ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF ZOOLOGICAL SCIENCES
(ECOLOGICAL AND SYSTEMATIC ZOOLOGY STREAM)

POPULATION STRUCTURE, BEHAVIOURAL ECOLOGY AND HABITAT VULNERABILITY OF GELADA (*THEROPITHECUS GELADA*) IN GUASSA COMMUNITY PROTECTED AREA, CENTRAL ETHIOPIA

BY

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ABSTRACT

Population Structure, Behavioural Ecology and Habitat Vulnerability of Gelada (*Theropithecus gelada*) in Guassa Community Protected Area, Ethiopia

Eshetu Moges, PhD Thesis, Addis Ababa University, 2015

Gelada is the only survivor of the genus *Theropithecus,* which once included several successful extinct species that lived in Africa and Asia. The wild populations of gelada are now restricted only to the Ethiopian plateau. The present investigation deals with population structure, behavioural ecology and habitat vulnerability analysis of gelada (*Theropithecus gelada)* population in Guassa Community Protected Area, Ethiopia. To collect data on population structure and behavioural ecology, three units were identified from six bands of geladas. In order to examine the social bonds among geladas, a total of 2,467 grooming interactions in 320 hours of grooming bouts were extracted from the data set. A total of 7, 890 and 6,250 feeding records were obtained from scan sampling during wet and dry seasons, respectively. Nutritive value of food plants of geladas was determined. For habitat vulnerability analysis, land-cover data from Landsat images of 1986, 2002 and 2013 were used. Structured interviews and group discussions were held with the local people to assess their attitude towards gelada and the protected area. The mean number of females per harem varied from 4.1 to 7.1 for the six studied bands. The sex ratio (females per males), the adult sex ratio and the mean number of reproductive females within the units were not statistically significant between seasons ($P > 0.05$). In the study bands, there was an overall increase of the population by 17.1 % per annum. The mean annual mortality rate of geladas was 1.4 %. Geladas spent significantly more time in foraging and moving during the dry season compared to the wet season, whereas the time spent in grooming, playing and resting were significantly more during the wet season. The food plants of geladas were better in protein, crude fibre and neutral detergent fibre constituents, but poor in fat. Change detection matrices revealed that within a representative subset of the study area, grassland, *Helichrysum*, farmland and shrubland have decreased from their previous extent of cover, whereas extents of forest and *Erica* have increased. The difference in the unit size and variations in time spent on activity patterns of geladas between seasons were related to seasonal variability. The extent of grassland, *Helichrysum* and shrubland decreased during the period 1986 – 2013. This might be due to human induced and ecological process, whereas the extents of forest and *Erica* have increased, which might be correlated with the increasing forest conservation efforts in the area. This investigation provides useful information on gelada population structure, habitat changes and attitude of local community towards gelada and their conservation in the study area.

Keywords: Behaviour, band, community participation, geladas, Guassa, habitat change detection, land-use/land-cover changes, population structure, nutritive value.

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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
AOAC	Association Official Methods of Analytical Chemistry
CSA	Central Statistical Authority
OMU	One Male Unit system
GCPA	Guassa Community Protected Area
ILRI	International Livestock Research Institute
EWCA	Ethiopian Wildlife Conservation Authority
EIGS	Ethiopian Institute of Geological Surveys
EWA	Ethiopian Mapping Agency
ETM+	Enhanced Thematic Mapper
ESDI	Earth Science Data Interface
EWNHS	Ethiopian Wildlife and Natural History Society
FZS	Frankfurt Zoological Society
PMGE	Provisional Military Government of Ethiopia
NHAAU	National Herbarium of Addis Ababa University
WPC	World Park Congress
WVE	World Vision Ethiopia

1. INTRODUCTION AND LITERATURE REVIEW

1.1. Introduction

The past geological history, unique topography and the wide ranging climate have made Ethiopia home for diverse biological resources with over 300 species of mammals (Afework Bekele and Yalden, 2013) and a variety of other fauna and flora. Among the mammals of Ethiopia, around 30 (10.5%) are species and subspecies of non-human primates (Kingdon, 1997; Grubb *et al*., 2003; Groves, 2005). Of these, three are endemic (Gippoliti, 2010) such as the Gelada baboon (*Theropithecus gelada*), the Blue monkey (*Cercopithecus mitis boutourlinii*) a sub-species of *Cercopithecus mitis* and the Bale monkey (*Chlorocebus djamdjamensis*). The central highlands of Ethiopia have been the refugia for many endemic and threatened taxa (Yalden *et al*., 1996). Among the endemic mammals, gelada baboon is restricted to the Ethiopian highlands (Hill, 1970). Gelada is the only survivor of the genus *Theropithecus*, which included several successful but now extinct species that once lived in Africa and Asia (Delson, 1993; Jablonski, 1993; Pickford, 1993; Dunbar, 1998). Wild populations of geladas are now restricted only to the Ethiopian plateau (Dunbar, 1993a).

Majority of the *T. gelada* populations live in the north-western area of the Great 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 gelada baboons living in the southern part of the Great Rift Valley (Iwamoto *et al*., 1996; Mori *et al*., 1997). According to Gurja Belay and Mori (2006), the two populations (currently living in four separate communities) possess varying genetic characteristics making the two communities living in the north western part of the Great Rift Valley a distinct subspecies from those living in the southern part of the Great Rift Valley. The genetic variation of the two groups was investigated using restriction fragment length polymorphism (RFLP) of mitochondrial DNA (D-loop), which 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 referred to as *T. gelada gelada,* and the central population as *T. gelada obscurus* (Gippoliti, 2010). A conservative estimate for the split of the northern and southern *T. gelada* populations would range from 696,000 to 1,637,000 years with an average of 1.17 million years. This provided enough time for the subspecies to form their own genetic variations (Gurja Belay and Mori, 2006).

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 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 this subspecies inhabits in the northern highlands particularly in the Gondar area (Yalden *et al*., 1977).

In 1990, a third distinct group of *T. gelada* was discovered from the eastern highlands of the Arsi region, close to the Bale Mountains National Park (Gippoliti, 2010). Based on preliminary studies, it has been proposed that the Arsi Region population can be regarded as yet another distinct subspecies, *T. gelada senex* (Gippoliti, 2010).

Taxonomy of gelada with 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 lone survivor of a clade that includes several extinct species. For this reason, and because of their divergent adaptations (Jablonski, 1993), they are generally considered genetically distinct. *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). However, molecular studies have revealed a sister-taxon relationship between *Theropithecus* and *Papio,* and the exclusion of *Mandrillus*, which has been grouped with *Cercocebus.* Moreover, 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). In these clades, sociality shows 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 (Grueter *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).

Geladas are unique among primates in their adaptation to the graminivorous niche (Mau *et al*., 2009) and are genuine grazers, the major diet being grass blades (Dunbar and Dunbar, 1974; Dunbar, 1977). Their dentition reflects adaptations characterized by high-crowned molars to resist wear and well-developed shearing crests to optimize the ability to masticate fibrous food items (Jolly, 1972; Eck and Jablonski, 1987). Moreover, gelada baboons are found to chew almost as efficient as zebras and are therefore nick-named ‘‘primate horses’’ (Dunbar and Bose, 1991). In addition to grass, they seasonally feed on seeds and in lesser amounts on herbs, fruits and rarely on insects (Iwamoto, 1993).

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 are 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. However, it is clear that without the ability to consume dicots as well as monocots, *T. gelada* is much more vulnerable to environmental changes than other baboon species (Mau *et al*., 2009). While *T. gelada* is unable to consume dicots, they have been observed to eat insects occasionally (Fashing *et al*., 2010). During a recent locust outbreak in the gelada territory in Guassa Protected Area, many animals including *T. gelada*, ravens and Ethiopian wolf were seen predating on locusts (Fashing *et al*., 2010). When the outbreak first began, geladas appeared to be afraid of locusts, uttering screams and other loud vocalization, generally associated with fear. However, once the locust density decreased, they began to catch them from the air as well as pounce on those already on the ground.

While this was a rare occurrence for *T. gelada*, it shows gelada baboons would occasionally navigate away from their graminivorous lifestyle and practice insectivory. Gelada has adapted its diet restrictions over its long existence, but it has also had to adapt itself to living at high altitudes in the Ethiopian highlands (Dunbar and Dunbar, 1975; Dunbar, 1998; Beehner and McCann, 2008). However, geladas' habitat has been seriously affected by natural processes and anthropogenic activities. Land-use/land-cover changes are major driving forces of habitat modification, and have important implications for the distribution of wildlife in general and geladas in particular (Mundia and Murayama, 2009). Conversions of grassland and associated habitat types into other land-use types have affected foraging ecology of wild herbivores and geladas. This gradually leads to a decline for a wide range of wildlife species (Houghton, 1994; Pimm and Lawton, 1998). In Guassa Community Protected Area (GCPA), only little emphasis was given for parts of an ecosystem without considering the driving forces, and thus do not provide sufficient insights into the spatial and temporal dynamics of these changes. Therefore, a comprehensive analysis of land-use/land-cover changes in connection with foraging ecology of major wildlife is needed to help in formulating a strategy for conservation of the gelada ecosystem.

1.2. Literature Review

Theropithecus is a successful Plio-Pleistocene cercopithecine genus (Delson, 1993; Jablonski, 1993; Pickford, 1993; Dunbar, 1998), which is currently represented only by a single relatively small-sized species, *T. gelada* of Ethiopia (Dunbar, 1993b; Mau *et al*., 2009). 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 *et al*., 1993; Jablonski, 1993; Jolly *et al*., 1997), and its range was extended during the earlier Pleistocene, eastward to the Near East in Israel (Belmaker *et al*., 2002), and as far as India (Pickford, 1993). This genus is also known for having expanded its range into southern Europe, occurring in the very late Early Pleistocene at Cueva Victoria, in southern Spain (~1.0 mya; Gibert *et al*., 1995). New *Theropithecus* fossils have been identified within the collection of the so called ‘‘Pirro Nord’’ faunal assemblage, from the early Pleistocene of southern Italy (Abbazzi *et al*., 1996). *Theropithecus* from Pirro Nord thus represents the oldest known of the genus in Europe (Rook *et al*., 2004).

Fossil remains of *Theropithecus* have been also found in a variety of Pleistocene sites throughout northern, eastern and southern Africa (Jolly, 1972; Szalay and Delson, 1979), and several taxonomic schemes have been proposed to account for their morphological diversity (Dechow and Singer, 1984). 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 male P_3 length and canine height, flattening of the upper symphyseal shelf, development of equal depth of the posterior and anterior mandibular corpus contrasting with the proposed primitive condition where the mandibular corpus deepens anteriorly, greater specialization of cheek teeth and reduction of incisor size (Jolly, 1972; Szalay and Delson, 1979).

As a result of these changes, most extinct species of the genus in different regions of Africa are recognized as distinct (Zeresenay Alemseged and Geraads, 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 species supposed to be as a form derived from the *T. darti-T. oswaldi* lineage, and was apparently restricted to northern Africa. This species, which is now much better defined, is clearly distinct from other species of the genus, which is thus more diverse than previously thought (Raynal *et al.*, 1990).

In the grassland habitats of sub-Saharan Africa, *T. brumpti* contributed a major component of the mammalian fauna as derived from the Shungura formation from sediments between 2.0 and 2.9 mya. It is also found in deposits of similar age in the Koobi Fora and Nachukui formations showing a far larger distribution and often in impressive numbers near Turkana-Omo basin in Kenya (Feibel *et al.*, 1989). The association of *T. brumpti* fossils with presumed forest-dwelling bovid fossils and the idiosyncratic pattern of dental wear led some to conclude that the species was a semiarboreal frugivore (Benefit and McCrossin, 1990).

In addition, specimens of *T. oswaldi* are regularly found in most fossil bearing sites of early Pleistocene age from Ethiopia in the north to the Republic of South Africa in the south (Eck and Jablonksi, 1987). However, the origin of the genus and the early divergence of its lineages are poorly documented (Elton, 2002). Sites containing sediments older than 3 mya are not common, and those known often produce small samples of monkeys or highly fragmented specimens (Jablonski *et al*., 2002). Specimens of *Theropithecus* older than 3.0 mya have been discovered from the Hadar, Usno and Shungura formation of Ethiopia, and the Koobi Fora, Nachukui, Lothagam and Chemeron formations of Kenya (Gilbert *et al*., 2011). The more complete of these from all but one site appears to show the evolution of *T. brumpti* and its ancestors, leaving only the Hadar formation as a source of information about the ancestor and evolution of *T. oswaldi,* the most common and widespread Pleistocene species of the genus (Cronin and Meikle, 1979), which has an extensive fossil record prior to 3.5 until approximately 0.25 mya, when significant changes occurred in global climate change and regional African habitats. It is also recognized as a terrestrial grazer based on its limb skeleton and carbon isotope ratios from enamel and dental microwear. This species comprised chrono-subspecies: *T. oswaldi darti, T. o. oswaldi* and *T. o. leakeyi* in Africa, and *T. o. delsoni* in India (Delson, 1993).

Furthermore, 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). Fossil records in Zambia showed that the area served as a corridor linking the eastern holotype to that of South Africa (Rook *et al*., 2004).

Geladas are sexually dimorphic; males are larger (20 kg) with long brown capes and having a baboon-like canine tooth. Females are about half the body weight of males. Both sexes have a chest patch of coloured skin, and females have ventral caruncles (beads), which signal their reproductive status (Bramblett, 1970). The molar teeth of geladas are very unusual and distinctive and are characterized by complex enamel folding with an hyposodont appearance (Szalay and Delson, 1979). They are primarily terrestrial, foraging throughout the day. They retreat to the cliffs at night (Fleagle, 1999).

Theropithecus gelada is unique in its dietary habits among primates. They have a diet that is almost more than 80% grasses (Iwamoto, 1993) and they harvest grasses primarily using the thumb and first finger while sitting and then ‘shuffling’ along the ground (Wrangham, 1980). The postcranial 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). Additionally, *Theropithecus* has postcranial traits associated with a high degree of terrestriality including an ulnar olecranon process that is highly retroflexed extending dorsally, and relatively short and robust manual and pedal phalanges (Jolly, 1972; Szalay and Delson, 1979; Frost and Delson, 2002; Guthrie and Frost, 2010).

In addition, geladas also have physiological adaptations for the high mountain grasslands, where temperature drops frequently, and hence, elevated glucocorticoid levels of geladas in order to 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, but not during times of heavy rainfall, which have also been known to cause stress among gelada populations (Hunter, 2001). They have at least two adaptations for living in cold weather conditions such as increased hair density and greater food intake (Dunbar, 1980). However, based on their higher glococorticoid levels, these changes are not enough to completely rectify their cold stress (Iwamoto and Dunbar, 1983). They respond well to cool, 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 were 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, thought to be related to both environmental and social factors (Beehner and Whitten, 2004).

Multilevel societies have superficially the most complex social system as seen among geladas, or primates in general (Grueter *et al*., 2012). Multilevel societies are distinct among primate social system, the key feature of which is single male – multifemale, core units within larger social bands, and it is extremely cohesive (Bramblett, 1970). They are not equivalent to fission–fusion societies, with the latter referring to routine variability in associations, either on an individual or subunit level (Snyder-Mackler *et al*., 2010). Multilevel societies are prevalent in three primate clades: papionins, Asian colobines and hominins (Grueter *et al*., 2012).

One of the most fluid multilevel societies is found among gelada baboons (Dunbar and Dunbar, 1975; Kawai *et al*., 1983; Dunbar, 1993b). However, confusion continues to surround the delineation of gelada social levels, when compared with those of other primates with multilevel systems, for e.g., hamadryas baboons (*P. hamadryas*). The primary level of organization in gelada society is the one-male unit, comprising a reproductive leader male, 1–12 adult females, their dependent offspring, and possibly one or more follower males (Dunbar and Dunbar, 1975). Although labeled as one-male unit, it is not solely one-male unit as they often include follower males (Dunbar, 1984), who occasionally father offspring (Snyder-Mackler *et al.*, 2010).

Another primary social group, the all-male group (AMG) contains 2–15 young adult and subadult males dispersed from their natal unit (Kawai *et al.*, 1983; Dunbar 1993a). Females within one-male units have close female bonds (Dunbar, 1978), and are also thought to be philopatric with respect to the unit (Dunbar, 1984). Although females are philopatric; their dominance ranks are reportedly not an inherited system based on matrilines, but rather a product of female age, aggression and coalition partnerships (Dunbar and Sharman, 1983, 1986, 1993a). Based on such a system, it was predicted that the strongest, prime aged females with strong coalitionary support would temporarily occupy top ranks (Le Roux *et al.*, 2011).

A secondary level of organization above the unit is the team, comprising two or more closely associated units (Dunbar and Dunbar, 1975; Grueter and Zinner, 2004) that are thoughts to have resulted from a recent unit fission (Kawai *et al.*, 1983). The team is not an obligatory level of gelada society, and most units are not involved in a team (Kawai *et al.*, 1983; Dunbar, 1984). At a third level of organization, the band is made up of multiple units and all male groups (Dunbar and Dunbar, 1975; Grueter and Zinner, 2004). As the members of a gelada band generally sleep and forage together (Dunbar and Dunbar, 1975; Kawai *et al.*, 1983), the band is thought to be equivalent to the baboon group, and the hamadryas band has been described as an ecological unit (Kawai *et al.*, 1983).

Finally, at the highest level of organization, the community (first introduced by 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 remain to be determined. This highest level in gelada society is sometimes confused with the term ‘‘herd’’. Herds, however, are not a stable social level, but rather temporary aggregations of gelada units with no particular allegiance or status (Dunbar, 1993a).

Therefore, a community is a stable social level (as are units, teams, and bands), 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 (team, band, herd and community) is yet to be quantified. In this case, aggregations of geladas followed by fission and fuse 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).

There are many factors such as predation risk (van Schaik, 1983), resource availability and competition (Wrangham 1980), foraging patch size, heterogeneity (Johnson *et al.*, 2002), disease/parasite risk (Freeland, 1976; Altizer *et al*., 2003), body mass (Clutton-Brock and Harvey, 1977), diet (Williamson and Dunbar, 1999), phylogenetic inertia (Di Fiore and Rendall, 1994), life history (Wittenberger, 1980), mating opportunities (Lindenfors *et al*., 2004) and travel costs that influence group size (Chapman and Chapman, 2000; Sernland *et al*., 2003). Group cohesion and stable relationships are maintained by calls and grooming (Sueur *et al*., 2011). In most matrilineally organized gelada and non-human primates, grooming is concentrated among maternally-related individuals, and especially within mother-offspring dyads (Schino, 2001), which form the stable core of the social group (Melnick and Pearl, 1987). However, grooming also occurs among non-related individuals. As it is costly to the actor and beneficial to the recipient, grooming is often considered as an act of altruism

(Kurland, 1977; Seyfarth and Cheney, 1984). However, such altruistic acts can be maintained only if the receiver of the benefit reciprocates to some extent (Trivers, 1971).

The function of grooming in geladas underwent an evolutionary change, altering its function from simple hygiene to, among other things, social bonding (Kummer, 1975). In addition to removing ectoparasites and lowering the risk of disease (Samish and Rehace,1999; Nunn andAltizer, 2006), grooming can also serve to strengthen social bonds (Waldman,1988), reduce tension (Judge *et al*., 2006), calm (Colmenares *et al*., 2002), soothe (Henzi and Barrett, 1999), appease (Lehmann *et al*., 1995), reassure (Swedell, 1997) and reconcile after an aggressive interaction (Kummer, 1995) or indicate sexual receptivity (Barton, 1985).

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 and can be observed in social groups and in solitary individuals (Dunbar, 1991). Adaptation for autogrooming such as dental combs and toilet claws in geladas as well as in other old world monkeys help to groom areas that are hard to reach (Barrett and Henzi, 2001). 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).

During Pleistocene times, the genus *Theropithecus* had apparently established itself as the most common large animal in the lowland woodland and grassland habitats of sub-Saharan Africa (Delson, 1993; Jablonski, 1993). The less well known *T. brumpti* associated with fossil fauna, pollen and paleosols indicate that it was restricted to more woodland and forest environments (Hill, 1970; Eck, 1973). In addition, *T. oswaldi* appears to be an excellent species to be used as an indicator species of expanding grasslands in the African Pleistocene (Kawai, 1979; Frost and Delson, 2002), whereas, the extant gelada is the last remaining member of a genus (Dunbar, 1998) currently restricted to an altitudinal range between 1,700 and 4,200 m, which also parallels the altitudinal belt of montane grasslands (Jolly, 1997; Dunbar, 1998).

Home range of geladas has been negatively correlated with the habitat quality (Iwamoto and Dunbar, 1983). Home range size also tends to increase with increasing band size (Dunbar and Bose, 1991). A similar relationship between band biomass and range size is observed to hold at the interspecific level (Fiore, 2003).

Day range length tends to scale with both band size and habitat quality. In many species, larger groups travel farther each day. Bands of geladas living in poorer habitats forage longer. In general, these relationships hold more strongly for frugivores and omnivores than for folivores (Chapman and Fedigan, 1984). These 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 (Grüter and Zinner, 2004).

In *T. gelada*, the daily foraging distance 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). As food availability is much greater in the highlands than in the lowland, geladas move for only a short distance each day, from 1.5 to 2.5 km, depending on the band size (Dunbar, 1986). On the other hand, hamadryas baboons have the largest day ranges recorded for any primate species (mean of 13.2 km and maximum of 19 km) (Kummer, 1975). In other sites in Ethiopia and in Saudi Arabia, the daily travel path length varied between 1–14 km. The long and variable travel path lengths of Hamadryas baboons do not necessarily reflect low food availability, but can be a result of scarcity of water sources and safe sleeping sites (Dunbar, 1992a).

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).

General considerations lead us to expect a linear relationship between feeding and moving time on the grounds that each unit would require a specific area to be searched (Dunbar, 1986). Mean day time journey is closely related with the band size, suggesting that each animal has to cover a fairly specific area each day to obtain its daily nutritional requirements. 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). Day time journey length increases as a linear function of band size as increase in food requirements with altitude offset by a corresponding increase in food density (Savini *et al.*, 2008).

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 encroachments by conspecifics (Bates, 1970). Territoriality in primates is linked to the defense of a geographical boundary. In geladas, spacing is maintained when any of these 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).

Long-distance vocalization appears to offer further clues to spacing among non-primates (Richman, 1978; Greene and Meagher, 1998). However, vocalizations indicate that they are more structural than other sounds in the repertoire in the sense that temporal organization is often elaborated (Bates, 1970; Stephan and Zuberbuhler, 2008). In geladas, long distance vocalization may serve as territorial; especially to identify the position of the troop with reference to a geographical location rather than merely distance from the neighbouring troop (Lowen and Dunbar, 1994). Moreover, vocalizations in geladas are made in many different contexts. Some are in response to external stimuli such as predators and food items (Richman, 1976). These are allospecific vocalizations, and include alarm calls. Alarm calls can communicate the degree of risk involved (Ohsawa, 1979) such as the predator types (i.e. aerial or terrestrial) (Ackers and Slobodchikoff, 1999), or combined information on risk and predator type (Greene and Meagher, 1998; Stephan and Zuberbuhler, 2008). Geladas in particular are known to produce alarm vocalizations specific to predator types (Aich *et al*., 1990). For example, active anti-predator behaviour against domestic dogs and leopards were recorded among geladas (Iwamoto *et al*., 1996).

They also show responses to jackal and other predators by alarm calls. However, in most cases, the northern geladas are not always timid against predators. In some areas of Ethiopia, serious anti-predator behaviour of gelada is not observed (Mori and Gurja Belay, 1990). Although in the population of northern geladas, a few active anti-predator behaviour were observed, the occurrence was quite rare. In anti-predator behaviour in response to domestic dogs or other predators, it is the male leader that usually threatens the predator, but females and juveniles run to the cliffs (Ohsawa, 1979).

Males also do not fight with dogs or jackal, but only snarl and threaten until the predator moves away (Dunbar, 1992a). However, population of the southern geladas shows a high rate of aggressive defense against predators, but to the contrary, the northern population usually prefers to flee (Dunbar and Dunbar, 1974), and geladas rarely show active defense against predators (Iwamoto *et al.*, 1996). Sleeping in the cliffs is also considered as a passive anti-predator behaviour, because such sites are too steep for predators to move through. Several reproductive units (one male unit) form a band with relatively loose relationship, and few of the bands aggregate to form a large temporary multiple bands of up to few hundreds of geladas (Kawai *et al*., 1983). Larger aggregation of geladas is also regarded as a passive anti-predator behavior in order to detect predators as early as possible (Iwamoto, 1993).

Apart from this, differences in anti-predator behaviour of the two gelada populations were observed. This might be related to genetic differences and geographical distribution (Mori and Gurja Belay, 1990). The second possibility is that the southern and northern populations of geladas separated about 3.5–4.0 million years ago when the Great Rift Valley was formed, and thereafter, they independently evolved specific anti-predator behaviours (Richman, 1976; Ohsawa, 1979; Iwamoto *et al*., 1996). In general, active anti-predator behaviour is found only in the southern population, and it is possible that both ecological and genetic factors have contributed for the development of this behaviour (Mori *et al.*, 1997).

Among geladas, mating pattern and reproduction are based on OMU system. The male has the potential and ability to monopolize several females within the OMU (Dunbar, 1980), and they are polygynous.

In geladas, sexual selection has produced dimorphic secondary sexual characteristics such as colour, ornamentation, vocalizations, enlarged canines, sexual dimorphism and related behavioural displays (Andersson and Bielert, 1994). In many cases, these characteristics communicate information about the signaler to a receiver, who are either a member of the same sex (intrasexual competition) or a member of the opposite sex (mate choice). Sexual selection plays a great role in the survival of male and female geladas. Female – female competition occurs for access to the male for advantages such as protection from predators and for resources (Palombit *et al.*, 2001).

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 winners and losers, individuals should display before fighting to resolve conflicts at the lowest possible cost (Smith, 1982). Among gelada females, chest patch colour changes with reproductive condition, growing brighter close to ovulation and as pregnancy progresses (Dunbar, 1977; McCann, 1995). However, 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 anecdotally 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 his quality. 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). 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). However, this prominent colour is affected by age and social status. In addition to age and status, two other factors might affect chest colour. First, if chest colour is a condition-dependent signal, then signal quality might vary seasonally with food availability (Nowicki *et al*., 2002) or weather changes. Second, the chest colour of males intensifies with its activity levels (Dunbar, 1984).

Female geladas also undergo highly visible morphological changes during their periovulatory period (Anderson and Bielert, 1994; Bergman *et al*., 2009). In some displays, adolescent females are more noticeable than those of adults. Adolescent females show an increase in body size signaled by menarche, and develop sexual swelling (Dunbar and Sharman, 1983). Females characteristically have an oestrus cycle of 15‒20 days (Moos-Heilen and Sossinka, 1990). Ovulation occurs during the final week of swelling in the monthly menstrual cycle when the skin in the anogenital region becomes swollen with bright pink or red and releases a pheromone with aliphatic acid, which enhances her attractiveness to the male (Altmann and Alberts, 2003).

Although, geladas advertise their reproductive status, the occurrence of adolescent exaggeration advertisement has rarely been noticed (Anderson and Bielert, 1994). Like other non-human primates, in female geladas, super-normal adolescent characters are observed. For instance, paracollosal skin, which is lighter pink in older adults, but, in adolescent gelada females become swollen and distended during estrus (Bergman *et al*., 2009). Moreover, gelada females have distinctive, pink hourglass shaped skin patches on the chest that change in appearance throughout their oestrus cycle. This allows males to know if the female is ready to mate (Savini *et al*., 2008). In addition, the colour, and blister-like "vesicles" appear on the chest and groin area signalling their reproductive status. All females of reproductive age tend to have vesicles appearing, unless they are pregnant (Dunbar and Dunbar, 1974).

In geladas, copulation is short in duration, usually lasting only around ten seconds, and are normally accompanied by vocalization (Lehmann *et al*., 1995). Post-copulation grooming occurs often. Most copulations occur during the morning hours, before the midday (Dunbar and Sharman, 1983). When in estrus, a female usually copulates 2‒5 times per day (Altmann and Alberts, 2003). Gestation is around six months in length. Although single infant is most common, twins are also seen occasionally (Bergman *et al*., 2009).

Female geladas terminate 80% of the pregnancy, once a dominant male is ousted and replaced by a bachelor, or unfamiliar male ("Bruce effect"). The bachelor male gains reproductive access to all females of the unit, and often kills any dependent offspring sired by his predecessor (Beehner and Bergman, 2008).

As a result of the single-male system in geladas, sperm competition is reduced (Dunbar and Sharman, 1983). Therefore, one normally finds smaller testes (Grüter and Zinner, 2004). Due to pre-copulatory competition and monopolization of females, the impact of sperm competition should be low compared to other related taxa that live in multi-male-multi-female troops with a more promiscuous mating system. However, competition among females can adversely affect their fertility of harem-forming species (Dunbar and Sharman, 1983). Hence, *T. gelada* males are characterized by small testes in relation to their body mass, as expected for a species living in a single-male mating system (Dunbar, 1978).

Among geladas, peripheral males compete for control over the unit and may acquire harem either by directly challenging the hegemony of the harem holder and taking over the entire unit or by entering the unit as a subordinate follower in order to buildup an incipient unit with one or two of the peripheral females (Mori *et al*., 2003). However, some reproductive units consist of more than one adult male, although the extra males do not play significant role in the reproductive processes (Ohsawa and Dunbar, 1984).

Males pursue different options for acquiring breeding females. They can join a unit as a submissive follower in order to build up a nuclear unit within an OMU with one or two of the peripheral females (Kawai *et al*., 1983). Such a nuclear unit could split off later and pursue independent existence. In the early stage, such a new OMU is characterized by strong control of females by the male (Bergman and Kitchen, 2008). A second male strategy for becoming the leader of an OMU is by a male member of the AMU attacking the OMU leader who is presumed to be weak. If he wins, he will take over the OMU and will become its new leader. In such a situation, the former leader will usually stay within the OMU as a second male

(Dunbar, 1978; Grüter and Zinner, 2004). Subadult, and adult males, who are not members of reproductive units form all-male groups that constitute discrete, long-lasting social units in their own right (Moss and Immelmann, 1987).

There are more than 22,000 people living in and around GCPA. The economic activity of the people in the area is predominantly mixed farming, which involves crop production and livestock rearing (Phillipson, 2010). Distribution of rainfall in the area is characterized by a bimodal pattern and as a result, people around this area use two cropping seasons. Out of the two cropping seasons, the short rainy season (Belg) is more important for the local people in the area as crop production in this season accounts for about 60% of the annual production (WVE, 2000). Barley, beans, lentils and wheat are predominantly cultivated in this area. Livestock husbandry is also a key element of the economy of the local people (Zelalem Tefera and Leader-Williams, 2006).

The Guassa area is known in sheep and cattle rearing, which are highly valued for their meat and wool production. The community can generate income from off-farm activities such as petty trading, selling local beer (‘Tella’), liquor (‘Arekie’) and local green tea. Some of them depend on food for labour program (safety-net). Wool processing is the most common off-farm activity of the Guassa community (Zelealem Tefera, 2001). The people in Guassa area depend upon the natural resources such as fodder, fuel and building materials. They harvest and subsequently sell *Festuca* grass in the nearby market for thatching, which represents an essential source of income of the local community, particularly during the drought season (Zelealem Tefera, 2001).

Natural resource management as a whole is being managed through Atsme Irist and Gult systems (Dessalegn Rahmato, 1984; Admassie Yeraswork, 2000). The natural resource management system of the Guassa area dates back to the 17th Century. This makes it one of the oldest conservation areas in the sub-Saharan Africa (Zelealem Tefera, 2001). This area had a well-defined and ancient indigenous common property resource management system (‘Qero system’). This indigenous resource management system works as fair distribution and protection of resources through enacting and enforcing byelaws (Hoben, 1973; Zelealem Tefera and Leader-Williams, 2006).

The ancient land tenure system adopted an indigenous institution in Ethiopia to manage the common property resources, which was unique to the Guassa area (Zelealem Tefera and Leader-Williams, 2005). In this system, a headman (‘Abba Qera’ or ‘Afero’) is unanimously elected, who will be responsible for protecting and regulating use of the Guassa area. The ‘Asbo’ and ‘Gera’ areas each had one ‘Abba Qera’. ‘Abba Qeras’ were mostly elected unanimously in the presence of all users of the common property resources (PRLME, 1975).

The Guassa area is now managed by nine Peasant Associations. These local institutions are guided by laws and rules, established across Ethiopia in 1975 for rural administration (PMGE, 1975). Guassa committee was formed from the user community to replace the traditional conservation management system and to oversee protection of the Guassa area (Tesfaye Tafesse, 1995). The main function of the Guassa committee was to control illegal uses of the area during the banning period. The committee usually uses the local militia from the adjacent Peasant Associations to conduct patrols. Offenders are charged at the local court to which they should pay the designated punishment, locally called ‘afelama’. If these offenders repeat crime,they will be taken to the Woreda Police, to be charged at the District Court. The activity of the Guassa Committee is supervised by the Woreda Administration Council and an evaluation of their activity is undertaken whenever the Woreda Administration Council thinks it is appropriate (Zelealem Tefera and Gebreyseus Tenagashaw, 1998).

The community still retains ownership, utilise the area and recognises its value in providing vital resources (Zelealem Tefera *et al*., 2012). However, this indigenous resource management system was not designed to conserve wildlife, but it allowed the co-existence of wildlife with the local community. The system has proved its importance as a poverty reduction system by providing the community with natural resources that can be sold and exchanged in the market during times of drought. Most of the livestock of the area survived droughts by migrating from the surrounding areas to the protected area and feeding on the lash growth of the highland grass. The Guassa area represents an interesting model of community led natural resource management regime that has operated for hundreds of years without fostering the tragedy of the commons (Hardin, 1968).

However, human population growth in Ethiopia has lead to rapid encroachments into wildlife habitats, restriction of larger animals into marginal habitat patches, and direct competition for resources with local communities. In gelada inhabiting areas, the current human population growth, land-use changes, degradation of natural habitats, increasing demand for natural resources and the growing demand for access to land have forced geladas to move into community areas (WPC, 2003). Additionally, due to their specialized diet, geladas are severely affected by soil erosion, drought, and possibly even by global warming (Dunbar, 1998). Hence, to conserve geladas more effectively in the protected areas, serious efforts are to be made using scientific knowledge, combined with indigenous knowledge, and participatory approaches with the local communities. In line with this, the change in land-use/land-cover has a huge influence on grassland habitat type, which directly affects gelada foraging ecology. As a result, change of grassland community to other habitat types and other factors of critical importance to the grassland are to be given importance in the assessment of grassland dynamics, and conservation of the gelada population in this area.

In this context, the present research project was planned to study the various aspects of population and feeding ecology of the gelada population in GCPA, habitat viability and the attitude of local people towards gelada conservation.

1.3. OBJECTIVES OF THE STUDY

1.3.1. General objective

The general objective of the present study was:

- to carry out an investigation on population structure, feeding ecology and habitat viability analysis of the gelada baboon (*T. gelada*) in the central highland (Guassa area) of Ethiopia.

1.3.2. Specific objectives

The specific objectives of the present study were:

- to determine population status of the geladas in the GCPA
- to determine the population structure of geladas in the study area
- to gather information on feeding habits of geladas
- to study the habitat viability of gelada baboons in the area
- to determine the attitude of local community towards gelada conservation
- to recommend conservation strategies/mechanisms for geladas in the study area

2. THE STUDY AREA AND METHODS

2.1. The study area

The present investigation was carried out in the Amhara Regional State of Ethiopia, in the North Showa Zonal Administration in Gera Keya Woreda (District). It is located at a distance of 265 km from Addis Ababa, the capital city of the nation, in the northeast direction, and 135 km from the Zonal Capital (Debre Birhan) in the north direction. Geographically, the study area is located in the central highlands of Ethiopia, which lies between 1134963–1156359 UTM N latitude and 583165–590076 UTM E longitude. The Guassa area of Menz, with a total area of 111 km^2 forms a part of the western edge of the Great Rift Valley, with an altitude ranging from 3, 200 to 3,700 m asl (Fig.1).

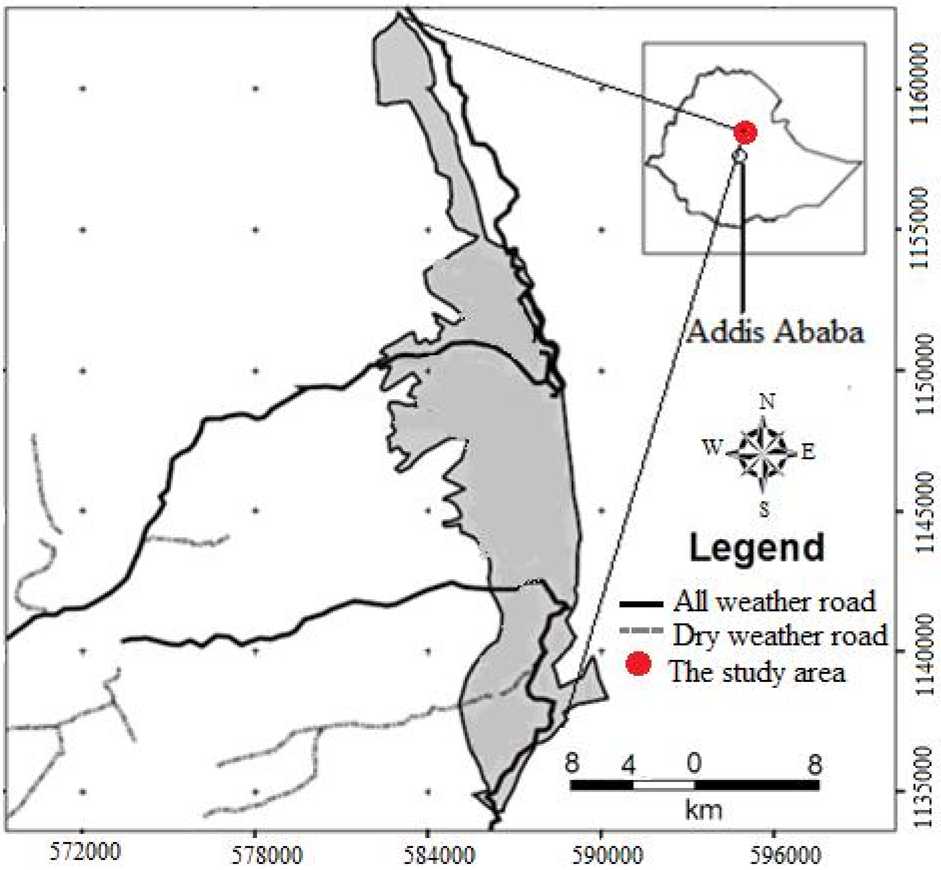


Figure 1. Map of the study area

2.2. Geology and Topography

Geologically, the study area lies on the tertiary volcanic deposits, which are extremely thick, with the soils principally of lithosols (McGinley, 2007). These highlands are of volcanic formation of 75 million years ago, and are glaciated. The area is characterized by rough topography with mountains, deeply incised valleys, escarpments and plateau, mostly covered by volcanic rocks mainly basalts of Tertiary age (Brooke and Robinson, 1959; Abate Ayalew *et al*., 2006).

In general, the area is rugged and its plateau is cross-cut by various gorges and river valleys that flow west and eastwards. It forms one of the most important watersheds of Abay (Blue Nile) and Awash basins (Mohor, 1963). Over 26 small and medium-sized rivers streams start from Guassa area flowing to the west and east of the mountain block. The swamps of the area provide water holding capacity and also limit runoff in the rainy seasons, thus providing flow all year round (Zelealem Tefera and Leader-Williams, 2005). The eastern part consists of abrupt cliffs that form the Great Rift Valley, and there are sharp elevation changes within a distance of 50 km stretch to the Awash plains (Fig. 2), which is 500 m asl forming the floor of the Great Rift Valley. Downstream users in the low-lying areas of Yifat, Merhabeti and the Afar Region are dependant on this water for livestock and farming.

Figure 2. Eastern watershed of Guassa Community Protected Area

2.3. Climate

The climate of the central highlands is characterized by a tropical type. The climate of Guassa area varies with altitudinal gradient and seasonal changes. At higher altitudes, wet season is characterized by a combination of high rainfall, frequent hail storms and occasional snow. During the dry season, frosts are common. The Equatorial Westerlies and the Indian Ocean air streams are the sources of rain in Guassa during different times of the year. Eventhough showers of light rain can occur in any month of the year, the distribution of rainfall in Guassa area is characterized by a bimodal pattern. A short rainy season occurs during February–April and the main wet season mostly occurs between June and September. The annual rainfall at Guassa ranges from 1,200 to 1,600 mm (Zelealem Tefera, 2001).

There are sharp temperature fluctuations between night and day time due to the altitudinal differences and the size of the mountain block. Temperatures are characterised by mild days and cold nights. In the driest months (December–February), daytime temperatures can rise up to 25^o C, while night time temperatures can fall down to -7^o C (a diurnal fluctuation of 32^o C).

The monthly mean minimum and maximum temperatures of GCPA from Debre Birhan Station are given in Figure 3.

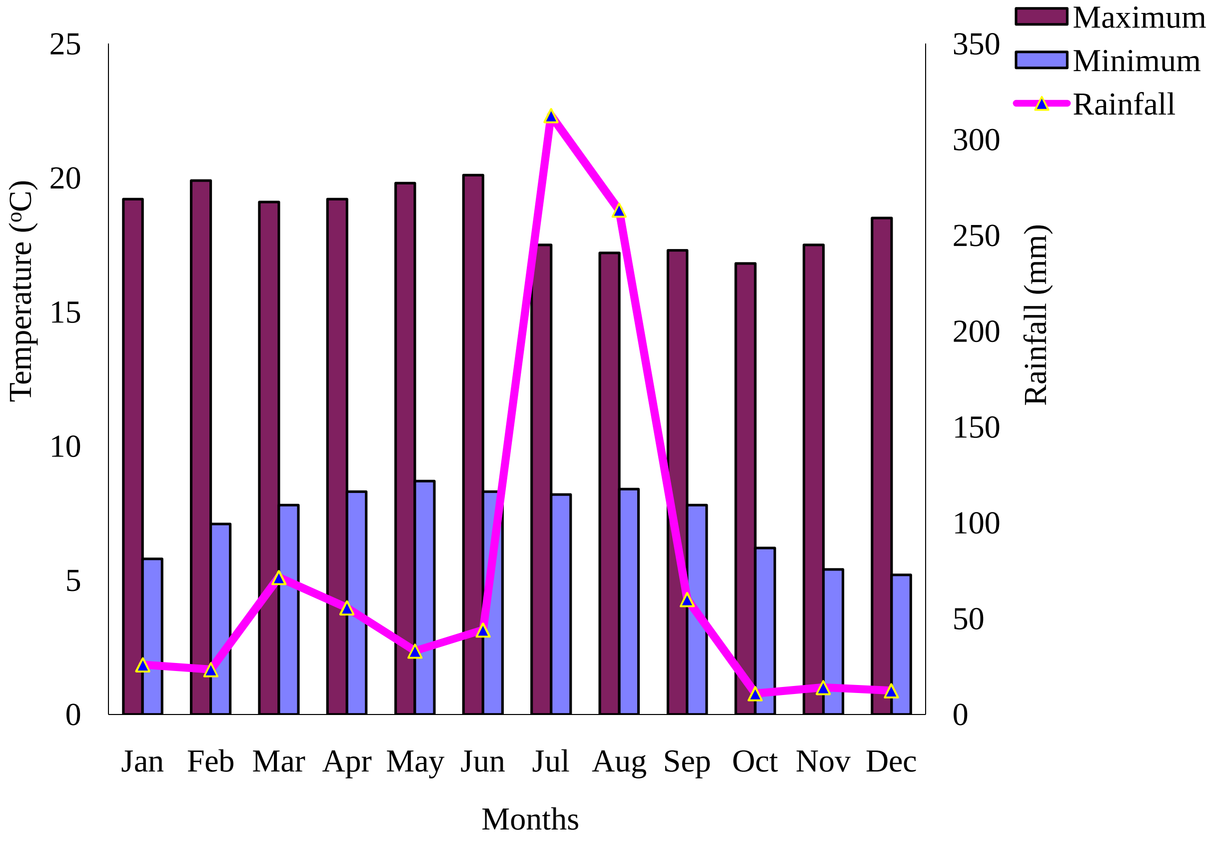
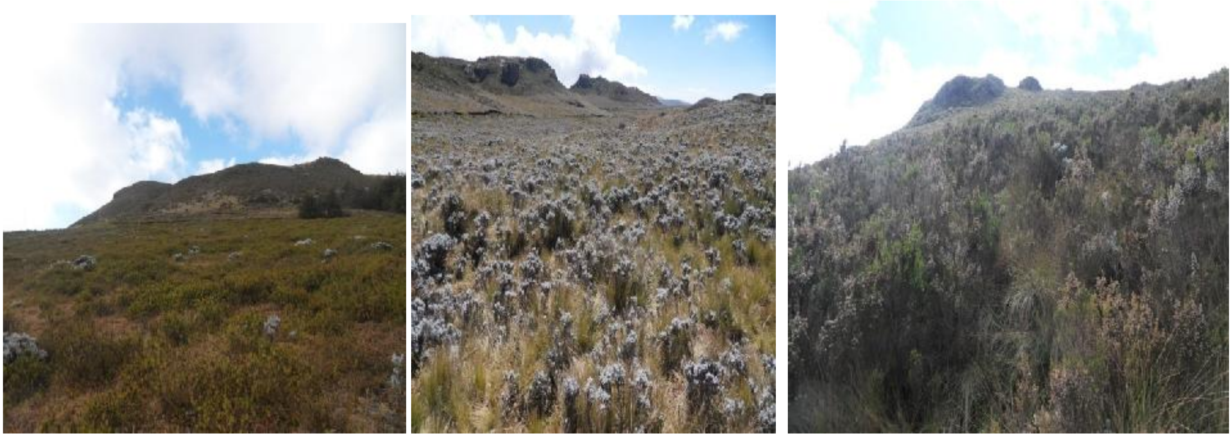


Figure 3. Monthly mean minimum and maximum temperatures and rainfall in Guassa Community Protected Area (2000–2014). (Source: National Meteorological Agency of Ethiopia).

2.4. Floristic composition and habitat classification

Vegetation in the Guassa area is characterised by high altitude Afroalpine vegetation, within which different vegetation communities exist. These are annual, biannual and perennial plants (FZS, 2007). The vegetation composition in the study area includes *Euryops alchemilla, Carex monistachia, Carex fischeri, Hydrocotyle mannie, Kniphofia foliosa, Euryops pinifolius, Lobelia rhynchopetalum, Cupressus lusitanica, Festuca abyssinica* and *Festuca macrophyla*. The afroalpine area is also known to have biannual plant species like *Haplocarpha schimperi, Rubus apetalus, Malva verticillata, Adenostemma caffrum, Thymus schimperi, Alchemilla abyssinica, Agrocharis melonata, Satureja pseudosimensis* and *Cotula cryptocephala*. Due to poor taproot system and low viscosity of water, plant species like *Galium asparinoides, Ranunculus multifidus*, *Eremurus robustus*, *Sonchus oleraceus L.*, and *Hypericum peplidifolium* are also growing as annual plants in the Guassa afroalpine area.

The compositions of different habitat types in the study area include *Euryops*J*Alchemilla* shrubland (22 %), *Festuca* grassland (20 %), *Euryops*J*Festuca* grassland or Mima mound (16 %) and *Erica* moorland (10 %). The remaining area is shared with *Helichrysum*J*Festuca* grassland (24 %) and other habitat types (8 %) (Fig. 4).



(a) (b) (c)

Figure 4. Habitat types in Guassa Community Protected Area (a; *Euryops Alchemilla*, b; *Helichrysum-Festuca*, c; *Erica* moorland (Photo: Eshetu Moges, 2013)

Additionally, the area is also characterized by swamp grassland intermixed natural and *C. lusitanica* plantation forest. *Festuca* grassland occurs where there is good drainage and deep soil. It grows on steep to moderately steep slopes up to an altitude of 3,500 m asl. *Euryops alchemilla* and shrubland occur on the flat and gentle slopes and in well drained areas, and is restricted to areas above 3, 200 m asl. *Helichrysum*J*Festuca* grassland is found on the high ground and hill tops, where there is poor soil structure. *Erica* moorland is found on higher ground areas with shallow and well-drained soil. Currently, *Cupressus lusitanica* forest covers the most rugged and previously degraded sites of the study area (Zelealem Tefera *et al*., 2012) (Fig.5).

Figure 5. *Cupressus lustanica* forest (plantation) in Gussa Community Protcted Area (Photo: Eshetu Moges, 2014).

Among the afroalpine vegetations, the giant lobelia (*L. rynchopetalum*) usually found above the ericaceous belt (3, 000 to 3500 m). This is occupied in the afro-alpine belt that starts above the more or less continuous ericaceous vegetation, and extends to the highest peak upto 3,700 m (Fig. 6).

Figure 6. Giant lobelia with *Euryops*J*Alchemilla* vegetation type in Gussa Community Protected Area (Photo: Eshetu Moges, 2014).

2.5. Fauna

Guassa is home of many of the species commonly associated with Afro-alpine ecosystem. These include 22 mammal species, 27% of which are endemic to Ethiopia. The area’s flagship mammal species is the most endangered canid in the world, the Ethiopian wolf (*Canis simensis*). The Guassa area harbours one of the packs of the Ethiopian wolf with a stable population of around 35 individuals (Marino, 1993). Other important species in the area include the gelada baboon that is the only surviving member of the once widespread genus *Theropithecus*. Although they have been assessed as a species of ‘Least Concern’ by IUCN, the population has been decreasing from time to time. However, the Guassa population of the species has doubled in the past, and is now the second largest population in Ethiopia, next to that in the Simien Mountain National Park (Fig. 7).

Figure 7. Geladas in Gussa Community Protcted Area (Photo: Eshetu Moges, 2014).

The study area harbours over 114 species of birds. Among them, 14 species are endemic to Ethiopia, including the restricted-range Ankober seedeater (*Serinus ankoberensis*) and Spot-breasted plover (*Vanellus melanocephalus*) (Zelealem Tefera *et al*., 2004). It also serves as a wintering ground for 38 species of Palearctic and intra–African migrant birds (Zelealem Tefera, 2001). A striking feature of the birdlife in the Guassa area is the abundance of birds of prey that feast along with the Ethiopian wolves on several species of rodents in the area, which form most of the diet of the endangered wolf (Yalden and Largen, 1992).

2.6. Significance and Exceptional Resource Values of Guassa Afroalpine Area

Guassa area of Menz is one of the highest ranges in the central highlands of Ethiopia. The traditional indigenous management of the natural resources of the area has helped the survival of various species of endemic fauna and flora that are locally extinct in other similar parts of the country. High levels of endemism is found in this area, and the region's biota demonstrates evolutionary links to both the Palaearctic and the Afrotropical realms. The vegetation, known as afroalpine, which consists of grasslands and moorlands with abundant herbs. Most plant species (many of which are endemic) show adaptations to the extreme climatic conditions of this high altitudinal area.

The escarpment of Guassa area is found on the edge of the Great Rift Valley that divides the Ethiopian highlands into two major topographic ranges. The escarpment on the eastern side of the Guassa area forms a continuous north-south wall, with sheer cliffs over 1 km long. This dramatic cliff formation has provided the area with spectacular scenic beauty and stunning views across the lowland areas of Yifat and the Great Rift Valley, up to the Awash Valley in the Afar Region. Apart from its wildlife, the spectacular scenry of Guassa attracts a number of tourists into the area (Fig. 8).

Figure 8. Tourists in Guassa Community Protected Area (Photo: Eshetu Moges, 2013 to 2014)

The ancient common property resource management system prevailing in the Guassa area is one of the oldest natural resource management systems in Africa (Zelealem Tefera and Leader-Williams, 2005). This unique management system in Ethiopia has allowed the survival of this afroalpine area with its endemic and rare floral and faunal assemblages. Other important cultural features of the area are the churches and homesteads of the Menz people, which are of particular interest even in the national context. In Yigem, the Arbhara Medhianialem monastery, 10 km south of Guassa, there is an old intact mummy. The monastery and various churches have old and extremely valuable artefacts, which are of interest to tourists (Fig. 9).

Figure 9. Arbhara Medhianialem and Ferkuta Saint Mary Monasteries in Guassa Community Protected Area (Photo: Eshetu Moges, 2014).

The Guassa area plays an important role in the livelihood and survival strategies of the local communities, particularly during the time of drought, by providing a refuge for the livestock (Zelealem Tefera, 2005). The *Festuca* grass provides thatching materials for houses, the shrubby vegetation provides firewood for keeping the households warm from the cold highland weather. These traditional practices of the common property resource management and sustainable use system has created a mosaic of different habitats arranged in intricate patterns at different spatial scales that are likely to have an effect on the associated small mammal communities (Zelealem Tefera and Leader-Williams, 2006).

The Guassa area, which is the second largest area of communal grazing locally provides prime grazing area for the Menz livestock population. Fuel wood is another key resource with the vegetation types of Cherenfi (*Euryops pinifolius*), Asta (*Erica arboria*), Gibera (*Lobelia rhynchopetalum*), Ameja (*Hypericum revolutum*) and Abelbila (*Kniphofia foliosa*), which are being used by local people, usually during the dry season. Cattle dung is also frequently used for fire.

Medicinal plants are also widely collected from the Guassa area to treat human and livestock diseases, with traditional knowledge passed over through generations. Wild berries such as *Rubes abyssinica* and *R. stedneri* are also collected, and thyme (*Thymus schimperi*) is used to make drinks and to flavour food. Stinging nettles (*Urtica slimensis*) is used to prepare a stew during the cultural fasting season in Ethiopia.

2.7. Methods

A reconnaissance survey of the study area was conducted during December 2011 to get basic information of the study area, the gelada population and the socio-economic background of the local community. Based on the information collected during the survey, vegetation distribution, types and representative habitat sites were identified for detailed investigation. Additional attempts were also made to find information on accessibility, climate, topography, infrastructure and approximate size of the population of geladas in the study area. Local people were also consulted to get basic information on the area, in addition to the basic information on human socio-cultural aspects.

Among the gelada populations in the study area, three units from different bands were identified, each at least 3 km apart. The identified units from each of the bands were taken as the focal units throughout the study period (Fig.10). Depending on the topographic differences, geladas were observed at a distance of 5–100 m, from January 2012 to February 2014. In contrast, geladas in rugged and cliffy areas were observed using binoculars at a distance of around 300 m. The study units were differentiated from others by unique body marks/scars on their body of few of the individuals of each unit and from the identify of their sleeping sites.

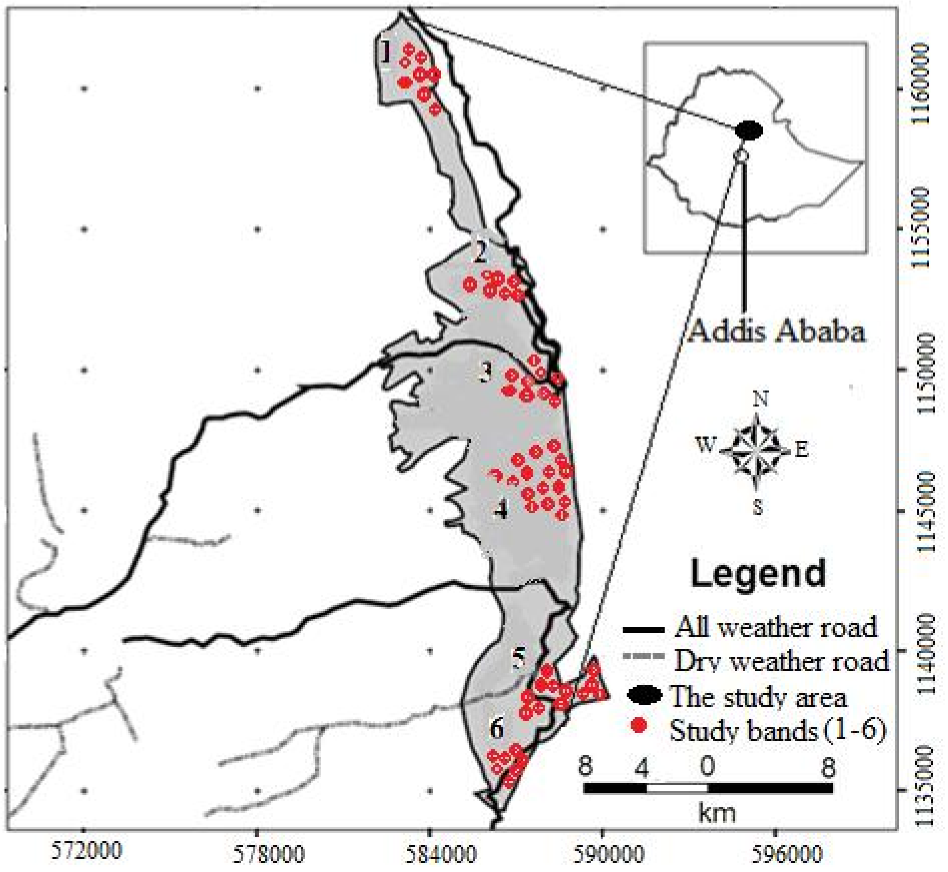


Figure 10. Location of the study bands of gelada in Gussa Community Protcted Area.

(1= band one, 2= band two, 3= band three, 4= band four, 5= band five, 6= band six)

Gelada units were followed on daily basis using GPS and range finder to assess their range size. Data on ranging patterns were gathered following them throughout the day time from 07:30 h to 18:30 h. The geographical centre of the units in every 15 minutes (Sigg and Stolba, 1981) was recorded using a Garmin etrex Legend handheld Global Positioning System (GPS). To assess community perception, key informants from randomly selected eight Peasant Associations around the GCPA were invited to participate in focus group discussions. During the group discussions, information about local community and perceptions of them towards geladas were gathered. Two focus group sessions were held per site with group sizes 7–15 people. Heads of households were randomly selected for interviews on a first come first serve basis. A total of 270 individuals from eight Peasant Associations were interviewed. This sudy included both closed and open ended questions across three broad categories to find out (i) views towards geladas and their conservation, (ii) views towards the Protected Area and (iii) a series of household demographic questions, including information on the source of income of each household (Appendix I).

At the beginning of the study, an intensive effort was made to obtain a complete census of all the units in the main band. Intact units in the band were randomly selected in order to collect data about population structure, feeding ecology and behavioural activities. Data were collected five days a week, between 07:30 h–18:30 h. Focal samples were observed at random, and the observed activities were recorded during the interval periods. Through systematic observations, behavioural data were collected using binoculars, an audio tape recorder and a stopwatch. Following Altman (1974), the focal animal observation sessions lasted for 25 minutes with 10 minutes interval between sessions. During the focal animal sessions, time of change in behaviour lasting for more than five seconds were recorded, allowing to calculate the duration of time engaged in particular activities. Focal animals were selected on a rotating basis, according to age and sex classes. The classes were of adult males, adult females, lactating females, sub-adult males, sub-adult females and juveniles.

Using group focal sampling technique (Altmann, 1974), all occurrences of grooming by members of the focal unit and their social cohesiveness were recorded, specifying the identity of both the groomer and the groomee. Moreover, grooming termination by different age and sex class categories of geladas was repeated in 25 minutes unit observations of all targeted individuals. In this case, a total of 2,467 grooming interactions making up 320 hours of grooming bouts were extracted from the data set, sorted into dyads (grooming interaction involving two individuals) and grouping into different age and sex class combinations. From this, the percentage of grooming time in minutes that each age and sex class combination contributed to the total grooming time of the study group was calculated. The percentage of mutual and unidirectional bouts that occurred between different grooming partners was also calculated. For each individual, percentage of their grooming time (mutual, unidirectional given and received) allocated to different age and sex classes was calculated together with the number of grooming partners between age and sex classes.

For population estimation, sweep census technique was used (Beehner *et al*., 2008) regularly at least once per month in each of the study sites across the study period, covering both wet and dry seasons.

Geladas were followed walking slowly from a distance of around 5 m and data were collected by means of instantaneous scan samples (Altmann, 1974). At each sample point, information was recorded on the identity of the forage species. Forage species was surveyed during both wet and dry seasons in six sample plots each of 100 × 100 m^2. From the sample plots, the frequency of occurrence of each forage species was recorded (7, 890 records) during wet and dry seasons (6, 250 records).

The relative proportion of plant species used as food by geladas was calculated from the seasonal percentage contribution of different species (Di Fiore, 2003; Di Fiore, 2004). The mean of the set of seasonal proportion of food items and food species consumed was used to calculate the overall wet and dry season data, and also food items and food species consumed by them throughout the year. Therefore, seasonal proportion of each food item was calculated as the total number of seasonal individual scans for each food item divided by the total number of individual scans for all food items of the unit.

For the purpose of identification of the forage species, samples of all plants consumed by geladas were collected and were arranged and pressed on newspaper, and taken to the herbarium (Woodland, 1997). Parts of the flowers were carefully spread without overlapping maintaing the original shape. The specimens were pressed and kept in drying box. Following the methods used by Jones and Luchsinger (1986), specimens were dried with the aid of electric lamps, or ventilators were used to press when plants were dried. The specimens were checked every three days, and the dried specimens were taken out. When all specimens were dried, they were placed in a refrigerator for three days. For identification of the species, Symoens *et al*. (1997) and Mesfin Tadesse (2004) were used and identified in the National Herbarium of Addis Ababa University.

Percentage utilization and food preferences of geladas were determined using the formula of Tomlinson (1980) as follows:

$$\%\ \text{utilization of diet} = \frac{\text{Total number of sightings of feeding on foraging species}}{\text{Total number of sightings for all species eaten}} \times \frac{100}{.}$$

To determine food preferences, the following formula was applied:

$$\text{Food preference} = \frac{\%\ \text{utilization}}{\%\ \text{availablity}}$$

Six sample plots were marked within the study area to determine relative density of forage species. The density of each species was determined by counting the total number of each species present in each of the plots, and the mean was calculated and percent of food availability was assessed in terms of the density of each species relative to every other species (Kershaw, 1979). For herbaceous plants, quadrats were used to estimate the number, and the density of each of the species was calculated.

For food analysis, major food items were systematically collected (leaves, stem and root; n=13 samples) of 18 species (14 herbs, 3 shrub, 1 tree) eaten by the geladas were used. Plant parts were collected based on consumption by geladas during the season when they were eaten. One sample per plant parts for each of the species used by geladas was collected and kept in open air until it was properly dried. Nutritional analysis was done in the Laboratory of College of Agriculture, Jima University. The nutritive values of the plant parts consumed by geladas were determined by methods of James (1995), AOAC (2000) and Chapman *et al*. (2003). Accordingly, protein, crude fibre, crude fat, ash and NDF of the samples were estimated.

Crude protein of the food item was determined using micro-Kjeldahl method as describe in AOAC (2000). Two g of the sample was taken in a digestion tube and 30 ml of concentrated sulfuric acid (H_2SO_4) was added followed by 3.0 g of digesting mixed catalyst ($CuSO_4$+ Na_2SO4) and 25 ml of concentrated Na_2SO4. The mixture was heated gently and then strongly once the frothing had ceased. When the solution became colourless, it was heated for one hour and allowed to cool, diluted with distilled water and transferred to 800 ml Kjeldahl flask. Three or four pieces of granulated zinc and 20 ml of 40% caustic soda were added and the flask was connected with the splash heads of the distillation apparatus. Later, 25 ml of 0.1 N sulphuric acid was taken in the receiving flask and distilled. When two-third of the liquid had been distilled, it was tested for completion of the reaction. The flask was then removed and titrated against 0.1 N caustic soda solution using methyl red indicator for determination of Kjeldahl nitrogen, which in turn gave the protein content. Percentage of nitrogen in the sample was calculated by the following formula:

$$\text{N \%} = \frac{1.4\ (V_1 - V_2) \times \text{Normality of HCl}}{\text{Weight of the sample}} \times 250\ (\text{dilution})$$

Protein content was estimated by conversion of nitrogen percentage to protein (James, 1995).

Protein % = N% × Conversion factor (6.25)

Where conversion factor = 100/N (N% in forage species)

To determine crude fibre, 2 g sample was treated with 200 ml of 0.25 M sulphuric acid solution in a flask, and the mixture was boiled under reflux for 30 minutes. The hot solution was quickly filtered under suction. The residues were thoroughly washed with hot water until it was acid free. Each residue was transferred into labeled flasks, and 100 ml of hot 0.3 M sodium hydroxide solutions was added and the mixture was boiled again under reflux for 30 minutes and filtered quickly under suction. The insoluble residue was washed with hot water until it was base free. It was dried to a constant weight in an oven at 100ºC and cooled in a desiccator and weighed (Chopra and Kanwar, 1991). The percentage of crude fibre was estimated as follows:

$$\text{Crude fibre} = \frac{(\text{c} - \text{b}) - (\text{d} - \text{b})}{(\text{a})} \times 100$$

Where; a = weight of sample, b= weight of crucible, c= initial weight of crucible containing tissue sample before ignition and d= final weight of crucible containing ash after ignition.

The crude lipid was analysed with diethyl-ether extract by soxhlet extraction method. Fat content was determined gravimetrically after extraction with diethyle ether (ethoxyethane) and petroleum ether from an ammonia alcoholic solution of the sample. Prior to this, about 5.0 g of the sample was placed in two different extraction thimbles and covered with cotton wool. Thimbles containing samples were placed in the extraction jacket. Two clean dried 500 ml round bottom flasks containing few anti-bumping granules were weighed (W_1) and 300 ml of petroleum ether was added into each flask and fitted with sohxlet extraction units. The round bottom flasks and the condenser were connected to the sohxlet extractor, and cold water circulation was put on. The heating mantle was switched on and the heating rate was adjusted until the solvents were refluxing at a steady rate. Extraction was carried out for six hours. The solvents were recovered and the oil was dried in the oven at 70ºC for one hour. The flask with oil was cooled and then weighed (W_2). The difference in the weights of the original flask and the flask plus extracted fat represents the weight of fat present in the original sample. The percentage of fat content of the sample was calculated by the following formula:

$$\%\ \text{of fat content of the sample} = \frac{W_2 W_1}{W_3} \times 100$$

Where W_1 = Weight of empty flask (g), W_2 = Weight of flask + fat (g) and W_3 = Weight of sample taken (g).

For determination of ash content, the method described by AOAC (2000) was adopted. Ten g of the sample was weighed in a silica crucible. The crucible was heated in a muffle furnace for about 4 hours at 550^{o}C until the completion of ashing. It was cooled in a desiccator and weighed. To ensure completion of ashing, it was heated again in the furnace for half an hour more, cooled and weighed. This was repeated till the weight became constant (ash became white or grayish white). Percentage of ash content was calculated by the following formula:

$$\text{Ash \%} = \frac{\text{Weight of ashed sample}}{\text{Weight of sample taken}} \times 100$$

Determination of neutral detergent fibre **(**NDF): Neutral detergent fibre gives an estimation of the total amount of cell wall present in the sample and was examined following the method of van Soest *et al*. (1991). Samples of neutral detergent fibber (digested residues) were analysed in the presence of sodium sulphite, but without α-amylase treatment, and presented as ash-free.

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 min (Sigg and Stolba, 1981) using a Garmin etrex Legend handheld GPS was recorded. Home range was defined as the total area used by these units over the course of the study period. It was calculated as the minimum convex polygon that included all recorded locations (from full and partial observation days) using ArcView GIs 3.1 software (Ostro *et al*., 1999). In this method, all points were connected by the smallest area polygon with interval angles less than or equal to 180^{o}.

In addition, for 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 hand-held 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.

In order to determine the carrying capacity of grassland of the study area to support geladas, seven sample sites were randomly selected. In each site, an area of 5.0 ×5.0 m^2 was marked within which 1.0 × 1.0 m^2 randomly selected quadrat was sampled. By using the procedure used by Bobbnik *et al*. (1989), fleshy grass were clipped off at 5 cm height from the ground in all these seven quadrats. After clipping, fresh/green samples were weighed in the field and then a subset of these samples were brought to the field camp and dried in open air. It was done for consecutive months at an interval of 28–30 days during both wet and dry seasons (Kent and Coker, 1992) (Fig. 11).

Figure 11. Phyto-biomass measurement during the field work (Photo: Eshetu Moges, 2013)

Once a sample was dried, the % dry matter = (Dry Wt./Fresh Wt.) × 100 was calculated (the dry weight was the weight of the sample after drying, and fresh weight was the weight of the sample recorded in the field). In order to assess the carrying capacity of the area, Kent and Coker (1992) equation was used as follows:

$$\text{Carrying capacity of the area} = \frac{\text{Annual forage consumption}}{\text{Available forage productivity (kg/ha)}}$$

To find out carrying capacity, forage productivity (kg/ha) and forage requirement per animal unit/ month/year were assessed.

The daily intake of geladas was determined using actual values derived from field studies (Dunbar, 1977; Iwamoto, 1979) for pick rates (dry matter g/min) and the percentage of time spent feeding per day in the wet (high quality) and dry (low quality) seasons. Daily dry matter intake was calculated as 1.37 g/min × percent of 12 h feeding for the wet season. For the dry season, it was calculated as 2.8 g/min × percent of 12 h feeding.

Datasets used for the present study are presented in Table 1. Landsat imageries were the main data source for classification and habitat change analysis. Landsat imagery data include LANDSAT TM and LANDSAT ETM+ (Enhanced Thematic Mapper) of years 1986, 2002 and 2013. These datasets were acquired from the Global Land Cover Facility (GLCF; www.glcf.org) through their Earth Science Data Interface (ESDI).

Table 1. Satellite images used in the present study

Image type	Spectral composition (no. of bands)	Spatial resolution	Date of acquisition
Landsat TM	8	30 m	28/10/1986
Landsat ETM+	8	30 m	27/1/2002
Landsat ETM+	12	60 m	01/12/2013

Digital image-processing software ERDAS Imagine was used to process and integrate spatial data and to generate the false colour composite by combining near infrared, red, green and blue bands. For processing, bands 7, 4 and 2 of 1986 satellite image and bands 5, 4 and 1 of 2002 and 2013 satellite images were used. Prior to analyses, the satellite images were pre-processed in order to enhance efficiency, harmonize data and to reduce error (Jensen, 1996). Firstly, the bands/layers were stacked to produce a multispectral image from each of the panchromatic bands provided per image, and after layer stacking; subsetting of the images was done for the different years satellite images using the study area boundary.

Six land-use/land-cover classes were identified for image classification based on the classification criteria of Allen (1992) and Alvo and Ponomarenko (2003). The land-use/land-cover categories in the study area are given in Table 2 with brief description.

Table 2. Land-use/land-cover categories in the study area.

Land-use/land-cover types	Description
Forest	Areas covered with trees that have open or closed canopy cover.
Grassland	Grass and herb cover with scattered trees and shrubs.
Helichrysum	A mixture of *Helichrysum* species with afro-alpine vegetation and tussock grass.
Farmland	Crop field, pasture and bare land.
Shrubland	Areas covered with shrubs and other small sized plant species.
Erica	Vegetation typically dominated by mixtures of cross-leaved heath plants, usually low growing shrubs or trees dominated by *Erica*.

A pixel based supervised image classification with maximum likelihood classification algorithm was used to map the land-use/land-cover classes. A total of 200 random points distributed evenly across the study area was generated and these locations were sub-sampled based on accessibility, locality and logistical feasibility. A total of 80 ground truthing points were used for the Maximum Likelihood Classifier Technique. Ground truthing points were located by hand-held Garmin GPS, and altitude and geographical coordinates were recorded. Photographs were also taken to provide a means of verifying consistency in the classification data during the field work. The ground truthing points made up the training areas around which polygons for each classification were drawn. These training areas were then used to define the digital signature used for the supervised classification. The training process was repeated independently for the three different years of satellite images. Supervised classifications of all images were carried out using the Maximum Likelihood Classifier ERDAS Imagine software version 10.

Overall accuracy and Kappa statistic were calculated from the error matrix following Hord (1982). Accuracy assessment was done for the classified map land-use/land-cover types of 1986, 2002 and 2013. These images were classified by the supervised method, and then random points were generated, in order to verify and assess the accuracy of the supervised classification. Accuracy was determined by superimposing the points on the classified images and obtaining the kappa coefficient (which expresses the proportion of reduced error as generated by the classification process compared with the error of a completely random classification and hence a value of one indicates an accuracy of 100% or zero error), and the overall percentage accuracy was detected using ERDAS Imagine.

The three images were compared to detect land-use/land–cover changes in the three phases, 1986–2002, 2002–2013 and 1986–2013. Classified images were compared using the post classification image comparison technique (Singh, 1989) in ERDAS Imagine. One image was created based on the differences of the two comparative images from each year and change statistics were computed by comparing image values of one data set with the corresponding value of the second data set in each period. The values were presented in terms of square kilometres, which provide a summary table of the overall changes per class; positive values denote an increase whereas negative values imply a decrease in the extent of each of the land-use/land-cover types.

In Post-Classification Change Matrix Calculation method, a 4-band multiseasonal composite was created from the 1986, 2002 and 2013 LANDSAT TM and ETM+ data. After classification, majority analysis was done in order to avoid minor fragmented classification arrangements on the out-put map. The majority analysis was repeated a number of times until the fine classification was achieved. The simple approach consisted of comparing the properly coded results of two separate classifications. Finally, ground verification after classification was made in order to check the precision of the classified land-use/land-cover map.

A post-classification comparison, which is the most straightforward technique, has been applied in this study. The land-cover maps for the years 1986, 2002 and 2013 were first simplified into the following six classes: forest, grassland, *Erica*, farmland, shrubland and *Hilichrysum* areas. The post-classification comparison was then applied by differentiating the corresponding classified maps to generate change maps. The result of the detection change entirely depended on the accuracies of each individual classification. Normally, the map from time one (T_1) is compared with the map of time two (T_2) and a complete matrix of categorical change was obtained. Thus, the two comparisons based on three satellite images of classified maps of 1986, 2002 and 2013 were made. A flow chart of the procedure is presented in Figure 12.

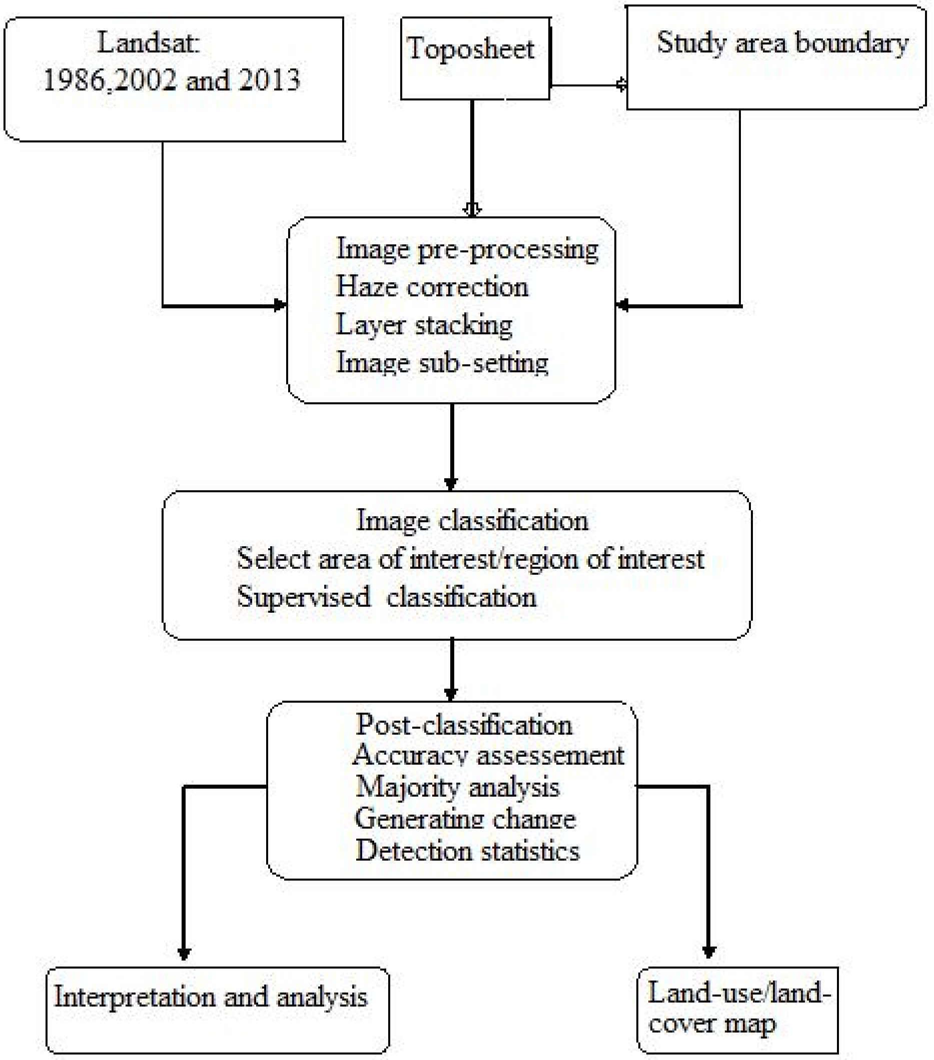


Figure 12. Flow chart showing the procedure of land-use/land-cover change analysis

2.8. Questionnaire survey

A structured questionnaire with open and closed ended questions was used to gather information from the local people from eight local districts around GCPA. It was developed in the local language and translated into English. The design was based on the preliminary data taken from local community, which included demographic data and inputs from field observation during the preliminary study.

Items of questionnaires were organized based on Likert scale technique (Burns and Grove, 1997). It was used to assess community attitude towards specific information (Bowling, 1997). A total of 270 households, including students and developmental agents were selected from eight local Kebels (Administrative villages) through stratified random sampling. It was carried out based on the population data available in the Kebeles. The number of respondents in each village was determined by the population size of the respective villages. The questionnaire was composed of both open and closed ended questions of the following three broad categories: views towards gelada baboon and conservation, views towards the protected area, and a series of household demographic questions, including information on the source of income of each household.

Focus group discussion and key informant methods were used to reinforce the questionnaire data (Bernard, 2002). Nine pre-designed semi-open ended questions were used for gathering information. Information was collected on how local communities perceive geladas/wildlife, how they access and use GCPA (e.g. *Festuca* grass, fire wood), the co-existence of geladas with communities and as a whole how local communities benefited from the conservation area. Two focus group sessions were held in each study site (Fig.13). The size in each session varied from 7 to 15 individuals. 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.

Figure 13. Questionnaire survey in different levels of the local community (a = questionnaire survey at villge level, b= group discussion and survey with local people, c= group discussion and questionnaire survey with students at school level, d= questionnaire survey at local kebele level.

The model that used to analyze the attitude of local community is given below:

$$Y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_x + \in$$

Where $Y_i = 1$ if a community has positive attitude

$Y_i = 0$ if a community has negative attitude

β_0 is the intercept

β_1 , β_2 and β_3 are the parameter estimators/ regression coefficients

$x_1, x_2 \ldots\ldots x_x$ are explanatory variables

As people living in similar types of settlements share similar perception, the likelihood ratio and correlations (r) were conducted to assess significant differences among groups of people living under different socio-economic profile in GCPA.

Demographic variables (age, sex and household size), education level, social network, farm size, income source, lack of infrastructures and alternative economic sources were identified as the determinants of attitude of the community towards GCPA. All these selected variables were supposed to determine the attitude of local peple in the study area and the case for low community participation towards conservation of geladas and the protected area.

2.9. Data Analyses

All statistics related to this dissertation were carried out on SPSS 17.0 software for Windows Evaluation Version. Statistical tests were one tailed with 95% confidence intervals. Non–parametric Mann-Whitney U tests were used to compare seasonal differences of quantitative variables obtained from two independent groups, and Kruskal-Wallis H tests were used to see the effects of independent variables on the demographic structure of geladas as the data were not normally distributed.

Wilcoxon Matched Pairs and Signed rank tests were used to make inferences about the mean differences of activity patterns between seasons. It was also used to analyse the percentage of time spend on each activity by the gelada, and to evaluate whether each activity changed in proportion to the day length. Wilcoxon Signed rank tests were used to establish whether the percentage of mutual and unidirectional bouts of interactions were significantly different within age - sex class combinations. Kruskal Wallace test was used to establish whether different age - sex classes distributed their grooming time evenly or unevenly across the group.

Land-use/land-cover classes were examined at intervals of thirteen years. The number of patches in each class, their areas and perimeters were determined for each classified image using spatial statistical tools of the Geoprocessing tools sets in ArcGIS 10 software. Then, by comparing the number and average area of patches in each of the considered years, relative patchiness was determined.

Logistic regression was used to determine the impacts of socio-economic status on conservation of geladas, and each socio-economic impact was considered with the independent variable coded as ordinal, dummy and continuous.

3. Results

3.1. Demographic structure of the gelada population

A total of 1502 individuals of geladas were recorded in the six study bands in GCPA during the present investigation. The population size of each of these bands and their structure varied between wet and dry seasons. Results on demographic structure of geladas have indicated that there was no difference in the mean reproductive unit size between seasons (Kruskal-Wallis H test, $P > 0.05$) (Table 3). Kruskal-Wallis H tests showed that there were significant differences in the band size of study population of Tsewo, Baltegra, Sefedmeda, Wochanka, Dejameda and Atsewuha between seasons ($P < 0.05$).

Table 3. Demographic structure of geladas during wet dry seasons

Study bands/ sites	Season	Band size	Number of		Repro-ductive unit size($\bar{x}$)	Adult sex ratio (F:M)	Adult females/ reproductive unit ($\bar{x}$)	Sex ratio (F:M)	Multi-male units (%)
			Units	AMU ($\bar{x}$)					
Tsewo	Dry	185	13	1	13.7	3.5	5.4	1.4	13.3
	Wet	233	14	1	15.2	3.7	6	1.7	28.6
Baltegra	Dry	249	16	2	14.1	2.3	6.1	1.5	37.5
	Wet	260	17	2	14.1	2.2	5.9	2.2	41.2
Sefedmeda	Dry	203	18	2	10.5	2.4	4.6	1.6	16.7
	Wet	260	19	2	12.9	2.5	4.6	1.3	21.1
Wochanka	Dry	532	24	3	20.1	3.2	7.1	1.8	25
	Wet	229	20	3	11.4	3.0	4.1	1.4	20
Dejameda	Dry	174	14	2	11.4	2.8	6	1.7	14.3
	Wet	246	16	2	14.1	2.7	5.8	1.7	18.5
Atsewuha	Dry	209	16	1	12.5	4.7	6.5	2.3	12.5
	Wet	235	17	1	13.4	4.3	6.1	2.1	17.6

The mean number of females per harem varied from 4.1 to 7.1 for the six bands. The mean harem, or reproductive female size in all study bands was not statistically different within season, or between seasons (Kruskal-Wallis H test, $P > 0.05$). However, the mean size of the reproductive unit (all ages and sex) of the geladas was significantly larger at Wochanka ($P < 0.05$).

The sex ratio was not statistically significant between seasons (Kruskal-Wallis H test = 0.01, $df_{1,}$ 3.34, $P > 0.05$). In addition, the adult sex ratio and the mean number of reproductive females within the units were not statistically significant ($P > 0.05$). In most cases, the reproductive unit has one adult male. However, some reproductive units contain more than one adult male (multimale units). The percentage of multimale units differed significantly between seasons (Mann-Whitney U test, $P < 0.05$).

Population growth rate per annum for the six bands are given in Table 4. The growth rate was based on the number of births and deaths relative to the band size. However, migration was not included due to high fusion and fission rates. Populations of geladas increased during the study period (overall mean = 17.1% per annum). There was a close correlation between the annual growth and birth rates. The overall mean growth rate was higher at Tsewo (20.3% per annum, $n = 47$) and lower at Baltegra (12.7% per annum, $n = 39$). The overall mean mortality rate was low (1.4 % per annum), and the lowest mortality rate was recorded at Deja Meda (0.78% per annum), and the highest mortality rate was recorded at Wochanka (1.99%).

The number of females per male was relatively lower in the study bands of geladas (Table 4). The lowest ratio of females to male was recorded in Baltegra band (2.3:1). Female to male ratio in Atsewuha was higher (4.5:1) than the other studied bands.

Table 4. Estimates of annual growth rates for the six gelada bands in Guassa Protected Area

Bands	Seasons	Female/ male	Birth/ female/ year	Gross annual growth rate	Mortality (n)	Mortality rate (%)	Net annual growth rate
Tsewo	Dry	3.5	0.6	+23.2	5	2.7	20.5
	Wet	3.7	0.6	+21.0	2	0.86	20.1
Baltegra	Dry	2.3	0.5	+18.1	6	2.41	15.7
	Wet	2.2	0.3	+11.2	4	1.54	9.7
Sefedmeda	Dry	2.4	0.5	+19.2	3	1.47	17.3
	Wet	2.5	0.7	+23.2	1	0.49	22.7
Wochanka	Dry	2.8	0.5	+21.3	5	0.93	20.4
	Wet	3.2	0.5	+17.3	7	3.05	14.3
Dejameda	Dry	2.8	0.3	+16.1	2	1.15	14.9
	Wet	2.7	0.5	+19.5	1	0.41	19.1
Atsewuha	Dry	4.7	0.3	+14.8	3	1.43	13.7
	Wet	4.3	0.4	+16.5	1	0.43	16.1

∗ Migration and emigration of each band have been not considered in the data.

As the regression line shows (Fig. 14), the value of R-squared on the graph for female per male with an equation y = - 0.004x + 3.162, R^2 = 0.000, the slope is not significantly greater than 0 (t_{22} = 1.72, P > 0.05), and hence, it did not show a true relationship between the number of female per male and annual growth rate. However, the number of births per female/year has resulted in a significant change in the population of geladas, and hence the regression line, y = 0.029x - 0.033, R^2 = 0.726. From the analysis, the value of R was closer to 1.0, fitting the regression line (P < 0.05), i.e, the closer the line passes through all of the points. Eventhough, information such as the number of data points to make an accurate statistical prediction as to how well the regression line represents the true relationship, equation two represents a better relationship of birth per female/year and annual growth of geladas (Fig.14).

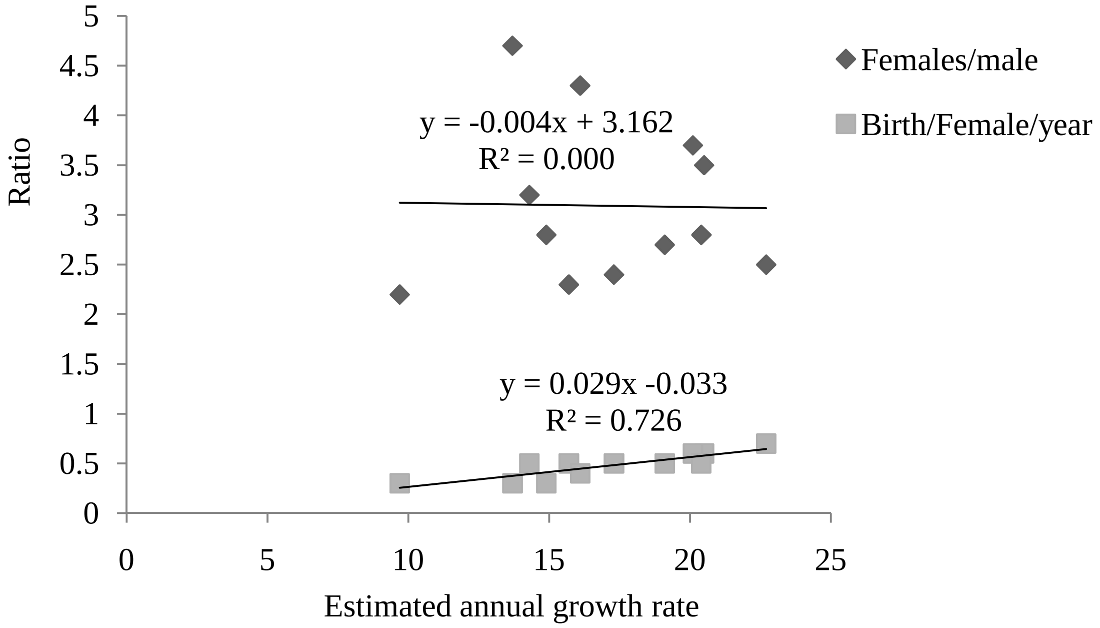


Figure 14. Annual growth rate of geladas in GCPA showing females to male and birth per female/year

3.2. Activity time budget

On an average, the time budget of the focal groups revealed 41.48 ± SD 5.42 % (range 35.73 – 51.03 %) of their active time was used in foraging, 21.21 % (range 16.76 – 26.42 %, SD ± 4.20 %) used in travelling, 14.56 % (range 9.36 – 18.62 %, SD ± 3.41 %) in grooming, 3.99 % (range 3.36 – 4.59 %, SD ± 0.42 %) in agonistic encounters, 4.27 % (range 1.06 – 8.24 %, SD ± 2.95 %) in playing, 7.31 % (range 3.96 – 11.26 %, SD ± 3.03 %) in resting and 7.17 % (range 4.87 – 9.65 %, SD ± 1.41 %) in other activities (observing, scanning habitat, scratching body and parental care) (Table 5).

Table 5. Proportion of time spent in different activities by gelada

		Proportion of time spent in different activities, %					
Study sessions	Foraging	Moving	Grooming	Agonistic	Playing	Resting	Other ∗ activities
Dry-1	43.14	25.88	12.94	4.31	1.47	5.78	6.47
Dry-2	45.18	26.42	10.65	3.79	2.24	4.36	7.38
Wet-1	36.35	17.73	18.62	3.36	6.37	10.11	7.45
Wet-2	38.04	16.76	17.2	3.81	5.34	9.2	9.65
Dry-3	51.03	24.62	9.36	3.64	1.06	4.18	6.11
Dry-4	44.84	23.12	13.72	4.59	1.81	3.96	7.91
Wet-3	37.56	18.23	16.42	4.05	7.61	11.26	4.87
Wet-4	35.73	16.92	17.56	4.41	8.24	9.62	7.52
Mean	41.48	21.21	14.56	3.99	4.27	7.31	7.17

∗ Others: observation, scanning habitat, scratching body and parental care)

Gelada spent significantly more hours per day in foraging ($Z = 1.82$, $P < 0.05$, $n = 8$), and moving ($Z = 1.82$, $P = 0.03$, $n = 8$) during the dry season compared to the time spent in the wet season. There was no significant difference between seasons in the time spent in agonistic interactions (Wilcoxon Matched Pairs Test: $Z = 0.36$, $P = 0.4$, $n= 8$) and other activities ($Z = -0.36$, $P > 0.05$, $n = 8$). The time spent in grooming ($Z = 1.83$, $P = 0.034$, $n = 8$), playing ($Z = 1.82$, $P < 0.05$), and resting ($P < 0.05$) were significantly more during the wet season than during the dry season.

During the day time, the percentage of time spent in foraging was significantly higher during the dry season (median 48 %, range 43.14 – 53.03 %) than the wet season (median 37.8 %, range 35.73 – 38.04 %; $Z = 2.10$, $P = 0.017$, $n = 8$), or 1.17 hour more than expected based on the increase in daylight hours (Fig. 15). The time engaged in moving was significantly more during the dry season (median 25.52 %, range 23.12– 26.42 %) than during the wet season (median 17.49 %, range 16.92 – 18.23 %; Wilcoxon Matched Pairs Test: *Z* = 2.52, P = 0.006, n = 8).

The time spent in grooming was less during the dry season (*Z* = 2.52, P = 0.006), or 70 minutes shorter than the wet season. Similarly, the time engaged in playing and resting during the dry season was also less than the wet season (P < 0.05). On the other hand, the time spent in agonistic encounters and other activities was not statistically significant (P > 0.05) between seasons (Fig. 15).

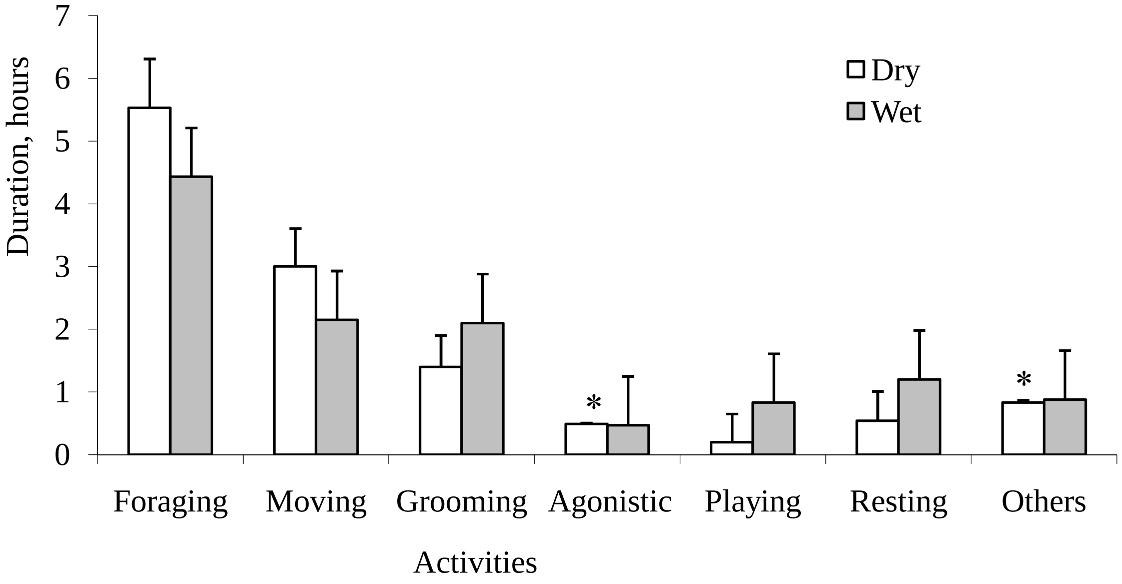


Figure 15. Duration in hours (mean ± SE) geladas engaged in the six major activities during wet and dry seasons.

∗ Statistically not significant (p > 0.05) between seasons.

Figure 16 shows the diurnal activity patterns of geladas. There were no significant differences in the frequency of foraging and travelling throughout the day during the dry season (χ^2 = 21.75, df = 16, P > 0.05, χ^2 = 8.82, df = 16, P > 0.05), respectively. However, grooming and agonistic behaviours showed statistically significant differences (χ^2 = 34.79, df = 16, P < 0. 01, χ^2 = 41.3, df = 16, P < 0.01), with a peak before dusk (18:00 h), and late in the afternoon (14:30

h), respectively. There were no significant differences for resting ($\chi^2 = 22.67$, df = 16, $P > 0.05$) and playing ($\chi^2 = 25.0$, df = 16, $P > 0.05$) throughout the day time.

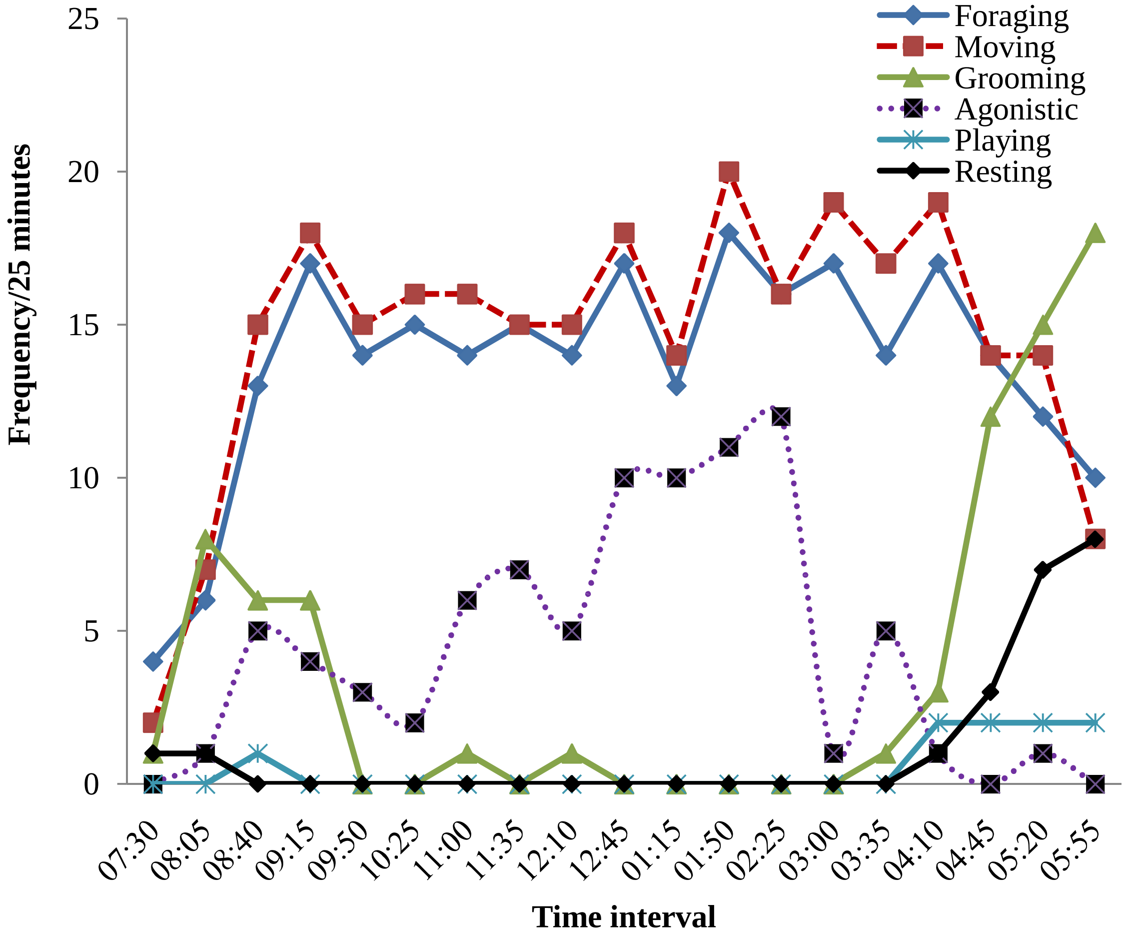


Figure 16. Activity patterns of geladas during the dry season

Frequencies of foraging and travelling showed statistically significant differences during the wet season ($\chi^2 = 26.45$, df = 16, $P < 0.05$, $\chi^2 = 47.39$, df = 16, $P < 0.01$, respectively). Grooming frequency also showed statistically significant difference ($\chi^2 = 104.6$, df = 16, $P < 0.01$) in the day time with a peak before the mid-day (09:00 -11:00 h), and after 16:00 h. Frequencies of agonistic encounters in geladas did not show statistically significant difference throughout the day time ($\chi^2 = 48.23$, df =16, $P > 0.05$). Playing and resting were also not significantly different ($\chi^2 = 12.05$, df =16, $P > 0.05$, $\chi^2 = 18.74$, df = 16, $P > 0.05$, respectively), throughout the day time during the wet season (Fig. 17).

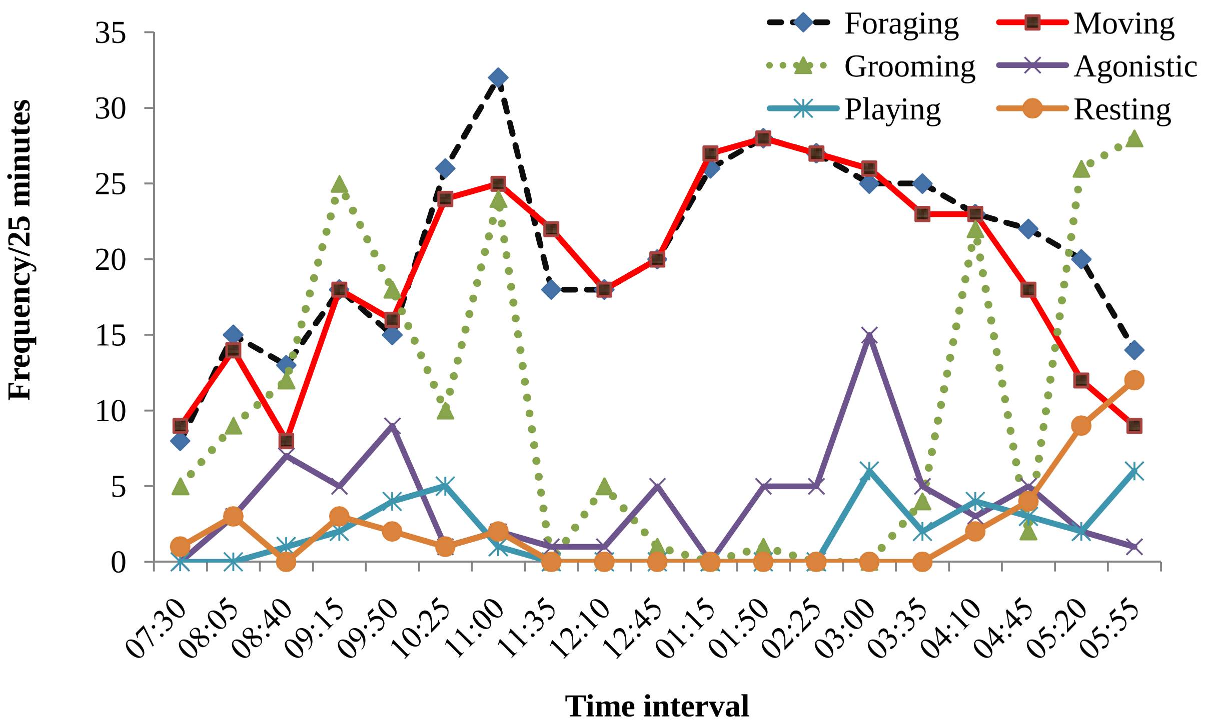


Figure 17. Activity patterns of geladas during the wet season

Grooming interactions between female and male geladas were initiated more frequently by females than by males ($P < 0.05$) (Table 6). Among juveniles also, females were more likely to initiate grooming interactions ($Z = 1.09$). Initiation of grooming interactions between sub-adult females and sub-adult males did not show a significant difference (Z = 1.16). Grooming between dominant males and others were more significantly initiated by the adult females ($Z = 10.15$) than by other members of the unit. In general, dominant males were less likely to initiate grooming interactions with unit members, and adult females were the major initiator in grooming interactions (Table 6).

Males were more likely to terminate grooming interactions than females. However, adult females were significantly more likely than sub-adult males to terminate grooming interactions

(*Z* = 5.165). Juvenile males and females were less likely than sub-adult females and adult males to terminate grooming interactions (*Z* = 3.289).

Table 6. Binomial test comparison of the number of initiation and termination of grooming by different age and sex class combinations among geladas

Age and sex classes	Grooming bouts (n)	Female initiation (n)	Male initiation (n)	Binomial test-z value	Female terminations (n)	Male terminations (n)	Binomial test z
AF-DM	237	196	41	10.15	92	164	-4.49
AF-SAM	52	47	9	5.08	51	13	5.17
AF-JM	164	142	25	9.04	63	124	-4.46
SAF-DM	78	69	12	6.3	17	65	-5.3
SAF-SAM	25	22	15	1.16	8	17	-1.8
JF-AM	64	46	18	3.48	5	59	-6.75
JF-SAM	96	79	41	3.46	41	56	4.53
JM-SAF	117	87	34	4.82	78	42	3.29
JM-JF	32	27	19	1.09	14	29	-2.28

(n= number of interactions, AF= adult females, DM= dominant males, SAM= sub-adult males, JM= juvenile males, SAF= sub-adult females, JF= juvenile females, AM= adult males).

A total of 2,467 bouts of grooming were recorded during 320 hours of observations between different age and sex classes of geladas. Adult females had grooming interactions mostly with dominant males with 45.46 % of the total grooming time (mutual 0.91 ± 0.51 %, give 24.09 ± 1.40, receive 20.45 ± 3.56 %). A higher percentage of grooming was imparted to the dominant male (24.09 ± 1.40) and to the dominant adult female (10.23 ± 0.67 %) in the form of unidirectional grooming bouts. They received more grooming bouts from dominant male

(20.45 ± 3.56 %) and adult/dominant females (10.23 ± 0.67 %). However, adult females allocated less time for grooming sub-adult females (6.36 ± 0.39 %), and sub-adult males (4.54 ± 0.35 %) (Table 7). Adult females were engaged in similar levels of mutual grooming bouts with dominant male (0.91 ± 0.26) and sub-adult males (0.45 ± 0.028), and gave equal unidirectional grooming bouts to juveniles and sub-adult females (10.87 ± 0.49).

The dominant male allocated most of its grooming bouts towards adult females (57.69 %, mutual 3.21 ± 0.20 %, give 23.72 ± 0.78 %, receive 30.769 ± 1.98 %). Dominant male received more grooming bouts from adult females (30.769 ± 1.98 %) and sub-adult males (9.62 ± 0.25 %) than they gave them (23.72 ± 0.78 % and 5.13 ± 0.21 %, respectively). Following adult females, the dominant male preferred to be involved in grooming interactions with sub-adult males (16.03 %) and juveniles (11.22 %). However, dominant males appeared to allocate less grooming time to submissive adult males (6.41 %). In grooming interactions, the dominant male received relatively long unidirectional grooming bouts from sub-adult males. Although the usual time recorded in unidirectional grooming bouts was between 1–3 minutes, the dominant male received grooming bouts for upto six minutes.

Sub-adult females were mostly engaged in grooming bouts with adult females (45.35 %, mutual 2.32 ± 0.22 %, give 17.44 ± 0.31 % and receive 25.58 ± 0.217 %). There were less grooming interactions recorded with juveniles (13.95 %). Sub-adult males spent most of their grooming bouts with the dominant male (36.42 %, mutual 1.32 ± 0.27 %, give 24.50 ± 0.40 %, receive 10.59 ± 0.24 %) and juveniles (25.17 %, mutual 3.97 ± 0.44 %, give 14.57 ± 0.19 %, and receive 6.62 ± 0.19 %). However, sub-adult males were less engaged in grooming with sub-adult females (7.95 %, mutual 1.32 ± 0.21 %, give 2.65± 0.27 %, and receive 3.97 ± 0.28%).

Table 7. Comparison between the percentages of mutual and unidirectional grooming bouts among the different age and sex class combinations of geladas (Mean ± SE).

			Unidirectional bouts		
Age sex class combination	No. of grooming dyads	Mutual (%)	give (%)	receive (%)	p-value
AF vs DM	70	0.91 (±0.26)	24.09 (±1.40)	20.45(± 3.56)	0.002
AF vs AF	52	1.36(±0.24)	10.23 (±0.67)	10.23(±0.67)	0.003
AF vs JF/M	38	2.27(±0.12)	7.27(±0.23)	3.6(±0.26)	0.002
AF vs SAF	27	3.18 (±0.27)	6.36(±0.39)	4.09(±0.31)	0.005
AF vs SAM	45	0.45 (±0.03)	4.54 (±0.35)	2.27(±0.21)	0.002
DM vs AF	87	3.21 (±0.20)	23.72 (±0.78)	30.80 (±1.98)	0.001
DM vs SAM	28	1.28 (±0.37)	5.13(± 0.21)	9.62 (± 0.25)	0.004
DM vs JM/F	62	0.96(± 0.12)	3.85 (± 0.23)	6.41 (± 0.19)	0.005
DM vs SAF	16	0.64 (±0.04)	3.53 (± 0.29)	5.77 (± 0.48)	0.002
DM vs A/DM	22	0.64(± 0.07)	2.56 (± 0.41)	3.21(± 0.40)	0.003
SAF vs AF	37	2.32(± 0.22)	17.44 (± 0.31)	25.58(±0.22)	0.001
SAF vs DM	61	2.41(± 0.26)	12.79 (± 0.28)	6.98 (±0.16)	0.004
SAF vs SAM	18	4.65 (±0.68)	9.30 (± 0.25)	2.32(± 0.24)	0.002
SAF vs JM/F	82	1.25(± 0.23)	11.63(± 0.19)	4.65(±0.23)	0.005
SAM vs SAF	14	1.32(± 0.21)	2.65 (± 0.27)	3.97 (± 0.28)	0.001
SAM vs JM/F	78	3.97(± 0.44)	14.57 (± 0.19)	6.62 (±0.19)	0.003
SAM vs DM	42	1.32(± 0.27)	24.50 (± 0.40)	10.59 (±0.24)	0.004
SAM vs AF	57	2.65(± 0.19)	5.29 (± 0.25)	14.56 (±0.36)	0.002
SAM vs SAM	13	0.82 (±0.23)	5.96 (± 0.33)	3.97 (± 0.33)	0.013
JF vs AF	98	3.95(±0.37)	23.68(±0.47)	15.79 (±0.46)	0.003
JF vs DM	74	2.63(± 0.24)	11.84 (±0.41)	7.89 (±0.45)	0.004
JF vs SAM	16	1.32(± 0.51)	5.26 (±0.50)	2.65(±0.27)	0.012
JF vs JM	29	0.29 (±0.01)	6.58 (±0.56)	3.95 (±0.43)	0.005
JF vs SAF	62	0.96(± 0.34)	5.26 (±0.48)	8.25 (±0.38)	0.002
JM vs JM	102	3.81 (±0.37)	15.24 (± 0.23)	17.14 (± 0.24)	0.006
JM vs SAM	85	1.90(± 0.48)	11.43 (± 0.22)	13.33 (± 0.32)	0.003
JM vs DM	38	0.26 (±0.01)	9.52 (± 0.34)	6.67 (± 0.54)	0.009
JM vs SAF	27	2.86(± 0.29)	3.81(± 0.45)	4.76 (± 0.35)	0.005
JM vs AF	19	0.52 (±0.03)	1.90(± 0.46)	5.71 (± 0.38)	0.001
JM vs JF	22	1.91(± 0.43)	0.95 (± 0.19)	2.86 (± 0.37)	0.007

AF = adult female, DM = dominant male, JF = juvenile female, JM = Juvenile male, SAF = subadult female, SAM = subadult male, AM = adult male.

Juvenile females were mostly involved in grooming with their mother/adult females (43.42%, give 23.68 ± 0.47 %, receive 15.79 ± 0.46% and mutual 3.95 ± 0.37%). In addition, juvenile females spent more of their grooming time with dominant males at an average of 22.37%.

Juvenile females engaged in low percentage of grooming bouts with sub-adult males. However, juvenile males were more engaged in grooming with the same age and sex classes and with sub-adult males. Juvenile males allocated low percentage of grooming bouts with juvenile females (Table 7).

As presented in Figure 18, grooming bouts given and received between individuals of the same or opposite sex do not show a strong linear relationship in geladas. Among them, grooming between males and females was relatively more asymmetrical than individuals of the same sex (Fig.18a). Therefore, differences in grooming bouts obtained subtracted bouts received from the bouts given, vary across individuals in respect of their sex. Sex had a significant effect on the difference in grooming bouts given and received across different individuals ($Z = -2.13$; $p = 0.016$). Moreover, hierarchical status of the individuals in the unit has significant effect in grooming bouts given and received ($P< 0.05$) among individuals.

Although allogrooming between two individuals of the same sex was relatively reciprocal and asymmetrical, data points of the regression (Figure 18b and c) were scattered and the slope was significantly different ($y = 0.148x + 0.607$; $P = 0.007$). Similarly, grooming bouts were not reciprocated equally in male–male grooming interactions shown by the number of data points on the regression line and the slope was significantly different ($y = 0.211x + 0.485$, $P = 0.001$). Therefore, the distribution of grooming bouts neither provided by females to other females and males were different nor were the bouts provided by males to other males or females.

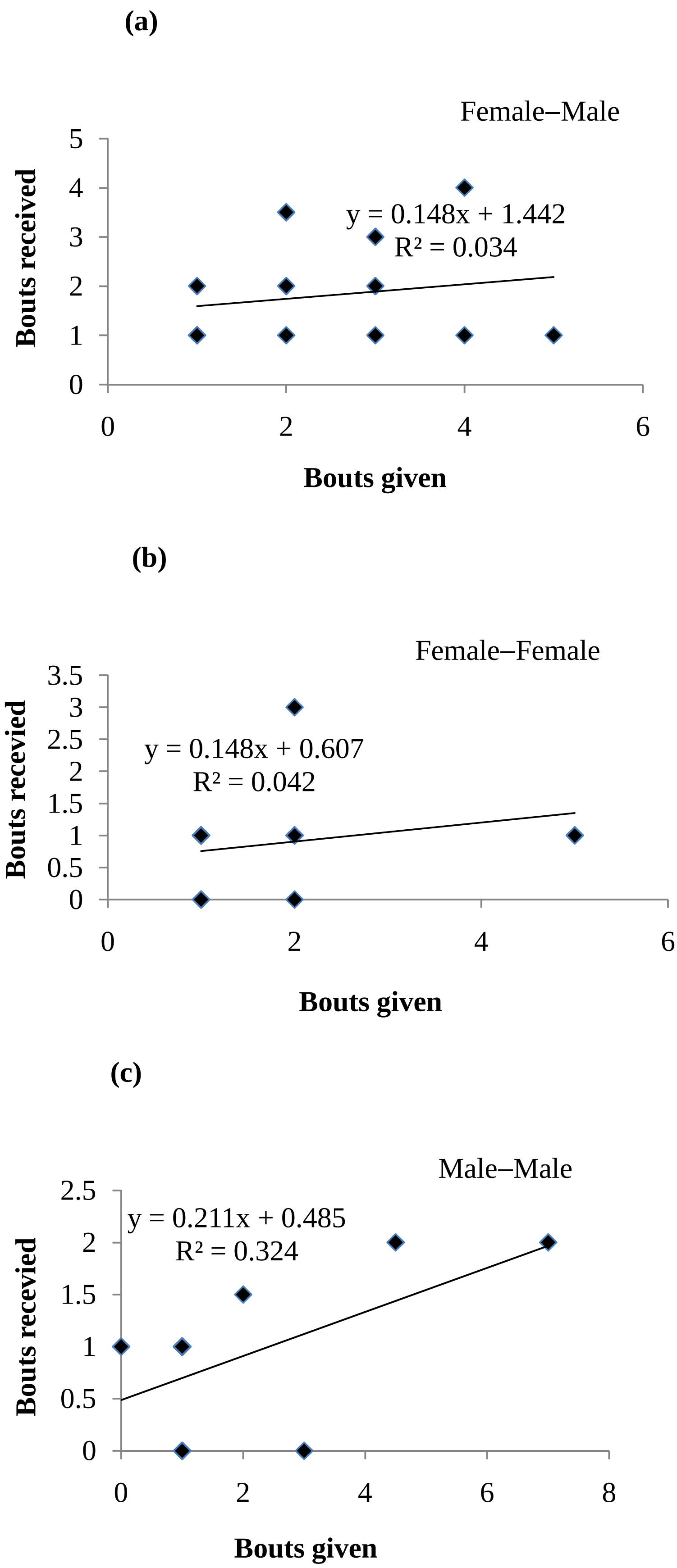


Figure 18. Bouts given and received by geladas

3.3. Feeding ecology

Out of the 18 foraged species recorded within the home range of geladas in the study area, 14 were herbs, three were shrubs and one was a tree species. Among these, two species were crop varieties. Geladas preferred to eat leaves, and they rarely feed on other parts including pollen, but never seen eating bark of plants (Table 8). The identified forage species were of 13 Families, and majority of them were of Asteraceae Family.

Table 8. Identified food items of geladas in Guassa Community Protected Area

			Parts eaten *					
Plant family	Species	Leaves	Fruit	Pollen	Seed	Stem	Bark	Root
Poaceae	*Festuca macrophyla*	*			*			*
Rubiaceae	*Galium asparinoides*	*				*		
Asteraceae	*Haplocarpha schimperi*	*						
Asteraceae	*Sonchus oleraceus*							*
Asteraceae	*Adenostemma caffrum*	*						
Asteraceae	Cotula cryptocephala	*				*		
Rosaceae	*Rubus apetalus*		*		*			
Rosaceae	*Alchemilla abyssinica*	*						*
Cupressaceae	*Cupressus lusitanica*			*				
Malvaceae	*Malva verticillata*	*						
Ranunculaceae	*Ranunculus multifidus*					*		
Aspholedaceae	*Eremurus robustus*					*		
Guttiferae	*Hypericum peplidfolium*	*						
Thyme	*Thymus schimperi*	*						*
Apiaceae	*Agrocharis melonata*							*
Lamiaceae	*Satureja pseudosimensis*	*				*		
Poaceae	*Hordeum vulgare*				*			
Poaceae	*Triticum aestivum*				*			

(Data are from scan sampling. ∗ Indicates that geladas were observed feeding on the reproductive parts of the plant).

A total of 12,520 feeding records were collected from scan sampling of the three selected units of geladas during the study period. Of the total feeding time, 68.6% was spent eating grass blades, and the average feeding time varied from 19.7 to 48.9% during the wet and dry seasons, respectively. Twenty one percent of their feeding was on *H. schimperi*, 13.3% *C. cryptocephala* and 11.1% seeds of *H. vulgare* during the dry season (Table 9).

Table 9. Plant species consumed by geladas and the total time spent on feeding

			Average time spent in feeding (min.)		Total feeding time (%)
Plant family	Species	Type	Wet	Dry	
Poaceae	*Festuca macrophyla*	Herb	131 (48.9)	68.3 (19.7)	68.6
Rubiaceae	*Galium asparinoides*	Herb	15.7 (5.8)	n.f.o	5.8
Asteraceae	*Haplocarpha schimperi*	Herb	20.9 (7.7)	48.4 (13.9)	21.6
Asteraceae	*Sonchus oleraceus*	Shrub	4.6 (1.7)	n.f.o	1.7
Asteraceae	*Adenostemma caffrum*	Shrub	3.1 (1.2)	12.5 (3.6)	4.8
Asteraceae	Cotula cryptocephala	Herb	7.8 (2.9)	36.1 (10.4)	13.3
Rosaceae	*Rubus apetalus* ∗ ♣	Shrub	5.42 (1.9)	n.f.o	9.1
Rosaceae	*Alchemilla abyssinica*	Herb	2.6 (0.96)	6.8 (1.95)	2.9
Cupressaceae	*Cupressus lusitanica*	Tree	10.7 (3.9)	17.3 (4.9)	8.8
Malvaceae	*Malva verticillata*	Herb	9.3 (3.4)	13.6 (3.9)	7.3
Ranunculaceae	*Ranunculus multifidus*	Herb	13.1(4.8)	8.7 (2.5)	7.3
Aspholedaceae	*Eremurus robustus*	Herb	16.37(6.1)	5.1(1.5)	7.6
Guttiferae	*Hypericum peplidifolium*	Herb	5.4 (2.0)	n.f.o	2.0
Thyme	*Thymus schimperi*	Herb	4.8 (1.8)	2.4 (0.7)	2.5
Apiaceae	*Agro charis melonata*	Herb	n.f.o	1.9 (0.5)	0.5
Lamiaceae	*Satureja pseudosimensis*	Herb	n.f.o	3.8 (1.1)	1.1
Poaceae	*Hordeum vulgare* *	Herb	n.f.o	38.6 (11.1)	11.1
Poaceae	*Triticum aestivum* *	Herb	n.f.o	18.5 (5.3)	5.3
Roots & others	-	-	5.2 (1.93)	24.0 (6.9)	8.8

(Numbers in parenthesis show percentage, n.f.o = no longer focal observations, ∗ = seeds, ♣= fruit).

A comparison of observations on feeding has revealed seasonal differences in the number of plant species contributing to the diet of geladas, which decreased gradually from the long rainy season of July−August to the peak dry months of January−February. They spent more time feeding on grass blades (48.9 %, SD ± 1.90), stem of *E. robustus* (6.1 %, SD ± 1.47) and *R.*

multifidus (4.8 %, SD ± 0.84) during the wet season than during the dry season (19.7 %, SD ± 2.58, 1.5 %, SD ± 0.94 and 2.5 %, SD ± 0.54, respectively). Fruits and seeds of *R. apetalus, G. asparinoides, H. peplidifolium* and *S. oleraceus* were consumed more during the wet season. They were engaged in feeding on leaves and stems of *H. schimperi* (13.9 %, SD ± 1.29), *C. cryptocephala* (10.4 %, SD ± 0.92) and roots (6.9 % SD ± 0.91) more during the dry season than during the wet season (7.7 %, SD ± 0.96, 2.9 %, SD ± 0.68 and 1.93 SD ± 0.07, respectively). Seeds of *H. vulgare* and *T. aestivum* were consumed during the dry season. Crop dependency of geladas were observed during autumn, after harvesting crop; mainly depending upon the leftovers in the farming area.

Time spent in feeding on different food items by geladas is also shown in Table 9. Results of Mann-Whitney U test showed that there were significant differences in the total time spent feeding on grass blades, *G. asparinoides, H. schimperi, S. oleraceus, C. cryptocephala, R. apetalus, R. multifidus, E. robustus, H. peplidifolium* and *S. pseudosimensis* ($P < 0.05$) between the seasons. On the other hand, there were no significant differences between seasons in the time spent on feeding *A. caffrum* ($P > 0.05$), *A. abyssinica* ($P > 0.05$), *C. lusitanica* ($P > 0.05$), and *T. schimperi* ($P > 0.05$). Geladas spent nearly equal time feeding during the wet and dry seasons on *M. verticillata* and *A. melonata.*

Data on selection of forage species by geladas during the wet season is presented in Table 10. Based on this data, *A. caffrum* was the most preferred plant species of geladas in the present study area with a percentage selection ratio of 87.00. *Sonchus oleraceus* was the second and *G. asparinoides* was the third most preferred forage species with dietary preference ratios of 39.00 and 37.50, respectively. Pollen of *C. lusitanica* had a low percentage preference ratio of 0.06, even though the percentage availability of this item was relatively high in the area.

Table 10. Preference ranking of various food items of geladas based on consumption and availability during the wet season

Family	Food item/forage plant species	%			Preference ranking
		Utilization	Availability	Preference	
Poaceae	Grass blades	64.14	95.5	0.67	11
Guttiferae	*Hypericum peplidifolium*	0.58	0.1	5.8	8
Ranunculaceae	*Ranunculus multifidus*	8.36	0.9	9.29	5
Aspholedaceae	*Eremurus robustus*	5.9	0.7	8.43	6
Malvaceae	*Malva verticillata*	2.92	0.5	5.84	7
Cupressaceae	*Cupressus lusitanica*	0.1	1.7	0.06	12
Rosaceae	*Rubus apetalus*	4.69	0.4	11.73	4
Rubiaceae	*Galium asparinoides*	1.86	0.05	37.5	3
Asteraceae	*Haplocarpha schimperi*	4.66	0.87	5.36	9
Asteraceae	*Cotula cryptocephala*	3.79	0.96	3.95	10
Asteraceae	*Adenostemma caffrum*	0.87	0.01	87	1
Asteraceae	*Sonchus oleraceus*	1.17	0.03	39	2

Grass contributed for the highest percentage of utilization (64.14 %) in the foraging of geladas. However, it had lowest percentage preference ratio (0.67 %) when compared to the availability in the habitat. The correlation coefficient between food utilization by geladas and the availability during the wet season was r = 0.99. The result showed that there was a positive or direct relationship between food availability and utilization by geladas. A test of significance of the r value also showed that the correlation coefficient for wet season was significant ($P < 0.05$).

During the dry season, *E. robustus*, *M. verticillata* and pollen of *C. lusitanica* were the most preferred food of geladas. The least preferred species were *T. schimperi* and *A. melonata* (Table 11). Roots, seeds and the remnants of grass blades were the most utilized forage during the dry season (24.43 %, 22.34 % and 20.94 %, respectively).

Table 11. Preference ranking of various food items of gelada based on consumption and availability during the dry season

Family	Food item/forage plant species	%			Preference ranking
		Utilization	Availability	Preference	
Poaceae	Grass blades	20.94	22.5	0.93	7
Aspholedaceae	*Eremurus robustus*	1.05	0.02	52.5	1
Malvaceae	*Malva verticillata*	1.75	0.05	35	2
Cupressaceae	*Cupressus lusitanica*	2.09	0.08	26.13	3
Asteraceae	*Haplocarpha schimperi*	10.12	32	0.32	11
Asteraceae	*Cotula cryptocephala*	12.57	34	0.37	10
Asteraceae	*Adenostemma caffrum*	1.39	0.86	1.62	5
Rosaceae	*Alchemilla abyssinica*	0.69	0.1	6.9	4
Thyme	*Thymus schimperi*	1.22	4.3	0.28	13
Apiaceae	*Agrocharis melonata*	0.52	1.8	0.29	12
Lamiaceae	*Satureja pseudosimensis*	0.87	2	0.43	9
Root	–	24.43	27.8	0.87	8
Seeds	–	22.34	18.9	1.18	6

The correlation coefficient between the availability of food and utilization by geladas during the dry season was r = 0.80. This revealed that there was a positive relationship between food availability and utilization by geladas. Test of significance of the r value also showed that the correlation coefficient for the dry season was significant ($P < 0.05$). However, this preference was independent of the source of energy as neither total carbohydrate content nor protein or lipid content correlates significantly with the diet preferences of geladas. The preference ranking also correlated positively with the water content in the food items Geladas preferred plants with high water content.

Results of the nutritive value of food plants of geladas in GCPA are presented in Table 12. For the crude protein content, *M. verticillata* (27.14 %) and *E. robustus* (18.96 %) scored higher values, while pollen of *C. lusitanica* (4.96 %) and *R. multifidus* (5.25 %) had the least crude protein content. In the case of crude fibre content, *H. schimperi* (48.75 %) and *E. robustus* (46.8 %) had high values, whereas *C. cryptocephala* (18.65 %) had the least crude fibre. Pollen of *C. lusitanica* (2.9 %) and *S. oleraceus* (0.1%) contained the highest and lowest crude fat, respectively. Ash content was more in *C. cryptocephala* (23.1 %) and in *F. macrophyla* (21.68 %).

Table 12. Composition of the nutrient value of food plants preferred by geladas

	Nutrient contents, %				
Forage plant	Protien	Fibre	Fat	Ash	NDF
Ranunculus multifidus	5.25	36.7	4.9	8.1	36.0
Cotula cryptocephala	16.1	18.65	1.65	23.1	17.78
Haplocarpha schimperi	10.21	48.75	2.65	13.2	45.23
Alchemilla abyssinica	9.05	20.61	1.6	16.2	18.2
Agrocharis melonata	12.54	32.1	2.4	21.1	29.0
Cupressus lusitanica (pollen)	4.96	30.35	2.9	10.84	30.0
Eremurus robustus	18.96	46.8	2.35	13.23	44.34
Adenostemma caffrum	15.76	37.5	2.0	17.62	33.46
Malva verticillata	27.14	45.0	1.7	19.58	41.83
Galium asparinoides	16.93	39.25	1.15	16.86	34.17
Festuca macrophyla	6.71	36.15	0.15	21.68	30.6
Sonchus oleraceus L.	5.54	44.4	0.1	17.86	39.98
Rubus apetalus	8.21	32.39	1.27	18.56	26.25

(NDF: neutral detergent fibre)

Nutrient content of food items of geladas varied across plant species and their parts (Table 13). For ingested leaf items, the amount of crude protein was significantly high in the leaf of *M. verticillata* (27.14 %), and low in *F. macrophyla* (6.71%). Leaf of *H. schimperi* contained high crude fibre and fat accounting for 48.75 % and 2.65 %, respectively. However, crude fibre and fat in *A. abyssinica* and *F. macrophyla* had the lowest concentration of 20.61% and 0.15 %, respectively. Ash content was high in *F. macrophyla* leaf (21.7 %) and low in *H. schimperi* leaf (13.2%). Similarly, neutral detergent fibre content was more in leaf of *H. schimperi* (45.23 %) and less in *A. abyssinica* (18.2%).

Stem of *E. robustus* contained higher crude protein, fibre, ash and NDF contents. Stem with leaf of *G. asparinoides*, contained higher crude fibre and NDF. In samples of root, pollen and fruit of *R. apetalus*, crude protein was high (8.21%), and low in pollen *C. lusitanica* (4.96 %).

The root of *S. oleraceus* contained high crude fibre and NDF, which accounted for 44.4 % and 39.98%, respectively. However, it contained the lowest crude fat (0.1%). The nutrient composition varied significantly ($P < 0.01$) with plant and with the specific parts of the species.

Table 13. Percentage composition of the nutrient value of food items of geladas

Species	Plant parts	Nutrient (%)				
		Protein	Crude fibre	Crude fat	Ash	NDF
Haplocarpha schimperi	leaf	10.21	48.75	2.65	13.2	45.23
Alchemilla abyssinica	leaf	9.05	20.61	1.6	16.2	18.2
Agro charis melonata	leaf	12.54	32.1	2.4	21.1	29.0
Adenostemma caffrum	leaf	15.76	37.5	2.0	17.6	33.46
Malva verticillata	leaf	27.14	45.0	1.7	19.6	41.83
Festuca macrophyla	leaf	6.71	36.15	0.15	21.7	30.6
Ranunculus multifidus	stem	5.25	36.7	4.9	8.1	36.0
Eremurus robustus	stem	18.96	46.8	2.35	13.2	44.34
Cotula cryptocephala	leaf/stem	16.1	18.65	1.65	23.1	17.78
Galium asparinoides	leaf/stem	16.93	39.25	1.15	16.9	34.17
Sonchus oleraceus L.	root	5.54	44.4	0.1	17.9	39.98
Cupressus lusitanica	pollen	4.96	30.35	2.9	10.8	30.0
Rubus apetalus	fruit/seed	8.21	32.39	1.27	18.6	26.25

(NDF: neutral detergent fibre)

The variation of crude protein of food items of geladas is given in Figure 19. Leaves and stems contained significantly higher amount of crude protein than root, fruit and pollen ($\chi^2 = 22.36$, df = 3, $P < 0.001$) (Fig. 19a). In leaves, or stem and root items, the amount of crude fibre was significantly high ($Z = 2.07$, $P = 0.046$, $n = 10$, and $Z = 2.02$, $P = 0.042$, respectively) (Fig. 19b). Crude fat was significantly high in stem and pollen samples ($\chi^2 = 3.76$, df = 4, $P< 0.05$), but low in root ($Z = 2.04$, $P = 0.043$, $n = 2$ (Fig. 19c). As Figure 19 d shows, the amount of ash in stem and leaves could be slightly higher than other food samples. Leaves and stems contained higher amounts of NDF than other food samples ($Z = 1.82$, $P < 0.05$, $n = 4$ (Fig. 19e).

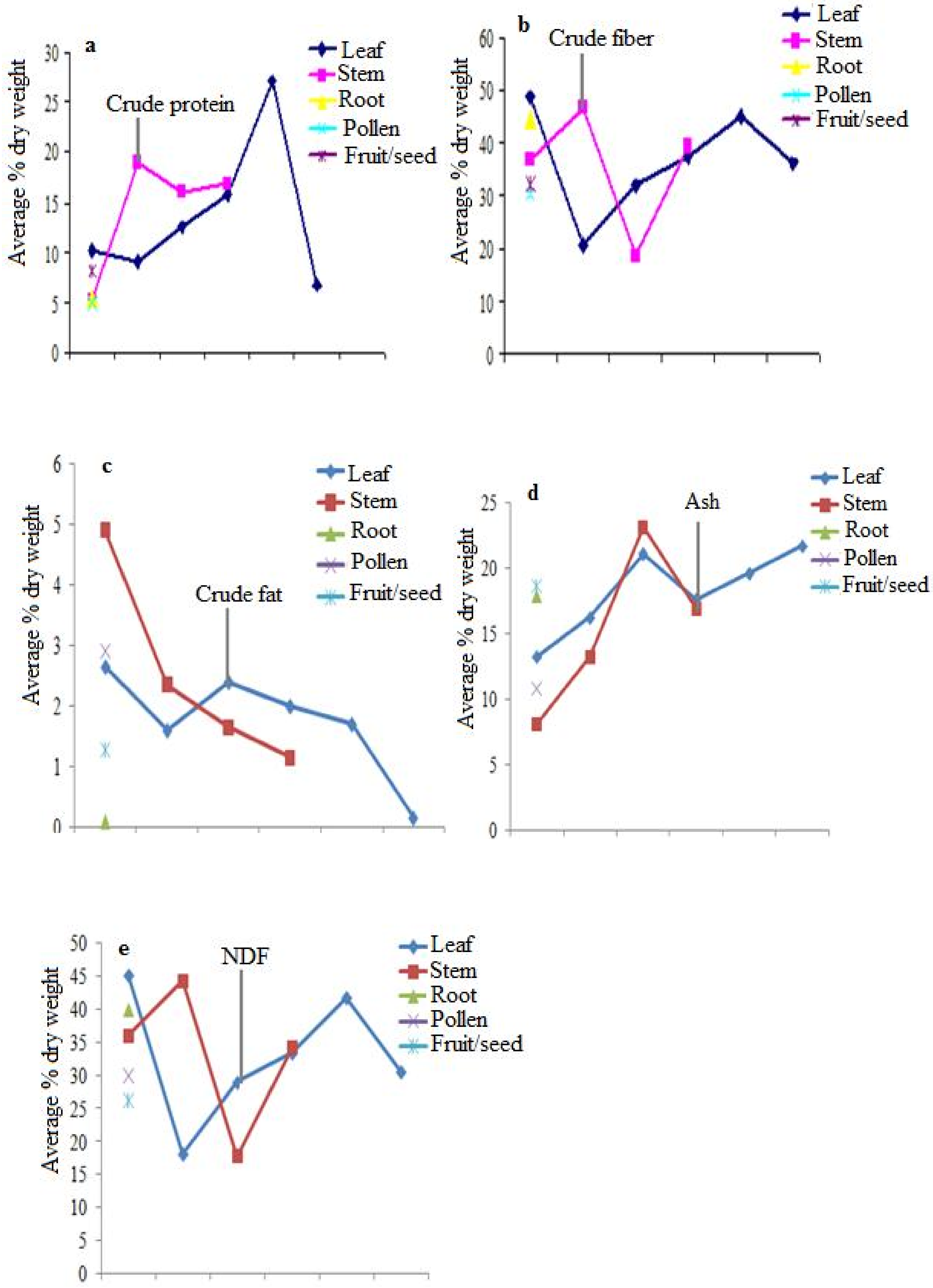


Figure 19. Variations of macronutrients in the sampled food items of geladas. (Leaf (n = 6); stem (n = 4); root (n = 1); pollen (n = 1); fruit/seed (n = 1).

3.4. Ranging Behaviour

Based on minimum convex polygon (MCP) method, the home range areas of gelada groups (1, 2 and 3) over the course of the study period were found to be 16.9 and 7.3 ha, for group one, 42.9 and 6.4 ha, for group two, 11.6 and 7.8 ha, for group three during dry and wet seasons, respectively (Fig. 20). The wet and dry season home range areas of the study groups are given in Table 14.

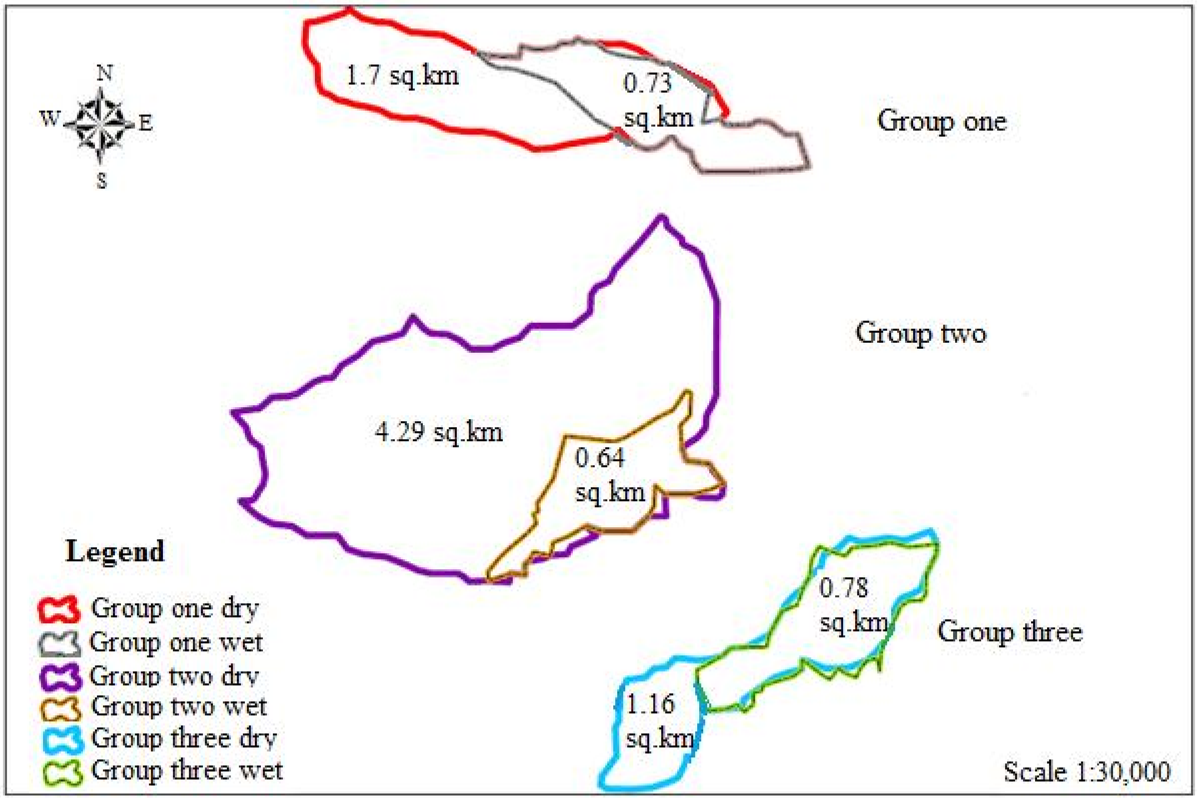


Figure 20. Wet and dry home range sizes of the study units of geladas using minimum convex polygon (MCP) method.

The home ranges of the study units were more extended during the dry season than the wet season. Results of Mann-Whitney U test showed significant difference in the home range size of the units between seasons ($P< 0.05$). The three study units occupied their own home range areas throughout the year with non-overlapping home ranges.

The average daily range length of units 1, 2 and 3 during the period of the study was 1082 m (range 900 – 1250 m, SD ± 126.4), 2460 m (range 1, 846 – 5,272 m, SD ± 1329.35) and 4280 m (range 3480 – 5065 m, SD ± 620.78), respectively. The mean daily range lengths of the three study units combined were 2607.33 m. The mean daily travel distance of unit 1 in the dry season (mean= 1,205.2 m, n = 10, SD = 40.71) was greater than that of the wet season (mean = 946.6, n= 13, SD = 25.31). There was significant difference in the daily distance travelled between the seasons (t = 2.55, df = 22, P = 0.63). Similarly Mann-Whitney U test showed significant difference in the mean daily travel distance of study units (2 and 3) between the wet and dry seasons (P< 0.05). The average daily range lengths and home range size for the wet and dry seasons are given in Table 14.

Table 14. Mean daily travel distance and home range size of gelada units 1, 2 and 3 during wet and dry seasons.

		Mean daily travel distance, m		Home range area, ha
Seasons	Units	Mean	SD	
Dry	1	1,205.2 (10)	40.71	16.9
	2	5,153.8 (14)	137.5	42.9
	3	5022.7 (12)	31.87	11.6
Wet	1	946.6 (13)	25.31	7.3
	2	1863.6 (13)	29.47	6.4
	3	3498 (10)	8.68	7.8

(Figures in parenthesis are number of observations of travel distance)

The band size and travel distances of geladas were found to have direct correlations. They travel longer distances when the group size was larger, and move shorter distance when the band size was small. Correlation coefficient between band size and travel distance was r = 0.97 (Fig. 21). Daily range direction of geladas was affected by wind as the direction was usually determined by the direction of the wind blow.

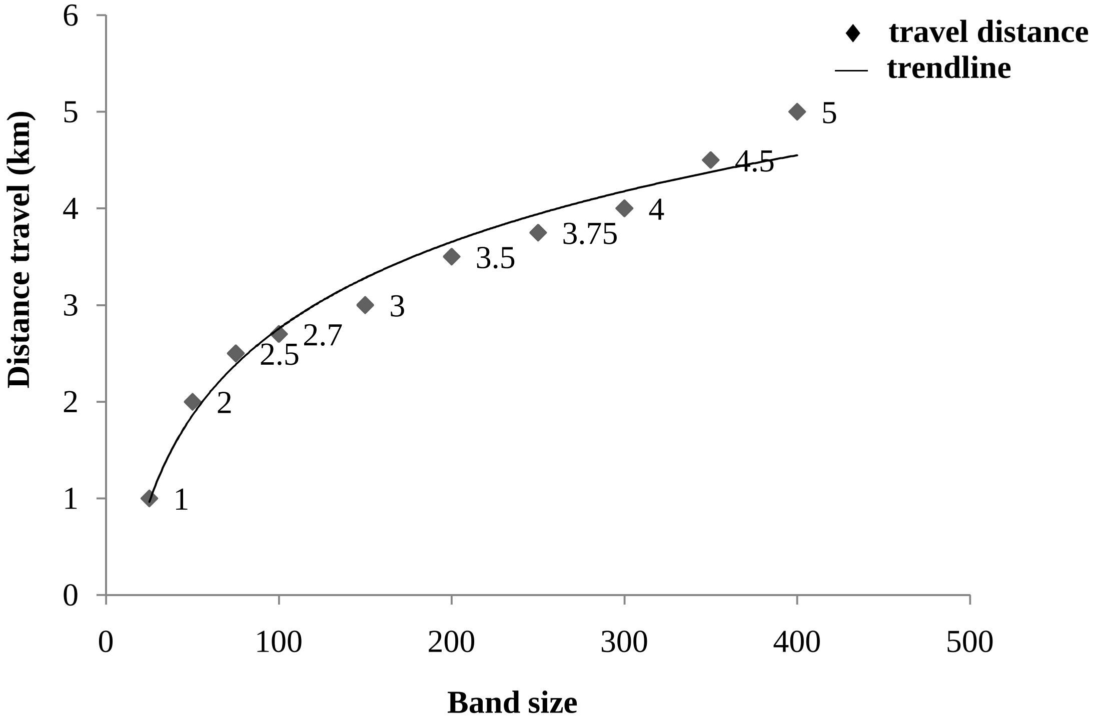


Figure 21. Band size and travel distance of geladas in the study area

3.5. Phytobiomass and carrying capacity of grassland community

Table 15 shows monthly variations in the phytobiomass values of fleshy grasses, litter biomass, dry weight per hectare and dry biomass of the grassland in the study area. The green biomass of grasses in the study area showed increase during August (1,440 g/m^2). However, during September to May, a gradual decrease in the green biomass was observed, and similar trends in the dry phytobiomass was also observed during the study period. It showed minimum values (120 g/m^2) and (1,200,000 g/m^2) in March per quadrat and hectare, respectively. Thereafter, the value increased and showed the peak during the month of August (700 g/m^2). The dry biomass in the area exhibited an increasing trend from June to August with a difference of 200 g/m^2. Thereafter the value declined from September to May (Table 15).

Table 15. Monthly variation of green and dry biomass per quadrat/hectare of the grass community in the study area

Months	Biomass			Total dry weight of grass community /month g/m^2
	Fleshy weight g/m^2/quadrat	Dry weight g/m^2/quadrat	Dry weight/ hectare g/m^2	
December	460	180	18×10^5	15588×10^5
January	560	280	28×10^5	24248×10^5
February	310	180	18×10^5	15588×10^5
March	240	120	12×10^5	10392×10^5
April	210	150	15×10^5	1299×10^6
May	360	140	14×10^5	12124×10^5
June	1200	500	51×10^5	44166×10^5
July	1100	540	54×10^5	46764×10^5
August	1440	700	70×10^5	6062×10^6
September	720	300	30×10^5	2598×10^6
October	700	280	28×10^5	24248×10^5
November	500	200	20×10^5	1732×10^6

∗ Fleshy and dry phytbiomass are average of phytobiomass taken from seven quadrats. Quadrat size = 1 ×1 m^2 (1 hectare = 100 ×100 m^2)

∗ Total area of grassland community with the mixed habitat type is 866 hectares.

Data presented in Figure 22 shows monthly changes in the green phytobiomass of different quadrats during different months of the year. The main growth period of the above ground green phytobiomass was during the rainy season. Peak value of green biomass was 1440 g/m^2 during August, and that accounts for 18.46% of the total annual green biomass production. High green biomass was also recorded in June (1200 g/m^2) and July (1100 g/m^2) and contributed for 15.38% and 14.10% of the total annual green biomass, respectively. The lowest green biomass was recorded in April (210 g/m^2) that contributed for 2.69% of the annual green biomass (Fig. 22). There was a significant difference in the green biomass production between months per quadrats ($P < 0.001$).

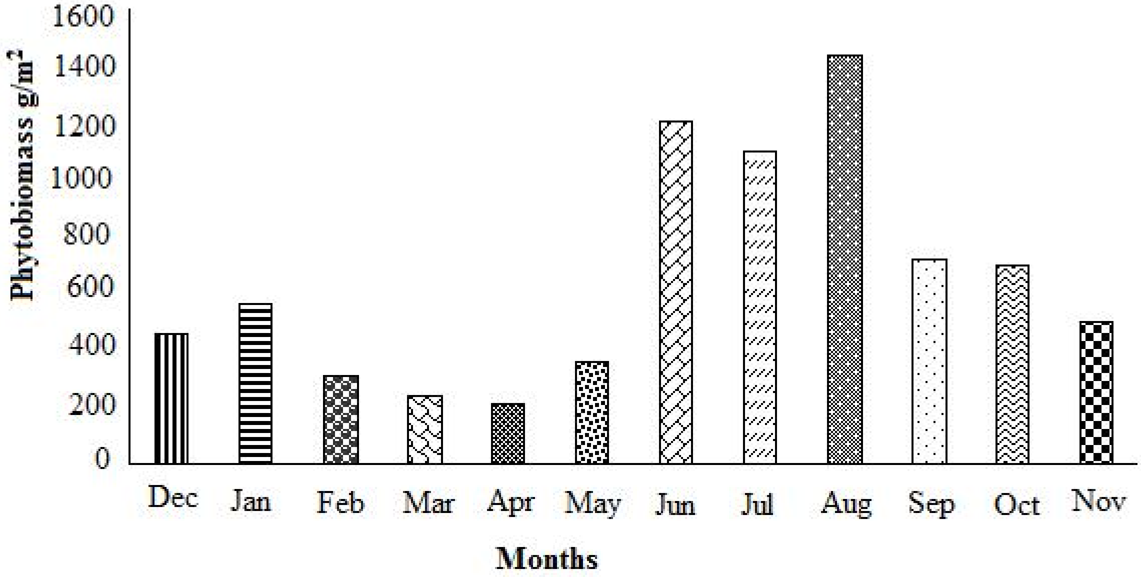


Figure 22. Monthly variations in the green grass biomass (g/m^2) per quadrat during different months of the year

Peak values of dry biomass per quadrat (700 g/m^2) was recorded in August, followed by 540 g/m^2) in July and 500 g/m^2 in June (19.61%, 15.13 % and 14.01%, respectively). The lowest dry biomass (120 g/m^2) was recorded in March, which contributed 3.36% of the annual dry biomass per quadrat. Monthly variation in the dry biomass per quadrat was statistically significant ($P < 0.05$). Maximum transfer was recorded during the wet season (464 g/m^2) per quadrat, and it showed an increase of 285.4 g/m^2 from the average shared during the dry season (178.6 g/m^2) (Fig. 23).

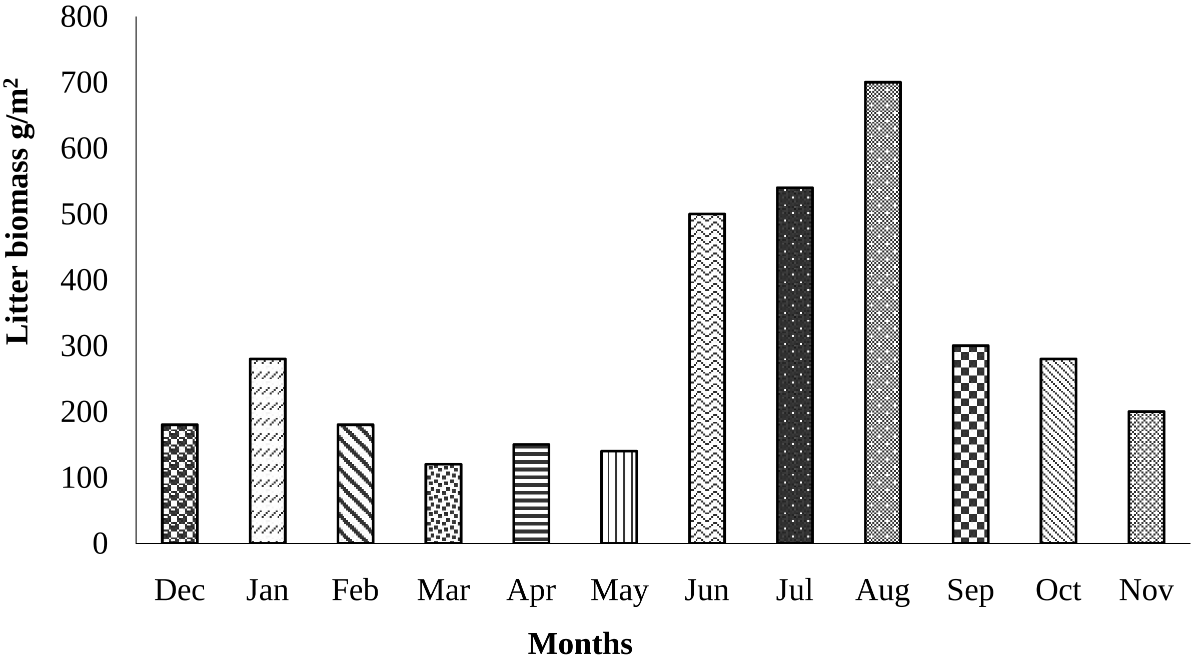


Figure 23. Monthly variation in dry biomass (g/m^2) per quadrat during different months of the year

The analysis of variance showed a significant difference between the dry biomass per hectare in different months (F = 8.5, df = 12, $P < 0.01$). Maximum production and rate of productivity of dry biomass was recorded in August (70×10^5 g/m^2) and minimum in March (12×10^5 g/m^2). A significant increase of dry biomass was also recorded in July and June accounting for 54×10^5 g/m^2 and 51×10^5 g/m^2, respectively. The variation in dry biomass per quadrat between wet and dry months was statistically significant ($P < 0.05$). However, the difference in the dry biomass between June and July did not show a significant difference ($P > 0.05$). Similarly variations in dry biomass between March – May and April – May were not statistically significant ($P > 0.05$) (Fig. 24).

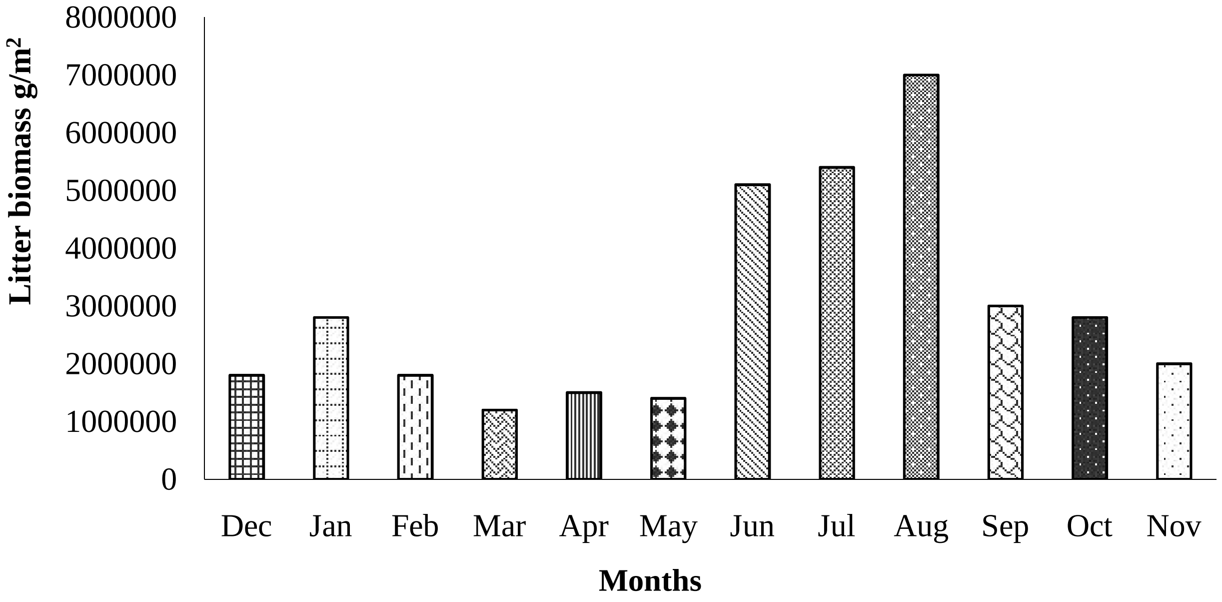


Figure 24. Monthly variation in total dry biomass (g/m^2) per hectare during different months of the year

During the present study, the dry matter production and carrying capacity were high in August and low in March (Table 16). Carrying capacity on the basis of gelada units (1 unit = 12−18 individuals) was highest in August (610 individuals per hectare) and lowest in March (39 individuals per hectare). In this case, the carrying capacity was statistically significant (χ^2 = 502, P < 0.001) between wet and dry seasons. The dry matter intake per individuals of geladas ranged between 369.9–971.6 g/day. The average requirement of dry matter intake per gelada per day was statistically different between wet and dry months (χ^2 = 268, P < 0.001). The dry matter intake of gelada was also statistically different between dry and wet months (P < 0.05).

The GCPA can support a large number of geladas. Thus, for the estimated geladas in the study area (nearly 1502 individuals), dry matter intake of the whole population was much less than its carrying capacity. Based on the data presented in Table 16, the area can support large number of gelada population (nearly 528, 260 individuals) in August. In contrast, the lowest carrying capacity of the area was estimated for the month of March with 33,774 individuals. Thus, the carrying capacity of the area for the gelada population was significantly different between months ($P < 0.05$).

Table 16. Dry matter production, intake and carrying capacity of the grass community to support gelada population in the study area

Months	Dry matter yield (g/ m^2/ha)	Total dry matter yield (g/m^2)/866 ha	Dry matter intake (g/ gelada/day)	Dry matter intake (g/ gelada/month)	Carrying capacity (gelada/ha)	Carrying capacity (gelada/ 866 ha) G
December	18×10^5	15588×10^5	971.6	30,119.6	59	51,094
January	28×10^5	24248×10^5	971.6	30,119.6	92	79,672
February	18×10^5	15588×10^5	971.6	27,204.8	66	57,156
March	12×10^5	10392×10^5	971.6	30,119.6	39	33,774
April	15×10^5	1299×10^6	971.6	29,148	51	44,166
May	14×10^5	12124×10^5	971.6	30,119.6	46	39,836
June	51×10^5	44166×10^5	369.9	11,097	459	397,494
July	54×10^5	46764×10^5	369.9	11,466.9	470	407,020
August	70×10^5	6062×10^6	369.9	11,466.9	610	528, 260
September	30×10^5	2598×10^6	369.9	11,097	270	233,820
October	28×10^5	24248×10^5	369.9	11,466.9	244	211,304
November	20×10^5	1732×10^6	971.6	29,148	68	58,888

G The total area of grassland community with mixed habitat types was 866 hectares. G Daily dry matter intake of gelada is adapted from values derived from field studies by Dunbar (1977) and Iwamoto (1979) i.e, 1.37 g/minute × percent of 12 h feeding for the wet season, and 2.8 g/minute × percent of 12 h feeding for dry season.

3.6. Land-use/land-cover changes in GCPA

Land-use/land-cover maps of GCPA of the years 1986, 2002 and 2013 are shown in Figure 25.

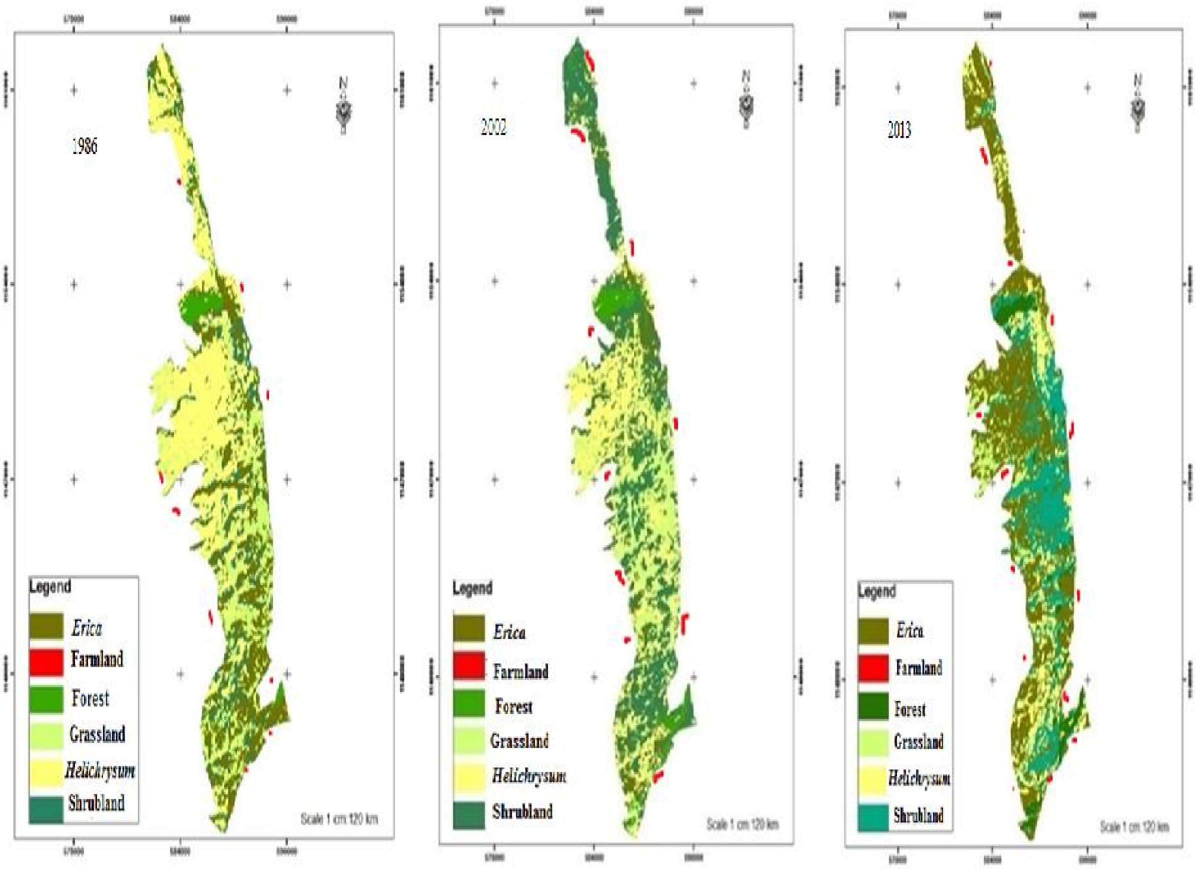


Figure 25. Land-use/land-cover maps of the study area for the years 1986, 2002 and 2013.

Table 17 shows the change detection made based on the classified images of 1986 and 2002. Forest class change with corresponding classes accounted for 0.56 km^2. The highest transition was 0.45 km^2, specifically to shrubland. Class change of grassland with the corresponding classes was 6.62 km^2 and the highest transition was 3.75 km^2, particularly to *Helichrysum*. *Helichrysum* land-use change was 15.24 km^2 with the highest transition of 10.26 km^2 to shrubland. Farmland land-use change with the corresponding classes was 0.01 km^2, shrubland 4.05 km^2 and *Erica* 18.29 km^2. The highest transitions for the corresponding classes were 0.01, 1.56 and 8.08 km^2 into shrubland, *Erica* and shrubland, respectively. Land-use/land-cover categories, which showed increase were open forest, farmland and shrubland, accounting for 0.86 km^2, 0.11 km^2 and 16.55 km^2, respectively.

The average rate of change of forest into corresponding classes was 0.04 km^2/year, average annual rate of change of shrubland into corresponding classes was 0.34 km^2/year and nil transition of farmland into corresponding classes. On the other hand, the land-use/land-cover categories like grassland, *Helichrysum* and *Erica* vegetation showed decreasing patterns acounted to – 0.27 km^2, –3.27 km^2 and –14 km^2, respectively. The average rates of change for these LU/LC classes were 0.55 km^2/year, 1.27 km^2/year and 1.52 km^2/year, respectively. Among the natural vegetation cover types, *Erica* and *Helichrysum* experienced the lowest persistence, whereas shrubland and forest were the most persistent cover types in the study area (Table 17).

Table. 17. Land-use/land-cover changes in the study area during 1986–2002

		1986 Area (km^2)							
		Forest	Grassland	*Helichrysum*	Farmland	Shrubland	*Erica*	Row Total	Class Total
2002	Forest	**2.42**	0.22	0.19	0	0.83	0.19	3.85	3.85
	Grassland	0.03	**6.39**	2.91	0	0.55	2.9	12.78	12.78
	Helichrysum	0.05	3.75	**14.83**	0	1.1	7.11	26.84	26.84
	Farmland	0	0.03	0.06	**0.01**	0.01	0.01	0.12	0.12
	Sherubland	0.45	1.73	10.26	0.01	**11.21**	8.08	31.76	31.76
	Erica	0.03	0.89	1.82	0	1.56	**2.43**	6.73	6.73
	Class total	2.98	13.01	30.07	0.02	15.26	20.72		
	Class change	0.56	6.62	15.24	0.01	4.05	18.29		
	Image difference	0.86	-0.27	-3.27	0.11	16.55	-14.04		

Overall accuracy = 89 %

Table 18 shows land-use/land-cover changes of the years 2002 and 2003. Among the changes, grassland change with the corresponding classes accounted for 11.65 km^2, and the highest transition was 5.04 km^2 to shrubland. The forest class change into the corresponding classes was 1.30 km^2, and the highest transition was to shrubland. *Helichrysum* class change with corresponding classes accounted for 23.91 km^2, with the highest transition of 6.45 km^2 to *Erica*. Farmland land-use change with the corresponding classes was 0.12 km^2, shrubland (22.84 km^2) and *Erica* (4.2 km^2). The highest transitions of farmland, shrubland and *Erica* were 0.08 km^2, 13.2 km^2 and 2.14 km^2 into *Erica*, *Erica* moorland and *Helichrysum*, respectively.

The land-use/land-cover categories, which showed increase in open forest and *Erica* vegetation accounted for 0.95 km^2 and 30.15 km^2, respectively. The average rates of change of forest and *Erica* into corresponding classes were 0.1 km^2/year and 0.34 km^2/year, respectively. Contrary to this, the land-use/land-cover categories like grassland, *Helichrysum*, farmland and shrubland showed decreasing patterns which accounted for – 8.33 km^2, –12.22 km^2, – 08 km^2 and –10.73 km^2, respectively during the period from 2002–2013. The average rates of change for these LU/LC classes were 0.95 km^2/year, 1.9 km^2/year, 0.01 km^2/year and 1.87 km^2/year, respectively (Table 18).

Table. 18. Land-use/and land-cover change analysis for the period 2002–2013.

		2002 Area (km^2)							
		Grassland	Forest	*Helichr-ysum*	Farmland	Sherubland	*Erica*	Row Total	Class Total
2013	Grassland	**1.36**	0	2.76	0	0.41	0.1	4.63	4.63
	Forest	0.53	**2.54**	0.18	0	1.4	0.13	4.78	4.78
	Helichrysum	1.94	0.32	**2.9**	0.01	7.44	2.14	14.75	14.75
	Farmland	0.01	0	0.02	**0.03**	0	0.01	0.07	0.07
	Shrubland	5.04	0.76	4.5	0.01	**8.98**	1.74	21.03	21.03
	Erica	3.91	0.22	16.45	0.08	13.2	**2.94**	36.8	36.8
	Class total	12.79	3.84	26.81	0.13	31.43	7.06		
	Class changes	11.45	1.30	23.91	0.10	22.45	4.12		
	Image difference	-8.33	0.95	-12.22	-0.08	-10.73	30.15		

Overall accuracy = 94 %

Table 19 shows a comparison of LU/LC classes of habitat types and changes from 1986 to 2013. Forest class change with the corresponding classes accounted for 1.12 km^2, grassland

12.33 km^2, *Helichrysum* 27.35 km^2, farmland 0.01 km^2, shrubland 8.55 km^2 and *Erica* 11.56 km^2. The highest transition during this period was 20.06 km^2 in *Helichrysum* to *Erica*, followed by *Erica* (5.82 km^2) to shrubland. The LU/LC categories showed increase for forest, farmland, shrubland and *Erica*, which accounted for 1.81 km^2, 0.03 km^2, 5.82 km^2 and 16.11 km^2, respectively. The average rate of change of forest into corresponding classes was 0.09 km^2/year, shrubland 0.71 km^2/year and *Erica* 0.96 km^2/year. On the other hand, LU/LC categories like grassland and *Helichrysum* showed decreasing patterns that accounted for – 8.6 km^2 and –15.49 km^2, respectively. The average rates of change for these LU/LC classes were 1.03 km^2/year and 2.3 km^2/year, respectively. Of the natural vegetation cover types, *Helichrysum* and grassland experienced low persistency, whereas forest was the most persistent cover type in the study area. The net change to persistence ratio is closer to zero for farmland, indicating that the extent of farmland has been constant. Overall, 21.29 % (i.e., sum of diagonal elements) of the total landscape remains unchanged (Table 19).

Table. 19. Land-use/land-cover change analysis for 1986–2013.

		1986 Area (km^2)							
		Forest	Grassland	*Helichrysum*	Farmland	Sherubland	Erica	Row Total	Class Total
2013	Forest	**1.86**	0.45	0.24	0	1.68	0.54	4.77	4.77
	Grassland	0	**0.74**	3.51	0	0.05	0.41	4.71	4.71
	Helichrysum	0.25	3.11	**2.73**	0	3.87	4.78	14.74	14.74
	Farmland	0	0.02	0.01	**0.01**	0	0.01	0.05	0.05
	Shrubland	0.64	4.5	3.53	0	**6.72**	5.82	21.21	21.21
	Erica	0.23	4.25	20.06	0.01	2.95	**9.23**	36.73	36.73
	Class total	2.98	13.07	30.08	0.02	15.27	20.79		
	Class changes	1.12	12.33	27.35	0.01	8.55	11.56		
	Image difference	1.81	-8.6	-15.49	0.03	5.82	16.11		

Overall accuracy = 96 %

A total area of 6.67 km^2 grassland habitat has been changed into different land-use types between 1986–2002, whereas the unchanged extent was 6.39 km^2. Because of serious effect of drivers such as anthropogenic and climatic factors, the unchanged grassland into different land-use types had decreased into 1.36 km^2 and 0.74 km^2 during the periods 2002–2013 and 1986–2013, respectively. On the other hand, change of grassland into different land-use types had increased from 6.67 km^2 to 13.06 km^{2,} between 1986 and 2013. As compared to the unchanged grassland during the three periods of analysis, in 1986–2002 grassland cover was in a better condition, which was 6.39 km^2. However, in relation with gelada home range size, it was not sufficient, and it might support only 3 to 4 bands of geladas with an average home range size nearly, 0.72 and 2.4 km^2 during wet and dry seasons, respectively. The grassland cover has seriously decreased during the periods 2002–2013 and 1986–2013 directly affecting geladas' feeding, and gelada bands negatively that depend on the grassland habitat (Table 20).

Table 20. Grassland habitat changes and gelada home range size in GCPA during wet and dry seasons.

		Area changed (km^2)			Gelada home range (km^2)	
Habitat	Class type	1986–2002	2002–2013	1986–2013	Wet	Dry
Grassland	Forest	0.22	0.53	0.75	0.72	2.4
	Helichrysum	3.75	1.94	5.69		
	Farmland	0.03	0.01	0.04		
	Shrubland	1.71	5.0	6.71		
	Erica	0.83	1.91	2.74		
	Unchanged	6.39	1.36	0.74		
Total changes		6.67	11.65	13.06		

3.7. Findings from questionnaire survey

Among the 270 respondents interviewed, 159 (59.1%) were males and 111 (41.1%) were females. Among them, 147 (54.4%) were of< 20 years old, 44 (16.3%) were of between 36–50 years, 42 (15.2 %) were of between 21–35 years, 27 (10.0 %) were of between 51– 65 years and 10 (4.1 %) were > 66 years old.

Among the respondents, 139 (51.4 %) had no education at all, 34 (12.6 %) attained informal education, 82(30.4 %) had primary level education, 15 (3.1 %) had secondary education and 6 (2.1 %) had attained tertiary level education. There was a significant difference ($\chi^2 = 139$, df = 4, $p < 0.001$) in the educational status among the respondents of the present investigation (Table. 21).

Table 21. Age category and education levels of the respondents of the present study

Age category	N	Level of education, %				
		Illiterate	Informal	Primary	Secondary	Tertiary
< 20	147	3.4	6.1	81.6	8.2	0.7
21-35	42	30.9	14.3	42.9	4.8	7.1
36-50	44	63.6	15.9	13.6	2.3	4.5
51-65	27	88.9	7.4	3.7	-	-
> 66	10	70	20	10	-	-
Total/average	270	51.4	12.7	30.4	3.1	2.4

Results of the present study have revealed that 52 (19.3 %) of the respondents depend on farming, 13 (4.8%) were engaged in animal husbandry, 158 (58.5 %) depended on both farming and livestock rearing and 47 (17.4 %) depended on other economic activities (Fig. 26). The majority of the respondents were mixed farmers, while few were engaged in animal husbandry. There was a significant difference among the livelihood activities of the respondents ($\chi^2 = 56$, df = 4, $p < 0.05$).

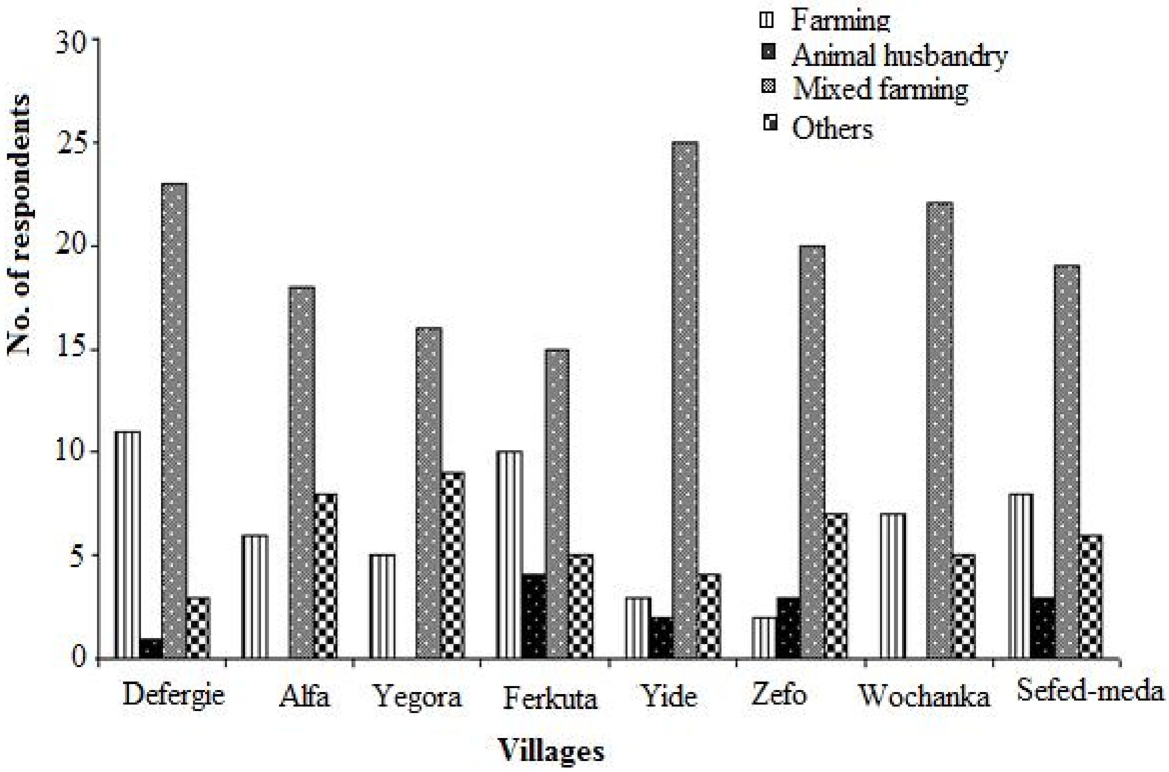


Figure 26. Livelihood activities of the respondents in each of the villages in the study area

The overall mean land holding per household in the study area was 1.14 hectare (Table 22). However, the average land holding per household varied among respondents of the study area. Results of the t-test showed statistically significant difference in the extent of land holding by the respondents between villages ($t_8 = 12.75$, df = 7, $P < 0.05$). Average crop yield also varied among respondents in the village. The respondents have revealed the use of modern technologies (selective seeds, fertilizers and pesticides) in each of the villages. The average annual crop yield per household was significantly different ($t_8= 10.5$, df = 7, $p < 0.001$) between respondents in the present study area. Additional average income per respondents was also significantly different between villages ($t_8 = 6.52$, df = 7, $P < 0.001$).

Table 22. Average land holding, annual crop yield and additional income per household in the study villages

Villages/study sites	Average land holding per household (hectare)	Average annual crop yield per household (kg)	Additional annual average income per household (in birr)
Defergie	1.5 ±0.10	650 ±72.94	462±55.72
Alfa	1.2 ±0.14	720± 50.92	375±90.94
Yegora	0.9 ±0.09	912 ±62.39	726.5 ±85.92
Ferkuta	1.4 ±0.11	1100 ± 117.85	210±80.74
Yide	0.81 ±0.06	713 ± 61.12	823±93.84
Zefo	0.91 ±0.07	1066±116.98	534.2±92.75
Wochanka	1.3 ±0.15	840 ±84.60	672.4± 66.34
Sefed-meda	1.1 ±0.12	1341 ±109.08	267.8±57.22

The herd structure of livestock and composition of the study sites are shown in Table 23. The average livestock holding per village was 46.87 ± 30.60 cattle, 131.37 ± 83.16 sheep, 55.13 ± 37.66 goats, 17.63 ± 9.35 donkeys and 10.25 ± 7.54 horse/mule. Sheep (50.29 %) was the main livestock type reared by the respondents and was used primarily for commercial purpose for livelihood income. Horse/mule was the least reared livestock type in the area, which accounted for 3.9 %. The number of livestock was statistically significant between villages ($\chi^2 = 553.18$, df = 7, $P < 0.001$). The number of each of these livestocks also showed statistically significant difference among respondents ($P < 0.05$).

Table 23. Number of livestock in each of the villages of the study area.

Villages	Cattle	Sheep	Goat	Donkey	Horse/mule	Total
Defergie	112	195	118	24	5	454
Alfa	37	75	26	15	13	166
Yegora	53	147	94	17	3	314
Ferkuta	65	250	57	34	23	429
Yide	36	220	41	23	19	339
Zefo	24	61	73	9	3	170
Wochanka	15	26	12	4	6	63
Sefed meda	33	77	20	15	10	155
Total	375	1051	441	141	82	2090

The average family size of the respondents was 5.05 per household. However, the mean family size per household varied among the study sites. It was 6.1 members in Defergie, 5.1 in Alfa, 4.6 in Yegora, 5.4 in Ferkuta, 5.7 in Yide, 4.9 in Zefo, 3 in Wochanka and 4.7 in Sefed-meda. The result of the analysis shows that the mean family size per respondents between study sites varied statistically ($P < 0.05$).

The local community harvest different resources including grass and firewood from Guassa area. Cattle and other livestock graze in the Guassa area, especially during the dry season. On an average, 32.7% of the respondents grazed their livestock in the study area (Table 24). Resource utilization among the villages significantly differed ($\chi^2 = 24.32$, df = 6, $P < 0.05$). The level of utilization of the area among the respondents for grazing livestock ($\chi^2 = 13.1$, df= 7, $P < 0.05$) for firewood ($P < 0.05$), *Festuca* grass ($P < 0.01$), medicinal plants ($P < 0.05$) and water ($P < 0.05$) were statistically significant. However, utilization of the area as a source of additional income from tourism did not show significant difference ($P > 0.05$) between respondents.

Table 24. Percentage of resource utilization by the respondents among different villages.

			Use of resources, %					
Village	270 (n)	Grazing livestock	Fire-wood	*Festuca* grass	Medicinal plant	Water	Rain	Income from tourism
Defergie	29	37.9	20.7	31	0	6.9	3.4	0
Alfa	37	45.9	18.9	24.3	0	8.1	2.7	0
Yegora	34	38.2	20.6	32.4	2.9	5.9	0	0
Ferkuta	33	36.4	24.2	30.3	0	3	6.1	0
Yide	32	34.4	18.8	28.1	0	9.4	6.3	3.1
Zefo	35	0	34.3	48.7	2.8	5.7	8.5	0
Wochanka	34	35.3	17.6	26.5	0	11.8	5.9	2.9
Sefed meda	36	33.3	22.2	27.7	2.8	8.3	5.6	0
Mean		32.7	22.1	31.1	1.06	7.4	4.8	0.75

Data on threat of wildlife as revealed by the respondents are given in Table 25. The threats included crop damage, livestock depredation and both crop damage and livestock predation. Among the respondents, 61.9 % reported both crop damage and livestock predation. Difference in crop damage, livestock depredation and both crop damage and livestock depredation caused by wildlife were statistically significant ($\chi^2 = 13.4$, df = 7, $P < 0.05$, $\chi^2 = 9.0$, df = 7, $P < 0.05$, $\chi^2 = 7.4$, $P < 0.05$, respectively). Most of the respondents from all villages faced problems of both crop damage and livestock predation.

Table 25. Percentage of respondents that faced different conflicts by wildlife (n = 270).

Villages	Distance from the protected area (km)	Respondents, %			
		Crop damage	Livestock predation	Both crop damage & livestock predation	No conflict
Defergie	1-2	17.2	10.3	72.4	0.0
Alfa	2-3	21.6	8.1	64.9	5.4
Yegora	0-2	14.7	17.6	67.6	0.0
Ferkuta	2-3	33.3	9.1	45.5	12.1
Yide	1-3	25.0	15.6	59.4	0.0
Zefo	3-5	17.0	20.0	62.9	0.0
Wochanka	0-2	29.4	14.7	55.9	0.0
Sefed-meda	1-3	19.4	13.9	66.7	0.0
Mean		22.2	13.7	61.9	2.18

The respondents noted that in all villages crop damage by geladas has increased during the last three years. Out of the 270 respondents, 85 % reported that the trend is increasing. This opinion of the respondents did not differ significantly among the study villages ($\chi^2 = 0.42$, df = 7, $P > 0.05$). Only 7.6 % of the respondents noted that the trend of crop damage by geladas was decreasing. Few respondents from different villages reported that they do not know the reason and the trend of crop damage by geladas (Table 26).

Table 26. Approximate distance from the protected area and the trends in crop damage by geladas in the last three years (n = 270)

Villages	Distance from the protected area (km)	Crop damage, %		
		Increase	Decrease	Unknown
Defergie	1-2	89.6	3.4	6.9
Alfa	2-3	78.4	8.1	13.5
Yegora	0-2	91.2	2.9	5.9
Ferkuta	2-3	84.8	9.1	6.1
Yide	1-3	90.6	3.1	6.3
Zefo	3-5	71.4	22.9	5.7
Wochanka	0-2	88.2	2.9	8.8
Sefed-meda	1-3	86.1	8.3	5.6
Mean		85.0	7.6	7.4

In the present study area, barley was the most cultivated crop. Out of the respondents, 52.6 % reported loss of barley, 27.3 % reported loss of barley and wheat (Table 27). The views of respondents from different villages differed significantly in terms of the type of crop damaged by geladas (F_7 270 = 42.5, $P < 0.001$). Among the villages, the level of loss of barley (χ^2 = 15.4, df =7, $P < 0.05$), wheat ($P < 0.05$), barley and wheat ($P < 0.05$), lentil ($P < 0.05$) and bean and pea ($P < 0.05$) with the loss of other crops were statistically different.

Table 27. Percentage and type of crops damaged by geladas in different villages (n= 270).

	Damage, %				
Villages	Barley	Wheat	Barley & wheat	Lentil	Bean & pea
Defergie	55.2	3	31	0	3.4
Alfa	40.5	13.5	32.4	5.4	8.1
Yegora	70.6	5.9	23.5	0	0
Ferkuta	60.6	6.1	24.2	0	9.1
Yide	56.3	9.4	28.1	0	6.3
Zefo	37.1	17.1	25.7	8.6	11.4
Wochanka	52.9	11.8	17.6	2.9	14.7
Sefed meda	47.2	5.6	36.1	0	11.1
Mean	52.6	9.05	27.3	2.1	8

Locals have adopted various methods to minimize crop damage by geladas in the study area (Table 28). These were guarding (watching, use of dogs); scarecrows, human distress calls and physical barriers such as terracing like walls and fence. In the study area, most respondents reported that guarding was the prominent method in all villages followed by human distress call and scarecrows, respectively (Table 28). There was a significant difference in the use of different techniques to control crop damage in the study area (χ^2 = 82.6, df = 4, $P < 0.05$). Physical barriers were not common in the area to minimize crop damage by geladas.

Table 28. Methods used in the study area to minimize crop damage by geladas (n = 270).

Villages	Techniques of crop protection against the geladas, %				
	Guarding (watching)	Chasing by Guarding dogs	Scarecrows (visual)	Distress calls	Physical barriers
Defergie	93.1	20.7	48.3	62.1	17.2
Alfa	86.5	18.9	40.5	54.1	13.5
Yegora	94.1	14.7	58.8	67.6	5.8
Ferkuta	84.9	6.1	36.4	45.4	9.1
Yide	87.5	3.1	37.5	46.9	6.3
Zefo	80	11.4	42.9	57.1	2.9
Wochanka	91.2	5.8	20.6	35.3	8.8
Sefed meda	83.3	13.9	36.1	41.7	5.6
Mean	87.6	11.8	40.1	51.3	8.6

Majority of the respondents held favourable attitude towards geladas and the protected area (Table 29). Among the respondents, 84.9 % either strongly agreed or agreed with the seven attitude statements. Mean scores on individual attitudinal statements ranged from 3.69 to 4.29 on a 5-point scale. Cronbach's alpha of an index of reliability for geladas and the protected area scale was 0.97, which indicated a high level of internal consistency for the scale with the sample. The mean scale score on a 35-point scale for geladas and the protected area was 28.4. A one-sample t test performed on the scale scores of attitudinal statements revealed that the residents around the protected area had a strong positive attitude towards geladas and GCPA ($P < 0.05$). The views of respondents towards geladas and GCPA are given in Table 29.

Table 29. Views of respondents towards gelada and the protected area

Views of respndents	Response (%)					
	SA	A	NO	D	SD	Mean ± SD
1. The existence of geladas in the area enables to increase tourist flow	28.9	54.1	10.7	4.5	1.8	4.03±0.86
2. Feeding competition is intense between geladas and livestock in the area	23.3	56.3	13.3	5.9	1.2	3.95±0.84
3. Geladas are considered as crop rider/pest in the area	32.6	60.4	5.9	0.7	0.4	4.24± 0.63
4. GCPA was established for the improvement of our society	15.6	49.6	25.9	6.7	2.2	3.69± 0.89
5. The community is highly benefited by GCPA	24.8	67.4	6.7	0.7	0.4	4.16± 0.59
6. I am generally satisfied that my village is located the GCPA	25.7	59.6	11.1	2.9	0.7	4.06± 0.74
7. Generally speaking, I like GCPA and conservation achievement implemented	34.5	61.7	2.4	1.1	0.3	4.29±0.60

(^{a}N =270. SA= strongly agree; A= agree; NO= no opinion; D= Disagree; SD= strongly disagree. ^{b}On a 1-5 scale, a high mean score indicates positive attitude. Respondents were assigned a score of 5 for SA, 4 for A, 3 for NO, 2 for D, and 1 for SD).

In response to the open-ended questions (Appindix-1) ‘if you like geladas and GCPA, why do you like it ?, 56.7 % of the respondents attributed their liking of geladas and the protected area. The attitude of individuals with better educational level was positive towards geladas and protected area compared to those who had no education. In response to the corollary open-ended question to Guassa protected area respondents ‘if you dislike gelada and the protected area, why you dislike it?, 29.6 % of the respondents attributed their dislike due to absence of economic sources, low economic status and low farm size in the area. People who owned enough land were more positive towards the protected area than those who were landless.

Among the respondents, 7.4 % disliked the protected area due to unfair sharing of benefits from tourism, and 24 % of the respondents disliked due to the restriction on resource use.

Logistic regression results have revealed that the respondents, who held positive attitude towards geladas and GCPA were likely to have alternate economic support ($P < 0.05$) and high level of education ($P < 0.05$) (Table 30). Although insignificant, a trend was noticed in low economic status ($P > 0.92$), absence of benefits from tourism ($P > 0.18$), lack of trainings ($P > 0.48$), age ($P > 0.91$), low farm size ($P > 0.26$) and restrictions on resources use ($P > 0.15$) responsible for negative attitude of the respondents towards geladas and GCPA.

Table 30. Logistic regression showing relationship between personal attributes and positive attitude toward the conservation of gelada and the protected area.

	Logistic regression				
Variable	B	SE	T	P	R
Alternative economic support	0.38	0.56	1.94	0.04	0.12
Low economic status	0.69	0.51	4.91	0.92	0.29
Tourism benefits	0.32	0.58	-1.32	0.18	- 0.08
Education (higher)	0.03	0.97	0.10	0.001	0.01
Age (older)	- 0.03	0.64	- 0.11	0.91	- 0.007
Sex (female)	0.50	0.61	2.29	0.12	0.14
Lack of training	- 0.21	0.87	- 0.70	0.48	- 0.04
Small farm size	- 0.32	0.69	-1.14	0.26	- 0.07
Restriction on resource use	- 0.25	0.45	-1.44	0.15	- 0.09

(N = 270. B = logistic regression coefficient, SE = standard error, Wald = Wald statistics, which has a χ^2 distribution), P = significance, and R = R statistic, indicating the relative contribution of each independent variable to the model in explaining the variance of the dependant variable).

3.8. Factors Affecting Community Participation towards Conservation of GCPA

Among the respondents 70.8 % revealed that socio-economic variables contributed a lot for poor participation towards conservation, whereas 19.8% had no opinion about the role of socio-economic variables on conservation (Table 31).

Table 31. View of respondents and the role of socio-economic variables on community participation in conservation in GCPA (n = 270).

Variable	Views of respondents, %				
	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
Education level	25.0	56.3	8.3	6.2	4.1
Low economic status	30.8	57.7	5.8	3.8	1.9
Access to education	18.1	66.3	10.0	3.2	2.4
Lack of training	13.7	62.7	17.6	4.7	1.2
Poor social network	27.1	48.5	13.6	7.8	3.1
Age (older)	21.3	28.0	37.1	11.8	1.7
Sex (female)	14.1	32.2	40.1	10.8	2.8
Small farm size	22.7	41.7	26.5	7.2	1.9
Mean	21.6	49.2	19.8	6.9	2.4

Education was one of the variables that positively influenced community participation in conservation in GCPA. Low economic status has negative effect on participation in conservation. Variables such as training and social network also positively affected conservation ($P < 0.05$). This shows that positive coefficient and correlation of these predictor variables demonstrates that lack of access to education, training and poor social network within the community have negative effects on community involvement in conservation. Similarly, age, sex and small farm size also act as limiting factors for community involvement in conservation in GCPA (Table 32).

Table 32. Logistic regression showing relationship between socio–economic variable and community participation.

	Logistic regression				
Variable	B	SE	T	P	R
Education level	0.41	0.050	6.99	0.00	0.43
Low economic status	- 0.25	0.039	-7.36	0.00	- 0.45
Access to education	0.19	0.043	5.78	0.00	0.37
Lack of training	0.39	0.045	7.22	0.00	- 0.44
Poor social network	0.47	0.050	8.72	0.00	- 0.51
Age (older)	- 0.03	0.035	- 0.06	0.008	- 0.004
Sex (female)	- 0.05	0.038	-1.27	0.002	- 0.08
Low farm size	- 0.16	0.052	-2.79	0.006	- 0.19

(n= 225. B = logistic regression coefficient, SE = standard error, T = t statistics, P = significance, and R = R statistic indicating the relative contribution of each independent variable to the model in explaining the variance of the dependant variable).

3.9. Focus Group Discussion

Focus group discussions have revealed that the present study area provides economic, social and environmental benefits to the local community. Some of the discussants have revealed that they had negative attitude towards larger carnivores and geladas. 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 in GCPA could be effective if the local community and government work with the stakeholders including the local people. However, some of the discussants noted that economic and administrative problems make them to form negative attitude to cooperate in conservation activities. Most of the discussants were dissatisfied about the local administrative management practices towards GCPA.

They also pointed out that the administrative system should be more effective to undertake conservation practices and to maximize the benefits from GCPA. Most of the discussants stated that sustainable use of resources and management practices in GCPA 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 protected area. The discussants believed that alternative economic sources should be developed to control such adverse effects in GCPA. Hence, they seriously demand government intervention for the sustainability of GCPA and the wildlife therein.

4. DISCUSSION

4.1. Demographic structure

In the present study area, the size of the reproductive unit of gelada was not significantly different between seasons. However, there was a difference in the unit size within the band and between seasons. This might be in relation to the variations in food availability between seasons. The variation of the unit size within the band is probably due to the demographic processes related to the unit. Variations in band size between the study sites may be due to the dynamics of individual bands driven by demographic processes. Studies in Semien Mountains National Park in Ethiopia have also revealed similar variations of the band size across populations of geladas due to internal changes (Ohsawa and Dunbar, 1984) that can not be determined by generalized environmental factors such as rainfall and temperature. Moreover, Dunbar (1980) also stated that internal processes like rates of birth and death could affect band sizes of geladas differently over time.

The mean number of reproductive females in the study bands did not show a significant change between seasons. This might be due to the fact that gelada females undergo long period of time in the category of harem, or reproductive females. The sex ratio of the study population also did not show major changes between seasons. This is probably due to sex ratio in the study population is insensitive to environmental variations between seasons. Similar findings were also reported by Ohsawa and Dunbar (1984), who stated that the sex ratio at birth is independent of changes in environmental conditions. In the present study, the number of multimale units varied between seasons. This might be due to the instability of units in relation to food availability during different seasons. During the dry season, resource availability usually decreases, agonistic interactions become intense, and the follower adult and sub-adult males leave their natal unit and join the peripheral males. Contrary to this, during the wet season, some members of all male unit system join reproductive units, when aggressive interactions decrease within the unit. Similarly, Dunbar and Dunbar (1974) and Mori (1979) have noted that acquisition of harems occurs through the entry of males from all male groups into reproductive units, thereby forming multi-male units. It is predicted that many of the variables correlate with each other in a predictable way due to the effect of increasing competition as more males are excluded from reproduction or holding harems. Furthermore, Grueter and Zinner (2004) noted that the change in multi-male units over time is due to ‘freelancers’. Adult males appear to represent prospect future member of the all male unit, and sometimes move with an AMU. They have also close relationship with specific units.

The population growth rate of the present study bands of geladas is slightly higher than that in the Semien Mountains National Park (Ohsawa and Dunbar, 1984). The mean growth rate of the study population was 17.1%. This high annual growth rate may be due to the better conservation practices undertaken in the area through the GCPA. The number of reproductive females per male was minimal, and the average size of females to the male enables to decrease intense competition of females to access male so that it has a great contribution for rapid growth of population of geladas in the study area. Other probable reason for the high annual growth rate of the gelada population might be due to low mortality rate. However, the mean annual growth rate varied from one study band to the other. This might be due to the variation in the overall environmental factors such as food, human effect and predators, and internal demographic processes of the band concerned. Similarly, Ohsawa and Dunbar (1984) have reported that the mean growth rate of geladas varied from one band to another in the Simien Mountains National Park. It was associated with the variation in climatic conditions between the study bands. Mortality rate also varied from one study band to another. Similarly, in the present study area, mortality rate varied from one study band to another. This is probably due to different factors, such as parasite caused by taenia worm. Exceptionally, gelada population in the Guasssa area is seriously affected by this infectious disease and the infected individual will not survive more than six months. Moreover, killing or trapping by humans and predators mainly in the case of the Wochanka band may have increased the mortality rate of geladas in GCPA.

In the present study population, the number of adult females per male varied from one band to another with a range of 2.4:1 to 4.5: l. This might be due to the variations in the composition of bands, which results in differences in the ratio of females per male. Dunbar (1980) also noted similar sex ratio of adult female to male in the Simien Mountains National Park. However, studies carried out by Zewdu Kifle *et al*. (2013) in Wonchit Valley, Ethiopia showed relatively high sex ratio of adult females to males that varied from 6.5:1 to 6.7:1. The present study has revealed that annual growth rate is not directly related with the number of females per male. This might be due to the fact that the growth rate is directly determined by the number of birth per female/year, which in turn is influenced by the habitat quality and demographic processes. Similarly, Dunbar and Sharman (1983) have reported that birth rate contributed for the population growth, and against the adult sex ratio. However, sex ratio is a causal precursor of birth rate (Ohsawa and Dunbar, 1984).

4.2. Activity time budget

The percentage of time spent on foraging and travelling during the dry season was longer than in the wet season. Dry season usually affects forage availability, and hence there might be shortage of forage. Moreover, during the dry season, fleshy grasses and other food sources are usually scarce, and 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 the nutritional requirements. In contrary, they require only less time 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). Vegetation cover is reduced during the dry season due to a combination of factors such as lack of water and high radiation load under cloudless skies (Dunbar, 1992b). Such conditions are usually associated with an increase in the fibre content of plants, and a consequent decline in the digestibility, and hence would require enhanced feeding time to compensate these adverse effects of climatic factors.

The time spent in grooming, playing and resting was significantly more during the wet season than during the dry season, and this might be related with the lower feeding and travelling times during the wet season. This will give geladas to spent their time more in social interactions (Zewdu Kifle *et al*., 2013).

During the dry season, the frequency of diurnal activity patterns such as foraging, travelling, playing and resting did not show differences throughout the day. In relation to factors such as the home range, resource dispersion and low food quality during the dry season forced geladas to spent more time in foraging and travelling without a difference in their time spent throughout the day time. Following post-harvesting season, geladas move towards the surrounding farmlands and villages as they were free to move at this time in the absence of guards around the farm. In addition, waterholes and food patches are both dispersed over an extreme area. All these factors might prolong the feeding and travelling time without making differences of their activities throughout the day. Iwamoto (1993) also reported similar findings in the Simien Mountains National Park, concerning feeding and travelling time of geladas during the dry season. Moreover, Zewdu Kifle *et al*. (2013) also described that during the post-harvest period, geladas cover wide ranges, and they are forced to use more time for foraging and travelling without making differences throughout the day. However, during the wet season, foraging and travelling showed different peak timings. In most cases, it reached a peak between 11:00–15:00 h. This might be related to the variation in the weather conditions during the wet season. Heavy rainfall, foggy and cloudy sky during the wet season might affect the activity patterns and its frequencies. As a result, grooming reached peaks before the mid-day and late in the afternoon. This might be related to increasing itching rate by tick load associated with solar intensity (Akinyi *et al.*, 2013). Post (1981) noted that grooming peaks occurred before the mid-day and late in the afternoon in the yellow baboon, when the proportion of time for feeding was low. However, he stated that grooming is a function of some exogenous variables, i.e, average nutritional quality of the food. The timing of agonistic peaks, in terms of actual clock time occurred late in the afternoon between 14:30 to 16:00 h during the wet season. This might be related to the decline in the feeding peaks, which leads to an increase in agonistic and grooming encounters. There was resting and playing peaks during the wet season in the morning and late in the afternoon. This might be due to the decreased feeding time during this season. Altmann and Altmann (1970) reported that social behaviour such as resting and playing in baboons showed peaks during the early morning and late afternoon hours during the rainy season.

Males were more frequently groomed by the females. This might be due to the fact that females are better to maintain social bonds than males among geladas. In addition, among the gelada social system, males disperse while females remain philopatric, and are more concerned for the integrity of the unit. The dominant male gelada is groomed by the members of the unit, mainly by adult females, juveniles and sub-adult males. This might be related to access for resources, protection and mating. De Waal (1997) reported that giving priority to initiate grooming is related with sharing, or access for resources. Barton and Whiten (1993) have reported that grooming in the dominant male and top ranked female baboons are initiated by females and other members of the unit, which might be to gain social acceptance by group members and tolerance at feeding sites. Hemelrijk (1990) has reported that priority initiation for grooming might be related to gain support during conflicts. Henzi and Barrett (1999) reported that grooming lactating females by other females is to get access to the new born infants.

Dominant male terminates grooming interactions more than do females. This is probably related with the dominancy, which enables access for grooming interactions from all members of the unit, and might lead the dominant male to develop negligence and terminate grooming as early as possible.

Adult females did not distribute their grooming time evenly with different age sex categories, and they mainly spend their time with the dominant male. This might be correlated with access to reproduction, food and protection. In contrary, studies carried out on savannah baboons by Henzi *et al*. (1997) showed that adult females spent more time with infants and juveniles. They allocated less time for grooming with sub-adult females and males. This might be due to the fact that both sub-adult females and males play less in maintaining group integrity. This was correlated with males, which usually leave their natal group and disperse through all male group. Sub-adult females also often form sub-core units with peripheral males. Similar result was reported by Colmenares *et al*. (2002) showing time allocation in grooming interactions within one-male/multi-female units of baboons based on their dominanc hierarchy. Thus, the time engaged in grooming was greater in higher ranking partners than in low ranking ones.

Adult females spent significantly more time with the linearly related females than with low ranked harem members. Frank and Silk (2008) have also stated that adult females of wild baboons (*Papio anubis*) spent more time with non-mothers, or linearly related females, and they were more responsible for initiating grooming bouts. This behaviour might have kin based coalitionary function in the unit.

The dominant male spent more time grooming with dominant/adult females. This was related to access for reproduction and to gain acceptance by adult females. Smuts (1985) also noted that high proportion of grooming time investment by the dominant male baboons with adult females is to gain acceptance. The dominant male appeared to allocate less grooming time to its counter parts, or the subordinate adult males. This might be due to the lower social ranking of the follower males in the unit. Sueur *et al*. (2011) recorded that the dominant male considers less time for grooming subordinates compared to its preferred partners. Following adult females, the dominant male spent more grooming with sub-adult males, and accept relatively longer unidirectional grooming bouts. This might be correlated with the enhancement of tolerance between dominant males and sub-adult males. The dominant males always watch over sub-adult males as lower ranking opponents for his hegemony. In order to lower the contention between them, sub-adult males give more grooming time to the dominant male. Seyfarth (1980) revealed that sub-adult males spent more grooming time with the dominant/adult males as they need to establish relationships with stable males for acceptance and support.

Juveniles are mostly involved in grooming with their mother/adult females. Adult females usually may not allow their juveniles to be in close contact with other adults. Cords (2000) reported that preferential grooming between mothers and juvenile offspring in baboons might be related with maternity relationship between them. In addition, juveniles spent more grooming time with adult males, which might help them to get benefit by the possible attitude of the dominant male. Juveniles have no incentive to offer an adult male in exchange for being groomed. In addition, high investment in grooming by adult male with juveniles may help to have a better chance for being accepted by adult females.

The differences between grooming given and received among opposite sexes were relatively equal. Grooming between the dominant male and adult females showed relatively equal interactions of bouts, and dominant males reciprocate promptly, probably to gain acceptance by females. In contrary, Saunders (1988) reported that dominant male baboons groomed less often than adult females, as males can provide important services, such as protection against infanticidal attacks and harassment. However, grooming bouts were not equally distributed among individuals of the same sex; the bouts were relatively reciprocal and asymmetrical. For instance, grooming between adult females and females with infant was quite different in the bouts given and received. This could be related with kin-based interactions that a mother with infant receive more grooming bouts than adult females. Similar findings were also reported by Frank and Silk (2009) in wild female baboons. This might be due to kin-based interactions between mothers and adult females, and females groom mothers longer when they handle her infant than when they do not. In addition, bouts given and received between dominant males and sub-adult males were not equal, sub-adult males give longer bouts than the dominant male. This might be associated with coalition support from the dominant males. Colmenares *et al*. (2002) have also reported similar findings of grooming bouts based on rank differences and coalitionary behaviour patterns.

4.3. Feeding ecology

During the present study, a total of 18 forage species of geladas were recorded. This lower number of forage species might be related to the lower level of diversity in the habitat in the higher altitudinal ranges in GCPA. In addition, high preference of grass might lead to narrow forage breadth in the area. 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. Fashing *et al*. (2010) have recorded that geladas feed on insects (locust) in the present study area during an outbreak of locust swarm. Kelil Abu (2011) reported around 17 plant species that contributed to geladas' diet in the eastern Arsi, Ethiopia. However, Zewdu Kifle *et al*. (2013) recorded around 60 species of 20 families of plants and three species of animals in the diet of geladas in Wonchit Valley in Ethiopia.

Blades and stem of grasses form the major diet of geladas in GCPA. However, they also feed on leaves of herbs, bushes and fruits of bushes, roots, flowers and pollen. They spent 68.6 % of their feeding time on grass blades. This might be correlated with the availability and dietary specialization of the species. Iwamoto and Dunbar (1983) and Dunbar and Bose (1991) reported that geladas spent more than 90 % of their feeding time on grass and grass blades. This shows geladas are specialized grass eaters.

Among the herbs, *H. schimperi, C. cryptocephala* and seeds of *H. vulgare* contributed to the diet of geladas during the dry season. The time spent for feeding *H. schimperi* and *C. cryptocephala* was also relatively high during the dry season. These species are evergreen and have fleshy blades as they are dominantly grown in drainage and flooded areas. Geladas also spent a good proportion of time in search of and feeding seeds of *H. vulgare.* This might be correlated with the availability of grasses and left over grains in farms after harvest.

During the wet season, geladas spent more time feeding on grass blades and fleshy leaves. Green grasses and leaf blades are 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 the decrease of time spent on grasses. Following grass blades and fleshy leaves, stems of *E. robustus, R. multifidus,* fruits and seeds of *R. apetalus, G. asparinoides, H. peplidifolium* and *S. oleraceus* provide major contribution to the diet of geladas during the wet season. The 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 (1998) 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.

The trend of food preferences shown by the geladas may possibly be attributed to the accessibility, availability and utilization of forage species. In addition, nutritive values also determine the preference of forage species by geladas from season to season. Petrides (1975) had reported that food preferences may have influence as a result of the nutritional values of the food items as well as microclimate, topography and accessibility in different locations and habitats where the animal lives. In the present study, *A. caffrum, S. oleraceus* and *G. asparinoides* were the most preferred plant species of geladas during the wet season. This might be correlated with the high utilization versus availability of the species. In contrary, Petrides (1975) stated that higher preference was due to avoidance of secondary compounds and a preference of high nutritional value (i.e. low fibre to high protein ratio). Pollen of *C. lusitanica* was not highly preferred. This might be related with the low percentage of utilization *versus* the availability of it in the area.

During the dry season, *E. robustus, M. verticillata* and pollen of *C. lusitanica* were the most preferred food of geladas in GCPA. This might be due to high utilization *versus* availability of the plant species. In addition, these species might have low fibre and high protein contents during the dry season. Garber (1987) had stated that seasonal preferences of the plant species by non-human primates might be correlated with their avoidance of secondary compounds and decreasing fibre content. *Thymus schimperi* and *A. melonata* were the least preferred species during the dry season. This might be related with the increase in the concentration of secondary compounds with correspondingly low nutritional values and high fibre to protein content ratio.

The percentage of crude protein content indicated highest value for leaves of *M. verticillata* and lowest value for *C. lusitanica*. This might be related with the lowest and the highest ratio of crude fibre to protein contents, respectively. Hanya *et al*. (2007) have reported that leaves used by baboons contained high crude protein and a high protein-to- neutral detergent fibre ratio. In the present study, gelada foraged plants showed high nutritional qualities. The mean protein content (12.1%) was above the values reported (plant portion of diet) for African cercopithecines. Similarly, it is already known that good quality forage generally will have higher protein content to the level of > 9 % (AOAC, 2000).

The crude fibre content of gelada foods (leaves, stem, root, pollen and fruit/seed) in the GCPA ranges from 18.65 to 48.75%. The variations in cellulose constituent among forage species vary considerably from site to site and from season to season. Sarkiyayi and Agar (2010) reported high crude fibre content in plants as a result of high cellulose concentration that it contains. In contrary, the lowest crude fibre content corresponds to less cellulose content. In the present study area, the diet of geladas contained appropriate proportion of crude fibres with an average of 36 %. This is similar to the proportion of crude fibre in grass/herbs recommended by AOAC (2000), i.e., < 50% is considered as of high quality.

Most plant food sources of geladas have low level of fat. However, better fat content was observed in the leaves of *R. multifidus* (4.9 %). Most plant species have low level of fat, except in some fatty fruits and seeds, such as of palms. Rothman *et al*. (2011) have reported a similar percentage of fat in the forage leaves of primates (5.3%). In the present study, the mean lipid content was lower than that reported for African cercopithecines. This shows that the food plants of geladas are poor in fat content.

High value of ash content (23.1%) in *C. cryptocephala* indicates a high proportion of mineral contents in it. *Ranunculus multifidus* had the lowest ash content than other forage plant species of geladas in the present study area. This might be correlated with low mineral contents in it. In general, dry matter content of animal food constitutes 20–30%, the rest being water which makes up 70–80% (Schmidt- Nielson, 1975). However, the food items used for the analysis were open air dried and water loss was not recorded for the present sample. Akosim *et al*. (2010) have reported that the dry matter content of baboon foods ranges between

23.6%–39.9%, which indicates that savannah baboons require food with high water content as the area is drier than the highlands. In order to compensate this shortage of water, they usually prefer food items with high water content. Neutral detergent fibre content was relatively high in *H. schimperi* and *E. robustus.* This might be correlated with high crude fibre content in this plant species. The average neutral detergent fibre of food items of geladas was consistent with the earlier observations for African cercopithecines (< 55%) (Rothman *et al*., 2011). Hence, food items of geladas are of high quality.

Percentage crude protein content in some of the food item of geladas was high; for example, the leaves of *M. verticillata* contained 27.14 % of crude protien. Some plant leaves may have high protein content than others. Hanya *et al*. (2007) have also recorded that leaves used by baboons contained high crude protein than other parts of the plant. Percentage of crude fibre was relatively high in the leaves of *H. schimperi* and stem of *E. robustus.* Leaves, stem and roots have better crude fibre content due to the high concentration of cellulose, hemicellulose, pectin and lignin in these parts of the plant. Ayuba *et al*. (2011) have also reported that stem and root of plants contained high crude fibre than leaves and seeds. The results of the present study showed that there is no significant difference in the crude fat content with regard to parts of food plant except stem of *R. multifidus* (4.9 %). Most plant parts are poor in fat content except for some fatty fruits and seeds (Rothman *et al*., 2011).

4.4. Ranging behaviour

The home range size of geladas varied between seasons in different study sites and also among bands within the study sites. The variations of resources in GCPA 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, there were no much human activities after harvest. Thus, geladas move freely from one patch of land to the other, increasing home range size during the dry season. Zewdu Kifle *et al*. (2013) have also reported variations in the extent of home range of geladas between seasons as a result of human induced activities. It was between 0.2 and 1.5 km^2 during wet and dry seasons, respectively. Moreover, Kelil Abu (2011) reported that the Arsi geladas range between 2.44 and 4.64 km^2 during wet and dry seasons, respectively. The home range of geladas in Guassa area varied from 0.64 and 4.29 km^2 during wet and dry seasons, respectively. This shows that the dry home range of Arsi and Guassa geladas was almost similar.

Iwamoto and Dunbar (1977), Dunbar (1983) and Hunter (2001) 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 addition, food selection and increasing band size of geladas may also be responsible for the variation in the extent of home range of geladas during the dry season. All these might contribute for variations in the home range of geladas between seasons. Phillips *et al.* (1998) and Moyer *et al.* (2007) have also stated that home range size was influenced by habitat diversity and quality; relatively homogeneous habitats having larger home ranges than in areas with a greater habitat diversity. Hence, seasonal changes in home range size are predicted to be inversely proportional to the availability of resources. Larger home ranges are needed when food availability is less. Furthermore, Pollard and Blumstein (2008) have also reported a positive correlation between troop size and estimated home range of baboons. Larger troops may deplete resources more quickly and thus spend more time travelling to meet their resource needs, extending into larger home ranges.

The range length of bands of geladas varied both daily and seasonally. The average daily movement distance of geladas was 1–5 km. The variation of the daily range length within a band, among bands, and between seasons might be correlated with differences in the resources available and the band size. Dunbar and Dunbar (1975) and Iwamoto and Dunbar (1983) noted that geladas move for only a short distance a day compared to other baboons, and the daily range length of gelada was 1‒2 km. They have also correlated the daily and seasonal variations of range length of geladas as a result of group size and scarcity of food. 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) and Kelil Abu (2011) have reported that the mean daily range length of geladas of Dissie and Arsi areas were 2.9‒4.5 km and 0.9‒1.2 km, respectively. These might be associated with the variations in food availability and band size in the respective study area and seasons. The group size is positively correlated with day range length (Barton *et al*., 1992). 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).

4.5. Phytobiomass and carrying capacity

Seasonal variations of phytobiomass in the habitat are influenced by the natural seasonality patterns of the area. In Ethiopia, rainfall is highly disproportionate among seasons, and hence affecting the phytobiomass cover of various habitat types. Peak green biomass of grassland in GCPA was noticed during the months of June‒August, correlated with the availability of rainfall, sufficient moisture and maximum humidity that favour increase of phyotbiomass (Karunaichamy and Paliwal, 1994). Moreover, decrease in grazing and cutting grass by the local community during the rainy season contributed to increase tiller production. As a general pattern, peak green plant biomass is high during the rainy and post-rainy months in the tropical areas (Senapati and Dash, 1981). Green biomass production is directly proportional to the amount of moisture present in the soil. In addition, Joshi and Pant (2012) have stated that root/shoot ratio was minimum during the rainy season due to increase in green biomass due to heavy rainfall. High moisture and humidity favour above-ground biomass.

The lowest green biomass was recorded in the dry season mainly during the months of February–April. This is probably due to the absence or shortage of rainfall and higher atmospheric temperature along with unfavourable soil conditions, which are unsuitable for the growth of grasses; which is inturn reflected in the decline in the green biomass observed during this period in GCPA. This pattern is similar to that reported by Karunaichamy and Paliwal (1994) in the Western Ghats in south India. The live green biomass of the grassland community gradually declined during the dry season. It indicates that with the increase in atmospheric temperature green parts of the flora dry up and turn yellow and hence in the month of April, usually the biomass is less in the present study area.

The reduction of dry biomass during the period of March–May might be related with the decrease in green biomass associated with inadequate moisture and unfavourable temperature. Bobbnik *et al*. (1989) and Pandey *et al*. (1989) have reported that low rainfall followed by atmospheric temperature were not the only factors responsible for decrease or increase in the standing dry biomass. Wind velocity, soil characteristics, soil organisms, species diversity and species interactions play a vital role for such decrease and increase of biomass. In general, biomass production in the present study area was higher than those reported from other dry and humid regions in the tropics. However, Singh and Joshi (1979) have reported that dry biomass is always lower in humid than in arid and semi-arid regions of the tropics.

The carrying capacity of the area to support gelada population was high in August and low in March due to the variations in phytobiomass productivity between the months of the year. The dry matter intake of geladas varies between wet and dry seasons, reflecting variations in the nutrient content of the food items. As a result, during the dry season, intake of the peak rate of geladas' was high, and more bulk food was taken in order to compensate the low nutrient content of the food. The present study area has a high potential to support large number of geladas (about 528, 000 individuals) in the month of August. This indicates that the area has high potential of productivity during the wet season. However, the potential to support animals in general and geladas in particular decrease to a population of about 33,700 individuals during the month of March due to the decrease in dry biomass available in the habitat during this month. Bell (1982) reported higher stock rate for herbivores/wildlife with increasing annual rainfall, and lower stock rate with decreasing rainfall. These might be correlated with variations in the biomass productivity between seasons.

4.6. Land-use/Land-cover Changes

The land-cover change matrix showed that about 61.95 km^2 of the land within the study landscape experienced LU/LC changes in one or the other way during the past 27 years from 1986 to 2013. The overall image difference of the forest land-use/land-cover category showed positive. This might be correlated with increasing conservation programme of forest in the area. The extent of grassland has been decreasing since 1986 to 2013. This might be mainly due to human induced processes. In addition, the grassland habitat has a tendency of succession due to direct and indirect impacts of drought and related physical factors. Thus, degradation of the grassland by anthropogenic factors and natural processes would have serious impacts on gelada foraging ecology as they mostly depend upon grasses. Diress Tsegaye *et al.* (2010) have shown direct and indirect impacts of drought on LU/LC dynamics in northern Afar rangelands of Ethiopia. Similar to the grassland land-use type, the extent of *Helichrysum* habitat also showed decreasing pattern of changes during the period 1986–2013. This was probably due to low persistence of the class type to changes. In addition, high rate of transition of *Helichrysum* into other land-use types could also be due to the dynamics and impacts of global warming and related factors. However, transition of farmland into other land-class types did not show a significant change during the period of comparison. This is due to scarcity of agricultural land surrounding the GCPA. Mengistie Kindu *et al.* (2013) have revealed that the extent of croplands/farmland in Munessa-Shashemene highland, Ethiopia is showing an increasing pattern. This trend is due to the extension of agricultural activities into forest as a consequence of the increasing human population pressure around forests, including conservation areas in Ethiopia (CSA, 2007). In contrary, in GCPA, transition of other land-use types to farmland, or cropland was minimal. This might be probably due to the less potential nature of the area for agriculture. During the initial stage of comparison, shrubland habitat showed changes into other land-use types to an extent of 4.07 km^2. However, there was transition of 22.84 km^2 during the second phase of comparison (2000–2013). This transition could be due to the driving forces such as severe droughts, in addition to collection of firewood by the local community. Similarly, Meze–Hausken (2004) has reported severe droughts as a cause for transition, or a rapid loss of a specific land-cover type in northern Ethiopia. In contrary, shrubland showed decreasing pattern during the whole period of the present study (1986–2013). It would probably be due to firewood collection by the local community. *Erica* land-use category showed increasing pattern of change during the first phase of comparison. However, unlike the first phase of comparison, transition of *Erica* into other land-use types showed a decreasing pattern in the second and third phases of the study period. This might be due to effective conservation measures undertaken by the management activities in GCPA during this phase of the study.

4.7. Livelihood Activities

Agriculture is the dominant economic and livelihood activity in the present study area**,** and barely is the main seasonal food-crop. Majority of the respondents 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 the local communities. Woldemedhin Zebene (2011) had reported that the main source of livelihood of the Guassa

Community was mixed farming; i.e., a combination of crop farming and livestock keeping, which accounts for 95.6 %. Pender *et al.* (2001) have reported that mixed farming practices in the highlands have intergraded functions to improve food security and alleviating poverty. Mixed crop-livestock production system was found to be the dominant farming system in the central highlands of Ethiopia for its integrated values (Belay Duguma *et al*., 2012).

Agriculture of the community in the present study area was mainly for subsistence, but the surplus was sold off. However, there are major constraints of marketing infrastructure almost all around GCPA. The average land holding per household in the present study area is 1.14 hectare, which is less than half of the average land holding per household in central Ethiopia (Belay Duguma *et al.*, 2012), where it is 2.5 hectare. This forced them to cultivate mountain hillside areas. Such areas are highly vulnerable to soil erosion, degradation and poor yield leading to poverty. Apart from this, the average crop yield also varied among villages, due to the soil types and differences in selection of seeds, fertilizers and use of pesticides.

The average annual crop yield per household among the communities in the present study area was relatively low to fulfil basic needs of the family. As a result, some of the respondents had to generate additional income from off-farm activities. Woldemedhin Zebene (2011) has revealed that majority of the households annual grain production in GCPA is about 5.4 ± 4.0 quintals (nearly half a ton), which is not enough to fulfil the basic requirements of the family. Some of the respondents are making additional income by selling grass illegally collected from the protected area while others generate income from off-farm activities such as petty trading, gardening, and selling traditional alcohol (‘Tella’ and ‘Arekie) , and some of them depend on ‘food for labour’, or safety-net programme (Engedasew Andarge, 2010).

Livestock rearing in GCPA 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 the mainly reared by the local community around GCPA. This shows that the area is highly favourable for sheep rearing. The current livestock population has increased by 1 % from the density of livestock estimation registered in 2001 (Zelealem Tefera, 2001). This resulted in encroachment into the protected area. Moreover, many livestock from the nearby and distant areas are also using Guassa area for grazing. It would accelerate the degradation process of gelada habitat in GCPA. Land degradation is the most threatening environmental problem in the highlands of Ethiopia due to over-grazing. In fact, around 75% percent of the livestock of the country is using such highly vulnerable highland areas (Aklilu Amsalu, 2006).

The local community depended on natural resources in GCPA for grazing, firewood, grass and medicinal plants. The area is also often viewed as a source of income from timber and tourism industry. However, the level of utilization of natural resources in GCPA by people of different villages varies. This might be due to the differences in the access to the resources from different villages. There is also difference in the awareness level among the villagers, which makes them to view the resources in the protected area differently. However, utilization of the area as a source of additional income from tourism did not show any difference among different villagers. In general, local community around the protected areas in developing countries highly depend on natural resources as sources of income (Rao and Geisler, 1990). In addition to its biodiversity values, it provides vital ecological services, *via* water catchments for the majority of the villages around and stabilizes weather conditions of the surrounding areas. It is already known that protected areas provide both ecological and economic benefits to the community (Pretty and Pimbert, 1995).

4.8. Human J wildlife Conflict

Human – wildlife conflicts are common in many parts of Ethiopia, which are negatively affecting wildlife conservation. In the present study area also, human – wildlife conflict is threating conservation activities. Human – wildlife conflict in GCPA is mainly due to crop damage and livestock predation by wildlife. However, the causes of the conflicts varied as per the views of respondents of the present study. Among the respondents, 61.9 % reported that the conflict was due to crop damage and livestock depredation, while 22.2 % and 13.7 % of respondents viewed that crop damage and livestock depredation, respectively. This difference in the opinion of respondents was due to variations in the type of vermin animals and predators in their specific localities. Engedasew Andarge (2010) also reported variations in the level of human – wildlife conflicts in GCPA. 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 local community values of wildlife are reasons for conflicts in relation to crop damage and livestock depredation (Shibia, 2010). 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.

4.9. Human – Gelada Conflict

In the present study area, human – gelada conflict was due to crop raiding behaviour of geladas and pasture land degradation. Balakrishnan and Ndhlovu (1992) and Sillero-Zubiri and Switzer (2001) have reported similar findings of human – baboon conflicts due to crop raiding behaviour of the species concerned. Hill (2000) reported that baboons have the potential to cause large extents of damage locally, and they raid farms more frequently than other species of wildlife. Most of the respondents in the present study area reported that intensity of crop raid by geladas have increased during the last three years. Nearly 85 % of respondents believed that the reason behind increasing crop raiding was associated with the increase of the population of geladas in GCPA. Mesele Yihune *et al*. (2008) have reported that increase in the crop damages caused by geladas in the Simien Mountains National Park was associated with the increase of the population of geladas. Additional factors likely to increase vulnerability to crop raiding by geladas include the distance of the farm to the forest edge, the number of other farms lying between, and the type of the crop grown. When natural food resources are limited, easily digestible human food crops provide an alternative source of food for geladas, and crop-raiding may intensify (Zewdu Kifle *et al*., 2013). They may prefer cereal crops more than natural grass as cereal crops may be more nutritious.

Geladas caused the major proportion of crop damage in the area. Barley is the most dominantly cultivated field crop in farmlands around GCPA and it is the staple food of most households in the area. Thus, barley is of great importance for food security of the community in Guassa. Geladas concentrate their feeding activities on barley crop especially during later stages in the crop development. Geladas damage to crops varied considerably from village to village, mainly due to the differences in the level of guarding crops by the locals as already reported by Mesele Yihune *et al*. (2008). The distance from gelada habitats to the crop field has also influenced the intensity of crop damage by geladas as reported earlier by Hill (2000) that vulnerability to crop damage by baboons is determined by distance from farm to forest edge, or roosting sites.

In the present study, the local community followed guarding, scarecrows, human distress calls and physical barriers to control crop losses. They also push geladas to congregate in few pathches to manage crop losses during the wet season, and during the harvesting period. Guarding crops by producing distress sounds was the prominent method in all villages studied. This might be correlated with the non-effectivness of other techniques to manage crop losses, as geladas, or other crop raiding wild animals get accustomed to most of the techniques human being adopt. Similarly, Shivik *et al*. (2003) have 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 single method. Zewdu Kifle *et al*. (2013) have reported that local people also utilize snare traps and gun to keep geladas away from farms besides using scarecrow, direct watching, making distress sounds and chasing by dogs. Hill (2000) also reported that guarding field crops, patrolling fields, chasing baboons away using dogs, bows and arrows, and bells to help scare away baboons from farmlands. Engedasew Andarge (2010) has suggested financial compensation for the damaged crops by gelada baboon from the government.

In the present study, respondents had positive attitudes towards geladas and the protected area. The mean scale score was 28.4 from a 35 point scale. In this case, the higher the mean score indicated, a positive attitude towards gelada and the protected area is evident. Mehta and Heinen (2001) based on their studies in Nepal have recorded the mean scale score on a 15 point scale for two different study sites was 12.7 and 11.6. The higher the mean scale score, the highest was the positive attitude of the local people towards conservation areas. Local people would also show a positive attitude towards wildlife and protected areas because of cultural, religious and economical reasons (Skehar, 1998). Woldemedhin Zebene (2011) noted that the local community around GCPA has a positive attitude towards the protected area as they get economic benefits out of this conservation programme.

There are different factors attributed for liking and disliking geladas and GCPA by the respondents. Most of the respondents indicated that their liking of the area and geladas is correlated with the direct dependence on resources available from the protected area. Benefits from tourism and related activities make the local people to give attention towards GCPA and geladas. Infield (1988) reported that the local community share resources from the protected area, which result in positive attitudes towards the protected area and wildlife. In addition, Heinen (1993) pointed out that literacy level and right of the local community to collect forest products lead to develop positive attitudes among the local people living around conservation areas.

Education is a fundamental factor to create community awareness towards GCPA and geladas. Higher levels of education or specific knowledge about wildlife are positively correlated with favourable attitudes. Tsehaye Gebrelibanos and Mohammed Assen (2013) have also reported that education is necessary to create public awareness for land resource conservation, and higher levels of education or specific knowledge about conservation are positively correlated with more favourable attitudes of local people towards wildlife conservation. A better level of education results in developing positive attitudes towards protected areas and wildlife (Heinen (1993). Gillingham and Lee (1999) have remarked that the odds of an individual liking protected area and wildlife are twice as great if he or she had four or more years of education compared to none at all. 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. It can be inferred that 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.

Nearly 30% of the respondents attributed their disliking of the protected area and geladas in the present study area. This might be correlated with lack of alternative economic sources, low economic status and the smaller farm area that they hold. Gillingham and Lee (1999) have stated that socio-economic status and farm size have significantly affected attitude of the local community around the Selous Game Reserve, Tanzania towards the protected area. In this case, the locals, who own land were about 1.5 times more likely to like the protected area and wildlife than those who were landless. It is also believed that forest dependency would increase and influence attitude of local people towards conservation programmes. Poverty and lack of off-farm employment opportunities lead to develop negative attitudes towards wildlife and conservation areas (Infield, 1988). Gillingham and Lee (1999) and Chalise (2000) have reported that negative attitude towards wildlife and protected areas are a function of contact with baboons and carnivores as pests and livestock depredation in different parts of the world.

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

In the present study, sex had no significant effect on attitudes among the local community towards GCPA and the wildlife present in this area. This indicates that within the local community, there is no significant difference in the awareness towards the protected area and wildlife between males and females. De Boer and Baquete (1998) and Infield (1988) have also reported that sex has no effect on the attitude of the local community towards conservation of wildlife. Shibia (2010) reported that the attitude of the local people towards wildlife conservation was independent of sex and conservation awareness. However, Gillingham and Lee (1999) and Mehta and Heinen (2001) have revealed that men are more positive towards protected areas and wildlife than women. Females usually show less positive attitude and more neutral ‘do not know ’ response than men towards wildlife conservation. This might be due to the low educational standards and awareness level of women about wildlife conservation.

Restricted use of wildlife resources had shown significant impacts on the attitudes of the local community towards geladas and other wildlife resources in the area. This might be correlated with the feeling of denial to the right of using wildlife resources, as they feel that the natural resources in the area belong to them, and they do not want any one else to restrict their rights over such resources by imposing legal regulations. De Boer and Baquate (1998) and Shibia (2010) have reported that restricted use of wildlife resources has significant effect on the attitudes of local communities. These results have been supported with the findings from other geographical regions as well (Heinen, 1993; Fiallo and Jacobson, 1995), that restrictions on grazing and collection of fuel wood have negative impact on conservation. Such restrictions may result in scarcity in the households in meeting their requirements and therefore negatively influence their attitude on conservation.

Education could be taken as an optimal measure of the socio-economic status of the local community. It has a strong correlation with conservation practice. In the community, educated people have better access for information and awareness towards conservation of protected area than illiterate people. In this case, higher levels of education also help to understand the role of the protected area and the usefulness of conservation of its biological diversity. Kideghesho *et al*. (2007) reported that the level of education is important to determine community participation in conservation practice. Mekbeb Tessema *et al*. (2007) have stated that education level is a key factor in explaining community views and achieving high levels of participation towards conservation activities.

Lack of access for wildlife education, awareness creation and lack of training on wildlife resource use have adversely affected community participation in conservation practices in GCPA. All respondents, who negatively viewed GCPA and gelada conservation practice have had no access to wildlife education and awareness creation. This supports the positive link between the level of community participation in protected area conservation and access to wildlife education/training to enhance and maintain positive attitude among local communities in favour of conservation (Gillingham and Lee, 1999; Anthony, 2007). A strong social network is important for community involvement in conservation activities. In the present study area, the rugged topography and terrain made settlements far apart, negatively affecting the social network such as public meeting, discussions, and local service associations (‘Edir’and ‘Ekub’), which are having far reaching effects, leading to poor participation of the local community towards conservation of GCPA and the gelada population. Over 75% of the respondents maintained poor social network within their community. Jacob (1995) and Kellert (1996) have reported that social network is important for sharing knowledge, which has an influence on attitudes towards conservation activities. Fiallo and Jacobson (1995) have also noted that the role of social networks in information dissemination could offer more insights, and lead groups to improve social network in order to have acceptable and effective conservation initiatives. In addition to these variables, age (getting older) and sex (females) are limiting factors to be actively engaged in conservation programmes. This might be correlated with loss of endurance, motivation and capabilities in relation to age and sex. However, Shibia (2010) noted that the length of experience with protected areas and benefits from wildlife and the associated costs may also influence the attitude of elders in conservation programme. Torgler and Gracia-Valinas (2005) have stated that older people are more risk averters than youngsters, and they have hindrance to be actively engaged in conservation practices.

Sex is a factor that hinders female participation towards the conservation of GCPA and geladas, particularly due to their domestic responsibilities. Kideghesho *et al*. (2007) have noted that lower participation of women in conservation may be due to their lower level of awareness on protected areas and wildlife conservation.

Low farm size also shows a negative relationship with participation in conservation activities. Nearly 65% of the respondents expressed low farm size as a constraint for active participation in conservation of GCPA. This suggests that households with small farms perceive conservation programmes as a factor limitating them to meet their subsistence needs, and hence they are likely to develop negative attitude towards conservation activities. Similar findings were also reported from Nepal (Nepal and Weber, 1995), correlating a positive relationship between farm size and participation of the households in conservation. Thus, it is expected that large farm size has a positive impact on the participation of the households in conservation. People who owned less land tend to have higher odds of disliking the area and less participation in conservation programmes (Infield and Namara, 2001). Masozera (2002) reported that larger farm size makes people more positive towards conservation. On the other hand, households with smaller farms see conservation as a limitation to expand their farms to be able to meet their requirements, and hence developing negative attitude towards conservation practices.

The logistic regression model showed a significant relationship between socio-economic variables such as educational level, income, access for education and trainings, social network and farm size with participation in conservation activities. These variables acting as determinant factors either alone or in combinations affect community participation towards the protected areas. In GCPA, lower educational level, low income, lack of access for education, training and awareness development programmes, poor social network and low farm size have negatively affected the attitude of respondents in conservation. Hence, it is mandatory that these variables should be considered as major factors to influence local communities to attract and motivate them for conservation activities in GCPA and elsewhere in the developing tropical nations.

5. CONCLUSION AND RECOMMENDATIONS

Conclusion

The present investigation provides useful information on gelada population, habitat changes and attitude of local community towards geladas in GCPA. Average reproductive unit size in geladas did not show any significant difference between seasons in each study bands. Band size of geladas varies between seasons. The study also revealed that gelada population growth rate is high in the study area. This shows that threats of predators in the area are minimal. The area with good ground vegetation shows the positive effect of better conservation practices undertaken in the recent past.

Foraging ecology of geladas in Guassa is not diverse compared to other afro-alpine areas in Ethiopia. Grass contributed for the highest percentage of utilization in geladas, as they are adapted to the graminivorous niche. High home range size and daily travel distance of geladas during the dry season indicates that food availability for gelada usually decrease during the dry season. Carrying capacity of the grassland and its associated communities decreases during the dry season.

A detailed analysis of land-use/land-cover changes in GCPA reveal that in the past 30 years the area has changed into different land-use types. Distributional surveys and detailed line-transect censuses at different sites demonstrate that the gelada population has faced habitat disturbances, and its main grassland habitat has changed into other habitat types like *Helichrysum* and shrubland. Analysis of land-use/land-cover changes in the area helped to understand the effect of disturbances and habitat dynamics on geladas.

Crop-raiding by geladas poses a significant threat to field crops, and thus the livelihoods of farmers. It results the intense human – gelada conflicts in the area. It also indicates that the conflicts between humans and geladas have been getting worse over time. Factors such as land holding type and distance from villages significantly influenced the attitude of local people on conservation of GCPA and wildlife. High negative attitude was exhibited by the local people, who own land near the protected area. High level of dependency of the local community on resources of the protected area indicates poor livelihood activities and absence of alternative economic sources of the local people around the GCPA. Therefore, policy measures that aim at increasing income from agriculture and generating off-farm employment opportunities for rural communities are needed to reduce natural resources dependency and to motivate them to actively participate in gelada and other wildlife conservation in the area. This study has revealed that forest dependency, unfair accesses to forest resources and lack of benefits from tourism activities are some of the major factors that hinder positive attitude towards the conservation of geladas as well as GCPA. There is a need to recognize the role of local communities in decision making and planning conservation programmes for geladas and the protected area.

Involvement of local people in conservation activities and participatory management programme would benefit conservation of geladas, other wildlife and GCPA ecosystems positively in the years to come.

Recommendations

- Grassland habitat of the geladas has been changing rapidly into shrubland and *Helichrysum* habitat types, which are of less ecological importance in the area and of geladas and other wildlife. Hence, further detailed research should be carried out to get valuable information on how rapid ecological succession has been taking place, and if possible rehabilitation of grassland habitats should be carried out.

- GIS based land-use/land-cover dynamics data should be updated every ten years in order to assess land-use/land-cover pattern changes in the area, and to make immediate corrective procedures in case negative effects are recorded.
- Guassa Community Protected Area is one of the afro-alpine areas in Ethiopia, and it harbours various endemic and endangered mammals and birds. Therefore, it is necessary to effectively conserve this area through community based conservation activities.
- Gelada in GCPA has great economic values for tourism development, which can enhance the socio-economic status of local community development. Therefore, it is necessary to give special focus on conservation of geladas and GCPA.
- In the study area, farmlands are close to gelada habitats and roosting sites. They are also extending their daily range length and home range size. Therefore, it is necessary to avoid farming near the boundaries of the protected area. If possible, additional land should be demarcated for GCPA.
- Standardized infrastructures like roads, lodges and hotels should be developed in the area to attract both local and international tourists.
- It is recommended that awareness creation among the community to help them know the essence of sustainable use of natural resources in the protected area, conservation of geladas and GCPA in general.
- Off-farm employment opportunities/alternative sources of livelihood like employment, trade, skill labour be provided for the local people to help them survive without over-dependence on natural resources.
- Different wildlife crop management options should be used in different localities of the study area to ensure that geladas do not turn out to be a regular crop raider in the area.
- Continuous monitoring and evaluation of human – gelada conflicts are needed for effective conservation measures in the future.

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APPENDIX

Appendix I: Questionnaire

A. Formal Interview questionnaires made from local communities around Guassa Community Protected Area.

Purpose: The purpose of the questionnaires is to gather important baseline information about the community perception/attitudes towards Guassa Community Protected Area and its wildlife. Interventions for (1) livestock impact on the depredation the protected area (especially on gelada habitats); (2) increasing household impact on the protected area (3) improve relations between local people and the protected area management authorities by highlighting benefits associated with wildlife conservation.

The first section is intended to gather information on personal background information while the second section is designed to gather information on community perception and impacts on Guassa Community Protected Area, whereas the last section focus on the socio-economic status of the community.

Regional code_____

Zone: ___________

Village: ____________

Date and time of interview______

I. Background information

Name of respondent: Age:_______ Sex:_____

Occupation (List all): --------------------------
----

1. How many people are living in your household? __________

Name	Age	Sex	Education	Occupation

1.1 How many people are living in your village/kebele ? ___________

2. Marital status

2.1 Single 2.2 Married 2.3 Divorced 2.4. Widow

II. Community perception and impacts on the protected area

3. How would you describe the level of community participation in the management of the protected area/Guassa?

a. Very high b. High c. Medium d. Low 5. Very low

4. Do you communicate with the villagers? a. More frequently b. Less frequently

c. Sometimes d. Very rarely e. Not at all

5. How often do you communicate with villagers? about the status of the protected area.

a. Once a week b. Once in weeks c. Each month d. Once in six months e. No communication

6. Do you have any social responsibilities? a. Yes b. No c. I don't want to say anything

7. If you say yes, in what community service you are going to involve?

a. Natural resource and wildlife management b. Health care service c. Agriculture and husbandry d. Other service, if any__________

8. Have you witnessed any change in Guassa and its wildlife in the past 10-30 years?

a. Very important b. Important c. Moderately important d. Of little important

e. Not important

8.1 Have you observed anyone who has expanded his settlement and/or farmland near to/within the boundary of Guassa Conservation Area? a. Yes b. No

8.2 How do you evaluate the size of Guassa area starting from you have been here?

a. Very much increasing b. Increasing c. Stable d. Decreasing

e. Extremely decreasing

8.2.1 If you say decreasing, what is/are cause/s ?

Cause for shrinking	**Yes**	**No**	**Comment if any other cases**
Expansion of agricultural land			
Expansion of pastoral land			
Establishment of settlement			
Deforestations and Fire			
Plantation			
Others If any specify			

8.3. How would you feel about the status of natural resources (vegetation) of Guassa area for the last 15-20 years?

a. Highly improving b. Improving c. Degrading d. Highly degrading e. No change

8.4 Community participation for conservation of Guassa area is very high

a. Strongly agree b. Agree c. Neutral d. Disagree e. Strongly disagree

8.5 Awareness creation towards community participation in conservation of the area

a. Very satisfied b. Satisfied c. Neither satisfied nor dissatisfied d. Dissatisfied

e. Very dissatisfied

8.6. Community based by law for conservation of the area.

a. Very strong b. Strong c. Neither strong nor weak d. Weak e. Very weak

8.7 Causes for degrading the area?

Cutting of festuca grass frequently	①	②	③	④	⑤
Farming	①	②	③	④	⑤
Overgrazing	①	②	③	④	⑤
Firewood collection	①	②	③	④	⑤

9. What wildlife species do you know in Guassa ? if you can mention some of them________

____

____

10. Mention some of the predators in Guassa area ? ________________________________

11. Did you face any problem of livestock damage of crops/lose by predators? a. Yes b. No

12. What type of problem did you face by wildlife in you locality? a. Crop damage b. Livestock predation c. Both crop damage and predation d. No conflict

13. How long you have seen gelada in this area ? a. 45-60 years b. 30- 45 years c. 20-30 years d. 10-20 years e. 5-10 years

14. Did you get any benefit/ lose in this area, being in the presence of geladas ?

a. Yes b. No c. I do not want to say anything

15. Geladas are considered as crop riders/pests in the protected area? a. Strongly agree b. Agree c. Niether agree nor disagree d. Disagree e. Strongly disagree

15.1. What type of crops damaged by geladas? a. Barely b. Wheat c. Barely & wheat d. Lentil e. Bean and pea

15.2. Which measures do you carry out to keep your crop from gelada?

a. Guarding b. Chasing c. Shooting d. Physical barriers e. Fear-provoking stimuli

16. How do you see the population status of geladas in this area? a. Significantly increase b. Increase c. No change d. Decrease e. Significantly decrease

16.1 If you say increasing, mention the cause/s ________________________________

____

III. Socio-economic status

17. **Settlement history**

1. How long have you lived in or around Guassa?

a. Starting from Emperors time c. Starting from EPRDF

b. Starting from Dergue regime d. Recently e. None

2. How far is your residence from Guassa (in km) _________

3. How did you settle here?

a. Inherited land from my ancestor b. Bought land c. Settled by the State, any other reason

18. What is your main occupation/income-generating activity?

a. Animal husbandry c. Mixed Farming

b. Agriculture d. Marketing e. Daily labourer

19. How would you characterize the socioeconomic status of villagers in Guassa? Are they poor? (If yes, what and why are the causes for their poverty?) ____________________

____

20. Do you have livestock currently? a. Yes b. No c. Not interested to mention

If yes to question15, how many livestock do you own at this time?

Livestock Type	**No.**	**Village/Kebele No.**	**Remark**
Cattle			
Donkeys			
Horses			
Mule			
Sheep			
Goats			

21. For how many years have you been grazing in your localities/Guassa area?

1. 1-5 years 2. 5-10 years 3. 10-15 years 4. 15-20 years 5. 20-25 years

22. Have you ever faced shortage of feed for your livestock? a.Very frequently b. Frequently c. Occasionally d. Rarely e. 5. Very rarely

22.1 If you say yes, how do you manage to satisfy feed requirements for your livestock?

a. Free grazing, b. Cut and carry c. Purchase of extra feed d. Others, please specify

23. What are the main crops do you harvest? and the average production in kg ?

Crops	Average production during 'bulg'	Average production during autumn	Total
wheat			
Barley			
Lentil			
Maize			
Bean			

24. How big is the size of the land that is under control of your household (ha)?_______

25. How would you express your additional sources of income?

a. Very satisfied c. Neither satisfied nor dissatisfied

b. Satisfied d. Dissatisfied e. Very satisfied

25.1 If you say ‘yes’ please indicate your source types and the monthly/annual income ?

Additional sources of income	Estimated monthly earn in birr	Estimated annually earn
Selling of fesucal		
Firewood		
As tour guide		
Daily labourer		
Others		

V. **Community participation and attitudes towards the protected area/geladas**

26. Do you participate in conservation activities in Guassa? a. Very frequently

b. Frequently c. Occasionally c. Rarely d. Very rarely

26.1 What factors hindered to participate in conservation? a. Age b. Farm size,

c. Social network d. Education level e. Access to education

26.2 Make (×) mark in the table below: socioeconomic variables (factors) that affect community participation toward the conservation of the protected area.

Variable	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
Education level					
Low economic status (Yes)					
Access to education (lack)					
Trainings (No)					
Social network (poor)					
Age (older)					
Sex (female)					
Low farm size					

27. Guassa Community Protected Area has a great benefit to the society ?

a. Stongly agree b. Agree c. No opinion d. Disagree e. Strongly disagree

27.1 How do you express the benefits of the protected area to the society ?

a. Very importantly b. Important c. Moderately important d. Little important

e. Not important

27.2 If you agree with yes for question No. 27, what is/are the benefit/s you get from Guassa Protected Area?

Benefit from Guassa Protected Area	**Highly important**	**Important**	**To some ex-tent**	**Not important**
Tussock grass for market				
Thatching house				
For grazing livestock				
For collecting fire-wood				
Source of Medicinal plants				
Tourism				
For recreation				
As a confreres/ meeting site				
Source of water				
Source of rain				
Habitat of geladas				

28. The protected area was established for the betterment of our community a. Strongly agree b. Agree c. No opinion d. Disagree e. Strongly disagree

29. I am generally satisfied that my village near to the protected area

a. Strongly agree b. Agree c. No opinion d. Disagree e. Strongly disagree

30. Generally speaking, I like the protected area a. Strongly agree b. Agree c. No opinion d. Disagree e. Strongly disagree

31. Feeding competition is intense between geladas and livestock in the area

a. Strongly agree b. Agree c. No opinion d. Disagree e. Strongly disagree

32. The presence of geladas enable to increase the tourist flow in the area

a. Strongly agree b. Agree c. No opinion d. Disagree e. Strongly disagree

33. Do you believe that tourism in Guassa area is important for the community? a. yes b. No, so what ? a. Very important b. Important c. Moderately important d. Little important e. Not important

34. What type of activities do you involve in tourism development in Guassa Area?

a. Providing mule/ donkey for the tourists as rent b. Providing fire wood for the tourist c. Serve as tourist guide d. Selling antique artefacts such as carpet, curtain, posters e. Providing food to the tourists

43.1 If you are benefiting from the tourism activities in Guassa area, how much you earn from this business?

Activities	Average/month earn from tourism (birr)	Annually earn (birr)	Remarks
Mule/donkey rent			
Selling of firewood			
Tour guide			
Selling of artefacts			
Providing food			
others			

35. Are these benefits sustainable in the long run? a. Yes b. No c. I don’t want say anything

36. What are some of the most significant problem that Guassa Community Conservation Area face ? ____

____

37. What types of involvement do you carry out for the protection of Guassa ? a. Involve in protection of Guassa as required by villagers b. Informing illegal activities c. Active participation in designing local laws d. Attending annual general meeting at ‘kebele’

level e. All aspects of involvement

38. Do the local community participate on conservation of the area? a. Very frequently b. Frequently c. Occasionally d. Very rarely

39. Do you like gelada and the protected area ? Why do you like/dislike it ?______________

____

____

39.1 What factors affect your attitude toward the conservation of gelada and the protected area? make a (×) mark in the table below.

Variables	**Strongly agree**	**Agree**	**No opinion**	**Disagree**	**Strongly disagree**
Absence alternative economic support (sources) in the area					
Low economic status					
In equlity of tourism benefits					
Lack of education					
Age (youngster)					
Sex					
Training (No)					
Low farm size					
Restriction on resources use					

40. How would you describe the level of community participation in the management of the protected area? a. Extremely high b. High c. Medium d. Low e. Very low

41. Rank the following issues or problems currently facing your community in order of 5 (most important) to 1 (least important).

Problems	Most important (5)	More important (4)	Important (3)	Some what important (2)	Least important (1)
Limited land					
Limited food					
Wildlife damage to crops					
Lack of access to forest resources/ products					
Lose of livestock by predator					
Shortage of social service					
Drought					
High cost of living					

Appendix II: **Focus group discussion with local community and Staffs of the Protected Area**.

1. What benefits have you been realized until now from the Protected Area ?
2. Do you think the local people around the protected area could affect the survival of geladas/wildlife?
3. How do local people and geladas, or wildlife in the protected area coexist in harmony?
4. What actions do you take to protect your crops from geladas damage?
5. What actions could stakeholders do to conserve the area by reducing degradation problems?
6. Who is responsible for conservation of gelada/wildlife in the protected area?
    a. Government
    b. Local community
    c. Non-governmental organizations (NGOs)
    d. All stakeholders

7. What impact is the protected area having on your effectiveness in forming and maintaining partnerships with external stakeholders?
8. To increase the local community benefits and at the same time to manage geladas/wildlife in the protected area, what should be done ?
    a. By local people
    b. By governments
    c. By conservationists
    d. NGOs
9. In order to bring sustainable use and implement proper management practices in Guassa Community Protected Area, what do you suggest?

Appindix III. List of animals occur in the Guassa Community Protected Area

Common name	Scientific name	Status
Ethiopian wolf	*Canis simensis*	endemic
Gelada	*Theropithecus gelada*	,,
Starck's hare	*Lepus starcki*	,,
Abyssinian meadow rat	*Stenocephalemus grisecauda*	,,
Unstriped grass rat	*Arvicanthis abyssinicus*	,,
Shrew	*Crocidura thalia*	,,
Shrew	*Crocudura baileyi*	,,
Common large mammals		
Serval cat	*Felis serval*	Least concern
Klipspringer	*Oreotragus Oreotragus*	Least concern
Grey duiker	*Sylvicipra grmmia*	,,
Spotted hyena	*Crocuta crocuta*	,,
Rock hyrax	*Procavia capensis*	,,
Leopard	*Felis paradus*	,,
Common jackal	*Canis aureus*	,,
Egyptian mongoose	*Herpestes ichneumon*	,,
White-tailed mongoose	*Ichneumia albicauda*	,,
Civet	*Viverra civeta*	,,
Honey badger	*Melivora capensis*	,,
Endemic birds		
Ankober serin	*Serinus ankoberensis*	endemic
Abyssinian cat bird	*parophasma galinien*	endemic
Abyssinian long claw	*Macronyx flavicoils*	,,
Blue-winged goose	*cyanochen cyanoptera*	,,
Black-headed siskin	*serinus nigriceps*	,,
Black-winged love bird	*Agapornis taranta*	,,
Rougets rail	*Rougetius rougetil*	,,
Spot-breasted plover	*Vannellus melaocephalu*	,,
Thick-billed raven	*Corvus crassrisiros*	,,
Wattled ibis	*Bostrychia carunculata*	,,
White-collared pigeon	*Columba albitorques*	,,
White-winged cliff chat	Myrmecocichla semirufa	,,
Common birds		
Auggeard buzzard	*Bueteo augur*	Least concern
Bearded vulture	*Gypaetus barbatus*	Least concern
Tawny eagle	*Aquila rapax*	,,
Golden eagle	*Aquila chrysaetos*	,,
Mountain buzzard	*Bueteo areophilus*	,,
Lesser kestrel	*Falco naumanni*	,,

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