ADDIS ABABA UNIVERSITY

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ECOLOGY OF THE GIANT MOLERAT, *TACHYORYCTES MACROCEPHALUS* (Rüppell, 1842) WITH EMPHASIS ON THE FEEDING ECOLOGY FROM THE SANETTI PLATEAU OF BALE MOUNTAINS NATIONAL PARK (BMNP), ETHIOPIA.

BY:

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***ABSTRACT*:** Studies on the feeding ecology, habitat use, activity pattern, and structure of the burrow system and population density of the giant molerats were carried out on Sanetti Plateau, BMNP from March, 2006 to January, 2007 covering both wet and dry seasons. The consumed plant materials and hay pile components from ten samples indicated that *Alchemilla abyssinica* and *Festuca* species were the major food items in terms of percentage frequency and dietary occurrence. Stomach contents from four animals and ten faecal samples showed higher percentage of dicots than monocots (X^2 = 23.8, df = 1, P< 0.01). In addition, different species of dicots were also consumed. Although there was a preference of occurrence, all plant materials surrounding the feeding holes were gathered. A large proportion (75. 6%) of time was spent under the ground compared to above ground activities. Out of the above ground activities, feeding consumed larger time compared to time spent for observation and digging. There was no significant difference on size and length of the burrow system between wet and dry seasons as well as between more and less populated areas(X^2 = .0.4, df= 1, P > 0.05). The mean estimated population density from ten plots was 6545/ $km.^2$ Giant molerat is a solitary animal, which mutually interacts with the alpine chat.

1. INTRODUCTION

In a natural ecosystem, wildlife interacts through various functional activities and ecological processes. This maintains wildlife in their natural habitats and promotes a crucial ecological course of action that links them in their ecosystem (Crawley, 1997).

Ethiopia is considered as one of the major centers of biodiversity in the African continent. This is related to the physical and climatic diversity of the country (ORLNRAA, 2004). Thus, its relief comprises an altitudinal range from below sea level to 4620 m above sea level with 40% of the highlands above 2500 m (Afework Bekele and Corti, 1997).

The Bale Mountains National Park (BMNP), as part of the highlands of eastern Africa encompasses a variety of habitats that supports a diversity of wildlife species. The habitat types include grassland, woodland, heather moorland and Afro-alpine vegetation (Hillman, 1986a, 1993, Miehe and Miehe, 1994; Sillero-Zubiri, 1994; Marino, 2003).

The extreme climatic conditions in the highlands of Bale Mountains, determine the structure of the mammalian community (Marino, 2003). Among mammalian species, rodents play important part in the ecosystem in restructuring soils and vegetation (Delany, 1986).

The Afro-alpine habitats, in the Bale Mountains National Park mainly harbor a variety of rodent species (Hillman, 1986b, 1993; Stephens, 1997; Marino, 2003). The Afro–alpine rodents show diurnal activities as an adaptation to the harsh climatic conditions. They exhibit wide array of morphological form (Delany, 1986). Out of these rodent species, the giant molerat (*Tachyoryctes macrocephalus*), is an important component of the ecosystem supporting the endangered and endemic Ethiopian Wolf (Sillero-Zubiri, 1994; Sillero-Zubiri and Gottelli, 1992, 1994).

The giant molerat, is endemic to the Bale Mountains occupying Afro-alpine heath, moor and grasslands (Yalden, 1975, 1985; Hillman, 1986b, 1993; Shimelis Beyene, 1986; Yalden and Largen, 1992). *T. macrocephalus* belongs to the family Rhizomyidae, which comprises three genera: *Tachyorcytes* in Eastern Africa; *Rhizomys* and *Cannomys* in southeastern Asia (Yalden, 1975, 1985; Yalden and Largen, 1992).

Rüppell originally described giant molerats in the genus *Tachyoryctes*: from "Shoa" using specimens that were collected by another collector (Yalden and Largen, 1992). This locality is currently known as Wollo or Begemedir, in the Lasta area of Lalibela. But, the species has never been found on the western plateau of Ethiopia since its original description.

Erlanger and Neumann have collected specimens in 1900 from Bale province of southeastern plateau of Ethiopia and subsequently described as a distinct sub-species *T. m. heckii* (Neumann and Rummler, 1928). Since then, studies have been carried out to some extent by Yalden (1975, 1985), Shimelis Beyene (1986) Yalden and Largen (1992), Sillero – Zubiri (1994), Marino (2003).

The two African species of Rhizomyidae, the root rat, *T. splendens* (Rüppell, 1835), type locality Gonder, Ethiopia, and the giant molerat, *T. macrocephalus* (Rüppell, 1842), type locality "Shoa, Abyssinia" are differentiated mainly by their size. *T. macrocephalus* is heavier in body weight (300 to 1000 g) than *T. splendens* (160 to 280 g) in addition to morphological differences (Yalden, 1985; Yalden and Largen, 1992).

The distribution of two species of *Tachyorcytes* in east African habitat is uneven. *T. splendens* is widely distributed in the highlands of Eastern Africa from Ethiopia to Malawi and in the Cameroon highlands. However, *T. macrocephalus* is limited to high altitude Afro–alpine heath, moorland and grasslands of Ethiopia (Yalden, 1975, 1985; Yalden and Largen, 1992; Kingdon, 1997).

The giant molerat is currently confined to the southeastern Ethiopian Afro-alpine highlands of the Bale Mountains with high densities in the Sanetti Plateau, followed by Web Valley (Sillero–Zubiri, 1994; Marino, 2003).

T. macrocephalus possesses pale brown pelage to silver shades and paler ventrally. It is also short-limbed and tailed. Body is cylindrical with a comparatively large head. Ears are partially hidden in the hairs, but visible. Head and body length of adults ranges from 210 to 313 mm; ear length 7 to 15 mm; tail length 40 to 65 mm and hind foot length without the claw ranges 31 to 38 mm (Yalden1, 975).

The fur is thick–soft with quite variable color. Some are with shiny black whereas others have black coloration when young. A black patch also occurs on their eyelids. The eyes are small but visible and functional. Generally, the ventral parts are silvery and lighter than the dorsal parts. The incisors project as deep orange color and frequently used for cutting roots.

Giant mole–rats occur at estimated density of 63 individuals/ha in the Afro-alpine habitat (Yalden, 1975). The population density of these animals was estimated to range from 5.7/ha and 60/ha at Badeae and Sanetti, respectively (Shemelis Beyene, 1986). The mean minimum and maximum density of the giant mole–rat is estimated to range from 17 to 90/ ha in sub-habitats of Web Valley and Sanetti Plateau (Sillero-Zubiri, 1994).

The Afro- alpine habitats of BMNP are categorized based on the vegetation type, height of vegetation, slope and terrain (Newey and Sillero-Zubiri, 2002). *T. macrocephalus* mainly occurs within low herb dominated habitats, swamp communities, alpine short grassland, *Helichrysum* bush and other moorland habitats (Yalden, 1975, 1985; Shimelis Beyene, 1986; Sillero-Zubiri, 1994)

T. macrocephalus feeds by gathering vegetation from a newly opened burrow during the day time (Yalden, 1975, 1985). Yalden (1975) was the first to identify the stomach contents of giant molerats with the equal proportion of monocots and dicots. On Sanetti Plateau, giant molerats gather vegetation near to feeding holes (Yalden, 1975, 1985; Shimelis Beyene, 1986; Yalden and Largen, 1992; Sillero-Zubiri 1994, Marino, 2003).

Information on the reproductive and underground activity of the giant molerats is lacking (Yalden, 1985). However, there are some records of the above ground behavior and one young per litter is documented (Yalden, 1975, 1985; Shimelis Beyene, 1986 Yalden and Largen, 1992, Sillero-Zubiri, 1994).

T. macrocaphalus is diurnal and spends on average, an hour above the ground between 10:00 a. m. and 3:00 p. m. The proportion of time spent above ground is correlated with the functional activities of the species, 6% observing the environment, 20% shoveling earth out of the burrow entrance and 74% food gathering (Yalden, 1985).

From two days observation, Yalden (1975) noted that out of the 460 minutes each day, the molerats were active above ground for about 170 minutes.

They become exposed to the Ethiopian wolves when they come to collect vegetation, which they gather from their burrow entrance with hindquarters remaining below ground. After collecting, they retract into their deep burrows. At night, they plug their burrow entrance with soil to regulate the temperature inside the burrow. This unique behavior makes the giant molerat well adapted to survive in the harsh Afro–alpine climate (Yalden, 1975, 1985; Yalden and Largen, 1992)

The major predator of giant molerats is the Ethiopian wolf (*Canis simensis).* The other potential predators include *Buteo rufofuscus, Bubo capensis* and *Felis serval* at lower altitudes (Yalden, 1985). Even though giant molerats together with the other rodent species and hares support Ethiopian wolves, 47% by weight of the diet of the Ethiopian wolves is giant molerat (Yalden, 1985; Yalden and Largen, 1992). The top located eyes of giant molerats serve as escaping strategy from aerial enemies (Shimelis Beyene, 1986).

The burrow depth of giant molerat ranges from 10 to 15 cm from the surface. The diameter of the tunnel was between 12 and 15 cm with the narrow entrance that ranges from 6 to 9 cm (Yalden, 1975). The two sets of tunnels depth of giant molerats ranged from 8 to 26 cm and from 26 to 52 cm. The cross-sections of the tunnels were found to be circular with the mean diameter of 14 cm (Shimelis Beyene, 1986).

The excavated burrow system of a giant molerat was 34 m long linear and branched to others short tunnels. A burrow system is occupied by a solitary individual (Yalden, 1975). The findings of a complete excavated burrow system revealed also a longitudinal network of foraging tunnels. This was further branched into short lateral tunnels, which contained food and faece. The central nest was a point of radiation for tunnels in a burrow system (Shimelis Beyene, 1986).

Giant molerats produce two types of soil mounds, large mounds with a conical shape and plugged holes at the center and earth plugs of old feeding holes (Shimelis Beyene, 1986). On the average, 3.4 holes were used per animal per day at Sanetti (Shimelis Beyene, 1986).

Hay pile is formed periodically from dried and /or fresh plant parts with the faeces on old feeding holes. In the habitats of giant molerats, the composition of hay piles and the surrounding vegetation is correlated positively to each other (Shimelis Beyene, 1986). In a burrow system of *T. macrocephalus,* there was a single functional nest that comprised nesting materials, mostly grasses (Shimelis Beyene, 1986). The plugged feeding tunnels serve as storage chambers, which mostly possesses grasses and /or herbs (Yalden, 1975; Shimelis Beyene, 1986). The number of storage chambers in a burrow system varied with altitudes. From evidence of partially excavated burrow system, storage chambers are higher in number (4 chambers/6 m excavation) at higher altitudes and lower (1 chamber/90 m excavation) at lower altitudes (Shimelis Beyene, 1986). Inter-hole distance of higher altitudes was greater than lower altitudes. The inter hole distance on Sanetti ranged from 13 to 340 cm (Shimelis Beyene, 1986)

Information on environmental conditions of burrow systems of giant molerats is lacking. However, environmental conditions for burrows of two species of African molerats, *Georhychus capensis* and *Cryptomys damarensis* in South Africa revealed higher mean concentration of CO_2 and lower mean concentration of O_2 than the surrounding soils/air. The temperature in burrows of *G. capensis* ranged between 18.5^{0}C and 24.2^{0}C, whereas the ambient temperature ranged from 16.9^{0}C to 26.8^{0}C.

In burrows of *C. damarensis,* the recorded temperature ranged from 19.6 to 29.3^{0}C compared to the ambient, 8.6 to 36.8^{0}C. Thus, in both burrows, temperature was buffered against the surrounding temperature changes (Roper, 2001). The main objectives of the present study are to gather information on the feeding patterns and other ecological aspects of the giant molerats.

2. OBJECTIVES

2.1 GENERAL OBJECTIVES

The aim of the present study was to gather information on different ecological aspects of giant molerat *(T. macrocephalus)* with emphasis on the diet and feeding behavior in selected habitat types of Sanetti Plateau, Bale Mountains National Park (BMNP). The study will provide basic information on food source, food preference, habitat or niche use, burrow structure, feeding behavior and current population density of the giant molerat.

2. 2 SPECIFIC OBJECTIVES

♣ To identify the diet and habitat preference of the giant molerat.

♣To describe the activity pattern of *T. macrocephalus*.

♣ To identify the structure of burrow system of *T. macrocephalus*.

♣To assess the current population density of the giant molerat.

♣To recommend measures to conserve the endemic giant molerat that largely supports the endangered and endemic Ethiopian wolf.

3. The study area

The study area is part of the Bale Mountains National Park (BMNP) in south eastern part of Ethiopia, 400 km by road from Addis Ababa (Fig. 1).

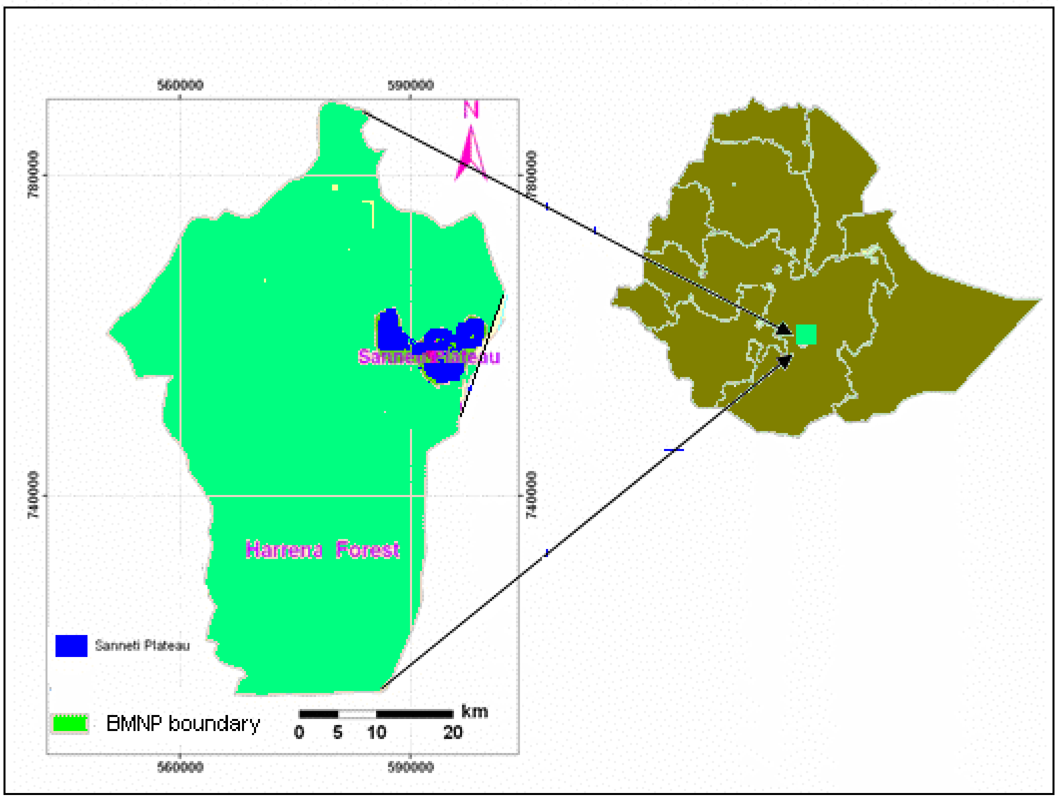

Figure 1. Location of the study area.

The Park is located between 6^0 29'and $7^0$10'N and $39^0$28' and $39^0$58'E. Its area is about 2,200 km^2 with altitudes ranging from 1,500 to 4,377 m above sea level. The Bale Mountains National Park was established in 1970 primarily for the conservation of the Mountain Nyala and the Ethiopian wolf. However, it still remains ungazetted (Hillman, 1986, 1993; Hedberg, 1986; Sillero- Zubiri and Gottellii, 1994, 1995).

The Bale Mountains National Park comprises many unique and diverse fauna and flora with the largest Afro-alpine (1000 km^2) and moist tropical forest in Africa. The Park is also a conservation site for major water catchments and a center of endemicity (Hillman, 1986, 1993; Hedberg, 1986; Sillerio-Zubiri, 1994).

The Bale Mountains National Park comprises five ecological zones that include the northern grasslands and woodlands, the heath moorlands (3,100-3,400 m above sea level), the Afro-alpine grasslands and moorlands above 3,400 m, and the Southern Harenna Forest (1,500-3,200 m above sea level) (Lisanework Nigatu and Mesfin Tadesse, 1989). The distribution of the vegetation in the Park is correlated with altitudes that vary based on climatic conditions. (Hedberg, 1986; Hedderg and Edward, 1989; Miehe and Miehe, 1994; Nauke, 2001).

The northern, grasslands and woodlands of the Park are dominated by *Hagenia abyssinica,* Sagebrush (*Artemesia afra*), Red-hot poker, (*Kniphfofia sp.), Nepata biloba, Juniperus* and *Podocarpus species* (Miehe and Miehe, 1994). The heath moorlands encompass mainly *Erica arborea* and *Hypericum* species. The Afro–alpine grasslands with altitude greater than 3,400 m above sea level mainly comprise *Erica arborea*, *Helichrysum* species, *Alchemilla* species, short alpine grass species and Giant lobelia. The southern part of the Park, Harenna Forest encompasses about half of the total area (Hillman, 1986, 1993; Hedberg, 1986; Lisanework Nigatu and Mesfin Tadesse, 1989, Menassie Gashew and Mesresha Fetene, 1996).

The faunal distribution is also not uniform throughout the Park. The major mammalian species in the northern woodlands and grasslands include the endemic Mountain Nyala, reedbuck, Menelik`s bushbuck, grey duiker, warthog, olive baboon, black and white colubus, golden jackal, spotted hyaena and serval cats (Stephens, 1997). At higher altitudes of rocky habitats, klipspringer and rock hyrax occasionally occur (Stephens, 1997).

The central Sanetti Plateau, supports the Ethiopian wolf (*Canis simensis),* giant molerat (*T. macrocephalus*) , Stark's hare *(Lepus starki*) and other densely populated rodent species. A variety of bird species also occur in these habitats (Hillman, 1986, 1993; Stephens, 1997; Lavrenchenko, 2000).

The upper geological strata of the Bale Mountains are mainly volcanic. The soils are largely formed from trachyte and basalt rocks, fertile silty loams with reddish brown to black color. The soil profiles have similar soil properties with clay fraction of the silt loams (10-15%) and chlorite dominate. The profile from the upper Harenna escarpment has higher proportion of sand and gravel than clay–minerals in the top soils. The top soil of the *Hagenia–Juniperus* forest has high proportion of organic carbon contents (Weinert and Mazurek, 1984 as cited in Miehe and Miehe, 1994). The eastern Sanetti Plateau possesses a high content of phosphorus (143 ppm) as a result of frequent fire in this area.

The Sanetti Plateau is the major Afro- alpine habitat with altitudinal range from 3,800 to 4,377 m above sea level. The name of the plateau is derived from harsh climatic conditions of Oromo word "Sanett" to mean "the area where strong wind blows."

The extreme climatic condition and burrowing activities of rodents in the area determined the type and distribution of the vegetation. The dominant plant species within this range of altitudes include *Helichrysum* scrubs such as *H. splendidium* (30 to 50 cm), *H. citrispinum* and *H. gofanse* (Hillman, 1993, Miehe and Miehe, 1994; Sillero-Zubiri, 1994, Marino, 2003). In areas of relatively lower altitudes of Sanetti Plateau, herbaceous communities, short tussock grasses, rosette plants, cushions and mosses are the prominent species (Miehe and Miehe, 1994; Marino, 2003). Afro-alpine herbaceous communities are largely dominated by *Alchemilla* species, which are the main habitats of giant molerats and other rodent species (Hillman, 1986, 1993; Sillerio-Zubiri, 1994, 1995; Marino, 2003).

4. Materials and Methods

4.1 Materials

The materials used during the study periods include Global Positioning System (GPS), live traps (15–30 m nooses), binoculars, dissecting kits, spring balance, camera, 70% - 90% ethanol, plastic bags, test tubs, petri dish, slides, microscope, distilled water, rulers, tape measure, compass and digging tools.

4. 2 Methods

A preliminary survey in the present study sites was conducted during March - April 2006. During this period, observations were made to gather information on the topography, vegetation type and coverage, climatic conditions, distribution of giant molerats and habitat types.

During the detailed investigations, during June-January, 2007, different approaches were used in data collection and diet identification of giant molerats. Quadrats, 0.5 m x 0.5 m were marked outside active molerat burrows, where the molerat was foraging.

The number of plants in each species was counted before and after each feeding hours. The counting was conducted during early morning (beginning of the activities and late afternoon (termination of activities) per day. Two different qoudrats, each within the ten foraging radius were sampled for both seasons. Thus, data were collected twice in each season.

Ten hay pile samples, measuring 0.2 kg each, were collected from periodically deposited old and /or fresh hay piles of functional holes in each season. The fragments of individual plant species in each hay pile sample were counted soon in sampled sites. The types of plant species and portion of the individual plant involved in the diet of giant molerats were recorded. Shoots and roots of the individual plant species were counted separately.

Fresh faecal pellets of giant molerats were collected randomly from the study area during both wet and dry season. A total of ten independent faecal samples, each with four pellets, were collected in each seasons. These were preserved in 70 % alcohol and latter used for analysis in the laboratory. Each faecal sample was washed, filtered and dried separately for observation under the microscope. Four slides were observed for each sample. The diet components were recorded by counting each fragment as monocot, dicot and undifferentiated (Putman, 1984).

For the stomach content analysis, four giant molerats were caught from different habitats during the two seasons. They were caught with the help of 15 to 30 m nooses-live trap (Plates 1 and 2). These were preserved in 70 % alcohol and latter used for analysis in the laboratory. Each sample was washed, filtered and dried separately for observation under the microscope. Four slides were observed for each sample. The diet components were recorded by counting each fragment as monocots, dicots undifferentiated.

July, 2006 by Mohammed Y.
Plate 1. Preparation hfor live trapping on Sanetti Plateau.

July, 2006 by Mohammed Y.
Plate 2. Giant molerat captured with the help of 15 to 30 m nooses-live trap.

Hide observations were also used to collect photographs, to record feeding pattern and ecological interactions.

To estimate the population density of giant molerats, suitable habitat was estimated along a two km line transects in a four square km area. Ten plots, 20 m x 20 m, were observed randomly in this habitat. Each quadrat was observed for a day and recorded at five minutes intervals. The maximum numbers of above ground individuals were taken as the population present for estimation.

To measure the time spent in each activity above and under the ground during the day time, nine individual animals were observed for nine days during each of the seasons.

The time spent for underground stay, observing, digging and feeding/ collections was recorded. This was carried out during the active time interval of an animal during the day and recorded.

Data on weather conditions were also recorded randomly at different sampling points and habitats. The Ethiopian wolf and livestock disturbances were also recorded. The number of holes used by a single animal and the foraging distance from each new hole was recorded. Additional ecological information was also noted using direct observation.

Burrow systems of the giant molerats were excavated at Sanetti. Four excavation sites were selected on active holes from more and less populated areas. Two sites were taken for each. Two were located in swamp area and the other two in *Alchemilla– Festuca* habitats. During excavation, tunnels were followed to get the end points. Tunnels were terminated at either nest or water logged or surface signs. However, some branches of tunnels were not terminated and it was difficult to follow directly up to the surface signs. During excavation, the excess soil was removed from the tunnels for measurements.

The internal structures and exposed parts of tunnels were measured and recorded. Data including the diameter of fresh feeding holes, internal tunnels, nest, branch number, number of individuals per system, depth from surface and length of excavated burrow were measured and recorded.

New holes (10 during the wet season and 12 during the dry season) were selected to record foraging distance and diameter of entrance points.

5. Results

Measurements and altitude for four captured giant molerats are given in the Table 1. Physical appearance of the animal is shown in Plate 3.

Table 1. Measurements of captured mole rats.

Parameters	**A**	**B**	**C**	**D**
Weight(g)	750	750	750	1,200
Sex	Female	Female	Female	Male
Head and body length (cm)	33	32	29	34
Tail length(cm)	6	6.4	5.5	6
Ear length(cm)	0.6	0.6	0.6	0.6
Hind foot length(cm)	6	6.2	5.5	6.5

Length of lower incisor(cm)	2.6	2.6	2.4	2.6
Length of upper incisor(cm)	1.5	1.5	1.4	1.5
Altitude(m)	4117	4103	4119	4120

A-D=Animals

July, 2006 by Mohammed Y.

Plate 3. Giant molerat from Sanetti Plateau.

A total of 1257 fragments of plants were gathered from 2, 906 counted number before feeding hour (available) plant materials on the surface of newly opened holes(plate 4) . This comprised 657 (52.3 %) *Alchemilla abyssinica,* 379 (30. 2 %) *Festuca* species, 163 (13 %) *Trifolium* species and 58 (4.5 %) other species.

The consumption was high during the wet season (X^2= 11.65, df = 1, P < 0.05). Percentage dietary occurrence, selectivity and availability were high for *A. abyssinica* and *Festuca* species (Table 2).

July, 2006 by Mohammed Y.

Plate 4. A newly opened burrow entrance.

Table 2. Percentage of dietary occurrence and selectivity of total eaten from available plant species during wet and dry seasons.

Plant species	Wet season			Dry season			Total	%
	Available	Consumed (% d.o.)	%sele-cted	Available	Consumed (%d.o.)	% selected	Consumed	
Alchemilla abyssinica	671	381(553)	56.8	537	276 (49)	51.4	657	52.3
Festuca species	499	232(33.7)	46.5	372	147 (26)	39.5	379	30.2
Haplocarpha rueppelli	120	6(0. 9)	5	284	1(0.2)	0.4	7	0.6
Trifolium species	114	46 (6.7)	40.4	363	117(21)	32.2	163	13
Satureja simensis	43	11 (1.6)	25	21	7(1.2)	33.3	18	1.4
Helichrysum								

gofanse	25	5 (0.1)	20	13	3 (0.5)	23.1	8	0.6
other plant species	87	8 (1.1)	9.2	67	17 (3)	25.4	25	2.0
Total	1559	689(100)	100%	1347	568	100	1257	100

(% d. o.) = Percentage dietary occurrence

Consumed=gathered plant fragments in number
Available= the number of plants in each species counted before feeding hour

Among the consumed plant species, shoots and roots in the hay pile was high during the wet season and low during the dry seasons respectively (Table 3). There was a significant difference between wet and dry seasons consumption (X^2= 58.8, df=1, P< 0.01).

Table 3. Percentage of shoots and roots from consumed plant species in wet and dry seasons.

	Wet season				Dry season			
Cosumed plant species	Shoot	%	Root	%	Shoot	%	Root	%
Alchemilla abyssinica	237	62.20	144	37. 80	112	40.58	164	59.42
Festuca species	218	93.97	14	6.03	40	27	107	72.79
Haplocarpha	1	14.29	6	85.71	_	_	3	100

rueppelli								
Trifolium species	34	73.91	12	26.09	50	42.74	67	57.26
Satureja simensis	11	100	-	_	-	_	7	100
Helichrysum gofanse	1	20	4	80	_	_	3	100
other plant species	5	62.5	3	37.5	6	35.29	11	64.71

Out of the total 3455 hay pile fragments, 1521 (44 %) comprised *Alchemilla abyssinica*, 1565 (44.3%) *Festuca* species, and 83 (2.4%) *Alchemilla species.* There were higher proportions of *Festuca* species and *A. Abyssinica* throughout the year (X^2= 0.05, df= 1, P > 0.05). *A. abyssinica* and *Festuca species* were also obtained with higher percentage of dietary occurrence (Table 4).

Table 4. Hay pile components in percentage dietary occurrence during the wet and dry seasons .

Hay pile components	Wet season		Dry season		Total	Percentage
	Counted fragments	% dietary occurrence	C. F.	%D.O.		
Alchemilla abyssinica	604	39.0	917	48.2	1521	44.0
Festuca species	752	48.6	813	42.7	1565	44.3
Alchemilla species	54	3.5	29	1.5	83	2.4
Rumex abyssinicus	22	1.4	13	0.7	35	1.1
Saliva nilotika	29	1.9	22	1.2	51	1.5
Helichrysum gofanse	20	1.3	7	0.4	27	0.1
Trifolium species	7	0.5	37	1.9	44	1.3
Haplocarpha Rueppelli	6	0.4	2	0.1	8	0.2
Galium aparinoides	24	1.6	9	0.5	33	1.0

Senecio species	4	0.3	21	1.1	25	0.7
Helichrysum citrispinium	7	0.5	3	0.2	10	0.3
Mosses	11	0.7	17	0.9	28	0.8
other plant species	8	0.5	14	0.7	32	0.9
Total	1548	100	1904	100	3455	100

C. F. = Counted Fragments%, D. O. = Percentage Dietary Occurrence

Percentage of pushed back shoots was high, where as low for roots. Percentages of roots were in general low in the hay pile during the dry compared to the wet season (X^2 =31, df=1, $P < 0.01$; Table 5).

Table 5. Percentage of shoot and root from hay pile components.

Hay pile components	Wet season				Dry season			
	Shoot	%	Root	%	Shoot	%	Root	%
A. abyssinica	558	92	46	8	893	97	24	3
Festuca species	573	76	179	24	701	86	112	14
Alchemilla species	22	41	32	59	18	62	11	38
Rumex abyssnicus	15	68	7	32	11	85	2	15
Saliva nilotika	21	72	8	28	19	86	3	14
Helichrysum gofanse	11	55	9	45	5	71	2	29
Trifolium species	4	57	3	43	33	89	4	11
Haplocarpha rueppelli	5	83	1	17	2	100	-	_
Galium aparinoides	18	75	6	25	3	33	6	67

Senecio species	3	75	1	25	18	86	3	14
H. citrispinium	5	71	2	29	2	67	1	33
Mosses	7	58	5	42	11	65	6	35
other plant species	6	75	2	25	9	64	5	36

A total of 589 fragments were counted from four stomach samples. Monocots comprised 179 (30.4%), dicots 284 (48.2%) and others 126 (21.4%). Dicot fragments were at a higher proportion than monocots ($X^2 = 23.8$, df = 1, $P < 0.01$; Table 6).

Table- 6: Stomach contents from four captured giant molerats

Animal	Monocots	Dicots	Others (undifferentiated)	Total
A	26	75	35	136
B	55	68	36	159
C	39	69	26	134
D	59	72	29	160

Total	179	284	126	589
Percentage	30.4	48.2	21.4	100

A total of 2705 faecal fragments (n=10) were counted. Out of these, dicots comprised 1318 (48.7%), monocots 864 (32%) and others 523 (19.3%). Dicots occurred at a higher proportion than other components (X^2 =47.231, d.f.=1, p< 0. 05; Table 7).

Table- 7: Faecal contents

Seasons	Monocots	Dicots	Others (unidentified)	Total fragments
Wet (n=10)	490	691	252	1433
dry (n=10)	374	627	271	1272
Total	864	1318	523	2705
Percentage	32%	48.7%	19.3%	100%

The number of bites per appearance (per out to the surface) varied from 3 to 15. Giant molerats gathered all parts of the plant materials (roots and shoots) and carry them to the holes. However, they collect only above ground parts of plants where it is difficult to dig.

The distance of areas from where food plants were collected varied seasonally. The preference on the surface among plant species was low. Giant molerats avoided rocky, hilly and outcrop sites. They frequent low herbaceous, alpine short grasslands and swamp vegetation communities.

Giant molerats appear through new holes that are either not covered or covered by plants. Bareland (not covered) holes are avoided and holes covered by plants are frequented. They do not appear on bare land sites for foraging. They either plug the bare holes or ignore them.

During foraging, fighting was observed between two animals where approach the same newly opened hole. Frequent fight was observed when two live captured animals were kept together. The major activities of the giant molerats on the surface were observing, digging, and foraging.

Out of a total of 2039 minutes observation, 1541 (75.6 %) underground, 308 (15. 1 %) feeding, 99 (4. 9 %) digging and 91 (4. 4 %) observations were spent during both dry and wet seasons (plates 5-7). There was no significant difference between dry and wet seasons in the activity patterns (X^2 = .0.4, df= 1, $P > 0.05$; Table 8; Figs. 2, 3).

July, 2006 by Mohammed Y.

Plate 5. Giant molerat observing the environment.

July, 2006 by Mohammed Y.

Plate 6. Giant molerat digging at burrow entrance.

July, 2006 by Mohammed Y.

Plate 7. Giant molerat gathering food.

Table 8. Time spent in minutes above the surface and under ground.

Seasons	Underground	Observation	Digging	Feeding	Observation period
Wet	730	40	38	190	998
Dry	811	51	61	118	1041
Total	1541	91	99	308	2039
Percentage	75.6	4.4	4. 9	15.1	100

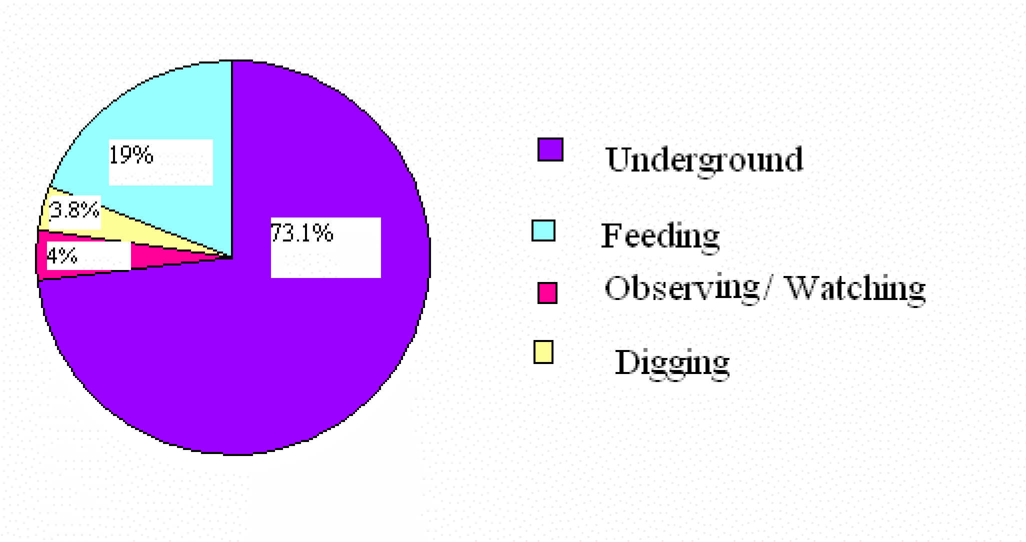

Figure 2. Time spent in different activities during the wet season.

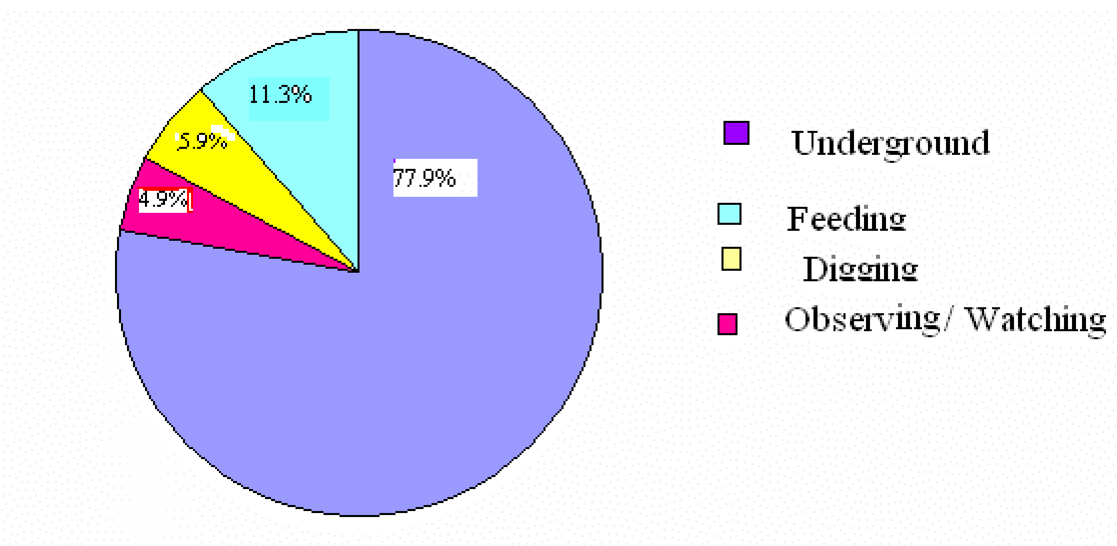

Figure 3. Time spent in different activities during the dry season.

The average foraging distance from feeding holes was 31.2 and 31.6 cm during wet and dry seasons, respectively (P>0.05). The average diameter of the feeding hole entrance was 9.42 and 9.39 cm during wet and dry seasons, respectively (Table 9). There was no significant difference between wet and dry seasons in foraging distances and diameter of feeding holes.

Table 9: Mean value of foraging distance and feeding holes diameter (in cm) of the giant molerats, during wet and dry seasons.

Seasons	Mean foraging distance from feeding holes (cm)	Mean diameter of feeding holes(cm)
Wet	31. 2$\pm$2.6	9.42$\pm$2.2
Dry	31. 6$\pm$3.2	9.39$\pm$2.4

Diameter of entrance and internal tunnel, branch number and depth of the burrow in areas high and low density is given in Table 10. There was no statistical difference in the size of burrow system in areas of higher or low density (p>.o5).

Table 10: Physical features of the burrow systems in less populated and densely populated areas.

Density /ha	Excavated distance(m)	Feeding holes Diameter(cm)	Internal tunnel diameter(cm)	Number of branch per burrow system(cm)	Nest per burrow system	Depth from surface (cm)
More	13. 37	9. 3	10.9	7. 5	1	23
Less	15.23	9.4	11.2	8. 1	1	21
Mean	14.3	9.35	11.1	7. 8	1	22

The population density during the wet season was 6750/ km^2 whereas the density during the dry season was 6340/ km^2 with the total count 45 per 4,000 m^2 and 43 per 4,000 m^2, respectively.

It was observed that among the rodent species, *T. macrocephalus* was a major prey for Ethiopian wolves. During the dry season, hunting and capturing were easier than during the wet season. Among the bird species, *Buteo rufofuscus* was frequently observed hunting on *T. macrocephalus.*

When predators approach, both rodents and birds (Alpine chat) produce sound, and the giant molerat responds by retracting into tunnels. Giant molerats provided soil microorganisms (food for Alpine chat) while digging, whereas Alpine chats forward alert sound to help them escape from predators. During the dry season, migration towards the wetlands and covered habitats was observed.

5. DISCUSSION

Although there was a difference in weight between females and a male, there was no significant difference in other measurements. This goes in line with other studies reported at different times (Yalden, 1975, 1985; Shimelis Beyene, 1986; Yalden and Largen, 1992)

In the present study, hay piles comprised a larger percentage dietary occurrence of *Alchemilla abyssinica* and *Festuca* species. The possible explanation for this could be the availability and relative preference of these plants in the surrounding surfaces of feeding holes (Shimelis Beyene, 1986). The surrounding surfaces might be extended up to 15 m from feeding holes. The size of a hay pile deposition varies seasonally. During the wet season, the deposition was large compared to the dry season. This could be as a result of seasonal fluctuation in the availability of plant species. The availability decreased during the dry season. Hay pile depositions did not occur on all feeding holes. Higher consumption of *Alchemilla abyssinica* and *Festuca* species among the hay piles suggests that they were preferred species.

In the current study, there was a positive relationship between hay piles components and consumed plant materials. In both cases *A. abyssinica* and *Festuca* species were higher in percentage dietary occurrence. In both methods, there were also similarities of results in the varieties of vegetation.

Out of the total 1257 consumed fragments, the majority were *Alchemilla abyssinica, Festuca* species and *Trifolium* species. This could be as a result of availability, selectivity and palatability of these species in the habitats of giant molerats. This suggests that *A. abyssinica*, *Festuca* species and *Trifolium* species were major contributors to the diet of giant molerats compared to the other species.

The proportion of dicots was higher(48.2%) compared to monocots(30.4%) in the stomach content of four individual giant molerats. This suggests that dicots are the frequent plants in the food compared to monocots. This is also shown in the components of the hay pile. Although only few animals were examined for stomach contents, hay pile and faecal component analysis also confirm this. There were two reasons for limitation of data in this part: the difficulties to trap giant molerats (Shimelis Beyene, 1986), particularly during the dry season. The low availability of vegetation increases the sensitivity of the animals. No attempts was made to sacrifice individuals as this is one of endemic species with the local distribution in a protected area. In the faecal analysis, dicots contributed a major proportion of fragments compared to monocots.

The higher proportion of dicot fragments suggests that dicot plants are the major part of dietary items for giant molerats. The results obtained from faecal analysis goes in line with the results obtained from stomach contents.

In the analyses of consumed plant materials and hay piles components, *Alchemilla abyssinica* and *Festuca* species occurred at a higher percentage dietary occurrences. The results from faecal analysis together with these suggest that in addition to *A. abyssinica*, the other recorded vegetation taxa are also more of dicots.

In the present study, the proportion of parts (roots and shoots) of plant species varied from sampling plot to plot. This is because of the differences in soil hardness. On the areas where the soil is loose to dig, the animals collected both parts of plant species whereas on soils that are too hard to dig, they gathered only above ground parts (mostly shoots) of the plant materials. In the current study, more shoots were consumed during wet and more roots during dry seasons. All different species of plants collected around the feeding holes show similarity with the previous reports by Yalden (1975, 1985), Shimelis Beyene (1986), Yalden and Largen (1992), Sillero-Zubri (1994) and Marino (2003).

The observed foraging distances varied widely. This could be as a result of variation in the availability of the food materials as well as disturbances.

In this survey, the feeding holes were either bare or covered with vegetation. However, they were not equally operational. During the initial foraging activity, giant molerats either appeared randomly in holes but immediately change from bare holes to covered ones or dig new holes.

In the present study, the two captured adult female giant molerats fought each other when they were kept in the same enclosion. During foraging activity, they were also seen fighting each other once, when they come out from the same feeding hole. This is probably because *T. macrocephalus* is a solitary animal. This idea is shared in the reports made by Yalden (1975, 1985), Shimelis Beyene (1986), Yalden and Largen (1992).

During diurnal observation, more time was spent underground in comparison to the time above ground. Feeding was the most pronounced activity above ground. The sensitive nature of the animal for disturbance might have contributed to more time spent underground.

There were no significant differences in the time spent above ground and underground activities between dry and wet seasons. During rain, the activity observed on the surface was limited. Scattered vegetation increases foraging distance of the animal, which also increases exposure to predator in the feeding area. As a result, the animals prefer to be under ground.

In this observation, the average diameters of feeding holes were constant throughout the study period. The feeding hole diameter largely concides with the size of animals but not with the variation in weather. The often broken soils on the nearby feeding holes made unusual shapes and this was not considered.

The estimated mean population density was 6540/km^2 on the Sanetti plateau. Different figures have been reported at different times on the estimation of population densities of giant molerats. Although there was a difference in the method of estimation, the result obtained from this finding agrees with the densities 6,300/km^2, 570/km^2 to 6000/km^2, and 1700/km^2 to 9000/km^2 reported by Yalden (1975), Shimelis Beyene (1986), and Sillero-Zubiri (1994) respectively

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Analysis on consumed plants and hay pile composition suggests that *A. abyssinica* and *Festuca* species were the major dietary items of the giant molerats in the Sanetti Plateau. Similarly, analysis of stomach contents and faeces indicated that dicots were the frequent food items of *T. macrocephalus.* Furthermore, on visual observation, all plant species on the surface of feeding holes were taken. Therefore, on the Afro-alpine parts of BMNP, it is possible to conclude that *A. abyssinica* and *Festuca* species are the two significant food items for giant molerats. On estimation of population densities, the obtained mean value was in the ranges of the previous findings (Yalden, 1975; Shimelis Beyene, 1986; Sillero-Zubiri, 1994).

T. macrocephalus is a solitary animal that spends more time under ground rather than on the surface. Of the three surface activities (observation, digging, and feeding), more time is devoted to feeding. The survey, on the physical surface and structure of burrow system indicated signs of presence/ absence of giant molerats in the area. The physical patterns of burrow systems were uniform and mainly related to the size of individual animals and soil characters rather than climatic factors throughout the year.

Observation on ecological interactions indicated that there were mutual benefit of (Alpine chat with giant molerats) and prey-predator relationship of giant molerat with the Ethiopian wolves and raptors on the Afroalpine habitats of the BMNP. These food chains help to balance the interactions in the ecosystem.

6. 2 Recommendations

Based on the obtained results of the present and study reviews of previous works, the following points are recommended:

- *Alchemilla abyssinica* with the other dicots and *Festuca* species are the most likely dietary items of the giant molerats. The endemic giant molerat is also a major dietary part for critically endangered Ethiopian wolf. So, sound management priorities must be taken to minimize disturbances by livestock in the area.
- Conservation program for endemic giant molerats in the BMNP should be established by NGOs and GOs.
- More attention should be given to giant molerats and their niche in the management plan of the Ethiopian Wolf Conservation Program.
- The identified, major food items of plant species should be conserved to keep the chain of balance of these endemic species.
- Further, long term research should be carried out on the reproductive

patterns of this endemic species.

7. APLLICATION OF THE RESULTS

The study on the ecology of giant molerats in the BMNP provides information on diet use, habitat use, activity patterns, population densities, and other ecological aspects. This information will be of great importance in the planning and management of the conservation of the endemic giant molerats and the predator, the endemic Ethiopian Wolf. They are a major resource use for the critically endangered Ethiopian wolf (major predator) on the Afro alpine habitats of the BMNP. This information will also be useful to increase the awareness of people on the ecology and behavior of *T. macrocephalus*.

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