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(Ecological and Systematics Zoology)



**POPULATION ESTIMATE AND STRUCTURE OF THE
GELADA BABOON, *Theropithecus gelada*, IN THE GUASSA
COMMUNITY CONSERVATION AREA, CENTRAL
ETHIOPIA**

BY
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Abstract: *Guassa area has a total area of 111km². Before the present study, no comprehensive census of geladas in the Guassa area had been carried out. The method used to census geladas living at Guassa was a total count. In addition, the age-sex structure of the geladas, the number of one male units (OMUs) per band, the size and composition of OMU and all male group (AMG), in the gelada population were investigated. A total of 1506 and 1543 geladas were counted during wet and dry seasons respectively. The adult sex ratio for both wet and dry seasons was 1:2.8 in favour of females. When the bachelors were excluded from the analysis, there were 4.1 adult females for each adult male. The ratio of sub adults, young, and infants to adults was 1:1.2. The ratio of adult females to infants was 1:2.5. With regard to the number of OMUs per band, there were 18.0 and 18.4 during wet and dry seasons respectively. The mean OMU size during the wet season was 12.15 of which 4.13 were adult females, 0.66 were sub-adult males, 1.92 sub adult females, 2.64 young and 1.70 infants. During the dry season, the mean OMU size was 1166 which was composed of 4.12 adult females, 0.59 sub-adult males, 1.93 sub adult females, 2.50 young and 1.46 infants. The mean AMG size during the wet season was 6.41. During the dry season, the mean size of AMG was 6.23.. The ratio of AMGs to OMUs was 1:10.0 and 1: 10.5 during the wet and dry seasons respectively. Generally, there was no significant difference among the total population number, age-sex categories, and the number of OMUs per band, the size and composition of OMU and the size of AMG during dry and wet season. Though the actual size of the gelada population is significantly lower than the expected, based on previous unpublished report of Fashing and Nguyen, 2007, the overall condition of the current population does not appear to be in jeopardy. But there are many conservation threats such as habitat degradation, introduction of non-native plant species and harvesting/gathering, which are*

directly or indirectly related with the growth of population in the area that will threat the future survival of the species.

Key words/phrases: AMG, Band, Conservation threats, Gelada baboon, Guassa area, OMU, Population census and total count

Introduction

Ethiopia is one of the most physically and biologically diverse countries of the world. It contains various wildlife and wildlife habitats ranging from alpine moorlands to lowland Savannas and arid lands, and extensive wet lands (Yalden, 1983). The main reason for the presence of diverse wild life and large number of endemic species is the rugged topography. This helped to create isolated and varied ecological environment. There are 861 species of birds, 277 species of mammals, 201 species of reptiles, 63 species of amphibians and 150 species of fishes in Ethiopia (Hillman, 1993). Among these, 31 mammals, 16 birds, 24 amphibians, 9 reptiles and 40 fishes are believed to be endemic (Hillman, 1993). Accurate population estimate of these diverse wild life forms is an integral part in the process of proper conservation measures. There are many reasons for deciding to carry out a population census. It may be used to determine:

1. the importance of a site for a ranging species. One of the major priorities for conservationists is to determine the most important areas for a given species or groups. Questions may include: how important is a particular country? Which sites within an area are most important?
2. The habitat requirements of the species which will include prey abundance, predator abundance and nesting sites, habitat structure and environmental variables.
3. Population dynamics; by measuring life history and estimating the population size it is possible to consider a range of questions: why does the population fluctuate from year to year? What determines the level of abundance? How strong is density dependence and at what life stage does it operate? What are the influences of competitors, herbivores or predators on the population?

The purpose of the present study is to provide the status and demography of geladas living in Guassa. A better understanding of the status and the demography of gelada is a critical first step to plan for conservation and management policies of this endemic species of the country.

2. LITRATURE REVIEW

2.1. Background and common features

The Ethiopian endemic species, *Theropithecus gelada*, commonly called the gelada baboon; was first discovered by a German naturalist called Ruppel in 1835 in a few areas of the Northern Ethiopian Highlands (Crook, 1966). Formerly, it was believed that the genus *Theropethicus* included several extinct species which were widespread and successfully found over much of Africa and India. But, at present, gelada is the sole survivor of the genus *Theropethicus* (Dunbar, 1998). Today, geladas are found in few areas of the Northern Ethiopian Highlands. It occurs predominantly in the Simien Mountains where it is observed in large numbers .But it also occurs in small numbers in Menz (Guassa), Debresina, Debrelibanos, and Wollo. An additional isolated population was discovered in the Arsi region, south of the Rift Valley and east of the Bale Mountains (Mori and Belay, 1990).

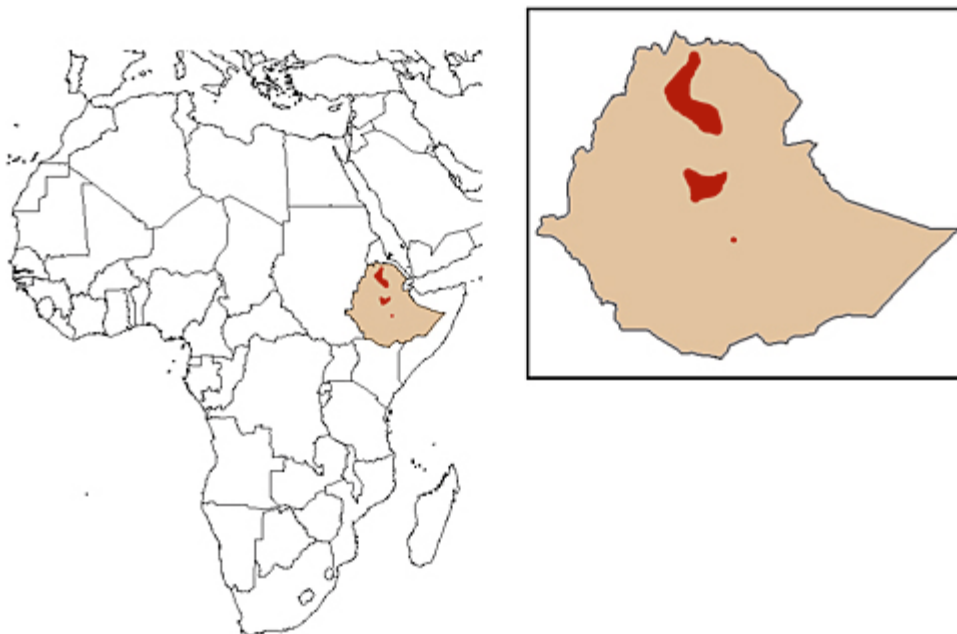


Figure 1 Range map for *Theropethicus gelada* (in red)

(Source: Gron. K.J. 2008)

Geladas have dark brown to buff coarse pelage, dark brown faces, and lighter pale eyelids. The tail with a tuft end is shorter than the body and the head (Napier, 1981). The adult male has a heavy cap of hair on its back. Between sub-species, *T. gelada gelada* has a pale brown to dark brown pelage while *T. gelada obscurus* is darker, ranging from dark brown to almost black (Yalden, et al., 1977). Gelada baboons can be distinguished from other baboons by their naked face, chimp-like than baboon like snout and hour glass-shaped patch of bare red skin on their chest (Napier, 1981; Ankel-Simons, 2007). The red chests are very distinctive features of geladas, and have earned them the alternative name of 'bleeding heart baboons'. In females, this skin patch is surrounded by pearl-like knobs of skin. On the average, males are larger than females and marked sexual dimorphism is characteristic feature of the species, with females averaging around two-thirds the size of males (Krentz, 1993; Jolly, 2007). Females average around 11kg while males weigh 18.5kg (Jolly 2007). Head and body lengths of the sexes combined range between 50 and 75cm and the tail is between 30 and 50 cm (Ankel-Simons, 2007). The species has highly opposable index fingers and thumbs (Napier, 1981). In addition, its fingers are short and substantially built allowing them to be used efficiently for digging (Dunbar, 1976). Geladas have specialized dentition adapted for their highly graminivorous diet, which is highly abrasive to teeth (Jablonski, 1994).

The mating system of a species has profound impacts on the morphology and physiology of both sexes. Monogamous and polyandrous species show virtually no dimorphism. But in species living in one male mating system, there is a marked sexual dimorphism. This is because; body and canine size dimorphism are closely associated with the amount of direct competition among males for mating success to females. On the other hand, species living in a multi male groups show intermediate level of dimorphism. In species living in multi male mating system, males usually have larger testes relative to their body size than species with single

mating system. In multi male mating system sperm investment competition may play an important role and hence larger amount of sperm produced by larger testes size may be advantageous. But in a single mating system, sperm competition is reduced and therefore, has smaller testes (Harcourt *et al.*, 1981).



Figure 2 Male (A) and Female (B) gelada baboon

Photo: Anonymous, 2002, 2003)

Pronounced sexual dimorphism in gelada suggests strong male-male competition (Plavcan and Van schaik, 1992) and is a prerequisite for a social system that is based on one male unit. As a result, males are larger than females. Adult male geladas have long cape of hair which probably function as an organ of attraction to females (Jolly, 1963; Kummer, 1968,). According to Zahavi (1975) or Hamilton and Zuk (1982), it could also be a signal of a male condition to both mates and potential rivals. In addition, adult males have a patch of sexual skin on their chest which is brightest in males that are successful in forming OMU. But in a defeated old leader, the brightness of his chest patches fades rapidly (Dunbar,

1984a). Because sperm investment competition is low in gelada, small testes in relation to its body size are expected.

2.2. Habitat

Geladas live in harsh mountain areas of the central plateau of Ethiopia, with an elevation ranging from 1500-4500m (Iwamoto, 1993). Recently an additional population was detected in the Arsi region, south of the Rift valley and east of the Bale mountains. Gelada present day habitat consists of montane grass and with no tall trees and is characterized as wet and cool (Dunbar and Dunbar, 1975). Gelada habitat is characterized by their proximity to cliffs for sleeping and the use of several different types of a relatively treeless and montane grass lands for foraging (Dunbar, 1979b; Kawai and Iwamoto.1979). Geladas are ill-adapted to arboreal way of life. Even where they occur in or near the forest, they rarely climb up trees. The gelada's dependence on gorge side has not only provided a refuge from the incursion of man and protection from the more conventional predators, but also a habitat to which the species is particularly well adapted (Jolly, 1972). In general geladas of the northern population live in a habitat that is relatively rich in terms of food availability with abundant sleeping and drinking sites. The higher the altitude, the longer the vegetation stays green, due to high rainfall and low temperature (Iwamoto, 1993).

On the Amhara plateau, the year can be divided in to rainy (June-September) and dry seasons within southern habitats showing a slight second rainy season in March and April (Iwamoto, *et al.*, 1996). Though the annual rainfall increases with altitude, annual rainfall in the gelada habitat is usually around 1200mm (Iwamoto and Dunbar, 1983). On the Amhara plateau, monthly average temperature ranges from 20⁰c (March-May) to 15⁰c (July-September) with a general trend towards lower temperatures as the altitude increases (Iwamoto, 1993). The daily

temperature may vary by up to 25⁰c and can drop below freezing (Iwamoto and Dunbar, 1983).

2.3. Ecology of Gelada

2.3.1. Feeding ecology: Geladas are one of the most terrestrial of the non-human primates, and are best described as nearly terrestrial quadrupeds with specialized morphological adaptations for their graminivorous feeding and moving on the ground (Krentz, 1993 and Dunbar, 1983b). The typical feeding posture and associated locomotion (shuffle-gait) is unique to gelada, and occurs in a sitting position (Dunbar, 1977b, 1983a). During this type of feeding locomotion, the animal squats, feeds and shuffles bipedally without changing its posture, allowing near-continuous foraging and consumption (Wrangham, 1980, Dunbar, 1983b). Due to high proportion of time spent feeding, the bipedal shuffle gait can comprise up to two third of the daily locomotion behaviour (Wrangham, 1980).

The typical feeding posture and associated locomotion varies with seasons. During the rainy season, geladas feed by sitting and foraging with both hands in turn, using their thumb and first digit to pick suitably green blades of grass (Crook and Aldrich-Blake 1968). During dry season, when preferred foods are often underground, gelada dig using both hands as a shovel (Crook and Aldrich-Blake 1968).

Theropithecus gelada is predominantly graminivorous (Iwamoto and Dunbar, 1983), with grass forming more than 90 % of the diet in most habitats and seasons. When the availability or the nutritional value of grass changes, there will be a shift to flowers, rhizomes, roots, herbs, fruits, and insects if they are easily accessible (Iwamoto, 1993). During dry season, it changes its dietary intake from grass to herbs and there is

an increased food intake by prolonging the time spent feeding. The time spent for feeding is also influenced by altitude. As altitude increases, the time spent feeding increases due to thermoregulatory energetic needs (Iwamoto and Dunbar, 1983). Furthermore, gelada populations appear to differ in their feeding habits. Diet of the Arsi population in the southern part of their range contain considerable amount of fruits which have rarely been used by the geladas living in the northern part (Iwamoto *et al.*, 1996).

2.3.2. Ranging Behavior: As food availability is much greater in the highlands than the lowlands, geladas move for only a short distance a day as compared to the hamadryas baboon (*Papio hamadryas*) (Dunbar and Dunbar, 1975). The daily moving distance of gelada is 1-2km (Iwamoto and Dunbar, 1983). Day range varies daily and seasonally but is closely related to group size (Kawai and Iwamoto, 1979). If food is limited, geladas with large group size move longer distances (Kawai and Iwamoto, 1979). Similarly to daily range, home range, which varies between 0.78-3.44 km² are related to group size, with large groups possessing larger home range (Iwamoto and Dunbar, 1983). Differential use of home range has also been observed in the dry and wet seasons due to the fact that green grasses are more patchily distributed during the dry season.

2.3.3. Activity patterns: In *Theropithecus gelada*, the typical pattern of habitat use is to sleep on cliffs during the night and to climb up the plateau for their daily activities. Geladas are diurnal: they are active during the hours of light and sleep when it is dark. In the morning, Geladas will climb from their sleeping cliffs to the top of the plateau. Soon after, they will commence social activities and feeding (Dunbar and Dunbar, 1974; Dunbar, 1977b). Feeding comprises the main activity of the day, it goes up until the evening when some social activity is seen again prior to descending to their sleeping cliffs (Dunbar and Dunbar, 1974). On the average, the daily time budget for gelada is; feeding (35.7-

62.3%) moving, (14.7-20.4%), resting (5.2-26.3%) and socializing (16.0-20.5%) (Iwamoto and Dunbar, 1983). However, in some studies feeding may go up to 81.6% with the remainder of the day spent mostly moving and grooming (Kawai and Iwamoto, 1979). On the average, the active period ranges between 11-12 hours and during the dry season, more time is spent feeding (Iwamoto, 1993). In addition to seasonality, altitude also has an effect on the daily time budget of gelada. As altitude increases feeding time goes up (Iwamoto and Dunbar, 1983). This is mainly because of a combination of increasing temperature dependent energy requirements and declining habitat quality (Iwamoto and Dunbar, 1983). In general, as feeding goes up, resting decreases, and relative to one another, time spent moving and in social interactions stay about the same (Iwamoto and Dunbar, 1983).

2.3.4. Predation pressure, conservation status and conservation threats: *Theropithecus gelada* probably experienced great predation pressure in the past. But, present predation pressure is minimal likely due to the proximity of humans to many habitats (Iwamoto, 1993). At present, the actual and potential predators that threatened the geladas are hyenas, foxes, leopards and dogs (Dunbar and Dunbar, 1975).

Geladas are protected in the Simien Mountains National Park, a UNESCO World Heritage site, and hunting of the species within its confines is forbidden (Oates, 1996). Formerly this park was established for the conservation of the extremely rare Walia Ibex (*Capra walie*) instead of the geladas (Dunbar, 1993).

The total wild population of gelada is estimated at slightly less than 250,000 individuals (Dunbar, 1998).

Human encroachment into the geladas preferred habitats for agriculture seriously endangered the geladas. This is because as the gelada preferred

habitat is destroyed, geladas will likely have to move to more marginal areas, and this leads to a reduction in the population density of the species (Dunbar, 1977c). Additionally, due to their specialized diet, geladas are severely affected by drought and soil erosion which are the results of mal-activity of humans. Geladas are also potentially threatened by global climate change predominantly due to their altitudinally restricted habitat. If temperature rises, the altitude of montane grassland would increase and eventually the gelada habitat would cease to exist

Clearing of vegetation in certain areas of gelada's habitat and replacing by quick growing non-native species such as *Eucalyptus globules* by the local farmers indirectly threatened the species. This invasive species do not retain soil and inhibit the growth of grasses which are the most preferred diet of geladas (Dunbar, 1977c).

In the past and even recently, local people killed male geladas for their mane to be used for ceremonial head-dresses. This discriminate killing which only reduces the male from the population, alters the species reproductive and social dynamics (Dunbar, 1993)

Though geladas' preferred diet is grass, in time of drought, they will raid crops especially during harvesting time (Dunbar, 1977c). This leads to a conflict between the geladas and local farmers.

At present, gelada's restricted home range and continued human encroachment has resulted in a 'rare' status of the gelada by IUCN and appendix II listing in the Convention of International Trade in Endangered Species (CITES).

2.4. Social System

Ecological factors, such as food distribution are among the most important determinant of the social organization of the gelada. They have also an impact on social structure and mating system (Van schaik, 1996; Sterck *et al.*, 1997; Lendenfors *et al.*, 2004). *Theropithecus gelada* form large groups or aggregations on a permanent or regular basis. These large groupings can be determined by various ecological needs such as predation avoidance, optimal habitat use and foraging, male mate defence and infanticide avoidance. Though group living has its own disadvantages, such as increased competition with other individuals for the same resources of food and mates, it maximizes their survival and that of their offspring.

The social system of gelada consists of the social organization, the social structure, and the mating system (Kappeler and Van schaik, 2002).

2.4.1. Social organization: The social organization of *Theropithecus gelada* includes group size and composition and spatio-temporal cohesion. The dynamic and complex social organization of gelada is a nested, multi-level hierarchy of social units consisting, in increasing order of size; reproductive units (1-12 adult females plus their dependent young and some juveniles, 1-4 males), and all-male groups (2-15 males), bands (2-27 reproductive units and several all-male groups), herds (ephemeral accumulations of 2-60 reproductive units, sometimes from different bands) and communities (1-4 bands that overlap extensively) (Crook, 1966; Kawai *et al.*, 1983; Dunbar, 1986; Gruter and Zinner, 2004). Kawai *et al.*, (1983) suggests that it may be possible to identify a social grouping (named *team*) intermediate between the OMU and the band since some units of the band associate more closely than they do with other units of the band.

In *Theropithecus gelada*, since one male monopolizes more than one female, a number of solitary males without their breeding females form all-male unit (AMU) that travel separately from the OMUs (Mori et al., 1999). AMU usually consists of adolescent and younger adult males (Dunbar and Dunbar, 1975) and ousted former OMU leaders (Dunbar, 1993). According to Mori (1979c) and Ohsawa (1979), the so called 'freelancers' which belong neither to the OMU nor to AMUs are found in gelada. 'Juniors freelancers' appear to represent prospective future members of the AMU. 'Senior freelancers' are full grown males whose age exceeds the average age of the AMU males (Mori, 1979c). The membership of gelada OMU in a certain band is not constant. The fluidity of the band is due to the fact that OMU may visit other bands or even pass their day alone. Fission of the band causes emigration of OMUs and usually involves two to six OMUs moving away to establish a new ranging area elsewhere (Dunbar, 1993). Predation pressure and resource competition have an effect on geladas grouping pattern. Large groups are formed on open grassland where predation risk is high. However this gathering has the side effect of increased food competition. But in habitat such as grassy slopes, where predation risk is less, bands split into segregated OMUs, with food competition concomitantly being reduced (Dunbar, 1986). Though gelada has low reproductive rate, mortality rate is so low that population growth rate is among the highest recorded for any primate (Ohsawa and Dunbar, 1984), As a result, fission of the band occurs in the interval of eight to nine years (Ohsawa and Dunbar, 1984).

In *Theropithecus Gelada*, females generally remain in their natal unit throughout their lives (Dunbar and Dunbar, 1975). Female transfers are extremely rare (Mori *et al.*, 2003; Dunbar 1979a). However, sub- adult males emigrate from their natal unit during puberty to join an AMU (Mori, 1979c). After spending two to four years they establish a new

reproductive unit of their own in acquiring breeding females (Dunbar, 1993).

2.4.2. Social Structure: The social structure of gelada refers social interactions and relationships which includes, inter and intra band relationships, inter-individual relationships, female-female relationships, female-male relationship and male-male relationship. In *Theropithecus Gelada*, large mixed bands are formed without recognition among individuals (Ohsawa , 1979). But almost all social interactions of adult are between individuals of the same OMUs (Dunbar, 1979a).

Little aggression within a reproductive unit is recorded, with the majority of aggression being directed outward towards non-unit individuals (Dunbar and Dunbar, 1975). During agonistic interaction towards the non-unit individuals, it is the females who initiate agonism and as the conflict escalates, both males and sometimes many females of the opposing sides get involved (Dunbar and Dunbar, 1975).

In *Theropithecus gelada*, grooming and social interactions occurs between not more than two to three kin- related females within the reproductive unit (Dunbar, 1979b; 1983a). The restriction in the number of individuals with which any individual female socially interacts may be explainable in light of time constraints enforced by large proportions of time spent feeding (Dunbar, 1983a). Reproductive units are limited in size. But periodic fission will occur when the reproductive units grow too large (Dunbar, 1993). The strong social relationships in gelada females seem to provide the basis for coalitionary support during agonistic encounters (Dunbar, 1980). It also provides a strong social cohesion even after the death of the leader male (Dunbar, 1983a; Mori, 1979d). Linear dominance rank orders are established among females within each OMU (Mori, 1979b; Dunbar, 1983a). The dominance rank of a female is matrilineally determined (Dunbar, 1980). The most dominant females of

each matriline determine the relative ranks of the matrilines. The more aggressive the female, the higher will be the rank of her matrilines and thus the rank of her relatives. Female's dominance rank within her unit depends on her intrinsic power due to her own physical capacities and the extrinsic power that she gains through support from other more powerful individuals (Dunbar 1993). Females that are low in the hierarchy suffer an accumulation of low-level aggression and harassment from the high ranked females. Coalition between females functions to reduce the stress (Dunbar, 1993). Females who are members of a coalition occupy significantly higher dominance rank within the unit than those who are not (Dunbar, 1993). The male, however has no effect on the female dominance hierarchy, so that unlike the female ally, he cannot raise his partner's in the hierarchy by supporting her against her rivals (Dunbar, 1993). But no female was observed to actively interfere with the solicitation or copulations of other females (Dunbar and Dunbar, 1977). No differences could also be found between dominant and subordinate females in the frequency of ejaculations received from their males (Dunbar and Dunbar, 1977).

In *Theropithecus gelada*, the unit leader male have a single predominant grooming partner. This single predominant social partner continues to remain even after he has been displaced from OMU leadership, though she now mates with the new OMU male (Dunbar, 1993). Those females who lack female relatives within the OMU cannot attain the status of male's main grooming partner. The frequency of herding by leader male is low and relatively ineffective (Dunbar, 1978) because the male may be chased by two or more females. As a result, he will behave rather defensively by emitting appeasement vocalization during the attempt of herding.

AMUs are closed social units: only few friendly interactions with non-members and agonistic interactions within the AMUs are rare (Dunbar and

Dunbar, 1975). But the relationship between the OMU leader and the AMU male is characteristically agnostic (Dunbar and Dunbar, 1975). There is no overt dominance rank among male unit leaders (Mori, 1979a). Dominant-subordinate relationship exists between the leader male and the second male in the unit (Mori, 1979b).

2.4.3. Mating system: *Thropithecus gelada* has a polygamous mating system. In the reproductive units of gelada, if more than one adult male is present, only one is reproductively active to the exclusion of extra male groups and thus the reproductive unit is effectively a single male unit (Mori et al., 1997; Ohsawa 1979). So only the unit leader male copulates with the unit females (Mori, 1979d). Before the onset of copulation, the leader male usually inspects the ano-genital regions and the chest of the unit female. But the majority of copulation is initiated (solicited) by females. When the female solicits the male, she shows a distinctive solicitation posture which can easily be understood by the unit leader male. The usual solicitation posture involves pointing and raising her abdomen towards a male and moving her tail to one side (Bernstein, 1975). Copulation usually lasts only around ten seconds which is accompanied by vocalization. Most copulation occurs during the morning before mid-day, and when in estrus, a female usually copulates 2-5 times per day. Though copulation occurs at any time in the estrus cycle, its frequency increases around ovulation. Males do not sexually interact with females of units other than their own (Dunbar and Dunbar, 1975).

In gelada, there are different options for a male to acquire breeding females. 1. By joining an OMU as a submissive follower (Kummer, 1968) and trying to establish relationships with the OMU females, in particular with young pre-reproductive females to build up a nuclear unit within an OMU. OMU leaders are normally not sexually interested in these young females, most likely because they are their offspring. After the young females have reached sexual maturity, the follower male separate his

females from an OMU to pursue an independent existence (Dunbar, 1984a; Mori, 1979c; Dunbar and Dunbar 1975). Acquiring breeding females by joining as a submissive follower is usually a gradual process and the two OMUs may remain in social contact for a considerable time (Dunbar and Dunbar, 1975). 2. By group take over which is fast and aggressive process. During this strategy, a younger male from the AMU attacks and defeats an older OMU leader who is presumed to be weak and take over the leadership of the entire unit. The deposed OMU leader will usually stay within the OMU as a second male (Mori and Dunbar, 1985). Despite the aggression between the leader male and the second male, the second male will support the leader male when the former is in fight with males from an AMU. The risk of takeover is higher in larger OMU size (4-10 females) than smaller OMU size (Dunbar, 1984a). Female's choice of a specific male exists in gelada (Dunbar 1984a). Females in the units play a key role in determining whether a new male will be accepted. So to be successful the intruder must not only defeat the leader male but also must solicit grooming and proximity with the females in the unit. The success of the leader male to drive the intruder or to give up his power is also determined by the reaction of the females. 3. According to Mori (1979d), OMUs having lost their leader remain intact and are taken over as a group by AMU male or merge entirely with another OMU. Because female-female relationship in gelada is so strong, splitting of females into different OMUs does not occur. 4. The simplest strategy for acquiring females would be to 'kidnap' a loose female and form a small unit with her. Dunbar (1984a) estimated that gelada male stays as OMU leader for 3-5 years and male life expectancy is 12.3 years. Defeated old OMU leader remain in the OMU for about two years and then seem to drift off to rejoin an AMU (Dunbar 1993). By staying within the OMU, the old leaders have a chance to protect their infant from infanticide (Dunbar and Dunbar, 1975).

In gelada females, the size and colour of the naked triangular chest patch is affected by cyclical hormonal changes. Sexual signals are thought to be located on the chest because of better visibility due to frequent sitting (Wickler, 1967). During estrus, females develop beadings at the border of their sexual skin, a naked reddish area on their chests (Alvarez, 1973) and additionally, a swollen, protruding vulva. In addition to hormonal changes, the colour of the chest patch does correspond with age. Younger females have purplish patches which fade to pink in older females (Dunbar, 1977a). During estrus, females also emit a specific type of estrus call to inform male of their condition (Moos-Heilen and Sossinka, 1990). The length of estrus cycle varies greatly in captive gelada females, but averages 37.3 days (McCann, 1995).

Births in geladas mostly occur at night but have also been observed in early morning (Dunbar and Dunbar, 1974a). At birth the infant is born with closed eyes, red face and black hair that covers the body until around three months old (Dunbar and Dunbar, 1984a; Mori, 1979a). At birth the infant weighs about 464g (Leutenegger, 1973). The mother remains on the periphery of the reproductive unit for sometime after the onset of birth. The mother carries the infant ventrally until five weeks old and predominantly on her back sometimes with the infant tail entwined with her after five weeks (Mori, 1979a; Barrett, *et al.*, 1995). The infant first starts to move away from its mother at two weeks old (Mori, 1979a). By the age of five months, the infant is more likely to move independently rather than being carried. Allo-parental cares are known in gelada. Only juvenile females are known to engage in allo-care (Dunbar cited in Ross and MacLarnon, 2000). They show keen interest to the neonate even up to a level of trying to take it from its mother (Mori, 1979a). When two males are present in the social units of gelada, the subordinate frequently affiliates with the infants which may be used to establish sexual relationships with the infant's mother (Mori, 1979b). Disposed OMU leader

actively defends the group's infants when threatened by the new leader or by other males (Dunbar and Dunbar, 1975; Dunbar, 1984b).

Infanticide has been frequently noticed in captive gelada after the replacement of the OMU leaders in the absence of the old followers (Angst and Thommen, 1977; Moos *et al.*, 1985). Infanticide due to change of OMU leader male were also observed in the field in Arsi (Mori *et al.*, 2003). There is evidence that as the number of males per groups' increases, the rates of infanticide by males reduces (Janson and Van Schaik, 2000) and possibly more common in a single mating system than in others. The presence of young or old follower in the gelada unit as a second male reduces the probability of infanticide (Dunbar, 1984a). Another strategy for a female to ensure protection against infanticide is association, and exclusive copulation with a single protective male. These result paternity concentration rather than paternity confusion. Confidence of paternity triggers protective behaviour towards infants in gelada. Tripartite male-infant-male interaction where young followers threatened by an OMU leader often grasp an infant and carry it in front of the adult male are known in geladas. Paul, *et al.*, (2000) argue that infanticide risk might provide an indirect explanation for why infants function as buffers in such tripartite interactions. Namely, by carrying unrelated infants to more dominant males who are likely to sire the infants, males would reduce the likelihood of an escalated fights because any severe aggression performed by the dominant male would put his own offspring at risk.

3. OBJECTIVES

3.1. General objectives:

- To estimate the total population size of gelada
- To determine the demography of gelada population in the Guassa Community Conservation Area

3.2. Specific objectives:

- To determine the size and composition of OMU and AMG
- To determine whether the number of gelada is being maintained, in decline or recovery
- To determine the effects of seasonal variations on the population number and structure of gelada

4. STUDY AREA

4.1. Location of the study area

The Guassa area of Menz is located in the Central Highlands of Ethiopia which lies between 10° 15'-10° 27' N and 39° 45'-39° 49' E (Zelalem Tefera *et al.*, 2005). The Guassa area is found in the Amhara Regional State, within the North Shoa Zonal Administration and in Gera Keya woreda (district). It is located at a distance of 265km away from the National capital, Addis Ababa in the north-east direction, 135km away from the zone capital (Debre Birhan) in the north direction, and 17km away from the district capital (Mehal Meda). There are eight peasant associations which are found adjacent to the Guassa area. These are: Chare; Dargegn; Gedenbo; Gragh; Kewula; Kuledaha; Quanguay; and Tesfomentir (Figure 3).

The Guassa area of Menz , with a total area of 111km², forms a part of the western edge of the Great Rift Valley, with an altitude ranging from 3200m to 3700m above sea level. In the eastern part there are sharp elevation changes which drop from 3600m above asl to 1000mm above sea level within a distance of 50km (Zelalem Tefera, 2001).

4.2. Geology and Soil

Guassa area is the result of tectonic movement during Oligo- Miocene. At present, the area consists of 15-26 million years old Miocene Thyolitites and basalts and 20-26 million years old Oligo-Miocene termaber basalts and Phonolites . The central highland consists of black-clay and reddish-brown heavy loam soil. Guassa area is characterized by deep and humic soil though the higher ground has shallow and highly mineralized soil.

4.3. Climate

The climate of Guassa area varies with altitudinal gradient and seasonal changes. At higher altitude, wet season is characterized by a combination of high rain fall, frequent hail storms and occasional snow. But during dry season, frosts are common. There are sharp temperature fluctuations between night and day time. Generally night times are colder than the day times.

4.3.1. Rain fall

The Equatorial Westerlies and the Indian Ocean air streams are the sources of rain for Guassa at different times of the year. Though showers of light rain can occur in any month of the year, the rainfall at Guassa is grouped in to main rainy season (*Kiremt or Meher*) in between June to September and minor rainy season (*Belg*) in February, March and April. The annual rainfall at Guassa ranges from 1200-1600mm (Zelalem Tefera, 2001). Due to data deficiency at Guassa, the data for rainfall was collected from Mehal Meda, the nearest meteorological station. The data collected for ten years (2000-2009) at Mehal Meda show a bimodal distribution of rain (Figure 4).

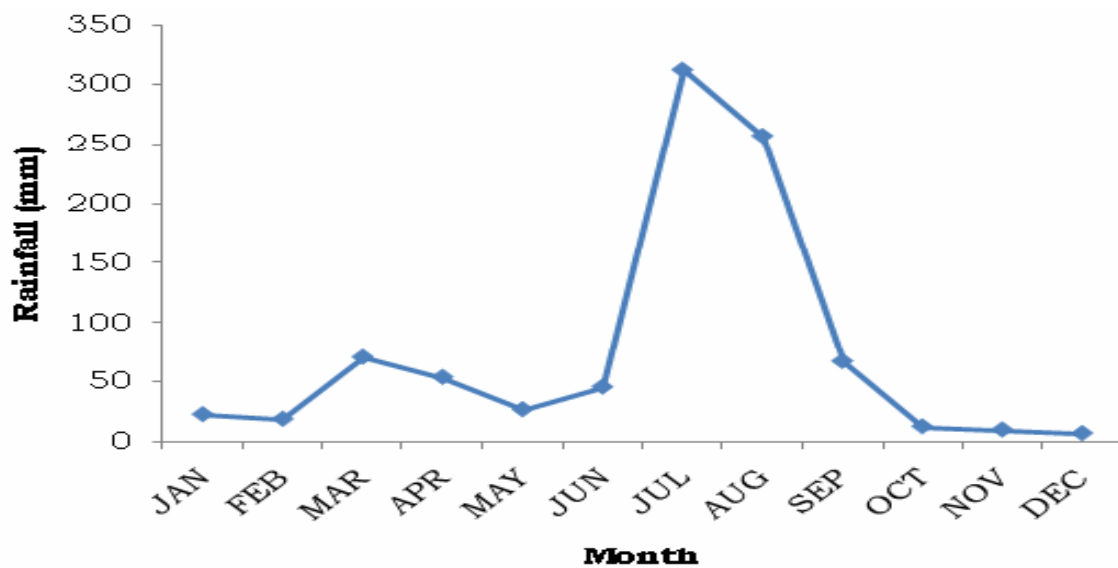


Figure 4 Monthly rainfall at Mehal Meda (2000-2009)

4.3.2. Temperature

Temperature data for Guassa was not available. Instead the temperature data recorded from the nearest meteorological station is used. The area is characterized by mild day temperatures and cold night temperatures.

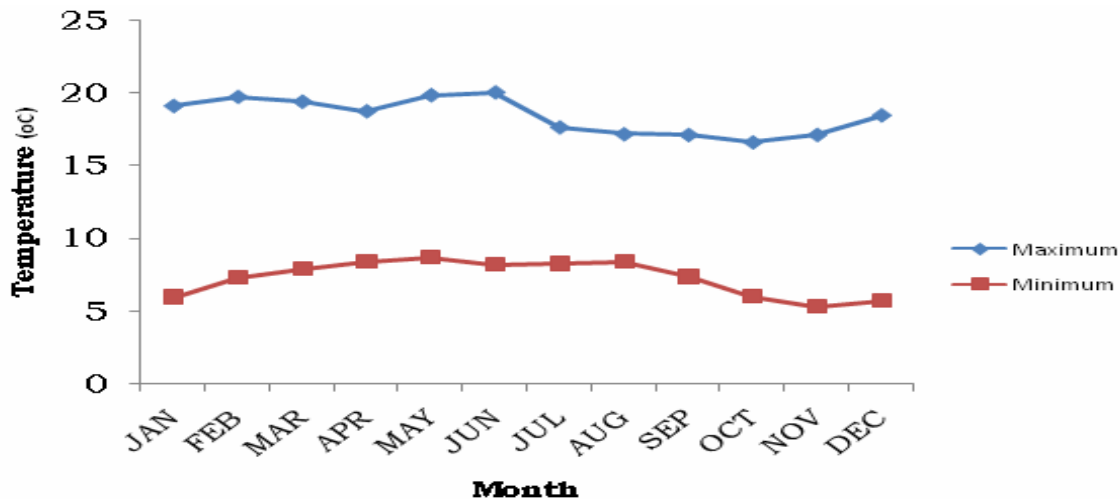


Figure 5 Mean monthly temperatures at Mehal Meda (2000-2009)

During the dry season (December to January), the temperature would rise up to 21°C at day time, but it falls to -7°C at night. In the wet season, the day time temperature is 12°C while a night temperature is 3°C (Zelalem Tefera, 2001). The temperature data collected from 2000-2009 show that the mean monthly minimum temperature ranges from 5.28°C-8.66°C while the maximum temperature ranges from 16.64°C-20.03°C (Figure 5).

4.3.3. Humidity

Figure 6 shows humidity data obtained from Mehal Meda meteorological station. Since recorded humidity data do not exist for Guassa, humidity recorded from the nearby Mehal Meda is used (Figure 6).

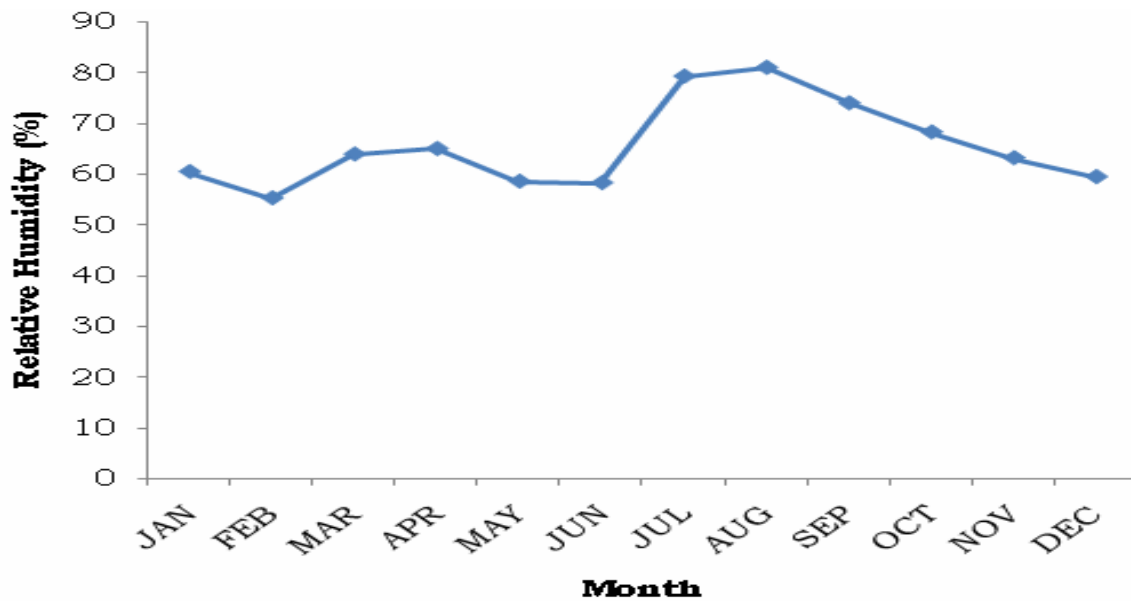


Figure 6 Relative humidity at Mehal Meda (2000-2009)

The area is characterized by high humidity in the wet season and low humidity in dry season. The annual humidity ranges from 55.18%-80.90%).

4.4. Flora

According to Zelalem Tefera (2001), the afro alpine vegetations of the Guassa area are classified in to the following habitat types.

4.4.1. Festuca Grassland (Guassa Grassland): The species that are common in Festuca grassland are *F. abyssinica*; *F. Simensis*. *F. Richardii*; *F. Macrophylla*; *A. abyssinicus*; *P. schimperina*; *T. barchellianum*; *T. multinerve*; *A. abyssinica*; *Alchemilla sp.*; *S. vulgaris*; *T. schimperi*; *H. formosissimum*; and *Artemesia*.

4.4.2. Euryops-Alchemilla Shrubland: The species that are common to this area are *Euryops pinifolius*; *Alchemilla abyssinica*; *kniphofia foliosa*; *Thymus schimperi*; *Urica simensis*; *Anthemis tigereensis*; *Echinops steudneri*; *Ferula communis*; *Hebenstretia dentata*; *Swertia erythraeae*; *Agrostis graclifolia*; *Granium arabicum*; *Kalanchoe deficiens*; *Senecio gigas*; *S. vulgaris*; and *S. Schul*

4.4.3. Euryops-Festuca Grassland (Mima Mound): In this area are *Euryops pinifolius*; *Festuca abyssinica*; *Festuca richardii*; *Festuca macrophylla*; *Festuca Simensis*; *Agrostis gracilifolia*; *A.klimandscharica*; *Andropogon amethystinus*; *alchemilla abyssinica*; *Anthemis tigereensis*; *Thymus schimperi*; *Rumex abyssinicus*; *Cirsium vulgare*; *Hebenstretia dentata*; *Hypericum peplidifolium*; *Lobelia rhynchopetalum*; and *Haplocarpha rueppellii*.

4.4.4. Helichrysum-Festuca Grassland: In this area the most common plant species are *Helichrysum splendidum*; *Helichrysum Gofense*; *Helichrysum Formosissimum*; *Sencio vulgaris*; *Fesuca simensis*; *Andropogon abyssinicus*; *Pinnisetum sp.*; *Alchemilla abyssinica*; and *Echnnops*.

4.4.5. Erica Moorland: The plants commonly found in this habitat type are: *Erica arboria*; *Thymus schimperi*; *Trifolium burchellianum*; *Alchemilla abyssinica*; *Helichrysum splendidum*; *Kniphofia foliosa*; *Swerti abyssinica*; *Rubes abyssinicus*; *R.stedneri*; and *Urtica simensis*.

4.4.6. Swamp Grassland: Common plant species of this habitat type are: *Carex monistachia*; *Carex fischeri*; *Hydrocotyle mannie*; *Alchemilla SP.*; *Swertia shiperi*; and *Kniphofia isoetifolia*.

4.5. Fauna

4.5.1.Mammals: There are two species of Shrews; six species of rodents; the Ethiopian wolf (*Canis simenis*); gelada baboon (*Theropethicus gelada*) ; Abyssinian hare (*Lepus starcki*); grey duiker (*Sylvicapra grimmia*); Klipspringer (*Oreotragus oreotragu*s); Common jackals (*Canis aureus*) ; spotted Hyena (*Crocuta crocuta*); civet (*Viverra civeta*); rattle (*Melivora capensis*); Egyptian mongooses (*Herpestes ichneumon*); and serval cat (*Felis serval*) (Zelalem Tefera, 2001).

Because Guassa harbours seven species of endemic mammals, it accounts for 22.6% of the endemic mammals of Ethiopia.

4.5.2. Birds: in Guassa, there are 111 bird species that accounts for 12% of the 861 species of birds in Ethiopia. Guassa harbours 14 endemic species of birds that accounts for 48.3% of the endemic birds of Ethiopia (Zelalem Tefera, 2001).

4.5.3. Reptiles and amphibians: Reptiles and amphibians are not abundant in Guassa because of its coldness. Two snakes, Abyssinian slug-eater (*Duberria lutrix*) and side-striped grass snake (*Psammophylax sp.*) as well as two toad species (*Bufo kerinyagae* and *Ptychadena sp.*) and a skink (*Mabuya megalura*) are common on tall trees (Zelalem Tefera, 2001).

4.6. Economic activities of the people and socio-economic values of the Guassa area,

There are 15,000 beneficiaries in the eight Farmer Associations in the Guassa area. About 94% of these people are rural dwelling that entirely depend on natural resources (NFEP, 2004).

The economic activities of the people in the area are predominantly mixed farming which involves crop production and livestock rearing. Out of the two cropping seasons, Belg is strongly emphasised by the locals in the area. Belg production accounts for about 60% of the annual crops production (WVE, 2000). Barley, beans, lentils, and wheat are predominantly cultivated. Livestock husbandry is the key element of the economy of the area. This is because of the unreliability of crop production due to the unpredictability of rain in the area. According to Solomon Gizaw (2008), there are about 1.5 million heads of Menz sheep, which are indigenous to the highlands of Ethiopia. Sheep are reared for their meat and wool. Wool production in the area is an important

household economy. Wool is frequently used for weaving traditional blanket (*Zitet* or *Banna*) for protection against severe cold.

Guassa area is an important source of income for the majority of households. *Festuca* grass grown at Guassa is used for thatching. It is estimated that 96% of the households in the district thatched using grass harvested at the Guassa area (NFEP, 2004).

Guassa area is a water tower for more than 26 large and medium sized rivers. Two major rivers of Ethiopia, Abbay (Blue Nile), and Awash, gain part of their water resource from Guassa area.

Especially during hard time of drought, the local people encroache the area and keep their cattle there for some time. Thus, Guassa area is an important site for livestock grazing by the locals.

4.7. Traditional Community Common Resource Management System in the Study Area

Under the "Qero" system, the community based management of the common resources stretches back to 400 years in the Guassa area. The "Qero" system at Guassa had begun by pioneer fathers (*Aqgni Abat*), Asbo and Gera in the 17th century (Zelalem Tefera and Leader-Williams, 2006). The functional members of the "Qero" system were land holding groups in the *Atsme Irst* land tenure system. In the system, the chosen head man (*Abba Qera or Afero*) given a full right to exercise his power for regulating and managing the common property of the Guassa community.

By this community based management system, the area was left aside 4-5 years from any sort of disturbances. Then after, through the agreement of the members of the system, the area was opened for livestock grazing and utilization of other resources. The length of closure of the area was strongly correlated with the time needed for the growth and recovery of

grass, the degree of community demands for the resources, crop failure, and the unpredictability of rainfall in the area.

Under this indigenous conservation system, the afro alpine ecosystem of Guassa had been conserved for long. Unfortunately, the "Qero" system had been nearly dissolved following the Land Tenure Reform in the 1970's. This reform had permitted an open access of the resources with no restrictions of when and how the community utilized the resources. This free exploitation ultimately resulted in a decline of habitat quality of the area. Because Guassa area was everything for the community, through the initiation of the community, the traditional management of the natural resources was once again operational. The chosen committee, locally known as Idir can put a penalty to whom that transgressed what the community had set as rules and regulations for conserving the area. The committee's efforts in reinforcing the rules and regulations are strongly backed by the district court (Zelalem Tefera and Leader-Williams, 2006)

5. METHODS

5.1. Study Period

Data collection was conducted during between September, 2009 and February, 2010. A total of two field trips (30 days from September to October, 2009 in wet season and 30 days from January to February, 2010 in dry season) were conducted.

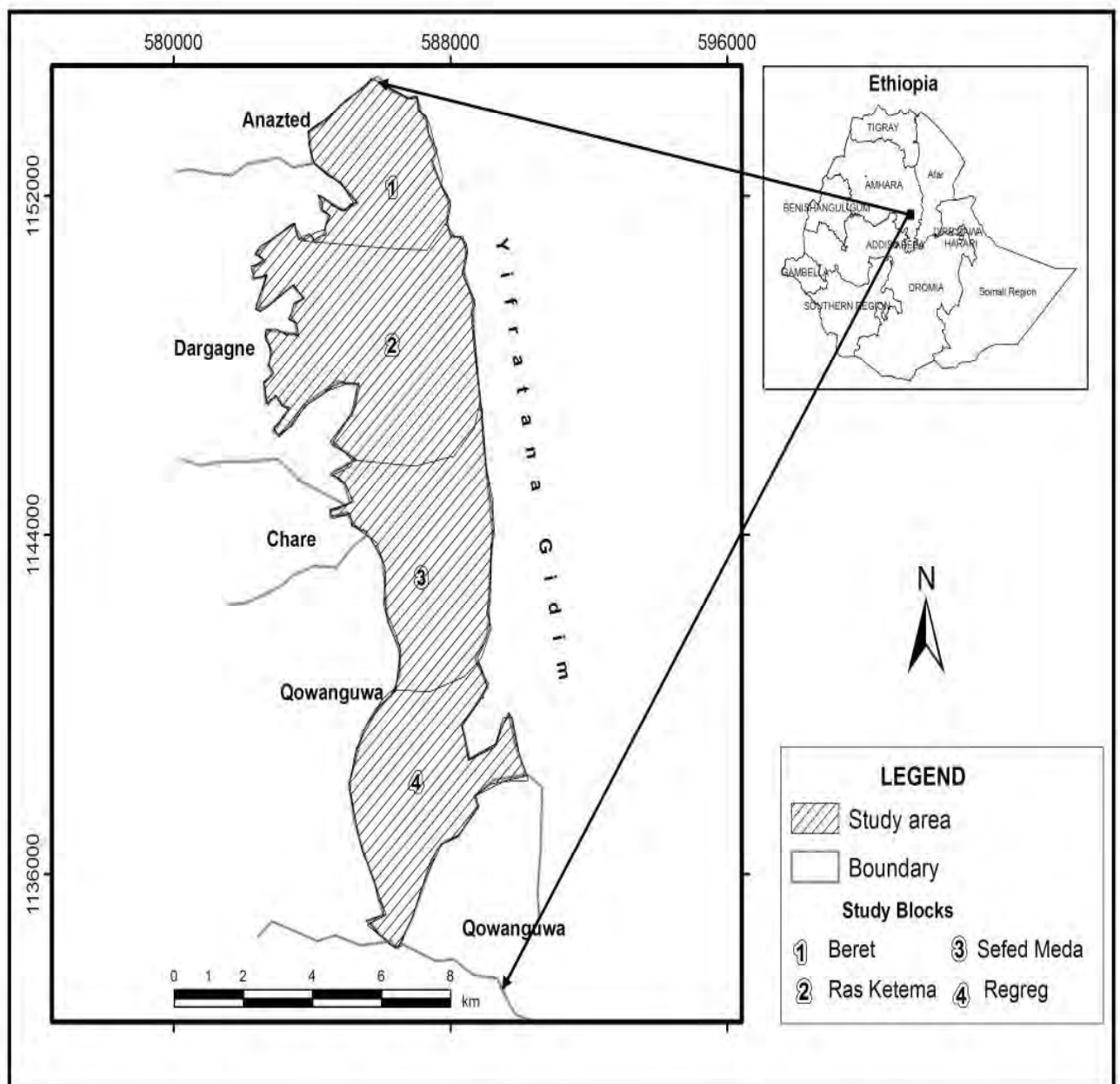


Figure 3 Map of the study area

5.2. Population estimate of gelada

Total count method was used to determine population size of the gelada. A total count is the most effective method for determining population estimates of a species that lives in open habitat where visibility and monitoring will be easy (Beehner, *et al.*, 2008). These characteristics hold true for geladas. In addition, around sun rise, geladas are found along cliff edges, where observers can find all individuals in a given area. The study area was divided in to four blocks: Beret, Regreg, Ras ketema and Sefed Meda. Beret and Regreg are located at north and south extremes of the Guassa area. In these areas exercising patrolling activity (though minimal) is unmanageable due to their remotness and a few numbers local people assigned from the adjacent farmer associations. As a result, Ras Ketema and Sefed Meda are more ecologically intact than Beret and Regreg. The total population count was conducted from September 26 to October 5, 2009 in wet season and from January 28 to February 7, 2010 in dry season. One observer was deployed to each of the four blocks. To avoid double counting, all geladas were counted simultaneously on the same time (from 9.00a.m to 1.00p.m) repeatedly for 20 days (10 days for wet season and 10 days for dry season). A short time of training was given to observers deployed in counting. The training focused on how to identify and separate geladas in to adult males, adult females, sub-adult males, sub-adult females, young and infants. Adult males were defined as males with visible manes and overall size about twice that of the adult females. Sub-adult males were defined as males similar in size to adult females with the beginning of manes. Adult and sub-adult females were identified based on body size. All other individuals were considered as young and infant based on their body size (Beehner *et al.*, 2008). Because of the smaller size of young and infants, identification of sex was difficult from a distance where adults and sub adults could easily be identified.

At Guassa, geladas' cliff edges that are far apart from each other, form almost a "line transect" which facilitates an easy access of geladas and to have enough time for an observer to record the components of social organization in geladas before they will merge. As a result, recording the mean number of bands, OMUs, AMGs and the size and composition of OMU and AMG was not challenging. Data collection on the mean number of bands, OMUs, AMGs and the size and composition of OMU and AMG was conducted from October 6-25, 2009 in wet season and from February 8-27, 2010 in dry season for a total of 40 days (20 days in wet season and 20 days in the dry season)

5.3. Data analysis

Seasonal population variations, sex ratio, band size and composition were statistically analysed using one-way ANOVA. Comparing of the age and sex ratio, the mean number of OMUs and AMGs and the size and composition of OMU and AMG within blocks were analysed using Student paired t-test.

6. Results

6.1. Demography of gelada population in the wet season

During wet season, a total of 1506 gelada population was counted. The total population was composed of 11.75% adult males, 33.33 % adult females, 6.77% sub adult males, 14.6 % sub adult females, 20.25% young and 13.21% infants. ANOVA showed that there was a significant difference among the different age groups during wet season ($F_{5, 18} = 6.19$, $p < 0.05$). In the total population of geladas, adult females comprised the largest proportion in terms of their number. Student paired t-test also showed that adult females were significantly different from adult males, sub-adult males, sub-adult females and infants ($df = 3$, $p < 0.05$) in wet season. Next to adult females, the largest proportion goes to young. Student paired t-test showed that young were significantly different from adult males, sub-adult males, sub-adult females and infants ($t = 2.60$, $df = 3$, $p > 0.05$). The rest age groups with a decreasing order of their number in a population were: sub adult females, infants, adult male and sub adult males (Table 1).

Based on location, out of the total population counted in wet season, 15.33% was from Beret, 28.22% was from Ras Ketema, 35.65% was from Sefed Meda and 20.78% was from Regreg. Student paired t-test indicated that the total population counted at Beret was significantly different from Ras Ketema ($t = -3.731$, $df = 5$, $p < 0.05$), Sefed Meda ($t = -3.080$, $df = 5$, $p < 0.05$) and Regreg ($t = -3.412$, $df = 5$, $p < 0.05$). But, Student paired t-test showed that there was no significant difference among the total population counted at Ras Ketema and Sefed Meda ($t = -2.33$, $df = 5$, $p > 0.05$) and Sefed Meda and Regreg ($t = 2.538$, $df=5, p>0.05$) (Table 1).

Adult males to adult females were found in the ratio of 1:2.83. In the above adult sex ratio, bachelor males were included in the analysis.

However, when the bachelor adult males were excluded from the analysis, there were 4.14 females for each adult male. The ratio of sub adults to adults was 1:2.1 and the ratio of sub adults, young and infants to adults was 1.2:1. The ratio of infants and adult females was 1:2.52.

Table 1 Demographic distribution of the gelada in the wet season

Block	Adult male	Adult female	Sub-adult males	Sub-adult females	Young	Infant	Total
Beret	22	70	17	39	47	36	231
Ras	54	140	25	60	86	60	425
Ketema							
Sefed	63	200	32	75	99	68	537
Meda							
Regreg	38	92	28	47	75	35	313
Total	177	502	102	221	305	199	1506

During wet season, the mean number of OMUs and AMGs was found to be 121 and 12.1 respectively. With respect to their ratio, there was 1 AMG for 10.0 OMUs. The mean number of OMUs and AMGs per band was 18 and 1.8 respectively (Table 2).

Table 2 Mean number of bands, OMUs and AMGs in the wet season

Block	Number of bands	Number of OMUs	Number of AMGs
Beret	1.4	17	1.8
Ras Ketema	1.7	39	2.8
Sefed Meda	2.0	43	4.2
Regreg	1.5	22	3.3
Total	6.6	121	12.1

In the wet season, the number of bands and band size were 6.6 and 228.1 respectively.

In relation with the OMU size and composition, during wet season, the mean OMU size was 12.15 of which 4.13 were adult females, 0.66 were sub adult males, 1.92 were sub adult females, 2.64 were young and 1.70 were infants. The proportion of the OMU was found to be 34.13% adult females, 5.45% sub-adult males, 15.72% sub-adult females, 21.64% young and 14.03% infants. Thus, females were found to be higher in number than adult females, young, and infants. Student paired t-test also showed that adult females were significantly higher than sub-adult males, sub-adult females, young and infants ($df = 3, p < 0.05$). Student paired t-test indicated that young were significantly higher than sub-adult males, sub-adult females and infants ($df = 3, p < 0.05$). ANOVA also indicated that there was significant difference among the different age groups ($F_{4, 15} = 48.75, p < 0.05$) during wet season (Table 3).

Table 3 Mean OMU size and composition in the wet season

Block	OMU size	AF	SAM	SAF	Young	Infant
Beret	13.11	4.11	0.64	2.29	2.76	2.11
Ras Ketema	10.38	3.58	0.53	1.53	2.20	1.53
Sefed Meda	11.86	4.65	0.58	1.74	2.30	1.58
Regreg	13.27	4.18	0.92	2.13	3.31	1.59
Average	12.15	4.13	0.66	1.92	2.64	1.70

Concerning to the AMG size and composition during wet season, the mean AMU size was 6.56 (Table 4).

Table 4 Mean AMG size in the wet season

Block	AMG size
Beret	6.11
Ras Ketema	6.78
Sefed Meda	6.42
Regreg	6.96
Average	6.56

6.2. Demography of gelada population in the dry season

During the dry season, a total of 1543 geladas were counted. Out of these, there were 34.59% adult females, 6.17% sub-adult males, 15.01% sub adult females, 20.15% young and 12.22% infants (Table 5). ANOVA showed that there were significant differences among the different age groups during dry season ($F_{5, 18} = 6.24, p < 0.05$). Adult females were higher in number when compared to other groups. Student paired t-test indicated that adult females were significantly higher than sub-adult males, sub-adult females and infants ($df = 3, p < 0.05$) and young were significantly higher than adult males, sub-adult males, sub-adult females and infants ($df = 3, p < 0.05$).

Table 5 Demographic distribution of the gelada in the dry season

Block	Adult males	Adult females	Sub-adult males	Sub-adult females	Young	Infant	Total
Beret	24	68	14	44	49	24	223
Ras	58	146	27	63	88	55	437
Ketema							
Sefed	60	217	29	74	104	66	550
Meda							
Regreg	40	101	25	50	69	48	333
Total	182	532	95	231	310	188	1543

Adult males to adult females were found in the ratio of 1:2.92. But when the bachelors were excluded from the analysis, the ratio was 1:4.15. The ratio of sub adults to adults was 1:2.19 and the ratio of adults to sub

adults, young and infants was 1:1.15. The ratio of infants to adult females was 1:2.8.

Based on location, out of the total population counted in the dry season, 14.47% was from Beret, 28.41% from Ras Ketema, 35.65% from Sefed Meda and 21.32% was from Regreg. Student paired t-test showed that the total population counted at Beret was significantly different from Ras Ketema ($t = -3.817$, $df = 5$, $p < 0.05$), Sefed Meda ($t = -2.773$, $df = 5$, $p < 0.05$) and Regreg ($t = -4.65$, $df = 5$, $p < 0.05$). But, Student paired t-test showed that there was no significant difference among the total population counted at Ras Ketema and Sefed Meda ($t = -1.764$, $df = 5$, $p > 0.05$).

The mean number of OMUs and AMGs were found to be 128 and 12.2 respectively. The mean number of OMUs and AMUS per band was 18.4 and 1.7 respectively (Table 6).

Table 6 Mean number of bands, OMUs and AMGs in the dry season

Block	Mean number of bands	Mean number of OMUs	Mean number of AMGs
Beret	1.5	16	1.6
Ras Ketema	1.8	42	3
Sefed Meda	2.2	40	4.5
Regreg	1.5	30	3.1
Total	7.0	128	12.2

In the dry season, the number of bands and band size were 7.0 and 219.7 respectively.

During the dry season, the mean OMU size was 11.66 of which 4.24 were adult females, 0.59 were sub-adult males, 1.93 were sub adult females, 2.50 were young, and 1.50 were infants. Student paired t-test showed that adult females (35.18%) were significantly higher than sub-adult males (5.16%), sub-adult females (16.44%), young (21.47%) and infants (12.94%) ($df = 3, p < 0.05$). Next to adult females, young were significantly higher than sub-adult males, sub-adult females and infants ($df = 3, p < 0.05$). ANOVA also indicated that there were significant differences among adult females, sub-adult males, sub adult females, young and infants ($F_{4\ 15} = 22.96, p < 0.01$) during the dry season.

Table 7 Mean OMU size and Composition in the dry Season

Block	OMU size	AF	SAM	SAF	Young	Infant
Beret	13.18	4.24	0.75	2.74	3.06	1.69
Ras Ketema	9.85	3.47	0.59	1.50	2.09	1.30
Sefed Meda	13.07	5.43	0.52	1.84	2.59	1.60
Regreg	10.56	3.36	0.53	1.66	2.29	1.43
Average	11.66	4.12	0.59	1.93	2.50	1.50

Table 8 Mean AMG size in the dry season

Block	AMG size
Beret	6.25
Ras Ketema	6.33
Sefed Meda	6.22
Regreg	6.12
Average	6.23

ANOVA showed that there was no significance difference among the mean AMG size during the wet and the dry seasons ($F_{1,6} = 3.01, p > 0.05$).

ANOVA showed that there was no significant difference among the different age groups ($F_{1,46} = 0.012, p > 0.05$) and the total population counted ($F_{1,6} = 0.007, p > 0.05$) in the wet and the dry seasons. The overall ratio of adult males to adult females was 1:2.85; adults to sub-adults was 2.14:1, adults to sub-adults, young and infants was 1:1.18 and infants to adult females was 1:2.66.

ANOVA showed that no significant difference was observed among the number of bands ($F_{1,6} = 0.042, p > 0.05$), the mean number of OMUs ($F_{1,6} = 0.041, p > 0.05$) and the mean number of AMUs ($F_{1,6} = 0.001, p > 0.05$) in the wet and dry seasons.

ANOVA showed that there were no significant differences among the mean OMU size ($F_{1,6} = 0.75, p > 0.05$) and the different age groups in the OMU ($F_{1,38} = 0.03, p > 0.05$) during the wet and the dry seasons.

Discussion

In the present study, the total number of individual geladas counted in the entire area of 111 km² of Guassa was 1506 and 1543 during wet and dry seasons respectively. The number of individual geladas counted during the dry season increased by 37 individuals when compared to that of the wet season. This insignificant difference might be due to the fact that during wet season, the weather in the study area was cloudy which could reduce the detectability of individual geladas while counting. According to Beehner, et al (2008), the population estimate of geladas in the SMNP range from 2450-2650 geladas which was higher than the total population counted at Guassa.

Out of the total population counted in the entire study area during wet season, 15.32% was from Beret, 28.22% was from Ras Ketema, 35.65% was from Sefed Meda and 20.78% was from Regreg. During dry season, of the total population counted, 14.47% was from Beret, 28.41% was from Ras Ketema, 35.76% was from Sefed Meda and 21.32% was from Regreg. Compared to Ras Ketema and Sefed Meda, which accounted 64.20% of the total population, smaller number of geladas (35.80%) was counted at Beret and Regreg. Ras Ketema and Sefed Meda are more ecologically intact than Beret and Regreg. Beret and Regreg are too remote to exercise patrolling activity (though minimal) by a few numbers of local people assigned from the adjacent farmer associations. Thus, the smaller number of geladas counted at Beret and Regreg might be justified in relation with their relatively poor habitat quality because of intense livestock grazing.

In both seasons, adult sex ratio was found to be closely the same, i.e. 1:2.8. In the above sex ratio, bachelor males were included in the analysis. This ratio was similar to that of the ratio determined by Beehner

(2008) in the SMNP, which was 1:2.8. But, the study conducted by Mori et al (1999) in Arsi revealed that the sex ratio was 1:1.87.

The Mean number of OMUs per band was 18 and 18.4 in wet and dry seasons respectively. But the total number of OMUs in the entire study area was 121 and 128 in wet and dry seasons respectively. Study conducted by Ohsawa and Dunbar (1984) showed that the number of OMUs per band at Sankaber was 10.7 which is smaller than the number of OMUs recorded at Guassa.

During the wet season, the mean number of bands and band size was 6.6 and 228.1 respectively. But during dry season, the mean number of bands and band size was 7.0 and 219.7 respectively. The study result of Dunbar (1984a) on the band size of geladas at Sankaber was 131.5, which is smaller than the mean band size recorded at Guassa.

With respect to OMU size and composition, during wet season, the mean OMU size was 12.15 individuals which were composed of a single breeding male, 4.13 adult females, 0.66 sub-adult males, 1.92 sub adult females, 2.64 young and 1.70 infants. The mean OMU size at Guassa did not deviate much from that of the OMU size determined by Dunbar (1984a) at Sankaber, which was 12.0. But the OMU size determined by Mori et al (1999) in Arsi was 8.8 which was smaller than the OMU size determined at Guassa. The mean number of adult females per OMU was 4.12 which were similar to the result of Dunbar (1984a) at Sankaber. But the number of adult females determined by Mori et al (1999) in Arsi was smaller than that of the adult females counted at Guassa. Geladas at Guassa frequently forage on open grassland where monitoring and controlling adult females by the leader male was easy due to better visibility than that of the Arsi gelada which uses cliff faces where monitoring and controlling several females was more difficult due to poor visibility. This

might be one reason why adult females and also OMU size were higher in Guassa than the Arsi gelada population.

The total population counted, the mean number of OMUs and AMGs, OMU size and composition and the size of AMG were found to be closely the same in the wet and the dry season at Guassa. This similarity might be explained in terms of the cool and less arid habitat of the study area which mitigates the negative effects of the dry season on food availability. Thus, the effect of seasonality is less pronounced in the study area

The mean size of AMG was 6.41 and 6.23 in the wet and dry seasons respectively. According Dunbar and Dunbar (1975), the mean AMG size at Sankaber and Bole valley was 7.8 which is nearly similar to the result obtained at Guassa.

Conclusions and Recommendations

The result of the current study suggests that the actual size of the gelada population is significantly lower than the expected based on the previous unpublished report of Fashing and Nguyen, 2007. But the overall status of the current population does not appear to be in immediate jeopardy. Based on the three months of observation, geladas coats were vibrant and intact and the discovery of the dead remains such as bones, teeth, hairs and skulls was very rare. At present, though gelada does not appear to be in immediate jeopardy in the study area, there are many conservation threats that could affect the species in future. These conservation threats are the results of an increased human population in the adjacent areas of Guassa. The conservation threats in the study area include human-induced habitat loss and degradation, replacement of native plant species in the gelada habitat by non-native invasive species and hunting. Human-induced habitat loss and introduction of quick growing non-native species, such as eucalyptus tree, may end up with drought, soil erosion and possibly even global warming, which will reduce the quality of the gelada habitat. As the quality of the gelada habitat declines, it will have a profound effect on the different aspects of the ecology of the species. In addition, the social organization, social structure and mating system of gelada will also severely affected by the scarcity of food in a degraded habitat.

The following solutions are recommended to mitigate the conservation threats that could be faced by the gelada.

- Local people should be encourage to reduce the number of livestock, to plant different vegetations outside Guassa for the purpose of fuel wood, fodder, and other use and to use more energy efficient technologies which will be supplied by the nearby rural development sector. These activities will greatly reduce the local

people dependency on the resources of Guassa and give a chance for areas of degraded gelada habitat to be rehabilitated.

- The human- induced habitat loss and degradation of the resources at Guassa may reduce the quality of the gelada habitat. These human activities may in turn force geladas to raid crops which will end up with a serious human-gelada conflict. Therefore, encouraging the local people to plant trees for different utilizations and grasses for grazing will highly reduce the potential for human-gelada conflict in the study area.
- Conservation measures will not be successful without the active participation of the local people. So community based conservation system (co-management) is an integral component for the conservation of gelada. If the community continues to have a say with active participation on gelada and other resources, they will develop a sense of ownership.
- Changing personal attitude and practice through environmental education focusing on the effects of deforestation, introduction of alien species, hunting and the like are equally important to increase the awareness of the local people about the resources of Guassa.
- Guassa has scenic geography with a high potential for ecotourism. But due to the lack of infra-structures, trained wildlife personnel and field guides, the area has not been used for such purposes. If such and others facilities are fulfilled, tourists will be encouraged to visit the area. This will establish economic returns from wildlife, such gelada and Ethiopian Wolf, which will improve the quality of life of the local people. The economic returns from wildlife also improve the attitude of the local people towards wildlife and help to

build a sense of ownership of the wildlife in the area. Gelada is a charismatic mammal that not only has a potential to bring much needed tourism to the area but also, as an Ethiopian endemic, represents a national treasure.

- As human population grows, geladas will come in to contact with humans as local farmers expand their cultivation and livestock grazing to steep hill sides once inhabited by geladas. This could lead to conflict between humans and geladas resulting marginalization of the geladas to areas near the cliffs. So developing family planning awareness will reduce human pressure in the area.
- The Guassa area of Menz is one of the very few areas in Ethiopia where a community based natural resources management system is operating today. This indigenous common property management system is important for sustainable utilization of the afroalpine ecosystem of the Guassa area. Thus, a responsible government who has the will and commitment in supporting and encouraging the conservation activities carried out by the local people is as equally important as the above suggested solutions. In additions, the government should maintain and enforce regulations and laws related to the conservation of endemic species.
- The size of the Guassa area is unmanageable for patrolling activity (though minimal) by few local people assigned from the nearby farmer associations. As a result, Beret and Regreg, which are located in the north and south extremes of Guassa respectively, are less ecologically intact as compared to Ras Ketema and Sefed Meda. This is because of their remoteness to exercise patrolling activity, there was intense livestock grazing in these area. So, the Gera Keya Woreda concerned rural development sector and the local people

should seek solutions in increasing the number of local people involved in patrolling.

- Before the present census study, no comprehensive gelada census of the area has been carried out. This single census in a short length of time cannot tell whether the gelada numbers are increasing, decreasing or remaining stable. So future gelada population censuses should be carried out in the future years to determine the population trends of gelada at Guassa.

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