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Master's Thesis

**Population census and ecology of a rare gelada population
(*Thereopithecus gelada* unnamed sub-sp.) in Indato, eastern
Arsi, Ethiopia**

by Kelil Abu

Advisor: Prof. Afework Bekele

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ABSTRACT

Gelada baboon (*Theropithecus gelada*) belongs to one of the few primate genera endemic to Ethiopia. *Theropithecus gelada* is the only living species of its genus. The present research was conducted from August 2010 to May 2011 to determine the habitat preference, population size, feeding ecology, distribution pattern, activity and ranging patterns of the gelada baboon sub-species (*Theropithecus gelada* unnamed sub-species), in Indato cliff, eastern Arsi, Ethiopia. Vegetation composition in the home range was determined by quadrat sampling method. The activity pattern, feeding ecology and ranging behaviour were studied with 15 minutes interval scan sampling. The population size of the geladas was determined from total (direct) count. A total of 529 individuals were recorded with a density of 0.34 gelada baboon/km². Feeding comprised the major activity (41.73%), followed by moving (20.27%), resting (18.98%), grooming (9.2%), playing (5.1%), aggression (3.26%), sexual activity (1.43%) and drinking (0.03%). Adult females spend 45.77% of the time feeding and 15.71% of their time resting. Adult males spend 39.23% of their time feeding and 29.21% through resting. The overall diet composition of gelada baboon was dominated by short grass blades contributing to 34.87%. Grass roots and long grass blades made the second and third largest portion of the overall diet of gelada baboons at 25.24% and 18.67%, respectively. Gelada baboon also consumed unidentified tubers (7.54%), herb leaves (7.30%), others (3.01%), herb roots (1.69%) and corms (1.67%). Gelada baboon consumed a total of 10 plant species which accounted for 100% of their diet over the course of the study period. Of these, the top four accounted for 97.21% of their overall diet. Jaldoo (*Hyparrhenia* sp) contributed 49.37% and Qarasoo (*Hyparrhenia hirta*) contributed 38.11% of their diet. The mean daily range length for the study troop was 1004.6 m and the average home range size was 4.91km². The narrow ecological niche of the species may be a threat for its survival due to grazing by cattle. Appropriate management action should be taken to conserve the species and their most important food resources.

Key words: Activity, diet, Gelada baboon, home range, Indato Forest, population size

DEDICATION

This thesis is dedicated to my mother Shamsiya Dawud and my father Abu Dale for their love and support and to My Advisor Prof. Afework Bekele for his help, sharing ideas and generosity in all this work.

1. Introduction

Ethiopia has long been recognized for its richness in natural resources (Jacobs and Schloeder, 2001). Ethiopia possesses a diverse mammalian fauna of 284 species of 52 families (Cole *et al.*, 1994), of which, 31 species are endemic (Jacobs and Schloeder, 2001). The high level of endemism in the fauna of Ethiopia is related to the large extent of highlands. The variations in temperature and rainfall in different habitats have led to the diversity of species (Yalden, 1983).

Primates occupy a wide range of habitats, even though they are a relatively small order. In addition, they occupy a wide diversity of ecological niches (Robbins and Hohmann, 2006). Africa has the largest primate fauna. There are 175 species and sub-species of primates listed in Africa (Grubb, 2006)

Different species and subspecies of primates occur in Ethiopia. These are Bush baby or Senegal lesser galago (*Galago senegalensis*) and Somali lesser galago (*Galago gallarum*) (Butynski and de Jong, 2004), Hamadryas baboon (*Papio hamadryas hamadryas*), olive baboon (*Papio h. anubis*), black and white colobus monkey (*Colobus guereza*), gelada baboon (*Theropithecus gelada*), grivet monkey (*Cercopithecus aethiops aethiops*), Black-faced vervet (*Cercopithecus aethiops pygerythrus*), Bale monkey (*Cercopithecus aethiops djamdjamensis*), De Brazza's monkey (*Cercopithecus neglectus*), Patas monkey (*Erythrocebus patas*), Sykes' Monkey (*Cercopithecus albogularis*) (Kingdon, 1997; Grubb *et al.*, 2003; Groves, 2005), two subspecies of blue monkeys (*Cercopithecus mitis stuhlmanni*) (Fairgrieve and Muhumuza, 2003) and *Cercopithecus mitis boutourlinii* (Kingdon, 1997).

Very few countries have endemic primate species. Ethiopia is fortunate to have an endemic Cercopithecine genus and species. Ethiopia is blessed with dozens of unique animals, many of them endemic to the Ethiopian highlands. Of these, three are endemic primate species/subspecies: the Bale monkey (*Chlorocebus aethiops djamdjamensis*), Boutourlini's blue monkey (*Cercopithecus mitis boutourlinii*) and the gelada baboon

(*Theropithecus gelada*). The latter belongs to one of the few primate genera endemic to Ethiopia. However the gelada taxonomy remains little investigated (Gippoliti, 2010).

The gelada (*Theropithecus gelada*) is an Old World monkey found only in the Ethiopian highlands, with large populations in the Semien Mountains. *Theropithecus* is derived from the Greek root word for "beast-ape." It is largely terrestrial, spending much of its time foraging on grasslands (McKenna *et al.* 1997).

Since 1979, it has become customary to place the 'gelada' in its own particular genus (*Theropithecus*). Gelada baboon are guenons whose taxonomy is a subject of much debate. According to Goodman (1998), this gelada should be grouped with its papionine kin; but according to McKenna *et al.* (1997), this species is even farther distant from *Papio*. While *Theropithecus gelada* is the only living species of its genus, larger species are known from the fossil record; *T. brumpti*, *T. darti* (Hughes *et al.* 2008) as well as *T. oswaldi*, formerly classified under the genus *Simopithecus* (Maeir, 1972).

The hierarchical classification of the Gelada baboon is as follows (Goodman, 1998):

Kingdom: Animalia

Phylum: Chordata

Class: Mammalia

Order: Primate

Family: Cercopithecidae

Subfamily: Cercopithecinae

Tribe: Papionini

Genus: *Theropithecus*

Species: *Theropithecus gelada*

Geladas prefer to sleep on rocky cliffs, from which they descend in the morning to forage in the nearby grasslands. Most of the gelada populations are found foraging in grasslands between 1500 and 4000 m altitude (Stammbach, 1987).

Male gelada baboons weigh an average of 20.25 kg. The body can reach from 69 to 74 cm in length while the tail is 45 to 50 cm long. Female geladas are smaller than males. They weigh an average of 14.8 kg and 50 to 65 cm in body length and their tail is 30 to 41 cm long (Van Hooff, 1990). Members of both sexes have short rostrums and wide nostrils. They have short brown fur and both males and females have a hairless patch on their chest, usually triangular in shape, which is outlined by white hairs. Both sexes have pale eyelids, which are used during expression. Males are marked by the presence of whiskers and a brown hairy mantle. Gelada is endemic to the Ethiopian highlands, the Blue Nile Gorge and the upper Wabi-Shebeli Valley, which mark the western and southeastern boundaries of their range, respectively (Woltheim, 1983).

Theropithecus gelada is currently divided into two subspecies; Northern gelada (*Theropithecus gelada gelada*) and Eastern gelada or southern gelada or Heuglin's gelada (*Theropithecus gelada obscures*), live in the northwestern “Rift Valley of Ethiopian highlands”. At present, geladas occur only in a few areas throughout the northern Ethiopian highlands. However, in the late 1980s, Mori and Gurja Belay (1990) found several new gelada populations in the Arsi region of the southeastern Rift Valley, Ethiopia. It is estimated that only about 50,000– 60,000 gelada baboons remain in the wild, and their numbers are thought to be declining. Forest fragmentation may cause local extinctions or a loss of genetic diversity (Lovejoy *et al.*, 1986). Before local extinctions occur, habitat fragmentation can have other, more subtle effects on the activity and the movements of the gelada baboons in their habitat. Increasingly, geladas come into contact with humans as local farmers expand their farm and livestock grazing to the steep hillsides once inhabited only by wildlife. Additionally, due to their specialized diet, geladas are severely affected by soil erosion and drought (Dunbar, 1998). At present, geladas have a restricted range. Continued human encroachment has resulted in a “rare” status assigned by the World Conservation Union (IUCN 2008) and are listed in Appendix II of the Convention of the International Trade in Endangered Species (CITES).

According to the population genetic analysis by Gurja Belay and Shokate (1998), the Arsi gelada population should be regarded as a distinctive sub-species (*Theropithecus gelada* unnamed sub-species). Furthermore, their physical appearances are different from the northern and central gelada population (Mori and Gurja Belay, 1990). The Arsi gelada also inhabits a lower altitude (1,800-2,300 m) than geladas elsewhere (Beehner *et al.*, 2007; Fashing *et al.*, 2010). The total population size is thought to be very small (perhaps only ~600), and their range of distribution is extremely restricted. The habitat of gelada at Arsi is disturbed primarily by human and grazing livestock (Gurja Belay and Shotake, 1998). The remaining gelada population is confined to a cliff and nearby livestock grazing and cultivation areas. Given the intense anthropogenic disturbance, geladas at Arsi face, are in a critical condition. As a result, the population status and ecology of this unique sub-species should be studied in detail and appropriate conservation actions are to be devised before it is too late.

Gelada baboons are classified by IUCN (2008) as “Least Concern”, a status which has been seriously questioned by recent surveys suggesting steep population decline in their Siamein Mountains stronghold (Beehner *et al.*, 2007). Furthermore, *Theropithecus gelada* unnamed sub-species is erroneously listed together with *Theropithecus gelada obscures* in the IUCN Red Listed category (IUCN 2008). This is a distinctive sub-species with a small remaining population currently threatened by extensive cultivation, human settlement, grazing, predation and elimination as a crop pest. Despite concern over the decline, there is no accurate census of the number of geladas living in eastern. We even have less knowledge about total numbers of geladas throughout Ethiopia. Accurate population estimates of geladas, as well as all of Ethiopia’s endemic species, are important for several reasons. First, population estimates across time will determine whether numbers of a particular species are maintained, in decline, or in recovery. Second, establishing accurate numbers for each species is a critical first step for conservation and wildlife management policies. Third, there have been increasingly more reports of human-gelada conflict in different areas, particularly with respect to crop-raiding. To date, no comprehensive gelada census of the area has been carried out. The most common method of censusing non-human primate population uses line transects

(Green, 1978; DeFler and Pintor, 1985; Brockelman and Ali, 1987; van Schaik *et al.*, 1995; Varman and Sukumar, 1995; Fashing and Cords, 2000). Because gelada individuals (and groups) are highly mobile and have a high degree of overlap with other geladas, calculating a species-specific mean group spread is not possible. A more accurate, though time-intensive, means of assessing primate population is through long-term monitoring of home range size and overlap in a population (Struhsaker, 1975; Brockelman and Ali, 1987; Chapman *et al.*, 1988; Whitesides *et al.*, 1988; Fashing and Cords, 2000). Direct count method requires the involvement of a large number of people to simultaneously cover all areas of interest. Furthermore, while a direct count avoids double-counting (because all animals are counted simultaneously), the results represent an underestimate of the total population. Therefore, independent census or estimates are necessary to determine the counting error. Despite these drawbacks, direct count may be the most effective method for determining population estimates of a species that (1) lives in wide open habitat facilitating visibility, (2) is easily detected by audible cues, (3) is highly mobile, and (4) has variable group sizes across time. The first two of the above characteristics are not true for geladas at Arsi. Furthermore, geladas are reliably found along cliff edges early in the morning, creating almost a “transect” where observers can find all individuals in a given area. For areas where we have additional data on population sizes, we compare the direct count from this census to our additional population estimates.

The ecology and behaviour of other geladas baboons have been relatively well studied. However, information on the ecology, conservation and behaviour of geladas at Arsi is lacking in fact, they remain one of Africa’s least known primates. In particular, there is inadequate data on the Arsi gelada baboon distribution, feeding ecology, activity pattern, habitat use, ranging behaviour and population biology. Due to this absence of data on its geographic distribution and population status, sofar the Arsi gelada area is unprotected (Gurja Belay and Shokate, 1998).

According to Grubb *et al.* (2003) and Addisu Mekonnen (2008), irrespective of the debate on the taxonomy of the species concerning information on taxonomic diversity

and distinctiveness, it is essential to examine the distribution pattern, ecology and degree of threat to establish priorities for long term conservation and management of the species. Thus, the objectives of the present study are to determine their distribution, conservation status, activity pattern, population status, habitat use, and feeding ecology of this little known endemic primate.

1.1. Objectives

General Objective

The goal of this study is to provide data on the distribution, population census, habitat use, feeding ecology, activity and ranging pattern of the rare gelada baboon subspecies (*Theropithecus gelada* unnamed sub-species), in Indato, eastern Arsi, Ethiopia.

Specific Objectives

- To determine the distribution.
- To assess the population census.
- To examine the habitat use.
- To identify the feeding ecology.
- To determine the activity and ranging patterns.

2. THE STUDY AREA AND METHODS

2.1. Location and topography

Indato area is part of the eastern Rift Valley of Ethiopia, which harbours diverse range of endemic fauna and flora (Myers *et al.*, 2000). It covers an area of 1,565 km² and located 420 km east of Addis Ababa (Figure 1). Indato forest is located to the northeast of Bale Mountains National Park (BMNP). The area is unprotected. The study area is a lowland consists of forested cliffs and valleys bisected by Wabe River. The altitude ranges from 1180 to 2434 m above sea level.

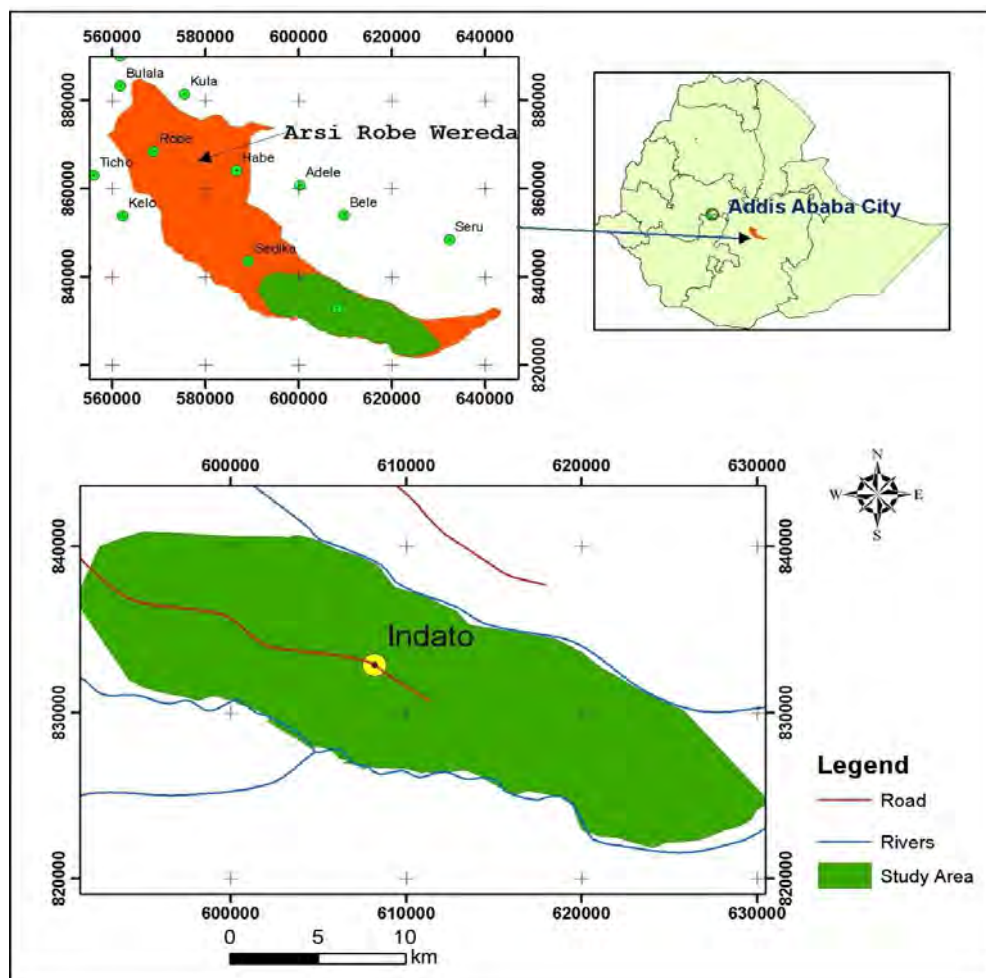


Figure 1. The main study area, Indato Forest.

2.2. Fauna

Besides the study animal, other mammals observed in the area included: Anubis baboon (*Papio hamadryas anubis*), hamadryas baboon (*Papio hamadryas hamadryas*), wartog (*Phacochoerus africanus*), Leopard (*Panthera pardus*), Abyssinian black and white colobus (*Colobus guereza*), common jackal (*Canis aureus*) and common duicker (*Sylvicapra grimmia*).

2.3. Vegetation

The Indato area is classified into Dugida Goro forested cliff, Hadan Guri cliffs, grassland and bushland. Dugida Goro forest habitat contains dominant *Dodonaea* trees (*Dodonaea angustifolia*) (Sapindaceae) with mixed other tree species such as *Rubus apetalus* (Rosaceae), *Rhus tenuinervis* (Anacardiaceae) (Plate 1).

Hadan Guri cliff habitat contains *Euclea racemosa* (Ebenaceae) with very few or no big trees at the edges of the cliff (Plate 2). Bushland habitat is dominated by *Dodonaea angustifolia* (Sapindaceae) (Plate 3).



Plate 1. View of Dugida Goroo forest habitat. (Photo: Kelil Abu, September 2010).



Plate 2. View of Hadan Guri cliffs habitat. (Photo: Kelil Abu, September 2010).



Plate 3. Bushland habitat dominated by *Balanites aegyptica* (Photo: Kelil Abu, September 2010).

From the vegetation data collected, the density of each plant species was calculated as the total number of each plant species divided by the total number of all plant species sampled per hectare in the home range. The density of plant species was calculated including the lianas > 2 m tall found in the home range of gelada baboons. In addition, plant species diversity was calculated using the Shannon-Wiener index, H' and plant species evenness was calculated using the evenness index, J .

$$H' = - \sum_{i=1}^s P_i \ln P_i$$

Where,

H' is Shannon-Wiener index of diversity

P_i is the proportion of plant species i from the s species.

S is the total species in the area sampled

Evenness of the species was calculated as

$$J = H'/H \text{ maximum}$$

Where,

H' is Shannon-Wiener index of diversity

H maximum is maximum diversity index

2.4. Preliminary survey and materials

The present research was conducted from August 2010 to May 2011. A preliminary survey was conducted for one week in August 2010 to identify study sites. Based on the reconnaissance survey, promising sites were identified and habitat types were classified based on the vegetation type. Two neighbouring gelada baboon troops were selected for scan sampling to record the activity, diet and ranging patterns. Organization and arrangement of the base camp and logistic support, hiring assistants, purchasing field equipment, and layout of transects was also carried out during this period.

Materials used for this study were telescope, a digital photographic camera, Garmin Global Positioning System (GPS) 12, and plant press.

2.5. Sampling design and detailed data collection

2.5.1. Habitat stratification and vegetation mapping

Habitat types in the Indato forest were classified based on the dominant vegetation they contained. These were Dugida Goroo forest, Hadan Guri cliff and bushland

No prior vegetation studies have been conducted in the Indato Forest. Details of the vegetation composition of the study groups home range was carried out by using twenty four 50X10 m quadrats (Siex, 2003) in each of the home ranges of the two study groups (A and B) plant samples greater than 2 m tall were taken. Quadrats were separated in space within each of the study group's home ranges to sample all plant species (Grassi, 2006). In each quadrat, the type and number of plant species were recorded. These quadrats were used to quantify the vegetation composition of the home ranges of the study groups.

2.5.2. Population estimate

After the distribution of gelada populations in Indato and surrounding areas were determined, censuses were carried out via the 'direct count method. Direct count method required the involvement of a large number of people to simultaneously cover all areas of interest. Although, direct counts avoid double-counting as all animals were counted simultaneously, the results from a direct count nearly always represent an underestimate of the total population (Beehner *et al.*, 2007). Therefore, to address this source of error, additional transect sampling method were needed but, I didn't use transect sampling method, because of the steepness of the cliff.

Population density estimates were obtained by multiplying the product of density estimates with the observed mean group size (Rosenbaum *et al.*, 1998; Fashing and Cords, 2000). The total population was estimated by multiplying the average group density estimates with the total area of suitable habitat at the study site (Chiarello, 2000; Addisu Mekonnen, 2008).

Density = Number of individuals in the area/ Total area in km.

2.5.3. Distribution pattern

Other potential areas of occupancy by gelada baboons were assessed via ground surveys. These surveys were also supplemented with a questionnaire survey using informal interviews (Iwanaga and Ferrari, 2002) focusing on the local people who are familiar with and reside near the vicinity of the cliffs and grassland areas by showing them photographs of the baboons. The presence or absence of gelada baboons were surveyed in twelve areas by field observations. At each survey area, when gelada baboons were sighted, GPS location, group size, altitude and habitat types were recorded. GPS locations recorded during the survey were incorporated into GIS (Arc map version 9.1) (Figure 2) to create a map of the distribution of the gelada baboons in Arsi and the surrounding areas (Baumgarten, 2006).

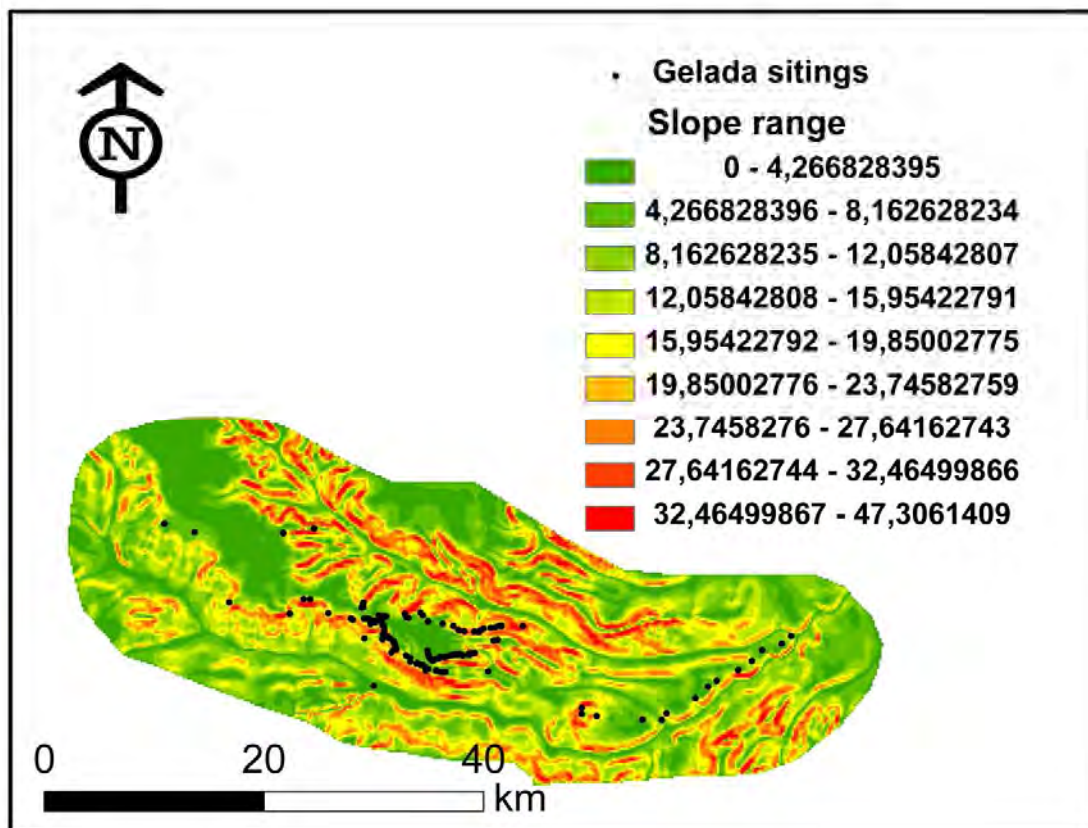


Figure 2. distribution map of the gelada baboons in Indato and the surrounding areas

2.5.4. Activity patterns

Behavioural data were collected on two study bands using instantaneous scan sampling method (Altmann, 1974). Activity types and dietary data were collected from the selected study groups/bands on an average of 10 consecutive days per month from August 2010 until May 2011, covering both wet and dry seasons. The focal groups were identified by the natural markings, sizes, coat colour and facial features of some distinctive members of each group. Wet season data were collected during August 2010 to October 2010 whereas dry season data were collected from November 2010 to May 2011.

During the activity scan sampling, the activities of gelada baboons were recorded at 15 minute intervals from 07:00-17:30h (Fashing, 2001a; Wong and sicottes, 2007). The activity recorded for each individual was the first activity that lasts for ≥ 3 seconds. During scan sampling, data were collected for the first 5 adults, sub-adults or juveniles

(Addisu Mekonnen *et al.*, 2010). The bands were scanned each time from left to right to avoid possible biases. Identification of the scanned individual was recorded and assigned to one of the following age/sex classes: adult male, adult female, sub-adult male, juvenile male and juvenile female. During scan sampling, individuals were recorded as performing one of the following behaviours on the standardized data sheet; feeding, moving, resting, playing, aggression, grooming, sexual activity, and or other (Fashing, 2001a, Addisu Mekonnen *et al.*, 2010). Feeding was recorded when the geladas manipulated, masticated and ingested a particular item of food. Moving was recorded when the geladas change their spatial position within or between the tree or showed any locomotor behaviour, including walking, jumping or running. Resting was recorded when the geladas observed were inactive alone or together either sitting or lying. Playing included chasing, hitting and other vigorous activities involving exaggerated movements and gestures by more than one gelada that were clearly interacting with each other in a non-aggressive manner (Fashing, 2001a). Aggression was recorded when a gelada chased, bit, grabbed, displaced, threatened another gelada or during crying as a result of aggression. Grooming was recorded when a gelada used its hands to explore or to clean its body or the body of another gelada. Sexual activity was recorded when a gelada groomed the sexual organs, mounted another gelada or engaged in mating activity. Other activities were recorded when the animal observed performing activities such as vocalization, defecation, looking towards the observer, or other activities that do not fit in any of the above category.

To calculate time budget, all activity records were first assigned to one of the activity categories to determine the proportion of time budget allocation of gelada baboons for different activities. First, the proportion of the number of behavioural records for each activity category represented was divided by the total number of activity records (Vasey, 2005). Time budget was calculated for the combined study groups A and B. The behavioural records of the combined groups were used to calculate the time budget for each day and then summed within each month to construct monthly proportions of time budgets. The grand mean the proportions of the monthly budgets provided the overall wet and dry season, and also yearly time budgets (Di Fiore and Rodman, 2001; Di Fiore, 2003). The percentage of time the combined study groups engaged in major activities was

compared between seasons using Mann-Whitney U test and across months using Kruskal-Wallis H test.

2.5.5. Feeding ecology

During instantaneous scan sampling, dietary data were collected at 15-minute intervals on members of the study bands. During activity scan sampling, if geladas were observed feeding, the type of food item: long grass blades, short grass blades, herb leaves, herb roots, grass roots, corms, unidentified tubers, cereals (teff/barley/wheat), animal prey or others (Fashing *et al.*, 2007), as well as what the species consumed was recorded on a standardize data sheet. The species consumed was noted in the field if possible while unidentified species were collected for later taxonomic identification in the National Herbarium, Addis Ababa University.

Diet compositions were evaluated by determining the proportion of different food items and type of species consumed by the gelada baboons. The daily food items and species consumed by the band were summed within each month to construct monthly proportion of food items and food species consumed. The monthly proportion of each food item in the scans was calculated as the total number of monthly individual scans for each food item divided by the total number of individual scans for all food items. The relative proportion of plant species used as food for gelada baboons was calculated from the monthly percentage contribution of different species (Fashing, 2001b; Di Fiore, 2004). Grand means of the monthly proportions of food items and species consumed were used to calculate the overall wet and dry season diets as well as the overall diets for the entire study period. The percentage contribution of food items and the species consumed by the combined study groups were compared between seasons using Mann-Whitney U test and across months using Kruskal-Wallis H test.

2.5.6. Ranging patterns

Total home range size and day range length was determined for each group based on the point to point movements of the group between consecutive GPS locations recorded (Di Fiore, 2003). Day range lengths were calculated based on full-day follows only (Kaplin,

2001) for each group from 07:00 to 17:00 hrs because sampling prior to 07:00 and after 17:00 was limited and the gelada baboons do not travel much before and after these periods. Each day range was drawn on a GIS-system generated map (ArcMap version 9.1) by connecting the consecutive GPS location records and the total distances traveled per day. These were calculated from the map by using measuring tools in the GIS software ArcGIS'9 (Di Fiore, 2003; Wong and Sicotte, 2007). Then mean day range lengths were calculated by averaging the wet and dry season day range lengths of the gelada baboons as the sample size of full-day follows varies across months. The wet and dry season day range lengths were compared using Mann-Whitney U test.

The minimum convex polygon method (MCP) was used to determine the home range sizes of gelada baboons. The MCP method has the advantage of not requiring independent data points and is a widely used method by many researchers (Swedell, 2002; Lehmann and Boesch, 2003; Williams-Guille'n, 2003; Barrett, 2005; Fashing *et al.*, 2007; Kumar *et al.*, 2007; Wong and Sicotte, 2007). GIS software (ArcMap version 9.1) was used to determine the home ranges of the gelada baboon by simple minimum convex polygon method (Lehmann and Boesch, 2003; Pombo *et al.*, 2004; Barrett, 2005; Fashing *et al.*, 2007; Kumar *et al.*, 2007; Wong and Sicotte, 2007). To estimate home range size, all day ranges were combined to generate a bounding polygon using 100% MCPs. The home ranges of gelada baboon was calculated by constructing a polygon around the outermost GPS locations used by gelada baboon during both wet and dry seasons (Wong and Sicotte, 2007). The seasonal and overall home range areas used during the course of the study period were calculated by GIS ArcView 9.1. The wet and dry season home range areas were compared using Mann-Whitney U test.

2.6. Data Analysis

All statistics were carried out using SPSS 15.0 software for Windows Evaluation Version. Statistical tests were two-tailed with 95% confidence intervals. Nonparametric Mann-Whitney U tests were used to compare seasonal differences and Kruskal-Wallis H tests were used to compare monthly variation as the data were not normally distributed.

3. RESULTS

3.1. Vegetation

A total of 10 tree species, two shrubs, one climber and five herbs were found within the study groups home ranges. Stem density per hectare for species sampled in the study groups' quadrats is presented in Table 1.

Table 1. Trees taller than 2 m, number and densities within the home range of gelada baboons.

Local name	Species name	Family	Type	No. of Stem per ha (density)	% of stem density
Kombolcha	<i>Maytenus obscura</i>	Celastraceae	T	70	2.37
Bakanisa	<i>Croton macrostachys</i>	Euphorbiaceae	T	2	0.07
Birbirsa	<i>Podocarpus gracilior</i>	Podocarpaceae	T	80	2.71
Dabobessa	<i>Rhus tenuinervis.</i>	Anacardiaceae	H	10	0.34
Dambii	<i>Myrica salicifolia</i>	Myricaceae	T	9	0.31
Dhittacha	<i>Dodonaea angustifolia</i>	Sapindaceae	H	700	23.74
Ejerssa	<i>Olea europaea</i>	Oleaceae	T	140	4.75
Galloo	<i>Psydrax schimperiana</i>	Rubiaceae	T	100	3.4
Goraa	<i>Rubus apetalus</i>	Rosaceae	C	183	6.21
Hadheesa	<i>Vepris dainelli</i>	Ruraceae	T	200	6.78
Aagamsa	<i>Balanites aegyptica</i>	Balanitaceae	Sh	758	25.71
Karoo	<i>Osyris abssinica</i>	Santalaceae	T	18	0.61
Kokolfa	<i>Rhus natalensis</i>	Anacardiaceae	T	193	6.55
Mi'essa	<i>Euclea racemosa</i>	Ebenaceae	H	400	13.57
Qaccama	<i>Myrsine africana</i>	Myrsinaceae	H	30	1.02
Qararuu	<i>Acokanthera schimperi</i>	Apocynaceae	H	20	0.68
Qilxuu	<i>Ficus vasta</i>	Moraceae	T	3	0.1
Xaxessa	<i>Rhus glutinesa</i>	Anacardiaceae	Sh	32	1.09

(T: Tree, H: herb, Sh: shrub, C: climber)

The home range areas on the average contained 2948 stems/ha of trees greater than 2 m. Balanitaceae (*Balanites aegyptica*) with the highest stem density is a small sized shrub. The plant species diversity in the home range of the study groups was 2.15. Evenness of the study groups home range was 6.16. There was high diversity of plant species in the home range. Plant species that occurred in the home range of gelada baboons were most evenly distributed.

3.2. Population estimate

The density of gelada baboons in the study area was 0.34/km².

3.3. Distribution

Gelada baboons are not evenly distributed across habitats. Their distribution is based on the availability of food and the distance from humans. Bushes and shrubs also provided shelter for geladas. Strategically, they are distributed at the edges of open cliffy grassland as shown in Figure 3. In the cliff Hadha Dale, the gelada baboons were distantly apart from each other for positioning as trees and bushes limit their vision. Total numbers of gelada baboons observed in the study area was 529 at 12 different places. Numbers of gelada baboon were seen at Wabe Kare (Table 2).



Figure 3. Gelada feeding at the edges of Wabe Kere cliff (Photo: Kelil Abu, October 2010).

Table 2. Locality where gelada baboons were observed during the survey.

Locality	Number observed	Elevation
Gujabe	19	1743-2100 m
Waba kere	130	1971-2342 m
Walda Wabe	24	1184-2237 m
Mararo	41	1947-2379 m
Sadika	47	2156-2246 m
Fincha Robe	47	2121- 2379 m
Kirbiny	25	1900-2042 m
Hujuba abotal	17	2035-2300 m
Goro	40	2000-2195 m
Kile hadha dale	21	1967-2214 m
Zakira	37	1500-2030 m
Mudhi kelo	72	1835-2069 m
Total	529	

3.4. Activity time budget

A total of 6153 individual behavioural observations were recorded. Feeding comprised 2481 and drinking 2 from group scans of a total of 90 days. The overall activity time budget of gelada baboons from the combined study groups is presented in Figure 4.

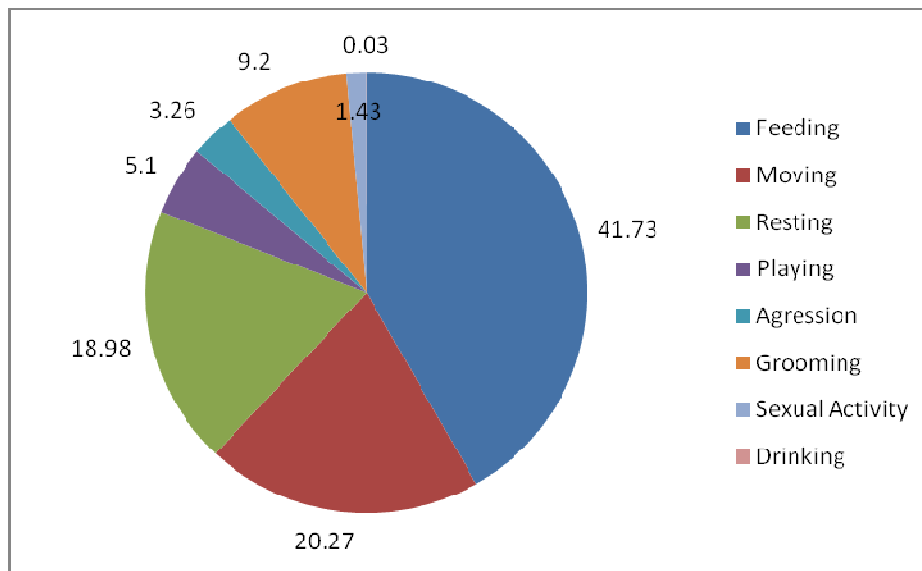


Figure 4. Overall activity time budget of gelada baboons in Indato.

On average, gelada baboons spent 41.73% (range 34.88-48.86%, $SD\pm 5.32\%$) of their time for feeding, 20.27% (range 14.49-31.87%, $SD 5.50\%$) for moving, 18.98% (range 14.04-23.81%, $SD\pm 3.28\%$) for resting, 5.1% (range 1.46-9.05%, $SD\pm 3.09\%$) for playing, 3.26% (range 0.41-6.48%, $SD\pm 1.81\%$) for aggression, 9.2% (range 2.34-15.05%, $SD\pm 3.54\%$) for grooming, 1.43% (range 0-5.60%, $SD\pm 1.78\%$) for sexual activity and 0.03% (range 0-0.15%, $SD\pm 0.06\%$) drinking.

Gelada baboons on an average spent more time on feeding (44.73%, $SD\pm 3.51\%$) during the dry season than the wet season (35.71%, $SD\pm 1.05\%$). The geladas spent more time moving (21.69%, $SD\pm 5.91\%$) during the dry season than the wet season (17.43%, $SD\pm 3.93\%$). Resting time (19.61%, $SD\pm 1.77\%$) during the wet season was higher than the dry season (18.67%, $SD\pm 3.95$). Playing was higher (8.13%, $SD\pm 1.38\%$) during the wet season than the dry season (3.59%, $SD\pm 2.49\%$). Aggression was higher (4.97%, $SD\pm$

1.73%) during the wet season than the dry season (2.41%, $SD \pm 1.20\%$). Grooming increased (10.79%, $SD \pm 4.07\%$) during the wet season than the dry season (8.4%, $SD \pm 3.34\%$). Sexual activity was higher (3.3%, $SD \pm 1.99\%$) during the wet season than the dry season (0.49%, $SD \pm 0.18\%$) (Figure 5).

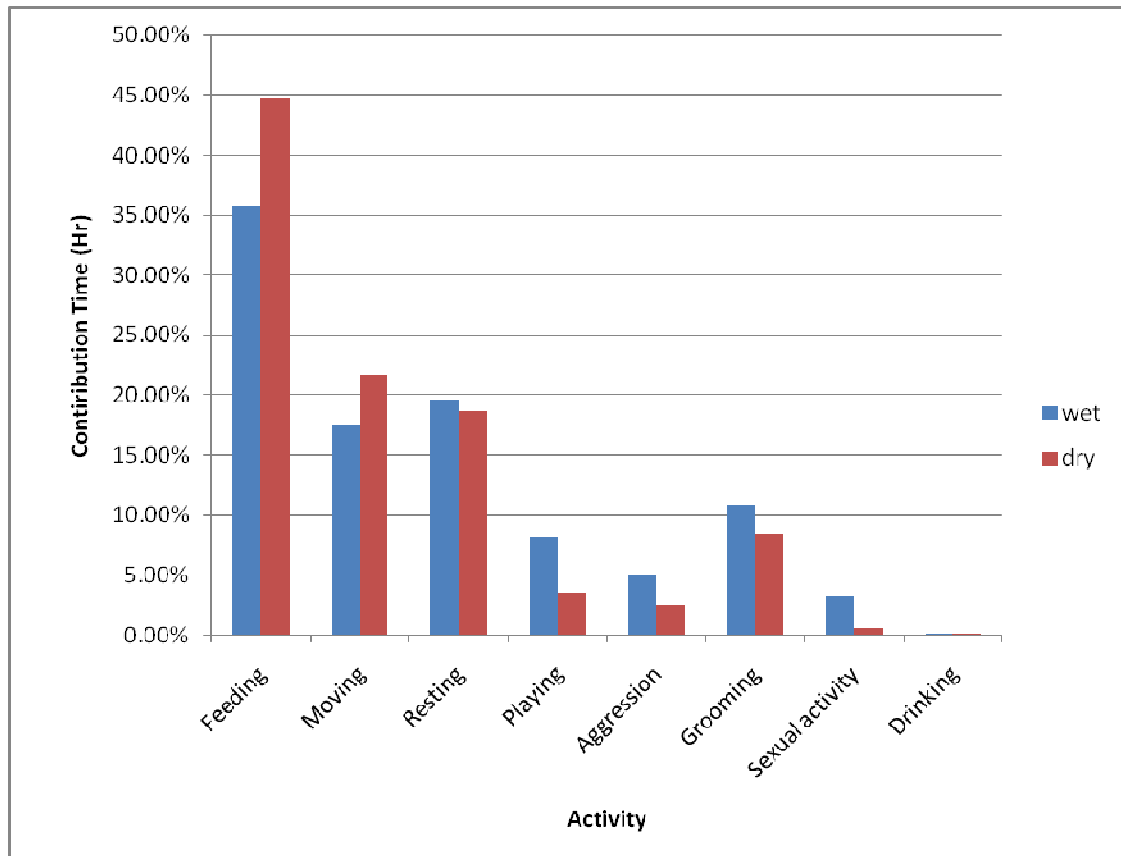


Figure 5. Seasonal activity time budget of gelada baboons on the Indato cliff.

Mann-Whitney U tests showed significant differences between seasons in time spent feeding ($P < 0.05$) and sexual activity ($P < 0.05$). However, there was no significant difference between seasons in time spent moving ($P > 0.05$), resting ($P > 0.05$), playing ($P > 0.05$), aggression ($P > 0.05$), grooming ($P > 0.05$) and drinking.

The feeding time of gelada baboons during the study period varied across months ranging from 34.88% during August to 48.86% during December. Moving ranged from 14.49% (December) to 31.87% (May) and resting ranged from 14.04% (May) to 23.81% (December). Playing ranged from 1.46% (May) to 9.05% during October. Aggression ranged from 0.41% (December) to 6.48% during August (Table 3) . However, there was no significant difference in the time spent for all activities across months (Kruskal-Wallis H test, $P > 0.05$).

Table 3. Monthly variation in the time spent by geladas for various activities.

Months	Activity (%)							
	Feeding	Moving	Resting	Playing	Aggression	Grooming	Sexual activity	Drinking
Aug	34.88	21.91	18.67	8.80	6.48	6.94	2.16	0.15
Sept	36.89	15.83	21.65	6.55	3.09	10.38	5.60	
Oct	35.36	14.56	18.50	9.05	5.35	15.05	2.14	
Nov	47.68	17.40	14.30	7.75	2.38	9.18	1.19	0.12
Dec	48.86	14.49	23.81	5.38	0.41	7.04		
Jan	40.21	22.32	21.90	2.95	1.89	9.89	0.84	
Feb	43.07	21.75	19.40	1.49	2.56	11.73		
Apr	41.80	22.29	18.58	2.48	3.72	10.22	0.93	
May	46.78	31.87	14.04	1.46	3.51	2.34		

Adult males spend most of their time feeding (39.23%), while 29.21% and 14.08% of the time was spent resting and moving, respectively. Only 0.98% of the time was used for playing. Adult females spend most of their time 45.80% feeding (Table 4). Yet, 19.81% and 15.73% of the time was used for moving and resting, respectively. Sub-adult males spent about 39.35% of their time feeding, while 20.98% and 18.70% of the time was spent resting and moving, respectively. Juvenile males spent 33.43%, 23.46% and 21.11% of their time feeding, moving and playing, respectively. Juvenile females spent 34.74%, 21.34% and 19.48% of their time feeding, playing and moving, respectively.

Table 4. Overall activity time budget of gelada baboons based on age-sex category.

Age-sex groups	Activity (%)						
	Feeding	Moving	Resting	Playing	Aggression	Grooming	Sexual activity
Adult male	39.23	14.08	29.21	0.98	6.16	6.94	3.41
Adult female	45.80	19.81	15.73	1.37	2.60	12.21	2.48
Sub-adult male	39.35	18.70	20.98	3.09	4.55	12.85	0.49
Juvenile male	33.43	23.46	14.08	21.11	2.05	5.87	-
Juvenile female	34.74	19.48	14.14	21.34	2.11	8.19	-
Neonate	8.62	12.07	8.62	60.34	6.90	3.45	-

All the age groups spent more time feeding during the dry season than the wet season (Comparison of activities during different season is given in table 5a and 5b).

Table 5a. Comparison of age-sex category of the geladas during the wet season.

Age-sex groups	Activity (%)						
	Feeding	Moving	Resting	Playing	Aggression	Grooming	Sexual activity
Adult male	31.87	13.16	31.10	0.77	7.48	9.29	6.32
Adult female	42.92	18.04	15.75	1.75	3.27	13.93	4.34
Sub-adult male	36.48	18.86	20.84	4.22	5	14.14	0.25
Juvenile male	30.32	19.68	15.42	26.60	3.19	4.79	
Juvenile female	29.43	15.46	15.71	27.68	2.74	8.98	
Neonet	8	8	8	64	9.33	2.67	

Table 5b. Comparison of age-sex category of the geladas during the dry season.

Age-sex groups	Activity by percentage (%)						
	Feeding	Moving	Resting	Playing	Aggression	Grooming	Sexual activity
Adult male	46.81	15.03	27.26	1.20	4.79	4.52	0.40
Adult female	49.00	21.73	15.79	1	1.93	10.55	
Sub-adult male	44.81	18.40	21.23	0.94	3.30	10.38	0.94
Juvenile male	37.25	28.10	12.42	14.38	0.65	7.19	
Juvenile female	40	23.46	12.59	15.06	1.48	7.41	
Neonate	11.90	19.05	9.52	52.38	2.38	4.76	

3.5. Feeding ecology

A total of 2481 feeding behavioural records were obtained from scan sampling of the two combined study groups. The overall diet of gelada baboons during the study period is presented in Figure 6. On an average, short grass blades formed the major diet of gelada baboon (34.87%, $SD \pm 4.31\%$). Grass roots formed (25.24%, $SD \pm 5.61\%$) and long grass blades formed 18.67%, $SD \pm 12.55\%$, as the second and third largest contributions to the overall diet of gelada baboons. Gelada baboons also consumed unidentified tubers 7.54% ($SD \pm 5.99\%$), herb leaves 7.30% ($SD \pm 6.99$) and others 3.01% ($SD \pm 7.58\%$). Herb roots 1.69% ($SD \pm 1.80\%$) and corms 1.67% ($SD \pm 4.34\%$) was consumed rarely (Figure 6).

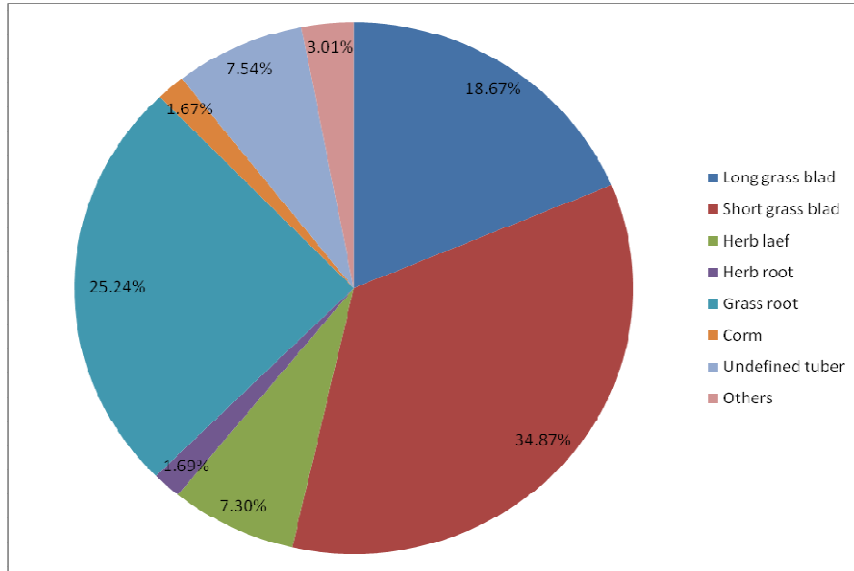


Figure 6. The overall time devoted for feeding different types of food items by gelada baboons.

Gelada baboons spent more time feeding on short grass blades (36.15%, $SD \pm 4.62$ %) and long grass blades (19.34%, $SD \pm 13.10$ %) during the dry season than during the wet season (32.33%, $SD \pm 2.48$ %) and (17.33%, $SD \pm 14.04$ %), respectively. Seasonal percentage contribution of food items is given in Figure 7. Mann-Whitney U tests showed that there was a significant difference in time spent feeding on Corm ($P < 0.05$) between the seasons. However, there were no significant difference observed between seasons in the time spent feeding on long grass blades, short grass blades, herb leaves, herb roots, grass roots and unidentified tubers ($P > 0.05$).

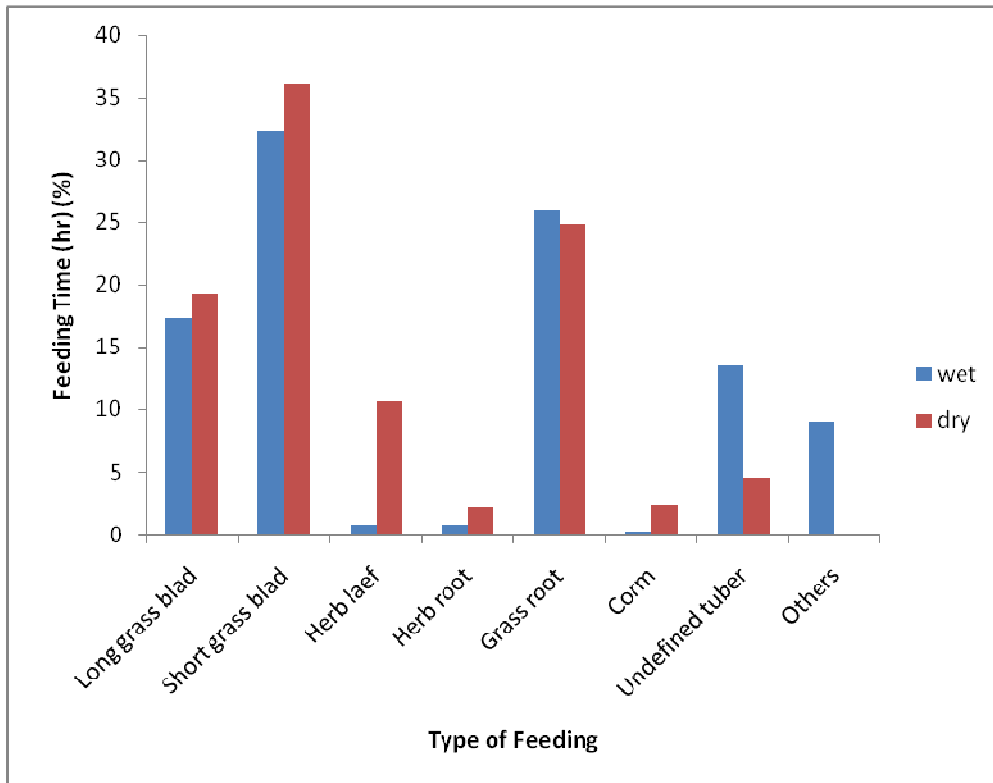


Figure 7. Seasonal food items of gelada baboons in Indato Forest.

The monthly time spent feeding on different food items by gelada baboons is shown in Table 6. Feeding time on short grass blades was high in all months. The minimum time spent feeding on short grass blades was recorded during April (29.93%) and the maximum was during May (40.94%). Gelada baboons spent more time feeding on long grass blades during October (33.17%) and the minimum time spent feeding on long grass blades was recorded during May (5.85%). Gelada baboons spent more time feeding on herb leaves was during April (18.37%) and the minimum time spent feeding on herb leaves during September (0.40%). During the study period, short grass blades were heavily consumed throughout year (Table 6). Kruskal-Wallis H tests showed that there were no significant differences in the time spent feeding on all food items across months ($P > 0.05$).

Table 6. Monthly variation in percentage contribution of food items.

Months	Diet (%)								Total
	Long grass blades	short grass blades	herb leaves	herb roots	grass roots	corns	unidentified tubers	Others	
August	12.39	32.05	1.71	1.71	19.23	0.85	17.09	14.96	100
Sept.	6.43	34.94	0.40	-	35.14	-	11.45	11.65	100
Oct.	33.17	30	-	0.49	23.66	-	12.20	0.49	100
Nov.	32.38	39.38	0.52	0.78	25.65	-	1.30	-	100
Dec	32.34	36.17	8.51	1.28	18.72	-	2.98	-	100
Jan.	28.64	31.16	14.07	0.50	20.60	-	5.03	-	100
Feb.	5.97	39.30	7.46	5.97	26.87	-	14.43	-	100
April	10.88	29.93	18.37	2.72	25.17	9.52	3.40	-	100
May	5.85	40.94	14.62	1.75	32.16	4.68	-	-	100
Mean	18.67	34.87	7.30	1.69	25.24	1.67	7.54	3.01	100

Gelada baboons consumed a total of 10 plant species, which accounted for 100% of their diet over the course of the study period. Percentage contribution and food items consumed are presented in Table 7. Among the 10 plant species contributing to the overall diet of gelada baboons, two species were trees, three were shrub, two were grass and three were herbs.

Table 7. List of plant species, food items consumed and percentage contribution of the diet of gelada baboons.

Local name	Species consumed	Family	Type	Food items consumed	% contribution
Qarasoo	<i>Hyparrhenia hirta</i>	Poaceae	Grass	SGB , R	38.11
Jaldoo	<i>Hyparrhenia</i> sp	Poaceae	Grass	LGB, R	49.37
Ashooka	<i>Opuntia strcta</i>	Cactaceae	Shrub	FR	3.24
Muka Abda	<i>Ipomoea hildrbrandii</i>	Convolvulaceae	Herb	ML,YL	6.49
Qilxuu	<i>Ficus vasta</i>	Moraceae	Tree	ML	0.79
Mi'essaa	<i>Euclea racemosa</i>	Ebenaceae	Herb	FR	0.37
Agamsa	<i>Balanites aegyptica</i>	Balanitaceae	Shrub	FR	0.65
Ejerssa	<i>Olea europaea</i>	Oleaceae	Tree	FR	0.28
Xaxessa	<i>Rhus glutinesa</i>	Anacardiaceae	Shrub	FR	0.28
Dhittacha	<i>Dodonaea angustifolia</i>	Sapindaceae	Herb	ML ,YL	0.42
Total					100

YL = Young leaves; ML = Mature leaves; R = Root; FR = Fruit; SGB=Short grass blades; Long grass blades

The top four most consumed plant species accounted for 97.21% of the overall diet of gelada baboons (Figure 8). Based on the overall percentage contribution of food items consumed, Jaldoo (*Hyparrhenia* sp) was the most consumed food species, which accounted for 49.37% for the overall diet of gelada baboons. *Hyparrhenia hirta* ranked second and *Ipomoea hildrbrandii* ranked third accounting for 38.11% and 6.49% of the overall diet, respectively.

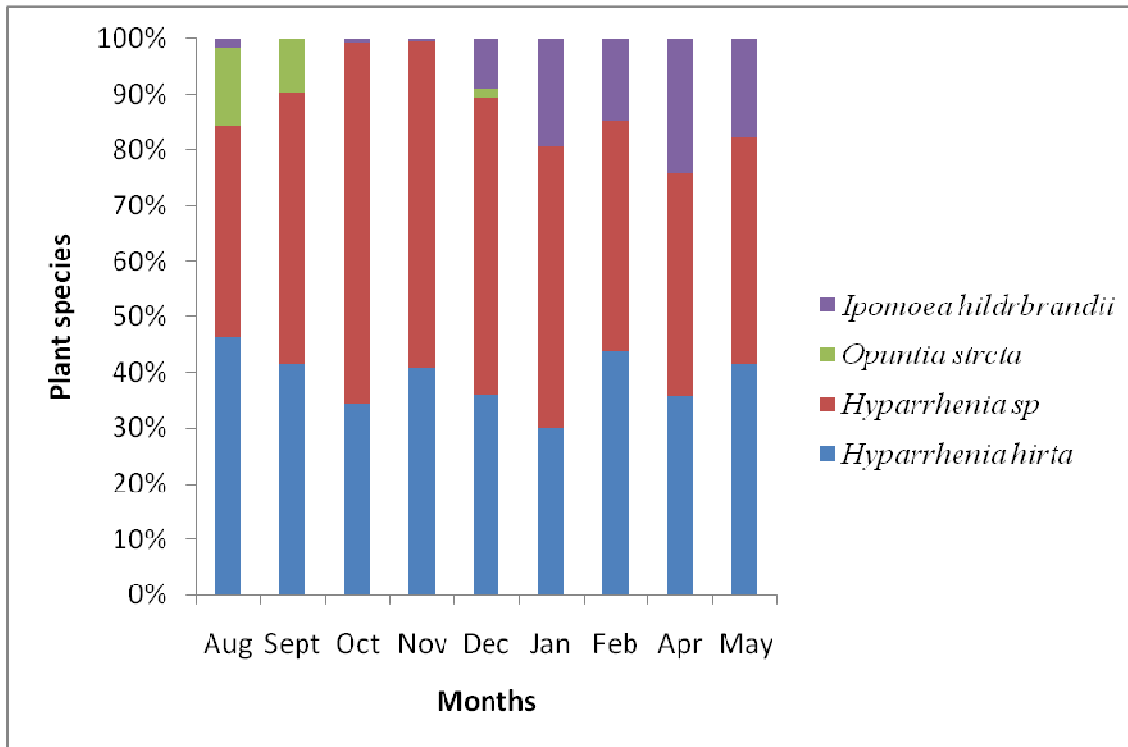


Figure 8. The major four plant species consumed by gelada baboons during the study period

On an average the geladas spent more time feeding on Jaldoo (*Hyparrhenia sp*) (50.04%, $SD \pm 14.37\%$) and *Hyparrhenia hirta* (39.95%, $SD \pm 5.17\%$) during the wet season compared to the dry season (45.31%, $SD \pm 7.66\%$) and (36.52%, $SD \pm 6.34\%$), respectively (Table 8). They showed significant difference in the time spent feeding on *Opuntia strcta* ($P < 0.05$), *Ficus vasta* ($P < 0.05$), *Balanites aegyptica* ($P < 0.05$), *Rhus glutinesa* ($P < 0.05$) and *Dodonaea angustifolia* ($P < 0.05$). During the dry season, they spent more time feeding on *Ipomoea hildrbrandii*.

Table 8. Seasonal percentage contribution of plant species consumed.

Species consumed	Wet season (%)	Dry season (%)
<i>Hyparrhenia sp</i>	50.04	45.31
<i>Hyparrhenia hirta</i>	39.95	36.52
<i>Opuntia strcta</i>	7.66	0.22
<i>Ipomoea hildrbrandii</i>	0.77	13.49
<i>Ficus vasta</i>	0.18	1.58
<i>Euclea racemosa</i>	0.18	0.53
<i>Balanites aegyptica</i>	0.53	0.91
<i>Olea europaea</i>	-	0.47
<i>Rhus glutinesa</i>	0.53	0.29
<i>Dodonaea angustifolia</i>	0.15	0.68
<i>Total</i>	100%	100%

The monthly percentage contribution of each plant species is presented in Table 9. The contribution of Qarasoo (*Hyparrhenia hirta*) and Jaldoo (*Hyparrhenia sp.*) in the diet of gelada baboons was regular in all months ranging from 26.32% in January to 43.03% in February and 36.36% in August to 65.02% in October, respectively. However, the comparison of plant species contribution across each month showed no significant difference in the time spent feeding on different species of plants ($P > 0.05$).

Table 9. Monthly percentage contribution of plant species consumed.

Species consumed	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Apr	May
<i>Hyparrhenia hirta</i>	44.39	41.19	34.28	40.53	33.93	26.32	43.03	33.86	41.46
<i>Hyparrhenia</i> sp	36.36	48.74	65.02	58.42	50	44.21	40.61	37.80	40.85
<i>Opuntia strcta</i>	13.37	9.61	-	-	1.34	-	-	-	-
<i>Ipomoea hildrbrandii</i>	1.60	-	0.71	0.53	8.48	16.84	14.55	22.83	17.68
<i>Ficus vasta</i>	0.53	-	-	-	1.34	4.21	-	3.94	-
<i>Euclea racemosa</i>	0.53	-	-	0.53	0.45	1.58	0.61	-	-
<i>Balanites aegyptica</i>	1.60	-	-	-	1.79	3.68	-	-	-
<i>Olea europaea</i>	-	-	-	-	1.79	1.05	-	-	-
<i>Rhus glutinesa</i>	1.60	-	-	-	-	0.53	1.21	-	-
<i>Dodonaea angustifolia</i>	-	0.46	-	-	0.89	1.58	-	1.57	-

3.6. Ranging pattern

Home range

The overall home range areas of gelada baboons was 4.91 km². The home range areas of the study groups were extended during the dry season than the wet season (Figure 9). The wet and dry season home range areas of the study groups are given in Table 10.

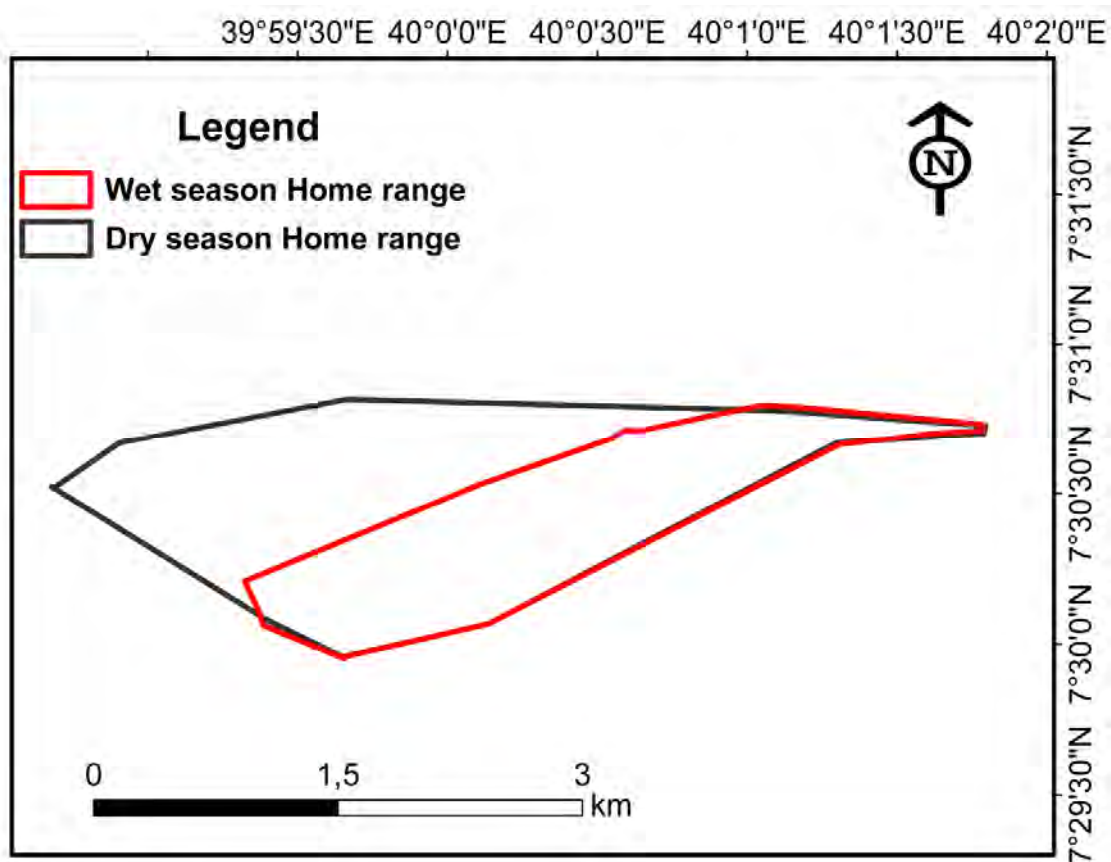


Figure 9. Seasonal home range size of gelada baboons (using the minimum convex polygon method).

Daily range lengths

The average daily range length for gelada baboons was 1004.6 m (range 574-1586 m, $SD \pm 354.8$). The mean daily range length was 1004.6 m. The average daily range lengths for the wet and dry seasons for the study groups are shown in Table 10. There was no significant difference in the daily range lengths of gelada baboons between the wet and dry seasons ($P > 0.05$).

Table 10. Mean daily travel distance and home range size of gelada baboon during wet and dry seasons.

Season	Mean daily travel distance (m)		Home range area (km ²)
	Mean (n)	SD	
Wet	1173(7)	111.8	2.44
Dry	903(14)	409	4.64

4. DISCUSSION

Density estimates for forest dwelling and unhabituated primates may not be accurate because of the difficulty to count the group size reliably (Shah, 2003). This problem is true for Indato due to the steepness of cliff and the poor visibility in the cliff habitat.

According to Chapman (2002) and Wallace *et al.* (1998), densities of primates were related to food quality and availability. The high densities of primates are associated with a combination of factors (Wallace *et al.*, 1998). The relatively low density of gelada baboons in the Indato Forest may be related to the low availability of grass and anthropogenic effect in the area.

According to Dunbar (1984), gelada baboons prefer open grassland habitats. But Arsi gelada baboons prefer closed cliff habitats. This may be due to the anthropogenic effect. Indato has large area which is not comfortable for agriculture. Only small area is inhabited by many people. These people have limited farmland to fulfill their basic need. So people expand their farm by cutting trees at the edge of the cliff. As a result, the gelada baboons are restricted to the closed cliff.

According to Wallace (2006), the availability of food at the edges of the cliff is less abundant. The result of the present study suggests that the distribution of Arsi gelada baboons is not evenly distributed. Their distribution is based on the availability of food and distance from human. To avoid the human conflict and other predators like leopard, they are concentrated at the edge of the closed cliff (Figure 3). However, at the edges of cliff, the food availability is less. So, to fulfill their needs, they move from one place to the other. According to Dunbar (1992), animals have to move less far when food sources are more densely distributed. The present study shows that the distribution of the Arsi gelada baboons is related with the distribution of the resource across the Wabe River. For example, during dry the season, they move from Wabe River to Robe River to get excess wet grass along the Robe River. During the end of the dry season, they return to Wabe River area.

In some localities, there occurs conflict between human and Arsi gelada baboons. This is mostly observed around Zakira area. These can be due to a stream, which is commonly used by gelada baboons, humans and their cattle. At the same time, the area is very cliffy so it is difficult for gelada baboons to collect food. Therefore, the gelada baboons have no other choice rather than consuming barley and teff.

According to Lehman (2004), habitat generalist primates show wider geographical range while habitat specialists show limited geographical distribution. Gelada baboons in Indato are the narrowly distributed across Indato cliff and they are habitat specialists.

Time spent for different activities in animals is an indication of balancing energy budget for various activities. Gelada baboons that can easily obtain food spend more time resting and grooming than feeding and moving (Dunbar, 1992). However, Arsi gelada baboons spend larger portion of their time feeding and moving than resting and grooming (Figure 4). Grooming maintains social relationships. Proportionately more time has to be devoted for grooming in order to maintain the cohesion of large groups (Dunbar, 1992). Even though Arsi gelada baboons are social animals, they spend less time for social activities such as grooming, playing, sexual activities and aggression. Results of the present study suggest that they spend more time feeding as they are restricted to cliff habitats, they may not get enough food. So to fulfill energy requirements, they spent more time feeding. Arsi geladas feed on grass most of the time that may have low energy value. Therefore, they have to spend more time feeding on more grass to satisfy their daily energy requirements than grooming and resting. During the study period, intar-group aggression and inter-group aggression was observed. Intar-group aggression was observed most of the time between adult male and adult female. But inter-group aggression was seen between all individuals of the group, especially females and juveniles were the main participants chasing one another in the agonistic interaction. This occurs when onther group approaches to their area. This may indicate that Arsi gelada baboons are territorial, which use their home ranges strictly.

Mann-Whitney U tests showed significant differences between seasons in time spent on feeding and sexual activity. However, there was no significant difference between seasons in time spent on moving, resting, playing, aggression, grooming and drinking.

According to Shah (2003), seasonal differences may be attributed to environmental and dietary variables. Arsi gelada baboons spent more time feeding and moving during the dry season than the wet season. This may be attributed to limited availability and quality of food during the dry season compared to the wet season. Therefore, to satisfy their daily energy requirements, they travel more in search of food. On the other hand, Arsi gelada baboons spent relatively more time resting, playing, aggression, grooming, sexual activity and drinking during the wet season than the dry season (Figure 5). The present study suggests that during the wet season, there is ample food compared to the dry season. So, Arsi gelada spent less time in feeding and moving and spend larger portion of their time for social activity during the wet season. These finding are similar to the observation of Dunbar (1992), who suggested that gelada baboons that can obtain food easily can spend more time resting and grooming than feeding and moving.

Adult females spend longer time feeding and moving than adult males. Adult females breast feed their infants. Therefore, to get more energy, they have to feed more. Adult males spend more time resting than the adult females.

All the age-sex categories spent more time feeding and moving during the dry season than the wet season. Dunbar (1992) also obtained similar results on activity time budget of age-sex category. The present study suggestes that during the dry season, the food quality and availability is less than that in the wet season. So, they spent more of their time feeding and moving.

Theropithecus gelada feeds on a variety of food resources. However, short grass blades are the most preferable diet of gelada baboon. However, if the grasses are not available they feed on herb leaves, herb roots and corms. They predominantly feed on grasses if available as reported by Iwamoto (1993).

Gelada baboons spent more time feeding on leaves and roots of herbs during the dry season than the wet season. This may be due to the steepness of the cliff as some area were not easily accessible to move and forage. So they restrict their movement to smaller extents.

Gelada baboons consumed a total of 10 plant species, which accounted for 100% of their diet over the course of the study period. The result of this study indicates that Arsi geladas show dietary rigidity and depend on few plant species. This dietary rigidity on a few species may be explained by a narrow distribution of the gelada baboons that restricted themselves in narrow habitat types and geographic range. According to Harcourt (2006), a species which has narrow geographical range with habitat and dietary specialization is considered as rare species. Therefore, gelada baboons could also be considered as a rare species in Indato.

On average gelada baboons spent more time feeding on Jaldoo (*Hyparrhenia* sp) and *Hyparrhenia hirta* during the wet season compared to the dry season. This may be due to high nutritional quality of *Hyparrhenia* sp and *Hyparrhenia hirta* during the wet season than the dry season. During the dry season, they spent more time feeding on *Ipomoea hildrbrandii*. The present study suggested that *Ipomoea hildrbrandii* grow very well and abundant during the dry season. In addition to that, it may have high nutrient content compared to other plant species that also grow well during the dry season.

Each animal has to search a given area of previously unharvested habitat each daily in order to find the food it needs. In addition, habitat quality is also known to influence day journey length (Dunbar, 1992): animals have to search proportionately larger areas to find the food they need as the sources decline. The present study also suggested that gelada baboon move less when food availability is high, but when food scarcity occurs, gelada baboons roam larger areas in search of food. The home range area of the gelada baboon was larger during the dry season than the wet season. During the dry season food availability is less so to fulfill their requirements, they travel long distances.

5. CONCLUSION AND RECOMMENDATIONS

The Indato people use the forest as a source for income. This accelerates deforestation from time to time and loss of biodiversity. The density of gelada baboons in the Indato forest is relatively low. This may be related to the low availability of grass and anthropogenic effect in the area. The distribution of the Arsi gelada baboons is related to the distribution of the resource across the Wabe River. Arsi gelada baboons prefer closed cliff habitats; this may be due to anthropogenic effect. Arsi gelada baboons spend larger portion of their time feeding and moving than resting and grooming. They are restricted to cliff habitats and may not get enough food. So to fulfill their energy requirements, they spent more time feeding. Adult female of Arsi gelada baboon spends a longer time for feeding and moving than adult male. Gelada baboons feed mostly on grass, but if the grasses are not available, they feed on herb leaves, herb roots and corms.

Gelada baboons consumed a total of 10 plant species which accounted for 100% of their diet over the course of the study period. Among them, Jaldoo (*Hyparrhenia* sp) was the most consumed food species, which accounted for 49.37% for the overall diet of gelada baboons. Arsi geladas show dietary rigidity that depended on few plant species. Gelada baboons move less when food availability is very high, but when food scarcity occurs gelada baboons explore larger area in search the food. The home range areas of gelada baboons were larger during the dry season than the wet season.

The results of the present study have several conservation and management implications for the species and their habitat.

Therefore the following points are recommended:

- Indato Forest was severely threatened by agricultural land expansion. So, the government should take action to prohibit agricultural land expansion.
- Grazing has a significant impact in the area in accelerating habitat degradation and competition with wildlife. In addition, firewood collection from the forest also leads to disturbance of wildlife. So, awareness creation among the local

community might be the possible solution for the current problems of the study area.

- In order to conserve these species and prevent future decline, conservation practice involving local people is important.
- The Indato, people use the forest as source of income. So, the government should recognize this and generate other income.
- The Indato forest is unprotected area and people cut trees without limitation. So, the government should protect the area to reduce deforestation.
- Indato area is comfortable to attract tourists, as the area contains many unique animals. So the government should give the attention to protect this area.

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Appendix 1. Daily activity pattern record sheet

Arsi gelada baboon activity pattern data sheet, eastern Arsi

Personnel _____

Time interval: 15 minutes

Group ID _____

Weather _____

Start Time_ End Time_____

Time seen	GPS Location		IND	Activity									Habitat type	Remark
	Loc x	Loc y					Social							
				F	M V	R	P	AG	GR	SA	DR	Os		
			AM											
			AF											
			SAM											
			JF											
			JM											
			NE											

F: Feeding; MV: Moving; R: Resting; P: Playing; AG: Aggression; GR: Grooming; SA: Sexual Activity; DR: Drinking; OS: Others (Defecation, Vocalization and others)

Age/Sex class (IND): AM: Adult male; SAM: Sub-adult male; JM: Juvenile; AF: Adult female; JF: Juvenile female; NE: Neonate

Appendix 2. Feeding activity data sheet for gelada baboon

Arsi gelada baboon feeding ecology data sheet, eastern Arsi

Group ID _____

Date _____

Start time _____ sex/age (IND):AM_____SAM_____JM_____

End Time_____ AF_____JF_____MJF_____

Time interval: 15 minutes

Time seen	GPS Location		IND	Types of diet/item										Types of species eaten	Remark	
	Loc X	Loc y		LGB	SGB	HL	HR	GR	CO	UT	CER	AP	OS			
			SAM													
			JM													
			AM													
			AF													
			JF													
			NE													

Type of Diet: LGB: Long grass blades; SGB: Short grass blades; HL: Herb leaves; HR: Herb root; GR: Grass roots; CO: Corms; UT: Unidentified tubers; CER: Cereals(teff/barely/wheat), AP: Animal prey; OS: Others

Appendix 2. Identified plant species within the home range of gelada baboons.

Local name	Species name	Family	Type	No. of Stem per ha (density)	% of stem density

Kombolcha	<i>Maytenus obscura</i>	Celastraceae	Tree		
Bakanisa	<i>Croton macrostachys</i>	Euphorbiaceae	T		
Birbirsa	<i>Podocarpus gracilior</i>	Podocarpaceae	T		
Dabobessa	<i>Rhus tenuinervis.</i>	Anacardiaceae	H		
Dambii	<i>Myrica salicifolia</i>	Myricaceae	T		
Dhittacha	<i>Dodonaea angustifolia</i>	Sapindaceae	H		
Ejerssa	<i>Olea europaea</i>	Oleaceae	T		
Galloo	<i>Psydrax schimperiana</i>	Rubiaceae	T		
Goraa	<i>Rubus apetalus</i>	Rosaceae	C		
Hadheesa	<i>Vepris dainelli</i>	Ruraceae	T		
Aagamsa	<i>Balanites aegyptica</i>	Balanitaceae	Sh		
Karoo	<i>Osyris abssinica</i>	Santalaceae	T		
Kokolfa	<i>Rhus natalensis</i>	Anacardiaceae	T		
Mi'essa	<i>Euclea racemosa</i>	Ebenaceae	H		
Qaccama	<i>Myrsine africana</i>	Myrsinaceae	H		
Qararuu	<i>Acokanthera schimperi</i>	Apocynaceae	H		
Qilxuu	<i>Ficus vasta</i>	Moraceae	T		
Xaxessa	<i>Rhus glutinosa</i>	Anacardiaceae	Sh		

(T: Tree, H: herb, Sh: shrub, C: climber)

DECLARATION

I, the undersigned, hereby declare that this thesis is my original work; it has not been presented in other University, College or Institutions. All sources of material used for the thesis have been duly acknowledged

Name: Kelil Abu Dale

Signature: _____

Date: 8-07-2011 G C

Place: Addis Ababa University

Date of Submission: _____

Advisors:

Name: Prof. Afework Bekele

Signature: _____

Date: _____