ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

COLLEGE OF NATURAL AND COMPUTIONAL SCIENCES

DEPARTEMEN OF ZOOLOGICAL SCIENCES

(ECOLOGICAL AND SYSTEMATIC ZOOLOGY)

ACTIVITY PATTERNS AND FEEDING ECOLOGY OF THE GELADA BABOON (*THEROPITHECUS GELADA ARSI)* AND HUMAN–GELADA CONFLICTS IN AMIGNA, EASTERN ARSI, ETHIOPIA

By

KELIL ABU

ADVISOR: PROFESSOR M. BALAKRSHNNAN

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DISSERTATION SUBMITTED IN PARTIAL FULFILIMENT FOR THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ZOOLOGY (ECOLOGICAL AND SYSTEMATIC ZOOLOGY)

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ABSTRACT

Activity Patterns and Feeding Ecology of the Gelada Baboon (*Theropithecus gelada arsi)* and Human–Gelada Conflicts in Amigna, Eastern Arsi, Eethiopia

Kelil Abu, PhD Dissertation, Addis Ababa University, 2017

Geladas are Old World monkeys found almost exclusively in the Afroalpine grasslands of the northern and central highlands of Ethiopia. However, a single cluster of gelada populations does exist south of the Great Ethiopian Rift Valley in the Arsi Region. This population was studied during June 2015–July 2017, focusing on activity patterns, diet, ranging ecology and Human–Gelada conflicts in the Amigna, eastern Arsi. Activity types and dietary data were gathered using instantaneous scan sampling method on an average of 10 consecutive days per month. Home range and day range length were determined for each unit based on point to point movements of the units between consecutive GPS locations recorded. These were calculated from the map using measuring tools in the GIS software ArcGIS'9. Human–gelada conflicts in the present study was carried out by means of questionnaire, field observation, and focus group discussions. The gelada baboon faecal dropping samples were also collected to compare the results with the questionnaire survey. Data were analyzed using descriptive statistics and responses compared using Chi-square test and one-way ANOVA. Logistic regression model was used to analyze the attitude of respondents towards gelada baboon and to determine the factors that cause crop loss by gelada baboon. The activity patterns observation showed that, feeding accounted for 40.31% of the activity budget, followed by movement (20.16%), rest (16.56%) and social (22.98%) activities. Geladas spent significantly more time in feeding ($P < 0.05$) and moving ($P < 0.05$) during the dry season compared to the time spent in the wet season. They spent significantly more time in resting ($P < 0.05$), playing ($P < 0.05$), grooming ($P < 0.05$) and aggression ($P < 0.05$) during the wet season compared to the dry season. Geladas diet mainly included grass blades (48.07% of feeding scans), though they also consumed grass roots (18.14%) and leaves of forbs (10.96%). Arsi geladas consumed a total of eight plant species. Among these, the top four accounted for 81.16% of their overall diet. *Hyparrhenia hirta* contributed for 64.76% of the overall diet of gelada baboons. *Ipomoea hildrbrandii* ranked second, *Euclea racemosa* third and *Ficus vasta* fourth accounting for 10.84%, 5.56% and 4.53% of the overall diet, respectively. There was significant differences in the total time spent in feeding on *Ipomoea hildrbrandii* ($P < 0.05$) and *Opuntia strcta* ($P < 0.05$) between dry and wet seasons. The average daily range lengths during the wet seasons was 792.60 m and during the dry seasons was 1022.87 m. The home range areas of gelada groups over the course of the study period was 3.26 km^2 and 5.44 km^2 during wet and dry seasons, respectively. Among the respondent, 79.85% reported that crop damage faced by gelada baboons were increasing from time to time. As distance from the gelada habitat increased, crop damage by gelada baboons was decreased and vice versa. There was a direct relationship between the type of crops grown and the type of crops damaged by geladas ($r = 0.23$, $P < 0.05$). Among the respondents, 25.84% had negative attitude towards gelada baboon, whereas 74.16% had positive. As crop loss by gelada baboon increased, good attitude of respondents towards gelada baboon was decreased and vice versa. In general, there was strong conflict between gelada baboon and the surrounding people in most parts of the study area. Narrow ecological niche, limited geographic distribution, and conflict with local people place Arsi gelada at the risk of extinction. To ensure long-term survival of Arsi geladas, appropriate management actions should be taken to conserve the species and to minimize human–wildlife conflict.

Keywords: Activity budget, anthropogenic disturbances, diet, gelada baboon, human–wildlife conflicts

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DEDICATION

This thesis is dedicated to my family for their encouragement and support.

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ACRONYM

AMU	All Male Unit system
OMU	One Male Unit system
EWCA	Ethiopian Wildlife Conservation Authority
NHAAU	National Herbarium of Addis Ababa University

1. INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

Ethiopia is one of the most physically and biologically diverse countries in the world. It comprises highland massive surrounded by arid lowlands, and possesses diverse wildlife and natural habitats (Yalden, 1983). Most of the Ethiopian highlands harbor many endemic organisims. The main reason for the presence of diverse wildlife and large number of endemic species in Ethiopia is its unique and rugged topography. This helped to develop isolated and varied ecological environments in the country. Ethiopia contains over 320 species of mammalians in 52 families, of which, 31 species are endemic (Hillman, 1993; Cole *et al.*, 1994; Jacobs and Schloeder, 2001; Afework Bekele and Yalden, 2013).

Among the mammals of Ethiopia, non-human primates comprised about 30 (10.5%) species and subspecies (Kingdon, 1997; Grubb *et al.*, 2003; Groves, 2005). Of these, the Gelada baboon (*Theropithecus gelada*), the Blue monkey (*Cercopithecus mitis boutourlinii*) a sub-species of *Cercopithecus mitis* and the Bale monkey (*Chlorocebus djamdjamensis*) are endemic to the nation (Gippoliti, 2010).

Ethiopia is characterized by unusually high endemism (Yalden and Largen, 1992). Despite high levels of habitat destruction and degradation due to high population growth, most of Ethiopia's unique primates remain little-studied. Among Ethiopia's endemic primates, the gelada baboon (*Theropithecus gelada*) has been the subject of detailed research in different areas (Dunbar and Dunbar, 1975; Kawai, 1979; Hunter, 2001; Eshetu Moges, 2015). However, even among the well-studied geladas, there is a rare and isolated subspecies, the Arsi gelada (*T. g.arsi*) occurring southeast of the Great Ehiopian Rift Valley, wich has received relatively little attention compared with its two conspecifics (*T. g. gelada* and *T. g. obscurus*) (Shotake *et al.*, 2016). Though some information are known about its genetic composition (Gurja Belay and Mori, 2006), social structure (Mori *et al.*, 1999), and infanticidal behavior (Mori *et al.*, 2003), only little is known on Arsi gelada's basic natural history, including diet and activity patterns.

Taxonomy of gelada with other baboons, and their relationships remain controversial (Frost *et al*., 2003). Molecular evidences suggest that geladas, and common baboons (*Papio hamadryas)* are closely related (Delson, 1993). However, each of them is the only survivor of a clade that includes several extinct species. For this reason, and because of their divergent adaptations, they are generally considered genetically distinct (Jablonski, 1993). *Theropithecus* and *Papio* were broadly sympatric, within the resolution of the fossil record in the Plio-Pleistocene (Cronin and Meikle, 1979). At present, *T. gelada* coexists with the olive baboon *(P. hamadryas anubis)* over much of the Ethiopian highlands. However, morphological analysis has considered *Mandrillus* to be more closely related to *Papio* than *Theropithecus*, which is often placed as a subgenus within *Papio* (Hill, 1970). Molecular studies have revealed a sister-taxon relationship between *Theropithecus* and *Papio* (Fig. 1), and the exclusion of *Mandrillus*, which has been grouped with *Cercocebus.* There are some morphological features showing a sister taxon relationship between *Mandrillus* and *Cercocebus*, as well as between *Papio* and *Theropithecus*. Thus, the two widely accepted groupings of African papionins, the larger baboons (*Papio*, *Mandrillus* and *Theropithecus*), and the smaller mangabeys (*Cercocebus* and *Lophocebus*) are both paraphyletic assemblages (Cronin and Meikle, 1982; Newman *et al*., 2004).

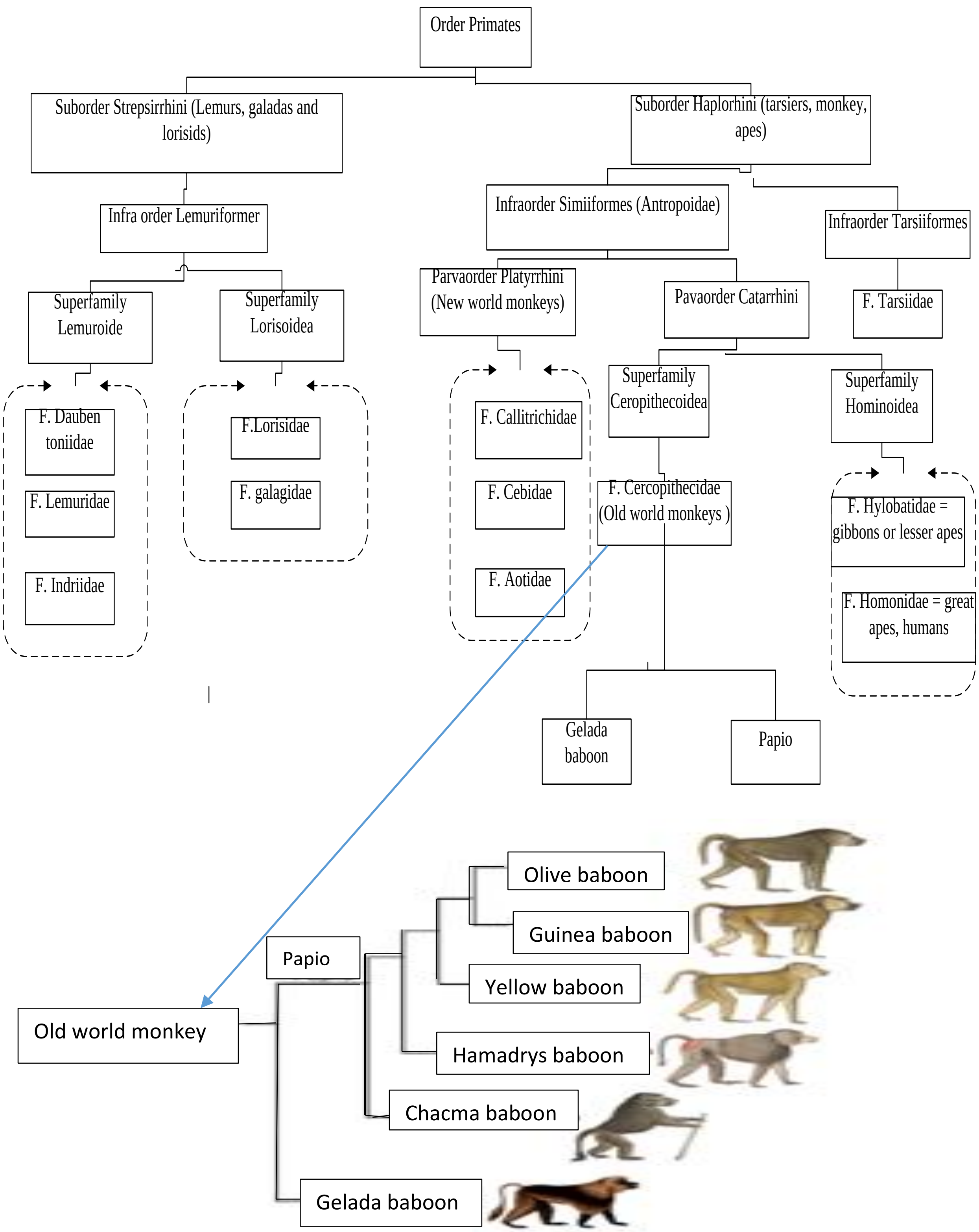

Figure 1. Primate phylogeny

In primate there is a strong tendency to live in cohesive groups. Compared to other mammalian orders, they exhibit a wide diversity of social systems (Kawai *et al*., 1983; Ren *et al*., 2010). Ecological and social factors promoted the emergence of modular social system in gelada and related taxa (Gruter *et al*., 2012). In this case, gelada social systems are limited by anti-predator behaviour, mate choice and access to food resources (Colmenares *et al*., 2002).

Generally, there is no agreement on the common classification of geladas (Frost *et al*., 2003). Crook (1966) first claimed the title gelada 'monkey' would be more apt than gelada 'baboon' suggesting that similarities in morphology, ecology and behavior were examples of convergent evolution (Hunter, 2001). According to Goodman (1998), gelada should be grouped with its papionine kin; but according to McKenna *et al*. (1997), gelada is even farther distant from Papio.

The hierarchical classification of the Gelada baboon is given below (Goodman, 1998):

Kingdom: Animalia

Phylum: Chordata

Class: Mammalia

Order: Primate

Family: Cercopithecidae

Subfamily: Cercopithecinae

Tribe: Papionini

Genus: *Theropithecus*

Species: *Theropithecus gelada*

Majority of the *T. gelada* populations live in the north-western area of the Great Ethiopian Rift Valley at altitudes varying from 2,000 to 4,500 m (Gurja Belay and Shotake, 1998). However, there is also a small population of them in the southern part of the Rift Valley (Iwamoto *et al*., 1996; Mori *et al*., 1997) (Figure 1). According to Gurja Belay and Mori (2006), these two populations possess varying genetic characteristics making the two communities distinct from each other. The restriction fragment length polymorphism (RFLP) test of mitochondrial DNA (D-loop), and revealed that the northern and southern populations formed two distinct gelada haplotype clades distinguished by 9.8% sequence divergence (Gurja Belay and Mori, 2006). This sequence divergence is higher by one order of magnitude than intra-specific population differences reported for mammals. Therefore, it can be assumed that the two populations are of distinct subspecies; the northern population is referred to as *T. gelada gelada,* and the central population is referred to as *T. gelada obscurus* (Gippoliti, 2010) (Fig. 2).

While the differences in *T. g. gelada* and *T. g. obscurus* are minimal, there are a few noticeable distinctions like the darker coloured dorsal fur and flesh coloured face of *T. g. obscurus* (Gurja Belay and Shotake, 1998). This subspecies inhabits the north-western area of the Great Ethiopian Rift Valley in Showa (Menz, Debrelebanos and Muger areas), and in the Wollo and Gojjam Provinces (Yalden *et al*., 1977). *Theropithecus gelada gelada* shows lighter appearance (Gippoliti, 2010) and inhabits the northern highlands, particularly in the Gondar area (Yalden *et al*., 1977).

Mori and Gurja Belay (1990) discovered and described a third new group of geladas in the Arsi region, which is bordered by the uppermost stream of the Wabe-Shebelle river on the southern plateau. Iwamoto *et al.* (1996) and Mori *et al.* (2003), conducted detailed studies on the social behaviour and ecology of this group and documented differences in social structures, behavior, and fur coloration, as compared with geladas on the northern plateau. Specifcally, Arsi gelada single-male units and bands are characterized by much smaller numbers than those of the northern plateau geladas, and their behaviors are characterized by infanticide, tree climbing, and mobbing behavior in response to predators, which are not observed on the northern plateau geladas. The Arsi gelada also inhabits at lower altitude ranges (1,800–2,300 m) than geladas elsewhere (Beehner *et al*., 2007; Fashing *et al*., 2010). Furthermore, their physical appearance is different from the northern and central gelada population, their fur color is lighter (Mori and Gurja Belay, 1990). Gurja Belay and Shotake (1998) compared genetic variation in blood proteins of these geladas with those from the northern plateau and reported large genetic differentiation, estimated to correspond to about 0.4 million years of divergence time between the groups, and suggested the third subspecies. On the basis of population genetic analysis, the Arsi gelada population should be regarded as a distinctive sub-species (*Theropithecus gelada arsi*) (Gurja Belay and Shokate, 1998; Shotake *et al.*, 2016).

Less than 1000 individuals of Arsi geladas are believed to remain, and their Afroalpine habitat is experiencing intense disturbances (Gurja Belay and Shotake 1998; Kelil Abu *et al*., 2017). The remaining gelada population is confined to a cliff and nearby livestock grazing and cultivation areas. Hence, conservation, and management plans of geladas at Arsi should focus on their dietary and habitat requirements.

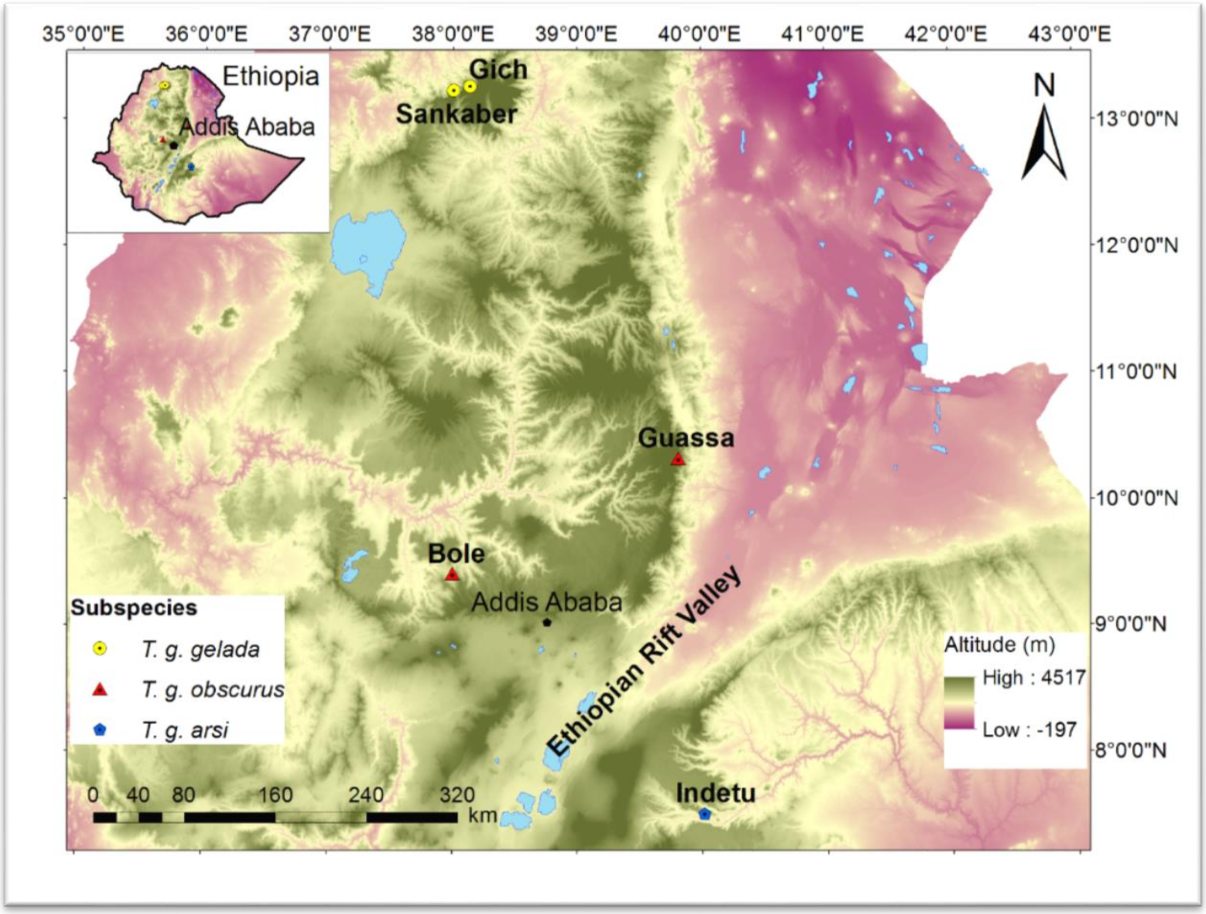

Figure 2. Distribution of *Theropithecus gelada* across Ethiopia

It is estimated that only about 50,000– 60,000 gelada baboons remain in the wild, and their number is declining (Lovejoy *et al.*, 1986). Forest fragmentation may cause local extinctions of geladas or loss of genetic diversity (Lovejoy *et al.*, 1986). Before local extinctions occur, habitat fragmentation may affect the activity patterns and movements of gelada baboons in their habitats. Increasingly, geladas come into contact with humans as local farmers expand their farm and livestock grazing to the steep hillsides (Kelil Abu *et al*., 2017). Additionally, due to their specialized diet, geladas are severely affected by habitat decline and drought (Dunbar, 1998).

Only little is known on the distribution patterns of geladas. According to the UN conservation category (IUCN, 2008) *Theropithecus gelada* is grouped under least concern, estimated with about 200,000 individuals (Gippoliti and Hunter, 2008). However, correct estimations show that their number is much lower. For instance, the largest gelada population, which is found in the Simien Mountains National Park is estimated to be only about 4300 individuals (Beehner *et al*., 2007). With the current known major population localities across the country, the gelada population could be less than 25,000 individuals (Beehner *et al*., 2007). However, the range of the species is not properly studied so far. Understanding the distribution pattern of geladas is important for the population estimate and conservation of the species that needs to be prioritized.

Theropithecus gelada arsi is erroneously listed together with *T. gelada obscures* in the IUCN Red List category (IUCN, 2008). They are currently threatened by extensive cultivation, extension of human settlements, grazing, and elimination as a pest.

Despite the concern over the decline of population, there is no accurate population census of geladas in the eastern Arsi. Currently, information on the population of geladas is insufficient. 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 the population of a particular species is maintained, in decline, or in recovery. Second, establishing accurate numbers of each species is a critical step for implementing conservation and management policies. Third, as there are increasingly more reports of human–gelada conflicts in different areas, particularly with respect to crop raiding, it is important to determine whether or not the gelada populations in different areas may be increasing beyond what the habitat can support (Beehner *et al.*, 2007).

1.2 Literature Review

1.2.1 Gelada baboon (*Theropithecus gelada*)

The Ethiopian endemic primate, gelada baboon, was first reported by the German Naturalist, Riippel in 1835 in the northern Ethiopian highlands (Crook, 1966). They are still the successful among the grass-eating primates (Delson, 1993). They were the predominant non-human primate during the Pleistocene. The genus *Theropethicus* included several extinct species. But, at present, gelada is the sole survivor of the genus *Theropethicus* (Dunbar, 1998). The extinct species of this genus was much larger than the extant gelada, and had much more extreme dental, cranial and skeletal specializations (Fleagle, 1999). *Theropithecus* was an abundant genus in the Plio-Pleistocene of Africa (Delson, 1993; Jablonski, 1993; Jolly *et al*., 1997), and its range was extended eastward to Israel (Belmaker *et al*., 2002), and as far as India (Pickford, 1993).

The most general scheme suggests the evolution of several cranial features throughout the Pleistocene, including reduction of the size of the fossa of the mandibular corpus, reduction of canine height, flattening of the upper symphyseal shelf, development of equal depth of the posterior and anterior mandibular corpus, greater specialization of cheek teeth and reduction of incisor size (Jolly, 1972; Szalay and Delson, 1979).

Due to the above changes, most extinct species of the genus in different regions of Africa are recognized as distinct (Zeresenay Alemseged and Gerads, 1998). In the late Pliocene, around 2.5

mya, a smaller species of theropithecine, *T. atlanticus* was known from northern Africa, and its fossil was found at the site of Ahl al Oughlam near Casablanca, Morocco (Feibel *et al*., 1989). This was a North African late Pliocene species, previously known only by its holotype, a lower molar from Algeria, and supposed to be derived from the *T. darti*-*T. oswaldi* lineage, which was apparently restricted to northern Africa. This species is now much better defined, and is clearly distinct from other species of the genus (Raynal *et al.*, 1990).

Furthermore, the Hadar sample of *T. darti* is the largest and the best preserved of its age so far found in Africa (Eck, 1993). Well preserved specimens allow unambiguous information about their morphological and taxonomical status, and relationships to later forms found elsewhere on the continent (Maier, 1972). The specimens clearly link an East African cercopithecoid taxon with one of those from the South African site of Makapansgat (Iwamoto, 1993).

Today, geladas are found only in few areas of the northern Ethiopian highlands and an additional isolated population is discovered in the Arsi region, south of the Great Ethiopian Rift Valley and east of the Bale Mountains (Mori and Gurja Belay, 1990). They are primarily terrestrial, foraging throughout the day. They retreat to the cliffs at night (McKenna *et al*., 1997; Fleagle, 1999; Huner, 2001; Hailu Beyene, 2010; Eshetu Moges, 2015). Geladas prefer to sleep on rocky cliffs, from which they descend in the morning to forage in the nearby grasslands (Yonatan Ayalew, 2009).

Geladas 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. Gelada baboons can be distinguished from other baboons by their naked face and hour glass-shaped patch of the bare red skin on their chest (Ankel-Simons, 2007). The red chest is a distinctive feature of geladas, and have earned them the alternative name 'bleeding heart baboons'. Their tail is shorter than their head-body length and have tuft at the end (Ankel-Simons, 2007). Adult males have a heavy cap of hair on their back.

Males are larger than females, and marked sexual dimorphism is a characteristic feature of this species (Krentz, 1993; Jolly, 2007). Average wt of females is 11kg while males 18.5kg (Jolly, 2007). Head and body lengths of the sexes combined range between 50 and 75 cm and the tail is between 30 and 50 cm (Ankel-Simons, 2007). They have highly opposable index fingers and thumbs. In addition, fingers are short used for digging (Dunbar, 1976). Geladas have specialized dentition adapted for their graminivorous diet, which is highly abrasive to teeth (Jablonski, 1994). Molar teeth of geladas are distinctive, and are characterized by complex enamel folding with an hyposodont appearance (Szalay and Delson, 1979).

1.2.2 Habitat

The ways in which a group of primates utilizes the space is influenced by the diet, feeding behavior, nutritional quality of food and the distribution and availability of preferred food items (Barton *et al.*, 1992; Hunter, 2001). Geladas live in harsh mountain areas of the central plateau of Ethiopia, with an elevation ranging from 1500 to 4500 m a.s.l. (Iwamoto, 1993; Yonatan Ayalew, 2009). The present day habitats of geladas consist of montane grasslands with no tall trees, and are characterized as wet and cool, but they may differ in geographic features, vegetation composition and climatic conditions (Dunbar and Dunbar, 1975; Hunter, 2001). At higher elevation, such as the

Gich plateau, grasslands stay green for a longer period of time due to high rainfall and low temperature (Iwamoto and Dunbar, 1983). This condition provides geladas with a better digestibility of grasses for a greater time span during the year. However, at very high altitude, grass protein content declines, which makes it hard for them to meet the nutritional requirements (Dunbar, 1998). Similarly, geladas face difficulty to cope with grasses at lower elevations, as the digestibility of grasses is too low (Demment and van Soest, 1985).

Gelada habitat is also characterized by the proximity to cliffs for refuge and for sleeping, and the use of several different types of relatively treeless and montane grasslands for foraging (Dunbar, 1979; Kawai and Iwamoto, 1979). Geladas are ill-adapted to arboreal way of life. Even where they occur in or near forests, they rarely climb up trees. Geladas' dependence on gorge side has not only provided a refuge from the incursion of man and protection from predators, but also a habitat to which the species is particularly well adapted (Jolly, 1972). In general, geladas of the Arsi population live in a habitat that is relatively low in terms of food availability (Kelil Abu *et al*., 2017).

1.2.3 Activity patterns

Geladas are almost exclusively diurnal and no activity is recorded besides resting between 18:30h to 06:30h at the sleeping cliffs (Kawai and Iwamoto, 1979; Hunter, 2001; Hailu Beyene, 2010; Eshetu Moges, 2015). In the morning, geladas climb from their sleeping cliffs to the top of the plateau. Soon after, they commence social activities and feeding (Dunbar and Dunbar, 1974; Dunbar, 1977). Feeding comprises the main diurnal activity of geladas; it goes up until the evening when they involve in social activities prior to descending to their sleeping cliffs (Dunbar and Dunbar, 1974).

1.2.4 Feeding ecology

Geladas are almost entirely terrestrial quadrupeds (Fleagle, 1999), and have specialized morphological adaptations for feeding and moving on the ground (Dunbar, 1986; Krentz, 1993). *Theropithecus gelada* is unique in its dietary habits among primates (Iwamoto, 1993) and they harvest grasses primarily using the thumb and first finger while sitting and 'shuffling' along the ground (Wrangham, 1980). The post-cranial morphology of *Theropithecus* has some unique features, thought to be adaptations for harvesting and feeding grasses. These adaptations are a relative elongation of the first metacarpal, a relatively short proximal phalanx of the second digit and a femur displaying a reversed carrying angle, which may be related to the habitual sitting and bottom shuffling form of locomotion (Jolly, 1972; Etter, 1973; Krentz, 1993).

The opposability of the first two digits of all catarrhine primates allows them to pick grass blades individually. Their phalanges are short and robust, which allows them to dig tubers efficiently when desired. These specializations allow gelada baboons to take advantage of grassland environments, which other primates could not inhabit successfully (Dunbar, 1977; Mau *et al*., 2009).

Geladas also have physiological adaptations for the high mountain grasslands, where temperature drops frequently, and hence, elevated glucocorticoid levels of geladas gauge their stress level during the cold weather (Iwamoto, 1993). Glucocorticoids are hormones that affect metabolism of carbohydrates, and they can be used to track changes in food availability or seasonal stressors

(Beehner and McCann, 2008). *Theropithecus gelada* exhibits elevated glucocorticoid levels during extreme cold weather (Hunter, 2001). They have at least two adaptations for living in cold weather conditions such as increased body hair density and greater food intake (Dunbar, 1980). However, based on their higher glucocorticoid levels, these changes are not enough to completely rectify their cold stress (Iwamoto and Dunbar, 1983). They respond well to cool, and dry climates, which is most likely why they are currently thriving in the Ethiopian highlands regardless of the very cold surroundings during times of extreme winter. However, regardless of their seemingly normal glucocorticoid levels, they do not fair well during the severe wet season (Beehner and McCann, 2008). Based on a study conducted by Dunbar (1980), births within groups are timed in order to decrease exposure of newborns to the conditions of the wet season. Females of the same reproductive groups experience close reproductive synchrony, believed to be related to both environmental and social factors (Beehner and Whitten, 2004).

Baboons, which consume a high dicot to monocot ratio of food items have higher amounts of proline-rich salivary proteins with tannin-binding capacity. Dicots produce tannins as a chemical defense system in order to discourage animals from eating them. However, animals with the ability to bind tannins are able to eat and extract nutrients from dicots with which they supplement their diet (Dunbar, 1977). Studies on the salivary compounds of *T. gelada* showed that they lack proline-rich salivary proteins, and therefore unable to consume dicots as a food source (Mau *et al*., 2009). Whether lack of tannin-binding proteins evolved in *T. gelada* had no need for them or lack of tannin-binding proteins forced them into their narrow feeding niche is yet to be conclusively proved (Mau *et al*., 2009). While *T. gelada* is unable to consume dicots, they have been observed to eat insects occasionally (Fashing *et al*., 2010).

Gelada baboons are herbivorous (Iwamoto and Dunbar, 1983), with grass forming more than 90% of the diet in most habitats and seasons. But, their choice of food changes depending on seasonal availability of food resources (Dunbar, 1977; Kawai, 1979). During the dry season, it changes its dietary intake from grass to herbs, flowers, rhizomes, roots and fruits and there is an increased food intake by prolonging the time spent feeding (Kawai, 1979; Jablonski, 1993). The time spent in feeding increases with altitude. This is a consequence of metabolic costs of maintaining body temperature as the ambient temperature declines with increasing altitude. The problem is compounded when foraging quality declines as altitude increases, and additional time is to be devoted for feeding to offset the shortfall in the nutritional intake (Warngham, 1980).

Geladas are vulnerable to the effects of grazing (Dunbar, 1984; Iwamoto *et al*., 1996). It has been noted that the reliance of geladas on grasses poses a number of important constraints on their ecology. It is generally assumed that a diet based on grass requires bulk feeding strategy, which in turn impinge on the animal's time budget as extra time is required for feeding (Iwamoto, 1979; Hunter, 2001). The narrow and specialized morphological adaptations of the species may drive such species to *extinction*. There are several reported cases for the population declines of grazing herbivores due to livestock grazing competition (de Leeuw *et al.*, 2001; Mesele *et al*., 2008; Hailu Beyene, 2010). In addition to the effects of direct feeding competition, this also may aggravate the land-use conflict with the agropastoral local people of the Arsi mountains. Hence, understanding the habitat use overlap between livestock and gelada baboon, and the extent of the grazing land conflict are important issues for conservation of geladas.

1.2.5 Ranging Behaviour

Home range of geladas has been negatively correlated with the habitat quality (Iwamoto and Dunbar, 1983). Day range length tends to scale with both band (aggregations of reproductive units and all-male groups) size and habitat quality. In many species, larger groups travel farther each day. Bands of geladas living in poorer habitats forage longer. This strongly implicate band energy requirements, resource availability and intragroup competition over food as critical factors affecting variation in gelada ranging, both within and across a band (Dunbar, 1991; Gruter and Zinner, 2004).

The daily foraging distance of *T. gelada* is between 1–2 km long. Differential use of the home range has been observed between wet and dry seasons due to patchy distribution of the green grass during the dry season (Fiore, 2003). On the other hand, hamadryas baboons have the largest day range recorded for any primate species (mean of 13.2 km and maximum of 19 km) (Kummer, 1975).

Increased intragroup feeding competition under conditions of scarcity of essential resources may lead primates to increase their individual foraging efforts, which might then be reflected in longer group day ranges, fast travel, increased time allocation for foraging, larger seasonal home ranges, and visits to more feeding patches each day (Fiore, 2003). In such cases, ranging behaviour might be correlated with other ecological variables, such as climatic conditions or the availability of alternative resources (Milton, 1976).

There is a positive relationship between feeding and moving time on the grounds that each unit would require a specific area of food resource to be searched (Dunbar, 1986). Mean day time journey is closely related with the band size, which suggests that each animal has to cover a specific extent each day to obtain its daily nutritional requirements (Savini *et al*., 2008). Further, the band size may be limited if travel time is insufficient to defend ranges (Pollard and Blumstein, 2008). This relationship is obtained despite considerable daily and seasonal variations in the length of journey (Iwamoto and Dunbar, 1983).

Through territoriality, a group defends its exclusive foraging rights in a specific area, and the composition of a group remains constant through time. Gelada band is a closed social and territorial unit (Denham, 2001). It also defends the territory against intrusion by conspecifics (Bates, 1970). In geladas, spacing is maintained when any of the essential resources is in short supply (Crook, 1972; Kummer, 1975; Denham, 2001). As a result, competition for the limited resources is expected in the context of evolution of territoriality (Mitani and Rodman, 1979; Chapman and Fedigan, 1984). In gelada intergrouping, separation is maintained by long distances and mutual vocalization-mediated avoidance (Waser and Homewood, 1979).

1.2.6 Social Organization

Theropithecus gelada form large groups or aggregations on a permanent or regular basis. These large groupings can be determined by various ecological requirements such as predation avoidance, optimal habitat use and foraging, mate defence and infanticide avoidance. In contrary, group living has its own disadvantages, such as increased competition with other individuals for the same resource of food and mate. The social system of geladas consist of social organization, social structure, and mating system (Dunbar, 1986; Gruter and Zinner, 2004).

The term ‘social’ indicates more than one individual living or associating together. But, all animal aggregations are not social. To be social, they must have some form of species-specific communication and behavioral display patterns, and stay together and involve in similar cooperative activity patterns, keeping them together on the basis of reacting to each other (Crook, 1966; Kawai *et al.*, 1983; Dunbar, 1986; Gruter and Zinner, 2004).

The dynamic and complex social organization of geladas consist of reproductive units, all-male groups, bands (reproductive units and all-male groups), herds and communities (Crook, 1966; Kawai *et al.*, 1983; Dunbar, 1986; Gruter and Zinner, 2004). Kawai *et al.* (1983) suggests that it may be possible to identify a social grouping (named *team*) intermediate between the OMU and the band.

Predation pressure and resource competition have effects on the grouping patterns of geladas. Large groups are formed where predation risk is high. However, this gathering has the side effect of competition for food. But, in areas where predation risk is less, bands split into segregated OMUs, which helps to reduce competition for food (Dunbar, 1986).

The basic social unit of geladas is one male with several females and their offsprings. Such a group is called one male unit (OMU) (Crook, 1966; Huner, 2001). This is the smallest grouping within the social system. More than one male unit may perform activities side by side or may travel in the same area making up a second level of organization called a band (Kawai *et al*., 1983). As individual, one male unit may separate from the other unit, so, membership within a band is not permanent. Outside of these social organizations are groups consisting entirely of males

(Stammbach, 1987). Two main components of the system are the individual reproductive units and the cluster of units (bands) that share a common home range. The one male unit provides the context in which most social behaviour and all reproductive activities takes place, whereas the band is the basic ecological unit. Gelada bands may also be the fundamental genetic unit. Members of a given band are genetically more homologous than members of all other bands (Gurja Belay and Shotake 1998; Gurja Belay and Mori, 2006).

Grooming is exhibited by all members of an OMU. Grooming between members is very important for social stability. When an OMU grows beyond capacity, the male is unable to attent all females in the unit. When this happens, unity within the group is lost, leaving a number of females unattended and able to form new groups with males from roaming associated male units (AMUs) (Dunbar, 1978).

Grooming can be categorized into self-grooming (autogrooming), social grooming (allogrooming) and mutual grooming (Ventura *et al*., 2005). Autogrooming is an activity done by an individual itself, which can be observed in social groups and in solitary individuals (Dunbar, 1991). Social grooming or allogrooming is an activity that occurs between individuals (Lehmann *et al*., 2007). The difference between autogrooming and allogrooming is that the former lacks element of sociality (Dunbar and Sharman, 1984). Allogrooming is a form of grooming where one individual grooms another so that social grooming tend to be a reciprocal interaction. It involves more than one individual (Dunbar *et al*., 2009). Mutual grooming occurs between two or more individuals, grooming each other without keeping a reciprocal interaction (Henzi and Barrett, 1999).

In *T. gelada*, as one male monopolizes more than one females, a number of solitary males without breeding females form as All–male unit (AMU) that travel separately from OMUs (Mori *et al*., 1999). All-male unit usually consists of adolescent and younger adult males (Dunbar and Dunbar, 1975) and removed former OMU leaders (Dunbar, 1993c). All-male groups are led by a single male individual, and normally contains one young adult and several sub-adult males, with individuals usually spending 2–4 years after emigration in an AMU before joining or attempting to join a reproductive unit. In general, interactions between AMUs, other AMUs, and reproductive units are mainly agonistic (Dunbar and Dunbar 1975).

Young males leave their natal units as juveniles or sub-adults to join or form AMU (Dunbar and Dunbar, 1975). All-male units may spend a considerable proportion of their time wandering alone, or attached to the adjacent band. Although the process whereby AMUs are formed is poorly understood. Dunbar and Dunbar (1975) suggested that young males might become members of an AMU either joining an existing unit or form a new unit through gradual intensification among male juvenile members. There is some indication that AMUs may function as buffer units in which males who are not members of a reproductive unit may reside (Mori *et al.,* 2003). Similar to the case of the reproductive unit, AMU is also aggressive to align group individuals, but not amongst themselves (Dunbar and Dunbar, 1975).

Finally, at the highest level of organization, the community (Kawai, 1979) is made up of any unit within the population that may associate together over a span of years, although any putative bonds between such individuals may be determined. This highest social level in gelada society is sometimes confused with the term ‘‘herd’’. Herds, however, are not a stable social formation, but rather temporary aggregations of gelada units with no particular allegiance or status (Dunbar, 1993a).

Therefore, in the geladas, a community is a stable social level, whereas a herd is a temporary association of units from multiple bands. There is little debate about the individuals that make up a unit. Adult males and females within any given unit are always found together. However, the pattern of association of the higher social levels of geladas (team, band, herd and community) is yet to be quantified. In this case, aggregations of geladas followed by fission and fusion throughout the day (Dunbar, 1993b), and neighbouring bands have overlapping ranges and regularly form mixed associations (Kawai *et al*., 1983). Short-term association patterns are not indicative of band membership. Further, there is uncertainty about whether the gelada band (or community) is indeed a level of organization at all. Perhaps bands (or communities) simply emerge from overlapping home ranges among units with no particular allegiance to one another (Snyder-Mackler *et al*., 2011).

1.2.7 Reproduction and mating system

Environment and seasons influence reproduction and mating systems of wildlife. Dominance hierarchy leading to mate and resource access is common among primates (Denham, 2001). Males compete for the control over the reproductive unit. Among geladas, males pursue the following different options for acquiring breeding females:

By joining a One Male Unit (OMU) as a submissive follower and trying to establish relationship with the OMU females, in particular with young pre-reproductive females to build up a nuclear unit within an OMU. Such a unit could split off later and pursue independent existence of the nuclear unit (Bergman and Kitchen, 2008). By group take over, which is a fast and aggressive process (Dunbar, 1978; Gruter and Zinner, 2004). One male units having lost its leader remain intact and taken over as a group by a male from all male unit (AMU) or merge entirely with another OMU (Mori, 1979). As female–female relationship in gelada is so strong, splitting of females into different OMUs does not occur; and the simplest strategy for acquiring females would be to' kidnap' a loose female and form a small unit with her. Some reproductive units consist of more than one adult male, although extra males do not play significant role in the reproductive processes (Ohsawa and Dunbar, 1984).

Dunbar (1984) estimated that the OMU gelada leader stay for 3–5 years. The male life expectancy is 12 years. Defeated old OMU leader remains in the OMU for about two years and then drift off to rejoin an AMU (Dunbar, 1993c). By staying within the OMU, old leaders have a chance to protect its own infants from infanticide (Dunbar and Dunbar, 1975).

Thropithecus gelada has a polygamous mating system. In the reproductive units of geladas, if more than one adult male is present, only one is reproductively active to the exclusion of extra males, and thus the reproductive unit is effectively a single dominant male unit (Ohsawa, 1979; Mori *et al.*, 1997). Before the onset of copulation, the leader male usually inspects the ano-genital region and the chest of females. However, majority of copulations is solicited by females. When the female solicits the male, she shows a distinctive posture, which can easily be understood by the unit leader. Among gelada females, chest patch colour changes with reproductive condition, growing brighter close to ovulation and as pregnancy progresses (Dunbar, 1977; McCann, 1995). The female also releases a pheromone with aliphatic acid, which enhances her attractiveness to the male (Altmann and Alberts, 2003). The usual solicitation posture involves pointing and raising her abdomen towards the male and moving her tail to one side (Bernstein, 1975). Copulation usually lasts only around ten seconds, which is accompanied by vocalization (Lehmann *et al*., 1995). Most copulation occurs during the morning, before the mid-day (Dunbar and Sharman, 1983). During estrus, a female usually copulates 2–5 times a day (Altmann and Alberts, 2003). Though copulation occurs at any time in the estrus cycle, its frequency increases around ovulation. Males do not sexually interact with females of units other than their own (Dunbar and Dunbar, 1975).

Gelada males often use sexually selected signals to advertise their abilities in competitive encounters with other males. As aggression can result in costly injuries to both the winner and the loser, individuals should display before fighting to resolve conflicts at the lowest possible cost (Smith, 1982). Among males, chest coloration has been hypothesized to reflect the frequency of involvement in agonistic encounters with other males (Dunbar, 1984). Further, male chest colour has been observed to turn pale after a male is defeated by a rival (Dunbar, 1977). As such, a male's chest colour might serve as a quality signal to other geladas, broadcasting its fighting ability or qualities. In addition, prime adult males (i.e., males 8–13 year old) exhibit significantly redder chest patches than with immature and older males (Bergman and Beehner, 2009). This prominent colour is affected by age and social status. Apart from this, male geladas also exhibit skin and pelage differences. They have a large prominent mane, which probably serves to make males appear larger (Dunbar, 1992b).

In gelada females, the size and colour of the naked triangular chest patch is affected by hormonal changes. Sexual signals are thought to be located on the chest because of better visibility, as they sit on the ground frequently (Wickler, 1967). Younger females have patches in purple, which fade to pink in older females (Dunbar, 1977).

Geladas have low birth rate compared to other baboons, and macaques. Females give birth for the first time at about four years of age and continue to produce offspring thereafter at an interval of approximately two years. Males are considered to be reproductively mature at six years of age (though they undergo puberty at the age of 3–4 years (Dunbar, 1980).

Pregnancy of individual females is influenced by females' age and her dominance rank within the unit. Females' age is probably a consequence for increasing ovulatory irregularity with age. Graham *et al.* (1979) found a positive correlation between the number of offspring a female had and her dominance rank. Stress from repeated harassment by higher ranking females cause ovulatory failure in low ranking individuals (Graham *et al.*, 1979).

Gestation period in gelada lasts between 5–6 months. Females generally give birth to one infant at a time, and females with infants are unestrus (Kawai, 1979; Smuts, 1987). Lactation lasts for about 12–18 months. Parental care is primarily the responsibility of females. Females carry, groom, nurse and protect their offspring until the young is independent. The role of males in the care of offspring is not clearly known.

Actual gene flow between bands occur as a result of two processes; migration of individuals from one band to another and the transfer of individual animals (usually males) between bands. Females have remained within their natal units together with their female relatives throughout their lives, whereas males first join an all-male group as juveniles or sub-adult and later move back to a reproductive unit in a different band (Ohsawa, 1979; Dunbar, 1980).

1.2.8 Conservation status

There is increasing human settlements and agricultural expansion throughout Ethiopia. This affects the unique biodiversity of the country. As a result some of the wildlife species are at the verge of extinction. Gelada baboon is one example. Based on morphological and genetic evidences, Gurja Belay and Shokate (1998) suggested that the gelada population in Arsi is a distinctive sub-species, while IUCN recorded it as unidentified sub-species (Gippoliti and Hunter, 2008). The Arsi gelada inhabits a lower altitude (1,800–2,300 m) than geladas elsewhere (Beehner *et al.*, 2007; Fashing *et al.*, 2010). This range is relatively good for agriculture and there is increasing use of the area for farming, human settlements and livestock grazing, pushing geladas to marginal areas mainly to bare rocky cliffs. This leads to a reduction in the population density of geladas (Dunbar, 1977). Due to its diet specialty behaviour, makes gelada highly sensitive and is at high risk.

Clearing of vegetation in certain areas of geladas' habitat, which was replaced by fast growing non-native species such as *Eucalyptus globules* by local farmers indirectly affect geladas. Soil erosion is a problem in *Eucalyptus* introduced areas and hence inhibits growth of grasses, which are the most preferred diet of geladas (Dunbar, 1977). Though geladas' preferred diet is grass, in time of drought, they raid crops especially during the harvesting season (Dunbar, 1977). This leads to a conflicts between the geladas and local farmers.

In the past, local people killed male geladas for their mane to be used for ceremonial head-dresses. Such killings reduce the number of males from the population and alter reproductive and social dynamics of the species (Dunbar, 1993c). Restricted home range and continued human encroachment have resulted in a 'rare' status of the gelada by IUCN listing in appendix II in the Convention of International Trade in Endangered Species (CITES) (Gippoliti and Hunter, 2008).

1.2.9 Human–Wildlife Conflict

Human–wildlife conflict is universal where wildlife and human populations share limited resources (Hillman, 1993). Large areas of Ethiopian lowland and highlands are changed into agricultural and pastoral lands. Vegetation is overused for fuel wood, construction purposes, and as timber. Increasing livestock and human population pressures coupled with misappropriate land-use has led to massive destruction, depletion and degradation of wildlife habitats as well as drastic reduction in wildlife population. Hence, wildlife resources of the country are now largely restricted to a few protected and inaccessible areas (Hillman, 1993).

Much of the current biodiversity crises arose as a result of intensive competition with humans for space and resources. Thus, protected areas become isolated islands of natural habitats invaded by human settlements all around (Sitati *et al*., 2005). Conflicts between human and wildlife populations are emerging as a major conservation issue worldwide. Crop raiders including elephants, primates, aves and rodents can destroy farmers' food and cash crops. Carnivores and larger crop raiders are often presumed to be a threat, and they are illegally shot on sight by the affected people (Mesele Yihune, 2006).

Human–wildlife conflict incidents are widespread, but not evenly distributed because they are dependent on the proximity of wildlife habitat. Different species of wild animals cause different types of damages at different times of the year (Mulonga *et al*., 2003). One of the major causes for human–wildlife conflict is increasing human population adjacent to wildlife areas. As human population increases and the demand for resources grows, the frequency and intensity of conflicts between wildlife and local people increases (Newmark *et al*., 1993). This can be manifested by increasing encroachments into wildlife habitats. As a result, species that are unable to adapt to altered and fragmented habitats are forced to decrease their number and invade marginal habitats (Naughton-Treves, 1997; Mesele Yihune *et al.,* 2008). But, those species that are able to adapt to the changing land-use patterns survive in agricultural systems and become involved in direct competition with humans (Kristin and Struhsaker, 1999; Deresse Dejene, 2003).

Cultivated crops have characteristics of increased yield, rapid growth and resistance to disease, making them vulnerable to of locally abundant herbivores (Messmer, 2000; Mesele Yihune *et al.*, 2008). Crop raiding has most likely been occurring since humans first settled down and started practicing agriculture. Different types of food items are targeted by wild animals, from cereals to fruits and from vegetables to trees (Sillero-Zubiri and Switzer, 2001; Mesele Yihune *et al.*, 2008).

1.2.9.1 Human–gelada baboon conflict

The potential threat for the survival of gelada baboon is the conflict with humans due to crop raiding and grazing land competition with livestock (Mesele Yihune, 2006). Conflicts between farmers and primates increasingly impacts conservation efforts. Due to increasing human settlements and expansion of cultivated land into wildlife habitats, crop raiding becomes one of the most common conflicts antagonizing human–wildlife relationships. Crop raiding may cause substantial damage to agricultural crops, and directly affects local food security (Hill, 2000).

Crop raiding also may result in increased time spent by humans in protection of their farmlands and potentially decrease yields per human labor effort (Loudon *et al.*, 2006). Such conflict usually reduces tolerance of wildlife within the neighbouring human communities (Sekhar, 1998). In the central and Smein Mountains National Park, gelada baboons are known to damage crops of the agro-pastoral people living in the vicinity of the Smein Mountains National Park (Mesele Yihune, 2006). In the Arsi mountains, no legally protected area is established for gelada baboon conservation so far.

1.2.9.2 Public Attitude towards Wildlife

At present, conflict between local people and wildlife is one of the major conservation issues (Newmark *et al*., 1993). The attitude of local communities living adjacent to protected areas is highly influenced by the problems associated with wildlife. People living around protected areas, who are unable to resist the losses caused by wildlife are likely to develop negative attitude towards wildlife (Newmark *et al*., 1993, 1994). In communities with a subsistence economy, even small losses can generate strong negative attitude towards wildlife (Oli *et al*., 1994). As reported by Newmark *et al*. (1994) in Tanzania, conservation attitude of local people living adjacent to protected areas is strongly influenced by problems from wildlife. On the other hand, people who get benefits from natural resources are likely to support wildlife conservation efforts and protected area systems (Zelealem Tefera, 2001).

Human attitudes and values about wildlife vary among and within different sectors of the society. The views of rural residents about wildlife may differ from those of urban residents due to the fact that rural people experience more of the problems caused by wildlife. Rural farmers are one sector of the society whose attitudes about wildlife continue to differ from other stakeholders. They continue to view wildlife in terms of its direct importance to them, and tend to be more concerned about how wildlife affects them economically (Messmer, 2000).

1.3 The present study

An understanding of the basic natural history of each of the primate species is vital to their conservation (Caro 1998, 2007; Fashing, 2007; Addisu Mokenen, 2010). For instance, data on feeding ecology of animals provide information on the individual food species necessary for the survival of the species, and its level of dietary specialization (Caro, 1998). The more specialized is the diet of a species, the greater is the risk of its extinction (Harcourt *et al.*, 2002). Data on activity patterns can help to guide monitoring strategies for threatened species (Caro, 1998). Activity patterns might reveal information about how gelada baboon adjust their limited energy budgets in response to local weather condition across seasons.

Data on primate ranging behavior are also critical for conservation planning. In particular, home range size and shape can contribute to decisions relating to design of reserves, while degree of territoriality influences the extent to which multiple groups can be distributed within a given patch of habitat (Caro, 1998). Data on human–gelada baboon conflicts are also critical for conservation planning (Caro, 1998; Mesele Yihune, 2008), as they also face threat from human beings.

Ecology and behaviour of some of the gelada populations have been studied. However, information on the ecology, behaviour and conservation of geladas at Arsi is lacking, and this sub-population remains one of Africa's least known primates. There is inadequate data on the Arsi gelada baboon distribution, feeding ecology, activity patterns and human–gelada conflicts. Due to the limited data on its geographic distribution, and population status, the Arsi gelada area is unprotected (Gurja Belay and Shokate, 1998; Kelil Abu, 2011).

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 geladas in Arsi. Thus, the goals of the present study on gelada in Arsi were, i) to study ecological and behavioral adaptations to life in cliffs; and ii) to reveal essential ecological information on the diet, activity patterns, and human–gelada conflicts. It is expected that these data will help to develop conservation strategies for one of the world's least known primates.

1.4 Objectives

1.4.1 General objective

The General objective of the present study was:

- ❖ to study the activity patterns, feeding ecology, home range of gelada baboon (*Theropithecus gelada arsi*) and conflict with human in Amigna, eastern Arsi, Ethiopia.

1.4.2 Specific objectives

The specific objectives of the present investigation were:

- to determine the activity patterns of geladas,
- to study the feeding ecology of gelada baboon in Amigna
- to analyse the home range pattern of Arsi geladas in different seasons,
- to study the presence of human–gelada conflicts in the study area,
- to determine the attitude of local community towards gelada baboon.

1.5 Hypotheses

- Pattern of movement and other activities of *T. g. arsi* differs from the northern geladas.
- *Theropithecus gelada arsi* have more limited diet/resource than other conspecifics.
- Seasonality affects Arsi gelada foraging ecology.
- Geladas have larger home ranges and high rate of home range exploitation during the dry season.
- There is a conflict between the local people and Arsi geladas.
- People living in Arsi gelada area have negative attitude towards the baboons.

2. THE STUDY AREA AND METHODS

2.1 The Study Area

The present study was conducted in Amigna Woreda, in the eastern Arsi, Oromia Regional State, Ethiopia. The study area is located between 07°43′–07°53′N latitude and between 039°49′–040°5′E longitudes (Fig. 3). It is located 370 km away from the capital city, Addis Ababa, in the southeast direction, and 155 km east of Asalla, capital of the zone. The study area is lowland and consists of forested cliffs and valleys bisected by streams. It is part of the eastern Rift Valley, with the altitudinal ranges of 1,600 – 2,512 m a.s.l.

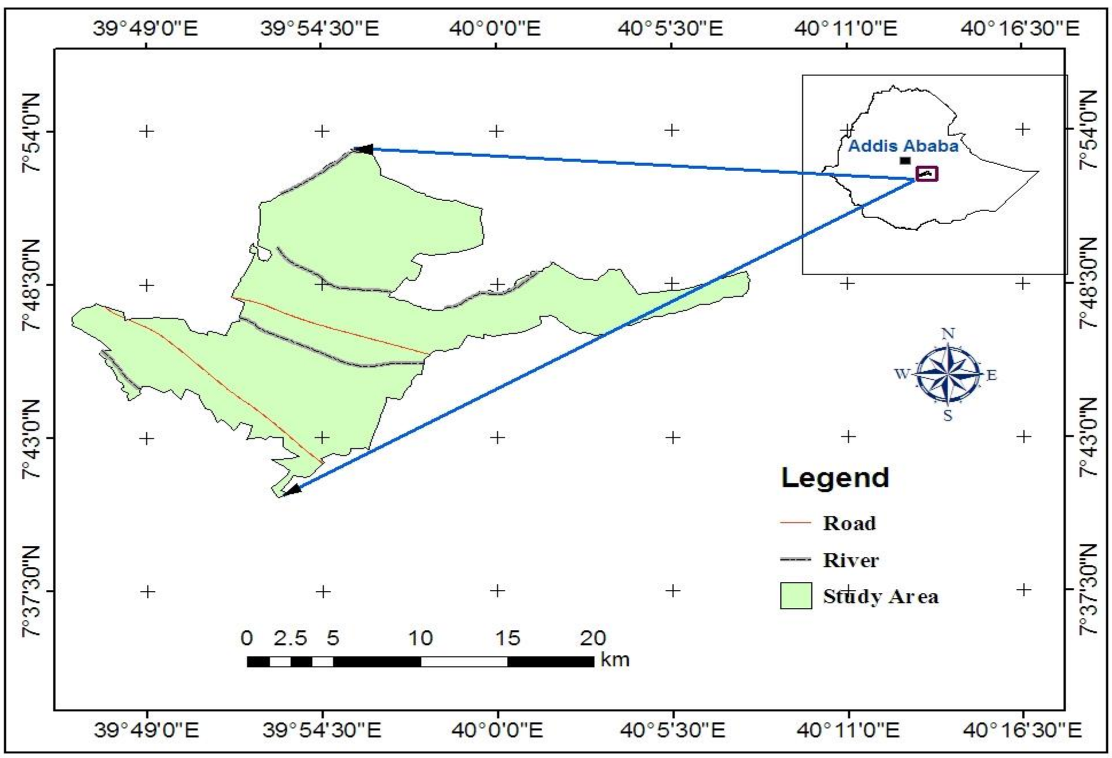

Figure 3. Map of the present study area

2.1.1 Climate

The climate of the eastern highlands of Ethiopia is characterized by tropical type. The climate of Amigna area varies with altitudinal gradients and seasonal changes. At higher altitudes, wet season is characterized by high rainfall. Eastern Arsi experiences wet season from June to October and dry season from November to May. The average annual rainfall at Amigna for the period from 1990 to 2016 was 821.1 mm per year. Rainfall at Amigna varied between a mean monthly minimum of 8.5 mm in January to a mean monthly maximum of 153.7 mm in August (Fig. 4). Temperature in the area ranged from the mean monthly minimum of 5.6ºC in December to the mean monthly maximum 24.14ºC in June (Fig. 5). Amigna experienced longer and intense period of dry season and relatively high temperature than at gelada range in northern part (Hunter 2001; Fashing *et al.*, 2014).

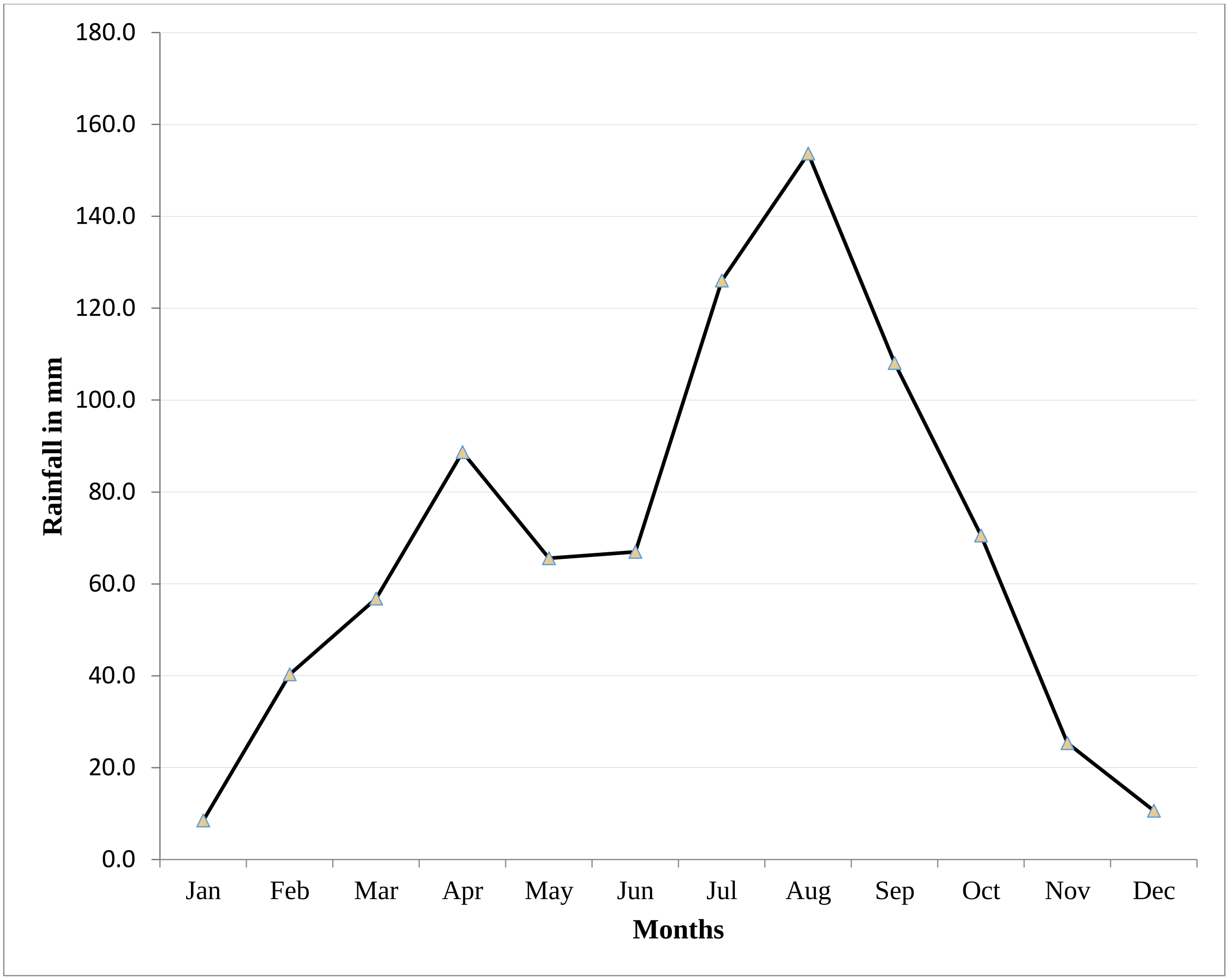

Figure 4. Monthly rainfall data of the study area (1990–2016) (Source: Ethiopian Meteorology Agency, Amigna Field Station) (2017)

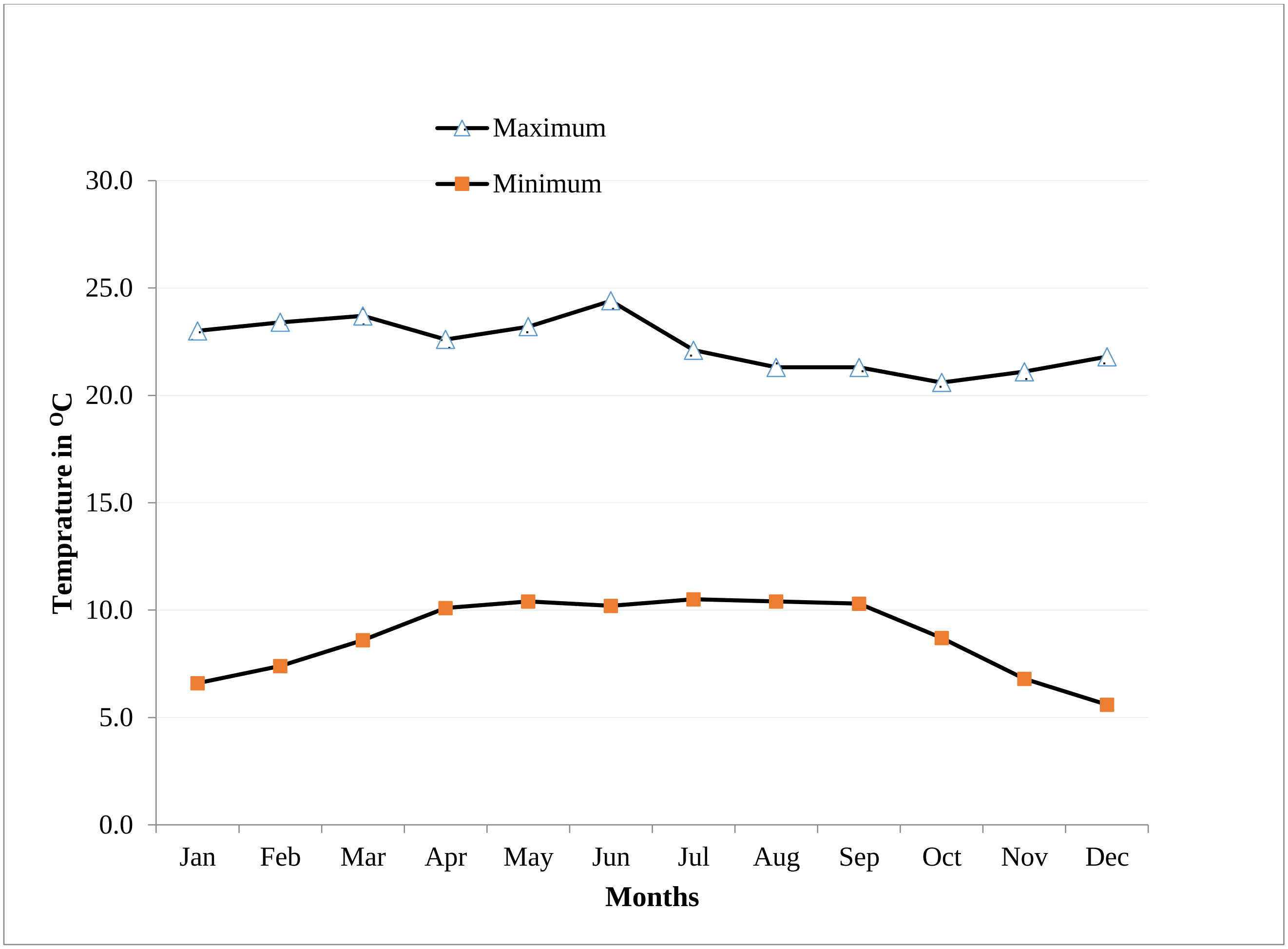

Figure 5. The mean minimum and maximum temperatures of the study area (1990–2016) (Source: Ethiopian Meteorology Agency, Amigna Field Station)

2.1.2 Fauna

Amigna is home to many species commonly associated with Afro-alpine ecosystem. The following mammalian species are known to occur in the study area: Anubis baboon (*Papio hamadryas anubis*), hamadryas baboon (*Papio hamadryas hamadryas*), gelada baboon (*Theropithecus gelada*) (Fig. 6), warthog (*Phacochoerus africanus*), Leopard (*Panthera pardus*), Abyssinian black and white colobus (*Colobus guereza*), common jackal (*Canis aureusa*) and common duicker

(*Sylvicapra grimmia*) (Mori *et al.*, 1999). The small mammals, birds and reptiles in the area are not evaluated so far.

Figure 6. Geladas foraging in Amigna Area (Photo: Kelil Abu, 2016)

2.1.3 Flora

Amigna area is characterised by different vegetation communities in all stand form (tree, shrub and herb) including, *Ficus vasta, Euclea racemosa, Balanites aegyptica, Rhus glutinesa, Dodonaea angustifolia, Maytenus obscura, Croton macrostachys, Podocarpus gracilior, Rhus tenuinervis, Myrica salicifolia, Olea europaea, Psydrax schimperiana, Rubus apetalus, Vepris dainelli, Osyris abssinica, Rhus natalensis, Myrsine africana* and *Acokanthera schimperi* (Appendix I)**.**

Habitat types in the Amigna area is classified into forested cliff (eg. Sadewole), bushland and grassland. Sadewole forest habitat contains *Vepris dainelli* mixed with other tree species such as

Olea europaea and *Psydrax schimperiana* (Fig. 7). Bushland habitat is dominated by *Dodonaea angustifolia* and also contains *Euclea racemosa*, *Balanites aegyptica* and *Rhus glutinesa* with very few or no big trees (Fig. 8).

Figure 7. Sadewole forested cliff (Photo: Kelil Abu, 2016)

Figure 8. Bush land habitat in the study area (Photo: Kelil Abu, 2016)

2.2 Method

2.2.1 Preliminary survey and materials

The present field work was conducted between June 2015 to July 2017. A preliminary survey was conducted for one week in June 2015 to gather basic information of the study area including the gelada population and the socio-economic background of the local community. During this period, information was gathered on the accessibility, climate, vegetation, fauna, topography, infrastructure and gelada baboon occupancy in the area. Based on the reconnaissance survey, appropriate study sites were identified for detailed observations. Local people were also consulted to get basic information on the area, in addition to the basic information on human socio-economic and cultural aspects. Organization and arrangement of the base camp and logistic support, hiring assistants and purchasing field equipment were also carried out during this period.

Among the gelada populations in the study area, two units from different bands were identified, each at least 4 km apart. The identified units from each of the bands were taken as the focal units throughout the study period (Fig. 9). Depending on the topography of the area, geladas were observed by naked eyes at a distance of 30–100 m. Geladas in rugged and cliffy areas were observed using binoculars from a distance. The study units were differentiated from others by unique body marks/scars on few of the individuals of each unit by identifying their unique sleeping sites. The population size of group A was 12 individuals and of group B was 9 individuals.

Materials used for this study were telescope, a digital photographic camera, Garmin Global Positioning System (GPS) 12, a pair of 10x42 bushnell binoculars, measuring tape, compass, plant press and map of the study area.

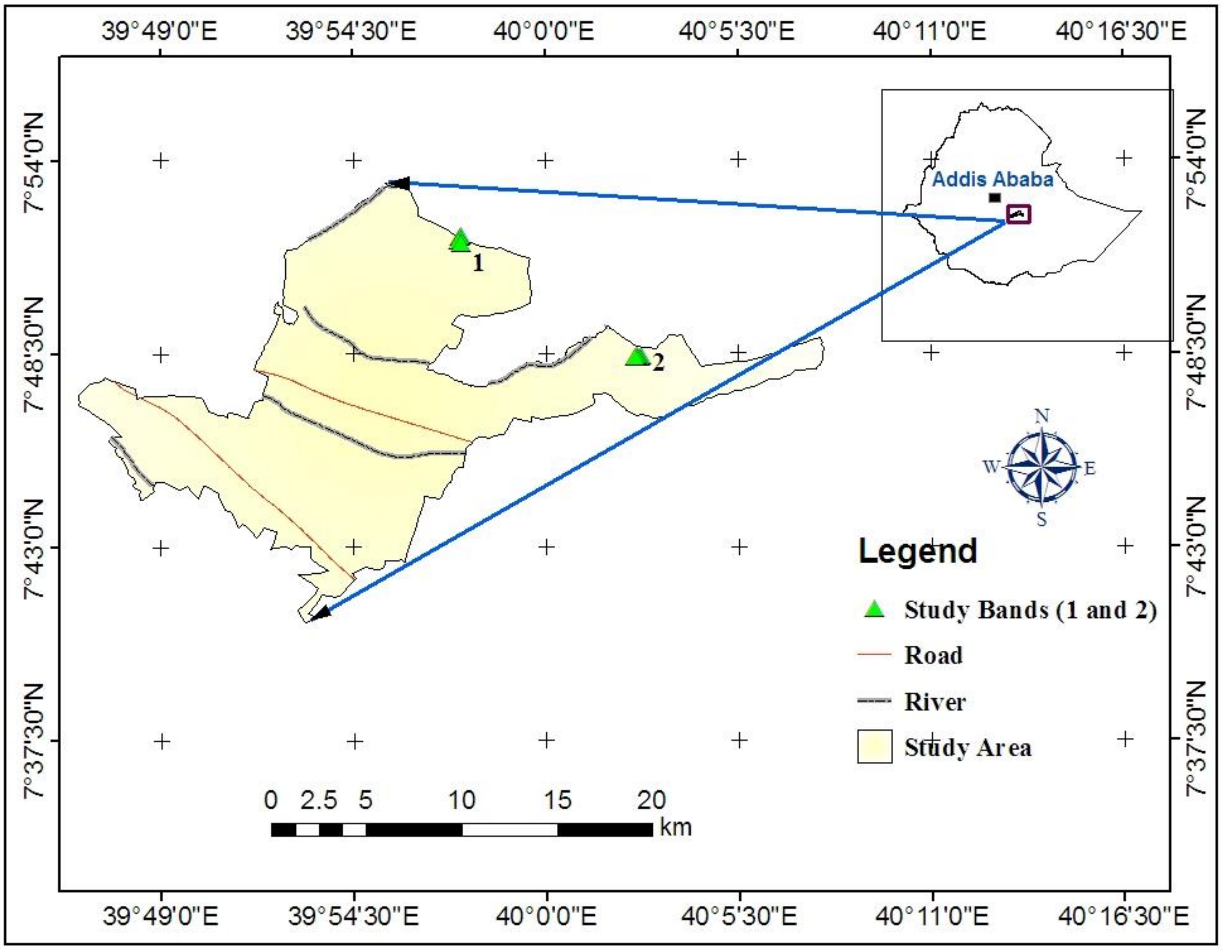

Figure 9. Location of the study bands of gelada in Amigna area

2.2.2 Data collection

2.2.2.1 Activity Budget

Behavioural data were collected on two study units using instantaneous scan sampling method (Altmann, 1974). Activity types and dietary data were collected on an average of 10 consecutive days per month from June 2015 until July 2017, covering both wet and dry seasons. Arsi geladas inhabiting cliff areas, were inaccessible for recording all activities. However, it was possible to record the activity of geladas on cliff faces on the opposite side of a gorge using binoculars (Fig. 10).

Following Altman (1974), the focal animal observation sessions lasted for 25 minutes with 10 minutes interval between sessions. During the activity scan sampling, activities of gelada baboons were gathered following them throughout the day time from 06:30 h to 18:30 h (Fashing, 2001a; Wong and sicottes, 2007; Hailu Beyene, 2010; Eshetu Moges, 2015**)**. During each of the scan samples, the first activity that lasted for greater than 5 seconds was recorded. Study animals were scanned consistently from left to right to avoid bias towards eye-catching activities (Addisu Mekonnen *et al.,* 2010). Scanned individuals were recorded and assigned to one of the following age/sex classes: adult male, adult female, sub-adult male, sub-adult female and juvenile. During scan sampling, individuals were recorded as performing one of the following behaviours: feeding, moving, resting, playing, aggression, grooming, sexual activity, and or other (Fashing, 2001a; Addisu Mekonnen *et al*., 2010; Eshetu Moges, 2015) **(**Appendix II). Feeding was recorded when the geladas manipulated, masticated and ingested a particular item of food. Shuffling forwards on the haunches (a behaviour unique of geladas) was always counted as feeding as they were collecting or ingesting food while doing so (Wrangham, 1980)**.**

Movement was recorded when geladas change their spatial position or showed any locomotory behaviour, including walking, jumping or running. Resting was recorded when geladas observed were inactive alone or together either sitting or lying. Playing included chasing, hitting and other vigorous activities involving fast movements and gestures by more than one gelada interacting with each other in a no aggressive manner (Fashing, 2001a). Aggression was recorded when a gelada chased, bit, grabbed, displaced, threatened another gelada or during crying as a result of fighting. Auto-grooming was recorded when a gelada used its hands to explore or to clean its body, and allo-grooming was recorded when a gelada clean 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 was observed performing activities such as vocalization, defecation, looking towards the observer, and other activities that do not fit in any of the above categories (Addisu Mekonnen *et al*., 2010; Eshetu Moges, 2015). To calculate the proportion of time the study animals engaged in each activity, the number of records of each activity category was divided by the total number of activity records, multiplied by 100 (Vasey, 2005).

Behavioral data of the units were used to calculate the activity time budget for each day. The average of the daily values within each month was taken to calculate monthly activity budget. The mean proportions of the monthly budget provided the overall activity budget for the entire study period (Di Fiore and Rodman 2001; Addisu Mekonnen *et al.*, 2010; Kelil Abu *et al*., 2017).

Figure 10. Photo showing a face of the gorge

2.2.2.2 Feeding ecology

At the time of each activity scan sampling, dietary data were collected on individuals scored as feeding. The type of food items such as grass blades, forb leaves, forb roots, grass roots, grass corm, succulent fruit, tree/shrub fruit, underground forb tubers, and other items (unidentified) were recorded (Fashing *et al.,* 2007) (Appendix III) and the species were recorded. All those plant species consumed by geladas were noted in the field specimens of unidentified species were collected and processed for later taxonomic identification. Identfication was done in the National Herbarium, Addis Ababa University, Ethiopia.

Diet compositions was assessed by determining the proportion of different food items and type of species consumed by geladas. Food items and species consumed by the band were summed within each month to construct monthly proportion of food items and 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 and multiplied by 100. 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). 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.

2.2.2.3 Ranging patterns

Home range is the total area used by these units over the course of the study period. Data on ranging patterns were derived from measuring the daily range areas by gelada units during both wet and dry seasons. The geographical centre of each of the gelada units in every 15 minutes was recorded using GPS (Sigg and Stolba, 1981). Total home range and day range length were determined for each unit based on point to point movements of the units between consecutive GPS locations recorded (Di Fiore, 2003). Day range lengths were calculated based on the ranges of the full day (Kaplin, 2001; Addisu Mekonnen *et al.*, 2010) for each group from gathered following them throughout the day time from 06:30 h to 18:30 h. 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 using measuring tools in the GIS software ArcGIS'9 (Di Fiore, 2003; Wong and Sicotte, 2007). Then mean day range lengths were calculated by taking the average of the wet and dry season day range lengths of geladas.

Minimum convex polygon method (MCP) was used to determine the home range of gelada baboons. This method has the advantage of not requiring independent data points, and hence is widely used method (Swedell, 2002; Lehmann and Boesch, 2003; Williams-Guille´n, 2003; Barrett, 2005; Fashing *et al*., 2007; Kummer *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 range of gelada baboon was calculated by constructing a polygon around the outermost GPS locations used by geladas during both wet and dry seasons (Wong and Sicotte, 2007). Seasonal and overall home range areas used by geladas during the course of the study period were calculated by GIS ArcView 9.1.

For the analysis of ranging patterns, a map of the study area was constructed using topographic maps based on satellite images obtained from the Ethiopian Mapping Authority. Landmark data were collected with a handheld Magellan 2000 GPS (with 100 m error), and marked points on the map in the range length of geladas. Travel directions and durations recorded every day were transcribed into the map, and path lengths were calculated.

2.2.2.4 Questionnaire survey

Information on the human–gelada conflicts in the present study was gathered by means of questionnaire, field observation, and focus group discussions to collect primary data among the households (Newmark *et al.,* 1994). Field observations were made to collect evidences related to human–gelada conflicts in the study area. During the preliminary survey, 20 individuals among the local communities were randomly selected and interviewed. Based on the result from the preliminary survey, the actual data were collected by means of face-to-face questionnaire interview. One to one interview was employed to get important details about human–gelada conflicts. A total of 200 people were interviewed. Of these, 45 respondents were females and 155 were males. The gelada baboon faecal dropping samples were also collected to compare the results with the questionnaire survey on the pest status of geladas. The questionnaire was designed mainly to check whether there is human–wildlife conflict or not in and around the study area and to assess related issues.

This study included both closed and open ended questions across two broad categories to find out (i) views towards geladas/wildlife and their conservation, and (ii) a series of household demographic questions, including information on the source of income of each household (Appendix IV). Open-ended questions were included to elicit information on knowledge about wildlife in the area, whether wildlife pose any problem in the community and attitude of local people towards wildlife. Respondents were asked whether conserving wildlife is important or not. Their answers were considered as positive if they replied as conserving geladas/wildlife is important. If they respond as conserving geladas/wildlife is not important, their answer was considered as negative. The positive attitude represents the respondents' good will to protect and utilize geladas/wildlife wisely, whereas negative attitude towards geladas/wildlife represents unwilling to utilize their natural resource in a wise way, rather wish to destroy it.

A series of supplementary questions were also used in the questionnaire to gather personal and socio-economic information at the level of individual respondents (Appendix IV). Interview was conducted in six randomly selected villages. These villages (Jafera, Ebicho, Tadecha and Sadewole near gelada habitat, and Bamo and Malakicho located about 5km away from gelada habitat) (Fig. 11). They were selected based on the information gathered during the preliminary survey. The interviewees were selected on the basis of chance encounter (Newmark *et al.*, 1993).

Focus group discussion and key informant methods were used to reinforce the questionnaire data (Bernard, 2002). Seven pre-designed semi-open ended questions were used for gathering information (Appendix V). Information was collected on how local communities perceive geladas/wildlife, how they access and use wildlife habitat (e.g. fire wood), the co-existence of geladas with communities and as a whole how local communities benefited from the wildlife habitat. Two focus group sessions were held in each study site. The size in each session varied from 10 to 14 individuals. The first group was made up of three experts of natural resource management from Agricultural and Rural Development Office, two experts from wildlife and forest enterprise of the districts, two experts from culture and tourism office of the district, and three people from Kebele (village) administratiors, whereas the second group was made up of seven elders of villages, two females from females association, four local leaders, and one person from the nearby school. Discussants were invited to discuss issues according to their convenience. They have discussed changes, problems, and challenges for conservation of gelada baboons. Information collected from the focus group discussions was collated and summarized using text analysis (Bernard, 2002) to discover the regularity with which discussants revealed their views.

Demographic variables (age, sex and household size), education level, farm size, source of income, and alternative economic sources were identified as the determinants of attitude of the community towards wildlife habitat. All these selected variables were supposed to determine the attitude of local people in the study towards conservation of geladas and wildlife habitat.

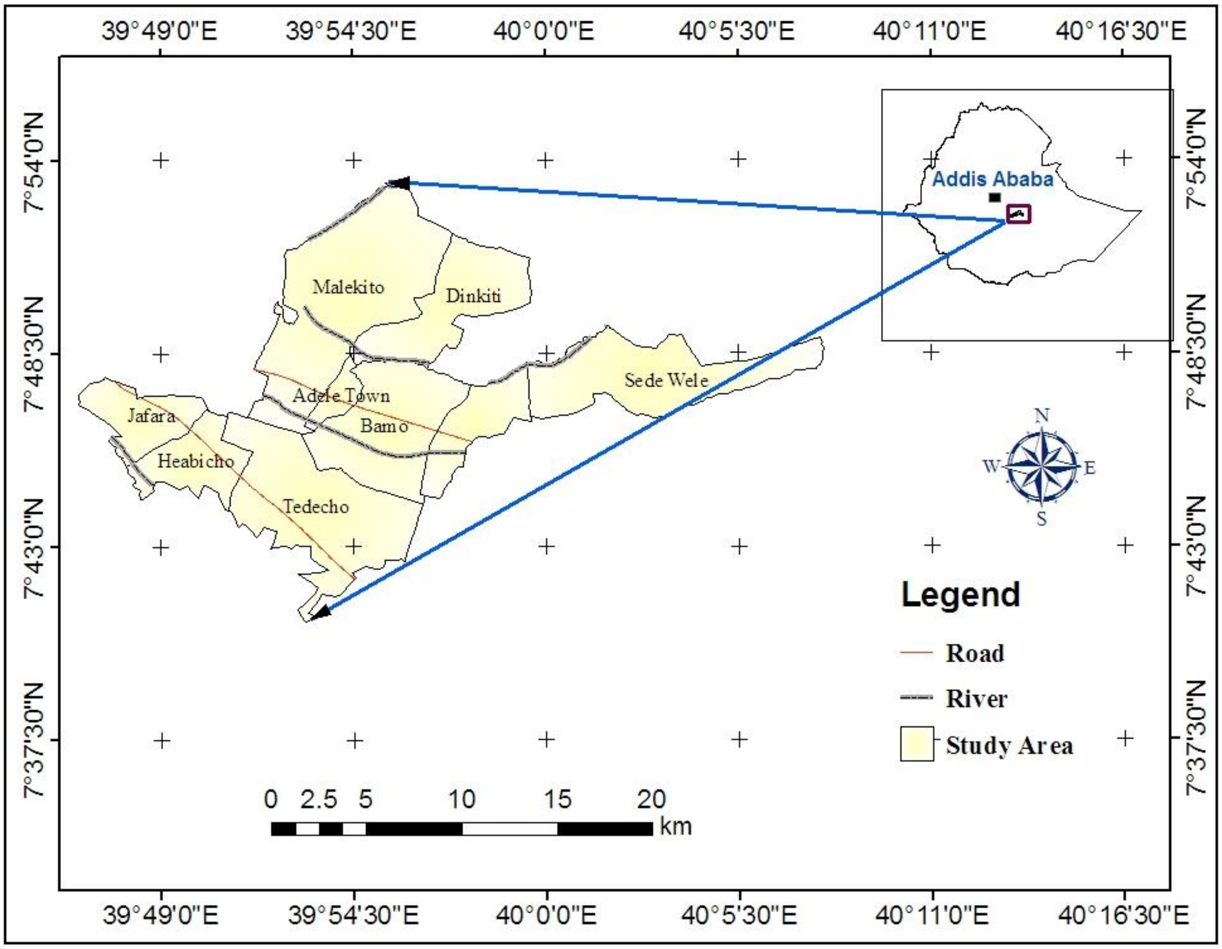

Figure 11. Map of the villages in which questionnaire study was carried out in Amigna

2.2.2.5 Faecal analysis

Ecological information can be deduced from the analysis of faecal deposits of animals (Putman, 1984). A total of 60 faecal samples of gelada baboons were collected from Ebicho, Tadecha, Jafera and Sadewole sites. Date and time of collection, approximate age of faeces and location and altitude of the site of collection were recorded (Appendix VI). The age of faecal samples was categorized into fresh (1 day old), recent (2–5 days old) and old (more than 5 days), following Breuer (2005).

Faecal samples of gelada baboons were analyzed macroscopically to determine the presence or absence of locally abundant seeds in the study area (Remis *et al.*, 2001). The presence of seeds (for cereal crops) was designated by '1' and the absence was designated by '0'.

2.2.3 Data Analyses

Statistical analyses were carried out using SPSS Version 20.0. All data were assessed to determine whether they were normally distributed. Where data did not follow a normal distribution, non-parametric tests were employed. Data were analyzed using descriptive statistics and compared using Chi–square test and one–way ANOVA. Statistical tests were two–tailed with 95% confidence intervals. Nonparametric Mann–Whitney U test was used to compare seasonal differences and Kruskal–Wallis H test was used to compare monthly variation as the data were not normally distributed. It was also used to make inferences about the differences of activity patterns between different age and sex classes. For data gathered using questionnaire, logistic regression was used to determine which factors might be important in determining the attitude of respondents expressed as positive or negative. Using the General Linear Model, variables age, sex, distance, educational level, village and family size were entered. The data collected from group discussion and key informants was summarized using a text analysis method and is presented in description.

3. RESULTS

3.1 Activity budget

A total of 21996 individual activity records were obtained during 5981 scan sampling conducted on 240 study days (group A: 103 days; group B: 137 days). Gelada baboons spent 40.31% (range 26.85–54.19%, SD ± 8.60%) of their time feeding, 20.16% (range 14.89–30.50%, SD ± 4.49%) moving, 16.56% (range 9.85 –25.02%, SD ± 5.82%) resting, 10.05% (range 4.67–13.57%, SD ± 3.09%) grooming, 5.71% (range 2.56–9.96%, SD ± 2.06%) playing, 4.68% (range 2.79–6.70%, SD ±1.24%) aggression, 1.94% (range 0.70–4.85%, SD ±1.07%) sexual activities and 0.6% (range 0–1.82%, SD ±0.6%) other activities (Fig. 12).

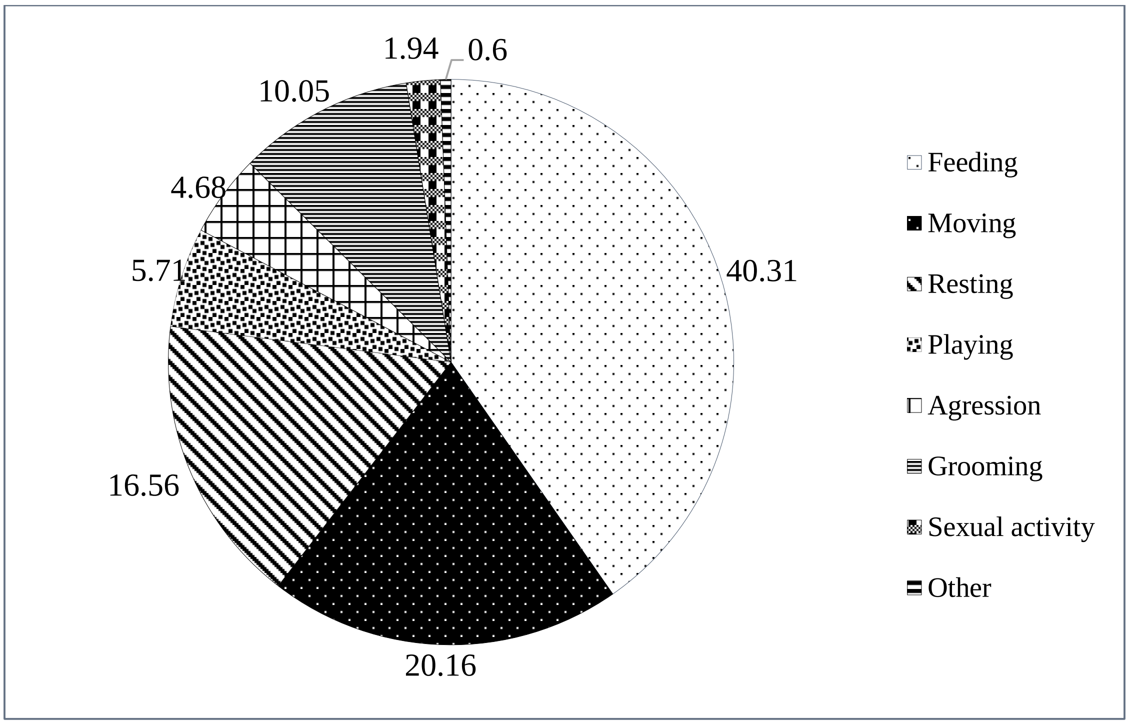

Figure 12. Overall activity time budget of gelada baboons in Amigna

There were differences in the time spent by geladas for various activities during wet and dry seasons. They spent more time for feeding during the dry season (46.20%, SD ± 4.97%) than during the wet season (32.08%, SD± 4.56%). They also spent more time moving during the dry season (22.78%, SD ± 3.96%) than during the wet season (16.48%, SD± 1.71%). Resting time was higher during the wet season (21.87%, SD ± 3.86%) than during the dry season (12.77%, SD ± 3.43). Playing was also higher during the wet season (7.64%, SD± 1.64%) than during the dry season (4.33%, SD ± 0.82%).

Aggression was higher during the wet season (5.74%, SD ± 0.95%) than during the dry season (3.91%, SD ± 0.78%). The frequency of grooming was also more during the wet season (12.81%, SD ± 0.66%) than during the dry season (8.07%, SD ± 2.51%). Sexual activity was also more frequent during the wet season (2.74%, SD± 1.19%) than during the dry season (1.36%, SD± 0.48%) (Fig. 13).

Mann–Whitney U test showed significant differences in the time spent in feeding ($P = 0.003$), moving ($P = 0.005$), resting ($P = 0.01$), playing ($P < 0.05$), aggression ($P < 0.05$), grooming ($P < 0.05$) and sexual activities ($P < 0.05$) between wet and dry seasons.

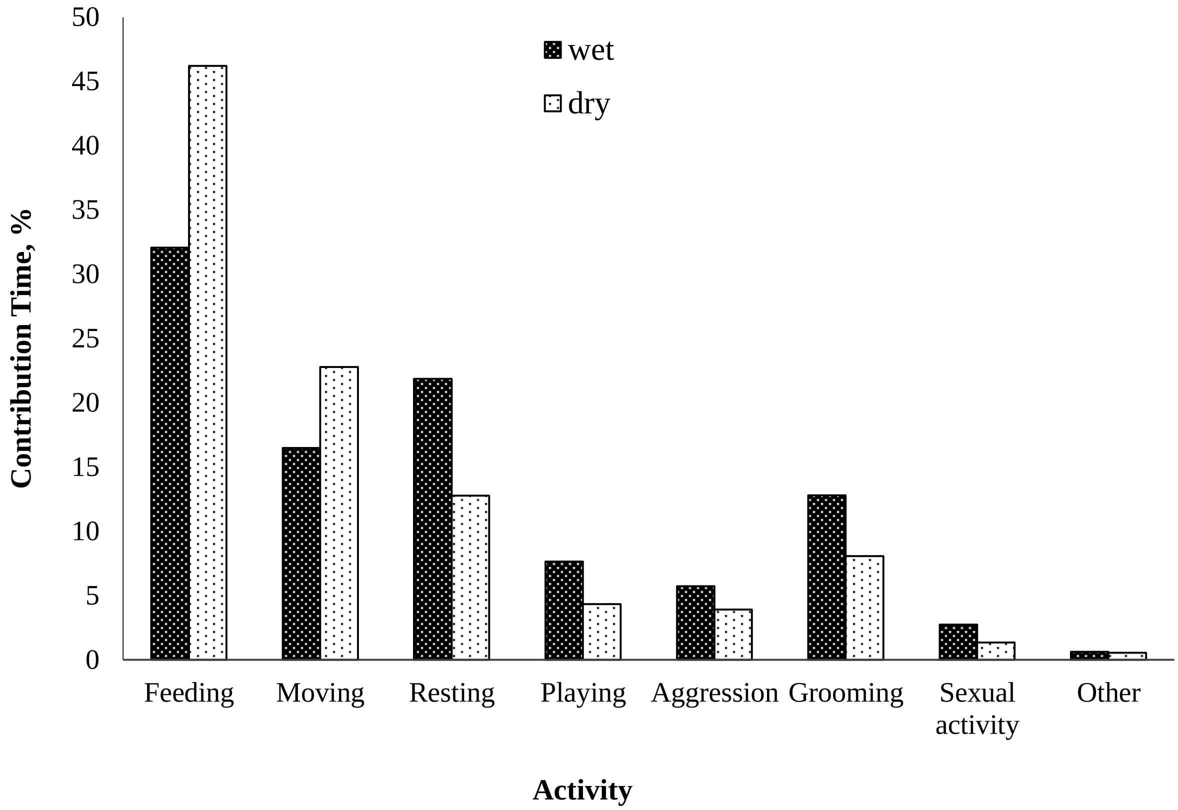

Figure 13. Seasonal activity time budget of gelada baboons on the Amigna cliff

Adult males spent most of their time feeding (39.21%), while they spent only 21.22% and 20.15% of the time in resting and moving, respectively. They used only 0.88% of the time for other activities. Adult females also spent most of their time feeding (45.63%), and 19.9% and 14.64% of the time was spent moving and resting, respectively. Sub–adult males spent 39.04% of their time feeding, while 18.06 % and 16.1% of the time were spent moving and resting, respectively (Table 1). Kruskal–Wallis H test showed that geladas of all the age – sex categories followed similar activity budgets, without any major changes ($P > 0.05$).

Table 1. Overall activity time budget of gelada baboons based on age–sex category

Age-sex groups	Activities (%)							
	Feeding	Moving	Resting	Playing	Aggression	Grooming	Sexual activity	Other
Adult male	39.21	20.15	21.22	3.4	5.41	6.3	3.42	0.88
Adult female	45.63	19.9	14.64	1.89	3.96	10.97	2.28	0.73
Sub adult male	39.04	18.06	16.1	3.64	8.11	13.28	1.14	0.63
Sub adult female	25.2	22.09	19.08	18	3.71	10.31	1.47	0.13
Juvenile	36.85	17.52	17.24	11.1	3.56	13.12	0.63	0

More time was spent by all age–sex groups for feeding and moving during the dry season than during the wet season. Both males and females spent more time feeding in the dry season. All the age–sex groups spent more time for resting, playing, grooming and sexual activities during the wet season than during the dry season (Fig. 14).

There was a significant difference between seasons across age–sex groups in time spent in moving ($P = 0.008$), grooming ($P = 0.016$) and sexual activities ($P = 0.032$). However, there was no significant difference between seasons in the time spent in feeding ($P = 0.056$), resting ($P > 0.05$), playing ($P = 0.222$), aggression ($P = 0.151$) and other activities ($P = 0.841$).

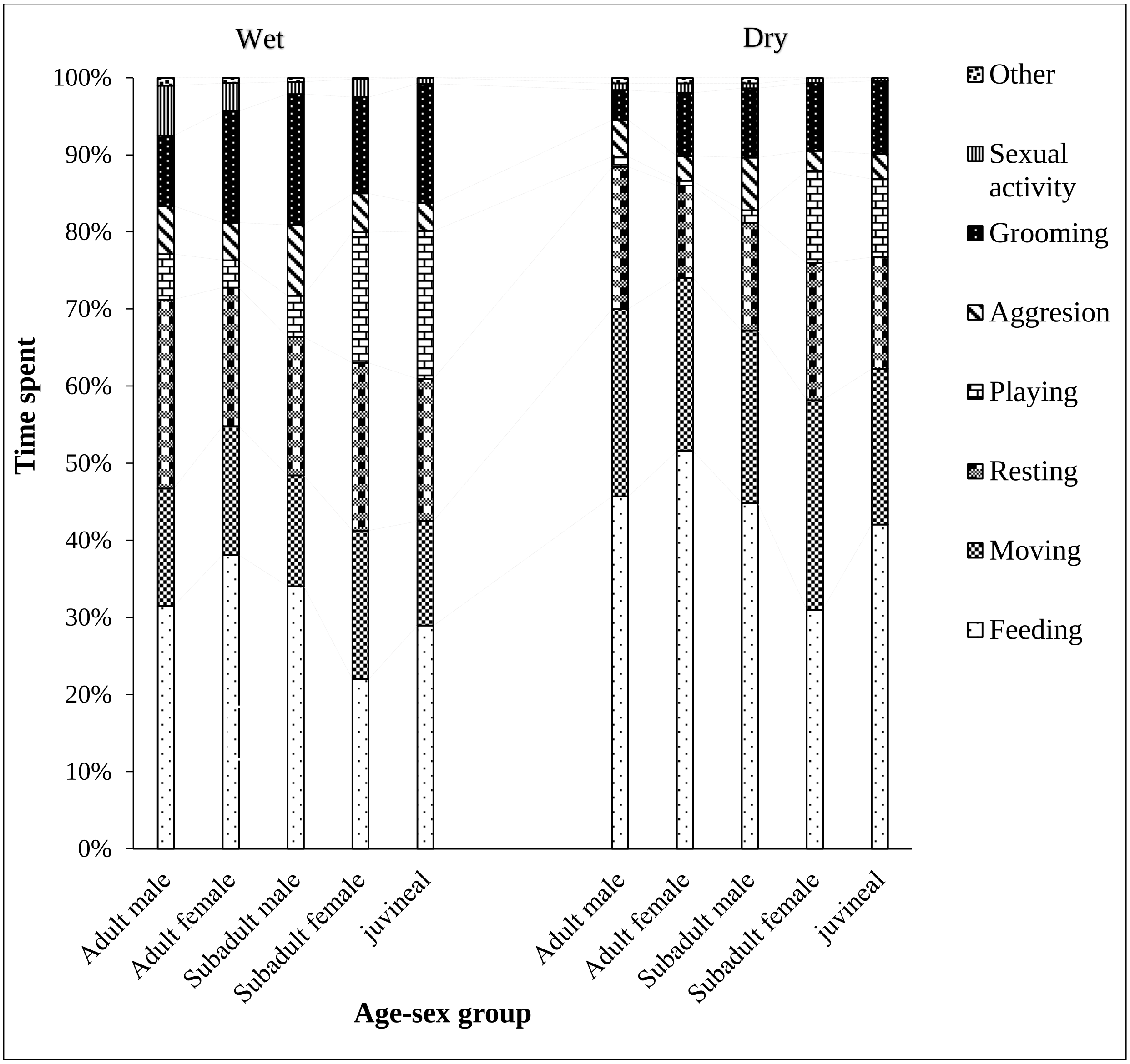

Figure 14. Comparison of activities based on age – sex categories of geladas during wet (left) and dry (right) seasons

3.2 Feeding ecology

A total of 4289 feeding records were obtained from scan sampling of the two study units. Grass blades, grass roots and forb leaves were the major diet of geladas in the study area (Fig. 15).

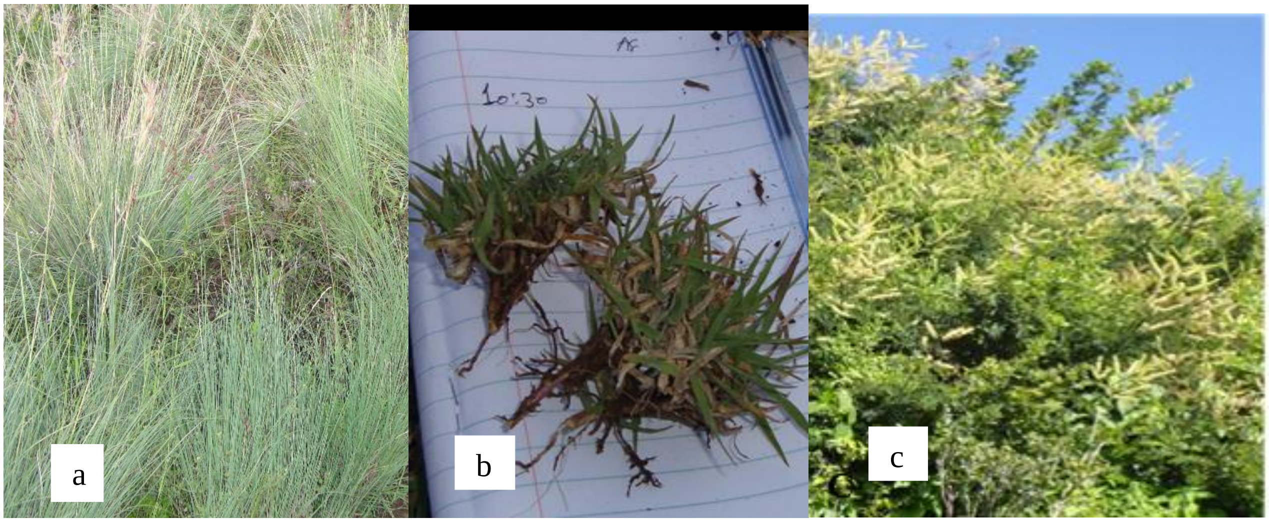

Figure 15. Major plant food items (a = Grass blades, b = roots, c = forb leaves) consumed by gelada baboons based on time spent for feeding during the study period

Grass blades formed the major diet of geladas in the study area (48.07%, SD ± 13.13%). Followed by grass roots (18.14%, SD ± 10.05%) and forb leaves (10.96%, SD ± 5.13%). Gelada baboons also consumed forb root (5.87%, SD ± 3.06%) and other food items, in lower proportions 3.14% (SD ± 4.23%) (Fig. 16).

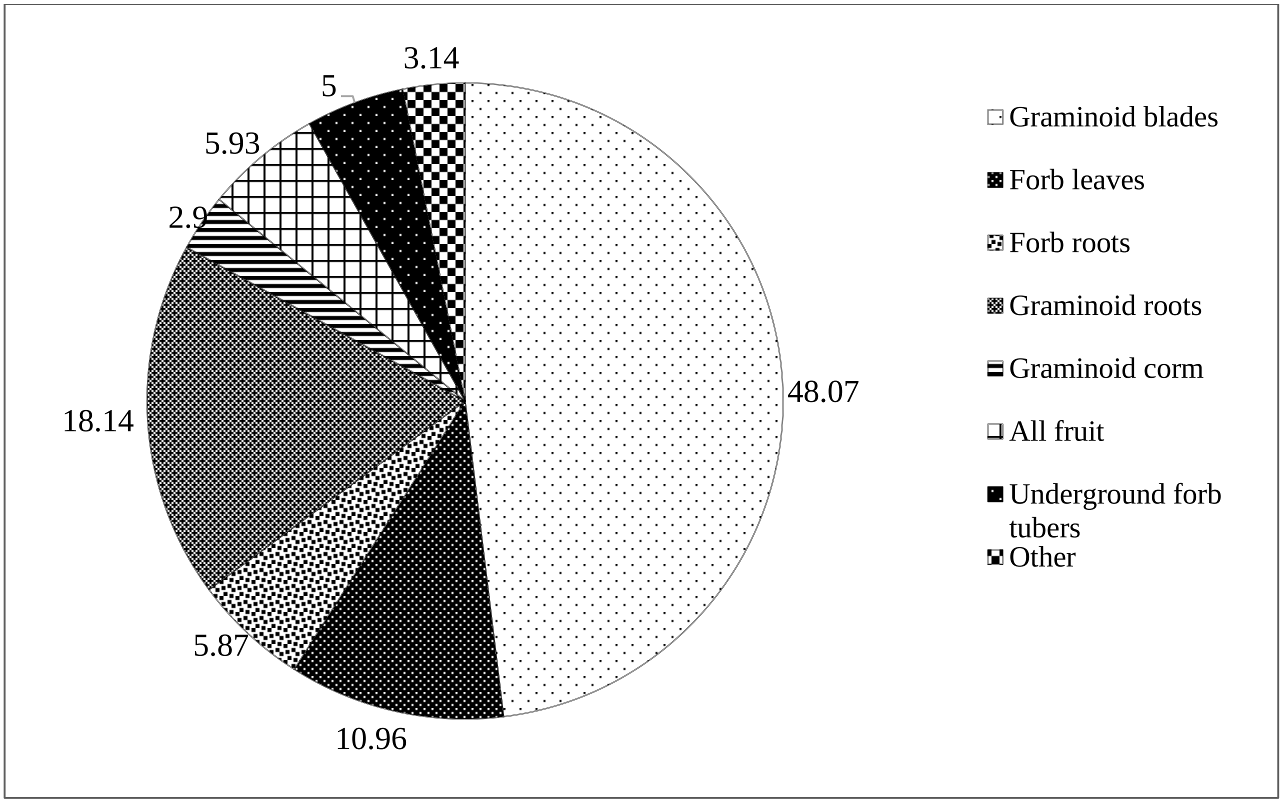

Figure 16. Overall time devoted for feeding different food items by gelada baboons in Amigna

Gelada baboons spent more time feeding on grass blades during the wet season (58.04%, SD ± 6.59 %) than during the dry season (40.94%, SD ± 12.03 %), but, they spent more time feeding on forb leaves during the dry season (12.15%, SD ± 3.75%) than during the wet season (9.29%, SD ± 6.73%). They spent more time feeding on grass roots during the dry season (24.01%, SD ± 9.32%) than during the wet season (9.92%, SD ± 1.59%) (Fig. 17).

Mann–Whitney U test showed that there was a significant difference in the time spent for feeding grass blades (P = 0.030) and grass roots (P = 0.003) between wet and dry seasons.

However, there were no significant difference observed between seasons in the time spent feeding on forb leaves (P = 0.53), forb roots (P = 0.639), grass corm (P = 0.202), underground forb tubers (P = 0.343), fruit (P = 0.755) and other items (unidentified) (P > 0.05).

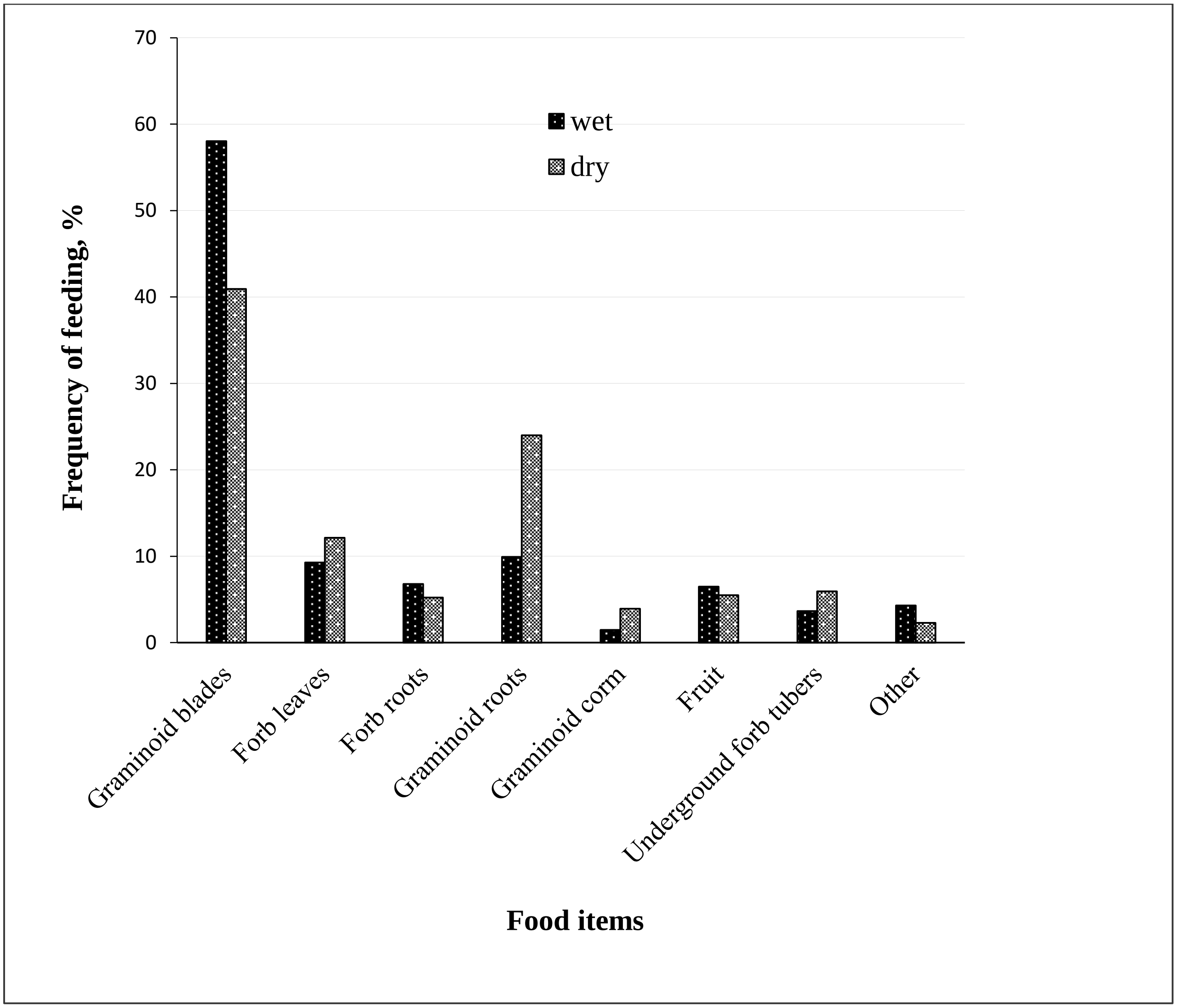

Figure 17. Frequency of feeding different food items by gelada baboons in Amigna during wet and dry season

Eight plant species were observed to constitute Gelada diet in Amigna area (Fig. 18). Among these, one tree species, three shrubs, one grass and three species of herbs. Percentage contribution of each of these food items consumed are presented in Table 2.

Table 2. List of plant species and their proportion contributed as diet of gelada baboons

Family	Species consumed	Type	Parts of food items consumed	% contribution
Poaceae	*Hyparrhenia hirta*	Grass	Gb , R	64.76
Cactaceae	*Opuntia strcta*	Shrub	Fr	4.09
Convolvulaceae	*Ipomoea hildrbrandii*	Herb	L, R	10.84
Moraceae	*Ficus vasta*	Tree	L	4.53
Ebenaceae	*Euclea racemosa*	Herb	Fr, R	5.56
Balanitaceae	*Balanites aegyptica*	Shrub	Fr	3.68
Anacardiaceae	*Rhus glutinesa*	Shrub	Fr	3.65
Sapindaceae	*Dodonaea angustifolia*	Herb	L	2.87
Total				100

Item key: Gb= Grass blades; R= Root; Fr= Fruit; L= leaves

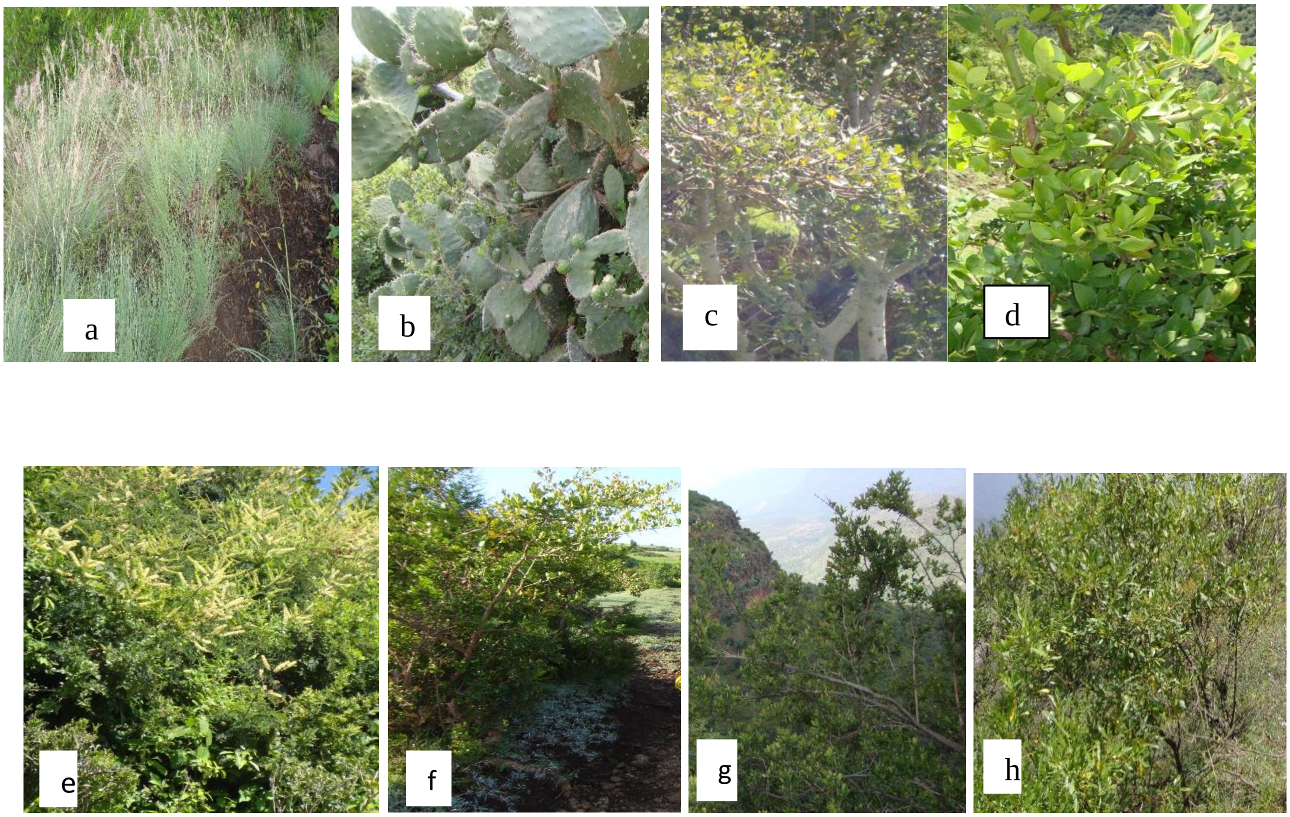

Figure 18. The plant species consumed by gelada baboons during the study period (a = *Hyparrhenia hirta*, b = *Opuntia stricta*, c = *Ficus vasta*, d = *Ipomoea hildrbrandii*, e = *Euclea racemosa*, f = *Balanites aegyptica*, g = *Rhus glutinesa*, h = *Dodonaea angustifolia*)

Time spent on feeding the four most consumed plant species accounted for 81.16% of the overall feeding time of gelada baboons (Fig. 19). Based on the overall percentage contribution of food items consumed, *Hyparrhenia hirta* was the most consumed food species, which accounted for 64.76% (± 15.14%) of the overall diet of gelada baboons. *Ipomoea hildrbrandii* ranked second and *Euclea racemosa* third accounting for 10.84% (± 9.25%) and 5.56% (± 3.63%) of the overall diet, respectively.

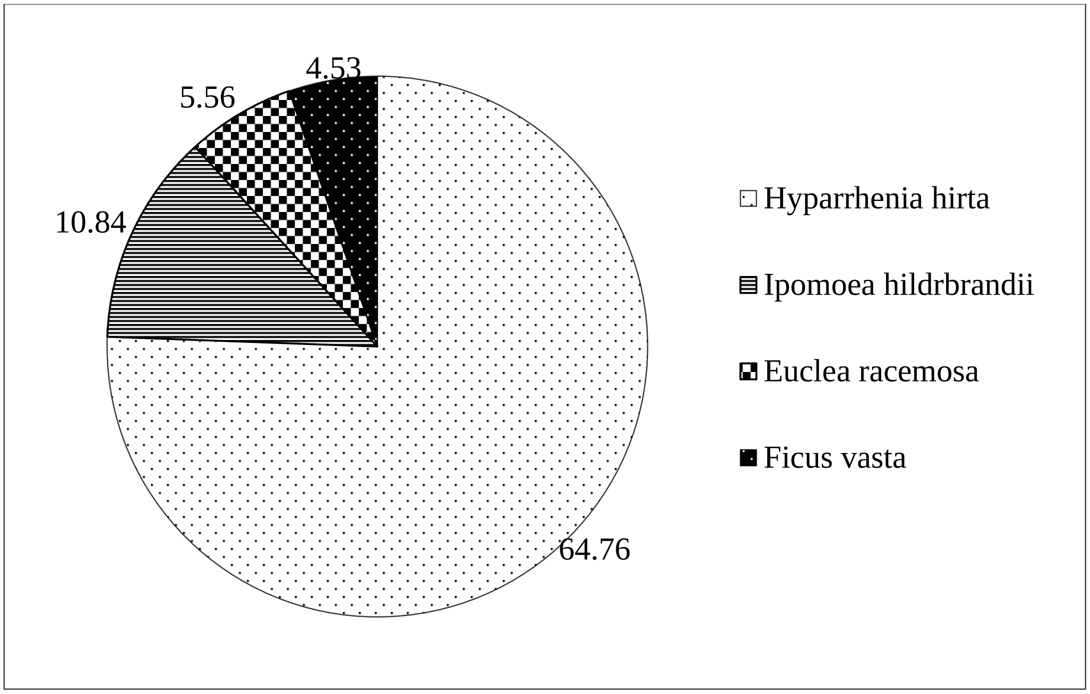

Figure 19. Percentage time spent for feeding the major plant species by gelada baboons during the study period

On an average, geladas spent more time feeding on blades of *Hyparrhenia hirta* (72.97%, SD ± 12.71%) during the wet season than during the dry season (58.90%, SD ± 14.71%) and they spent more time feeding on fruits of *Opuntia strcta* (8.70%, SD ± 6.59%) during the wet season than during the dry season (0.79%, SD ± 1.59%). On the other hand, they spent more time feeding on leaves of *Ipomoea hildrbrandii* (16.65%, SD ± 7.44%) during the dry season than during the wet season (2.71%, SD ± 3.26%) (Fig. 20). Results of Mann-Whitney U test showed that there were significant difference in the total time spent feeding on *Ipomoea hildrbrandii* (P = 0.005) and *Opuntia strcta* (P = 0.048) between wet and dry seasons. There was no seasonal difference in the time spent on feeding *Hyparrhenia hirta* (P = 0.268), *Ficus vasta* (P = 1.00), *Balanites aegyptica* (P = 0.755), *Rhus glutinesa* (P = 0.343) and *Dodonaea angustifolia* (P = 0.268) by geladas.

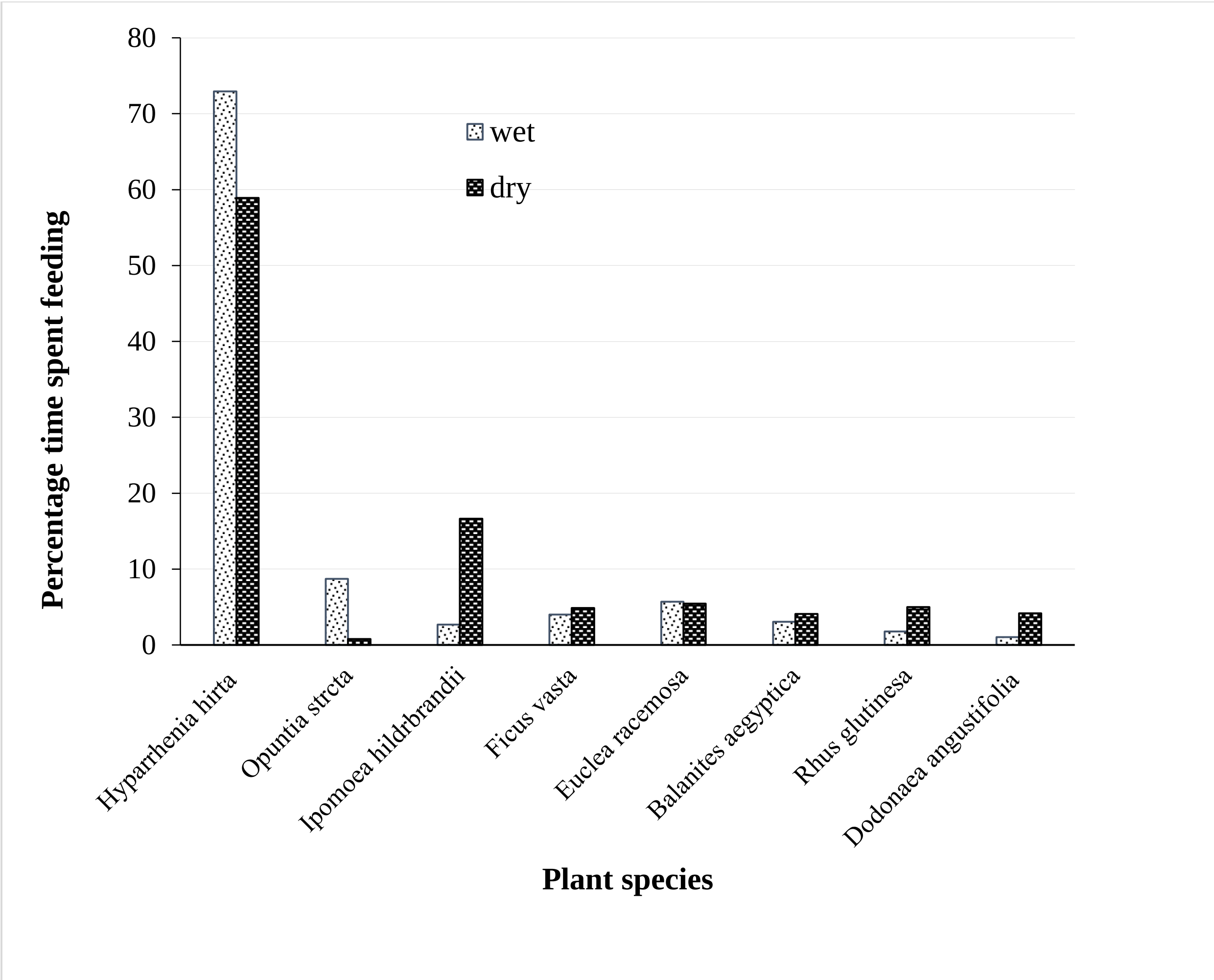

Figure 20. Comparison of time spent on feeding different plant species by geladas between seasons

Hyparrhenia hirta contributed in the diet of gelada baboons regularly in all months ranging from 45.32% in January to 85.21% in October. Gelada baboons spent more time feeding on *Opuntia strict* during July (15.35%), but not consummed during January to June. They spent more time feeding on *Ipomoea hildrbrandii* during March (24.87%) and no feeding on this species in June and July (Fig. 21).

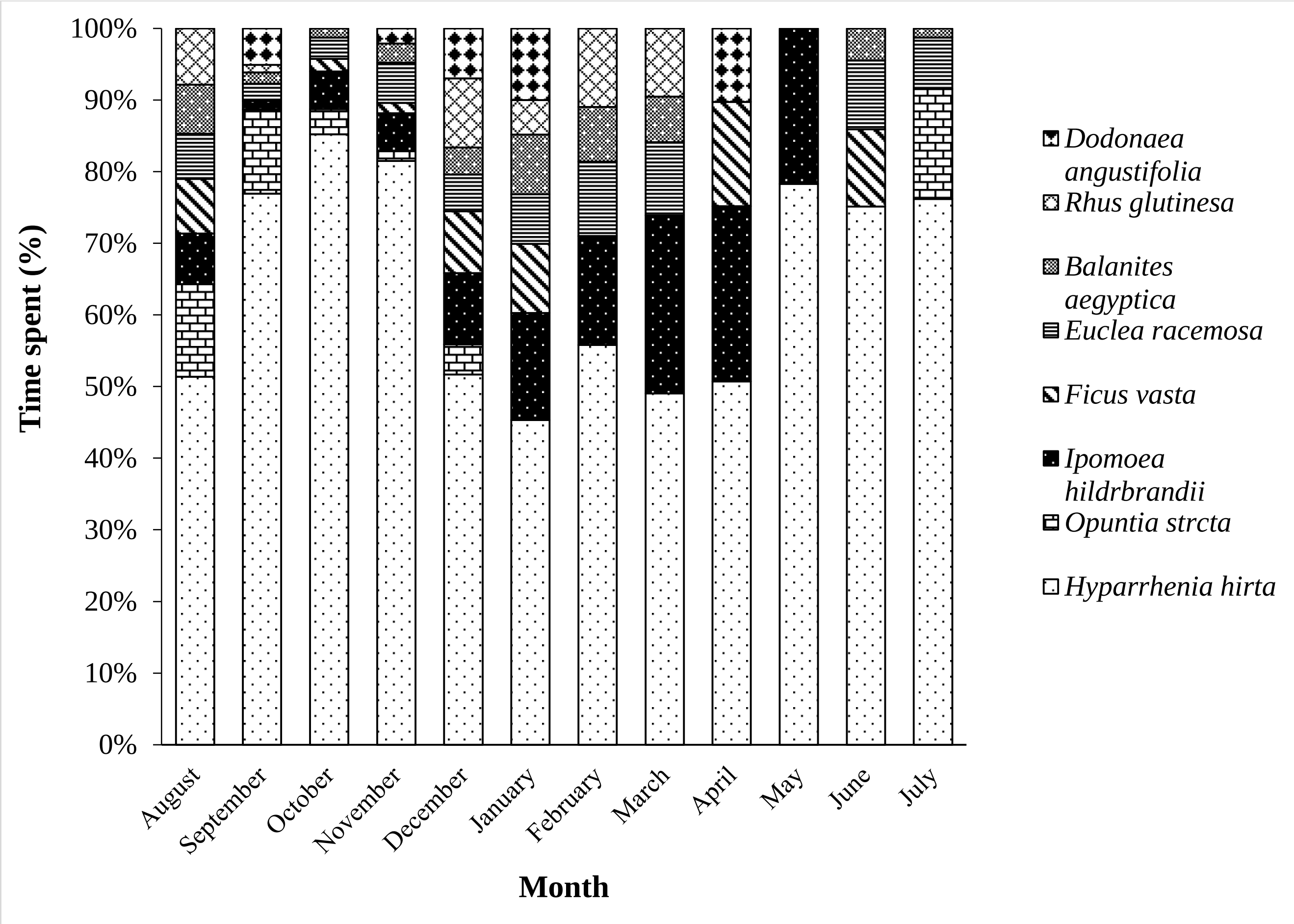

Figure 21. Percentage of time spent on consuming different plant species during different months

3.3. Ranging pattern

Home range areas of gelada units over the course of the study period was found to be 3.26 km^2 and 5.44 km^2 during wet and dry seasons, respectively. Home ranges of the study units were more extended during the dry season than during the wet season. Results of Mann-Whitney U test showed significant difference in the home range size of the units between wet and dry season ($P = 0.048$).

The average daily range length of the two study units combined during the study period was 930.76 m (range 410 – 1500 m, SD ± 257.67). The average daily range lengths for the wet seasons was 792.60 m (range 410–1200 m) and for the dry seasons was 1022.87 m (range 750–1500 m) (Table 3).

Mann–Whitney U test showed that there was significant difference in the daily range lengths of gelada baboons during wet and dry seasons ($P < 0.05$). The average daily range length and home range size for the wet and dry seasons are given in Table 3.

Table 3. Mean daily travel distance and home range size of gelada baboons during wet and dry seasons

Seasons	Mean daily travel distance (m)		Home range area (km^2)
	Mean(n)	SD	
Wet	792.60(10)	250.64	3.26
Dry	1022.87(15)	225.19	5.44

Figures in brackets denote number of days observed

3.4 Questionnaire survey

3.4.1 Socio-economic status of the respondents

The respondents were of various sex, age groups, and religious groups, and having different occupation and educational background. Out of the 200 respondents, 155 (77.5%) were males and 45 (22.5%) were females. Among them, 99 (49.5%) were between 18–30 years old, 37 (18.5%)

were between 44–56 years, 35 (17.5 %) were between 31–43 years, 24 (12.0 %) were between 57–69 years and 5 (2.5 %) were > 70 years.

Among the respondents, 66 (33%) had no education at all, 21 (10.5%) attained informal education, 95 (47.5%) had primary level education, 13 (6.5%) had secondary education and 5 (2.5%) had beyond secondary-level education. Most of the respondents from old age groups were illiterate, and 79.80% of the respondents from younger age groups attained primary education. There was a significant difference ($\chi^2 = 150$, df = 4, $p < 0.05$) in the educational status among the respondents of the present investigation.

Majority 111 (55.89 %) of the respondents reported that they depended on mixed farming, whereas 47 (23.09 %) depended on farming, 15 (7.12%) were engaged in animal husbandry and 27 (13.90 %) were depended on other economic activities (Table 4). There was a significant difference among the respondents ($\chi^2 = 109.68$, df = 3, $p < 0.05$) in their livelihood activities.

Table 4. Livelihood activities of the respondents in each of the villages in the study area

Villages	n = 200	Livelihood activities of the respondents (%)			
		Farming	Animal husbandry	Mixed farming	Other activities
Jafera	31	35.48	6.45	51.61	6.45
Ebicho	39	28.21	-	58.97	12.82
Tadecha	27	18.52	-	59.26	22.22
Bamo	35	25.71	14.29	45.71	14.29
Sadewole	43	18.60	13.95	55.81	11.63
Malakicho	25	12.00	8.00	64.00	16.00
Average		23.09	7.12	55.89	13.90

Among the respondents, 37.38% holds 1–2 hectars of land, whereas 23.47% holds less than half a hectar and 11.84% have had no land. Only 6.49% had greater than three hectars of land (Table 5). There was significant difference in the extent of land holding among the respondents ($\chi^2 = 58.60$, df $= 4$, $p < 0.05$).

Table 5. Average land holding per household in the study area (n=200)

Villages	Land holding per household (%)				
	No private land	< 1/2 hectar	1–2 hectar	2–3 hectar	> 3 hectar
Jafera	16.13	25.81	38.71	12.90	6.45
Ebicho	20.51	25.64	41.03	7.69	5.13
Tadecha	11.11	18.52	29.63	25.93	14.81
Bamo	-	14.29	45.71	31.43	8.57
Sadewole	23.26	32.56	37.21	6.98	-
Malakicho	-	24	32	40	4
Mean	11.84	23.47	37.38	20.82	6.49

Besides farming, livestock rearing is the other economic activity of the people living in and around the study area. The major livestock kept by the community in the area are cattle, sheep and pack animals (horse, mule and donkey). Cattle are used for ploughing and threshing harvested crops. They are also used for meat and milk. The average livestock per village are 24.50% cattle, 38.67% sheep, 25.72% goats, 5.23% donkeys and 5.38% horse/mule. Sheep is the main livestock type reared by the respondents and is used primarily for commercial purpose for livelihood income. Donkey is the least reared livestock type in the area (Table 6).

There was a significant difference in the number of cattle owned by each household among the six villages ($F_{5\ 194} = 29.372$, $P < 0.05$). Tukey test showed that there was a significant difference in mean holding of cattle between Sadewole and Jafera ($P < 0.05$). Thus, Sadewole had the least number of cattle per household, while Jafera had the largest number of cattle per household. There was also significant difference in the number of sheep owned by each household among the six villages ($F_{5\ 194}$ = 70.97, P < 0.05). The result from Tukey test showed that, there was a significant difference in the mean holding of sheep between Tadecha and Jafera (P < 0.05). Tadecha had the least number of sheep per household, while Jafera had the largest number of sheep per household. There was a significant difference in the holding of donkey per household among the villages ($F_{5\ 194}$ = 4.88, P < 0.05) and horse/mule per household among the villages ($F_{5\ 194}$ = 6.73, P < 0.05). There was a significant difference in the holding of goat per household among the villages ($F_{5\ 194}$ = 28.23, P < 0.05). Results of Tukey test showed, a significant difference between Bamo and Jafera (P < 0.05). Jafera had the largest number of goat, whereas, Bamo had the least number of goat.

Table 6. Number of livestock in each of the villages in the study area

Villages	Cattle	Sheep	Goat	Donkey	Horse/mule	Total
Jafera	157	231	140	13	21	562
Ebicho	87	113	97	17	9	323
Tadecha	69	83	102	11	25	290
Bamo	78	198	45	29	47	397
Sadewole	59	124	119	31	16	349
Malakicho	93	108	67	15	12	295
Total	543	857	570	116	130	2216

Among the respondents, 42.10% (SD ± 4.71%) had 7–10 members with their families, whereas 25.34% (SD ± 5.33%) had 3–6 members. Only 5.18% was single (Table 7). The result of the analysis showed that the mean family size per respondents between study sites varied statistically ($\chi^2 = 79.85$, df = 4, $p < 0.05$).

Table 7. Average family size of the respondents (n=200)

Villages	Average family size (%)				
	Single	1–2 member	3–6 members	7–10 members	>10 members
Jafera	3.23	6.45	29.03	35.48	25.81
Ebicho	5.13	15.38	30.78	38.46	10.26
Tadecha	11.11	14.81	22.22	40.74	11.11
Bamo	-	8.51	25.71	45.71	20
Sadewole	11.63	18.60	16.28	44.19	9.30
Malakicho	-	24	28	48	-
Mean	5.18	14.63	25.34	42.10	12.75

3.4.2 Resource Utilization

The local people in the study area utilize wildlife habitats for livestock grazing. Those who are living closer to the wildlife habitat effectively exploit such resources throughout the year (Fig. 22). Among the respondents, 37.12% utilized wildlife habitats as grazing land (Table 8). There was significant difference ($F_{5\ 194} = 25.859$, $P < 0.05$) among the respondents of different villages in using wildlife habitats for grazing.

Figure 22. Livestock grazing inside wildlife habitats in Amigna (photo: Kelil Abu 2016)

Table 8. Grazing in and outside wildlife habitat in different villages

Villages	n = 200	Grazing in the wildlife habitat, %	Grazing outside wildlife habitat, %
Jafera	31	54.83	45.16
Ebicho	39	23.08	76.92
Tadecha	27	70.37	29.63
Bamo	35	-	100
Sadewole	43	74.42	25.58
Malakicho	25	-	100
Mean		37.12	62.88

Most (62.50%) of the respondents never utilize wildlife habitat, whereas 33.33% use wildlife habitats for more than seven months for grazing (Table 9). Villages differed significantly in the number of months they used wildlife habitats for grazing purpose ($F_{5\ 194} = 31.532$, $P < 0.05$).

The duration of grazing in the wildlife habitat was negatively correlated ($r = -0.366$, $P < 0.05$) with the distance from villages to the wildlife habitat. As distance between villages to the wildlife habitat decreased, the level of using wildlife area for grazing increases.

Table 9. Duration of grazing in the wildlife habitat in different villages

Villages	n =200	Duration of grazing by the respondents (%)				
		Never uses	1–2 months	2–4 months	5–7 months	> 7 months
Jafera	31	45.16	-	3.23	6.45	45.16
Ebicho	39	76.92	2.56	12.82	-	7.69
Tadecha	27	29.63	-	-	-	70.37
Bamo	35	100	-	-	-	-
Sadewole	43	23.26	-	-	-	76.74
Malakicho	25	100	-	-	-	-
Mean		62.50	0.43	2.68	1.08	33.33

The main source of household energy around Amigna was firewood. The respondents used different types of plant species and cow dung as source of energy for cooking. Major plant species used were *Ficus vasta*, *Rhus glutinesa*, *Eucalyptus*, *Myrica salicifolia* and *Rhus natalensis*. There was significant difference among the villages ($F_{5\ 194} = 6.132$, $P < 0.05$) in terms of firewood collection in the wildlife habitat. Most respondents (67.44%) from Sadewole, 41.03% from Ebicho and 38.71% from Jafera, 22.86% from Bamo and 18.52% from Tadecha collected firewood from wildlife habitats (Table 10). Collection of firewood is negatively correlated with distance from the village to the wildlife habitat ($r = -0.241$, $P < 0.01$). Respondents closer to the wildlife habitat collect firewood frequently from the wildlife habitat.

Table 10. Firewood collection by respondents from the wildlife habitat and outside the wildlife habitat among villages

Villages	n =200	Firewood collection by respondent (%)	
		Outside wildlife habitat	From wildlife habitat
Jafera	31	61.29	38.71
Ebicho	39	58.97	41.03
Tadecha	27	81.48	18.52
Bamo	35	77.14	22.86
Sadewole	43	32.56	67.44
Malakicho	25	80	20
Mean		65.24	34.76

3.4.3 Human–wildlife conflict

Crop damage, livestock predation, both crop damage and livestock predation and disease transmission were the major problems identified in the study area. Among the respondents, 41.09% reported that they faced crop damage due to wildlife, where as 13.04% reported livestock predation by wildlife. Only 9.05% reported that they did not face any problem caused by wildlife, and 5.74% (SD ± 6.65%) reported problems of disease transmission (Table 11). There was a significant differences (χ^2 = 100.150, df = 4, P < 0.05) in the problems caused by wildlife among the six villages.

Table 11. Percentage of respondents faced different problems caused by wildlife

Villages		Respondents, %				
	n = 200	No conflict	Crop damage	Livestock predation	Both crop damage & livestock predation	Disease transmission
Jafera	31	0.00	64.52	3.23	32.26	0.00
Ebicho	39	0.00	48.72	5.13	46.15	0.00
Tadecha	27	7.41	22.22	18.52	37.04	14.81
Bamo	35	22.86	28.57	11.43	37.14	0.00
Sadewole	43	0.00	46.51	27.91	13.95	11.63
Malakicho	25	24.00	36.00	12.00	20	8.00
Mean		9.05	41.09	13.04	31.09	5.74

3.4.3.1 Conflict with Gelada Baboon

Among the respondents, 79.85% reported that crop damage by gelada baboons were increasing from time to time, whereas 17.38% reported that they did not know the reason and the trend of crop damage by geladas. Only 2.78% of the respondents reported that crop damage by gelada baboons were decreasing. The view of the respondents differed significantly among the villages ($F_{5\ 194}$ = 4.455, P < 0.05) in terms of crops damage by geladas. Respondents from Jafera (83.87%), Ebicho (92.31%), Tadecha (81.48%) and Sadewole (83.72%) reported increase in the tendency of crop damage by gelada baboons (Table 12).

Table 12. Approximate distance from the gelada habitat and the trend in crop damage by geladas

Village	n =200	Distance from the gelada habitat (km)	Changes in the levels of damage, %		
			Unknown	Increased	Decreased
Jafera	31	0–1	6.45	83.87	9.68
Ebicho	39	0–2	7.69	92.31	0.0
Tadecha	27	2–3	18.52	81.48	0.0
Bamo	35	3–5	34.29	65.71	0.0
Sadewole	43	0–2	9.30	83.72	6.98
Malakicho	25	2–5	28.00	72.00	0.0
Mean			17.38	79.85	2.78

Villagers adopted different methods to minimize crop damages by gelada baboon in the study area. Major techniques deployed were direct watching (guarding), direct watching and making scarecrow, direct watching and using guarding dogs and producing distress calls. Most respondents reported guarding as an effective method in all villages (57.89%), followed by direct watching and making scarecrow (24.80%). There was significant difference in the use of different techniques to control crop damage among the village in the study area (χ^2 = 137.44, df = 3, P < 0.05). Most respondents from Tadecha (74.07%), Jafera (67.74%), Sadewole (62.79%) and Bamo (51.43%) reported using direct watching (Table 13).

Table 13. Techniques followed by respondent of different villages to minimize crop raid by gelada baboons

Village	n = 200	Methods of crop protection against the geladas by respondents, %			
		Distress calls	Direct watching	Direct watching and using dogs	Direct watching and scarecrow
Jafera	31	0.0	67.74	0.0	32.26
Ebicho	39	0.0	51.28	0.0	48.72
Tadecha	27	7.41	74.07	3.70	14.81
Bamo	35	37.14	51.43	0.0	11.43
Sadewole	43	0.0	62.79	11.63	25.58
Malakicho	25	44.0	40.0	0.0	16.0
Mean		14.76	57.88	2.56	24.80

Respondents significantly differed ($\chi^2 = 138.35$, df = 4, $P < 0.05$) in their views on the means to control conflicts with geladas. Among the respondents, 44.5% expect possible solution from the government, whereas, 10.5% proposed to relocate gelada baboons to the other areas. Only 2% of the respondents suggested killing all geladas around their farming area (Fig. 23).

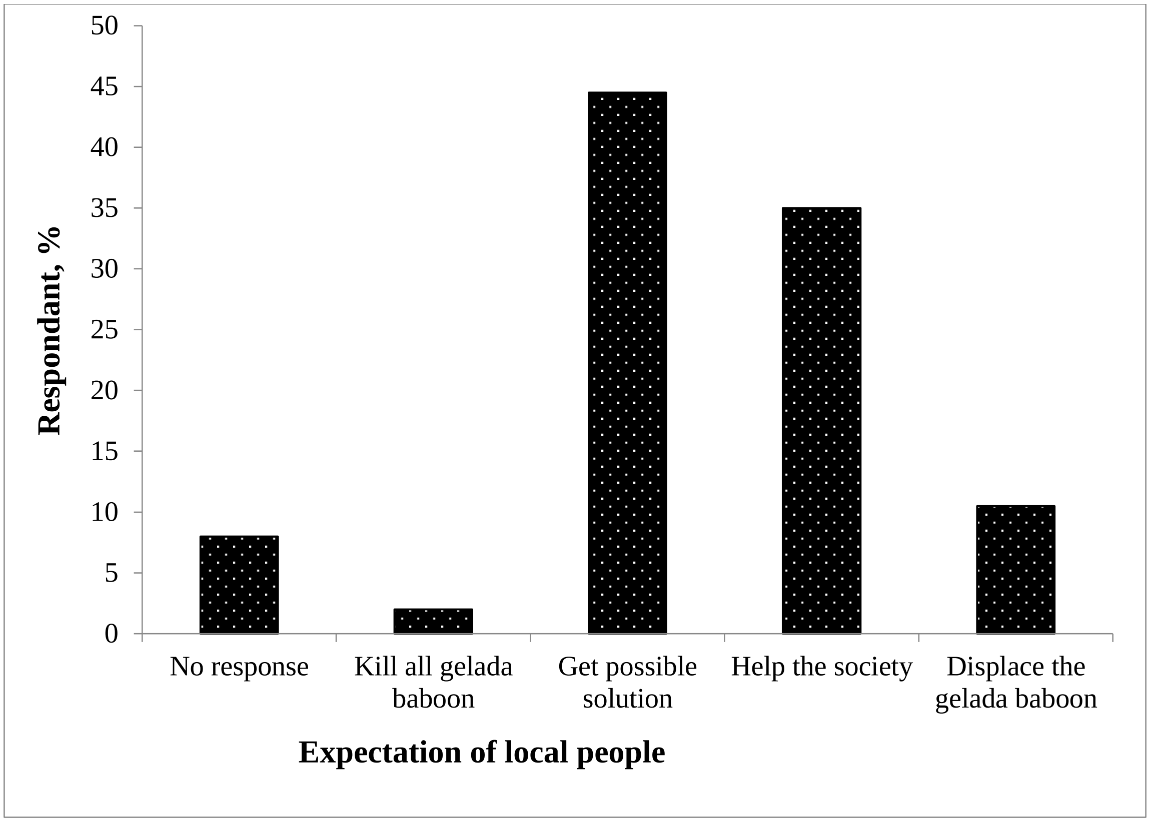

Figure 23. Expectation of local people from government to minimize crop lost by gelada baboon

Respondents did not differ in terms of the type of crops grown ($F_{5\ 194} = 0.81$, $P > 0.05$). Among the respondents, 36.13% cultivated wheat, while 22.22% cultivated wheat and barley and 18.32% cultivated barley only (Table 14).

Table 14. Type of crops grown by local people in the study area

Villages	Type of crop grown by local people (%)				
	Wheat	Barley	Wheat and barley	Wheat, barley and maize	Wheat, barley maize, bean and pea
Jafera	38.71	16.13	25.81	12.90	6.45
Ebicho	46.15	7.69	25.64	12.82	7.69
Tadecha	37.04	25.93	18.52	11.11	7.41
Bamo	40	22.86	17.14	11.43	8.57
Sadewole	34.88	9.30	30.23	13.95	11.63
Malakicho	20	28	16	24	12
Mean	36.13	18.32	22.22	14.37	8.96

Distance from the geladas habitat and the frequency of crop damage by gelada baboon were negatively correlated ($r = -0.059$, $P > 0.05$). There was positive correlation ($r = 0.23$, $P < 0.05$) between the type of crop grown and the crop damage caused by geladas. Gelada baboons frequently caused damage on wheat as it was the most common cultivated crop in the study area for a long period of time. Out of the respondents, 35.23% reported loss of wheat, and 29.89% reported loss of barley (Table 15). The respondents did not differ in terms of the type of crops damaged by geladas ($F_{5\ 194} = 0.473$, $P > 0.05$).

Table 15. Type of crops damaged by geladas in different villages (n= 200)

Villages	Crops damage by geladas, %				
	Wheat	Barley	Wheat and barley	Wheat, barley and maize	Wheat, barley maize, bean and pea
Jafera	35.48	32.26	9.68	19.35	3.23
Ebicho	41.03	23.08	10.26	20.51	5.13
Tadecha	33.33	22.22	25.93	14.81	3.70
Bamo	34.29	28.57	20	2.88	14.29
Sadewole	23.26	37.21	16.28	20.93	2.33
Malakicho	44	36	8	4	8
Mean	35.23	29.89	15.03	13.69	6.11

3.4.3.2 Gelada faecal analysis

Among the analysed faecal samples, 52.46% (SD ± 3.04%) had wheat and barley, 27.52% (SD ± 7.28%) had wheat, barley, and maize, whereas 20.03% (SD ± 9.43%) had wheat, barley, maize and poaceae species (Table 16).

Table 16. Percentage of raided crops as revealed from the geladas faecal analysis in four different collection sites (n=60)

Village	Types of crop raided (%)		
	Wheat and barley	Wheat, barley and maize	Wheat, barley, maize and poaceae spp.
Jafera	56.25	31.25	12.50
Ebicho	53.57	32.14	14.29
Tadecha	50.00	30.00	20.00
Sadewole	50.00	16.67	33.33
Means	52.46	27.52	20.03

3.4.4 Conservation attitude towards wildlife

There was a significant difference among the respondents from different villages in the conservation attitude of the respondents towards wildlife (χ^2 = 38.72, df = 1, $P < 0.05$). Most of the respondent (72.66%) had positive attitude towards wildlife, whereas 27.34% had negative attitude. Majority of the respondents from Jafera (67.74%), Tadecha (74.07%), Sadewole (69.77%) and Bamo (82.86%) had positive attitude towards wildlife. However, 38.46% from Ebicho, 32.26% from Jafera and 30.23% from Sadewole had negative attitude towards wildlife (Table 17).

Table 17. Conservation attitude of the respondents towards wildlife

Village	n = 200	Negative attitude (%)	Positive attitude (%)
Jafera	31	32.26	67.74
Ebicho	39	38.46	61.54
Tadecha	27	25.93	74.07
Bamo	35	17.14	82.86
Sadewole	43	30.23	69.77
Malakicho	25	20.00	80.00
Mean		27.34	72.66

Wilcoxon Matched Pairs Test revealed that there is a significant difference (Z =-5.793, $P < 0.05$) between male and female respondents in conservation attitude towards wildlife. Most male respondents (80.65%) had positive attitude towards wildlife, whereas 19.35% had negative attitude towards wildlife. Among the female respondents, 64.44% had positive attitude towards wildlife and 35.56% had negative attitude towards wildlife (Table 18).

Table 18. Conservation attitude towards wildlife between male and female respondents (n=200)

Sex	n =200	Positive attitude	Negative attitude
Male	155	80.65	19.35
Female	45	64.44	35.56
Mean		72.55	27.45

As educational level of the respondents was positively correlated with conservation attitude towards wildlife. Eighty percent of the respondents, who had beyond secondary level of educational had positive attitude towards wildlife, whereas 40.91% of respondents, who had no education had negative attitude towards wildlife (Table 19). Respondents having different levels of education differed significantly (χ^2 = 34.658, df =1, P < 0.05) in their attitude towards wildlife conservation.

Table 19. Level of education of the respondents and conservation attitude towards wildlife (n=200)

Level of education	n =200	Positive attitude	Negative attitude
Illiterate	66	59.09	40.91
Informal	21	71.43	28.57
Primary	95	75.79	23.95
Secondary	13	76.92	23.08
Beyond secondary	5	80	20
Mean		72.65	27.35

Result of Pearson Correlation Coefficient test showed that there was negative correlation (r = -1, P < 0.05) between problems caused by wildlife and conservation attitude of the local people. Those who faced frequent problems by wildlife had negative attitude whereas those who faced little or no problem with wildlife had positive attitude towards conservation. There was positive correlation (r = 0.136, P > 0.05) between distance of respondents from wildlife habitat and their attitude for conservation of wildlife.

3.4.5 Conservation attitude towards gelada baboon

Majority of the respondents (74.16%) had positive attitude towards gelada baboon, whereas only 25.84% had negative attitude towards gelada baboon. Most respondents from Jafera (61.29%), Ebicho (64.10%), Tadecha (77.77%), Bamo (85.71%), Sadewole (72.09%) and Malakicho (84%) had positive attitude towards geladas. However, 38.71% of the respondents from Jafera and 35.90% from Ebicho had negative attitude towards gelada baboon (Table 20). Respondents from different villages differed ($\chi^2 = 44.18$, df = 1, $P < 0.05$) in their attitude towards gelada baboon.

Table 20. Conservation attitude of respondents towards gelada baboon

Village	n = 200	Attitude of respondents towards geladas (%)	
		Negative attitude	Positive attitude
Jafera	31	38.71	61.29
Ebicho	39	35.90	64.10
Tadecha	27	22.22	77.77
Bamo	35	14.29	85.71
Sadewole	43	27.91	72.09
Malakicho	25	16.00	84.00
Mean		25.84	74.16

Results of Logistic Regression analysis have revealed that the respondents, who held positive attitude towards geladas and wildlife habitat were likely to have large extent of land ($p < 0.05$), gender (females) ($p < 0.05$) and young age ($p < 0.05$). Although insignificant, a trend was noticed in large family size ($p > 0.05$), low education level ($p > 0.05$), and nearer distance to wildlife habitat ($p > 0.05$) responsible for negative attitude of the respondents towards geladas (Table 21).

Table 21. Attitude of respondents towards gelada baboon based on logistic regression analysis

Variable	Results of Logistic Regression				
	B	SE	Beta	T	P
Gender(female)	-0.431	0.066	-0.411	-6.524	0.000
Age(young)	-0.079	0.033	-0.213	-2.441	0.016
Family size of respondent (large)	0.051	0.034	0.122	1.474	0.142
Distance from habita by km (near)	0.034	0.028	0.118	1.239	0.217
Educational level (illiterate)	-0.033	0.028	-0.080	-1.159	0.248
Land holding	0.080	0.028	0.195	2.820	0.005

(n = 200. B = logistic regression coefficient, SE = standard error, T = t statistics, P = significance, and R = R statistic indicating the relative contribution of each independent variable in explaining the variance of the dependent variable).

3.5. Focus group discussion

The discussants have revealed that the present study area provides economic, social and environmental benefits to the local community. They have revealed that activities such as livestock grazing, fuel wood gathering and farming practices were performed by the local community. Most of them described shortage of private grazing land and small farmland holding due to large population. This may have increased pressure on the wildlife habitat for livestock grazing and agricultural expansion. Some of the discussants have revealed that they had negative attitude towards larger carnivores and geladas. Some discussants were not happy with the existence of gelada baboons. They considered these wild animals as a limiting factor to improve their livelihood due to crop raiding problem they cause for local people. However, the majority had positive attitude towards geladas and other wildlife in the area. They stated that they have been living in harmony with geladas and other wildlife by controlling, or minimizing their damage by different techniques. During focus group discussions, the discussants stated that conservation of geladas and other wildlife could be effective if the local community and governments work together. However, some of the discussants noted that problems caused by wildlife/gelada and lack of awareness lead them to develop negative attitude for wildlife conservation in the area.

Most of the discussants stated that demarcation of open grazing land near the cliff as buffer zone and establishment of Arsi gelada sanctuary in the area should be a priority for the future survival of Arsi geladas and other wildlife in the present study area.

Most of the discussants stated that sustainable use of resources and management practices in the area could be effective if essential livelihood income is generated in the area. As stated by them, the jobless/landless youth have been responsible for encroachment into the wildlife area. The discussants believed that alternative economic sources should be developed to minimize such problems. Hence, they seriously demand intervention of government for sustainability of area and the wildlife therein.

4. DISCUSSION

Arsi geladas at Amigna are graminivorous, feeding mainly on grass to meet their daily energy needs. Amigna and surrounding areas are unsuitable habitats for Arsi geladas with the lowest altitude compared to the northern and southern gelada populations. Arsi geladas are highly affected by anthropogenic threats because of habitat loss and fragmentation due to human settlement, agricultural expansion and grazing competition. In addition, climate change and global warming associated with shortage of water and shortage of food plants during the dry season appears to put Arsi geladas at a very high risk of extinction in its narrow geographic range (Dunbar, 1998).

4.1 Activity budget

Studies on activity time budget of a species help us to understand how it maximizes its energy earning and spending from time to time and season to season, and limit its energy expendition at a minimum to conserve energy for various essential biological activities. Gelada baboons spent much time in feeding. The problem of undigestiable cellulose in herbivores is compensated by feeding large quantity of grass (Ohsawa, 1979). When they feed, they do not forage in one place for long time, rather they move from one place to another. This is an important adaptation for the sustainability and helping the area to regenerate at the optimum level. Therefore, moving takes the second major act in their daily activity patterns. When gelada get more food, they spend more time resting and grooming than feeding and moving (Dunbar, 1992c). However, Arsi geladas spend larger portion of their time feeding and moving than resting and grooming. Among primates, grooming maintains social relationships, so proportionately more time is devoted for grooming in order to maintain the cohesion of large groups (Dunbar, 1992c). 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, and as they may not get enough food resources. So, to fulfill their energy requirements, they have to spend more time feeding. Arsi geladas feed on grass most of the time; which may have low energy value. Therefore, they have to spend more time feeding to eat more grass to satisfy their daily energy requirements. So, more time is devoted by geladas for foraging and feeding than grooming and resting.

Arsi gelada baboons spent more time feeding and moving during the dry season than during the wet season. During the dry season, factors such as resource dispersion and low food quality force geladas to spend more time in feeding and moving. After the harvesting season, geladas move towards the surrounding farmlands and villages. At that time, they were free to move, in the absence of guards around farms. All these factors might be responsible to extend feeding and moving time. Iwamoto (1993) reported similar findings in the Simien Mountains National Park, concerning feeding and travelling time of geladas during the dry season. Zewdu Kifle *et al*. (2013) also described that during the post-harvest period, geladas cover wide ranges, and they use more time for foraging and travelling.

Dry season usually affects forage availability, and hence might be attributed to limited availability and quality of food. Moreover, during the dry season, green grasses and other food sources are limited, which leads geladas to spend more time in travelling and searching food in order to satisfy their nutritional demands. Iwamoto and Dunbar (1983) and van Doorn *et al*. (2010) have stated that feeding time increases in response to the decrease in the protein content of the dry season forage, and hence feeding time would increase with respect to nutritional requirements. In contrast, they require only less time to locate food and to feed when productivity of the habitat increases during the wet season. Further, differences in time budgets for feeding and travelling between seasons reflects differences in the distribution and abundance of food resources (Stacey, 1986). On the other hand, they spent relatively more time resting, playing, aggression, grooming and in sexual activities during the wet season than during the dry season. Result of the present study suggests that during the wet season, enough food resource are available compared to the dry season. So, Arsi geladas spent less time in feeding and moving and spent more time in social activities during the wet season. These findings are similar to the observation of Dunbar (1992a), who suggested that gelada baboons when obtain food easily spend more time in social activities than feeding and moving. Arsi geladas spent significantly more time in feeding and moving during the dry season compared to the time spent in the wet season.

All age–sex categories spent more time feeding and moving during the dry season than during the wet season. Dunbar (1992a) also obtained similar results on activity time budget of different age–sex categories. Result of the present study suggest that during the dry season, when food quality and availability were less than that during the wet season, they spent more of their time feeding and moving.

During the present study period, intra-group aggressions and inter-group aggressions were observed. Intra-group aggression was observed most of the time between adult male and adult female. But, inter-group aggressions were seen between all individuals of the group. Females and juveniles were the main participants chasing one another in agonistic interactions. This occurs when another group approaches their area. This may indicate that Arsi gelada baboons are territorial, which use their home ranges strictly.

4.2 Feeding ecology

Geladas are unique among primates due to their high degree of specialization for a graminivorous diet (Dunbar and Bose, 1991; Mau *et al.*, 2009). They have long been regarded as obligate graminivores (Dunbar and Dunbar, 1974; Dunbar, 1977; Iwamoto, 1993). Arsi geladas are graminivorous, primarily feeding on grass blades accounting for 48.07% of their overall diet during the course of this study. This might be correlated with the availability and dietary specialization of the species. Iwamoto and Dunbar (1983) and Dunbar and Bose (1991) have reported that geladas spent more than 90% of their feeding time on grass blades. This shows that geladas are specialized grass eaters. They preferred grass blades than herbs and shrubs when green grass was available. Geladas possess a number of behavioural and morphological adaptations, which enable them to utilize their specialized ecological niche (Crook, 1966; Jolly, 1972). Further evidence for geladas' high degree of dietary specialization for grasses might have come from the less-diverse nature of their diet, as well as based on the lower biodiversity of the Arsi gelada habitat in Amigna.

Geladas have shown seasonal variation in their foraging strategy, which is reflected by the increased time they spent feeding during the period of food scarcity during the dry season (Crook, 1966; Hunter, 2001). Changes in the foraging strategy of geladas were associated with seasonal variations in food availability. Similarly, some primates modify their foraging strategy in response to seasonal variations in the availability, relative abundance and distribution of food (Barton *et al.*, 1992). Hill and Dunbar (2002) have suggested that some primates have remarkable abilities to modify their foraging behavior and diet in response to the prevailing ecological conditions. Geladas have similar ability to change their foraging behaviour in response to variations in the availability of food. Seasonal patterns in their diet have shown that when preferable food types were less abundant during the dry season, diet choice becomes less selective and geladas broaden the diet by including less-desirable food items. On the other hand, when desirable food types become abundant (e.g., green grass blades) geladas were more selective in food choice and diet tended to be narrow. Previous studies have shown a noticeable change in gelada diet as the preferred green grass leaves desiccate during the dry season (Crook, 1966; Dunbar, 1977; Iwamoto, 1979). Hughes (1993) suggests that diet choice in animals reflects the types of food that are most accessible in the habitat and can give maximum energy. Changes in foraging patterns and diet in geladas were directly associated with seasonal variations in resource availability. However, foraging behaviour is rarely influenced by one factor alone (Iwamoto and Dunbar, 1983), but is responsive to changing environmental and ecological factors, such as rainfall and temperature (Brownikowski and Altmann, 1996).

In the present study area, geladas shift their feeding strategies to tolerate the harsh dry season. They feed on a variety of food resources to overcome harsh environmental conditions. When grasses are not available, they feed on herb leaves, herb roots and corms. However, they predominantly feed on grasses, if available, as reported by Iwamoto (1993). Gelada baboons spent more time feeding on grass blades, forb roots, and fruits during the wet season than during the dry season. They spent more time feeding on forb leaves, grass root and grass corm during the dry season than during the wet season. There was a significant difference in the time spent feeding on grass blades and grass roots between seasons. However, there was no significant difference between seasons in the time spent feeding on forb leaves, forb roots, grass corm, underground forb tubers, fruit and other items (unidentified). This might be due to high conflict between local people and gelada baboon for grazing land and crop raiding problems. During the wet season, local people graze their livestock at the edge of the cliffs as they have no sufficient land to graze their cattle.

During the present study, gelada baboons consumed a total of only eight plant species. This lower number of forage species might be related to the lower level of diversity in the habitat to which Arsi geladas lived. Similarly, Demment and van Soest (1985) have stated that when compared to other closely related sympatric genus *Papio*, geladas have narrow feeding niche. The loss of salivary tannin-binding capacity of geladas is the result of a long process of narrow specialization. Eshetu Mogose (2015) reported around 18 plant species that contributed to geladas' diet in the Guassa area, Ethiopia. The result of the present 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 the narrow distribution of the gelada baboons that restricted themselves in the 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 a rare species. Therefore, geladas in the present study area could also be considered as a rare species, and which a species at risk of extinction.

During the wet season, geladas spent more time feeding on grass blades of *Hyparrhenia hirta*. This may be due to the availability and high nutritional quality of *H. hirta* during the wet season than during the dry season. Green grass is available in plenty during the wet season than during the dry season. During the dry season, grass blades were less in the area, leading to reduced time spent on grasses. Following grass blades, fruits of *Opuntia strcta* provide major contribution to the diet of geladas during the wet season. Time spent in feeding on each of these species was relatively high during the wet season than during the dry season, probably due to the seasonal availability of the species during the wet season than during the dry season. This might force geladas to engage more time with the available food items. Richard (1999) had reported seasonal variability and availability of food items and indicated that food plant availability varies between seasons, determining the time engaged in for each forage species by primates.

During the dry season, geladas spent more time feeding on leaves of *Ipomoea hildrbrandii*, on fruits of *Balanites aegyptica*, on fruits of *Rhus glutinesa* and on leaves of *Dodonaea angustifolia*. These species are evergreen, and available during the dry season.

4.3 Daily range and home range

The home ranges of the study units were more extended during the dry season than during the wet season. Variations in the availability of resources in study area during different seasons will have impacts on ranging behaviour of geladas. During the wet season, geladas were constrained with movements from one area of land to the other due to human activities. However, during the dry season, after harvest, there were no much human activities. Thus, geladas move freely from one patch of land to the other, increasing home range size during the dry season. Eshetu Mogose (2015) also reported variations in the extent of home range of geladas in Guassa between seasons as a result of human induced activities. It was between 0.64 and 4.29 km^2 during wet and dry seasons, respectively in Guassa. However, the home range of geladas in Amigna area varied from 3.26 and 5.44 km^2 during wet and dry seasons, respectively.

During the dry season, food availability is less, and to fulfill their nutritional requirements, geladas travel longer. In general, the larger the group size, the longer the day journey and home range. The longer the day journey, the greater the time to be devoted, which turn, place further constraints on the time budget of geladas. The only way in which the time budget can be adjusted while conserving social time is to reduce the band size in order to reduce the distance to be covered each day. Hunter (2001) have noted that use of the extended home range during the dry season might be due to more patchily distribution of green grasses during the dry season in the habitat.

The range length of Arsi geladas varied both daily and seasonally. The variation of the daily range length might be correlated with differences in the resource availability and the band size. In addition, habitat quality also influences daily range movement of animals (Dunbar, 1992c). When food is limited, geladas with large band size move longer distances. Zewdu Kifle *et al*. (2013) have reported that the mean daily path length of geladas was 0.6 and 1.5 km during wet and dry seasons, respectively. Yonatan Ayalew (2009) have reported that the mean daily range length of geladas of Dissie and Guassa areas were 2.9−4.5 km.

Such variations in the extent of daily range might be associated with the variations in food availability band size, and human related factors in the respective study areas and seasons. The present study also suggested that geladas move less when food availability is high, but when food sources are scarce, they roam larger areas in search of food. Thus, foraging effort and distance travelled may change depending on the size of the band. Large bands would travel longer distances to satisfy their nutritional requirements than small bands (Collins, 1984; Noser and Byrne, 2007).

4.4 Livelihood activities

Majority of the respondents in the present study area were engaged in mixed farming activities. This might be due to the fact that monoculture practice was not effective in the area as mixed crop – livestock farming was more likely to benefit local communities. Wheat and barley are the main seasonal food crops in the present study area. Pender *et al*. (2001) reported that mixed farming practices in the highlands have intergraded functions to improve food security and to alleviate poverty. Mixed crop – livestock production system was found to be the dominant farming practice in the central highlands of Ethiopia for its integrated values (Belay Duguma *et al*., 2012).

In the present study area, majority of household (37.38%) owned 1–2 hectares of land, where as 11.84% of the respondent were landless. Only few households owned more than 3 hectare. This forced them to encroach in to wildlife habitats and cultivate even at the edges of cliffs. Such areas are highly vulnerable to crop raiding by geladas, soil erosion, degradation and poor yield leading to poverty. Such encroachments to wildlife habitats increases human–wildlife conflicts especially human–gelada conflicts. Some of the respondents are making additional income by selling wood collected from the wildlife habitats and some of them depend upon 'food for labour', or safety-net programmes.

Livestock rearing in Amigna area is also a source of income of the communities. Livestock acts as a source of wealth and social status in the community. Among the livestocks, sheep is mainly reared by the local community and is used primarily for commercial purpose for livelihood income in the study area. This shows that the area is favourable for sheep rearing.

Majority of respondents (42.10%) have 7–10 family members per household, whereas 25.34% have only 3–6 members in the families. However, the mean family size per household varied among the study sites. To feed this large number of family, the house hold must depend on agriculture. Due to the small extent of land most of the family holding, they encroach wildlife habitats for agricultural activities. This in turn have a great impact on wildlife.

4.5 Resource utilization

Livestock grazing is a major challenge for gelada baboons in the present study area. Livestock of the local people graze in gelada habitat and compete with gelada baboons. The presence of excess number of livestock causes direct threat for gelada baboons and other wildlife in the area. High number of livestock and scarcity of grazing land made the local people to use even difficult cliffy areas for grazing and agriculture. This has been observed during field observation in the study area and confirmed by the local people during focus group discussions.

The local people in the study area depend on wildlife habitat also for grazing and firewood collection. However, the level of utilization of natural resources among different villages varies. This might be due to the differences in the access to the natural resources from different villages. There are also difference in the awareness level among the villagers, based on the distance from wildlife habitat and educational level of the respondent. Decreasing (nearer) distance of the habitat from the village increased the frequency of grazing inside the park. Thus, larger proportion of the respondents from Jafera, Tadecha and Sadewole villages reported that they graze their livestock in side the wildlife habitat for more than seven months in the year. Therefore, those who are closer to the wildlife habitat play greater role in the destruction of natural habitat. Similarly, as reported by

Zelalem Tefera (2001) and Eshetu Mogose (2015), livestock from nearby villages stay for longer time in the wildlife habitat in Guassa area than from villages far away from wildlife habitat.

Fire wood collection is another type of exploitation, which has a detrimental effect in the study area. Among the respondents, 34.76% reported that they collect fire wood from the present study area. Even though, it is not pronounced like livestock grazing, it also has a significant impact on the habitat quality by removing shrubby vegetation. Firewood collection is negatively correlated with the distance from the wildlife habitat. Those who live closer to the wildlife habitat collect firewood more frequently than those who live far from the wildlife habitat. Similar result was observed in the study conducted in Guassa area. Peasant association closer to the Guassa area used firewood more frequently than those further away (Zelealem Tefera, 2001). In general, local community around protected areas in developing countries highly depend on natural resources as sources of income (Rao and Geisler, 1990).

4.6 Human–wildlife conflict

In many parts of Africa, the conflict between local community and wildlife is a serious problem in areas adjacent to natural habitats (Newmark *et al.*, 1994). In the present study area also, human–wildlife conflict is a major problem in the conservation of geladas. The major conflicts between wildlife and local community in Amigna are crop raiding and livestock predation. However, the causes of conflicts differ as per the views of respondents of the present study. Among the respondents, 90.95% reported problems with wildlife. Among the local people who reported problems caused by wildlife, 41.09% reported crop damage, while 13.04% reported loss of livestock due to wild predation and 31.09% reported both crop damage and loss of livestock to wildlife. Akama *et al*. (1995) and Distefano (2005) have stated that human–wildlife conflicts arise as a result of destruction of crops by crop raiding wild animals and due to depredation of livestock by predators. Rapid population growth and changes in the local community values of wildlife are reasons for conflicts in relation to crop damage and livestock depredation (Shibia, 2010; Eshetu Mogose, 2015). Hill (2000) and Mesele Yihune *et al*. (2008) have stated that many of the wildlife, baboons in particular, are of major threat to the livelihood of local communities due to their crop raiding activities around Simien Mountains National Park, Ethiopia. Similar findings were also observed from Tanzania on conflicts between wildlife and local people living adjacent to protected areas (Newmark *et al.*, 1994). During the present study in some villages like Tadecha and Sadewole, disease transmission was also reported. This is because the settlements was not distant from wildlife habitat, and have possibility of direct contact between the human and wildlife.

4.6.1 Conflict with gelada baboon

Gelada baboons prominently feed upon grass species (*Poaceae*). They also feed upon cultivated crops like wheat, barley, maize, bean and pea during harvesting season. This leads to conflict with the community living in and around Amigna.

Baboons are notorious crop raiders across much of their range in Africa and Arabia (Sillero-Zubiri and Switzer, 2001). The result of the present study has clearly shown that there is a strong conflict between gelada baboon and local community in Amigna due to the crop raiding behaviour of geladas. Balakrishnan and Ndhlovu (1992) and Sillero-Zubiri and Switzer (2001) have reported similar findings of human–baboon conflicts due to crop raiding behaviour. In the present study, major crop loss was reported in Jafera, Ebicho and Sadewole villages. This is because farmlands in these villages are located close to the habitat of gelada baboons. Thus, farmers could not reach their farmland early to guard their crops from gelada baboons. Similarly, those farms located at the edges of forests are exposed to frequent losses to primates (Naughton-Treves, 1997). Hill (1997) also found that most of the farms which experienced sever crop raiding in western Uganda were within 100 m of the forest area.

Most of the respondents (79.85%) in the present study area reported that intensity of crop damage by geladas have increased in the recent years. This is probably associated with the increase of the gelada population, human population, and the number and extent of farmlands close to the habitat of geladas. Mesele Yihune *et al*. (2008) have reported that increase of crop damages caused by geladas in the Simien Mountains National Park was associated with the increase of the population of geladas. In the present study, the local community followed direct guarding, direct watching and scarecrows and direct watching and using dogs to control crop losses. In the present study area, majority of the respondents reported using direct guarding to minimize crop damage. Eshetu Mogose (2015) had reported direct guarding is the best option to prevent crop losses by wildlife. It also helps to avoid the risk of crop raiders habituated to any of the other single methods.

Respondents significantly differed in their expectation from the governments to reduce loss of crop. Majority of the respondents expect possible solution from the governments to minimize problems caused by gelada baboons, whereas 10.50% of respondents were interested if the government displaces gelada baboons, from farmland areas to other areas. Few of respondents were of the opinion that the government should exterminate all gelada baboons. This might be due to the hardships to which local people are subjected to as a result of problems caused by geladas.

Gelada baboons frequently cause damage on wheat. This is because wheat was the most common cultivated crop (36.13%) in the study area when compared with the other crops. Among the respondents 35.23% reported the loss of wheat and 29.87% reported the loss of barley. The result from faecal analysis showed that 52.46% of the faecal samples contained wheat and barley whereas 27.52% of the faecal samples contained wheat, barley and maize. Similarly, Hill (1997) suggested that some crops may receive more damage simply because they are more widely grown than other crops. In addition, a study in Entebbe (Uganda) on crop raiding showed that crops most commonly damaged by the vervet monkeys were those crops that were most commonly grown in the area (Saj *et al*., 2001). In general, the type and the extent of the crops grown and the type of crop damaged were positively correlated. Thus, commonly and frequently cultivated crops had greater chance to be more damaged by crop raiders than other crops.

4.6.2 Attitude of local people towards wildlife

Majority of the respondents had positive attitude towards wildlife habitats in the study area. Skehar (1998) had stated that local people would show a positive attitude towards wildlife and wildlife habitats because of cultural, religious and economic reasons. Attitude of local people towards wildlife vary among rural agricultural producers (Messmer, 2000). Deresse Dejene (2003) revealed that the local communities are not entirely antagonistic to wildlife conservation. In the present study area, 72.66% of the respondents have positive attitude towards wildlife. However, 38.46% of the respondents of Ebicho village and 32.26% of the respondent of Jafera village had negative attitude. This is because they frequently face problems caused by wildlife. Problems caused by wildlife and conservation attitude towards wildlife were negatively correlated. Those who faced frequent problems by wildlife had negative attitude towards wildlife, whereas those who faced little or no problem with wildlife had positive attitude towards wildlife and conservation.

Even though there was high level human–wildlife conflict (90.95%) in the present study area, 72.66% of the respondents had positive attitudes towards wildlife. This may be due to awareness creation among the local people in the present study area or might be due to cultural and religious aspects of the local people.

In the present study area, sex had major effect on attitudes among the local community towards wildlife. This shows that within the local community, there is significant difference among males and females in the awareness towards conservation of wildlife. Men are more positive towards protected areas and wildlife than women (Gillingham and Lee, 1999; Mehta and Heinen, 2001). Females usually show negative attitude than men towards wildlife conservation. This might be due to the low educational standards and awareness levels of women about wildlife conservation. However, Infield (1988) and De Boer and Baquete (1998) have reported that sex has no effect on the attitude of local communities towards conservation of wildlife. Shibia (2010) also reported that the attitude of the local people towards wildlife conservation was independent of sex and conservation awareness.

In the present study area, age of the respondents had significant effect in the attitude for conservation of wildlife. Majority of the young respondents of the present study were well informed of geladas and wildlife habitat, and they showed more positive attitude for conservation of wildlife habitat and geladas than the elders. This might be correlated with the educational level and awareness that the young respondents have had on wildlife. Elders are less likely to support conservation programme based on studies in Tanzania rather than younger people (Newmark *et al*., 1993). Similar findings were also revealed by Heinen (1993) on the relationship between different age groups and their attitude towards wildlife conservation in Kosi Tappu Wildlife Reserve, Nepal. It is associated with the length of experiences with wildlife benefits and their associated cost. Based on their studies, Fiallo and Jacobson (1995) have reported that age significantly affects the attitude of local people in Machililla National Park, Ecuador; where residents over 54 years were less likely to feel positively towards protected area than middle-aged people.

Education has a great role on the attitude of local community towards wildlife. Higher levels of education or specific knowledge about conservation are positively correlated with more favourable attitudes of local people towards wildlife conservation (Tsehaye Gebrelibanos and Mohammed Assen, 2013). A better level of education results in developing positive attitudes towards protected areas and wildlife (Heinen, 1993). However, de Boer and Baquate (1998) have stated that education level had no significant effect on attitudes of local community in the vicinity of the Maputo Elephant Reserve, Mozambique. In general, a society with high percentage of educated people may have high level of awareness than those with low level of education to influence positive attitudes among the public.

4.6.3 Attitude of local people towards gelada baboon

Most respondents of the present study area have shown positive attitude towards gelada baboon. Especially, residents of Malakicho (84%) and Bamo (85.71%) have positive attitude towards geladas. These villages are located far away from the habitats of geladas, and only negligible crop damage was recorded when compared to the other villages studied. In communities with subsistence economy, even small loss can generate negative attitude towards wildlife (Oli *et al.*, 1994). Most respondents (38.71%) from Jafera showed negative attitude towards gelada baboons. This is because gelada baboons frequently cause crop damage in this area. There was negative correlation between the attitude of respondents towards gelada baboon and crop loss. As the crop loss by gelada baboon increases, the attitude towards the animal becomes negative. Those with positive attitude towards wildlife had more likely positive attitude towards gelada baboon. Variables such as sex, age, family size, distance from wildlife habitat and educational level were the determinant factors for the attitude of respondents towards wildlife and gelada baboon in the present study area.

4.7 Conservation implication

Arsi geladas are under immense anthropogenic pressure because of habitat loss and fragmentation, human settlements, and grazing land competition (Mori and Belay 1990; Gippoliti and Hunter 2008). Considering these threats along with their narrow geographic range, low density and generally small remaining population accompanied with the harsh weather and lack of water during the dry season make the geladas at Arsi to face a very high risk of extinction (Harcourt *et al*. 2002; Harcourt *et al*. 2006). Furthermore, conservation threats facing these small isolated populations with low genetic diversity (Belay and Shotake 1998) are very high in the eastern Arsi human dominated landscapes outside protected areas. The new isolated Arsi gelada population will not be sustainable over the long-term in the absence of immediate conservation actions. The new distinctive subspecies should be classified under 'Endangered' category of IUCN Red List of Threatened Species from its erroneously designated status together with the central gelada (*T. g.*

obscurus) (Gippoliti and Hunter 2008). Due to lack of understanding on the taxonomy of this *Theropithecus* subspecies may have negative influence on the development of conservation management strategies of geladas in general and possibly this third *Theropithecus gelada arsi* subspecies in particular (Gippoliti 2010; Shotake *et al.,* 2016). The conservation of Arsi gelada is currently impossible unless conservation measures are undertaken to create potential buffer zone between the cliff and human settlement areas, where its longer-term survival mainly depends on the availability of adequate grazing land. Effective conservation management plan of geladas at Arsi should focus on their dietary and habitat requirements, where they need open grazing land suitable for green grasses near cliffs, which are important for roosting. So, demarcation of open grazing land near the cliff as buffer zone and establishment of Arsi gelada sanctuary in the Wabe Shebelle and Amigna gorge should be a priority for the survival of this rare geladas. Furthermore, the effect of habitat loss and degradation, climate change and human–gelada conflict management should be analysed in detail to devise better management plans for sustainability of the Arsi geladas in Amigna, eastern Arsi, Ethiopia.

4.8 CONCLUSION AND RECOMMENDATIONS

Human population growth in Ethiopia has lead to rapid encroachments into wildlife habitats, restriction of movement of larger animals into marginal habitat patches, and direct competition for resources with local communities. In gelada inhabiting areas, the current human population growth, degradation of natural habitats, increasing demand for natural resources and the growing demands for access to land have forced geladas to move into community areas.

Arsi geladas show dietary rigidity. They depend upon only few plant species. Grass contributed for the highest percentage of the diet of geladas, as they are adapted to the graminivorous niche. Gelada baboons move less when food availability is high, but when food scarcity occurs, they explore larger areas in search of food. The home range areas and daily ranges of gelada baboons were larger during the dry season than the wet season.

Wildlife habitats are altered and fragmented in the past for agricultural extention; which, resulted in lack of enough space, food, and other resources for survival of wildlife. Gelada baboons and local communities use the same habitat and compete for resources. The requirements of wildlife overlap with those the people in the area. This causes conflicts between local people and gelada baboons. Gelada baboons consumed crop of local people. This made a major conflict between the local people and gelada baboon. Crop-raiding by geladas poses a major problem to field crops and the livelihoods of farmers. It makes intense human–gelada conflicts in the area. Factors such as educational level, land holding type and distance of villages from farmland influenced the attitude of local people on conservation of geladas in the area. Negative attitude was exhibited by the local people, who own land near the wildlife habitat.

Fire wood collection, agricultural and grazing land expansion have significant impacts on accelerating degradation of habitats and cause competition between wild and domestic animals for resources. These problems are highly affecting the status of gelada baboons in Amigna area.

The results of the present study have several conservation and management implications for Arsi geladas and their habitats. Hence the following recommendations are suggested for consideration by the conservationist:

- Amigna forest is severely threatened by agricultural expansion. Governments should take action to control agricultural land expansion towards gelada habitat.
- Grazing has a negative impacts in the area in accelerating habitat degradation and competition with wildlife. In addition, firewood collection from the forest also leads to disturbances for wildlife. So, awareness creation among the local community might be the possible solution for the current problems in the study area.
- In order to conserve Arsi geladas more effectively, serious efforts are to be made using scientific knowledge, combined with indigenous knowledge, and participatory approaches with the local communities.
- The local people use forest as a source of income. So, governments should recognize this and generate other means of income for the local people.
- Amigna forest is an unprotected area. Demarcation of open grazing land near the cliff as buffer zone and establishment of Arsi gelada sanctuary in the Wabe Shebelle and Amigna gorge should be a priority for the future survival of geladas in this area.
- Farmers should cooperatively keep their farm against gelada baboon and other crop raiders to minimize crop loss by using the most effective methods in the area.

- Further investigation must be carried out to identify alternative crops that can be rejected by gelada baboon and other crop raiders in the area. Then, it should be applied for the farms around to deter crop raiders.
- Both the Federal and Regional governments should take strong measures to curtail deforestation in the area.
- Continuous monitoring and evaluation of human–gelada conflicts are needed for effective conservation measures in the future.
- Governments and NGOs should work hand in hand to increase awareness of the local people about the importance of wildlife conservation in general and gelada conservation in particular.

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6. APPENDIX

APPENDEX 1

Identified plant species within the home range of gelada baboons.

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

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

APPENDEX 2

Arsi gelada activity pattern data sheet, eastern Arsi

Time interval: 15 minutes

Group Id.________________ Weather___________________

Date____________________ Start time__________________ End time___________

Time seen	GPS Location		IND	Activity									Habitat type	Remark
							Social							
	Loc x	Loc y		**F**	**MV**	**R**	**P**	**AG**	**GR**	**SA**	**DR**	**Os**		
			AM											
			AF											
			SAM											
			SAF											
			JV											

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; AF: Adult female; SAM: Sub-adult male; SAF: Sub-adult female; J: Juvenile

APPENDEX 3

Arsi Geda Feeding Ecology Data Sheet, Eastern Arsi

Personnel ______________________

Group id _______________

Date___________________________

Start Time______________________

End Time_______________

Time Seen	GPS Location		IND	Type of diet/item											Type of species eaten
	Loc X	Loc Y		LGB	SGB	HL	HR	GR	CO	UT	CER	AP	FR	OS	

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

APPENDEX 4

Household questionnaire for local people inside and around gelada baboon habitat in Arsi

A. Household Demographic Questions

1. Name of respondent (number)----------------

    a. Sex------------------ c. Occupation----------

    b. Age------------------

2. Residence

    a. Kebele------------, c. Distance from the geladas habitat------

    b. Village------------, d. Woreda----------------------

3. Marital status…………….

4. Family size………………

5. Education Status (level)

    a. No formal education…………

    b. Primary education…………...

    c. Secondary education…………

    d. Beyond secondary education…….

    e. Others

B. Household Economy and Resource Use

6. Household economy and resource use

    a. Pastoralist b. Farmer c. Both

7. What is the size of your farmland? ……………………………….

8. What type of crop did you grow?

a. …………………………..   c. ……………………………

b. …………………………..   d. ……………………………

9. How much did you get last year?...........................

10. Do you have livestock? Yes/No, if yes

a. No. of cattle---------   d. No. of donkeys------

b. No. of sheep--------   e. Others----------------

c. No. of goats---------

11. Where do they graze?

a. In the study area   b. Other

12. If in the study area, for how long they graze?

a. 1-2 months   b. 2-4 months   c. 5-7 months   d. above 7 months

13. Do you have a private grazing land? Yes/No

a. If yes, what is the size of your private grazing land?......................

b. How many months do they graze in your grazing land?.................

c. How many months do they graze in the study area?......................

14. Do you have private wood plot? Yes/No

a. If yes, what is the size of your private wood plot?

15. Are you dependant on the habitat of gelada for livelihood activities?   Yes/No, if yes, how?

16. Where do you collect fire wood?

a. From the geladas habitat   b. Outside the geladas habitat

C. Conflict and Damage

17. The type of wildlife that you know in the area…………..

18. What kind of problems do you face because of wildlife?

a. Crop damage   b. Predation   c. Disease transmission   d. Others

19. How is the extent the damage by wildlife?

a. Very much   b. Much   c. Little   d. No

20. What control measures have been taken to safeguard the damages?

21. Have you lost any livestock to wildlife? Yes/ No

a. If yes, How many?

b. What is the species involved?

22. Which animal are the most problematic in terms of livestock predation

	predator	prey	Extent (Number killed)		
1			Last year	In the last 5 years	In the last10 years
2					
3					
4					
5					

23. Which animals are most problematic in terms of crop damage?

number	Animal type	type of damaged crop	Extent of damage (last year)
1			
2			
3			
4			

24. How do you minimize the damage?

25. Do you get help from other sources to solve your problem?

Yes………… No……………..

26. If yes, from where do you get the help?

27. What is the tendency of the crop damage from time to time?

a. Increasing…………….

b. Decreasing……………

c. un known

28. At what time is the problem of crop damage more severe? (Specify the month)

29. At what stage do gelada baboons attack your crops most?

Stages	Crop				
	bean	barely	wheat	pea	others
planting					
seedling					
vegetative					
harvesting					

30. Describe the different techniques you use to control (minimize) the damage caused by gelada baboon.

a. Direct watching
b. Direct watching and using dog
c. Direct watching and scarecrow
d. All
e. None

F. Other

31. Which of these techniques are

a. Most effective………..

b. Least effective……….

32. What measure do you think should be taken by the following in order to prevent the damage?

a. By the government

……………………………………………………………………………………

……………………………………………………………………………………

b. By the private sector

……………………………………………………………………………………

…………………………………………………………………………………

c. By the farmers

……………………………………………………………………………………

……………………………………………………………………………………

33. Do you believe wildlife is careful resources to be conserved? Yes/No

34. Do you want to involve yourself in gelada baboon protection? Yes/No, if no, why?

35. What type of advantage do you get from geladas habitat?

36. What do you think the effects on your economy if there is conservation area here?

a. Positive effect, how?

b. Negative effect, how?

c. Neutral effect

37. Do you think that livestock and wildlife can live together? Yes/No, if yes, how?

38. Do you think the presence of people and livestock in the gelada habitat affect the area? Yes/No, if yes, in what way?

APPENDEX 5

Focus group discussion with local people inside and around gelada habitat

1.In what way and what benefits have been realized until now from the gelada habitat?

2. Do you think that local people and livestock affect wildlife?

3. How do local people and wildlife in the gelada habitat coexist in peace and harmoniously?
4. To increase the local community benefits and at the same time to manage wildlife in the area, what should be done?
   a. By the local people?
   b. By conservationist?
   c. By government?
5. In order to bring sustainable development for the local community, what do you suggest?
6. What actions do you take to protect your crops from geladas damage?
7. Who is responsible for conservation of gelada/wildlife in the protected area?

a. Government c. Non-governmental organizations (NGOs)

b. Local community d. All stakeholders

APPENDEX 6

Data Collection Sheet for Gelada Baboon faecal analysis

area	locality	altitude	position	date of collection	time of collection	age of faeces	type of crop eaten

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

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