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Population Size, Group Composition and Behavioural Ecology of Geladas (*Theropithecus gelada*) and Human-gelada Conflict in Wonchit Valley, Ethiopia

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Abstract: Primates that live in protected areas are intensively studied; however, those that live outside protected areas are less studied by primatologists. Therefore, the present study was carried out outside protected areas on the endemic gelada (*Theropithecus gelada*) to estimate the population size and group composition and human-gelada conflict in Wonchit Valley, Ethiopia from August 2008-March 2009. Total count method was used to determine the population size and group composition of geladas. A band of geladas was selected to carry out behavioural research. Data were collected on activity, diet and ranging patterns for one band of geladas using scan samples at 15 min intervals. Data on human-gelada conflict was gathered using questionnaire interview method. The total number of geladas in the study area was 1525. The average size of one-male unit was 16.96. Adult male to adult female sex ratio was 1.00:6.61. The average size of the band was 58.03. Group size ranged from 3 to 220. Geladas spent 65.2% of their time feeding, 16.3% moving, 4.6% resting and 13.9% socializing. The total time spent feeding on grass blades was 83.8% and 11.8% for bulbs and roots. The home range size was 1.5 km^2 during the dry season and 0.2 km^2during the wet season. Geladas in the study area caused crop damage and shared pasture and drinking water with livestock. They consume crops during harvesting stage more than the seedling and vegetative stages. The study has immense contribution for the conservation and management of this endemic primate in unprotected areas.

Key words: Total count, group composition, band, gelada, scan sampling, ethiopia

INTRODUCTION

The fauna and flora of Ethiopia are remarkable containing distinctive endemic plants and animals. Out of the 284 documented mammalian species in Ethiopia 31 are endemic (Refera and Bekele, 2006). Gelada baboon (*Theropithecus gelada*) is one of the 31 endemic mammals of Ethiopia. Geladas are the only extant species of the genus *Theropithecus* which was once found throughout eastern and southern Africa. Currently, geladas are confined to northern highlands and southern part of the Rift Valley of Ethiopia (Mori and Belay, 1990).

The most distinguishing characteristic of gelada is the presence of hairless pink or red skin on its chest. Geladas inhabit terrestrial habitats and possess a complex social organization (Mori *et al*., 1999). They frequently spend their day time on the plain near the edges of the cliffs and they sleep at night on the nearby cliffs. There are two established subspecies: *T. gelada* and *T. gelada obscurus* (Mori and Belay, 1990). *Theropithecus gelada senex* is considered as another subspecies that occurs south of the Rift Valley in Arsi Province of Ethiopia.

Gelads travel short distance for forging every day in order to conserve energy. While other Primates species spend much of their time by travelling long distance for forging each day to get high quality of food items (Fashing *et al*., 2007). Geladas are graminivorous (grass-eating) primates. In addition to these, they also exhibit foraging a wide varieties of food items which include fruits, leaves and insects (Iwamoto, 1993).

The increase of human pressure on wildlife habitats leads to conflicts throughout the world (Hill, 1997). These conflicts intensify if rural poverty and dependency on land increase coupled with population growth (Hill, 2002). Primates are the most frequently identified crop-raiding animals in many African countries (Naughton-Treves *et al*., 1998). In Ethiopia, geladas are protected officially only in the Simien Mountains National Park (Beehner *et al*., 2008). The expansion of agriculture and livestock grazing are seriously affected the habitat of geladas especially in the unprotected areas of their range (Yihune *et al*., 2009). Hence, they are coming into contact with humans to steep hillsides once inhabited only by this primate and other animals in Wonchit Valley.

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Geladas that live in protected areas have been studied at different times. However, information is lacking on the population size, group composition, behavioural ecology and human-gelada conflict in geladas that live in un protected areas of Wonchit Valley. Hence, this paper is an attempt to fill the gap.

MATERIALS AND METHODS

Study site: The study site was Wonchit Valley. Wonchit Valley is located between 10° 15' to 10°30' N latitude and 39°15' to 39°25' E longitude (Fig. 1) in the Amhara Region between North Shewa and South Wollo zones of Ethiopia at ~260 km north of Addis Ababa. Wonchit is a perennial tributary of the Blue Nile. The site consists of extremely steep escarpments leading up to a strip of plateaux. The altitude ranges between 1500 and 2700 m asl. The area experiences one rainy season that occurs from June to September. The average annual rainfall in the area is 784 mm. The mean annual minimum and maximum temperature (1996-2005) are 7.4°C and 23.4°C, respectively.

The most predominate flora in the study area include *Acacia* spp. (Fabaceae), *Albizia shimperiana* (Fabaceae), *Rhus retinorrhoae* (Anacardiaceae), *Rhus glutinosa* (Anacardiaceae), *Rhus vulgaris* (Anacardiaceae), *Croton macrostachyus* (Euphorbiaceae), *Dodonaea angustifolia* (Sapindaceae), *Euphorbia abyssinica* (Euphorbiaceae), *Myrica salicifolia* (Myricaceae), *Olea europaea* (Oliniaceae), *Premna schimperi* (Verbacaceae), *Acokanthra schimperi* (Apocynaceae), *Calpurnia aurea* (Fabaceae), *Rosa abyssinica* (Rosaceae), *Rumex nervosus* (Polygoneceae), *Becium grandiflorum* (Lamiaceae), *Euclea divinorum* (Ebenaceae), *Opuntia ficus-indica* (Cactaceae), *Aloe* spp. (Aloaceae), *Combretum molle* (Combretaceae) and *Carissa edulis* (Apocynaceae). In addition to geladas, hamadryas baboons (*Papio hamadryas*), olive baboons (*Papio anubis*), vervet monkeys (*Ceropithecus aethiops*), klipspringers (*Oreotrogus oreotragus*), rock hyraxes (*Procavia capensis)*, spotted hyaenas (*Crocuta crocuta*), striped hyaenas (*Hyaena hyaena*), common jackals (*Canus aureus*), crested procupines (*Hystrix cristata)* and common duikers (*Sylvicapra grimmia)* of mammals occur in the study area.

Preliminary survey: The study was carried out from August, 2008 to March, 2009. A preliminary survey was conducted prior to actual data collection to become familiar with the study area. Based on this reconnaissance survey, the study area was divided into three census zones based on altitude and vegetation coverage. Each of the census zones again was classified into eight blocks depending upon the natural boundaries such as escarpment, gorges, rivers, farmlands and roads. Hence, a total of eight blocks was used in the study.

Population estimation: Total count method was applied to estimate the population size of geladas in open habitats (Sutherland, 1996; Beehner *et al*., 2008). Each block was assessed three times per month to estimate the population size and group composition. Morning counts were begun when all the geladas groups left their sleeping cliffs and moved to the plateau or cliff edge for foraging (Hunter, 2001). During the counting process, suitable vantage points (Refera and Bekele, 2006) were selected to check whether there was a movement of geladas from one block to the other. Hence, at this suitable vantage point,

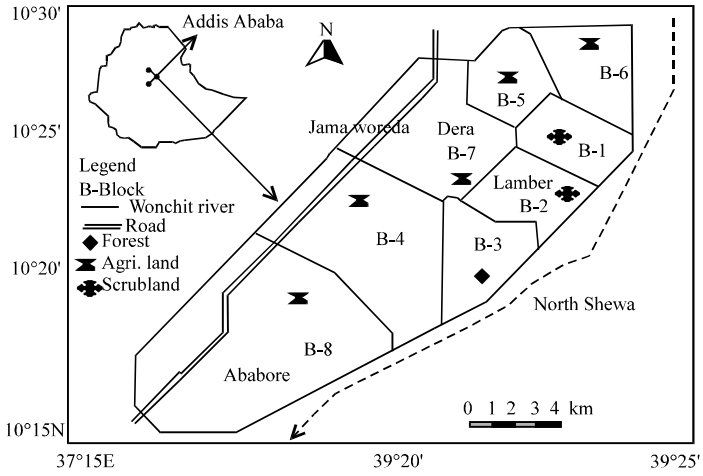

Fig. 1: Map of the study area

two individuals were stationed at the border of nearby blocks to check and count if geladas cross from that block to the other. At the same time, the other two individuals were deployed to count geladas in that nearby vantage point of the particular block. To avoid double counting in a particular block, we used group size, individuals with specific identities such as swelling on the body part and other special features.

During the population census, each of the individuals in the group was categorized as adult male, adult female, sub-adult male, juvenile male, juvenile female, yearling and infant. Sub-adult estrous females were categorized as adult females for the present study. Identification of sex and age categories was carried out using body size, genitalia and red patches of skin anogenital regions, cape of hair on the back, size of mantle and whiskers (Mori *et al*., 1999). To determine group sizes, once gelada groups were spotted, they were categorized based on social organization and grouped into one of the following: One-male unit also called "harem", band and all-male units. One-male unit was defined as those groups that lived in reproductive units containing a single adult male and his followers in a particular place. Band was referred to as an association with two or more adult males with their followers that lived together in their own home range (Beehner *et al*., 2008). All-male unit was defined as those groups that contain only bachelor sub-adult males in their groups forming their own home range.

Activity time budget: A band of geladas was also habituated for a study of activity budgets, ranging patterns and diet in the study area. We collected data from the study band on activity patterns using instantaneous scan sampling (Fashing, 2001) for 5 consecutive days per month during four months spanning both wet and dry seasons. We conducted scans at 15 min intervals from distances of 5-15 m between 7:00 h and 18:00 h (Fashing, 2001). Each animal was observed for 5 sec after being detected (Di Fiore, 2003) and its predominant behaviour during that period was recorded. The activities of scanned individuals were grouped into one of four broad categories: feeding, moving, resting and other social activities (Dunbar, 1992; Hunter, 2001). Feeding was recorded when individuals were grazing, foraging or digging and processing or consuming food items. Moving was recorded when geladas were walking or running without feeding. Resting was recorded when they were inactive while sitting, lying down, immobile in a quadrupedal stance, or self-grooming. Social activities were recorded when the geladas were playing, grooming with other individuals, engaging in aggression, copulating, presenting or embracing.

Feeding ecology: On occasions during which feeding was recorded as an individual's activity, we also noted the species and parts of plants consumed (blades, leaves, stem, bud, roots, bulbs, flowers and fruits) during scan sampling (Hunter, 2001; Di Fiore, 2004). Samples of plants eaten by geladas were collected and taken to the National Herbarium, Addis Ababa University for identification.

Ranging pattern: During instantaneous scan sampling record of the activity time budget, the global position system 72, GPS coordinate of the centre of the selected band location was also recorded at 15 min intervals, walking through the periphery of the group (Fashing *et al*., 2007; Wong and Sicotte, 2007) to estimate the home range. When the band of the group started moving, the subsequent route was mapped by recording a GPS coordinate at that particular time of the day during both the wet and dry seasons.

Human-gelada baboon conflict: Human-gelada conflict in the study area was studied using direct observation and personal interviews using questionnaires. Three villages (Dera, Lamber and Ababore) were selected randomly from the study area for this information. A total of 150 people (50 people from each village) were interviewed using the prepared questionnaire. The questionnaire included both open-ended and fixed response questions. These questions were designed to elicit information on how much human-geladas conflict is intensified. The questions also sought information on the attitude of local people towards geladas, the cause of conflicts, methods of crop protection by local farmers and their knowledge on the endemic species.

Statistical analysis: All the data collected were conducted using SPSS version 15 computer software program. The differences in the population size and group composition and behavioural ecology during the wet and dry seasons were compared using chi-square test. Chi-square was also used to assess the differences in human-gelada conflicts among the respondents of selected villages. All tests were two tailed with 95% confidence interval and level of rejection set at $p = 0.05$.

RESULTS

Population size: The maximum number of gelada in the study area was 1447 and 1683 during the wet (II) and dry (II) seasons, respectively. On the average, the total number of geladas counted in the study area of Wonchit

Table 1: Number of geladas counted in each counting block during the wet and dry seasons

Season	Month	Year	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	Total
Wet I	August	2008	198	196	216	103	120	285	-	297	1415
Wet II	October	2008	212	211	208	97	141	293	-	285	1447
Mean			205	203.5	212	100	130.5	289	-	291	1431
Dry I	January	2009	78	124	73	143	267	312	201	357	1555
Dry II	March	2009	65	112	75	199	347	350	168	367	1683
Mean			71.5	118	74	171	307	331	184.5	362	1619

Valley was 1431 during the wet season and 1619 during the dry season. The population observed was significantly higher during the dry season than during the wet season (wet season 1431 and dry season 1619; χ^2 z = 11.558, df =1, $p<0.05$; Table 1. Among the blocks, the highest number was recorded in block 8 during both the wet and dry seasons and the lowest was in block 1 during the dry season.

Population structure: During the wet season, the maximum group size of one-male unit was 23 and the minimum was 8. The maximum and the minimum overall group size of one-male unit during both the study seasons was 25 and 8, respectively. The overall maximum and minimum group size for the band type social system of gelada was 220 and 25 during both the wet and dry seasons, respectively (Table 2). There was no significant difference between the mean band size (wet season 54.66 and dry season 60.98; $\chi^2 = 3.430$, df = 1, $p>0.05$), one-male unit (wet season 16.69 and dry season 17.33; $\chi^2 = 0.106$, df = 1, $p>0.05$) and all-male unit (wet season 6.17 and dry season 6.44; $\chi^2 = 0.032$, df = 1, $p>0.05$) during the wet and dry seasons.

The sex ratio of adult male to adult female was 1.00:6.52 during the wet season and 1.00:6.70 during the dry season (Table 3). There was a significant difference between adult male and adult female sex ratio during the wet (adult males 84 and adult female 547.5; $\chi^2 = 340.658$, df = 1, $p<0.05$) and dry seasons (male 93.5 and female 626.5; $\chi^2 = 394.021$, df = 1, $p<0.05$; Table 4). The sex ratio of adult male to adult female and male (adult male and sub-adult male) to adult female was 1.00:6.61 and 1.00:2.41, respectively during the course of the study period. The age ratio of adult male to infant was 1.00:0.25 in the study area (Table 5). From the total average number, 88.8(5.8%) were adult males, 587(38.5%) adult females, 155(10.2%) sub-adult males, 177.75(11.7%) juvenile males, 189.5(12.4%) juvenile females, 175.5(11.5%) yearlings and 151.5(9.9%) infants (Fig. 2).

Activity budget: We carried out a total of 880 group scans on 3520 individuals during 220 h of observation. The overall average activity time budget of geladas in the study area was 65.2% feeding, 16.5% moving, 4.5% resting and 13.8% socializing. During the wet season, the

Table 2: Group type and size of gelada social system during the wet and dry seasons

Social system	Season	Group size Max.	Group size Min.	Mean group size	N	OMUs/band
One-male unit	Wet	23	8	16.69	51	
	Dry	25	14	17.33	39	
	Overall	25	8	16.96	90	
All-male unit	Wet	12	3	6.17	12	
	Dry	12	4	6.44	16	
	Overall	12	3	6.32	28	
Band 2-8	Wet	137	27	54.66	35	
	Dry	220	25	60.98	40	2-14
	Overall	220	25	58.03	75	2-14

OMUs: One-male unit, N: Total number of groups

Table 3: Mean sex and age ratio of geladas during the wet and dry seasons

	Sex ratio			Age ratio		
Season	AM:AF	SAM:AF	M:AF	AF:YR	AF:IN	AM:SAM
Wet	1.00:6.52	1.00:3.99	1.00:2.48	1.00:0.30	1.00:0.27	1.00:1.63
Dry	1.00:6.70	1.00:3.69	1.00:2.35	1.00:0.29	1.00:0.25	1.00:1.85

AM: Adult male, AF: Adult female, YR: Yearling, IN: Infant, SAM: Sub-adult male, M: Adult and sub-adult male

Table 4: Sex and age distribution of geladas during the wet and dry seasons

Season	AM	AF	SAM	JM	JF	YR	IN	Total
Wet	84	547.5	137	170	180.5	166.5	145.5	1431
Dry	93.5	626.5	173	185.5	198.5	184.5	157.5	1619

AM: Adult male, AF: Adult female, SAM: Sub-adult male, JM: Juvenile male, JF: Juvenile female, YR: Yearling, IN: Infant

Table 5: Overall mean sex and age ratio of geladas in the study area

Sex ratio			Age ratio		
AM:AF	SAM:AF	M:AF	AF:YR	AF:IN	AM:SAM
1.00:6.61	1.00:3.79	1.00:2.41	1.00:0.29	1.00:0.26	1.00:1.75

AM: Adult male, AF: Adult female, SAM: Sub-adult male, YR: Yearling, IN: Infant, M: Adult and sub-adult male

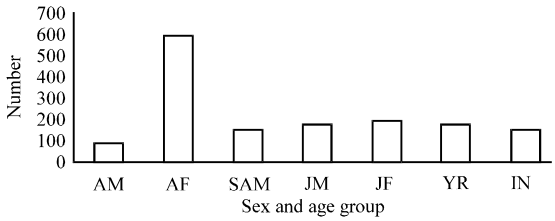

Fig. 2: Overall sex and age number of gelada baboons, Am: Adult male, AF: Adult female, SAM: Sub-adult male, JM: Juvenile male, JF: Juvenile female, YR: Yearling, IN: Infant

activity budget consisted of 64.4% feeding, 10.8% moving, 7.0% resting and 17.8% socializing; while during the dry season, 66.0% feeding, 22.3% moving, 2.0% resting and 9.8% socializing (Table 6). During the wet and dry seasons, the band spent more or less equal time for feeding. There was no significant difference between feeding time budget during the wet and dry seasons (wet season 64.4% and dry season 66%; $\chi^2 = 0.449$, df = 1, $p>0.05$). However, there was a significant difference between the wet and dry seasons in moving (wet season 10.8% and dry season 22.3%; $\chi^2 = 27.393$, df = 1, $p<0.05$), resting (wet season 7.0% and dry season 2.0%; $\chi^2 = 25.474$, df = 1 $p<0.05$) and socializing (wet season 17.8% and dry season 9.8%; $\chi^2 = 23.809$, df = 1, $p<0.05$ Table 6).

Diet: A total of 60 species belonging to 20 families of plants and three species of animals were identified in the study area as contributing to the diet of geladas. Grass blades were the most common food item during both the wet and dry seasons (Table 7). During population census and vegetation sampling, we also observed that geladas consumed the resin of *Acacia* spp., *Rhus glutinosa* and

Table 6: Activity time budget during the wet and dry seasons in the study area

	Activity budget (%)			
Season	Feeding	Moving	Resting	Socializing
Wet	64.4	10.8	7.0	17.8
Dry	66.0	22.3	2.0	9.8
Overall/mean	65.2	16.5	4.5	13.8

Table 7: List of plant species consumed by geladas during the study period

				Season	
Local name	Species name	Family	Parts consumed	Wet	Dry
Akirma	*Eleusine floccifolia*	Gramineae	BL	x	X
Wisha sar	*Sporobolus pyramidalis*	Gramineae	BL	X	X
Wisha sindodo	*Sporobolus thunbergii*	Gramineae	BL	X	X
Serdo	*Cynodon dactylon*	Gramineae	BL, ST	X	X
Gaja	*Chloris pycnothrix*	Gramineae	BL	X	X
Gita	*Pennisetum sphacelatum*	Gramineae	BL	X	X
Shikoko sar	*Pennisetum mezianum*	Gramineae	BL	X	X
Wisha sindodo	*Pennisetum thunbergii*	Gramineae	BL	X	X
Labasar	*Pennisetum villosum*	Gramineae	BL	X	X
Nech sar	*Pennisetum cladestinum*	Gramineae	BL	X	X
Wisha sar	*Pennisetum glabrum*	Gramineae	BL	X	X
Senbelat	*Hyparrhenia rufa*	Gramineae	BL, ST	X	X
Senbelat	*Hyparrhenia hiruta*	Gramineae	BL, ST	X	X
Senbelat	*Hyparrhenia nyassae*	Gramineae	BL, ST	X	X
Yetafa zer	*Eragrostis tenella*	Gramineae	BL	X	X
Yetafa zer	*Eragrostis lepida*	Gramineae	BL	X	X
Yetaf zer	*Agrostis quinqueseta*	Gramineae	BL	X	X
Gaja	*Andropogon gayanus*	Gramineae	BL	X	X
Gaja	*Andropogon abyssinicus*	Gramineae	BL	X	X
Gaja	*Andropogon distachyos*	Gramineae	BL	X	X
Gaja	*Andropogon greenwayi*	Gramineae	BL	X	X
Lesslassasar	*Digitaria abyssinica*	Gramineae	BL	X	X
Lesslassasar	*Digitaria ternata*	Gramineae	BL	X	X
Senbelat	*Cymbopogon* spp.	Gramineae	BL	X	X
Senbelat	*Themeda triandra*	Gramineae	BL	X	X
Senbelat	*Exotheca abyssinica*	Gramineae	BL	X	X
Gaja	*Botriochoa iuscupta*	Gramineae	BL	X	X
Muja	*Snowdenia polystachya*	Gramineae	BL, ST	X	
Muja	*Snowdenia petitiana*	Gramineae	BL, ST	X	
Lesilasasar	*Ehrharta abyssinica*	Gramineae	BL	X	X
Lesilasasar	*Poa annua*	Gramineae	BL	X	X
Lesilasasar	*Poa leptoclada*	Gramineae	BL	X	X
Lesilasasar	*Poa schimperiana*	Gramineae	BL	X	X
Kechinmuja	*Bromus leptoclados*	Gramineae	BL, ST	X	
Kechinmuja	*Bromus pectinatus*	Gramineae	BL, ST	X	
Irat	*Aloe* spp.	Aloaceae	FL		X
Yewofkollo	*Romulea fischeri*	Iridaceae	BU		X
Yewofkollo	*Merendera abssinica*	Colchicaceae	BU		X
Gemedsar	*Cyperus rigidifolius*	Cyperaceae	LE, RO	X	X
Dog	*Kniphofia foliosa*	Asphodelaceae	ST	X	
Beles	*Opuntia ficus-indica*	Cactaceae	FR,LE		X
Yelamtut	*Chlorophytum tetraphyllum*	Anthericaceae	RO		X
Sindalit	*Chlorophytum pterocarpum*	Anthericaceae	RO		X

Table 7: Countinue

Local name	Species name	Family	Parts consumed	Season	
				Wet	Dry
Yeberachew	*Epilobium hirsutum*	Onagraceae	FL, LE	X	
Maget	*Trifolium* spp.	Fabaceae	FL, LE	X	
Adayababa	*Bidens prestinaria*	Asteraceae	FL, LE	X	
Adayababa	*Cotula abyssinica*	Asteraceae	FL, LE	X	
koshim	*Dovyalis abyssinica*	Flacourtiaceae	FR		X
Kimo	*Rhus vulgaris*	Anacaridaceae	FR	X	
Agam	*Carissa edulis*	Apocynaceae	FR	X	
Kega	*Rosa abyssinica*	Rosaceae	FR	X	X
Dibrik	*Salvia schimperi*	Lamiaceae	FL	X	
Berakolet	*Holothrix unifolia*	Orchidaceae	RO	X	
Shenbeko	*Arundo donax*	Gramineae	BD		X
Enibus	*Rns glutinosa*	Anacardiaceae	BD		X
Warka	*Ficns Vasta*	Moraceae	FR		X
Woira	*Olea europaea*	Oleaceae	FR		X
Motishi	*Becium grandiflorum*	Lamiaceae	FL	X	
Gimamuch	*Plectranthus ornatns*	Lamiaceae	LE	X	
Chifrig	*Sida schimperiana*	Malvaceae	FL, LE		X

BL: Blade, LE: Leave, FR: Fruit, FL: Flower, BD: Bud, BU: Bulb, RO: Root, ST: Stem, X: Plants parts consumed during the seasons

Albiza schimperiana and animals which included flying ants, ants (genus *Formica*) and termites and cereals like pea, bean, barley, teff, wheat, sorghum, chickpea, grass pea and lentil.

Chlorophytum tetraphyllum, *Chlorophytum pterocarpum*, *Romulea fischeri*, *Merendera abssinica* and *Cyperus rigidifolius* were the main plant subterranean food sources used by gelada during the dry season in the study area. A total of 2200 feeding behavioural records were collected from scan sampling of the selected band during wet and dry seasons. The average time spent on feeding grass blades was (83.8%), roots and bulbs (11.6%), fruits (1.9%), leaves, buds and stems (1.4%) and flowers (1.3%) during the course of the study.

During the wet season, the time spent by the selected band for feeding on grass blades was 93.2%, leaves, buds and stems 2.0%, flowers 2.0%, fruits 1.5% and bulbs and roots 1.3%; while during the dry season, grass blades was 74.2%, leaves, buds and stems 0.8%, flowers 0.5%, fruits 2.3% and bulbs and roots 22.2% (Table 8). There was a significant difference in time spent for feeding on grass blades between the wet and dry seasons (wet season 93.2% and dry season 74.2%; $\chi^2 = 4.298$, df = 1, $p<0.05$). There was also a significant difference in the time spent feeding on bulbs, rhizomes and roots between the wet and dry seasons (wet season 1.3% and dry season 22.2%; $\chi^2 = 36.750$, df = 1, $p<0.05$). However, there was no significant difference in time spent for feeding on leaves buds and stem (wet season 2.0% and dry season 0.8%; $\chi^2 = 0.667$, df = 1, $p>0.05$), flowers (wet season 2.0% and dry season 0.5%; $\chi^2 = 1.800$, df = 1, $p>0.05$) and fruits (wet season 1.5% dry season 2.3%; $\chi^2 = 0.500$, df = 1, $p>0.05$) between the wet and dry seasons (Table 8).

Table 8: Seasonal percentage contribution of diet item by geladas

Season	Types of diet and feeding time (%)				
	Grass blade	Leaves, buds and stems	Flowers	Fruits	Bulbs and roots
Wet	93.2	2.0	2.0	1.5	10.3
Dry	74.2	0.8	0.5	2.3	22.2
Overall/mean	83.7	1.4	1.3	1.9	11.7

Ranging pattern: The mean daily path length of geladas was 600 m during the wet season and 1560 m during the dry season. There was a significant difference in the distance traveled during the wet and dry seasons ($\chi^2 = 21.429$, df = 1, $p<0.05$). The home range size of gelada in the study area was more extended during the dry season than during the wet season (Fig. 3). It was 0.2 km^2 and 1.5 km^2, respectively, during the wet and dry seasons. There was a significant difference between the ranging pattern during the wet and dry seasons ($\chi^2 = 16.071$, df = 1, $p<0.05$).

Human-gelada conflict: Geladas in the study area caused crop damage, shared drinking water and livestock pasture and damaged the grazing pasture by digging the ground. Among the respondents, 62.7% stated crop damage by gelada, 8.0% stated both crop damage and sharing drinking water and 11.3% stated crop damage, sharing drinking water and damaging livestock pasture 18.0% stated crop damage and sharing livestock pasture (Table 9). There was no significant difference among the villages on the views of damage caused by geladas ($\chi^2 = 2.489$, df = 6, $p>0.05$). Geladas raid crops like pea, bean, barley, teff, wheat, sorghum, chickpea, grass pea and lentil in the study area.

The attitude of respondents towards gelada in the study area varied among the respondents. Only 14.7%

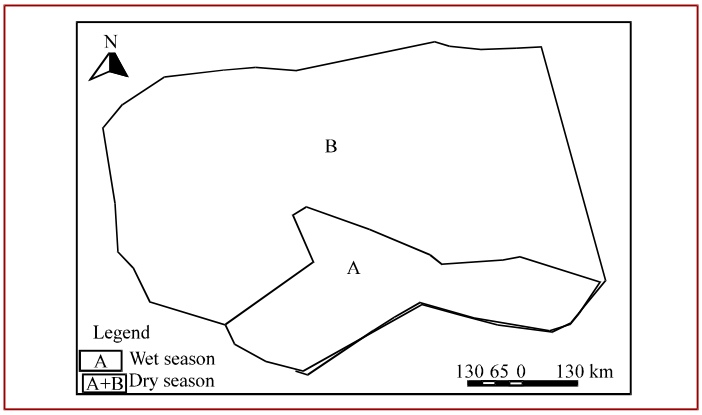

Fig. 3: Home range size of geladas during the wet and dry seasons

Table 9: Problems caused by gelada baboons to the local people in the study area

	Response of villagers,%			
Problem type	Dera	Lamber	Ababore	Total
Crop damage	58	64	66	62.67
Crop damage and sharing drinking water	6	10	8	8.00
Crop damage, sharing drinking water and livestock pasture	14	8	12	11.33
Crop damage and sharing livestock pasture	22	18	14	18.00
Causing disease	0	0	0	0.00

Table 10: Views of respondents on the problems caused by geladas during different months of the year

	Response of villagers,%			
Month	Dera	Lamber	Ababore	Total
June/July	0	4	10	4.67
August/September	0	10	12	7.33
October/November	10	80	76	55.33
December/January	90	6	2	32.67

Table 11: Number of months per year guarding crops from gelada raiding

	No. of respondents,%			
No. of months	Dera	Lamber	Ababore	Total
2	70	10	8	29.33
3	28	4	2	11.33
4	2	6	8	50.33
5	0	20	18	12.68
6	0	60	64	41.33

had positive attitude toward gelada and the rest (85.3%) had negative attitude. There was no significant difference among the villages on the attitude of respondents on geladas (χ^2 = 0.746, df = 2, p>0.05). Out of total respondents, only 4.7% of the respondents stated that geladas caused damage during the months of June/July and 55.3% during October/November (Table 10). There was a significant difference among the villages on the months that gelada caused problem in raiding crops (χ^2 = 11.584, df = 6, p<0.05). Geladas frequented more on the seed of cereal crops than the vegetative parts.

Among the respondents, 77.3% protected their crops from gelada damage for about 12 h per day and they were vigilant throughout the day by standing in front of their crops. The rest 2.7, 4.0 and 16.0% stated that they protected for about 2, 6 and 9 h per day from raiding their crops by the gelada, respectively. There was no significant difference among the villages in duration of time spent per day to protect crops from geladas (χ^2 = 3.681, df = 6, p>0.05). Out of the total respondents, 29.4, 11.3 and 5.3% stated that they devoted 2, 3 and 4 months per year to guard farmlands from raiding by the geladas, respectively (Table 11). While the others 12.7% and 41.3% guarded their crops for about 5 and 6 months, respectively. There was a significant difference among the villages in the number of months to protect crops from geladas (χ^2 = 103.184, df = 8, p<0.05).

Among the respondents, 81.3% protected their crop by standing in front of their farmlands and watching the progress of movement of geladas. This method of protection was the most frequent and effective in the study area. When the geladas approach the farmland, the guards shout and retreat them away by using sticks or pieces of stone. This requires a lot of energy and they have to be vigilant throughout the day. However, 6.0% of the respondents used dogs and 8.7% used scarecrow as frequent methods. The remaining respondents used snare traps (1.3%) and gun (2.7%). There was no significant difference among the respondents of different villages in displaying specific methods to protect crops from geladas (χ^2 =10.930, df = 8, p>0.05).

Table 12: Factors that cause crop raiding by geladas in the study area

	Response of villagers (%)			
Factors	Dera	Lamber	Ababore	Total
Increase in the number of gelada	22	20	18	20.00
Agricultural expansion	64	60	66	63.33
Increase of livestock	0	0	0	0.00
Availability of crops	14	20	16	16.67

Among the respondents, 20% responded the cause of crop raiding was due to the large number of gelada in the study area (Table 12). But, 63.3% of the respondents responded that agricultural expansion towards the gelada habitat was the main factor that caused raiding of crops. None of the respondents considered livestock grazing as a factor that led to crop raiding. There was no significant difference among the respondents of different villages on the cause of crop raid by geladas (χ^2 = 0.907, df = 4, p>0.05; Table 12).

Among the respondents, 72.7% believed that they were not interested to conserve gelada because they damage their crops. However, 27.3% of the respondents believed that geladas should be conserved. There was no significant difference among the villagers on their view on the need to conserve geladas (χ^2 = 1.880, df = 1, p>0.05). Among the respondents, 86% had no knowledge about the endemicity of gelada and only 14% had knowledge on the gelada being endemic. From the respondents of the local people, 10% knew that geladas are importance to the ecology of the environment as well as to the country. Geladas dig the ground facilitating ploughing of the farmland. They add their scats to the farmland that increases soil fertility. In addition to this, the county can obtain income from tourism industry. However, 90% of the respondents considered that geladas are useless except that they devastate crops.

DISCUSSION

There was a significant difference in the number of geladas between seasons due to migration to different areas. The study area was used for human settlements, agricultural and livestock rearing purposes. At the beginning of the wet season, farmers sow cereal crops and chase geladas away from their farmlands of the escarpment to other areas in order to reduce crop damage. During the post-harvest season and threshing, more geladas immigrate towards the abandoned farmlands. Following harvest, the geladas were free to move and they congregate on the few patches of dried sward left by villagers for their domestic animals. Therefore, these might be the reasons for the increase in the number of geladas during the dry season compared to the wet season.

The study shows that the population composition of geladas consisted of unequal sex and age ratio in the area. The unequal sex ratio between adult males and females was high compared to other study areas in Arsi (Mori *et al*., 1999) and Gich population (Ohsawa and Dunbar, 1984). This may be due to an increase in predation pressure on sub-adult males by dogs and leopards. The band or the harem feeds on open plain that helps to observe predators easily and control the females from being taken away by bachelor sub-adult males. When the bachelor males approach the foraging place of the bands, the males from the band cooperate to fight and chase bachelor males away from that area. This may help keeping more females within the harem or the band leading to large number of adult females per male. In addition to this, the frequency of adult males migrating out from the band is high in the present study area in contrast to the Arsi population (Mori *et al*., 1999). This high adult female to adult male ratio may also be due to the combination of adult females to estrous sub-adult females in this study, as females reach sexual maturity earlier than males. This skewed sex ratio in gelada was also proposed due to earlier maturation of females (Ohsawa and Dunbar, 1984). In addition, bachelor males are bold and frequently try to steal crops from the nearby farmlands by moving far, separating from the groups. The farmers use snare to trap and kill them. This also results in the decrease in the number of adult males compared to adult females.

The band group size of geladas was larger during the dry season than during the wet season. Ohsawa (1979) reported that the largest multi-band troop (up to 620 animals) at Gich occurred most often in the middle of the dry season. Troop size increases more during the dry season than the wet season due to spatial restriction (Beehner *et al*., 2008). Thus, the size of the band increases and they forage together during the dry season in areas where good cover of grass and water are available. After post-harvest, geladas congregate on the few patches of dried sward left by villagers for their domestic animals leading to increase in the size of the band during the dry season. However, during the wet season, the farmers disturb the size of bands due to cultivation of cereal crops. At that time, the gelada baboons may be segregated into smaller groups and live in small patches of land on the plain and habitats that are too steep to ploughing.

The mean size of one-male unit in the study area was 16.96. Ohsawa and Dunbar, 1984 reported that, the size of one-male unit is independent of environmental factors. This mean size of one-male unit was greater than other

study areas and similar to the Bole Valley population (Dunbar, 1984). The units in the study area may act cooperatively to each other in displaying and chasing out challenging bachelor males, thus increasing the chance of a leader male for several followers. The mean band size of geladas in the study area was lower than that of the Simien population but similar to that of the Arsi (Mori *et al*., 1999) and Bole population (Dunbar, 1984). According to Balakrishnan and Ndhlovu (1992), in few unbroken grassland areas, the size of the group becomes less. Similarly, in Wonchit Valley, the available grasslands are broken down into smaller fragmented areas leading to the small size of the band compared to the Simien population, which lives in large unbroken grasslands.

There were significant differences between the seasons on moving, resting and socializing of geladas. The seasonal difference in activity time budget of an animal may be caused by environmental variables (Shah, 2003). Geladas spent more time for feeding during the dry season than during the wet season (Iwamoto, 1993). However, there was no significant difference in the time spent for feeding during the wet and the dry seasons in the study area. Geladas spend more time moving during the dry season. This may be due to the restriction to small patches of land left by the farmers during the wet season. Such rocky small patches of land left by the farmers are not suitable for farming other than pasture for livestock, being the major competitor to geladas in such patches. Therefore, geladas spend less time feeding during the wet season by decreasing movement and by competing with the livestock in order to compensate the daily energy requirement from these patches. Feeding time may increase as food quality and quantity diminish and when the number of competitors increases within small patches of land. However, during the dry season, when the farmers harvest their crops, geladas move from one patch of land to the other to get grass cover between the boundaries of agricultural land. Therefore, during the dry season, the animal spends more time moving from one patch of land to the other in order to search and obtain food. This in turn might only slightly extend the feeding time budget of gelada during the dry season compared to the wet season. During the wet season, water is available around the foraging area. Thus, geladas do not move far away in search of water reducing the time budget for movement. However, during the dry season, geladas move long distances from the foraging area in search of water, increasing the time spent for moving thereby reducing the activities spent for resting and socializing. The type of diet may also be another factor that may lead to slight increase in time spent for feeding during the dry season. This is due to the consumption of more bulbs, roots and rhizomes during the dry season, which have high nutritional value and water content than dry blades of grasses to satisfy their daily energy requirements.

Diet based on grass requires a bulk feeding strategy, which in turn will impose on the animal's time budget requiring extra time for feeding (Hunter, 2001). Geladas in the present study area spend more time feeding than other activities and less time resting compared to other study areas. Feeding time increases as the habitat quality of a certain area declines to compensate the energy requirements (Hunter, 2001). Therefore, due to a decline of the habitat quality in the study area, the animals spent more time feeding. Resting time was used as reserve from which additional feeding time could be drawn (Fashing, 2001). In addition to this, moving time may increase compared to resting in broken and poor grasslands. Geladas of the northern population live in a relatively rich habitat in terms of food availability throughout the year compared to Wonchit Valley that may lead to increase in time spent for feeding. According to Fashing (2001), social interaction of animals is restricted by time budget constraints such as availability of nutrition in the area. This is in particular important for using less time for socializing in the study area as compared to other areas. As the environment is very harsh in terms of availability of food, these geladas spend more time feeding by reducing the other activities such as socializing and resting.

Different species of grasses comprised the main food item of geladas. Geladas are grass consumers where grasses form more than 90% of the diet during most seasons (Dunbar and Bose, 1991). Blades and stems of grasses, leaves of herbs, flowers of herbs and bushes and fruits of bushes and trees and bulbs, rhizome and roots provided a significant contribution to the diet of geladas in the present study area. Thus, geladas in Wonchit Valley feed on diverse food items that are not identified as a diet of geladas in other study areas. This may be due to the harsh environmental condition in terms of the grazing pressure by livestock and reduced the existing foraging area. All the accessible land was used for agricultural purposes forcing the geladas to survive on different food items, which are not registered as diets in other study areas such as Gich and Sankaber areas in the Simien Mountains National Park and in Bole around Debre Lebanos (Iwamoto, 1979). When the geladas face problems in obtaining their common diet, they may shift to other types of food items and plant parts. For example, the diet of the Arsi population of gelada consists of considerable amount of fruit (Iwamoto *et al*., 1996) as

compared to the northern population. The same was true for the present study in Wonchit Valley in which the diet contains high amount of fruits as compared to the other study area.

Exploitation of underground food items represents an adaptation that allowed all the Theropithecus to tap a grassland food source (i.e., subterranean storage parts) that is unavailable to the gelada's main competitors, namely ungulates (Dunbar and Bose, 1991). Hunter (2001) pointed out that as the green grasses dry out, geladas can shift their foraging profile to digging for more subterranean food sources. Chlorophytum tetraphyllum, Chlorophytum pterocarpum, Romulea fischeri, Merendera abssinica and *Cyperus rigidifolius* were the main plant components used by geladas during the dry season in the present study area. These food items may be more nutritious and help geladas to survive in the study area during the dry season. However, seeds of *Trifolium arvense* and leaves and roots of *Cotula cryptocephala* provided the bulk of plant components in the Simien population during the dry season (Dunbar, 1977).

Studying the home range of animals in a certain area is important to identify the presence of feeding competition and recognize the relationship between ecological variables of ranging behaviour (Di Fiore, 2003). The home range size of gelada's behaviour varied within seasons. During the wet season, geladas restrain movements from one patch of land to the other due to human activities, so that they may be restricted within that small patch of land. But during the dry season, restriction by the farmers on the patch of land ceases after harvest. Thus, geladas move freely from one patch of land to the other increasing the home range size during the dry season. Differential use of home range by gelada has been observed during the wet and dry seasons in other study sites also as green grass is more patchily distributed during the dry season compared to the wet season (Hunter, 2001).

The result of the questionnaire shows that there was intense conflict between the local people and geladas in the present study area. Primates are the dominant crop raiders in Africa (Balakrishnan and Ndhlovu, 1992). Most of the respondents from the selected villages reported that the cause of crop damage is very high and intense. There was significant difference on the number of months per year among the villages in guarding their farmlands from gelada damage. Most of the respondents from Lamber and Ababore villages reported that they guard their crops for about six months per year. This is because the farmlands of these villages are located near to the edge of gelada habitats. Primate species that live in close proximity to human settlement areas frequently visit villages and become crop-raiders (Saj *et al*., 2001). The local people who have farmlands near to the edge of the gelada nesting cliff guard their crops for more months per year than those who have farmlands away from the cliff.

Most of the respondents (85.3%) from the selected villages had negative attitude towards geladas. This may be due to the crop raiding habit of geladas and the expense of energy and human power required to guard crops throughout the day during the harvesting season. Similarly as reported by Yihune *et al.* (2009) the attitude of the local people towards gelada is negative due to crop damage.

Most of the respondents (63.3%) from each village believed that the reason behind crop raiding problems was lack of foraging area and all the accessible lands were used for agricultural purposes. When the geladas move from their nesting site up or down, they come in contact with the cereal crops leading to more conflict, especially during the harvesting season. When natural food resources are limited, easily digestible human food items provide an alternative source of nutrition for primates, intensifying the conflict (Horrocks and Baulu, 1994). Geladas may be interested to consume cereal crops more than grass in the study area because cereal crops are more nutritious and tastier than grasses.

CONCLUSION

Data collected during the present study will provide important information on the population size and behavioural ecology of geladas. The average population number of geladas in the study area was 1525. They spent most of the activity time budget for feeding other than moving, resting and socializing in order to compensate the daily energy requirements from this harsh environment. The home range of gelada is restricted into small patch of land. A total of 60 plant species was consumed by geladas throughout the study period. Geladas dig the ground until the virgin land seems like the surrounding farmlands in order to get bulbs, rhizomes and roots. The requirements of this primate overlap with the local people and lead to severe competition for resource. The only safe haven for gelada baboons is the cliff.

The government should sensitize the local people and officials about the importance of geladas. Further research should be undertaken to save the geladas in this highly modified environment. Protected area should be established in the Wonchit Valley by translocating some of the local people in order to save geladas and other wildlife. The government should provide work

opportunity for the increasing people to avoid farming steepy land by shovel to harvest crops. These steepy land and edge of the cliff are the ideal foraging habitats for geladas.

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REFERENCES

Balakrishnan, M. and D.E. Ndhlovu, 1992. Wildlife utilization and local people: A case study in upper lupande game management area, Zambia. Environ. Conserv., 19: 135-144.

Beehner, J.C., G. Birhanu, T.J. Bergman and C. McCann, 2008. Population estimate for geladas (*Theropithecus gelada*) living in and around the Simien Mountains National Park, Ethiopia. Ethio. J. Biol. Sci., 30: 149-154.

Di Fiore, A., 2003. Ranging behaviour and foraging ecology of lowland woolly monkey (*Lagothrix lagotricha poeppigii*) in Yasuni National Park, Ecuador. Int. J. Primatol., 22: 449-480.

Di Fiore, A., 2004. Diet and feeding ecology of woolly monkeys in a Western Amazonian rainforest. Int. J. Primatol., 25: 767-801.

Dunbar, R.I.M., 1977. Feeding Ecology of Gelada Baboons: A Preliminary Report. In: Primate Ecology: Studies of Feeding and Ranging Behaviour in Lemurs, Monkeys and Apes, Clutton-Brock, T.H. (Ed.). Academic Press, London, Pages: 631.

Dunbar, R.I.M., 1984. Reproductive Decisions: An Economic Analysis of Gelada Baboon Social Strategies. Princeton University, Princeton, ISBN: 9780691083605, Pages: 265.

Dunbar, R.I.M. and U. Bose, 1991. Adaptation to grass-eating in gelada baboons. Primates, 32: 1-7.

Dunbar, R.I.M., 1992. A model of the gelada socio-ecological system. Primates, 33: 69-83.

Fashing, P.J., 2001. Activity and ranging patterns of guerezas in the Kakamega forest: Intergroup variation and implications for intragroup feeding competition. Int. J. Primatol., 22: 549-577.

Fashing, P.J., F. Mulindahabi, J.B. Gakima, M. Masozera, I. Mununura, A.J. Plumptre and N. Nguyen, 2007. Activity and ranging patterns of *Colobus angolensis ruwenzorii* in Nyungwe Forest, Rwanda: Possible costs of large group size. Int. J. Primatol., 28: 529-550.

Hill, C.M., 1997. Crop raiding by wild veterbrates: The farmers perspective in an agricultural community in western Uganda. Int. J. Pest Manage., 43: 77-84.

Hill, C.M., 2002. Primate conservation and local communities: Ethical issues and debates. Am. Anthropol., 104: 1184-1194.

Horrocks, J. and J. Baulu, 1994. Food competition between vervets (*Cercopithecus aethiops* sabaeus) and farmers in Barbados: Implications for management. Rev. Ecol., 49: 281-294.

Hunter, C., 2001. Ecological determinants of gelada ranging pattern (*Theropithecus gelada*). Ph.D. Thesis, Liverpool University, Liverpool.

Iwamoto, T., 1979. Ecological and sociological studies of gelada baboons. Feeding ecology. Contrib. Primatol., 16: 279-330.

Iwamoto, T., 1993. The Ecology of *Theropithecus gelada*. In: *Theropithecus*: The Rise and Fall of a Primate Genus, Jablonski, N.G. (Ed.). Cambridge University Press, Cambridge.

Iwamoto, T., A. Mori, M. Kawai and A. Bekele, 1996. Anti-predator behavior of gelada baboons. Primates, 37: 389-397.

Mori, A. and G. Belay, 1990. The distribution of baboon species and a new population of gelada baboons along the Wabi-Shebeli river, Ethiopia. Primates, 31: 495-508.

Mori, A., T. Iwamoto, U. Mori and A. Bekele, 1999. Sociological and demographic characteristics of a recently found arsi gelada population in ethiopia. Primates, 40: 365-381.

Naughton-Treves, L., A. Treves, C. Chapman and R. Wrangham, 1998. Temporal patterns of crop-raiding by primates: Linking food availability in croplands and adjacent forest. J. Applied Ecol., 35: 596-606.

Ohsawa, H., 1979. The local gelada population and environment of the Gich area. Contrib. Primatol., 16: 3-45.

Ohsawa, H. and R.I.M. Dunbar, 1984. Variations in the demographic structure and dynamics of gelada baboon populations. Behav. Ecol. Sociobiol., 15: 231-240.

Refera, B. and A. Bekele, 2006. Population status and structure of Swayne's Hartebeest (*Alcelaphus buselaphus swaynei*) in Mazie National Park, Ethiopia Int. J. Ecol. Environ. Sci., 32: 259-264.

Saj, L.T., P. Sicotte and J.D. Paterson, 2001. The conflict between vervet monkeys and farmers at the forest edge in Entebbe, Uganda. Afr. J. Ecol., 39: 195-199.

Shah, N.F., 2003. Foraging strategies in the two sympatric mangabey species (*Cercocebus agilis* and *Lophocebus albigena*). Ph.D. Thesis, Stony Brook University, Stony Brook.

Sutherland, W.J., 1996. Ecological Census Technique: A Handbook. Cambridge University Press, Cambridge, pages: 336.

Wong, S.N. and P. Sicotte, 2007. Activity budget and ranging patterns of *Colobus vellerosus* in forest fragments in Central Ghana. Folia Primatol., 78: 245-254.

Yihune, M., A. Bekele and Z. Tefera, 2009. Human-gelada baboon conflict in and around the Simien Mountains National Park, Ethiopia. Afr. J. Ecol., 47: 276-282.