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Demographic Structures of Gelada (*Theropithecus gelada*) in Guassa Community Protected Area, Ethiopia

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Abstract- In geladas, sociality and population structure are unusual because they establish highly differentiated bonds with other group members. Such bonds are particularly pronounced among female geladas, with female philopatry and male dispersal. In the present study, gelada band size and population structures varied between wet and dry seasons. The mean number of females per harem varied from 4.5 to 7.1. In addition, the mean harem, or reproductive female size in all study bands is not statistically significant within season, or between seasons ($P > 0.05$). The sex ratio did not also show any significant differences between seasons. However, the adult sex ratio and the mean number of reproductive females within the units were statistically significant ($t_{10=}$ -5.6, $P < 0.05$). Gelada population growth rate is relatively high (mean = 17.1 % per annum) in Guassa Community Protected Area, and it could be deduced by the differences in number of birth and death at a given period of time within the natural population. Ratio of females per male was relatively lower in the study bands of geladas in present study area, and it doesn't show a true relationship annual growth rate of gelada population. However, the number of births per female/year has brought a significant change on gelada population.

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I. Introduction

The gelada baboon (*Theropithecus gelada*) pose multi-female organization is known to have a multi-level (modular) social system (Le Roux *et al.*, 2011). Thus, although this species attests to the relationship between philopatry and stable dominance hierarchies (Dunbar, 1986). Among the Cercopithecine, gelada exhibits multilevel societies based on one-male unit system (Mori, 1979; Kawai *et al.*, 1983). Each one-male unit has a number of adult females and one leader male that has exclusive reproductive access to unit females. Females within one-male units are reported to have close female bonds (Johnson *et al.*, 2013) and are also thought to be philopatric with respect to the unit (Dunbar, 1993). Gelada units and bands are relatively stable in composition during stable environmental conditions (Ohsawa and Dunbar, 1984), although this stability may break down in more extreme environments (Mori *et al.*, 1999). Thus, geladas present an ideal example for examining the relationship between a multileveled society, male dispersal and female philopatry (Le Roux *et al.*, 2011).

Demographic structures of geladas more likely shaped by both dependant and independent factors (Ohsawa and Dunbar,1984). Population variables can also determine by a combination of environmental, demographic and social factors interacting in complex ways (Altmann and Altmann, 1970). Geladas birth rates and survivorship (growth) are adversely influenced by local climatic conditions. These independently influenced sex ratio, which in turn determine the proportion of male to female ratio and multimale reproductive units in the population (Hill and Lee, 1998).

II. The Study Area and Methods

a) *The study area*

The Guassa Community Protected Area (GCPA) is one of the high altitude ranges in the central highlands of Ethiopia located at a distance of 265 km from Addis Ababa, in the north-east direction, and 135 km from the zonal capital (Debre Birhan) in the north direction, this area lies between 10° 15'–10° 27' N latitude and 39° 45'–39° 49' E longitude (Fig.1). The GCPA with a total area of 111 km^2, forms part of the western edge of the Great Rift Valley, at an altitude range of 3, 200–3,700 m asl. Rainfall of the area is characterized by a bimodal pattern. The major wet season occurs during June and September and a short rainy season during February and April. The annual rainfall in the area ranges from 1,200 to 1,600 mm. Temperatures of the area is characterised by mild days and cold nights. In the driest months (December–February), day time temperatures can rise upto 25°C, while night time temperatures may fall to –7°C (a diurnal fluctuation of 32°C). The area is characterized by high altitude vegetation types. Traditional indigenous management of natural resources in the area has helped the survival of various species of endemic fauna and flora that are locally extinct in similar parts of the country (Zelealem and Leader-Williams, 2005; Zelealem *et al.*, 2012).

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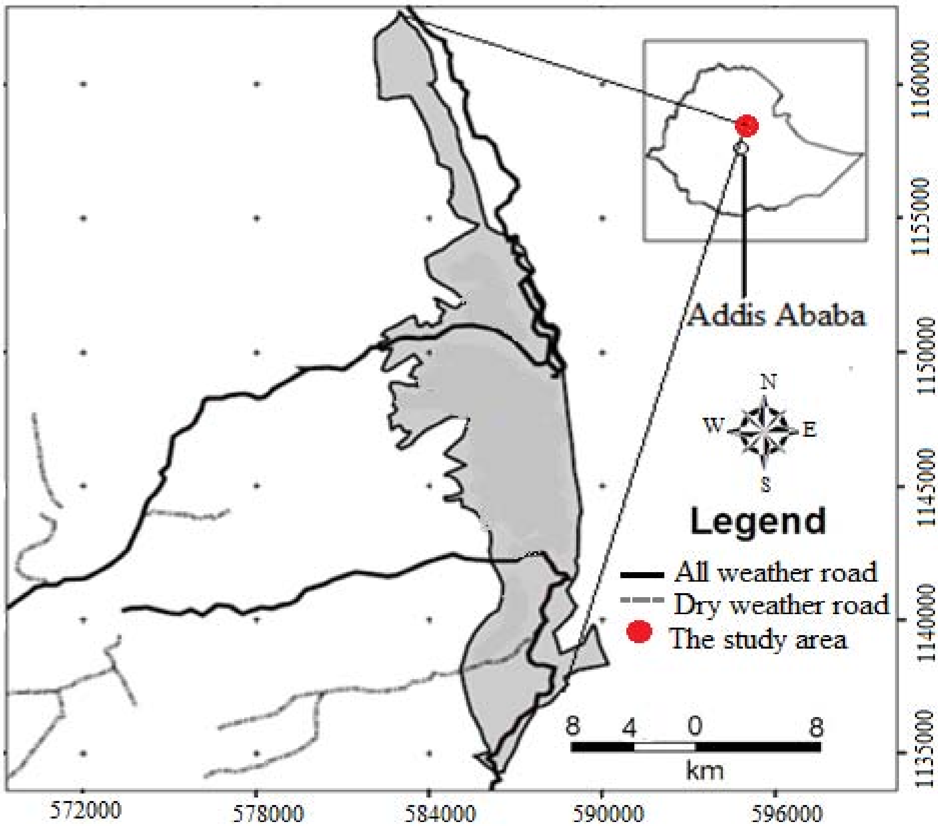

Figure 1 : Map of the study area

III. Methods

In the beginning of the study, an intensive effort was made to obtain a complete census of all the units in the main bands. Intact units in the band were randomly selected in order to collect data about population structure and behavioural activities. The geladas were followed walking slowly from a distance of around 5 m and data were collected by means of focus group sampling (Altmann, 1974). Data were collected five days a week, between 07:30 h–18:30 h. For population estimation and growth change of geladas in the study area, sweep census technique was used (Beehner *et al.*, 2008) regularly at least once per month in each of the study sites across the study period, covering both wet and dry seasons.

IV. Results

a) Demographic structure of the gelada population

A total of 1502 individuals of geladas were recorded in the six study bands in GCPA during the present investigation. The population size of each these bands and their structure varied between wet and dry seasons. Results on demographic structure of geladas have indicated that there was no difference in the mean reproductive unit size between seasons (Kruskal-Wallis H test, $P > 0.05$) (Table 1). Kruskal-Wallis H tests showed that there were significant differences in the band size of study population of Tsewo, Baltegra, Sefedmeda, Wochanka, Dejameda and Atsewuha between seasons ($P < 0.05$).

Table 1 : Demographic structure of geladas in dry and wet seasons

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

The mean number of females per harem varied from 4.5 to 7.1 for the 6 bands. The mean harem, or reproductive female size in all study bands is not statistically significant within season, or between seasons (Kruskal-Wallis H test, $P > 0.05$). However, the mean size of the reproductive unit (all ages and sex) of the geladas was significantly larger at Wochanka ($P < 0.05$).

The sex ratio (females per male) was not statistically significant between seasons (Kruskal-Wallis H test = 0.01, $df_{1,}$ 3.34, $P > 0.05$). There was no significant difference in the sex ratio within season across the study bands ($P > 0.05$). However, the adult sex ratio and the mean number of reproductive females within the units were statistically significant ($t_{10=}$ -5.6, $P < 0.05$). In most cases, the reproductive unit has one adult male. However, some reproductive units contain more than one adult male (multimale units). The percentage of multimale units differed significantly between seasons (Mann-Whitney U test, $P < 0.05$).

Population growth rate per annum for the six bands are given in Table 2. The growth rate based on the number of births and deaths relative to the band size, (however migration was not been included due to high fusion and fission rates). Populations of geladas were increased (overall mean = 17.1 % per annum). There is a close correlation between annual growth rate and birth rate. The overall mean growth rate was higher at Tsewo (20.3 % per annum, n = 47) than at Baltegra (12.7 % per annum, n = 39). The overall mean mortality rate was low (1.4 % per annum), and the lowest mortality rate was recorded at Deja Meda (0.78 % per annum), and the highest mortality rate was recorded at Wochanka (1.99 %).

The number of females per male was relatively lower in the study bands of geladas (Table 2). The lowest ratio of females to male was recorded in Baltegra and Sefed Meda bands (2.4:1). However, females to male ratio in Atsewuha were higher (4.5:1) as compared to the other studied bands.

Table 2 : Estimates of annual growth rates for the six gelada bands in Guassa Protected Area

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

∗ Migration and emigration of each band have been not considered to this data.

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

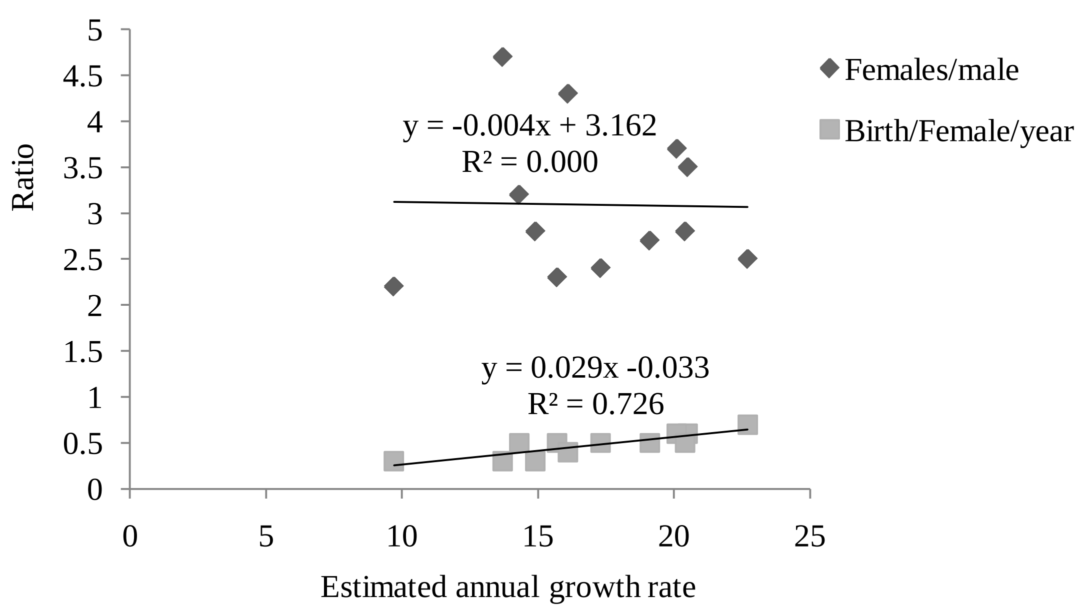

Figure 2 : Annual growth rate of geladas in Guassa Community Protected Area showing females to male and birth per female/year

V. Discussion

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

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

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

In the present study population, the number of adult females per male varied from one band to another with a range of 2.4:1 to 4.5: I. This might be due to the variations in the composition of bands, which results in differences in the ratio of females per male. Dunbar (1980) also noted similar sex ratio of adult female to male in the Semien Mountains National Park. However, studies carried out by Zewdu *et al*. (2013) in Wonchit Valley, Ethiopia showed relatively high sex ratio of adult females to males that varied from 6.5:1 to 6.7:1. The present study has revealed that annual growth rate has no direct relationship with the number of females per male. This might be due to the fact that the growth rate is directly determined by the number of birth per female/year, which in turn is influenced by the habitat quality and demographic processes. Similarly, Dunbar and Sharman (1983) have reported that birth rate (number of births per mature female per year) contributed for the population growth, and against the adult sex ratio. However, sex ratio is a causal precursor of birth rate (Ohsawa and Dunbar, 1984).

VI. Conclusion

The present investigation provides useful information on gelada population structure and growth rate of the species in the area. Average reproductive unit size in geladas did not show a significant difference between seasons in each study bands. Variations of unit size in the band between seasons have no significant change on the average size of the reproductive unit. Band size of geladas varies between seasons. The study also revealed that gelada population growth rate is high in the study area. This shows that threats of predators in the area are minimal. The area with good ground vegetation shows the positive effect of better conservation practices undertaken during the study period.

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