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Activity budget and behavioural patterns of Gelada *Theropithecus gelada* (Mammalia: Primates: Cercopithecidae) on the Gich Plateau of the Simien Mountains National Park, Ethiopia

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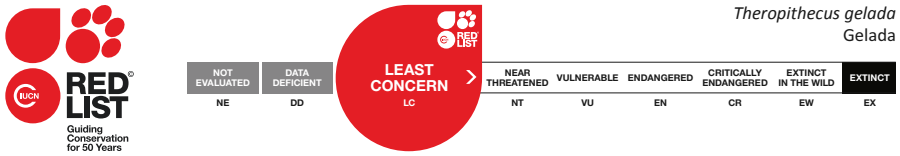
Abstract: The time budget and behavioural patterns of Gelada were studied on the Gich Plateau of the Simien Mountains National Park, Ethiopia. The plateau is dominated mainly by Afroalpine grasses and the endemic giant *Lobelia rhynchopetalum*. Gich lies on the climatic and altitudinal limits of the Gelada's geographical distribution. Activity data were collected using continuous focal animal scan sampling method during 10 consecutive days each month (from May 2013 to April 2014). Data were recorded for different age/sex classes. The Gelada spent on average 56.7% of daylight hours feeding, 14.1% travelling, 10.7% resting, 17.5% socializing and 1.1% in other non-social activity. There was seasonal variation in activity budgets, indicating a significant increase in time allocation for feeding activity, but a decrease in resting time during the dry season. The age/sex classes showed variation in activity budgets, except for social activity.

Keywords: Activity budgets, activity patterns, Gelada, Gich.



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INTRODUCTION

Primates that live in environments where there are seasonal variations of food and climatic conditions exhibit behavioural and physiological adaptations to deal with ecological and energetic challenges (Iwamoto & Dunbar 1983). Many species have scheduled periods of growth and infant weaning to coincide with seasons of favourable conditions. During the climatically and/or energetically most demanding time of the year, some species reduce energy expenditure by reducing overall activity or lowering metabolic rates (Bronikowski & Altmann 1996). Folivorous primates in general spend less time feeding, more time resting and have shorter day ranges than frugivores, due to the abundant and relatively even distribution of leaves in many areas (Dasilva 1992). These behavioural patterns are thought to associate with a strategy of energy conservation (Stanford 1991; Milton 1998).

The relationships among ranging behaviour, habitat quality, group size and diet of a primate species do not always show a consistent pattern (Dunbar 1988; Hunter 2001), probably due to the ability of different species to cope with resource scarcity and feeding competition in different ways. Increased intragroup feeding competition under conditions of resource scarcity may lead animals to increase individual foraging efforts, which may be reflected in longer group travel distance, increased time allocation to travelling and larger seasonal home ranges (Hunter 2001). Some primates could respond to food scarcity without changing their ranging behaviour considerably by broadening the diet or by spending more time in each feeding patch (Di Fiore 2003).

Many factors influence activity budgets of primates in natural habitats, most of which are related to the challenges of acquiring food energy (Coelho 1986). Activity budgets are directly associated with energetic requirements of animals and may vary with seasonal changes in resource availability (Hunter 2001) or reproductive stages (Halle & Stenseth 2000). The ways in which animals allocate time to the main activities provide insights into their adaptation strategies (Iwamoto & Dunbar 1983; Hunter 2001).

Theropithecus gelada is a primate endemic to the central and northwestern highlands of Ethiopia and is the only extant species of the genus *Theropithecus* (Dunbar 1998). Its geographic range is restricted to high elevation montane grasslands (Mori & Belay 1990). At different times researchers (e.g., Iwamoto & Dunbar 1983; Hunter 2001) have carried out short to medium-term studies on the behavioural ecology of Gelada in the Simien Mountains National Park (SMNP). However, there is inadequate data on the behavioural patterns of Gelada at the Gich area. The objective of this study was to conduct the first detailed investigation on the activity budget and behavioural patterns of Gelada. We specifically aimed to: (1) determine the activity budgets, (2) examine whether activity budgets vary with season, and (3) elucidate age/sex class differences in activity budgets.

METHODS

Study Area

The SMNP is located in the North Gondar Zone of the Amhara National Regional State, Ethiopia (Fig. 1). The Park was formally founded in 1966 to ensure the survival of the endemic Walia Ibex (*Capra ibex walie*) and gazetted in 1969 (Hunter 2001). It covers a geographical surface area of approximately 412km^2 of the Simien Mountains watershed (Gebremedhin et al. 2009). The study was conducted on the Gich plateau of the national park (13^{0}06'44.09"–13^{0}23'07.85"N & 37^{0}51'26.36"–38^{0}29'27.59"E). The plateau is characterized as the climatic and altitudinal limits of the Gelada's geographical distribution (Iwamoto & Dunbar 1983). The area is a treeless landscape dominated by grasses as well as the endemic giant *Lobelia rhynchopetalum* (Images 1 & 2).

Data collection

Four social groups of Gelada inhabited various portions of the plateau. The band that ranged into the major area of Gich was the primary focus of the study. The study band varied in size from 183 animals at the start of the study in May 2013 to 205 by the end of April 2014, due to the birth of individuals. At the beginning of the study, the band consisted of 31 adult males, 47 adult females, 35 subadults of both sexes, 20 juveniles and 16 infants. There were three all-male groups of 23 individuals, which were considered to be part of the focal band as they had completely overlapping home ranges. We began habituating members of the band to the presence of observers in February 2013. Gelada could be followed at a distance of <10m and many individuals were easily identifiable based on natural markings.

Activity data were collected using continuous focal animal scan sampling method (Altmann 1974) during 10 consecutive days each month (from May 2013 through April 2014). Individual Gelada was made the focus of

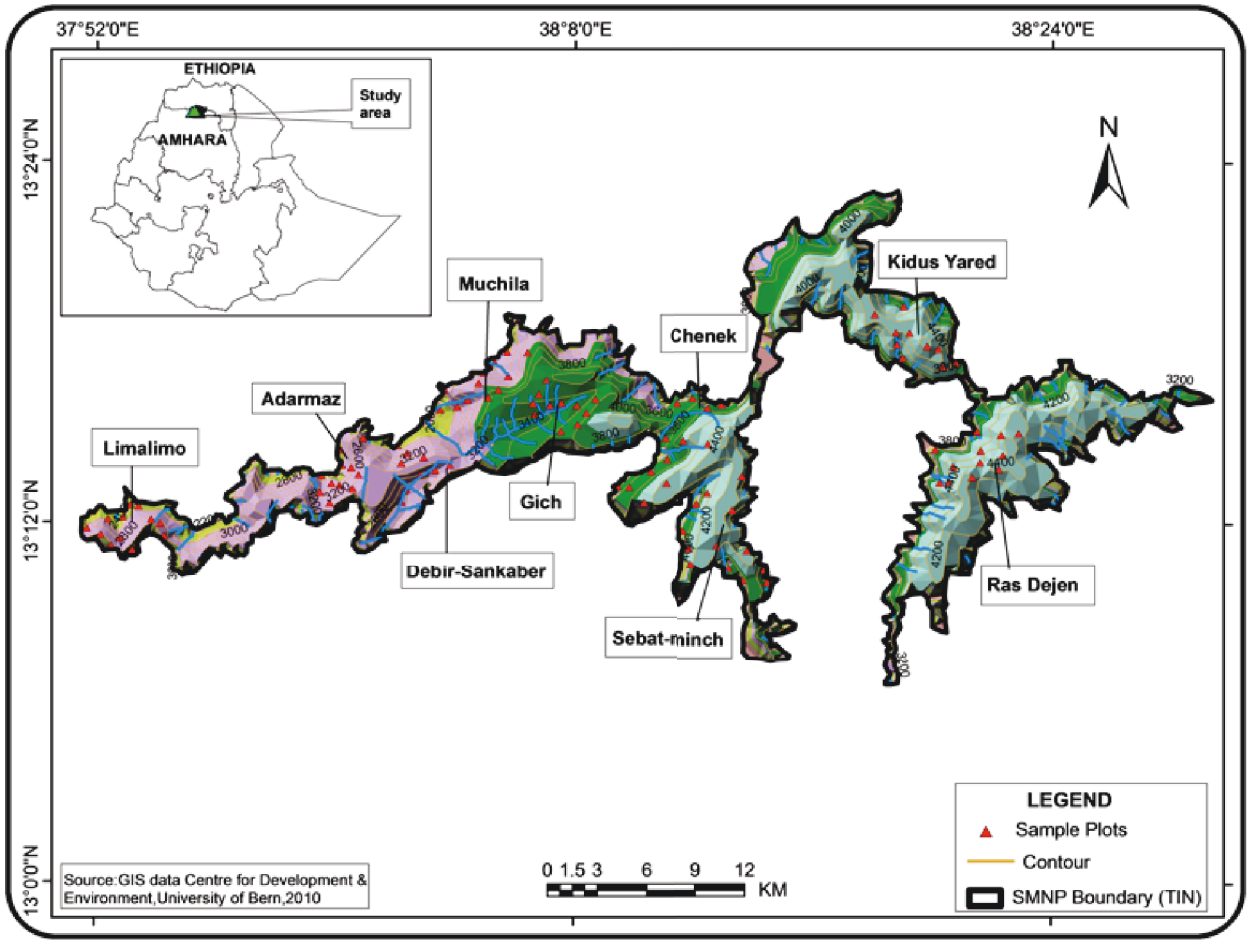

Figure 1. The Simien Mountains National Park showing the study site

Image 1. *Theropithecus gelada*

Image 2. The Gich plateau - a treeless landscape

dawn-to-dusk follows from 07:00 to 18:00 hr. Data were recorded for different age/sex classes, which were selected opportunistically. Age/sex classes were assigned to each individual based on physical size and development characteristics (Kawai et al. 1983).

Activity of the focal individual was recorded at 30 one-minute sequential scans (Hunter 2001). If contact with the focal animal was lost, the data collection process continued with another individual of the same age/sex class. At the end of each scan sample, a new focal animal was chosen from individuals furthest away from the previous focal individual. Each focal animal

was recorded as performing one of the following four mutually exclusive behavioural states: feeding, travelling, resting and socializing. Feeding was recorded when the animal was plucking or eating short grasses, plucking or eating above ground food other than grass, and digging or eating underground food items (Hunter 2001). Travelling was recorded when the focal individual moved at least five paces. Resting was recorded when the subject was standing, self-grooming and reclining/sitting, without being engaged in any other activity. Socializing was recorded when the animal was engaged in interaction with other individuals, including grooming another individual or being groomed by others, fighting, chasing and threatening. When the animal was engaged in behaviour that cannot be easily characterized by the above activity states, it was recorded as "other".

Data analysis

Statistical analysis was performed using SPSS statistical software (version 16.0) for windows. Prior to statistical analysis, all data were assessed to determine whether they were normally distributed. Non-parametric tests were used for data that were not normally distributed. All statistical tests are 2-tailed with a level of rejection set at p=0.05, although if trends are apparent in the data, precise p values may be listed.

RESULTS

Gelada are very active animals, allocating more than 70% of their time to feeding and travelling activities. The overall activity budget was dominated by feeding (Fig. 2), which contributed to 56.6% (grazing 44.7%, foraging 3.5%, digging 8.4%) of the time Gelada spent on the four main activities recorded. Feeding occurred at a rate of 34.0 minutes per focal hour of observation. Socializing was the next most common activity, accounting for 17.5% (allogroom 14.9%, aggression 0.9%, play 1.7%) of the time (10.5 min/focal h). Travelling contributed to 14.1% of the time (8.5 min/focal h) recorded. Resting was the least common activity, accounting for 10.7% (self-grooming 2.6%, standing 0.8%, reclining/sitting 7.3%) of the time (6.4 min/focal h). Other non-social activity contributed to 1.1% of the time.

The analysis of the daily activity patterns of gelada revealed many active peaks (Fig. 3). Feeding activity indicated an increase during the late morning, at early afternoon (13:00–14:00 hr) and towards the end of the early afternoon (15:00–16:00 hr). Gelada travelled the longest distance during the late morning between 10:00 and 11:00 hr, travelling at an average speed of 343m per hour. Travel speed decreased between 16:00 and 17:00 hr to an average of 205.2m/h, but after 17.00hr, distance travelled increased again as the animals headed for a sleeping site. Gelada usually had a long resting period from 08:00–10:00 hr, 12:00–13:00 hr and 15:00–16:00 hr. Social activity peaked from 08:00–09:00 hr. Similarly, other non-social activity was peaked from 13:00–14:00 hr. In general, resting and socializing were predominant activities during the early morning and late afternoon hours. Gelada stopped every activity during heavy rainstorms.

Adults of both sexes were observed leading band progressions, but males were recorded to lead more often than females. Group movements were usually initiated by an adult male of the all-male group, although this animal did not necessarily stay at the head of the progression. As band movements were not cohesive, different subgroups followed different pathways, with the entire band reassembling at the end of a group movement.

There were monthly differences in the activity budgets of gelada (Table 1). The proportion of time spent feeding ranged from 50.2% during the height

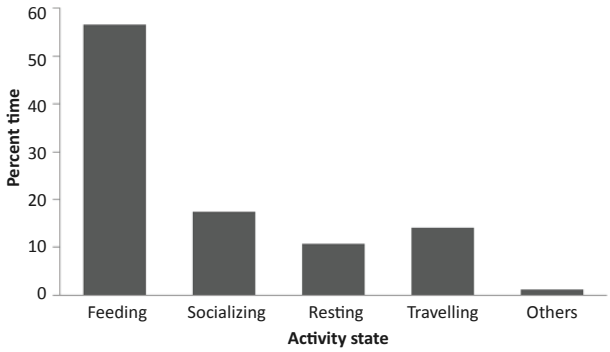

Figure 2. Percentage of total time budget spent by gelada in each of the main activities during the study period

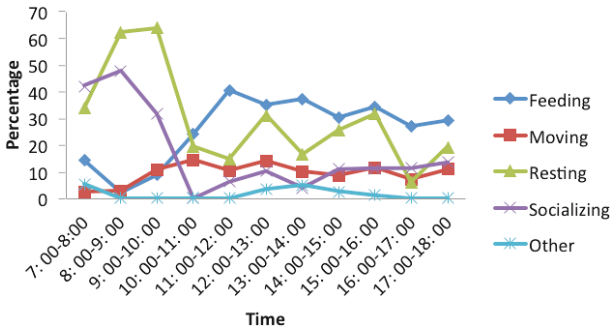

Figure 3. Daily activity patterns of gelada during the study period

Table 1. Monthly time budgets as the percentage of time spent in each activity state

	Activity state					
Month	Feeding	Travelling	Resting	Socializing	Others	No. of records
May	57.0	14.6	11.1	16.4	0.9	2,563
Jun	52.1	16.7	13.2	17.0	0.9	2,143
Jul	50.6	16.7	13.7	17.9	1.1	1,621
Aug	50.2	17.4	12.1	18.9	1.5	1,433
Sep	54.2	17.2	10.2	17.3	1.1	2,019
Oct	54.5	15.4	12.1	16.4	1.4	1,696
Nov	57.3	12.2	10.1	19.5	0.9	2,209
Dec	57.7	10.8	9.9	21.0	0.7	2,286
Jan	59.0	15.1	8.7	16.6	0.8	2,619
Feb	60.8	11.6	8.3	17.8	1.8	2,590
Mar	62.7	11.2	9.6	15.1	1.5	2,434
Apr	62.8	10.5	9.5	16.5	0.9	2,565
Mean ± SD	56.6 ± 4.3	14.1 ± 2.7	10.7 ± 1.7	17.5 ± 1.6	1.1 ± 0.3	2,181 ± 441

of the wet season (August) to 62.8% in the dry season (April). Time spent travelling also varied; it was at its lowest during the dry season (April, 10.5%) and peaked in the wet season (August, 17.4%). Social time was lowest at 15.1% during the dry season (March) and was peaked at 21.0% in December. Resting time peaked in June during the early wet season at 13.8% and was the lowest in February (8.3%) in the dry season.

Pairwise comparisons of the activity states through LSD multiple comparisons demonstrated that feeding and social activities had significantly (p<0.05) more time allocation compared to travelling and resting. Feeding and socializing time budgets were significantly different (p<0.05). The travelling time budget was significantly more than the resting time budget (p<0.05). During the dry season, gelada allocated time for the main activity states in the same trend like the wet season.

The time budgets for different activities of the age/sex classes were analyzed. One way ANOVA demonstrated that the age/sex classes differ in all activity budgets, except for social activity (feeding: $F_{[4,55]}$=8.89, p<0.001; travelling: $F_{[4,55]}$=4.99, p<0.01; resting: $F_{[4,55]}$=7.27, p<0.001; socializing: $F_{[4,55]}$=1.12, p>0.05; others: $F_{[4,55]}$=4.72, p<0.01).

Adult females spent significantly more time feeding compared to adult males, whereas adult males spent more time in resting (paired-samples t test, feeding: t=-3.56, p<0.01, resting: t=2.72, p=0.05; n=12 mo). The two sexes were alike in the proportion of time allocated to travelling, socializing and other non-social activity (travelling: t=-1.04, p=0.319; socializing: t=0.17, p=0.863; others: t=1.26, p=0.233). Adults spent significantly more time in travelling and other non-social activity than subadults (travelling: t=2.77, p<0.05; others: t=2.63, p=0.05). There was no significant difference in all activity budgets between the sexes of subadult individuals. Juveniles were significantly different from adults and subadults in time budgets for many of the activity states. Adults spent significantly more time in feeding and other non-social activity than juveniles (feeding: t=12.95, p<0.001; others: t=3.91, p<0.01), but they spent significantly less time resting (resting: t=-3.40, p<0.01). Similarly, subadults spent significantly more time in feeding than juveniles (feeding: t=11.83, p<0.001), but they spent significantly less time resting and travelling (resting: t=-3.40, p<0.01; travelling: t=-3.89, p=0.01). The annual time budgets for different activities of the age/sex classes are presented in Table 2.

Table 2. The mean (± SD) proportion of time (%) spent on the activity states by the age/sex classes

	Adult		Subadult		Juveniles
Activity state	males	females	males	females	
Feeding	55.8±4.4	58.9±6.2	57.0±3.3	61.0±4.4	50.3±4.7
Travelling	14.5±4.2	15.4±4.1	11.8±3.1	11.6±3.3	17.3±4.0
Resting	10.8±3.7	7.6±1.9	10.9±3.6	10.0±2.3	14.2±3.2
Socializing	17.3±3.3	17.0±3.1	19.4±3.5	16.5±4.1	17.5±3.8
Others	1.7±0.7	1.4±0.5	1.0±0.6	0.8±0.5	0.8±0.7
No. of records	4,864	5,551	5,421	5,325	5,017

Table 3. The mean (± SD) proportion of time (%) spent on the activity states by gelada during the dry and wet seasons

Activity state	Dry season	Wet season	$F_{[1,58]}$	*P*
Feeding	60.1±4.7	53.1±4.7	32.843	0.001
Travelling	16.3±4.0	11.9±3.2	22.326	0.001
Resting	9.3±3.2	12.1±3.6	9.675	0.030
Socializing	17.8±3.9	17.3±3.4	0.242	0.625
Others	1.1±0.7	1.2±0.6	0.069	0.794

Age/sex differences in some of the main activities were apparent. Specifically, females groomed more than males. Most of the grooming involving adult females were engaged in by lactating females. The greater amount of time spent engaged in play behaviour by individual members of the band is attributed to the juveniles. Juveniles were recorded as playing during approximately 10% of all activity scans involving juveniles.

There were seasonal differences in the activity budgets of Gelada. The proportion of time allocated for different activity states by the Gelada varied with season, except for socializing and other non-social activities as shown in Table 3.

DISCUSSION

This study indicated that gelada devote more than half of their time to feeding over other activity states. The reason for the high proportion of time allocated to the feeding activity may be due to Gelada's dietary specialization on grass (Dunbar & Bose 1991). Dunbar (1992) suggests that the availability of food and its energy content are critical determinants of an animals' daily activity pattern, therefore factors that influence food availability have a strong effect on time allocation decisions.

Resting received the least amount of time, probably due to the Gelada's habitat at Gich being more resource constraining. The nutritional stress associated with resource scarcity might have resulted in reduced resting time (Dunbar & Bose 1991). The observed prioritization of time allocation for feeding and social activities by the Gelada agrees with findings from the studies of Hunter (2001) and (Iwamoto & Dunbar 1983). The Gelada under this study had always more time for social activity than resting monthly and seasonally. Dunbar (1992) and Bronikowski & Altmann (1996) have reported that time allocated to various activity states by baboons was typically determined in consideration of time left over after feeding. There are, however, differences among baboon groups and their environments. The lower time budget for resting by the Gelada is normal for baboons because resting needs less time compared to feeding and other activities. Dunbar (1992) suggested that ecologically stressed Baboons may reduce rest and social times for increased feeding time under poor ecological circumstances. This suggestion gives support to our finding in that Gelada at Gich also increased feeding time, but reduced resting time during a period of food scarcity in the dry season. For the gelada, social time was maintained significantly higher than resting, which shows that they could spare more time for social activity than they do for resting. Dunbar (1992) pointed out that many social animals, such as primates, require time to establish and maintain social relationships that affect their access to resources or mates. Social interactions like grooming service relationships that maintain group cohesion (Dunbar & Dunbar 1988). Where two activities cannot be performed concurrently, some individuals may allocate time between various behavioural options better than others (Mangel & Clark 1986; Dunbar 1988).

Gelada showed significant monthly differences in activity budgets. Time spent feeding was highest during the dry season months, especially between January and April. Although significant monthly differences were found in resting and other behavioural activity states, these were not concentrated at any time of the year. There were also significant seasonal variations in the proportion of time allocated to the main activities. Gelada spent significantly more time feeding during the dry season than in the wet season. The significant increase in feeding time is due to the paucity of the preferred green grass leaves (Crook 1966) and thus the shift to underground food items which require increased processing time (Hunter 2001). Isbell & Young (1993) have reported that activity budgets of primates may vary seasonally in response to changes in the abundance, quality or distribution of important food resources. Similarly, Hunter (2001) has reported that Gelada at the Sankaber area of the SMNP adjust their activity budgets seasonally according to the availability and type of food resources in the habitat. Gelada are faced with low availability of food resources during the dry season as the grasses become desiccated and thus less preferable (Crook 1966). The seasonal variation in feeding time is thus related to ecological variables characterizing resource availability and climatic conditions (Iwamoto & Dunbar 1983).

Thermoregulatory burden is another factor worth

considering in relation to seasonal activity budgets of gelada at the Gich area. During the dry season months, especially between December and April, the plateau experiences near freezing night-time temperatures. Iwamoto & Dunbar (1983) suggest that Gelada allocate more time to feeding over other activities as elevation increases, due to the increased metabolic energy requirements resulting from lower ambient temperatures. Furthermore, at high elevations such as the Gich Plateau, there is an overall decrease in the diversity of food resources (Iwamoto & Dunbar 1983).

We found significant differences in activity budgets between the age/sex classes of Gelada. Age/sex classes differ in all activity budgets, except for social activity. Although adult females are about half of the body size of adult males (Ohsawa 1979), they spent significantly more time in feeding than adult males, which spent more time resting. Many of the adult female focal individuals were either pregnant or had dependent offspring. The increased feeding time in adult females may be due to the extra energetic requirements of natal care giving. Shanee & Shanee (2011) have reported similar results for free-ranging Yellow-tailed Woolly Monkeys *Oreonax flavicauda*. Adult females with dependent infants spent the least time resting of all age classes. Adults spent significantly more time travelling and in other activity states than subadults. Adults and subadults may not have the same energetic requirements due to physical size differences.

Detailed data on activity budgets of Gelada that spans a year or more are lacking from the SMNP and other habitats. Therefore, comparisons to our results are impossible. Further studies are needed from other areas to enable proper comparison to our findings. Particular emphasis should be put on studying Gelada at sites with different habitat types and at different elevations.

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