaeli (1976) in Mt. Kilimanjaro in Tanzania. During this investigation, breeding activities were not related in relation with calling behaviour but calling follows intense feeding periods. Milner and Harris (1999a) and Kingdon (1971) have linked territoriality and sexual function in relation with calls of hyraxes. Such loud calls of the tree hyraxes were one of the most characteristic sounds of west and central African forests (Roberts, 2001). Loud call is expensive for tree hyraxes in terms of predation risk. Vocalization usually involved a single individual, sitting in a prominent position. Occasionally, it was heard following aggressive interactions, but the significance of this vocalization was not clear in the present study.

4.3. Traditional Medicinal Use

In the present study area, Manja Clan has been using different body parts of tree hyraxes to treat different ailments. Alves and Alves (2011) have revealed that different body parts of animals provide the raw material to prepare different remedies, which were prescribed to treat various

diseases. Avenant (2011) reported that wild and domestic animals and their body parts (hooves, skin, bones, feathers and tusks) form important ingredients in the preparation of curative, protective and preventive medicines in traditional healing practices.

Manja Clan used stomach parts of tree hyrax to treat diseases. They prepare traditional medicine by drying and powdering body parts of tree hyrax. The Hadza or Watindiga, a Bushman tribe in Tanzania, hunt rock and bush hyraxes for meat and skin. The crystallized excrement of the tree hyrax has been used by South African tribes to treat epilepsy, hysteria and general injuries (Hoeck, 2001). Kingdon (1971) reported that the meat of tree hyrax is used as a vitamin supplement and humans hunt *D. arboreus* for food. Hyrax urine is used to treat syphilis (Vats and Thomas, 2015). The principal medicinal use of tree hyrax in the study area was to cure deep coughing by drinking the ash of burnt hairs mixed with water in the Kafa Zone. Similarly, forest dwelling people of the Southwest Mau use tree hyraxes in their traditional medicine as a means of prevention and to cure cough by drinking the ash of hairs mixed with honey (Gaylard and Kerley, 1997). The Manja Clans in the Kafa Zone uses tree hyrax stomach as a medicine. Several African tribes hunt, snare or trap hyraxes as a food and for skin (Gaylard and Kerley, 1997).

In the present study, Manja Clans used different methods of administration of different body parts of tree hyraxes to treat deep coughing and protein deficient. Sixteen species of medicinal animals were collected and identified for treating 18 different human ailments along the Kafta-Humera District, Northern Ethiopia (Yirga Gidey *et al.*, 2011).

Different animal parts are used in traditional medicine in different countries. For example, hair of red colobus to treat skin burns, cough and to heal fresh wounds; flying squirrel fur to treat skin burns and wounds; marsh mongoose teeth to treat snake bites; potto skulls, limbs and limb

bones to treat hernia, to promote breast milk abundance and to strength the physical and mental growth of children; monkey jaw to treat toothache and intestinal worms; African forest buffalo bones to treat goiter, limbs to treat abscesses and African civet gland secretion to treat convulsions (Kadiri *et al.*, 2015).

During this investigation, the local people were preparing the medicine by cooking, cooking and powdering, drying and powdering and fresh body parts of tree hyraxes. Highest proportion of flesh in traditional medicine preparation has been observed by Alves and Alves (2011) in Northeastern Brazil. Similar observations were also reported by Zein and Kloos (2008). Different techniques of preparation of traditional medicine have been reported by Yirga Gidey (2010). Animals are not only used in traditional medicines, but are also increasingly needed as raw materials in the preparation of modern medicines. Nearly 8.7% of the 252 essential compounds selected by the World Health Organization came from animals (Dedeke *et al.*, 2006). The methods of administration for remedies in the present investigation was mostly oral. Derje Woldeyohanis and Messert Chane (2014) reported that Kore people in Amaro Woreda use traditional sources as remedies and they follow dermal application in South Ethiopia.

In the present study, the percentage of animal sources for producing essential medicines is quite significant. There has been increasing attention paid to animals as sources for traditional medicines (Jain *et al.*, 2007). Indigenous people have been collecting medicines from local plants and animals without threatening the population dynamics of the species (Jain *et al.*, 2007).

4.4. Conclusion

The data collected during the present study provide valuable information on the feeding behaviour, activity patterns and traditional medicinal use of the tree hyraxes in the Kafa Zone,

Southwest Ethiopia. Tree hyraxes depend on forest for their essential resources. The tree hyrax species are probably sensitive to habitat degradation, as they are mainly confined to primary forests. The best habitat of tree hyrax is generally acknowledged to be forest, away from human disturbances.

The tree hyrax is principally folivorous, eating mature leaves, young leaves and twigs. As the tree hyraxes have been depending only on few trees in the present study area, removal of these plants would result in loss of dietary resources of the species, particularly as they do not exploit other species of plants.

Tree hyraxes were observed moving, feeding, vocalizing and fighting in the morning, noon and afternoon hours. But, due to the predators the tree hyraxes displayed a variety of behavioural responses such as reduced activity, relocating to new areas of habitat and changes of activity time. Tree hyrax body parts are being widely used traditionally for medicinal purposes, especially to cure deep cough, protein deficiency and to support fast growth of children in the present study area. Furthermore, there is a need for ethnobiological studies in Southern parts of Ethiopia given the increasing relevance of this science across community.

5. Reference

- Afewerk Bekele and Yalden, D.W. (2013). *Mammals of Ethiopia and Eritrea*. Addis Ababa University Press, Addis Ababa.
- Altmann, J. (1974). Observational study of behavior: sampling methods. *Behaviour* **49**: 265–267.
- Alves, R.R.N. and Alves, H.N. (2011). The faunal drug store: animal-based remedies used in traditional medicines in Latin America. *J. Ethnobiol. Ethnomed.* **7**: 1–43.
- Asher, R.J., Novacek, M.J. and Geisher, J.H. (2003). Relationships of endemic African mammals and their fossil relatives based on morphological and molecular evidence. *J. Mamm. Evol.*, **10**: 131–194.
- Ashford, R., Bray, M., Hutchinson, M. and Bray, R. (1973). The epidemiology of cutaneous leishmaniasis in Ethiopia. *Trans. R. Soc. Trop. Med. Hyg.*, **67**: 569 – 601.
- Ashford, R. (1997). The leishmaniasis as model zoonoses. *Ann. Trop. Med. Parasitol.* **91**: 698–701.
- Avenant, N. (2011). The potential utility of rodents and other small mammals as indicators of ecosystem integrity of South African grasslands. *South Afr. J. Wildl.* **38**: 626–639.
- Bennett, E.L., Milner-Gulland, E.J., Bakarr, M., Eves, H.E., Robinson, J.G. and Wilkie, D.S. (2002). Hunting the world's wildlife to extinction. *Oryx* **36**: 28–32.
- BIDNTF (2010). *Ethiopia: Overview of Selected Biodiversity Indicators*. Biodiversity Indicators Development National Task Force, Addis Ababa.
- Bothma, J. P. (1966). Hyracoidea. **In**: *Preliminary Identification Manual of African Mammals*, pp. 1– 15, (Meesters, P.J. ed). Smithsonian Institution Press, Washington D.C.
- Brooks, T., Hoffmann, M., Burgess, N., Plumptre, A., Williams, S., Gereau, R.E.,

- Mittermeier, R.A. and Stuart, S. (2004). Eastern afro-montane. **In:** *Hotspots Revisited: Earth's Biologically Richest and Most Endangered Ecoregions*, pp. 240–275, (Mittermeier, R.A.; Robles-Gil, P.; Hoffmann, M.; Pilgrim, J.D.; Brooks, T.M., Mittermeier, C., Lamoreux, J.L. and Fonseca, G., eds). 2nd edn., CEMEX, Mexico City.
- Cerriaco, L.M.P. (2012). Human attitude towards herpetofauna: The influence of folklore and negative values on the conservation of amphibians and reptiles in Portugal. *J. Ethn. Ethnomed.* **8**: 6–9.
- Cole, F.R., Reeder, M.D. and Wilson, D.E. (1994). A synopsis of distribution patterns and the conservation of mammal species. *J. Mamm.* **75**: 266– 276.
- Corbet, G. (1979). The taxonomy of *Procavia capensis* in Ethiopia, with special reference to the aberrant tusks of *Procavia capensis capillosa Brauer* (Mammalia, Hyracoidea). *Bull. Br. Mus. Nat. Hist.* **36**: 251– 259.
- Cork, S.J. and Foley, W.J. (1991). Digestive and metabolic strategies of arboreal mammalian folivores in relation to chemical defences in temperate and tropical forests. **In:** *Plant Defences Against Mammalian Herbivory*, Pp. 45–48, (R. T. Palo. and C. T. Robbins.eds). CRC Press Inc., Boston.
- Dedeke, G.A., Soewu, D.A., Lawal, O.A. and Ola, M. (2006). Pilot survey of ethnozoological utilisation of vertebrates in Southwestern Nigeria, Indilinga. *Afr. J. Indigenous Knowl. Syst.* **5**: 87– 96.
- Dereje Woldeyohanis and Messert Chane (2014). Ethnozoological study of traditional medicinal animals used by the Kore People in Amaro Woreda, Southern Ethiopia. *Intl. J. Mol. Evol. Biodivers.* **2**: 1–8.

- Dirzo, R., Mendoza, E., Cachú, Y. and Gomez, W. (2009). *Status of Large and Medium-Sized Mammals at JRBP, in Jasper Ridge Biological Preserve State of the Preserve Assessment*. Stanford University, California.
- Estes, R.P. (1991). *The Behavior Guide to African Mammals, Including Hoofed Mammals, Carnivores, Primates*. University of California Press, Berkeley.
- EWNHS (1996). *Important Bird Areas of Ethiopia: A First Inventory*. Ethiopian Wildlife and Natural History Society, Addis Ababa.
- Friedman, J., Yaniv, Z., Dafni, A. and Palevitch, D. (1986). A preliminary classification of the healing potential of medicinal plants, based on a rational analysis of an ethnopharmacological field survey among bedouins in the Negev desert, Israel. *J. Ethnopharmacol.* **16**: 275–287.
- Friis, I. (1992). Forests and forest trees of Northeast tropical Africa. Kew Bulletin. (Additional Series No 15).
- Friis, I., Ramussen, F.N. and Vollesen, K. (1982). Studies in the flora and vegetation of Southwest Ethiopia. *Opera. Botanica* **63**: 56–70.
- Gaylard, A. and Kerley, G. (1997). Diet of tree hyraxes *Dendrohyrax arboreus* (Hyracoidea: Procaviidae) in the Eastern cape, South Africa. *J. Mamm.* **1**: 213–219.
- Gebremeskel Teklehaimanot (2015). *Population Ecology and Threats of the Rock Hyrax (Procavia Capensis) in Bale Mountains National Park, Ethiopia*. Ph.D. Thesis. Addis Ababa University, Addis Ababa.
- Giday Mamo, Asfaw Zeleke, Woldu Zewude and Teklehaymanot Teka. (2009). Medicinal plant knowledge of the Bench ethnic group of Ethiopia: An ethnobotanical investigation. *J. Ethnobiol. Ethnomed.* **5**: 34– 38.

- Hillman, J.C. (1993). *Ethiopia: Compendium of Wildlife Conservation Information*. New York Zoological Society and Ethiopian Wildlife Conservation Organization, Addis Ababa.
- Hoeck, H.N. (1975). Differential feeding behaviour of the sympatric hyrax *Procavia johnstoni* and *Heterohyrax brucei*. *Ocelot* **22**: 15 – 17.
- Hoeck, H.N. (1978). *Systematics of the Hyracoidea: Towards a Clarification*. Bulletin Carnegie Museum of Natural History, Pittsburgh.
- Hoeck, H.N. (1982). *Ethologie von Busch-und Klippschliefer*. Film D 1338 des IWF, Publikation von, Gottingen.
- Hoeck, H. (2001). Hyraxes. **In**: *The New Encyclopedia of Mammals*, Pp. 448–451, (D. Macdonald. and S. Norris. eds). Oxford University Press, Oxford.
- Hoeck, H. N. (2003). Hyrax: Behavior ecology of two species. Max Planck Institute for Behavior Physiology Seewiesen. Online retrived fom www.calacademy.org/research/bmammals/afrotheria/Hyracoidea.html, accessed on 18 February, 2012.
- Hoffman, B. and Gallaher, T. (2007). Important indices in ethnobotany. *Ethnobotany Res. Appl.* **5**: 201–218.
- IUCN (2008). *IUCN Red List of Threatened Species*. Online retrived from www.iucnredlist.org, accessed on 24 October, 2012.
- Jain, A., Katewa, S.S., Galav, P.K. and Nag, A. (2007). Unrecorded ethnomedicinal uses of biodiversity from Tadgarh-Raoli Wildlife Sanctuary, Rajasthan, India. *Acta. Botanica. Yunnanica* **29**: 337– 344.
- Jones, C. (1978). *Dendrohyrax dorsalis*. *Mammalian Species* **113**: 23– 30.
- Kadiri, S. B., Fodjou, F. M. and Bonito, C. N. (2015). Wildlife use and the role of taboos in

- the conservation of wildlife around the Nkwende Hills Forest Reserve; South-west Cameroon. *J. Ethnobiol. Ethnomed.* **11**: 6–12.
- Kingdon, J. (1971). *East African Mammals: An Atlas of Evolution in Africa*. Academic Press, London.
- Kingdon, J. (1997). *East African Mammals: An Atlas of Evolution in Africa*. Academic Press, London.
- Kingdon, J. (2004). *The Kingdon Pocket Guide to African Mammals*. Princeton University Press, Princeton and Oxford.
- Kleinschmidt, T., Czelusniak, J., Goodman, M. and Braunitzer, G. (1986). Paenungulata: a comparison of the haemoglobin sequences of elephant, hyrax and manatee. *Mol. Biol. Evol.* **3**: 427– 435.
- Kundaeli, J.N. (1976). Distribution of tree hyrax (*Dendrohyrax validus validus*) on Mt. Kilimanjaro, Tanzania. *East Afr. Wildl. J.* **14**: 253–264.
- Larrenchenko, L.A., Voyta, L.L. and Hutterer, R. (2016). Diversity of shrews in Ethiopia, with the description of two new species of *Crocidura* (Mammalia: Lipotyphla: Soricidea). *Zootaxa* **4196**: 38–60.
- Lawes, M., P. Mealin and Piper, S. (2000). Patch occupancy and potential metapopulation dynamics of three forest mammals in fragmented afro-montane forest in South Africa. *Conserv. Biol.* **14**: 1088– 1098.
- Liljequist, G.H. (1986). Some aspects of the climate of Ethiopia. *Symb. Bot. Ups.* **10**: 19– 30.
- Litvaitis, J.A., Titus, K. and Anderson, E.M. (1994). Measuring vertebrate use of terrestrial habitats and foods. **In**: *Research and Management Techniques for Wildlife and Habitats*, Pp. 234-238, (T. A. Bookhout. ed). Wildlife Society, Bethesda.

- Martin, G.J. (1995). *Ethnobotany. A Methods Manual, WWF for Nature International*.
Chapman and Hall Press, London.
- McGinley, M. and Hagon, C.M. (2009). Biodiversity in Africa. **In:** *Encyclopedia of Earth. Environmental Information Coalition, National Council for Science and the Environment*, Pp. 234–241 (Cleveland, C. J. ed.). United Nations Environment Programme (UNEP), Nairobi.
- McNab, B.K. (1978). Energetics of arboreal folivores. **In:** *The Ecology of Arboreal Folivores*, Pp. 67 – 71, (G. Montgomery. ed). Smithsonian Institution Press, New York.
- Milner, J. and Harris, S. (1999a). Activity patterns and feeding behaviour of the tree hyrax, *Dendrohyrax arboreus*, in the Parc National des Volcans, Rwanda. *Afr. J. Ecol.* **37**: 267–280.
- Milner, J. and Harris, S. (1999b). Habitat use and ranging behaviour of tree hyrax, *Dendrohyrax arboreus*, in the Virunga Volcanoes, Rwanda. *Afr. J. Ecol.* **37**: 281–294.
- Milstrey, R. (1985). Rock hyrax-little brothers of elephants. *Inter. Zool. News*, **32**: 11–13.
- Myers, P. (2000). Hyracoidea. Animal Diversity Web. Retrieved January 30, 2014.
- Ngwenya, M.P. (2001). Implications for the medicinal animal trade for nature conservation in KwaZulu-Natal. Ezimvelo KZN Wildlife Report no. NA/124/04.
- Norbury, G. L. and G. D. Sanson. (1992). Problems with measuring diet selection of terrestrial, mammalian herbivores. *Austr. J. Ecol.* **17**: 1– 7.
- Olds, N. and Shoshani, J. (1982). Mammalian Species: *Procavia capensis*. *Am. Soc. Mamm.* **171**: 1–7.
- Padmanabhan, P. and Sajan, K. (2006). Animal products in traditional medicine from Attappady hills of Western Ghats. *J. Ethnobiol.* **1**: 1–2.
- Prinsloo, P. (1993). *Molecular and Chromosomal Phylogeny of the Hyracoidea*. PhD.

- Thesis. University of Pretoria, Pretoria.
- Prothero, D.R. (1993). Ungulate phylogeny: Molecular vs. morphological evidence. **In:** *Mammal Phylogeny*, pp. 173–181, (Szalay, F.S., Novcek, M.J. and McKenna, M.C., eds). Springer-Verlag, New York.
- Quave, CL., Lohani, Verde, U., A., Fajardo, J., Rivera, Obón, D., Valdes, C., A. and Pieroni, A. (2010). A comparative assessment of zootherapeutic remedies from selected areas in Albania, Italy, Spain and Nepal. *J. Ethnobiol.* **30**: 92–125.
- Rafai, L.B., Abubaker, M. and Amr, Z.S. (2000). Ecology, distribution and status of the Rock Hyrax, *Procavia capensis syriaca*, in Jordan. *Zool. Middle East* **521**: 19– 26.
- Rahm, V. (1969). Notes sur le cri du *Dendrohyrax dorsalis* (Hyracoidea). *Mammalia* **33**: 68–79.
- Rasmussen, D.T., Gagnon, M. and Simons, E.L. (1990). Taxeopody in the carpus and tarsus of Oligocene Pliohyracidae (Mammalia: Hyracoidea) and the phyletic position of hyraxes. *Proc. Nat. Acad. Sci.* **87**: 4688–4691.
- Pardini, A.T., O'Brien, P.C.M., Fu, B., Bonde, R.K., Elder, F.F.B., Ferguson-Smith, M.A., Yang, F. and Robinson, T.J. (2007). Chromosome painting among Proboscidea, Hyracoidea and Sirenia: Support for Paenungulata (Afrotheria, Mammalia) but not Tethytheria. *Proc. Biol. Sci.* **274**: 1333–1340.
- Redeat Habteselassie (2012). *Fishes of Ethiopia: Annotated Checklist with Pictorial Identification Guide*. Ethiopian Fisheries and Aquatic Science Association, Addis Ababa.
- Ru' bsamen, K., Hume, I.D. and Engelhardt, W.V. (1982). Physiology of the rock hyrax. *Comp. Biochem. Physiol.* **72A**: 271–277.
- Richard, P.B. (1964). Notes sur la biologie du daman des arbres (*Dendrohyrax dorsalis*). *Biol. Gabon.* **1**:73–84.

- Roberts, D. (2001). *Geographical Variation in the Loud Calls of Tree Hyrax (Dendrohyrax validus) in the Eastern Arc Mountains, East Africa: Taxonomic and conservation Implications*. M.Sc. Thesis. University of Reading, Reading.
- Rudnai, J. (1984). Activity cycle and space utilisation in captive *Dendrohyrax arboreus*. *South Afr. J. Zool.* **19**: 124–128.
- Sale, J.B. (1965a). *Some Aspects of the Behaviour and Ecology of the Rock Hyraces (Genera Procavia and Heterohyrax)*. PhD. Thesis. University of London, London.
- Sale, J.B. (1965b). The feeding behaviour of rock hyraces (Genera *Procavia* and *Heterohyrax*) in Kenya. *East Afr. Wildl. J.* **3**: 1–18.
- Sale, J.B. (1966). Daily food consumption and mode of ingestion in the hyrax. *J. East Afr. Nat. Hist. Soc.* **25**: 215–224.
- Sale, J.B. (1970). The behaviour of the resting rock hyrax in relation to its environment. *Zool. Afr.* **5**: 87–99.
- Schmitt, C.B. (2006). *Montane Rainforest with Wild Coffea arabica in Bonga Region (SW Ethiopia) Plant Diversity, Wild Coffee Management and Implications for Conservation*. PhD. Thesis. Rheinischen Friedrich-Wilhelms University, Goettingen.
- Simelane, T.S. and Kerley, G.I.H. (1998). Conservation implications of the use of vertebrates by Xhosa traditional healers in South Africa. *South Afr. J. Wildl. Resour.* **28**: 121–126.
- Skinner, J.D. and Smithers, R.H.N. (1990). *The Mammals of the Southern African Subregion*. University of Pretoria Press, Pretoria.
- Smithers, R. (1966). *The Mammals of Rhodesia, Zambia and Malawi*. Collins Clear-Type Press, London.

- Smithers, R.H.N. (1986). South African Red Data Book: Terrestrial Mammals. *South Afr. Nat. Sci. Program. Rep.* **125**: 23–27.
- Springer, M. S., Cleven, G. C., Madsen, O., deJong, W. W., Waddell, V. G., Amrine, H.M. and Stanhope, M. J. (1997). Endemic African mammals shake the phylogenetic tree. *Nature* **388**: 61–64.
- Tabuce, R., Asher, R. J. and Lehmann, T. (2008). Afrotherian mammals: a review of data. *Mammalia* **72**: 2–14.
- Teketay Demel and Bekele Taye (2002). *Indicators and Tools for Restoration and Sustainable Management of Forests in East Africa: I-TOO working paper No.1; State of Forests and Forestry Research in Ethiopia*, Addis Ababa.
- Tesfaye Awas (2007). *Plant Diversity in Western Ethiopia: Ecology, Ethnobotany and Conservation*. PhD. Thesis. University of Oslo, Oslo.
- Topp-Jørgensen, J.E., Marshall, A.R., Brink, H. and Pedersen, U.B. (2008). Quantifying the response of tree hyraxes (*Dendrohyrax validus*) to human disturbance in the Udzungwa Mountain, Tanzania. *J. Trop. Conserv. Sci.* **1**: 63– 74.
- Unnikrishnan, P.M. (1998). Animals in Ayurveda. *Amruth* **1**: 1–15.
- Vats, R. and Thomas, S. (2015). Study on use of animals as traditional medicine by Sukuma Tribe of Busega, District in Northwestern Tanzania. *J. Ethnobiol. Ethnomed.* **11**: 38.
- Vaughan, T.A., Ryan, J.M. and Czaplewski, N.J. (2000). *Mammalogy*, 4th edn. Saunders College Publishing, Orlando.
- Voultsiadou, E. (2010). Therapeutic properties and uses of marine invertebrates in the ancient Greek world and early Byzantium. *J. Ethnopharm.* **130**: 237– 247.
- Wallmo, O.C., Gill, R.B., Carpenter, L.H. and Reichert, D.W. (1973). Accuracy of field estimates of deer food habits. *J. Wildl. Manag.* **37**: 556–562.

- White, F. (1978). The afro-montane region. **In:** *Biogeography and Ecology of Southern Africa*, Pp. 234–243, (Werger, M.J. ed). Dr W. Junk Publishers, Hague.
- White, F. (1981). The history of the Afro-montane archipelago and the scientific need for its conservation. *Afr. J. Ecol.* **19**: 33–54.
- Yalden, D.W. (1983). The extent of high ground in Ethiopia compared to the rest of Africa. *SINET: Ethiop. J. Sci.* **6**: 35–39.
- Yalden, D.W., Largen, M.J., Kock, D. and Hillman, J.C. (1996). Catalogue of the mammals of Ethiopia and Eritrea. 7. Revised checklist, Zoogeography and Conservation. *Trop. Zool.* **9**: 73–164.
- Yirga Gidey (2010). Assessment of indigenous knowledge of medicinal plants in Central Zone of Tigray, Northern Ethiopia. *Afr. J. Plant Sci.* **4**: 6–11.
- Yirga Gidey, Mekonen Teferi and Yemane Gebreslassea (2011). Ethnozoological study of traditional medicinal animals used by the people of Kafa-Humera District, Northern Ethiopia. *Int. J. Med. Sci.* **6**: 316–320.
- Young, T.P. and Evans, M.R. (1993). Alpine vertebrates of Mount Kenya, with particular notes on the rock hyrax. *J. E. Afr. Nat. Hist. Soc. Nat. Mus.* **82**: 1–25.
- Zein, A. and Kloos, H. (2008). The ecology of health and diseases in Ethiopia, Addis Ababa. *J. Biol. Soc. Sci.* **21**: 507–808.

Appendices

Appendix 1. Data sheet used for collecting feeding behavior and activity patterns of tree hyrax
(*Dendrohyrax arboreus*)

Date and time _____ Site _____

No.	Date & Month	Time	Activity	No. vocalization	Fighting	Feeding bouts	Feeding item	Plant item	Weather condition	Others
1										
2										
3										
4										
5										
6										

Appendix 2. Plant species that recorded in the Kafa Zone during the study time.

T=Trees, Sh=Shrubs, H=Herbs, C= Climbers, L= Lianas, F=Ferns, E= Epiphytes, G=Grass

Local name (Kafegna)	Species name	Type of species	Local Name (Kafegna)	Species name	Type of species
Dooli mocoo	<i>Arthraxon micans</i>	G	Shinaato	<i>bamboo Arundinavia</i>	T
Booqo	<i>Bersama abyssinnica</i>	T	shawukko	<i>Dombeya torrid</i>	T
Huqicho	<i>Physlis peruviana</i>	H	Bago	<i>Combretum paniculatum</i>	C
Geco	<i>Desmodium repandum</i>	H	Naallexo	<i>Commelina berghalensis</i>	H
Haggi	<i>Digitari abyssinnica</i>	G	Mico	<i>Cyprus rigifolus</i>	G
Dupho	<i>Embelea schimperi</i>	C	Yimberoo	<i>Ipomoea tenuirostris</i>	C
Nace caroo	<i>Ficus sur</i>	T	Nace garo	<i>Rubis apetatu</i>	C
Shimbrikko	<i>Girardina divesifoilia</i>	H	Eeko	<i>Stephanica abyssinnica</i>	C
Phi'o	<i>Hippocratea Africana</i>	C	Shakki shimbriko	<i>Tragia pungen</i>	C
Qawee qombo	<i>Hippocratea goetzei</i>	C	Pheco	<i>Acanthus pubescens</i>	H
Nace qombo	<i>Jasmium abyssinicum</i>	C	Bagee geeco	<i>Achyranthes aspera</i>	H
Caatto	<i>Albizia gumifera</i>	T	Yameshe gabo	<i>Aspilia mossambicensis</i>	H
She'oo	<i>Allophyllas abyssinicum</i>	T	Geco	<i>Desmodium repandum</i>	H
Xigaa go	<i>Ficus thonningi</i>	E	Bago	<i>Combretum paniculatum</i>	C
Caphero	<i>Ficus vasta</i>	T	Ufoo	<i>Asparagus africanus</i>	T
Biberoo	<i>Millefria ferrginea</i>	T	Miico	<i>Cyperus rigidifolius</i>	G
Yahoo	<i>Olea welwetschia</i>	T	Garoo	<i>Rubus studneri</i>	C
Zigiba	<i>Podocarpus falcatus</i>	T	Caammero	<i>Snowdenia polystchya</i>	G
Qarero	<i>Pouteria adolfi-friederici</i>	T	Moco	<i>Stellaria sennii</i>	G
Sheddo	<i>Sapium ellipticum</i>	T	Moggeco	<i>Triumfetta rhomboidea</i>	H
Butoo	<i>Scheffleria abyssinnica</i>	T	Yemo	<i>Landolphia buchananii</i>	C
Wundifo	<i>Apodytes dimidiate</i>	T	Shobo	<i>Lantana trifolia</i>	H
Shakkeroo	<i>Macaranga capensis</i>	T	Bayiro	<i>Oncinotis tenuiloba</i>	C
Mogeco	<i>Triumfetta rhomboidea</i>	H	Shomekko	<i>Panicum subabidum</i>	G
Qatoo	<i>Ilex mitis</i>	T	Yeboo	<i>Phoenix reclinata</i>	T

Appendix 3. Questionnaire used during the present study to interview local people in Kafa Zone Southwest Ethiopia.

Interview questions for local people in Kafa Zone. The purpose of this interview is to gather information on traditional medicinal use of tree hyrax in Kafa Zone. Thus you are kindly requested to be considerate in responding the interviews. Your cooperation in responding the interview is highly appreciated.

Note

- A. Any of your information or suggestions will be kept secret and used for research purpose only.
- B. Your names are not writing on the interview question papers by interviewer.
- C. Give appropriate response to the following interview.

1. BACK GRAUND OF THE LOCAL PEOPLE

Date _____ Village _____

1.1. Sex 1) Male 2) Female

1. 2. Age (in years) 1) < 18 2) 18 – 24 3) 25 – 34 4) 35 – 44 5) 45 –54 6) ≥ 55

1.3. Educational level 1) Illiterate 2) No formal education 3) Primary 4) Secondary

5) College/University

1.4. Occupation? _____

1.5. What is your household size? 1) <5 2) 5 – 10 3) > 10

1.6. How long (in years) you have been living in this village? a) < 10 b) 10– 30 c) >30

2. INTERVIEW QUESTION FOR THE LOCAL PEOPLE

2.1 Do you know what a tree hyrax is? 1) Yes 2) No

2.2. What is important of the tree hyrax? _____

Do you know traditional medicines use of tree hyrax? _____

2.3. Do you use meats of tree hyrax? Yes No

Are there medicinal value? Yes No

2.4. Which parts you use? 1) Feces 2) Stomach contents 3) Flash 4) Fur 5) Bile 6) Bone

If any other body parts of tree hyraxes were used to treat ailment? _____.

2.5. How do you take the medicine for remedy of the disease? 1) Oral 2) Dermal 3) Nasal

4) Ear canal. The healing of ailments have equal value of treatment in all age groups?

Yes No If any ways of administering _____.

Have differences in cure of disease in age groups. Yes

2.6. For what types of disease it cure? _____ Explain any others _____.

2.7. How to prepare the traditional medicine from tree hyraxes? 1) Fresh 2) Cooking

3) Powdered 4) Cooking and powdering

2.8. Do you have any taboo, religious case related with tree hyraxes? _____

2.9. What do you think about the use of these tree hyraxes for long times related with its value?

2.10. What do you think about their movement, feeding, sound, the time of they seen of tree hyrax in the forest? _____

Tell any unmentioned/missed points of the tree hyraxes about medicinal use.

